Developing a block diagram for the earthquake warning device.

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Additional determination of the earthquake characteristics from the data of each separate station is prospective way in developing the earthquakes early warning systems. It allows using advantages of a method of the single sensor and, first of all, to reduce a radius of a dead zone, in which the warning is impossible, up to 20 kilometers and even less. However if the separate stations are used as a part of a seismic network, the end user loses such useful properties of his station, as possibility of independent activity and simple way to transfer a warning signals. This work is devoted elimination of these contradictions.

There are two methods to implement ultrashort warning of an earthquake, each has occurred: the method based on a dense network of seismic stations and the “single sensor” method [Wu, Kanamori, 2005]. The advantages of an early warning system based on a seismic network include a high reliability of warnings and the prediction of earthquake shaking intensity at each site in the alarm area. The main drawbacks of such systems:

- complexity and high costs related due to the deployment of a dense network of seismic stations;
- unsolvable operation during later shocks in case some of the stations, power supply or communications facilities have been damaged;
- the presence of an extensive dead zone (~50 km) where no warning is possible;
- difficulties in providing relevant information to the user;
- the necessity of deploying the sensors at low-noise sites.

The advantages of the early warning systems based on the “single sensor”:

- expensive seismic networks are not required;
- self-contained operation is possible;
- the dead zone is reduced to 20 km or still less;
- information comes directly to the end user.

However, these systems also have significant drawbacks: the warnings are less reliable compared with the network-based systems and earthquake shaking intensity is not calculated in this connection it seems promising to develop a hybrid warning system, the “single sensors” being incorporated in the existing dense network warning system [Kanamori, 2005].

The basic principles underlying the operation of this system have been formulated. In order to implement an earthquake warning system based on the principle of a “single sensor” the following have the following prerequisites [Gravirov et al., 2010]:

- the identification of first earthquake onsets in a noise whose amplitude exceeds that of the signal. The assumption is that the noise involves diverse types, viz., stationary and nonstationary, chaotic and impulsive.
- the determination of basic earthquake characteristics from identified signals (approximate magnitude and epicentral distance);
- the use of fast algorithms and convenient hardware implementation;
- high reliability;
- the system should be able to operate after the main earthquake has occurred;
- Service and deployment simplicity, low cost.
- the option of self-contained operation;
- the information connectivity to external systems.

The main requirements on operative parameters (temperature, humidity, power supply, magnetic fields, and vibration) of the single sensor system realization is shown in Fig. 1. Below we briefly describe each of the units presented in the diagram.

The power supply unit is connected to the mains. The unit provides a stable power supply for the other permanent and temporarily connectable units. When there is an interruption in the mains supply, the unit must provide for self-contained operation during at least 14 days.

The sensor is a three component accelerometer with a linear response function in the range of 0.1 to 10 Hz. The sensor is rigidly clamped in order to prevent the device from being displaced and torn off from the base during strong ground motion. The sensor mechanics and electronics must serve the shaker of a major earthquake. The protection against temperature changes must ensure that the time constant is very small at least at three hours. A correct implementation of the device is possible involving foaming seal.

The ADC, two ADC types can be used for transforming seismic signals whose spectrum is concentrated in low and very low frequencies (from the standpoint of electronics), and which have a wide dynamic range, namely, those based on integration or on the sigma-delta converter. Such ADCs have the greatest number of digits (resolution), which ensures signals conversion without detection in a dynamic range as great as 140 dB (with 24 bits).

Comparison between these approaches shows that, with about the same accuracy of conversion, the microchips of the sigma-delta converter are much cheaper, and this makes them preferable. The sampling rate is 100 Hz.

The communications unit allows data from the “single sensor” system to be input into the existing network systems: a local network to be organized of “single sensors” to communicate to a data center and from the user. Apart from being sent from the alert signal generation unit to the seismic network data center, the warning signal can also be sent from the data processing unit, provided the amplitude exceeds a defined level.

The adjustment-testing unit allows the sensor to be calibrated, the system operation to be tested, and permits specifying the system’s sensitivity and the reliability levels at which earthquakes are to be detected. The unit allows for the initialization of the system, the estimation of the sensor’s characteristics and the visualisation of seismic signals.

The alert signal generation unit generates electrical earthquake signals at first that will be processed and then the probable event of the probability of in event. At lower probability levels alerts may be declared in a fire stations, blocking may be carried out. The alert signal is generated in computer centers, and on so. At higher levels one

would require shut-down of hazardous facilities and a public alert signal. Also the information in case of all alerts is envisaged. The generation unit can receive connections from the alert and light warning devices to detect a locally generated seismic signal.

The data processing unit detects the onsets of P and S-waves from earthquakes. Its functional elements are shown in Fig. 2.

Fast estimation of the earthquake parameters through deconvolution classification using wavelet transforms and neural networks is also possible. These methods can handle signals that are contaminated by noise. The robustness of the earthquake parameters are transmitted in the warning signal. The use of the neural networks make it possible to design a faster and more powerful network data center via the commutation unit. A warning signal for a concrete user can in that case be obtained either from the warning signal generation unit or from the data center. The warning becomes more accurate thereby and can be received before the sensor records the P-wave, provided the epicenter is distant enough. This justifies the additional expenses to be incurred by the user to install the sensor.

**Fig. 1.** Simple connection of a “single sensor” to the seismic network involved in earthquake warning

![Fig. 1](image1)

The power supply unit is connected to the mains. The unit provides a stable power supply for the other permanent and temporarily connectable units. When there is an interruption in the mains supply, the unit must provide for self-contained operation during at least 14 days.

![Fig. 2](image2)

**Fig. 2.** Block diagram of the seismic data processing unit.

![Fig. 3](image3)

**Fig. 3.** A block diagram for the modified seismic signal processing unit.

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**References**
