A New Self-Calibrating Infrasound Sensor Design

Carrick Talmadge, Hank Buchanan, Jonathan Parsons, David Harris, Chad Williams and JaQwan Works

National Center for Physical Acoustics / University of Mississippi

Hyperion Technology Group Inc. / Tupelo Mississippi

INTRODUCTION AND MAIN RESULTS

Because of environmental, cost, and other constraints the need to verify sensor function and calibration *in situ* has become crucial to CTBTO and others in the geoscience community. In infrasound stations the CTBTO has started installing reference sensors collocated with array sensors to accommodate this requirement.

This project seeks to provide a compact and self contained *in situ* calibration scheme to improve the CTBTO's ability to analyze and verify the calibration of the Hyperion Infrasound Sensor

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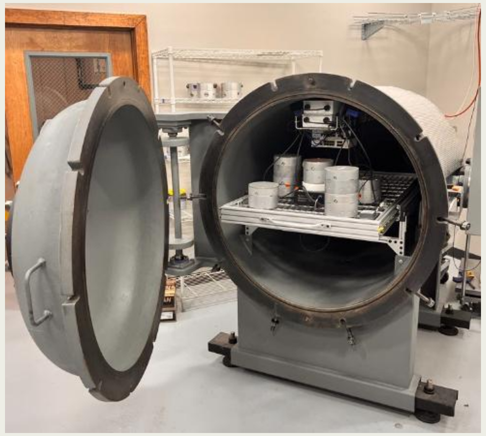
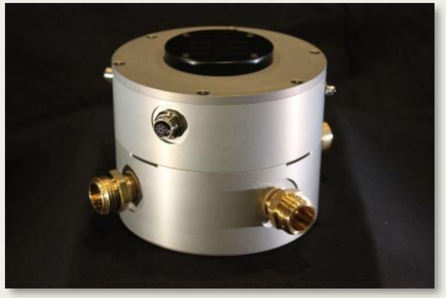
Introduction



- Infrasonic monitoring has become integral in the collection of geophysical and human activity.
- Recent advancements, resulting in field-hardened and robust infrasound sensors capable of tactical deployment with laboratory grade sensitivity, have allowed for the expansion of infrasonic sensing applications.
- This widespread adoption has brought to the forefront the need to verify calibration of sensors in an effective manner without requiring removal from installation sites.
- The constraints on removal of individual sensor units for calibration are often associated with sensors deployed in remote, hostile, and periodically inaccessible areas which, none the less, need to maintain accurate and continuous monitoring.
- NCPA and Hyperion have performed significant work to develop experimental in-situ calibration methods for the Hyperion sensor.



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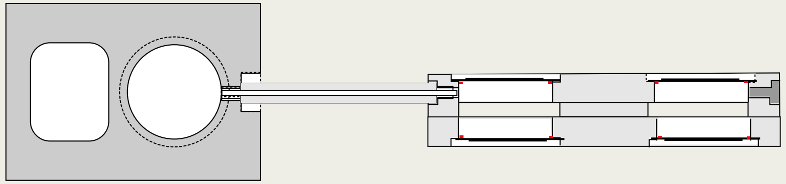
Early Work and Prototype

The technological innovation is to inject a pressure signal into the back-volume of the sensor, in this case via its vent screw opening.



This requires a much lower volume source than would be required to inject a signal into the fore-volume, and the calibration values obtained this way are insensitive to how the fore-volume of the sensor is configured.

Theoretically:

$$P_{bv}(f) = \gamma(f) P_0 \frac{v_{dr}(f)}{v_{net}}.$$

In an adiabatic environment $\gamma(f) = \gamma_a \cong 1.4$. More generally $\gamma(f)$ will need to be measured or modelled, as the empirical value will depend on thermoacoustics effects as well as the internal resonances of the driver/back-volume system.

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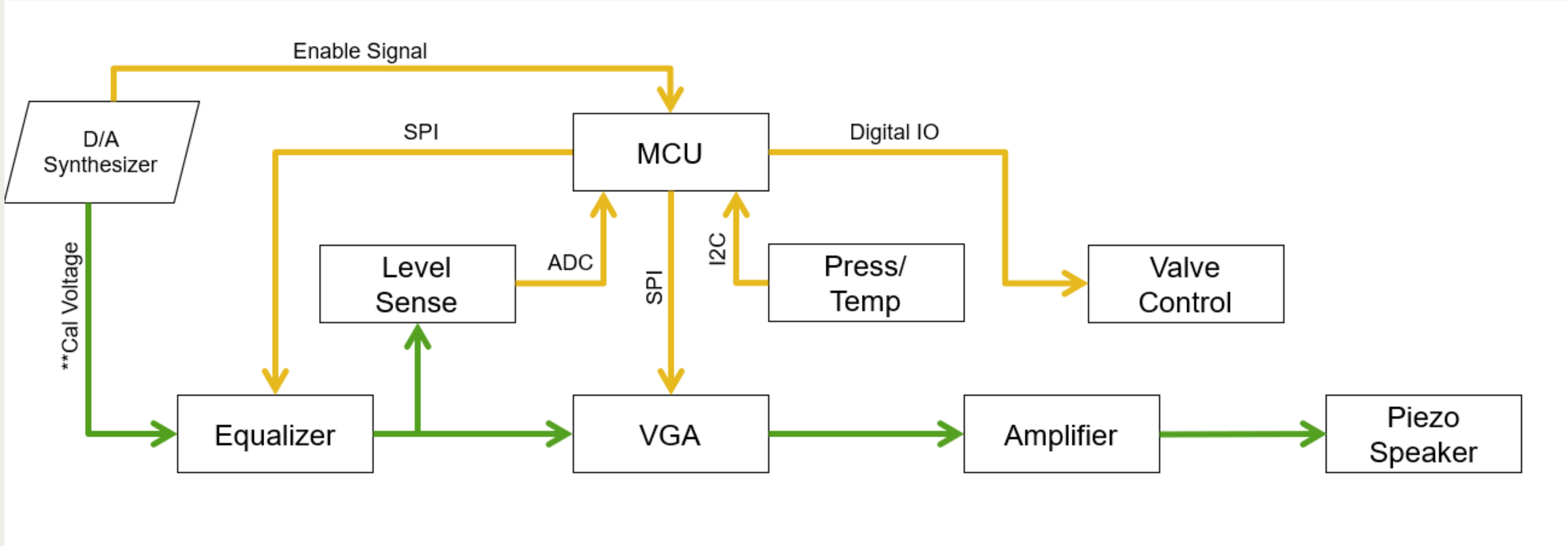
Method of Operation



- Add an integrated source to existing and new sensors that will provide a pressure signal to verify sensor's response and calibration.
- When a command signal is received from the digitizer the digitizer out. D/A puts a calibration voltage at a specific frequency and amplitude.
- The calibration voltage passes through a custom amplifier block.
- This amplifier feeds voltage to a driver which interfaces to the back volume of the Hyperion sensor.
- The standard output of the sensor is interfaced to the analog input of the digitizer unit which records the output of the sensor.

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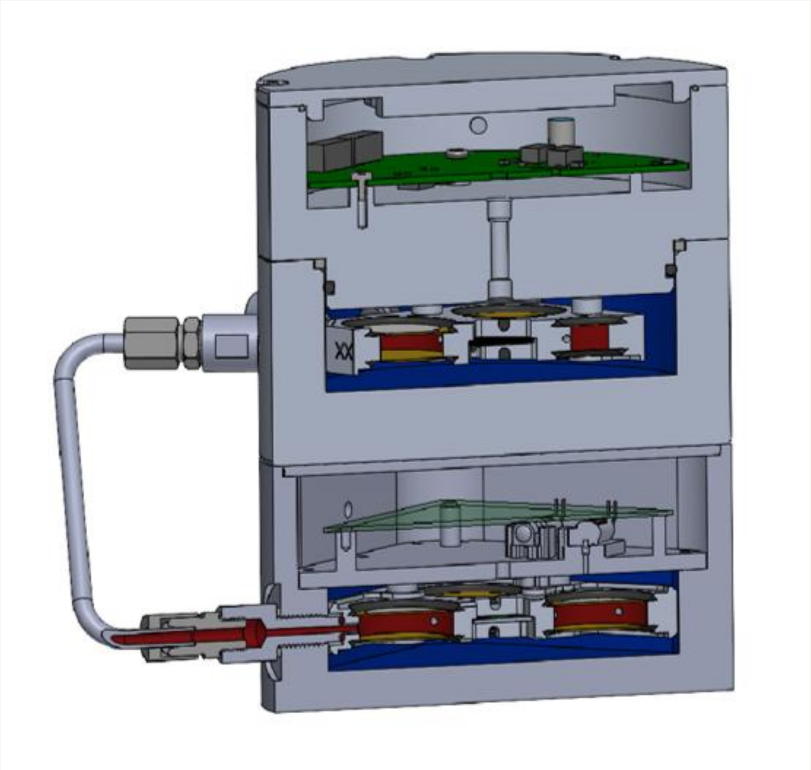
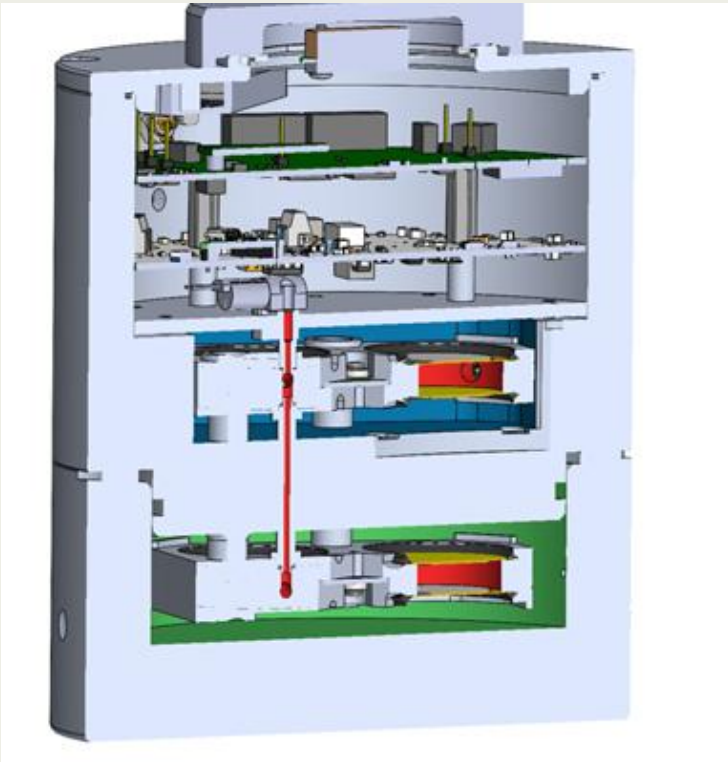
Integration Of Pressure Driver



Hyperion realization of NCPA modular driver



Final integrated hardware & electronics.

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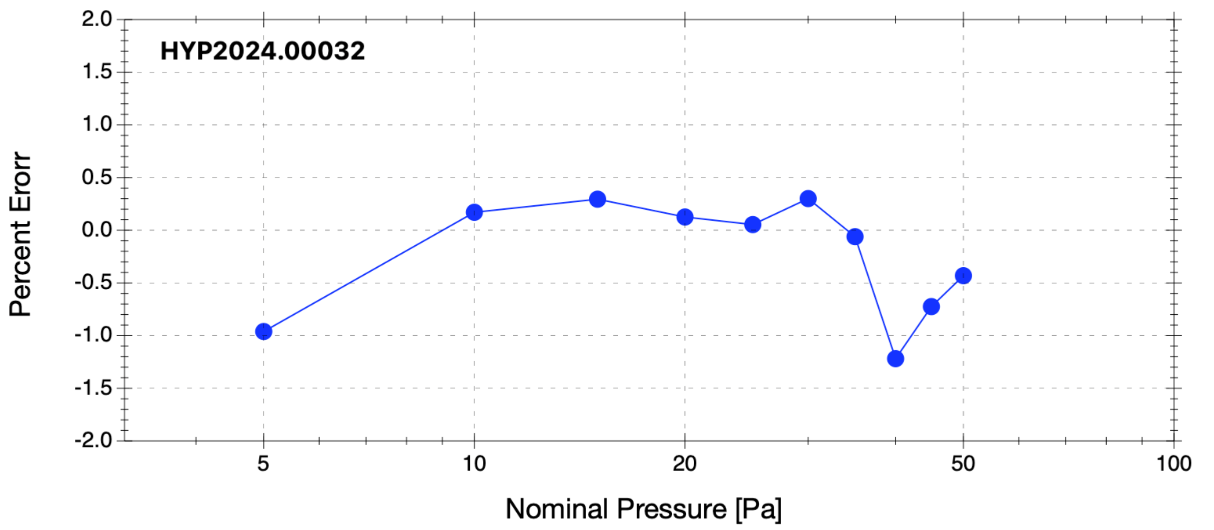
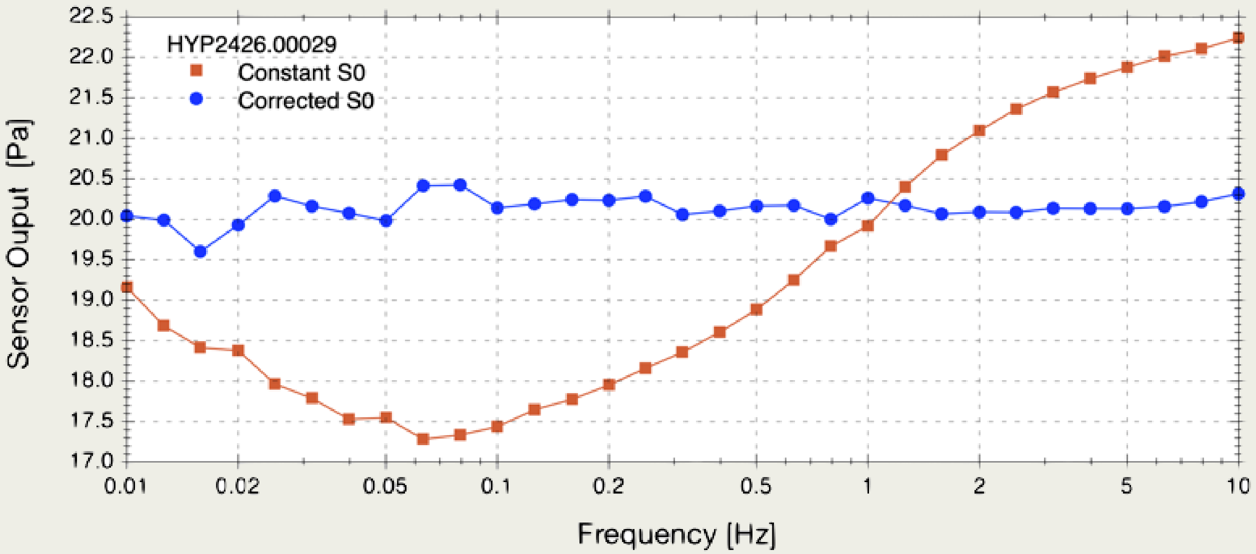
Prototype Performance



Our initial effort yielded roughly ±0.25% error over a wide range of levels—likely the range where this is true can be improved using further refinements of the model parameters.



We can just use software (instead of the built-in hardware) to equalize the frequency response of the calibrator. Red is constant (or uncorrected), blue applies a correction for the frequency response. This can be improved by iteration.

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Summary of New Capabilities

- Maximum pressure is now about 50-Pa (up from roughly 30-Pa in previous NCPA version).
- Remote control of digitizer using a computer
- Software selectable pressure amplitude
- Direct calibration of the sensors using the BMP 390 pressure sensor. [*]
- The capability to iterate on corrections, even to choose new algorithms, for correcting the calibrator behavior (without flashing the device).
- Many new capabilities are yet to be explored with this device!!!

[*] Future need: the ability to calibration the BMP 390 via an access port to the sensor back-volume (similar to a vent screw opening).