TBILISI STATE UNIVERSITY EXTREMELY LOW FREQUENCY RADIATION RESEARCH NET (ELFTSU NET)

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Summary: *A new instrument had been developed for observation of extremely low frequency (ELF, 300–3000 Hz) radio emission from natural sources related to seismic activity. We improve the design used for decades at Abastumani Astrophysical Observatory. This equipment was designed to study ELF earthquake precursors. We discuss the advantage to use the frequency of observations below the critical frequency of the ionosphere. The monitoring of the state of tectonic faults system in Caucasus requires dense network of stations equipped by identical, standardized receivers. Tbilisi State University Extremely Low Frequency Radiation Research Net (ELFTSU Net) is a project of Electrical and Electronics Engineering students. Students take part in the design and in the testing, also in the process of preparing documentation and models for its industrial production. The student expedition has collected various data of phenomena. These data are compared with the level of urban electromagnetic background. We have developed the modular concept of standard observation station which provides the possibility to choose the most convenient configuration required by the specific characteristics of the fault and the operating and maintenance conditions. The station is completely autonomous, can accumulate and transmit data and have significantly improved noise characteristics.*

Key words *– extremely low frequency (ELF) radio observations, earthquake ELF precursors, EM waves and applications.*

1. INTRODUCTION

Tbilisi State University Extremely Low Frequency Radiation Research Net (ELFTSU Net) is a project of a network of Extremely Low Frequency (ELF, 300–3000 Hz) receivers for Caucasus tectonic faults system state monitoring [1-3]. It uses a new instrument, which has been developed for reception of ELF radio signals from sources related to seismic activity and is improved version of instrument, which was used for decades at Abastumani Astrophysical Observatory by which have been registered earthquake precursors [4].

Extremely Low Frequency Tbilisi State University Net (ELFTSU Net) is conceived as a base for scientific and educational activity of Electrical and Electronics Engineering students in practical analog and digital electronics, different sensor signal processing and transmission, modeling of natural electromagnetic phenomena and corresponding observational system, organization of scientific data collection networks.

The scientific concept of the project concerns that the seismicity of Caucasus geographical region includes external triggering and synchronization mechanism of earthquakes [5]. The Earth's luni-solar solid tide tension modulates tectonic tension of charging/discharging process of faults system. In accordance with the concept of self-organizing criticality [6], the energy discharge of fault, or earthquake, is an unpredictable phenomenon determined by entire system development. However, tension external modulation synchronizes the triggering moments with tides and discharge favorable critical time intervals are computable and observable.

There is a principal possibility of predicting earthquakes occurrence probability and power by monitoring the evolution and critical state of appropriate physical variables of tectonic faults system. Various studies [7-10] show that ELF radiation measurements at fault sites should be considered as the mean for monitoring seismic region critical state.

The phenomenon of seismic ELF generation is very complicated. Our experience and observations [4] also shows that the ELF radiation can be regarded as the product of tectonic fault activation and can be used for analysis of Caucasus fault system state.

For example we represent signal behavior observed in Abastumani before, during and after big earthquake. The M6.0 earthquake occurred near city Oni (Georgia; 2009/09/07 22:41:36.5 UTC; 42.66 N, 43.42 E; depth – 10 km; distance – 100 km from Abastumani). The ELF signal related to this strong event were recorded during the month befor and the month after earthquake (Fig. 1).

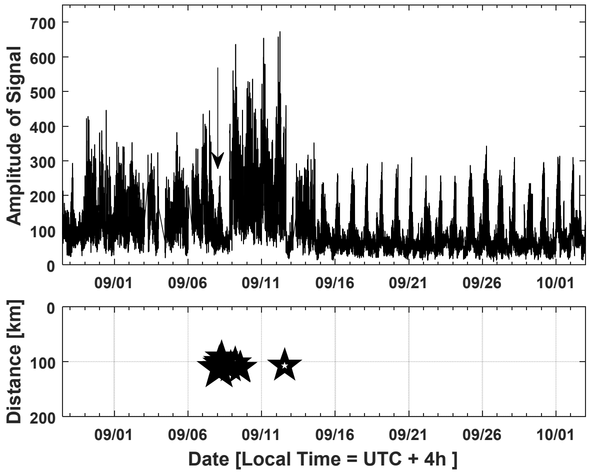

Fig. 1. The record of ELF radio emission before and after M6.0 earthquake (the magnitude is presented in receiver scale). The arrow indicates the time of the Oni M6.0 earthquake, subplot – distance and time of quakes, stars – M>4 aftershocks.

Firstly, two phases of phenomena are clearly separated. They can be called disturbed and calm. A clear sign of calm is a clear daily variation of the signal. For this record one can distinguish some characteristic phases:a change of the shape of the diurnal variation of the signal, an increase of the noise component; a sharp decrease of noise before the main shock of earthquake; a sharp increase in both the noise and diurnal variations during big aftershoks; Restoration of calm.

2. The concept and structure of ELF observation station

We develop dense network of standardized ELF 0.3-3 kHz receivers with high technical parameters. The central frequency of this band – 0.8-1 kHz corresponds to half of critical frequency of the waveguide formed by the Earth's surface and the lower edge of the ionosphere located at the altitudes of about 100 km. The ELF radiation on this frequency does not propagate in the waveguide Earth-Ionosphere and in this frequency range it is possible to receive a signal only near its source. Our sources are tectonic faults.

Caucasus geographic region can be represented as a network of natural transmitters, and the observation network should be represented as a network of associated standardized receivers. The scientific and practical result of the network will depend on its density and uninterrupted long-term work. This establishes high technical requirements for receivers and their life support systems.

Modern analog and digital electronics make it possible to easily create complex and reliable systems. In the practice of scientific research, it is very important to adapt the technical means optimally to the task to be solved. It is necessary to identify the main modules of the device responsible for measuring the physical variables of the observed phenomenon, and additional, complementary modules supporting the functionality of the main ones.

The technical uniqueness of our task is determined by the following contradictory circumstances:

- The signal of interest to us is a natural electromagnetic noise accompanying tectonic processes and in contrast to the known radio engineering methods, the extension of the frequency band of our receiver improves the reception conditions of the signal of interest to us.
- The frequency range chosen by us is extremely unfavorable for the propagation of the electromagnetic signal, but this circumstance makes it possible to significantly improve the spatial selectivity of the

network. If the receiver is on a tectonic fault, the conditions for receiving a signal from it are most favorable. Geological data should be used to determine the locations of the ELF network stations.

There is still an emphasis on the development of expensive space monitoring systems, although the development of electronics and communications has made geophysical projects so cheaper that land-based earthquake precursor monitoring projects will compete with space projects.

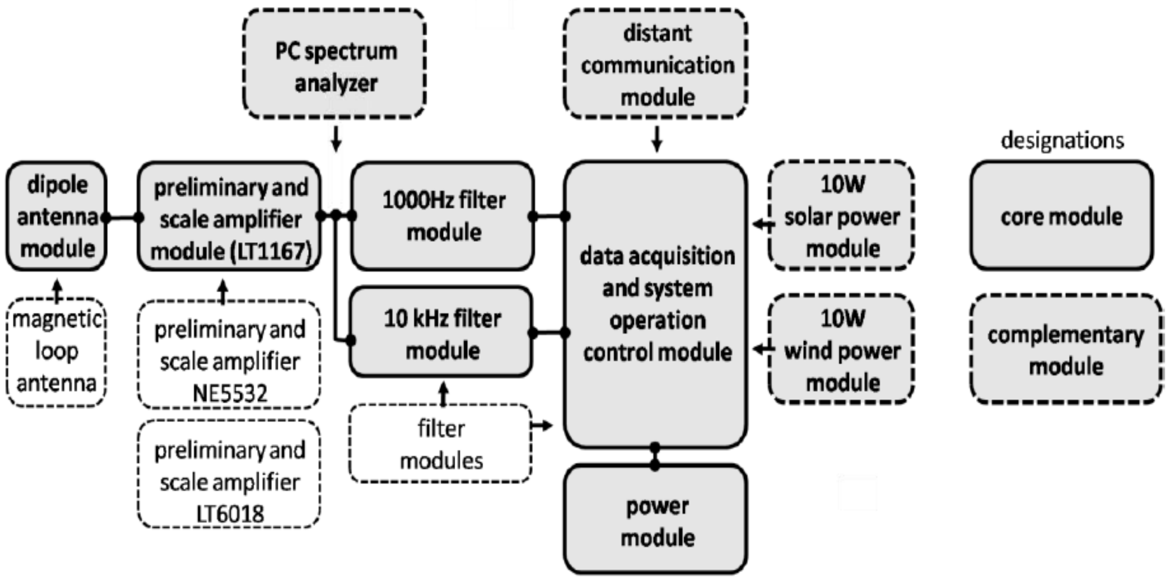

Fig. 2. The modular structure of ELFTSU Net station is represented by core modules and complementary modules.

Figure 2 represents the modular structure of ELFTSU Net station. The core modules are receiver antenna and preamplifier with scale amplifier, matching signal with dynamic range of analogue to digital converter. Our preamplifiers are instrumental amplifiers – the best technical solution in accordance with our objectives. Each modification has the gain equal to 1000 and differs by internal noise characteristics.

Different modifications of receivers will be offered to different groups of project participants for solving different tasks:

- Station with amplifier modification based on low noise operation amplifier may be offered to project participant Universities and students as kit for electronics and signal measurement study.
- The modification with an integrated high-quality amplifier significantly reduces the length of the antenna, allows deploying stations with two antenna and receivers to determine the direction to the signal source.
- The modification with amplifier based on ultralow noise operational amplifier has unique electrical parameters acceptable for precise observations, for example the ELF Earth eigenmodes.

The purpose of other modules is clear from Fig. 2. It is sufficient to perform one single measurement of the average value of the signal rectified and integrated in the receiver band once every 10 seconds.

3. THE STUDENT EXPEDITION

Planning the field testing of equipment, we also set the task to assess the electromagnetic situation at the points of the first observation stations [1]: to determine the characteristic background values of natural signals and electromagnetic pollution in the form of different harmonics radiated by the local power greed. We chose resorts Akhaldaba and Abastumani, city Akhalkalaki and the mountain Abuli. The data are complemented by the measurements carried out in Tbilisi, in one building of University (Tbilisi 1) and in nearby city park (Tbilisi 2). The summary result of all time series is shown in Fig. 3.

Records in Akhaldaba and Abastumani indicate the presence of the weakest background phenomena. On the plateau of Akhalkalaki we observed the entire process of formation of a hail storm cloud. The planned network will inevitably reflect thunderous meteorological activity. The task of the following expeditions and stationary observations is a reliable recording of diurnal and semi-diurnal fluctuations.

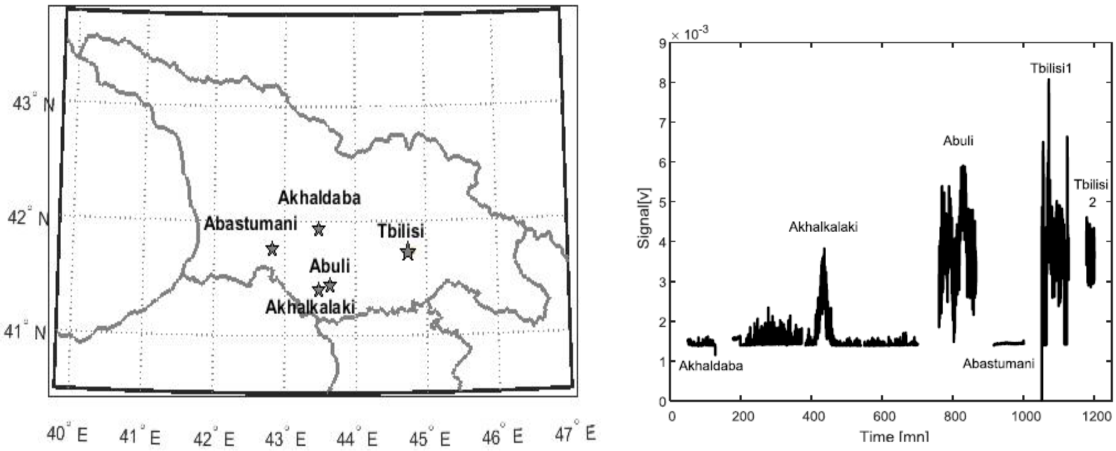

Fig. 3. The summary result of conducted measurements.

Our experience shows that situation associated with seismic activity is expressed as the increase in noise to such an extent that diurnal waves cannot be observed.

4. CONCLUTION

The monitoring of the state of tectonic faults system in Caucasus can be done by the network of extremely low frequency (ELF, 300–3000 Hz) receivers of ELFTSU Net, which is conceived as a base for academic collaboration of Universities.

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