

# DESIGN OF NETWORK TO MONITOR INFRASOUND FROM THUNDERSTORM EVENTS: DEVELOPMENT OF SENSOR

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**Abstract.** This paper describes the implementation of the autonomous infrasonic sensor for thunderstorm events recognition. Original hardware – microcontroller system with microphones, GPS-based time synchronization and GPRS-modem data transmission is described. The characteristics as calibration results is reviewed.

## 1 Introduction

Along with the study of large-scale planetary phenomena, such as earth magnetic field variations, alterations in solar activity, its influence on atmospheric electric circuit, and others, geophysicists also take interest in so-called single large energy events [1, 2]. The infall of meteorites, industrial explosions, forest fires, earthquakes, etc. fit into this group. As a rule, such events are very difficult to detect. Even if some minor earthquakes and induced explosions are detected and localized by the networks of seismic stations, it is still a rather problematic task to determine the coordinates of the other aforementioned events in a real time environment.

The studies of infrasonic waves have shown [3, 4, 5] that the overwhelming majority of the large-energy events named supra and even the events of considerably smaller magnitude (small forest fires, the fall of spent rocket stages) are accompanied by strong fluctuations in air masses in a range of 0.1 to 2.5 Hz. This means that monitoring of the sub-herz range of infrasonic waves makes it possible to observe and localize such phenomena.

In order to solve such problems, global networks and separate points of infrasonic observation stations are created [6]. The international network CTBTO (<https://www.ctbto.org/>) can serve as a model for such networks. However, a lack of widespread access to the resulting data and the considerable remoteness of tracking stations

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from the areas which are of interest for carrying out a variety of small-scale scientific observations make such measuring networks of little use for studying moderate and small energy events. The issue is that such events have a high-frequency (herz) range of radiation of infrasonic waves. The decay coefficient for such waves is considerably higher than for sound waves of a sub-herz range. This is connected to the scattering effect of sound waves of a relatively small length on the obstacles of a terrestrial landscape which leads to a rather fast loss of their amplitude depending on distance.

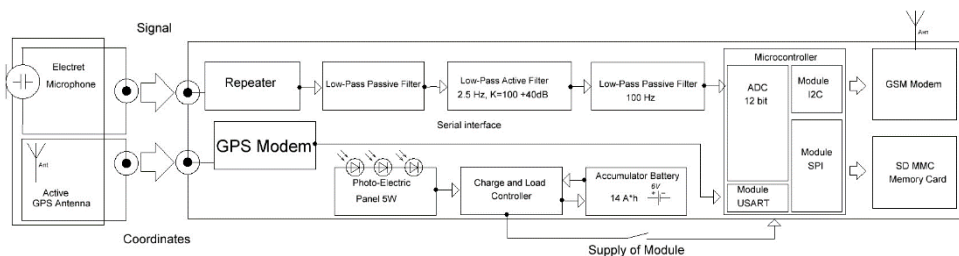
For a detailed study of such infrasonic waves, it is enough to place an inexpensive temporary portable local monitoring network in the region that is of interest to the observer which would have a considerably smaller point-to-point distance in comparison with standard measuring networks and would be equipped with rather cheap (sensitive enough, but more narrow-band) measuring equipment.

## 2 Design and construction

The Laboratory of Robotics Technology at Gorno-Altai State University has designed and produced a prototype for an infrasonic measurement module for equipping measuring networks of this type.

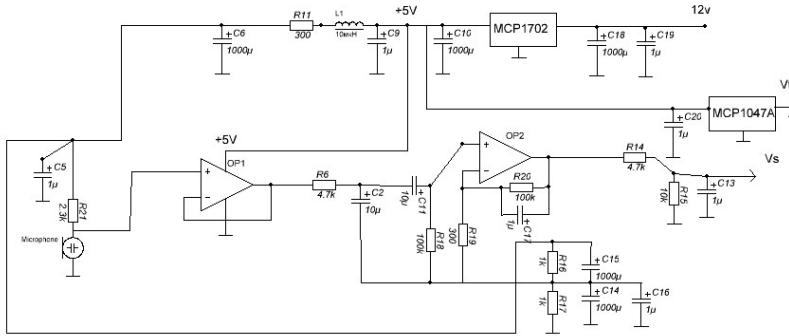
The prototype infrasonic measurement module (Figure 1) consists of the following:

- An infrasonic sensor whose design is based on the piezoelectric microphone cap connected to the enhancement filter of the first level with the Amplitude Frequency Response (AFR), selected in order to provide necessary amplification of signals in the low-frequency section of the microphone and to reduce the signals in its higher-frequency section;
- A recording device on the base of the 16-bit DSP of the microcontroller dsPIC33FJ128GP502 using the digital processing of an input signal and saving the data on an SD-flash card with a file system Fat-32;
- A transmission device on the base of the GSM-modem connected through a consecutive interface to the microcontroller of the recording device;
- A synchronizing source for the exact time based on the GPS-receiver, which is also connected to the microcontroller of the recording device;
- A renewable energy source based on the photoelectric panel with a power of 5 W and a 6-volt battery with a 14 Ah capacity.



**Fig. 1.** Flow chart of infrasonic module for local measurement network

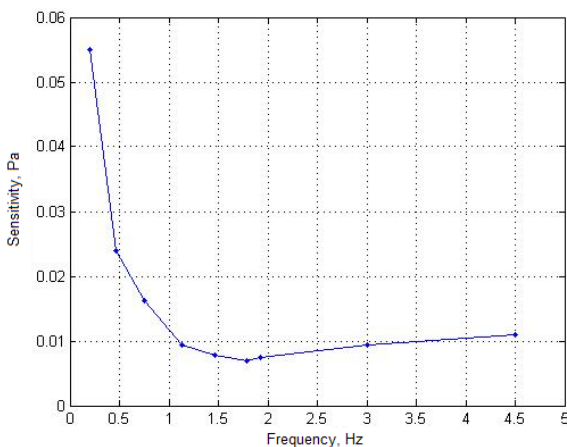
Figure 2 shows a basic block diagram of the microphone enhancement filter of the infrasonic measurement module.



**Fig. 2.** The microphone enhancement filter

### 3 Calibration

The calibration of the infrasonic measurement module was done by the method of Pistonphone which is one of the basic methods of microphone calibration on infrasonic frequencies [3, 7]. The microphone sensor of the infrasonic measurement module was placed in a plastic sound-proofed pipe with a diameter of 110 mm and a volume of 52 liters. A disposable 1mm<sup>3</sup> syringe was connected to the same pipe by means of a flexible plastic tube with a length of 0.5 m and a diameter of 5 mm. The electromotor with a worm gear drive by alternation of direction of gyration provided a reciprocating motion of the syringe plunger in a range of 1.5-2 mm. On this basis, the volume of air which fluctuated under the influence of the syringe plunger with a frequency of 0.25 to 4.5 Hz was estimated as  $5 \cdot 10^{-6}$  liters. Thus, the amplitude of the pressure variation in this calibration experiment, registered by the measurement module, made up about 0,1 Pa. As a result of the calibration experiments the alternating output voltage of the sensor was registered for different frequencies in a range of 0.25 to 4.5 Hz (the range constraint of calibration frequencies was determined by design features of the calibrator mechanism). The sensor was estimated to have a mean-square value of 0,01 W from sounds coming from the sensor itself. A curve of the sensitivity of the sensor was created from the aggregate of all of the collected data, correlated to the natural noise of the sensor itself (Fig. 3).



**Fig. 3.** Curve of the sensitivity of the sensor

Previous experience of using similar devices shows that the sensor of the measurement module under analysis can work in a wider (in comparison with Figure 3) frequency range. According to the evaluation of experts, the infrasonic measurement module is capable of registering power-intensive processes, such as the fall of the Chelyabinsk meteorite at a distance of 1-2 thousand km, per the sensitivity parameters in the given frequency range. [8, 9, 10]

## 4 CONCLUSION

This paper describes the infrasonic measurement module developed by the Laboratory of Robotics Technology at Gorno-Altai State University. This module enables registration of the infrasonic waves generated by moderate and large energy events of manmade as well as natural origin. In addition, the measurement module has a self-contained power supply, a data transmission channel connected to the INTERNET network via GSM modem and a GPS synchronization module. Thanks to the simplicity of technology, its small size, and a self-contained power supply from a renewable energy source, this module is portable, self-sufficient, and has a low cost. These characteristics make widespread use of the module possible during the designing of easily convertible local measuring networks.

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