Network system of seismic monitoring NSSM

System designation of NSSM

The network system of seismic monitoring NSSM (NSSM system) manufactures of Elgeo LLP is intended for the organization of monitoring of seismic activity for the regional forecast of a shock hazard of sites of the massif of rocks and ores.The NSSM system is the technical tool used at realization of actions of protection against the emergency situations bound to development of mineral deposits.

In Kazakhstan the systems of seismic monitoring are already used on some fields. Use of systems of seismic monitoring on all fields of ore minerals where production is made in underground excavations is perspective.

Economic effect of use of system of seismic monitoring consists in decrease or prevention of damage from emergency situations, the bound to a collapse of underground excavations. The well-timed forecast allows to bring personnel and an expensive inventory out of a dangerous zone in advance, to execute other protective measures and, thus, to prevent costs of restitution of an inventory, payment of compensations by the victim which can be the considerable.

The range of application of the NSSM system is not limited only a shock hazard fields of solid minerals. The NSSM system can be applied to monitoring of harbingers of emergency situations everywhere where as a harbinger of emergency situation serve the physical phenomena causing emergence of seismic waves, for example accidents on oil fields, the bound to formation of underground emptiness at oil recovery, accident on oil pipelines and others.

Principle of work of the NSSM system

The forecast of a shock hazard of sites of the massif of rocks and ores is based on the common regularity of development of geomechanical processes per which infrequent important events (a collapse of large volumes of the massif) are prepared bymany more shallow events (emergence micro and macro cracks, breaks). Therefore, to predict emergence of large-scale destructions, it is necessary to monitor constantly accumulation of shallow damages of the massif of rocks. One of ways of such tracking is filing of seismic events - the geodynamic phenomena which are characterized by emergence in the massif of rocks or ores of the seismic waves arising at formation of damages of the massif of rocks with the subsequent calculation of geographical coordinates of their epicenters and assessment of their seismic energy by means of systems of seismic monitoring.

The network system of seismic monitoring NSSM consists of network of the seismic units connected in uniform system which allows revealing within the mine field of a zone, dangerous on mountain blows, based on the continuous filing of parameters of seismic activity. The NSSM system in 2014 is installed on the field at the customer. The map of placement of 20 field units is given in fig. 1.

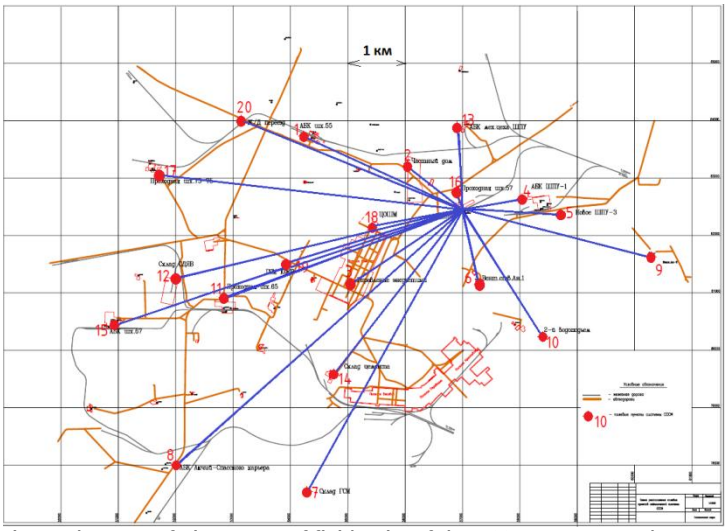

Fig. 1. The map of placement of field units of the NSSM system on the field

The seismic signals received by geophones continuously are analyzed in the automatic mode. At identificationby means of an express algorithm of signals of a seismic event, the fragment of the data entering fromgeophones registers in the file of a seismic event which comes to the center of collecting and processing to the operator of system. The operator makes in the interactive mode by means of the express computer program processing of the file of an event. Processing's are result geographical coordinates of epicenter and a power class(seismic energy) of a seismic event. In process of accumulation of data array about seismic events there is possible a forecast of emergency situations.

For a direct vision of work of system, the operator has a possibility of simultaneous viewing of all seismic signals in system on the monitor screen in the form of the multi-channel running oscillogram in real time.

Appearance of the oscillogram of all seismic signals in real time is given in fig. 2. The example of filing of aseismic event is shown in fig. 3. Display of seismic events on the plan of mining operations per calculation of coordinates is shown in fig. 4.

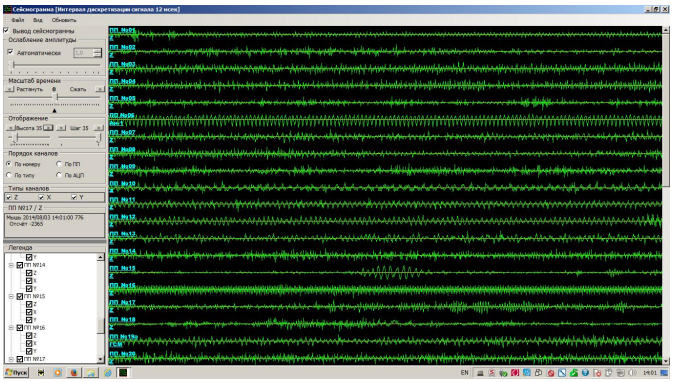

Fig. 2. The oscillogram of seismic signals of the NSSM system in real time

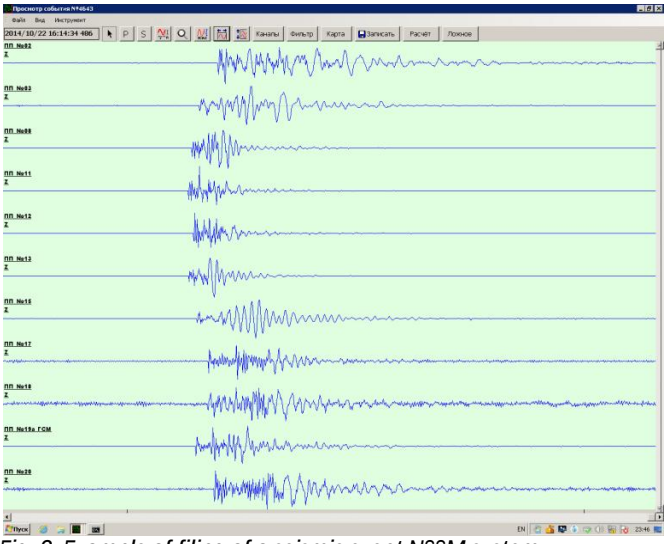

Fig. 3. Example of filing of a seismic event NSSM system

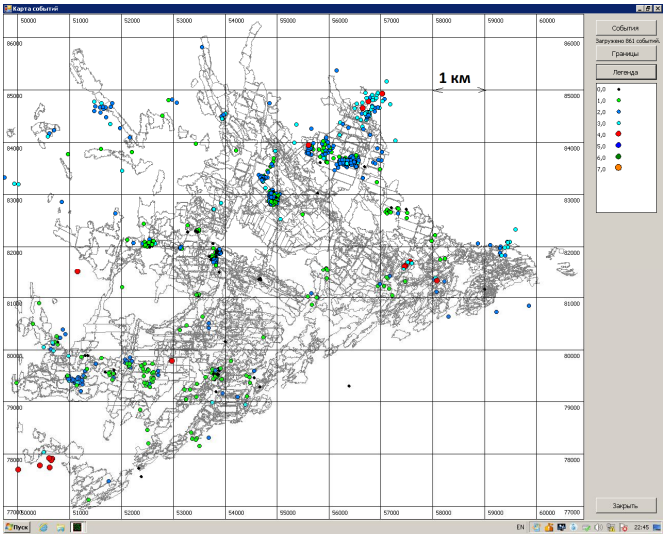

Fig. 4 Display of the seismic events registered by the NSSM system on the plan of mining operations

Principles of the organization of the NSSM system

The system of seismic monitoring of NSSM is intended for use as system of the continuous automated monitoring of a stressed state and a shock hazard of the massif of rocks. Important property of system is high efficiency ofcollecting and processing of seismic information. Therefore,infrastructure bases of system are communication channels for transfer of digital seismic information in the Center of collecting and processing of system.

The modern development of the equipment of digital communication is characterized by wide use of the protocols and methods originally developed for the organization of office local computer networks, but in process of widespread introduction of computer technologies in daily practical activities gained broad development and for coverage of the considerable territories. Therefore, at development of the system NSSM use of network based on standards of Ethernet of computer networks was accepted for the organization of information transfer. Such approach allows to apply wide scale of the modern digital telecommunication inventory as a part of system of seismic monitoring and to create the flexible infrastructure of communication channels allowing to use different types of communication depending on an installation site of field units of the NSSM system – a wireless communication or connection with use of the dedicated wire lines, or their combinations. At the dense network on small squares it is possible to use the ordinary equipment of local computer networks, and, on the contrary, if necessary it is possible to use optical lines, satellite channels.

Indispensable condition of functioning of systems of seismic monitoring is the precise time reference of all recorded information. Land field stations can be synchronized by means of GLONASS/GPS receivers, but for underground field units application of GLONASS/GPS is impossible. Recently the protocol of precise synchronization of time of PTP (Precise Time Protocol) known also under the name IEEE1588 gained serious development. During development of the system of NSSM the possibility of synchronization of the field units established undergroundfrom land to receiver GLONASS/GPS through the system of synchronization of time working under the PTP protocol viathe Ethernet interface is reached.

Considering explained the following structure of creation of network system of seismic monitoring of NSSM,fig. 5 is accepted. The NSSM system consists of the arbitraries number of field units. The geophone, the seismic module is a part of each field unit. The seismicmodule receives signals from the geophone, and has an entrance for input of signals of synchronization of time. For communication with the center of collecting andprocessing the seismic module has the computer Ethernet interface. Communication of land field stations with the Center of collecting and processing is carried out through wireless network Ethernet, synchronization of time of ground field station is carried out from receiver GLONASS/GPS.Communication of underground field units with the centerof collecting and processing is carried out to the Earth's surface - through a dedicated wire communication link by means ofXDSL modems and further through wireless network Ethernet. Synchronization of time of underground field units is carried out from land by receiver GLONASS/GPS via modules of synchronization IEEE1588 interacting among themselves through the same line of a communication along wires. Thus, the made technical solutions of the NSSM system provideflexibility of architecture of system, both concerning a coherent inventory, and concerning the equipment for synchronization of time.

Roughing-out of the recorded seismic signals and selection of seismic events is made immediately in the seismicmodule of field unit. Only the marked-out seismic events therefore the common load of the environment of information transfer is small are transferred to the center of collecting and processing. At the same time, all volume of the

accepted seismic data registers in the carrier (SD card) in field unit. The written-down informationis accessible to re-treatment by transfer of all or a part of the written-down information through a communication channel at the request of the center of collecting and processing. Management of parameters of filing and all duties of field unit is made remotely from the Center of collecting and processing. Provided on fig. 5. the structure ofthe NSSM system is only one option of use of system. Depending on specific conditions of use of system otherinventory of communication and other structure of system of seismic monitoring with use of the modules made by Elgeo LLP can be chosen.

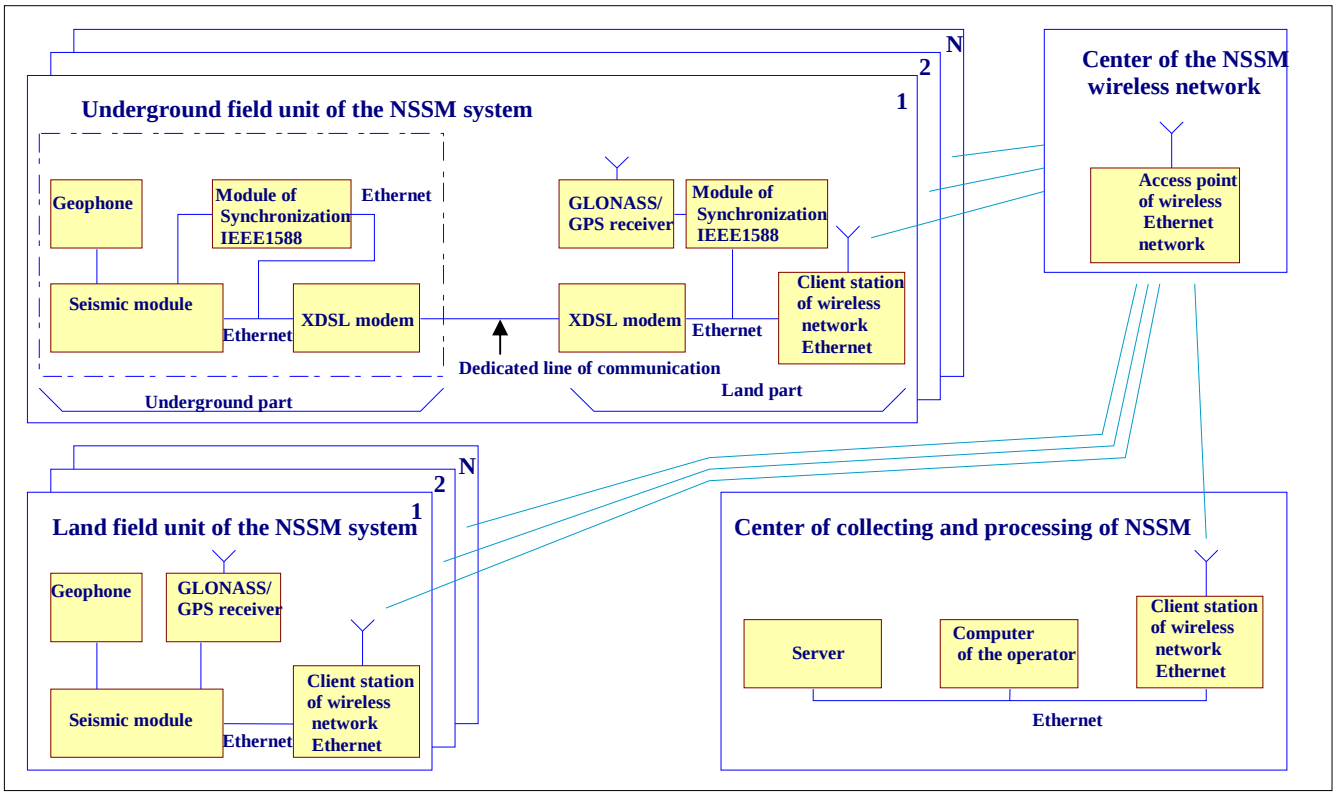

Fig. 5. Example of structure of the NSSM system

Main principal specifications of the NSSM system

The number of field units – is unlimited.
Number of seismic channels as a part of field unit – 3, 6.
Number of bits of analog to digital converter (ADC) in the seismic channel – 24 (23+ sign).
Amplification of the amplifier on ADC input – 1, 10 or 100.
The sampling Interval of ADC – 2 ms.
Frequency range of the seismic channel – from 0 to 200 Hz.
Noise level of seismic channels in a frequency range from 0 to 200 Hz, an effective value – no more than 0,08 micro-volt.
Dynamic range of seismic channels – not less than 130 dB.
Seismic information from each field unit (FU) is transferred to the Center of collecting and processing (CCP) forthe telecommunication channel.
Check of work of software and installation of parameters is carried out remotely via the telecommunication channel.
As the telecommunication channel, any telecommunication inventory having the Ethernet interface can be used.
Information from all FU of system is transferred to CCP where are carried out its processing.
Information binding to the exact time is carried out in field units by the quartz watch.
Stability of the course of clocks is not worse than ±1 • 10-6.
Correction of the course of clocks of land field stations is carried out by the GLONASS/GPS receiver.
Correction of the course of clocks of underground field units is carried out by the GLONASS/GPS receiver viasynchronization modules under the protocol of precise synchronization of time IEEE1588. Accuracy of synchronization is not worse than 0.1 ms.
Power supply of the equipment of field units is carried out from the alternating current power line of 220 V ± 10%, 50Hz.
The firmware software of field unit provides:

- reception and storage of all entering seismic information;
- selection of seismic events;
- file transfer of the marked-out events in CCP on demand;
- transfer to CCP on demand in the continuous mode of all accepted information for monitoring of function-ing and control of system;

Fig. 6. Installation of the geophone on the concrete foundation

Fig. 7. The geophone for well installation

Fig. 8. Field unit of the NSSM system for land installation

The software of the center of collecting and processing provides:

– remotely, via the telecommunication channel management of parameters of filing of information in field units;

– maintaining archive of the marked-out events;

– maintaining the catalog of the marked-out events;

– a possibility of viewing of information entering from FU on the screen;

– processing of the marked-out events for determination of coordinates of hypocenters of events, apower class of events, display of epicenters of events on the plan of mining operations.

Geophones

In system of seismic monitoring geophones of any type can be used. Elgeo LLP is ready to deliver as a part of system geophones for the surface installation and for installation in superficial wellsexecuted based on sensitive modules of geophones with own frequency of 4.5 Hz. The system of seismic monitoring can be installed in places with the increased level of the industrialnoise. Therefore, the geophone is mounted in the steel housing which is well protecting from low-frequency electromagnetic disturbances. The geophone has three obstinate screws and bubble level for horizontal installation. The example of installation of the geophone on the concrete foundation is given in fig. 6. Appearance of the geophone for well installation is given in fig. 7.

Design

The design of field unit of the NSSM system allows placing it both on a land surface, and in underground excavations, explosion-proof on gas and dust. The seismic field unit for land installation is shown in fig. 8. The seismic field unit for underground installation is shown in fig. 9. Any modern means of communication compatible to technologies of computer networks can be used to communication of field units with the center of collecting and processing. Wireless computer networks are convenient for the field units established on the Earth's surface. In fig. 10 the access point of the center of a wireless communication network is shown. Client stations of wireless network for communication with the center of collecting and processing are shown in fig. 11 and fig. 12. For communication with the field units established underground in mines, the allocated wire lines, optical lines must be applied.

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Fig. 9. Field unit of the NSSM system for underground installation

Fig. 10. Access point of the center of a wireless communication network of NSSM

Fig. 11. The client station of a communication network of NSSM for average distances

Fig. 12. The client station of a communication network of NSSM for long distances