Low Cost Infrasound Monitor Project - real geophysics research on a budget

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Abstract. Described is a well established opensource geophysics project to monitor atmospheric infrasound 24/7. It employs a modern digital, I^2C enabled diferential pressure sensor - unlike the older analog devices typically used. The system automatically uploads plots whilst data is stored in standard *.mseed* format for further analysis. Very open-ended with lots of opportunities for students of all levels, schools and above, to redesign and test replacement components. This is real science, in a little studied area. The equipment required is relatively cheap to build and offers many opportunities for students to build and refine a sensing system of research quality.

1. Why Infrasound?

This is a relatively little studied area of geophysics wide open to further study. The sources of infrasound are both manmade and natural. Natural sources include volcanoes, earthquakes, avalanches, tides, lighting in the upper atmosphere and meteorites. Man-made sources may be windfarms, aeroplanes, rockets, large industrail plant and explosions. Infrasound monitors around the world are part of the Comprehensive Nuclear-Test-Ban Treaty Organization (C.T.B.T.O.) looking for signals indicating an atmospheric nuclear explosion [1, 2].

2. Infrasound

Infrasound may be defined as any below the range of human hearing i.e. below about 20Hz. Pressure variations with a period greater than 100 seconds are

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swamped by variations due to the weather so the range of interest is ~ 0.01 to 20Hz.

Sound is a periodic pressure variation of the air. The human ear is sensitive to frequencies from ∼20Hz to ∼ 22kHz at birth. The upper frequency tends to decline with age and exposure to loud sounds. Amongst other mammals some cetacea such as porpoises may be sensitive up to 150kHz whilst elephants are believed to communicate via Infrasound.

Infrasound propages well through the atmosphere and may be detected hundreds of km from the source.

3. Historical

4. Infrasound Detection

Infrasound may be registered with either a 'slow' microphone or a fast pressure (barometric) sensor. Capacitive microphones have been used widely though cheaper electret devices suffer from a marked non-linerarity at low frequencies [4].

'Fast' pressure sensors may be used , either absolute sensors which measure the total atmospheric pressure or differential senors mesuring the difference in pressure between their two ports.. To measure with a resolution of say 0.1Pa an absolute sensor will need a resolution of $1{:}10^6$ which is difficult to achieve and requires very stable voltage supply.

This system uses a digital differential device, employing a mems sensor to monitor the pressure difference between its two ports with a resulution of approximately 0.04Pa across a range of $\pm$ 125Pa. One port is connected to the atmosphere via some windshield whilst the other 'reference' port is connected to a slighty leaky enclosure - the backing volume.

5. The System

6. The Backing Volume

A differential pressure transducer measures difference in pressure between its two ports, one cannected to the atmosphere, the other to a sealed container generally known as the backing volume. This backing volume needs to be leaky for two reasons. Firstly too great a pressure difference may damage the sensor. Secondly the leak acts as a pneumatic filter, removing very low frequency signals, ideally less

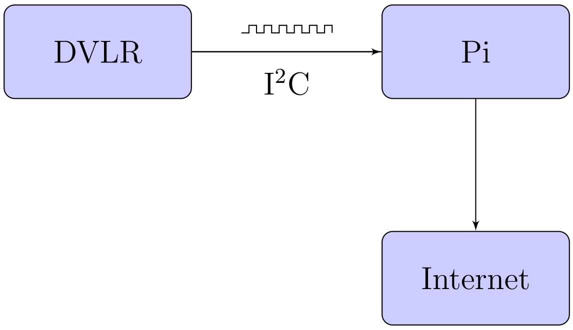

Figure 1: System Overview

that 0.01 Hz caused by atmospheric pressure variation. The aim being to measure Infrasound signals rather than the weather.

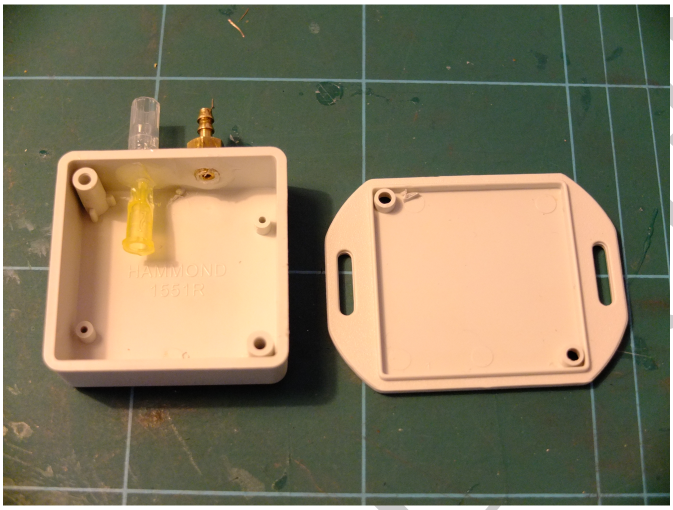

Figure 2: Pnuematic Filter ‘Backing Volume’

7. Wind Filter

8. National and International Scope

9. Educational Benefits

Few pre-university science students have direct experience of real science. Projects such as this combine real science with real-world systems engineering. Students can work in teams to build, test and install rather sophisticated realtime geophysics monitoring systems. This project contains elements of physics, electronics, geology, space science, computer programming, and networking. When the initial install is up and running it can them be further developed, different pressure sensors, various windshields such as porous hose may be tested, wireless links between the sensor and base station, statistical filters added to the software. I designed this to be sufficiently simple to allow construction by 11-16 yr olds (I have already done this) yet sufficient development potential for older students. Students are attracted to the combination of physics, computing and electronics along with space science and geophysics.

Geophysics is under-appreciated, even at A-level despite the stellar career prospects. Such projects would promote physics, computing and geology.

10. Cost

The hardware costs are small, each sensor rig will cost no more than £100, less of one has a spare P.C. or Raspberry Pi. *The authors have no commercial interets in this project or with any equipment suppliers*

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