SAND2013-6646C

Infrasound Sensor Evaluation Comparison – Sandia Facility for Acceptance Calibration and Testing

US Infrasound Calibration Team Meeting

Albuquerque, NM

August 13-14, 2013

Sandia National Laboratories

FACT Site Sensor Swap

Outline:

- Test Plan
- Equipment
- Testbed configuration
- Overview of Tests
- Sandia Results

Facility Comparison - Sensor Swap Experiment

Test Plan:

- **Single Frequency / Single Amplitude: 0.5 Hz at 2 Pa peak-to-peak and duration of 900 seconds.**
  Analysis: sine-fit every minute, fit 10 cycles for voltage and sensitivity.

- **Broadband White Noise: 0.02 to 10 Hz at 2 Pa peak-to-peak and duration of 4000 seconds.**
  Analysis: PSD of data corrected for bit-weight and sensitivity (obtained from previous test) and no shape correction by instrument response model; compute coherence, relative gain and phase to reference sensors used in test. Provide reference PSD of input white noise signal spectrum.

- **Two-Tone: F1= 0.02 Hz at 5 Pa peak-to-peak and F2=0.5 Hz at 0.5 Pa and duration 900 seconds.**
  Analysis: High pass filter to observe 0.5 Hz sine and estimate modulation index.

FACT Site Sensor Swap

Equipment:

Signal Generator: Quanterra Supertonal

Acquisition System: Smart24R s1043

- DCA calibrated 6.26.2013
- 100 samples per second

Sensors Tested:
I56US MB2000 1254
Chaparral Physics 2.2c 051694

Testing Environment:
Vaisala PTU303 – Absolute Pressure, Temperature and % Relative Humidity

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FACT Site Sensor Swap

Acquisition System: Smart24R s1043

- DCA calibrated on 6.26.2013

Waveform	Sensitivity	LSB	Percent error	DC Offset
s1043:c1p	306360 count/V	3.26413 uV/count	-0.17948 %	-42.51 uV
s1043:c2p	307877 count/V	3.24806 uV/count	-0.67109 %	19.62 uV
s1043:c3p	306789 count/V	3.25957 uV/count	-0.31908 %	-52.32 uV
s1043:c4p	307351 count/V	3.2536 uV/count	-0.50141 %	-19.62 uV
s1043:c5p	307391 count/V	3.25319 uV/count	-0.51415 %	-55.59 uV
s1043:c6p	305941 count/V	3.2686 uV/count	-0.04285 %	3.27 uV

FACT Site Sensor Swap

Martec MB2000 Primary Reference

Martec MB2005 Secondary Reference

Power: MB2000 = 4 watts and MB2005 = 1.6 watts @ 12V

Sensitivity: MB2000 100 mV/Pa and MB2005 97.6 mV/Pa

Noise: -64 dB rel 1 Pa^2/Hz ~ 0.7 mPa rms (0.5-2 Hz)

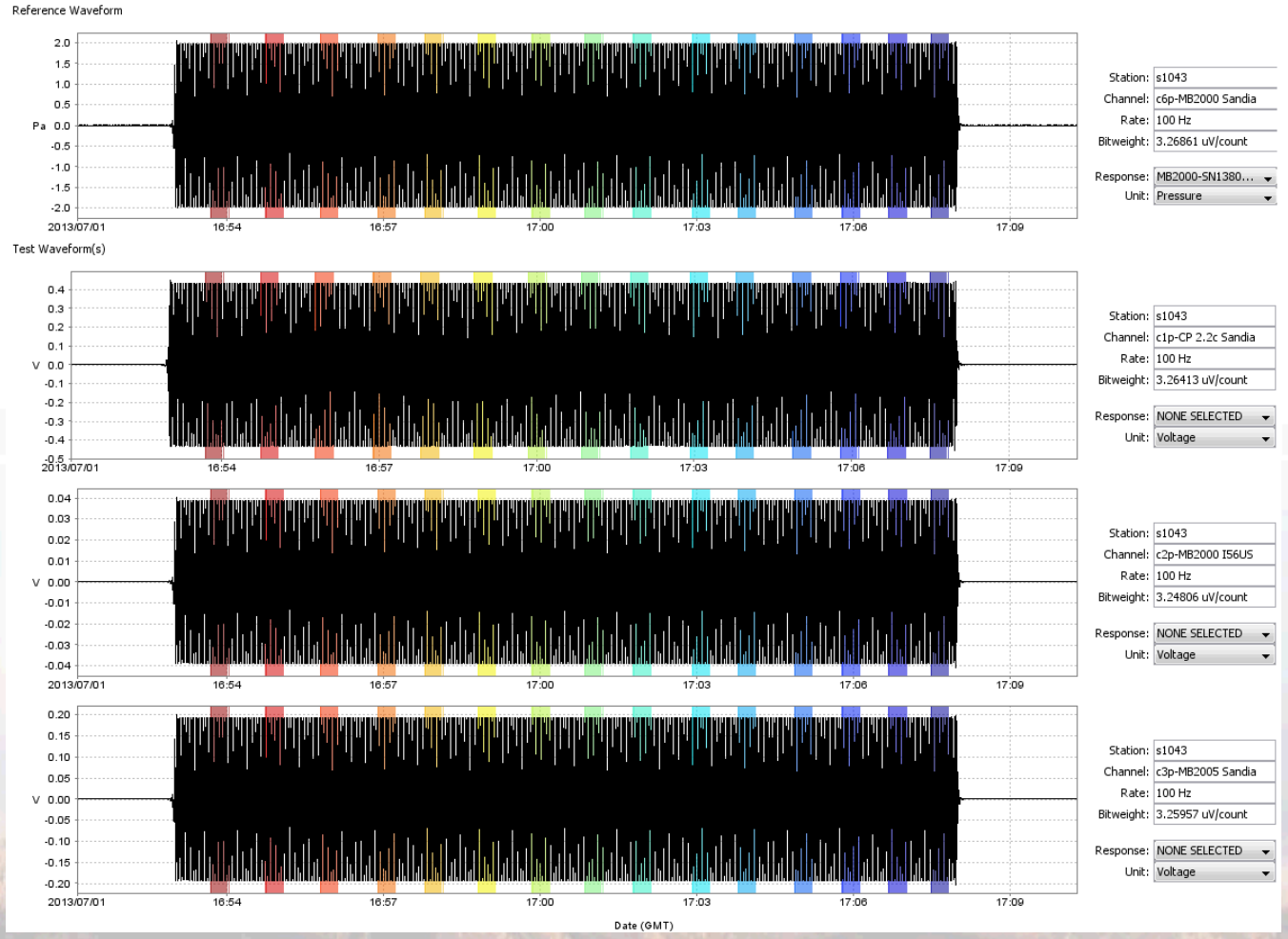
Full-scale Pressure: 107 Pa (zero to peak)

Dynamic Range: 104 dB

Passband:0.02 – 10 Hz

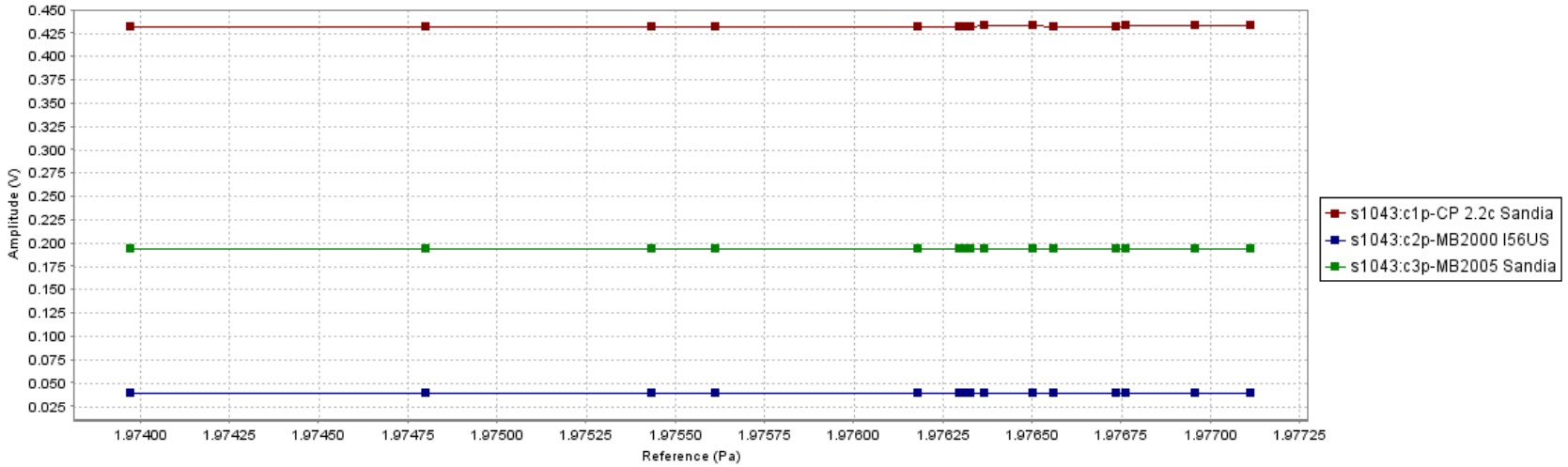
Single Frequency / Single Amplitude

Analysis: perform three parameter sine fit to obtain amplitude, phase and DC offset. Sine Fit performed using 10 cycles of data.



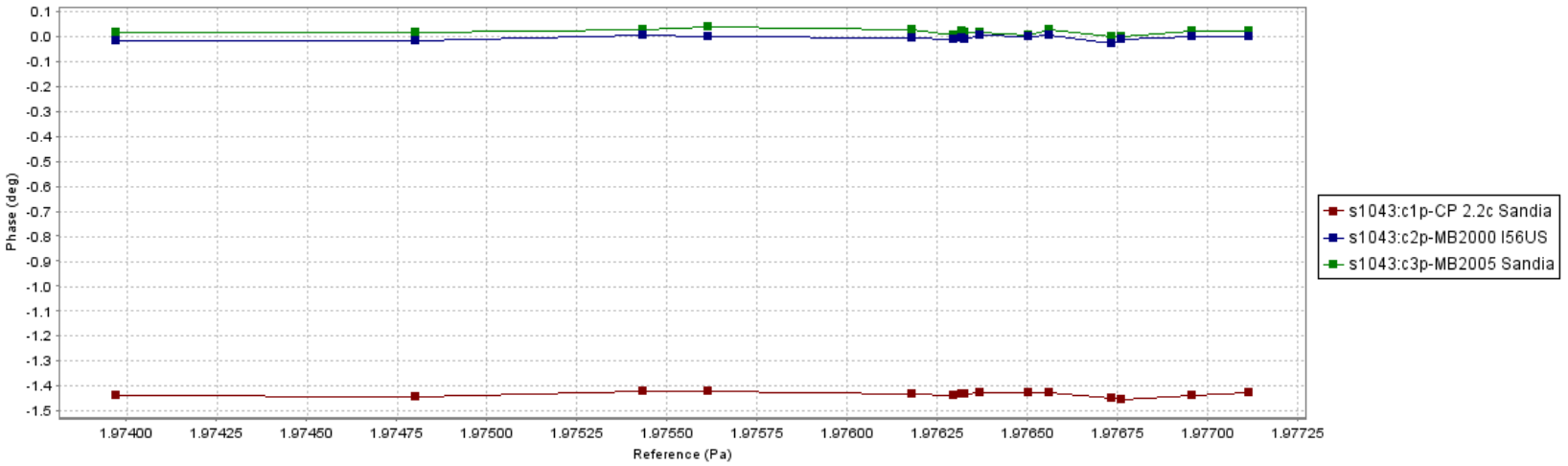
Single Frequency / Single Amplitude

Amplitude (Voltage)



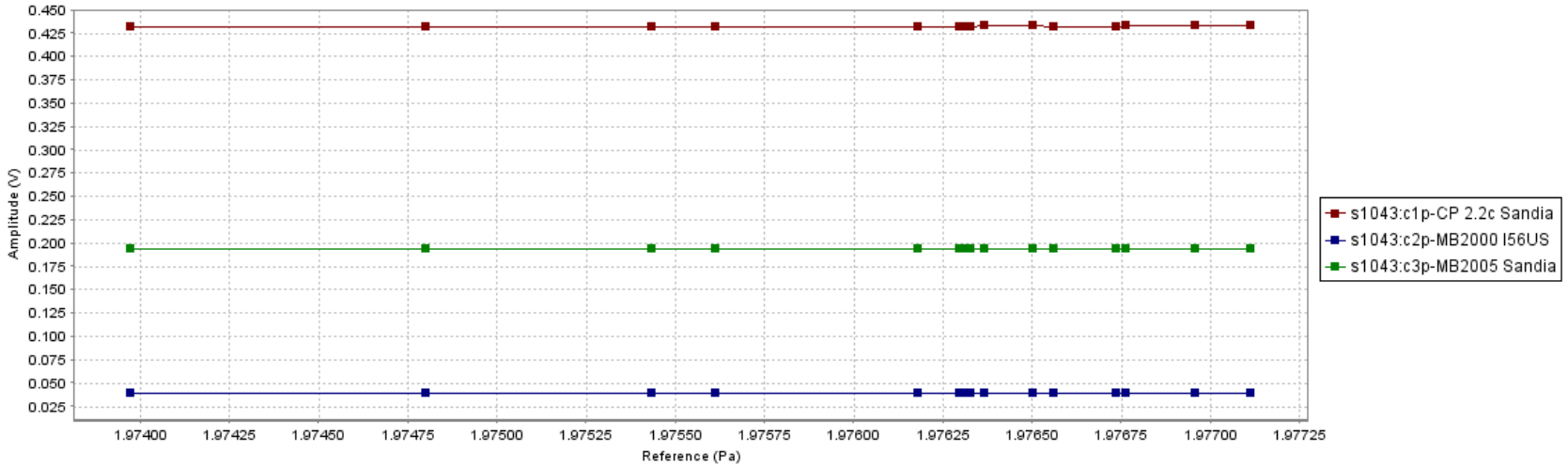
Single Frequency / Single Amplitude

Phase (Degrees)



Single Frequency / Single Amplitude

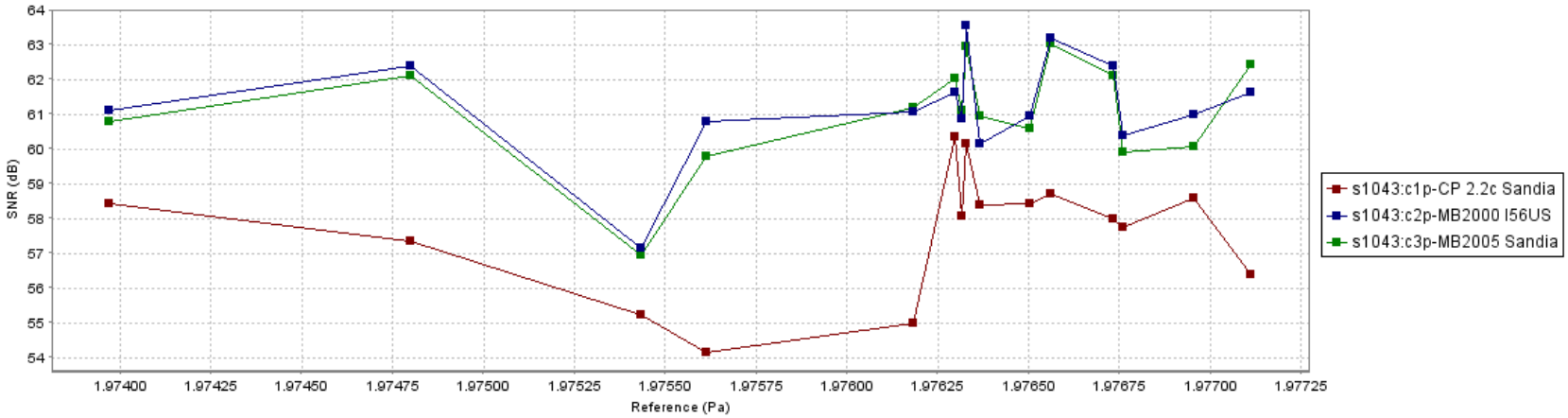
Sensitivity (mV/Pa)



Observed Reference (Pa)	1.976129	0.000848
Sensor ID	Sensitivity (mV/Pa)	Standard Deviation (mv/Pa)
s1043:c1p-CP 2.2c Sandia	218.597	0.318
s1043:c2p-MB2000 I56US	19.641	0.00194
s1043:c3p-MB2005 Sandia	97.735	0.0129

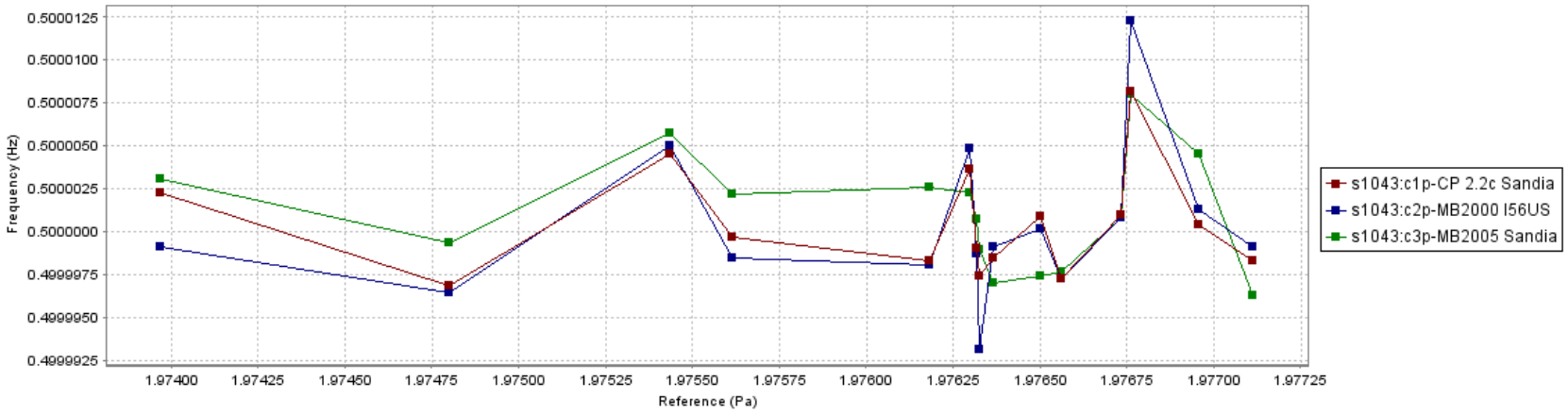
Single Frequency / Single Amplitude

Signal to Noise



Single Frequency / Single Amplitude

Frequency (Hz)



Response Verification

Analysis: Window one hour of data;

Compute PSD:

Block-by-block DC removal

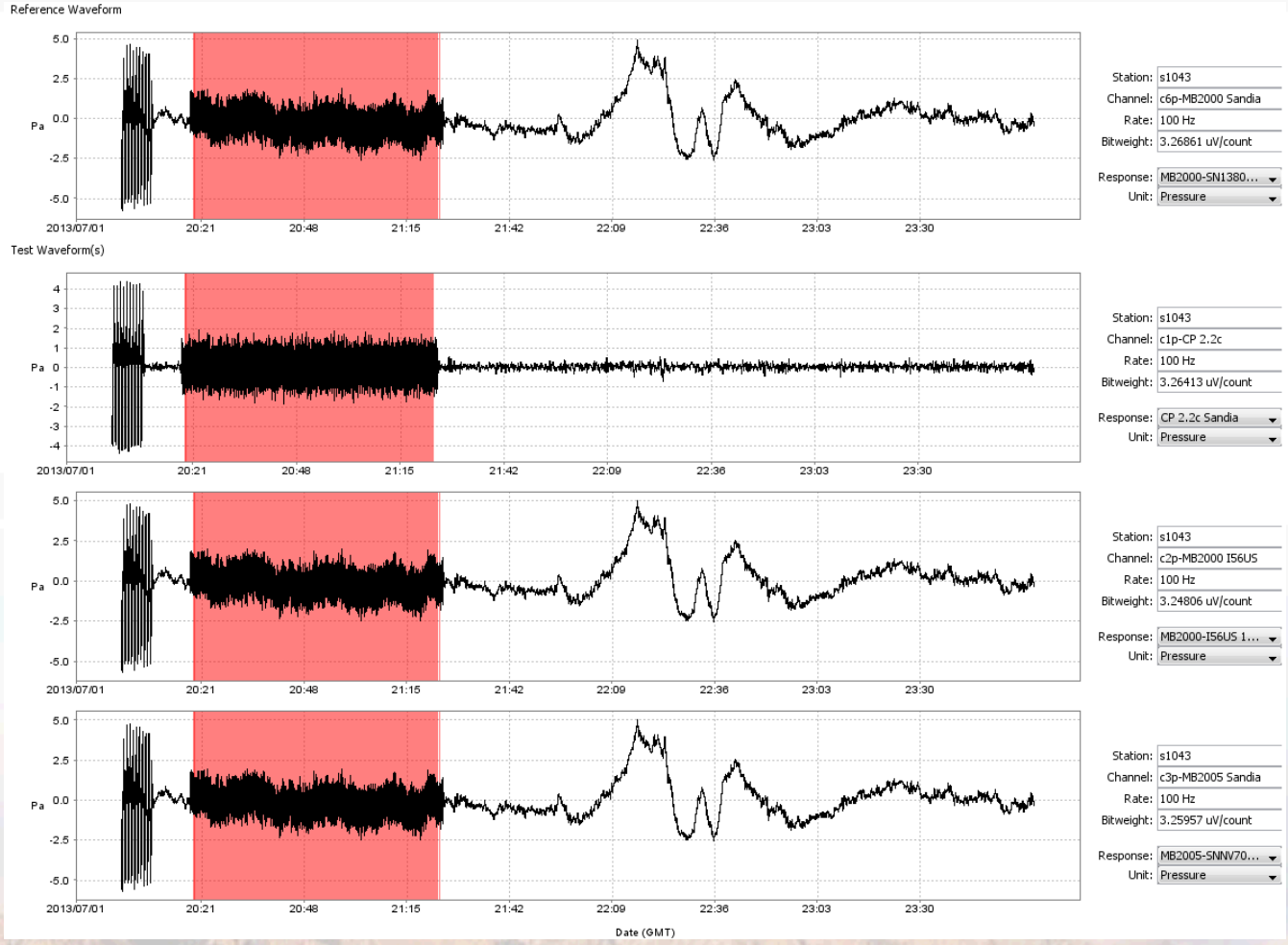
Hann Window

FFT length 32K

FFT Overlap 5/8

Provide 90%

Confidance = 2.11 dB



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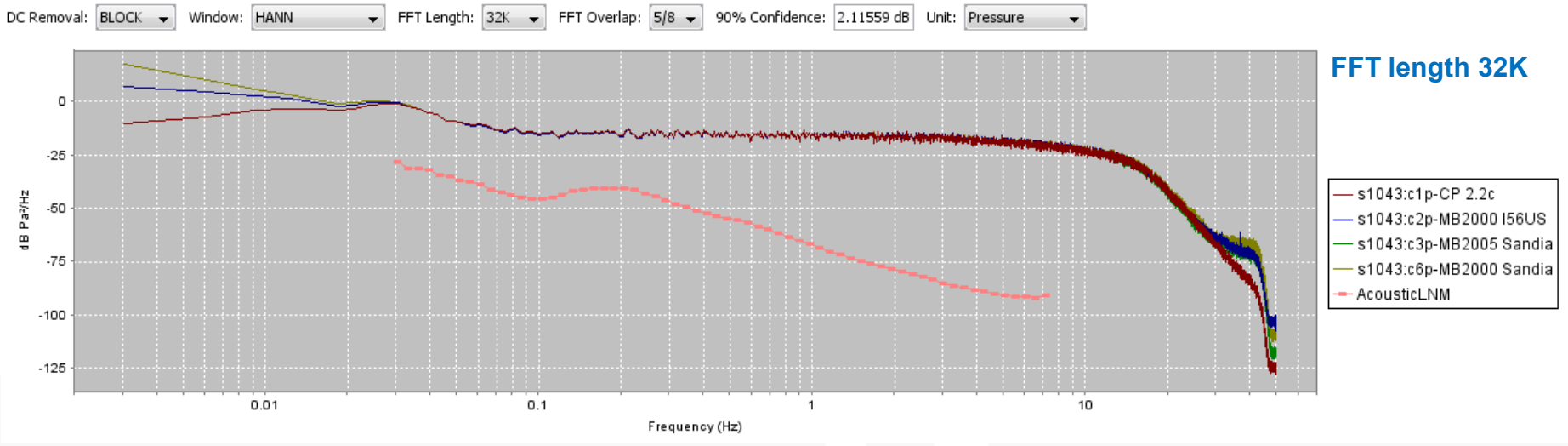
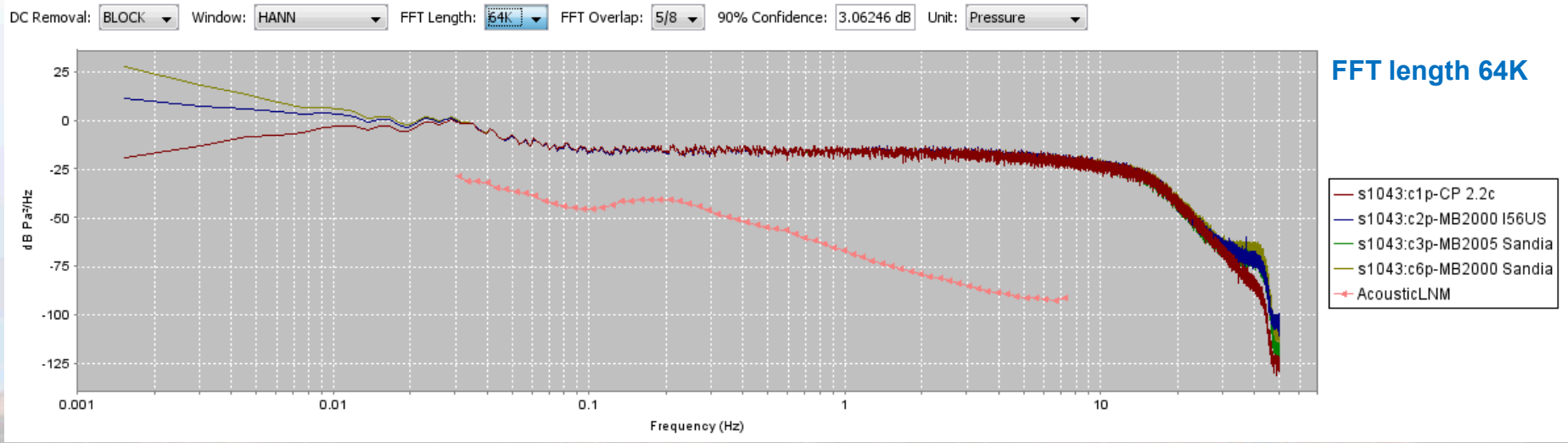
Response Verification

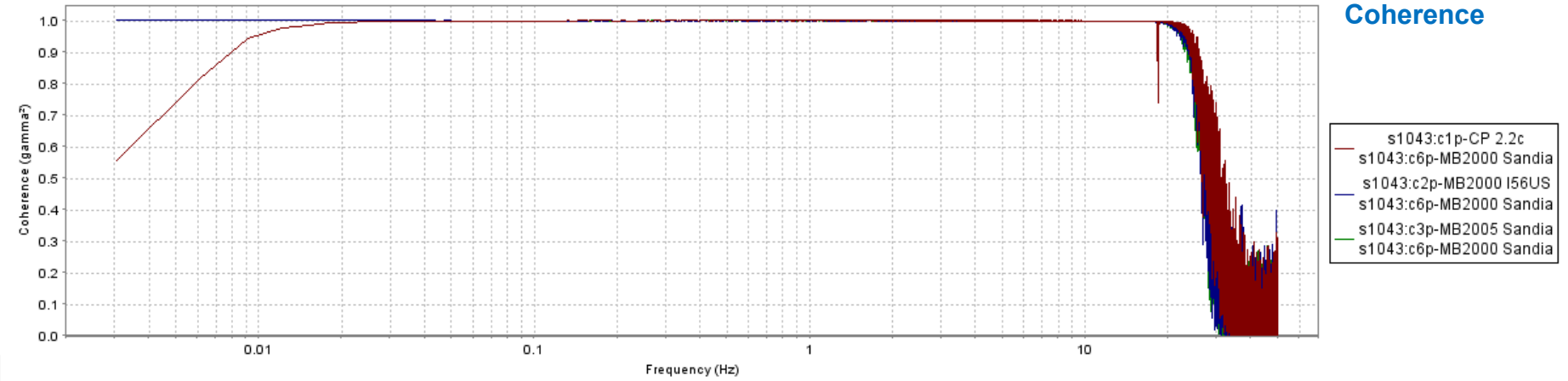


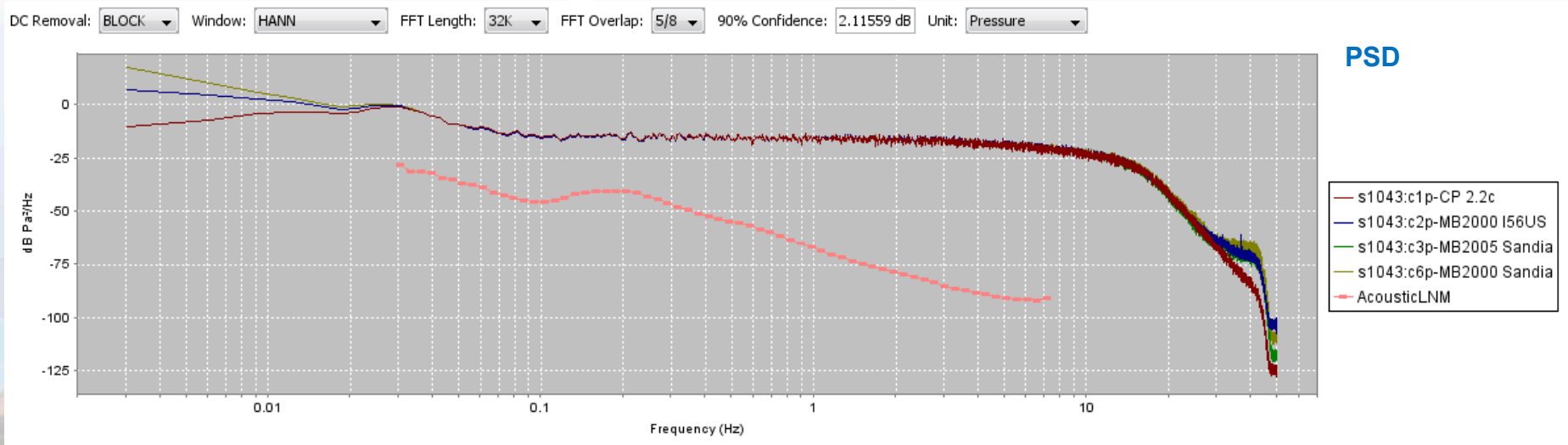
FFT length 32K



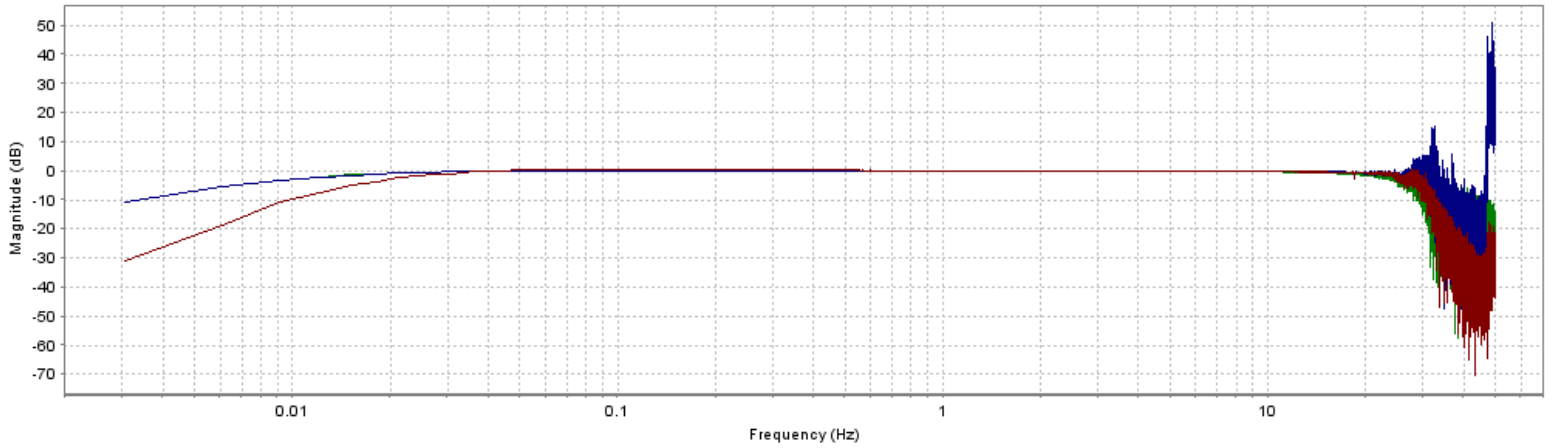
FFT length 64K

Response Verification



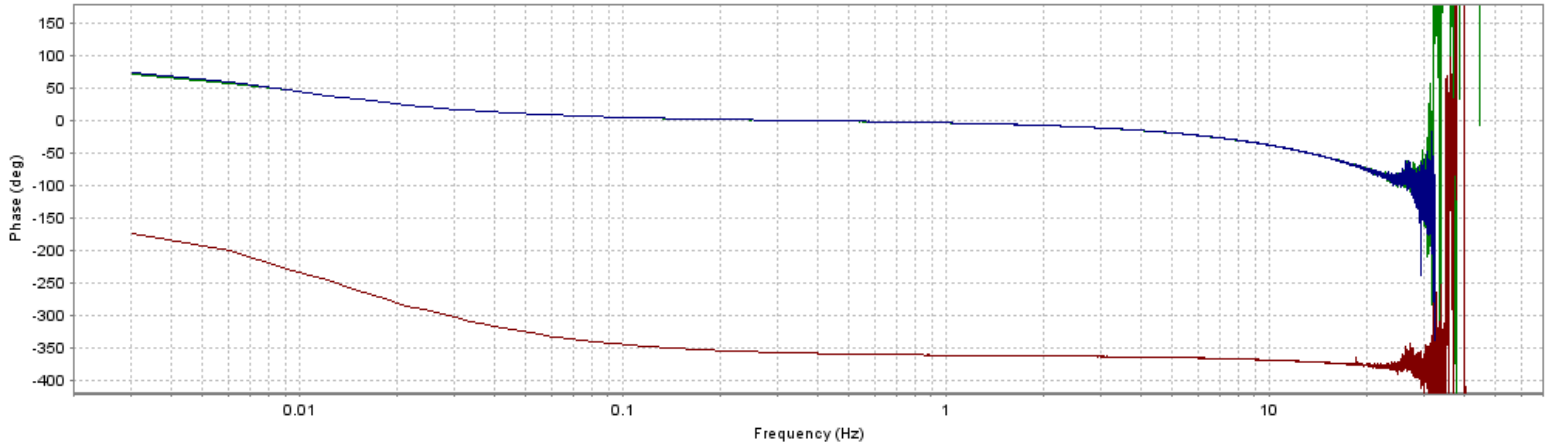


Response Verification



Relative Gain

s1043:c1p-CP 2.2c
s1043:c6p-MB2000 Sandia
s1043:c2p-MB2000 I56US
s1043:c6p-MB2000 Sandia
s1043:c3p-MB2005 Sandia
s1043:c6p-MB2000 Sandia

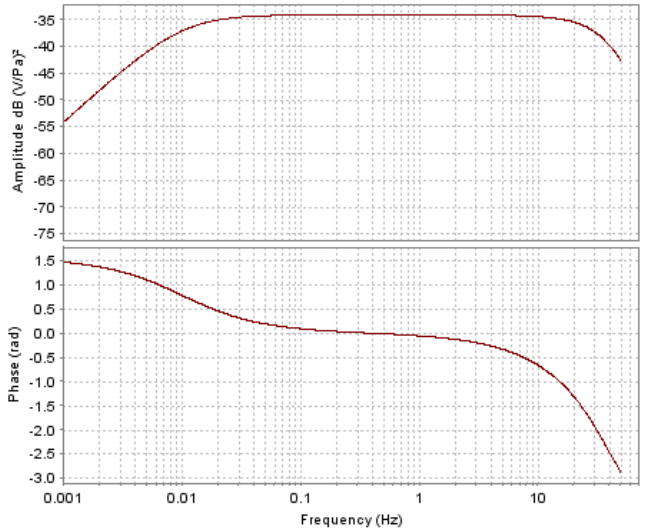


Relative Phase

s1043:c1p-CP 2.2c
s1043:c6p-MB2000 Sandia
s1043:c2p-MB2000 I56US
s1043:c6p-MB2000 Sandia
s1043:c3p-MB2005 Sandia
s1043:c6p-MB2000 Sandia

Response Verification

Response Models

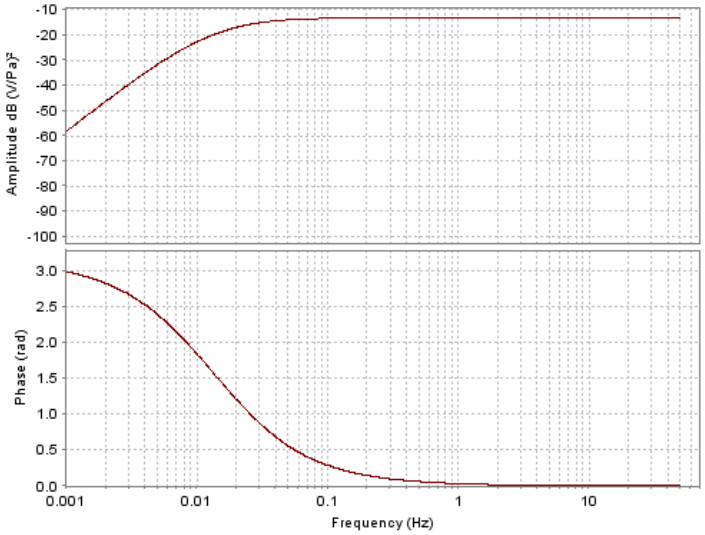


Poles:
-206.69, 0.0
-177.7, 177.8
-177.7, -177.8
-4.3, 819.6
-4.3, -819.6
-4.0, 1116.7
-4.0, -1116.7
-0.06283, 0.0

Zeros:
-468820.0, 0.0
0.0, 0.0

A:
458,719.01499 MV/Pa

MB2000/MB2005-CEA



Poles:
-0.127033, 0.0
-0.056235, 0.0

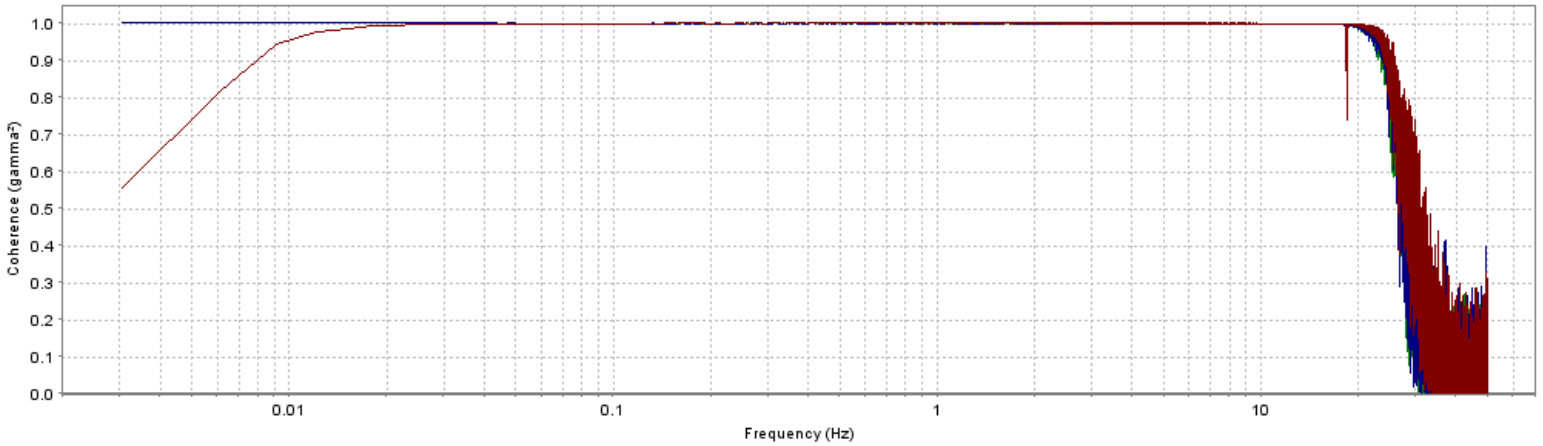
Zeros:
0.0, 0.0
0.0, 0.0

A:
0.21671 V/Pa

Chaparral Physics 2.2c - Sandia

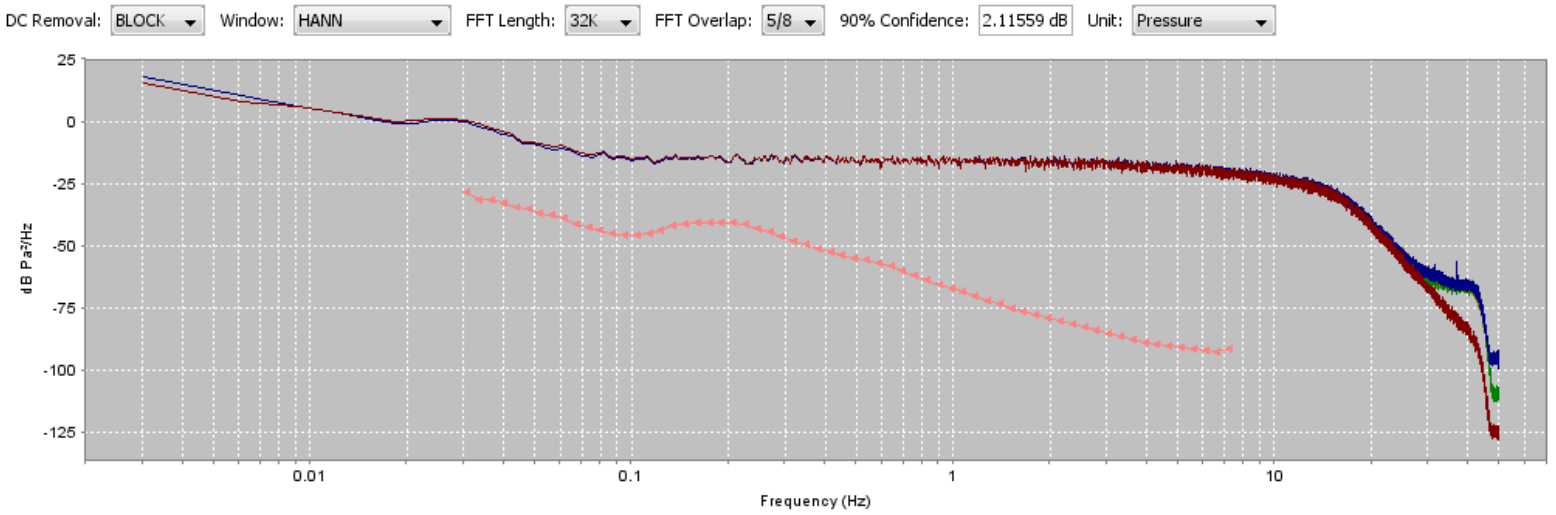
Response Verification

Response Verification – Response Corrected



Coherence

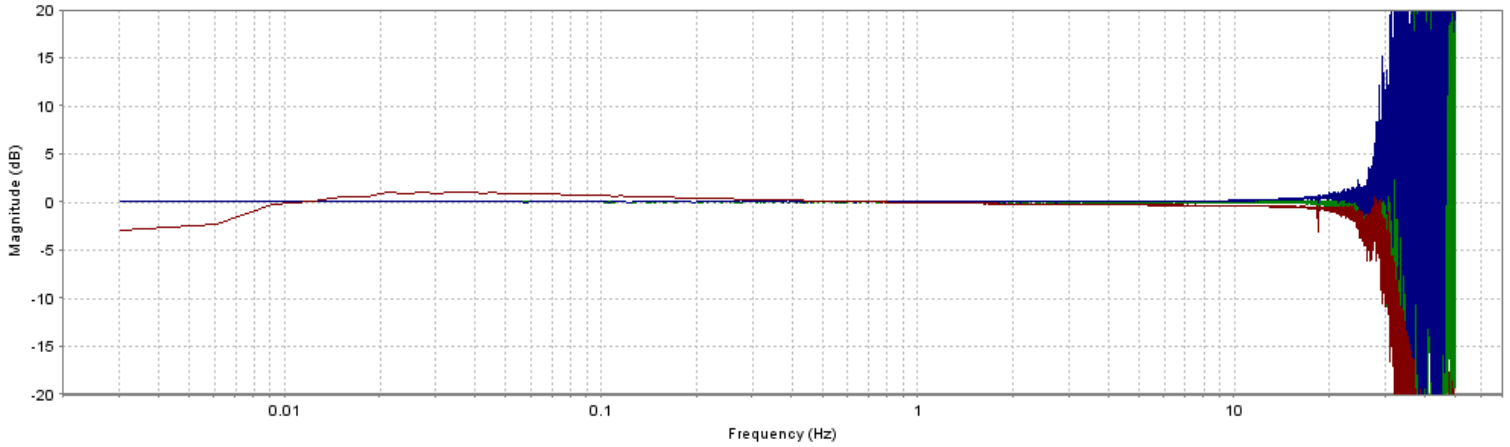
- s1043:c1p-CP 2.2c
  s1043:c6p-MB2000 Sandia
- s1043:c2p-MB2000 I56US
  s1043:c6p-MB2000 Sandia
- s1043:c3p-MB2005 Sandia
  s1043:c6p-MB2000 Sandia



PSD

- s1043:c1p-CP 2.2c
- s1043:c2p-MB2000 I56US
- s1043:c3p-MB2005 Sandia
- s1043:c6p-MB2000 Sandia
- AcousticLNM

Response Verification



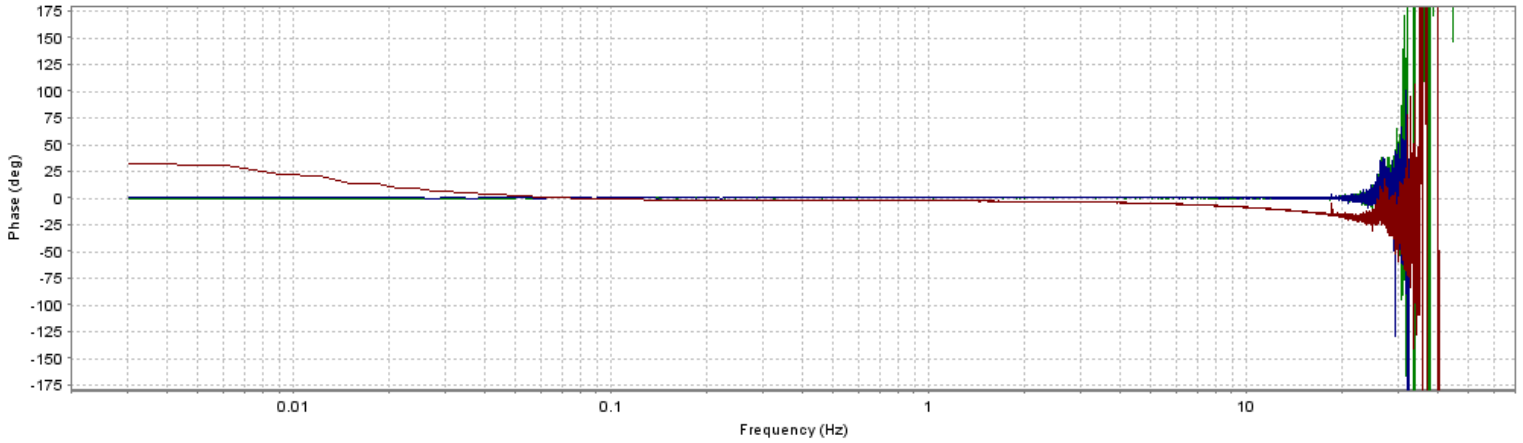
Relative Gain

s1043:c1p-CP 2.2c
s1043:c6p-MB2000 Sandia
s1043:c2p-MB2000 I56US
s1043:c6p-MB2000 Sandia
s1043:c3p-MB2005 Sandia
s1043:c6p-MB2000 Sandia

CP:~1 dB at 0.04 Hz and 0.4 dB at 10 Hz

MBI56:~0.007 dB at 0.04 Hz and 0.14 dB at 10 Hz

MB2005:~0.007 dB at 0.04 Hz and 0.007 dB at 10 Hz



Relative Phase

s1043:c1p-CP 2.2c
s1043:c6p-MB2000 Sandia
s1043:c2p-MB2000 I56US
s1043:c6p-MB2000 Sandia
s1043:c3p-MB2005 Sandia
s1043:c6p-MB2000 Sandia

CP: 10 deg at 0.02 Hz and -9 dB at 10 Hz

MBI56/MB2005: 0.3 deg at 0.02 Hz and 0.25 deg at 10 Hz

Two Tone Linearity

Sandia MB2000 SN1380

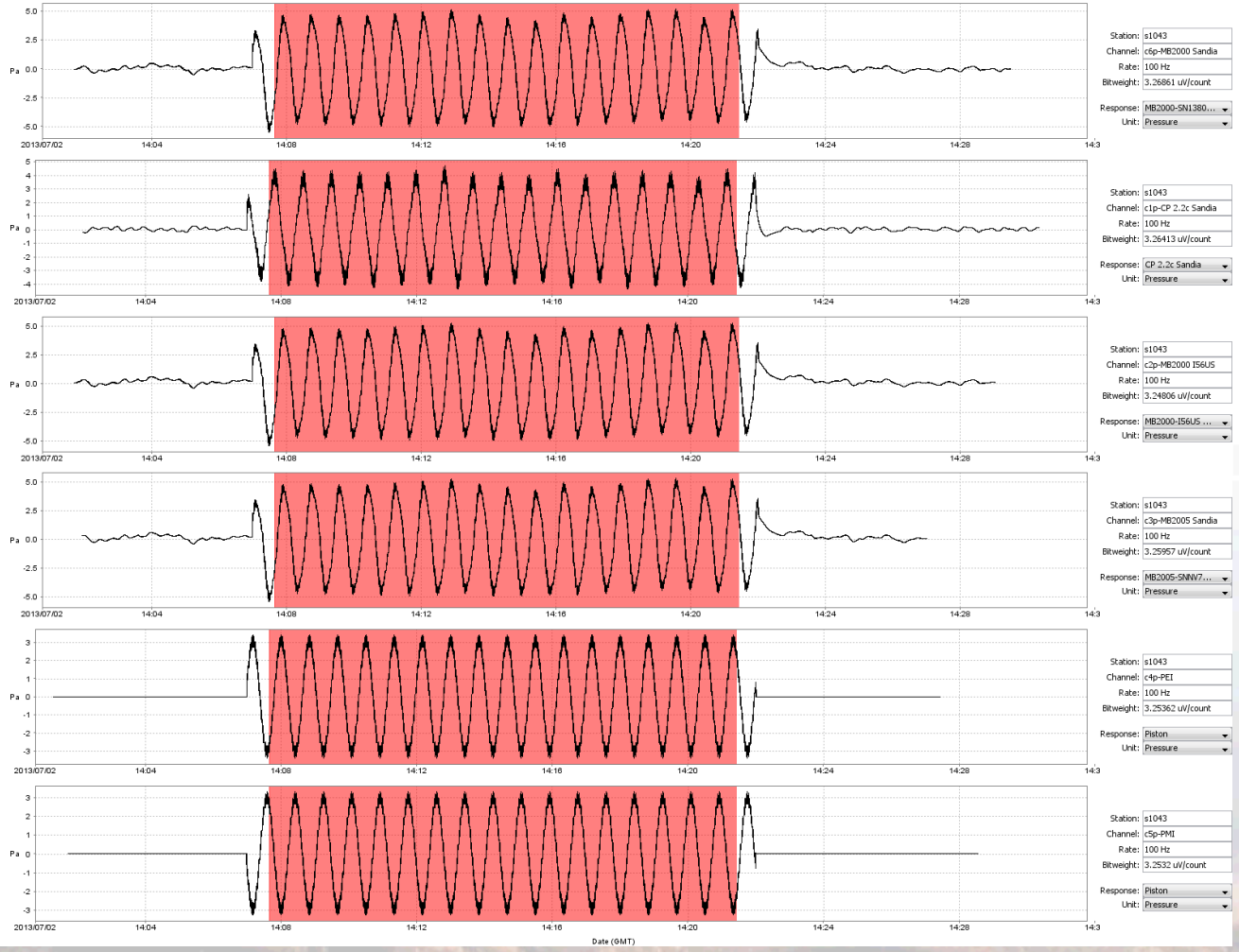
CP 2.2c SN 051948

I56US MB2000 SN1258

Sandia MB2005 NV7009

Piston Electronics Input

Piston Mechanical Input



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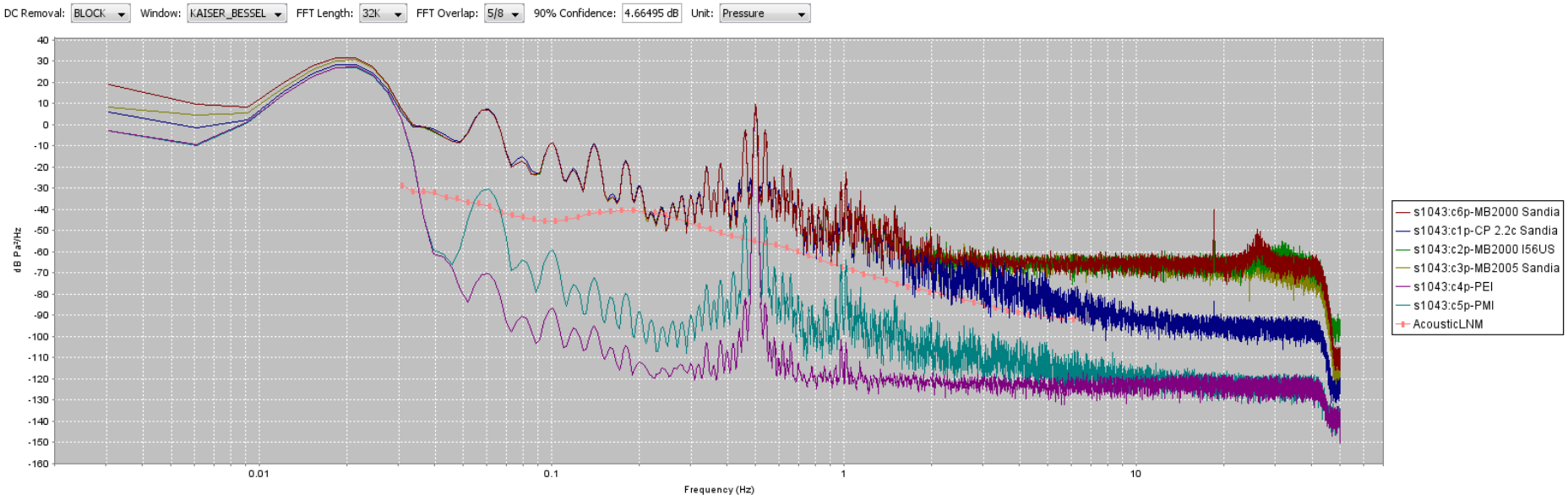
Two Tone Linearity



PSD - Two Tone Input Signal

Issues:

Significant distortion of input signal

Sample rate too high to properly resolve o.02 Hz signal

Two Tone Linearity

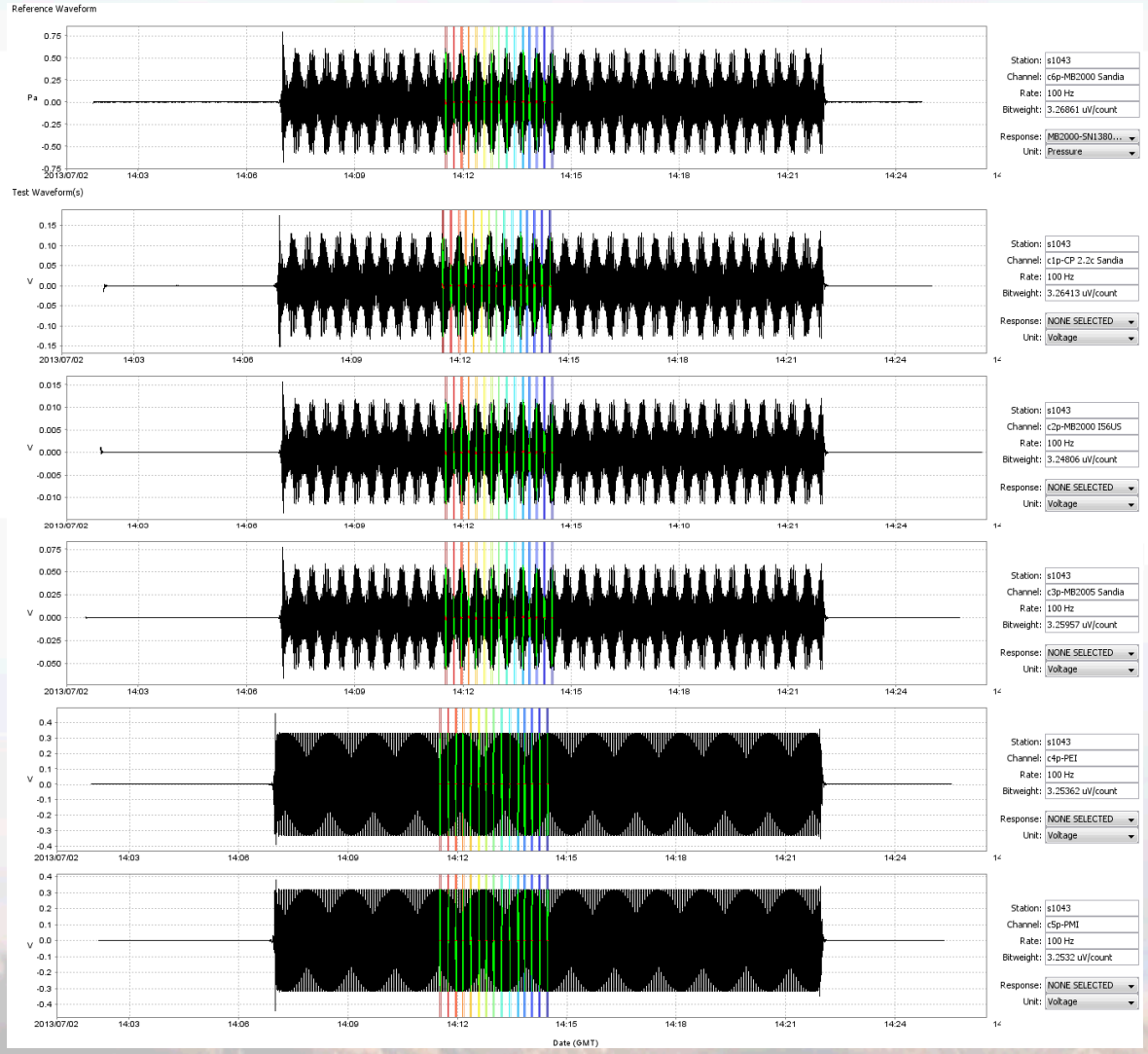
Bandpass filtered between 0.3 and 0.8 Hz.

Observations:

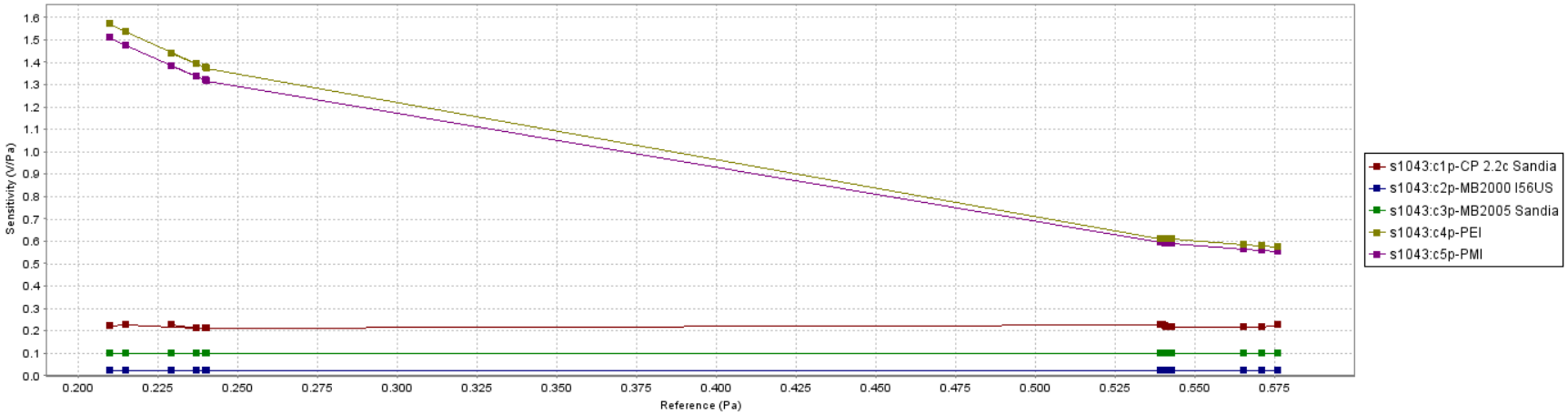
Amplitude modulation on all sensors

Amplitude Modulation Index ~0.4 for all sensors.

	Modulation Index	Standard Deviation
Observed Reference Pressure	0.414263	0.024386
s1043:c1p-CP 2.2c	0.412605	0.023653
s1043:c2p-MB2000 I56US	0.414066	0.023536
s1043:c3p-MB2005 Sandia	0.413899	0.023431



Two Tone Linearity



Sensor ID	Sensitivity (mV/Pa)	Standard Deviation (mV/Pa)
s1043:c1p-CP 2.2c Sandia	219.01	5.427
s1043:c2p-MB2000 I56US	19.77	0.065872
s1043:c3p-MB2005 Sandia	96.99	0.369641