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A Differential Highly Sensitivity Sensor for Accounting of Seismic Devices Instrumental Thermal Noise

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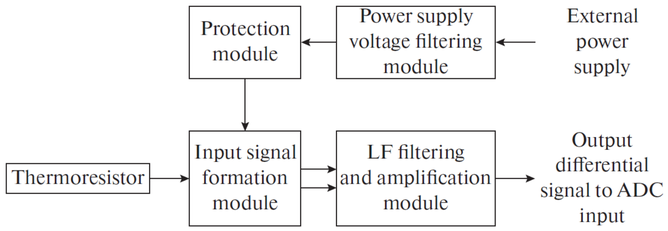
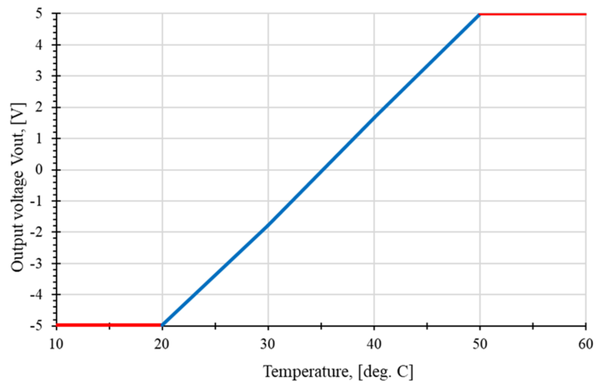
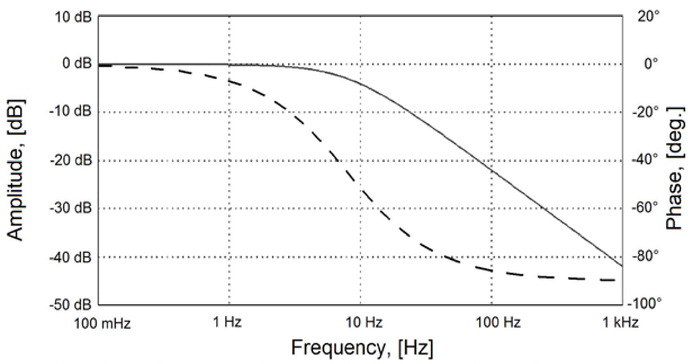
One of the main factors causing noise in the records of precision long-period seismometers is the temperature fluctuations of the mechanical elements of the seismometers and their sensitive sensors caused by temperature fluctuations in their internal space due to the presence of local heat sources. Electronic components, for example, operational amplifiers, resistors and inductances that are part of the electronics of such devices, can be act as local heat sources. Heat is generated during the operation of mechanical elements too. A very complex dynamic temperature pattern is created in the internal volume of the device. To reduce the effect of this type of noise, we suggest using adaptive and optimal filtering of seismic signals based on high-precision temperature recording of key elements of seismic instruments. To date, there were not so small systems capable of recording temperature changes inside seismic instruments with sufficiently high accuracy. The highly sensitive thermometer developed by us is capable of simultaneously monitoring the temperature at several of the most important points of any seismic device with an accuracy of up to 0.001 degrees Celsius.



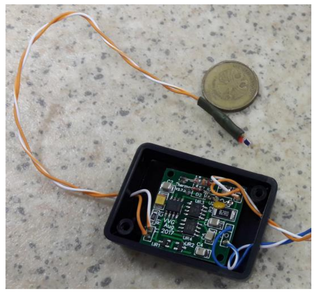
Block-diagram of the differential highly sensitivity thermosensor.



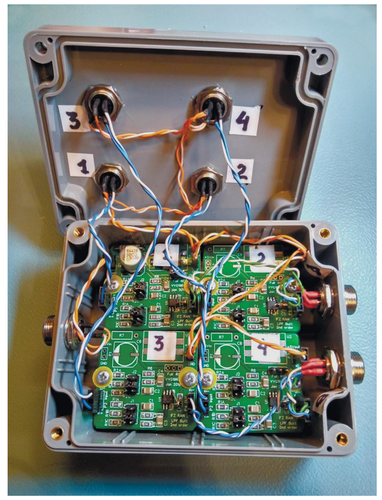
Theoretical output signal of the thermosensor



The phase-frequency (dashed line) and amplitude-frequency (solid line) characteristics of the output low-pass filter.



Temperature sensor with temperature sensor module (in the upper figure) and 4-channel instrument temperature amplifier (in the right figure).

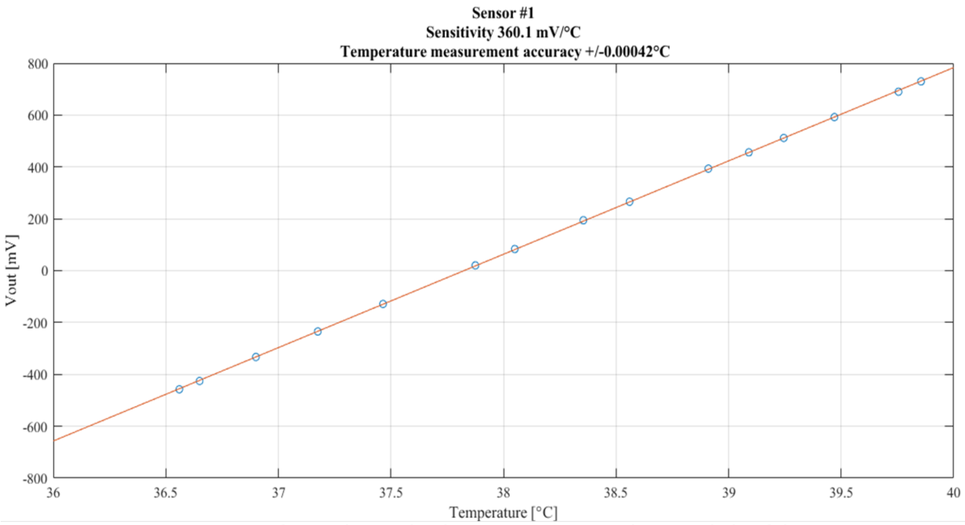


The fluctuations of temperature are one of the main noise generation factor at any seismic observations. Whatever physical principles are used in seismic instruments, it is not possible to eliminate this problem completely. There are many ways of penetrating the temperature noise to the recording. Seven such ways have been identified for traditional pendulum systems:

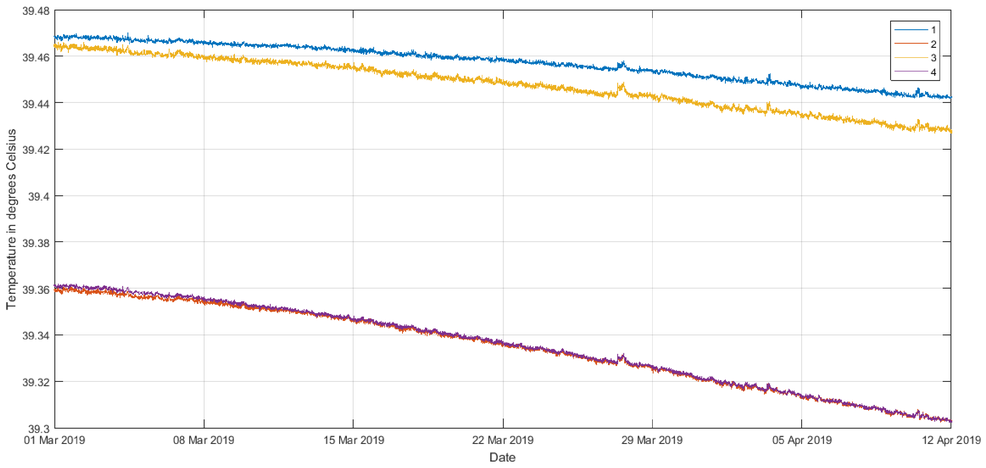
1) Changes in linear dimensions of the device elements, recorded by a seismometer as the oscillations of the Earth or actions on the pendulum as an additional force (changes in the forces' arms, the deformation of the springy elements, etc.).
2) Changes in the elastic characteristics of the crossed leaf rotary flexural system and spring of the vertical pendulum.
3) The flexure of device basement (plate) due to difference of temperature coefficients of linear extension the device metal plate and concrete pier.
4) The self-noise of the electronic displacement transducer, thermal noise in electronic circuits of the device, the thermal fluctuations in power attenuation.
5) The noise arising from the uneven distribution of the temperature in different parts (elements) of the device, including convective heat currents.
6) Changes in transfer function of the device due to changes of the size structural elements and characteristics of seismometer electronic components.
7) Thermal noise associated with a change of pressure in the enclosed volume of the device.

The devices, working on the principles of molecular electronics, add their own characteristics, associated, for example, with changes in the temperature of the electrolyte. Laser gyroscopes, which are beginning to be used in rotational seismology, have a problem of temperature instability of the perimeter. Thus, there is no method and means of measurement for seismic parameters, free from the noise effect of temperature.

One of the most effective tool for reduction of temperature influence is the optimal filtering. At the same time, there might be occasions where the external temperature does not play a role, but relative temperature some components of the device is very important. Recall that not the absolute value of the temperature is important, but accurately measured amplitude of its fluctuations. In a more complex case, it may be necessary to measure the temperature in several points of the device or their relative changes with greater accuracy.



Fragment of experimental voltage-temperature characteristic of the sensor. The sensor is configured for a working range from 23 to 53 ºC.



Example of temperature recording measured by set of differential thermosensors.