UDC 628.396

D.V. SHAPOVALOVA*,* student, NTU “KhPI”
V.A. PULYAYEV, D.Sc., Prof., deputy director, Institute of Ionosphere, Kharkiv

REFINEMENT OF THE INCOHERENT SCATTER RADAR CONSTANT

Examined a variant of the software for procedure realization for comparing the level of noise at the input of the incoherent scatter radar, order to improve its constants without using information from the ionospheric station.

Keywords: scattering signal, the constant radar, software algorithms, ionospheric station, the parameters of the ionosphere.

Introduction. Dynamic processes, which occur in the ionospheric plasma and largely determine the structure of the field F, we have enormous influence on the radio waves propagation channel. The study of these processes is associated with the need to predict the state of the ionosphere and determine the optimum conditions for the short-wave communication. The electron density N_e is one of the main defined parameters of the ionospheric plasma.

The method of incoherent scatter (IS) to obtain information about the basic parameters of the ionosphere suggests as one of the options, attraction the IS radar constant C_{et}, which show the state of its technical systems [1]. However, some difficulties encountered, when we using a constant. These include situation in which the current state of technical systems varies and differs from the primary, when was determined the constant C_{et} for radar.

The periodic heating and cooling of the large surfaces waveguide lines, which occur due to changes network supply voltage and fluctuations the ambient temperature is the main causes of instability of the characteristics of hardware. Also the situation is complicated with change of solar activity during magnetic and ionospheric storms. It is causing the necessity in adjusting the amplitude for the input signal dynamic range of the ADC by changing the amplification factor in the receiver. The result is a divergence with the radar constant C_{et}. To resolve this, is applied periodic refinement a constant using the automatic ionospheric station – the ionosonde.

In [2] proposed a variant of carrying out correction for the values of the constant C_{et} in another way – using the information about changing the noise power $P_c(t)$, which present at the input of the IS radar on the current day of the experiment.

The purpose of this article is to develop software algorithms for the implementation the procedure refinement for the IS radar constant by information about changing the noise power at the radar input.

Implementation of program for the processing mode. In [2] analyzed the components of the background noise that enters the area of the antenna pattern.

For information about the changing technical characteristics of the IS radar will compare next graphic lines: the diurnal cycle power $P_{et}(t)$, recorded during the calculation of the constants C_b in the test day, with noise power $P_c(t)$, obtained within the time $t = \overline{0, T}$ on the current day (see block diagram in Fig. 1).

For convenience, such a comparison will put the condition that the array $P_{et}(t)$ consisted of $N = 365$ samples, allowing to realize a cyclic shift of the graph along the time axis with a step of $1/N$, corresponding to $\Delta t \approx 4$ min. This shift corresponds to a change of position of the Earth in relation to the sky for a period of one day. Similarly, in an array $P_c(t)$ readings must attend with the same discreteness. And since in the IS method for the formation of the daily line taken receive counts of the noise power for each interval of 15 minutes, using the programmatic transformation primarily necessary spend interpolation between points for values $P_c(t)$, aligning dimension of arrays.

After interpolation, necessary implement the cyclic shift of one of the graphs (Fig. 2) along a horizontal line, and simultaneously run the iterative procedure for finding the minimum value of $\Delta(n)$ in the form [2].

$$\Delta(n)\big|_{n=\overline{0,N}} = \sum_{t=0}^{T} \{P_{et}(t) - [P_c(t - n\Delta t)\}^2 \Rightarrow \min .$$

The following procedure will give the opportunity to fix the coincidence of minima and maxima of the two lines along the horizontal. Incidentally, at this point ($t_0\big|_{\Delta(n)=\min} = t - n_0 \Delta t$), spending the count for number of shifts ($n_0 = 304$ in Fig. 3), can refine the date of the measurements.

In the next step alternately will changing the values of variables k and d (step depends by precision) and must be implemented the procedures of finding a minimum meaning of $\Delta(k, d)$ as [2]

$$\Delta(k, d)\big|_{\substack{k=\overline{-2,+2} \\ d=\overline{-2000,+2000}}} = \sum_{t=0}^{T} \{P_{et}(t) - k \cdot [P_c(t_0) + d]\}^2 \Rightarrow \min ,$$

which gives an opportunity to compare the lines ($k_0 = 0{,}5$ and $d_0 = 1132$ in Fig. 4), but along the vertical.

Execution completes these procedures the constant C_c in current day is calculated as [2]

$$C_c = \frac{C_{et}}{k_0}\left[1 - \frac{k_0 \cdot d_0}{P_=}\right] = C_{et} \cdot 0{,}5 ,$$

where $P_= = 750$ – a component of the noise level, which is fixed during the definition of the constant C_{et} at the IS radar, using the transmitter, which is currently is disabled.

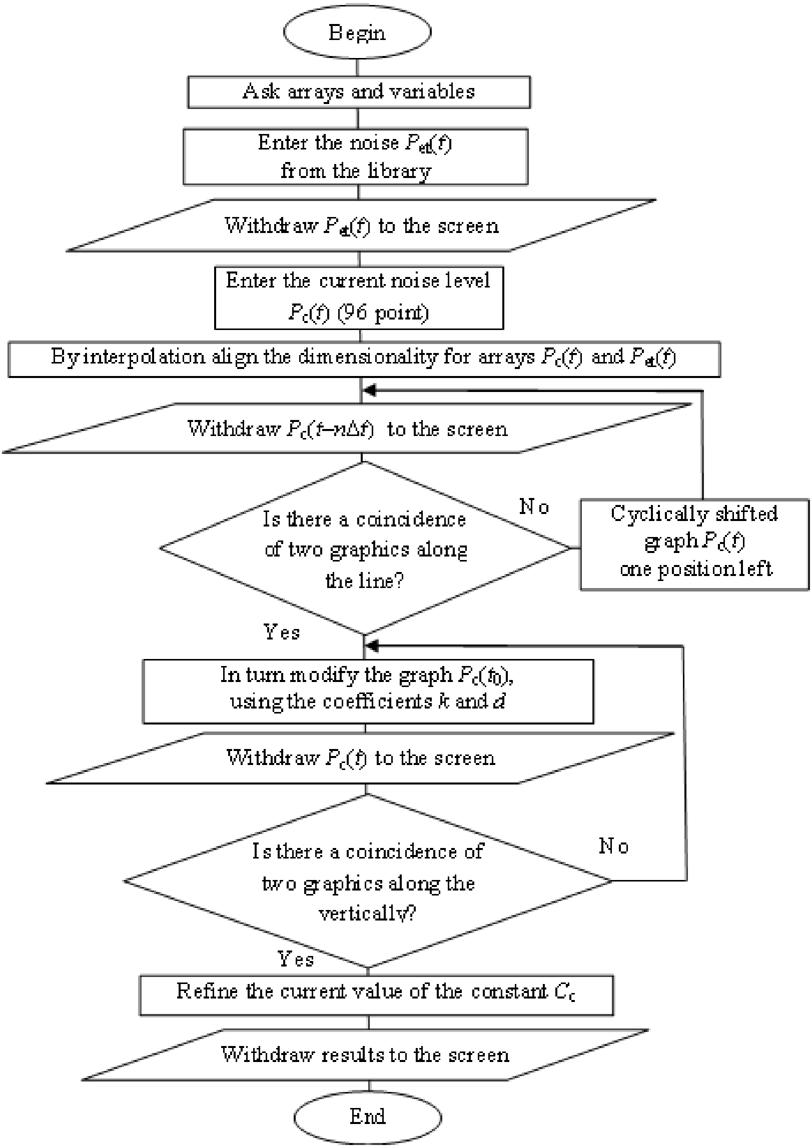

Fig. 1 – The flowchart of algorithm for correction of constant C_c

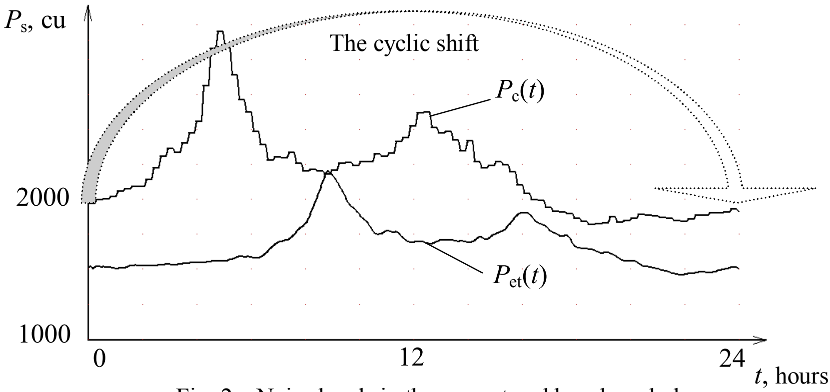

Fig. 2 – Noise levels in the current and benchmark days

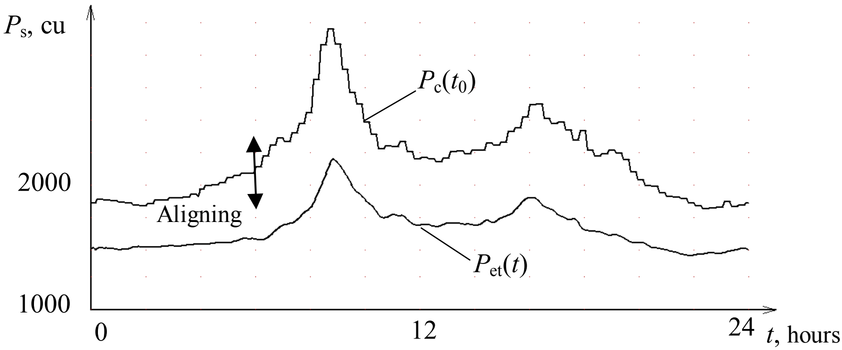

Fig. 3 – Moment of aligning lines along the horizontal

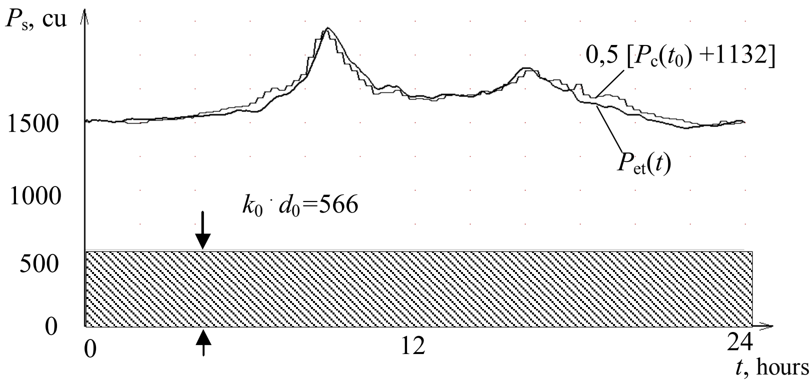

Fig. 4 – Moment of aligning lines along the vertical

Conclusions. In this article describes the procedure that implements the checking and refinement the constant of IS radar and making possible to use it in the future for more accurately assess of the electron density N_e in the ionosphere by the measured the scattering signal.

It is shown that the constant does can not track changes in the characteristics of the technical systems of radar in time, for its refinement is necessary the station for vertical sounding. In the above work, alternatively, for independent verifying the constants considered the way, based on the using of information that provided by the noise and obtained by the receiving antenna. Flowchart and software, using the language operators of *FreeBASIC*, was developed for implementation of this method. Using the mathematical transformations for arrays which containing information about the distribution of the noise power in the etalon and in one of the working days of the measurements, have been demonstrated the one is example for comparing the noise elements.

The comparison results showed that, with ratio to the benchmark day (C_{et} constant was determined June 1), the information of the current day was obtained by the cyclically shift left on n_0 = 304 positions that correspond to the calendar date on April 2.

After that there were obtained coefficients k_0 = 0,5 and d_0 = 1132, which provided information on changes in the receiving and transmitting IS radar systems, which led to the nonconformity of reality for the constant C_{et} on 50%.

References: 1. *Evans J.W.* Theoretical and practical issues to investigate the ionosphere by means of incoherent scattering of radio waves / *J.W. Evans* // PIEEE. – 1969. – Vol. 57, № 4. – P. 139-175. **2.** *Pulyayev V.A.* Defining the parameters of the ionosphere method of incoherent scattering of radio waves: Monograph / *V.A. Pulyayev, D.A. Dzyubanov, I.F. Domnin*. – Kharkiv: NTU "KhPI", 2011. – 240 p.

Received 20.05.2014

UDC 628.396

Refinement of the incoherent scatter radar constant / D.V. Shapovalova, V.A. Pulyayev // Bulletin of NTU "KhPI". Series: Radiophysics and ionosphere. - Kharkiv: NTU "KhPI", 2014. – No. 47 (1089). – P. 5-9. Ref.: 2 titles.

Рассмотрен вариант реализации процедуры программного сравнения уровня шума на входе радара некогерентного рассеяния для уточнения его константы без использования информации с ионосферной станции.

Ключевые слова: сигнал рассеяния, константа радара, программные алгоритмы, ионосферная станция, параметры ионосферы.

Розглянуто варіант реалізації процедури програмного порівняння рівня шуму на вході радару некогерентного розсіяння для уточнення значення його константи, не використовуючи при цьому інформацію з іоносферної станції.

Ключові слова: сигнал розсіяння, константа радару, програмні алгоритми, іоносферна станція, параметри іоносфери.

UDC 621.396, 004.457

O.V. BOGOMAZ, research scientist, Institute of ionosphere, Kharkiv;
D.V. KOTOV, PhD, research scientist, Institute of ionosphere, Kharkiv

A LIBRARY OF ROUTINES FOR INCOHERENT SCATTER RADAR DATA PROCESSING

The structure of the developed dynamic link library of routines for incoherent scatter radar data processing and incoherently scattered signals simulation and the examples of its application are described.

Keywords: incoherent scatter, data processing, simulation, numerical computing routines.

Introduction. Incoherent scatter radar data processing is produced by the complicated program packages GUISDAP and UPRISE for example [1, 2].

GUISDAP (Grand Unified Incoherent Scatter Design and Analysis Package) is used on EISCAT radars and needs a MATLAB environment in the Linux or Windows operating system (OS). The MATLAB application is built around the own high-level language and provides a lot of numerical computing routines for data processing. These features make GUISDAP sources more clear to understand and simpler to improve.

UPRISE (Unified Processing of the Results of Incoherent Scatter Experiments) package is used for processing of the data obtained by means of Kharkiv incoherent scatter radar (ISR). The package includes programs for viewing the initial data, interference filtering, time integration, altitudinal correction and estimating of ionospheric plasma parameters. It is written using FreeBASIC, runs in Windows OS and doesn't need any third-party software. The most used routines for UPRISE were exported to the dynamic link library (DLL) *albom.dll* written in C programming language.

Purpose of the article is to present the developed dynamic link library of routines for incoherent scatter radar data processing.

Library structure. *Albom.dll* consists of more than 100 functions that can be divided into several groups.

The first group is represented by functions for manipulating the initial data. The library can handle files produced by all Kharkiv ISR data processing systems operating since 1996. There are functions for loading and saving files of data processing system based on TMS320 signal processors [3], multichannel programmed correlator [4] and the data acquisition system based on E20-10 analog-to-digital conversion module [5]. There are functions for file testing and metadata reading and writing.

Functions for calculating altitude of the scattered volume are also present in this group. An altitude h can be calculated using $h = H_0 + \Delta h \cdot i$ formula, where Δh –