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Application of a Spektra CS-18 Seismic Calibration System at Sandia National Laboratories

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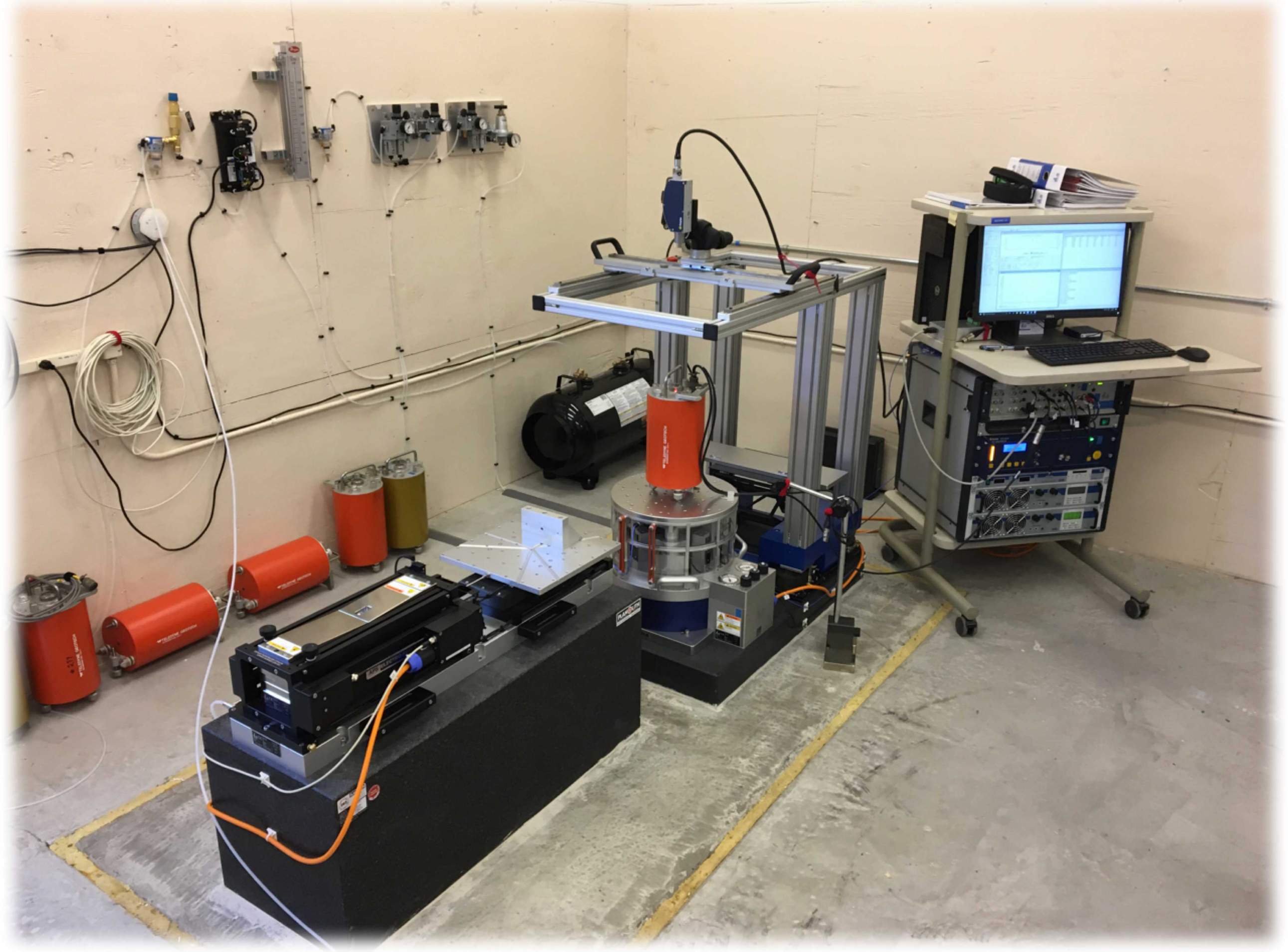
National Nuclear Security Administration

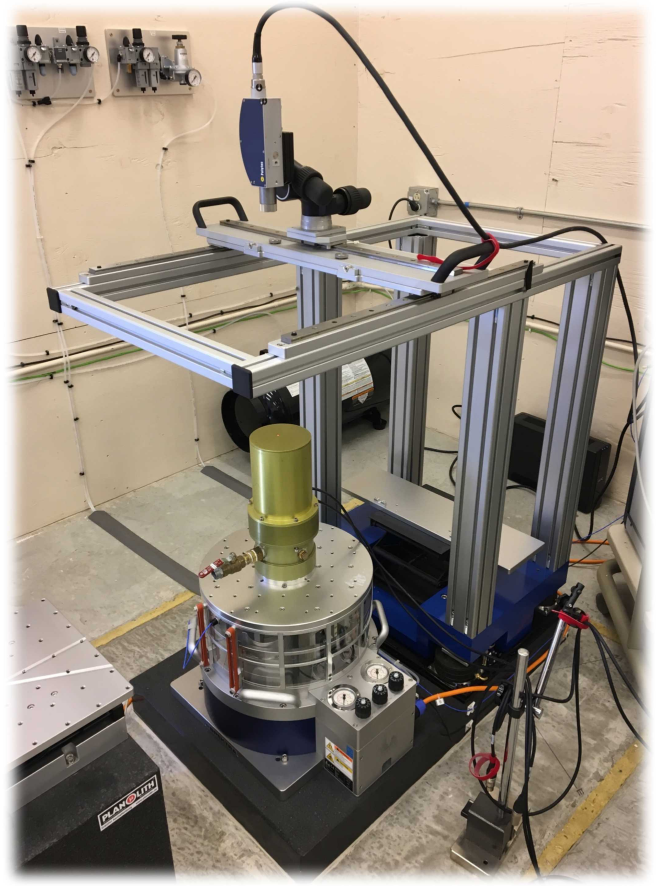
Introduction

The Facility for Acceptance, Calibration and Testing (FACT) at Sandia National Laboratories has been a valued resource for the U.S. monitoring community for decades. The FACT site hosts a number of capabilities focused on component evaluation, including a recently purchased Spektra CS-18 seismic calibration system. The system utilizes a laser vibrometer as a means of independently measuring the shake table's motion; an advantage over accelerometers which are often employed for such measurements, especially considering our efforts to provide NIST-traceable measurements in our component evaluation work. Instrument calibrations utilizing the Spektra system have been conducted on a number of seismic sensors, providing amplitude and phase responses, and on infrasound sensors, to assess their susceptibility to seismic-like ground vibration. Calibrations of seismic sensors thus far have shown the calculated instrument responses are sensitive to a variety of factors, which if properly mitigated, improve upon the repeatability of the calibration information provided by the system. We have observed calibration results may vary with selection of the laser vibrometer reflection point, for example, the reflection point being on the sensor case, on the table surface immediately adjacent to the sensor or on the edge of the table surface. Initial results also appear to be sensitive to whether or not a sensor is secured to the table, regardless of whether it being placed on the horizontal or vertical table, and despite the relatively low accelerations imposed upon the sensor by the shake table system during a calibration procedure.



The Spektra CS-18 calibration system consists of vertical and horizontal tables, mounted on granite piers, and amplifiers for each; a laser, providing independent and precise measurement of sensor motion, mounted on an vibration isolation platform; a vibration control system and computer, which hosts the software that drives the system.

Seismic Susceptibility Testing of Infrasound Sensors

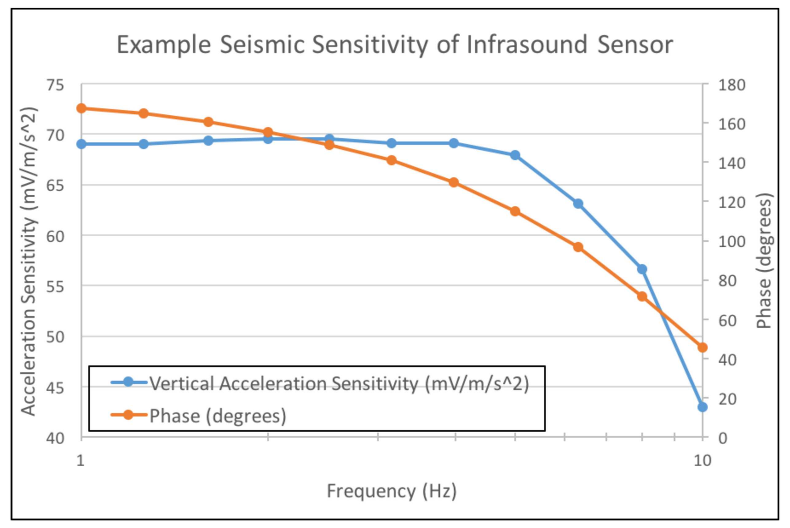


An Infrasound Sensor's Response to Vertical Acceleration

The Spektra system allows for convenient and objective evaluation of an infrasound sensor's sensitivity to vertically-induced acceleration.

System typically configured as follows:

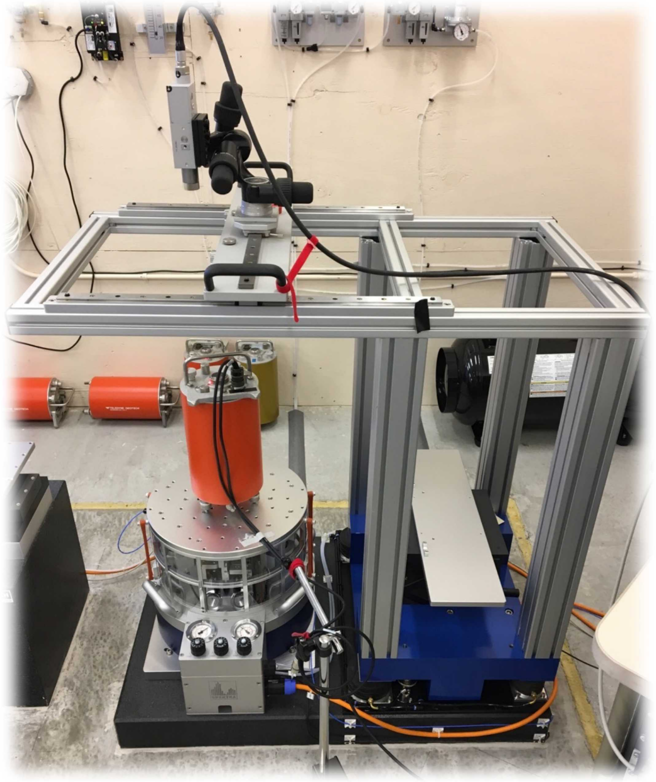
- Uniform 10%g acceleration (may be displacement-limited at low frequencies)
- Sinusoidal motion
- Discrete frequencies; 1 Hz to 10 Hz, 1/3 octave spacing.

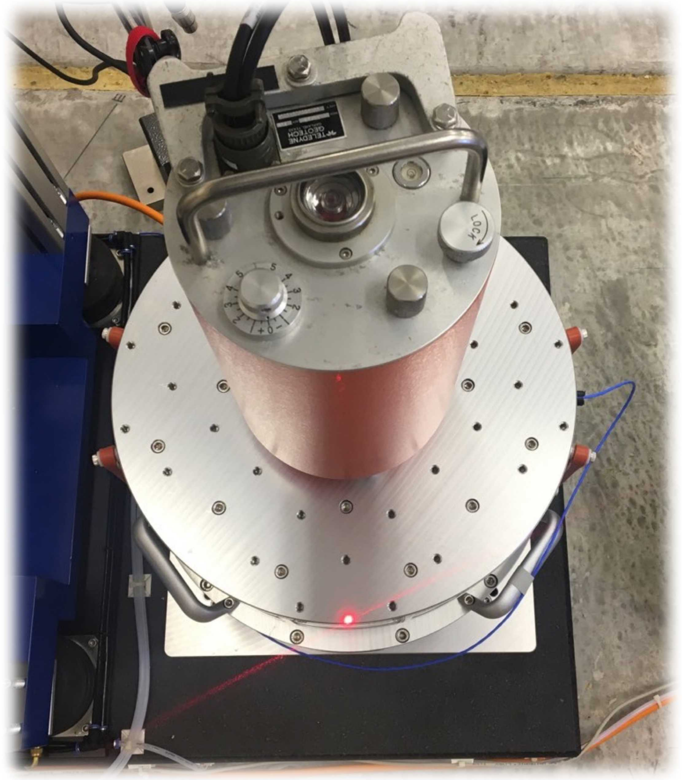


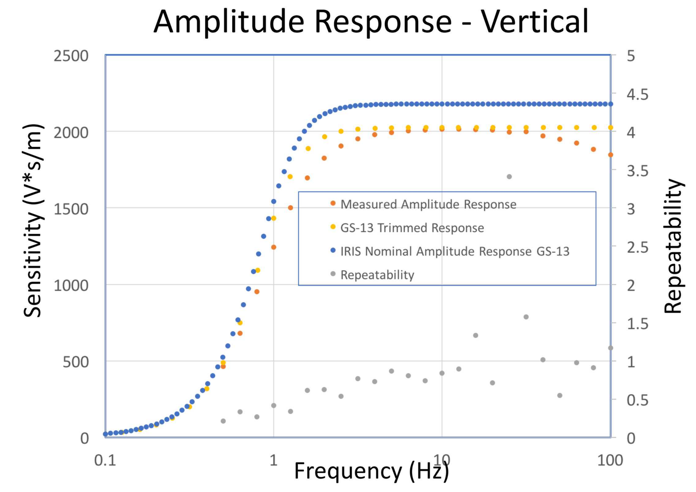
- Sensor has a relatively flat response to acceleration between 1 Hz and 5 Hz.
- Note the plot is an example and does not represent results from the sensor in the photo.

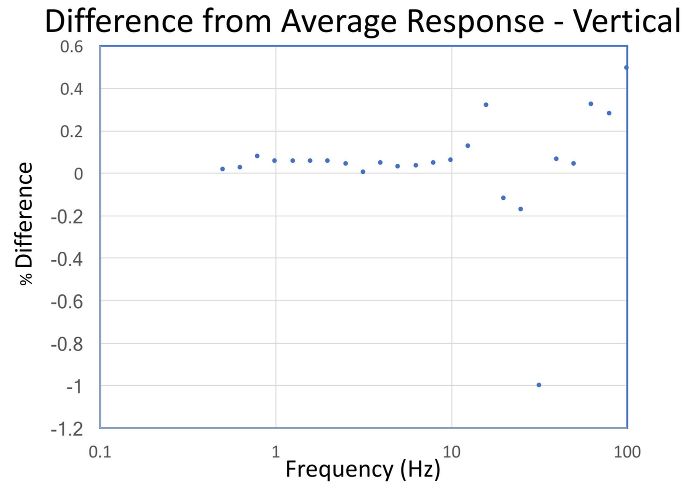
A view of the FACT site, looking northeast. In addition to the recently purchased Spektra CS-18 seismic calibration system, the FACT site hosts a number of additional capabilities, including an underground bunker and seismic pier (center of photo), numerous boreholes, a telemetered, shallow vault array for seismic and infrasound studies and an acoustic isolation chamber, for infrasound sensor testing, which in addition to isolating sensors from the environment, allows for pressurization to sea-level conditions or evacuation to high altitude conditions.

Calibration of a Geotech GS-13 Sensor

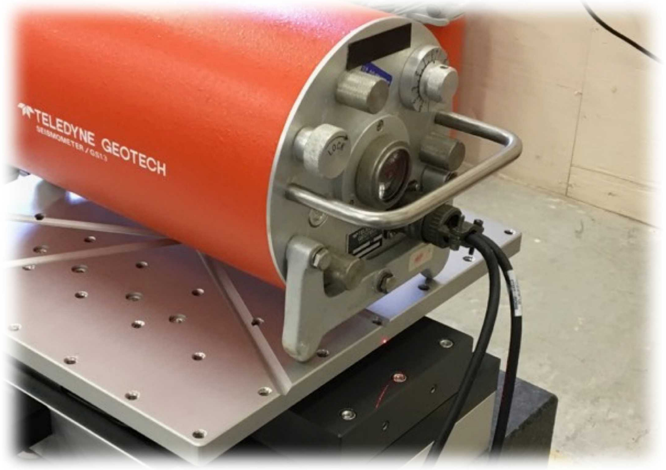


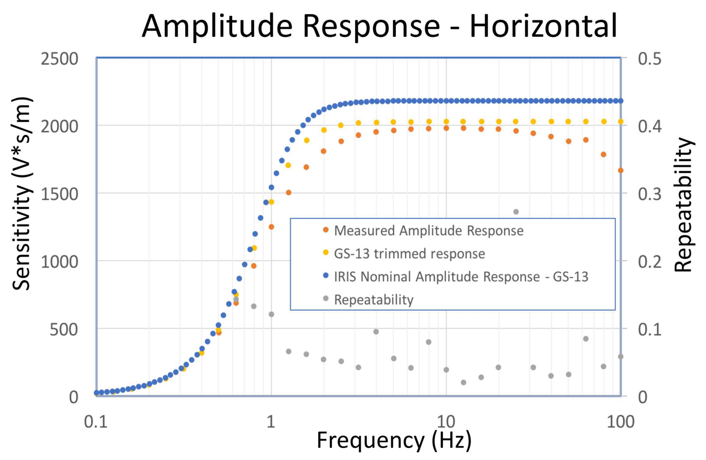


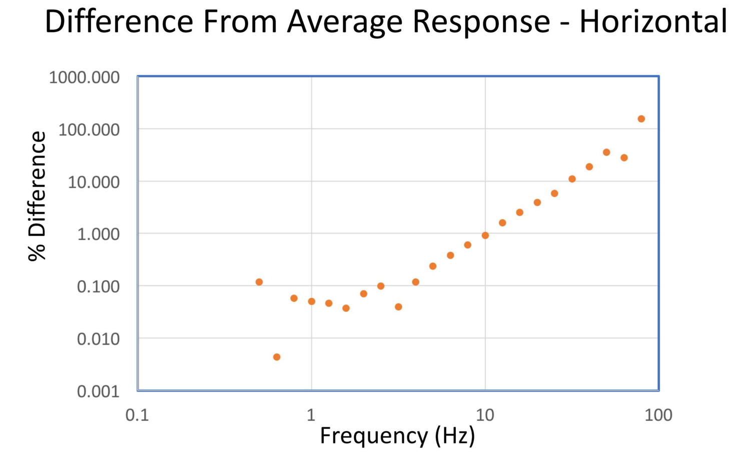




Upper Left - Vertical table configured for calibration. *Upper Right* - Close up of vertical table with laser focused on extreme edge of table. *Lower Left* – Measured vs. nominal amplitude response* plotted with measurement repeatability. *Lower Right* – Percent difference of measured sensitivity (with laser focused on table extreme) from the average measured sensitivity (with laser centered on sensor).

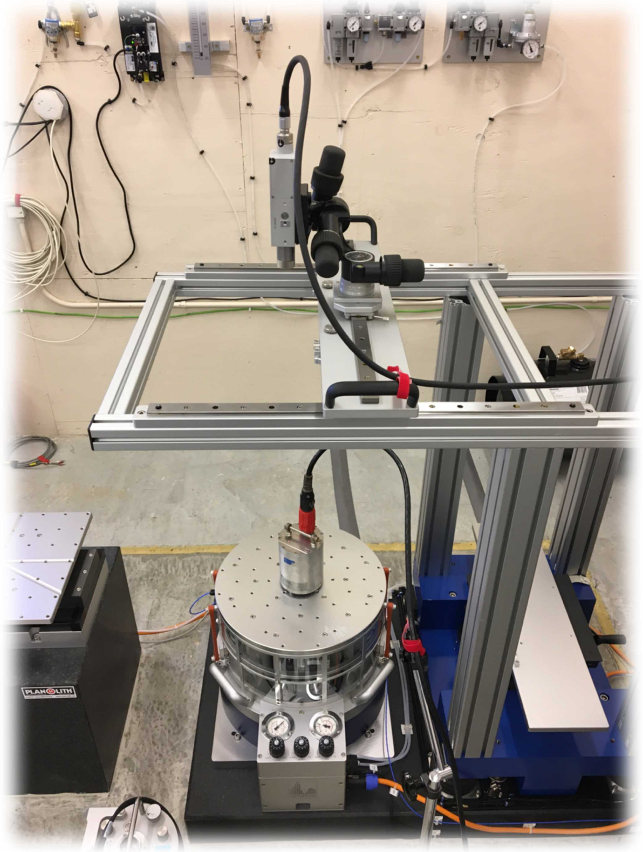


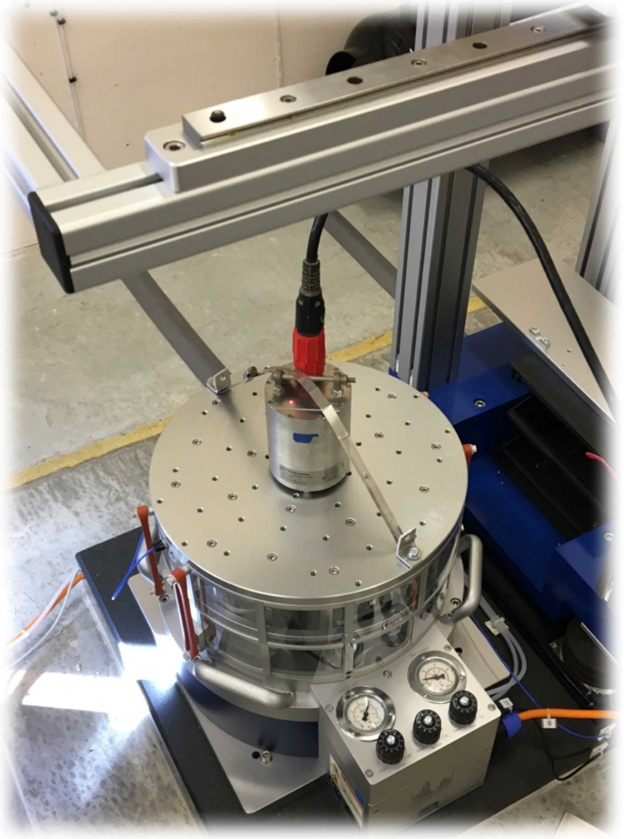


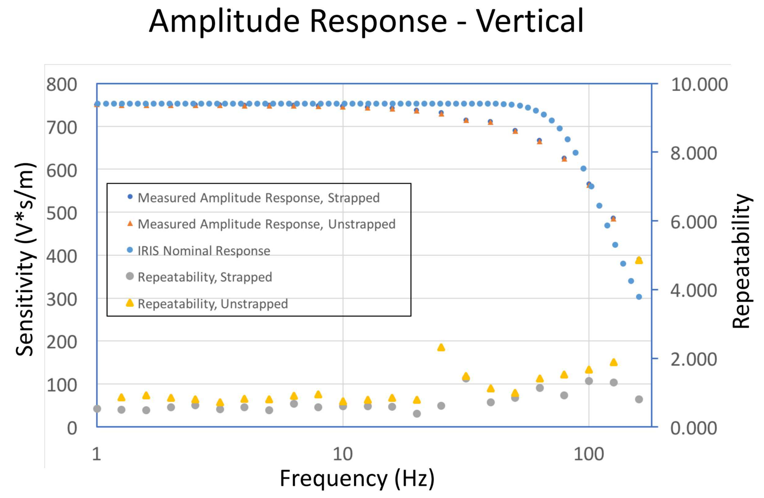


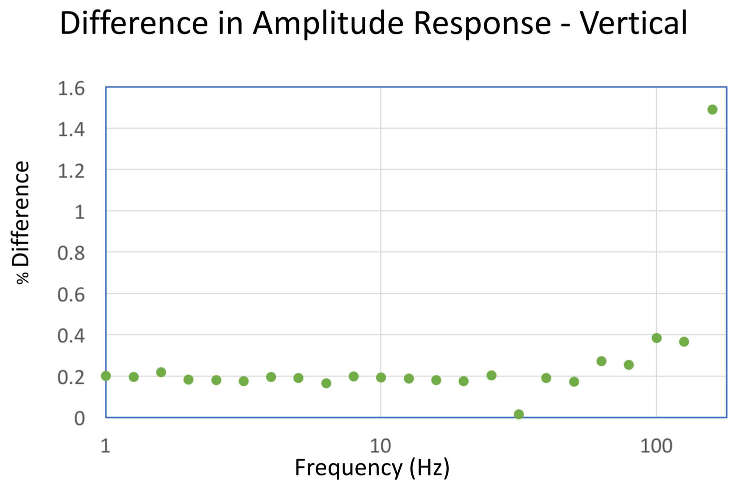
Upper Left - Horizontal table configured for calibration. *Upper Right* -Close up of horizontal table with laser focused on table. *Lower Left* – Measured vs. trimmed sensitivity and nominal amplitude sensitivity* plotted with measurement repeatability. *Lower Right* – Percent difference of measured sensitivity (with laser focused on table) from the average measured sensitivity (with laser centered on sensor).

Calibration of a Nanometrics Trillium Compact Post Hole Sensor

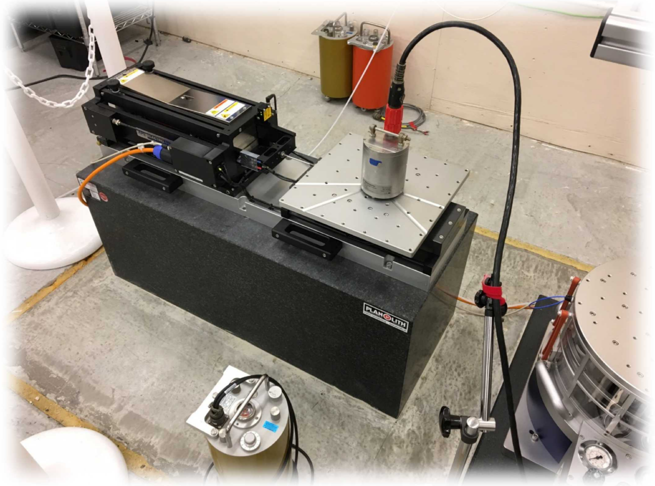


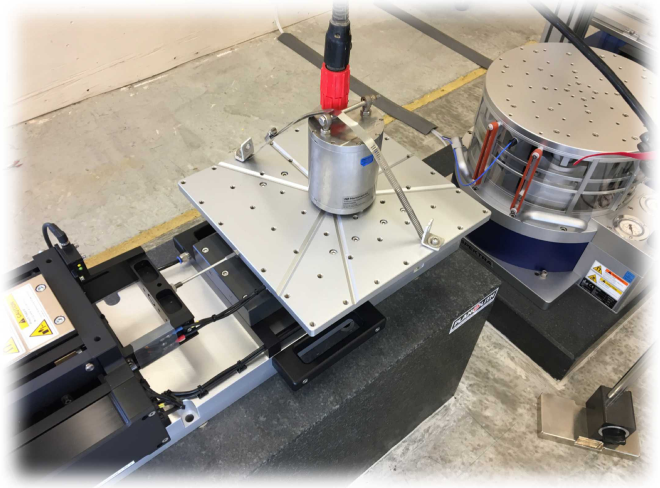


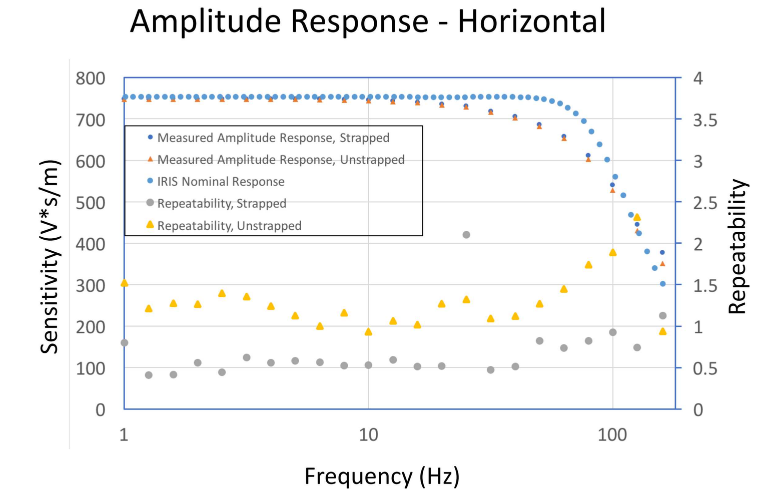


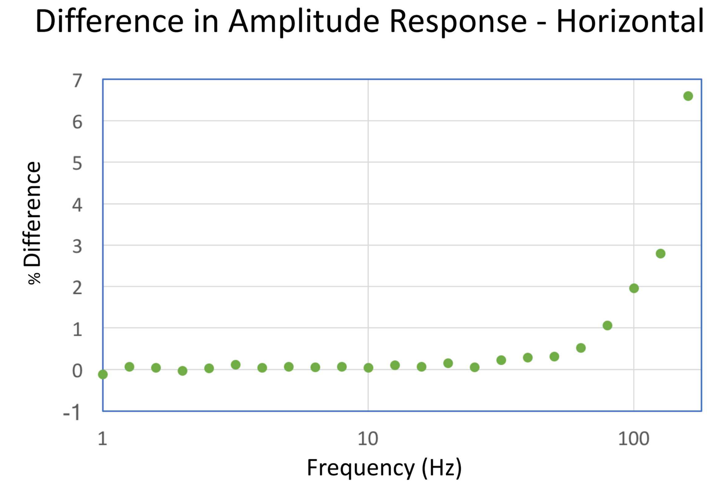


Upper Left - Vertical table configured for calibration, sensor unstrapped. *Upper Right* – Close up showing the Trillium Compact strapped onto the vertical table. *Lower Left* – strapped response, unstrapped and nominal amplitude response* plotted with measurement repeatability. *Lower Right* – Percent difference in amplitude sensitivity between strapped sensor versus the unstrapped sensor.









Upper Left - Horizontal table configured for calibration, sensor unstrapped. *Upper Right* – Close up showing the Trillium Compact strapped onto the horizontal table. *Lower Left* – strapped response, unstrapped and nominal amplitude response* plotted with measurement repeatability. *Lower Right* – Percent difference in amplitude sensitivity between strapped sensor versus the unstrapped sensor.

Future Work

- Lower the low frequency bound of the system from 0.1 Hz to 0.05 Hz and test systems behavior (observing repeatability).
- Attempt calibrations on a broadband sensor (e.g. STS-2 or Trillium 120).
- Test other (more rigid) means of anchoring sensors to the tables.
- Research potential table enclosures in an attempt to minimize the effects of air currents on low amplitude calibrations (e.g. when utilizing a pre-amplifier).

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