

AN APPROACH FOR MEASURING THE ELECTRIC AND MAGNETIC FIELDS IN THE SYSTEM IONOSPHERE-ATMOSPHERE-LITOSPHERE

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Abstract. A system for measuring the electrotelluric and geomagnetic fields in the ULF range is suggested. The physics of the ULF disturbances produced by ionospheric currents and their field penetration to the earth are considered and requirements to the measuring system are subsequently pointed out. The earth electric potentials and implications for seeking various seismic precursors are also examined.

Introduction

There are several reasons for measuring the electric and magnetic field variations on ground. First, the short-term variations are connected with the external sources of the Earth magnetic field changes being due to the magnetosphere-ionosphere processes. Second, we use electrotelluric measurements for geological purposes, Third, the earth electric potential variations are often treated as a possible precursor of earthquake events. A method for predicting earthquakes has been elaborated known as VAN method [1].

The frequency diapason of the ULF electric and magnetic fields is less than 100 Hz. The ULF electric and magnetic fields in the environment have a natural and antropogenic origin. The sources are the solar activity, the magnetosphere and the ionosphere. The natural ULF fields although too weak have the property to penetrate through the atmosphere and the earth crust. The naturally observed electric field reaches 0.01 V/m, the magnetic field – 100 nT. The industrial fields are usually much stronger but they are confined in localized regions around the technical constructions, e.g. in the vicinity of the energy power netcables, railway lines, transformator stations, etc.

Measurements of ultra-low-frequency electric and magnetic fields on ground

The measurements of ULF fields in the territory of Bulgaria are conducted since the midst of the 80th. These measurements were connected with programs for seeking preseismic precursors in the Geophysical Institute, the Vitosha observatory, Krupnik, etc [2,3]. Processes induced by the solar activity, ionosphere and the magnetosphere have similar frequency interval, dynamical diapason of the measured sygnals and the electronic solutions are analogous to those used for the preseismic electromagnetic precursors. At the beginning of 2000 a joint team of the Space Research Institute and the Geophysical Institute began a work for a new measuring system for ULF fields, a storage of the data and interpretation. A system for measuring, saving and visualization of sygnals from electric and magnetic field sensors was constructed (Fig. 1). The technical characteristics of the system are as follows:

1. Input signals. The input signals are differential voltage between two inserted in the earth sensors which measure the earth electric potential. The resistivity between the ground and the sensors over a distance of 200 m is below 10000 ohm. The interface with the measuring system is realized through isolated non-screened wires. The signals from the magnetic sensors are gained from separate electronic devices with an output impedance lower than 1000 ohm at a distance of 25 me and fulfilled with a screened cable.

2. Dynamic diapason and frequency range.

2.1. Quasistatic electric potentials. There are two tracks in N-S and E-W directions. The differential input interval -0,5V + 0,5V. Their frequency range is 0 Hz +0,02 Hz. In order to enhance the threshold sensitivity and our accuracy the ULF electric field component is measured through separate channels. We use the same tracks, the corresponding signal is filtered and amplified additionally.

2.2. ULF electric signals. There are two channels. The expected voltages are in the range $-0,02V \div +0,02V$. The frequency diapason is $0.002Hz \div 1Hz$.

2.3. The magnetic sensors are separate devices with own power supply. Their signals are also processed and stored in the system. The signal characteristics are: the voltage is $-0,01V \div +0,01V$. and the frequency interval is $0.002 Hz \div 1Hz$.

3. Filtering and electromagnetic compatibility. Due to the nature of the electric field measurements and non-screened interfaces the above mentioned signals are influenced by noises of atmospheric and industrial origin. The radio broadcasting are also additional sources. The measuring system filters the useful information and the information has a 12 bit accuracy. The input filter consists of two parts with a buffer repeater between them. The entire damping for disturbances in co-phase with a net frequency 50 Hz exceeds 100 dB.

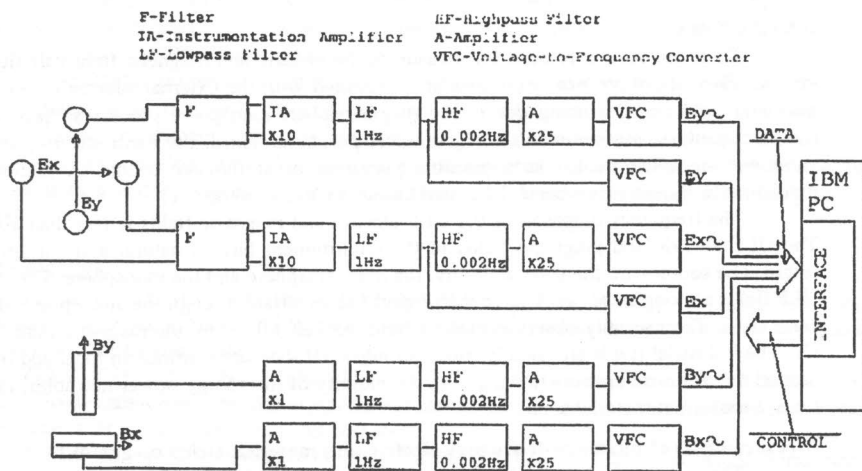


Fig. 1.

4. Measurements and sensitivity. The amplified and filtered signals from every channel are directed to the input of voltage-frequency converter. It converts the analogous signals into frequency samples with frequencies lying between 10000 Hz and 110000 Hz. The zero voltage corresponds to frequency 60000 Hz. With the use of optical disconnection these frequencies are directed to a interface block where the signals are counted. Further the information is directed to the PC slots to be processed and stored. The accepted conceptions for an use of VFC is required because of the necessity of galvanic disconnection of the interface and the PC with the analogous electronic and the sensors systems. The saved in the PC counts are 12 bit numbers and cover the full dynamical diapason both negative and positive values of the input sygnals given above.

5. Sampling rate. In order to quarrantee the frequency range needed the sampling rate is 5 measurements per second for both electric and magnetic ULF variations; the quasistatic electric potential variations are gathered with one measurements per minute.

6. Storage of the information. The gained digital information of the measured signals is stored in the PC memory through an interface modul and an appropriate programme package. The corresponding arrays of data in binary code contain an information for the sygnal amplitude, its sequential number and the time of measurement. It allows a correct restore and visualization of the processed information.

7. The information transferring. The information can be transferred by a floppy (1.44 Mb disquettes); standardized serial interface RS232 and a cable connection with another PC; and a modem by telephone line.

8. Visualization. For operative use the information is visualized through a simple algorithm. The visualization on the PC monitor allows to control all the principal features of the measured signals, the amplitude variations for the last 90 seconds (the ULF electric and ULF magnetic field measurements) and the last 9 hours for the quasistatic electric field potentials, the calibrated signals which appears at the beginning of every hour. The visualization is performed by an appropriate programme for every channel and with parameters pointed out concretely by the users.

Experimental data and polarization analysis.

We have started a test of the measuring system at the Vitosha observatory ($L=1.75$, Sofia). We have gathered data for nearly two weeks. The data set was sampled with 0.2 sec sample interval (18000 points per hour). The orientation of x,y coordinates are as follows: X is North-South and Y is East-West. The axis are geomagnetic (we aligned the coils with a compass).

The available data, of course, need to be multiplied by a factor to get to mV/m. For polarisation analysis, the X and Y channels have essentially the same response (amplitude and phase). Thus, for our purposes we do not need to calculate the conversion. The only filtering is as done by the instrument i.e. induction system.

An example of our data collecting at Observatory Vitosha are shown on Fig. 2. We observe a set of pulsation phenomena of one hour duration for dayhours and nighthours.

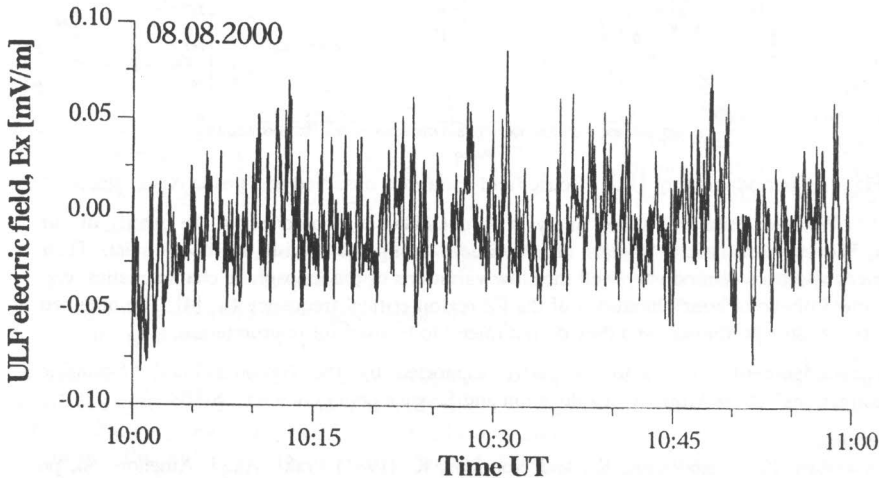


Fig. 2. Example of the ULF electric field record on August 8, 10-11 UT

Although they usually have diurnal course in our preliminary data it is not observed. Instead of this diurnal course we often observe amplitude variations with a period of 5-20 min. The following figure (Fig. 3) will demonstrate this peculiarity of the quasistatic electric field variations on ground.

Following our data analysis we observe that the mean period of these quasistatic earth electric potential variation is 15-20 minutes during night hours and 5-15 minutes during day hours. A periodogram for the first 6 hours, i.e. for the hours after the midnight is shown on Fig. 3. One sees additional maxima at 20 min and 80 min. Hence, the night oscillations have a period of around 20 minutes. A new period of 80 minutes is also

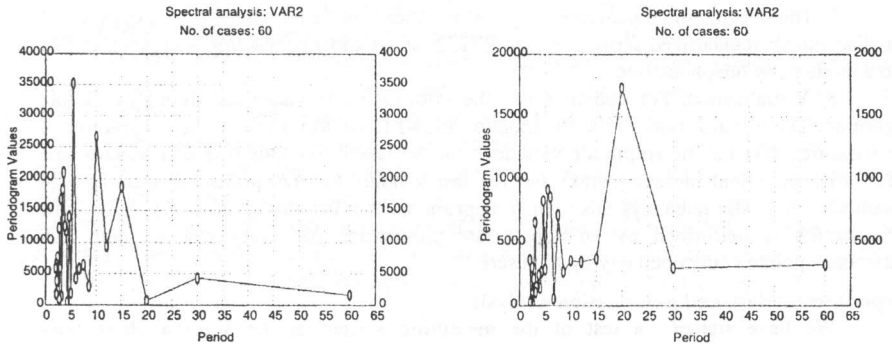


Fig. 3. Typical day and nighttime quasistatic variations (of the N-S component) on ground. a characteristic phenomenon. In Fig. 4 we see a periodogram of ULF electric field variations for a hour interval. Two main periods of 12 min and around 30 min are observed.

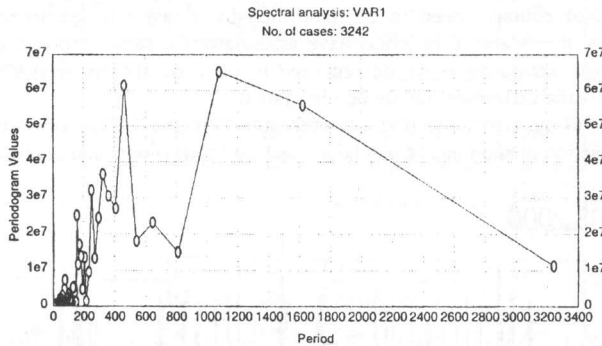


Fig. 4. A periodogram of ULF electric field variations observed at Vitosha observatory.

We have used the Fourier analysis on our data set in order show the quality of our data. We see that natural signals of amplitudes comparable with the noise exist. Their frequency spectrum remind very well the slow variations of the ionosphere characteristics, e.g. the slow (minute or hour) variations of the F2 region critical frequency f_{OF2} [4]. The obtained results are only preliminary and they do not intend to be used for interpretation.

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