Pressure signal processing

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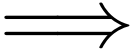
Going from raw data to clean spectra

Raw measurements from pinhole (PH) mic.  Cleaned pressure spectra.

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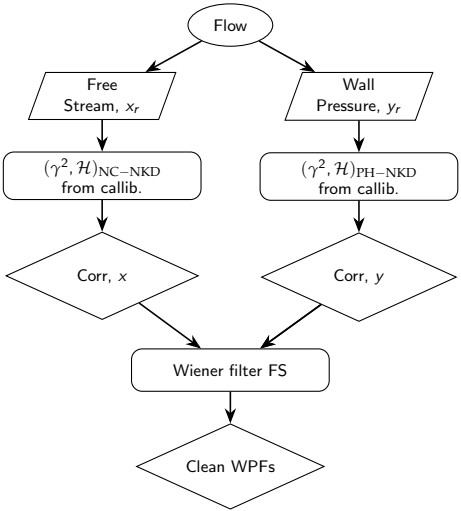
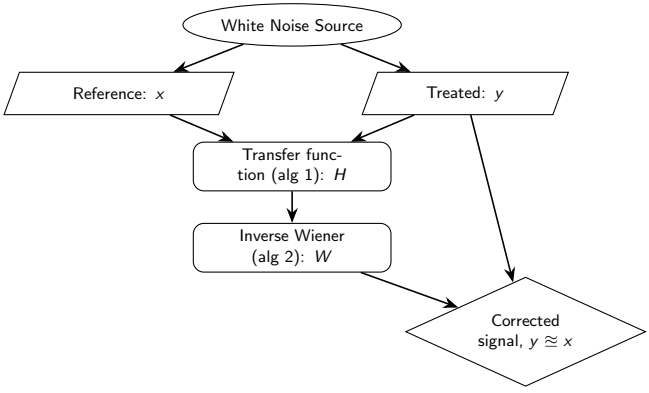
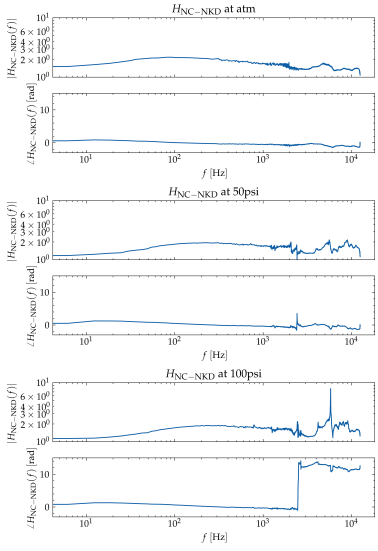


Figure: Complete pressure processing pipeline for measurement of the WPFs through a pinhole microphone. similar to Tsuji *et al.* (2007)

Microphone calibration: Nose Cone (NC)





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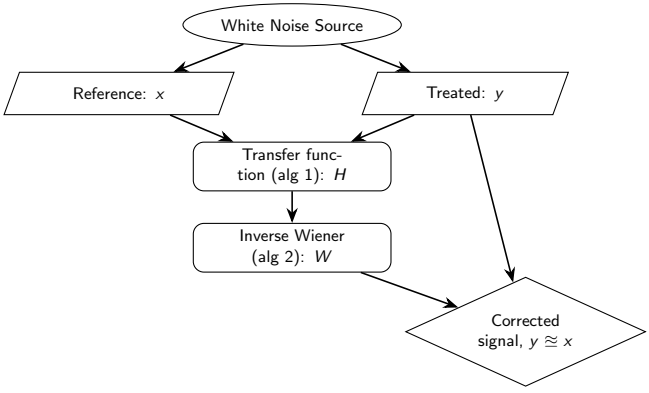
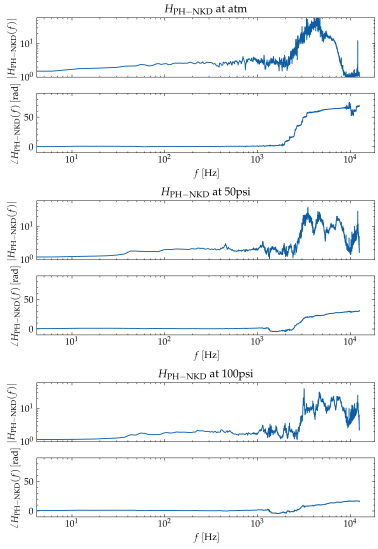
Microphone calibration: Pinhole (PH)





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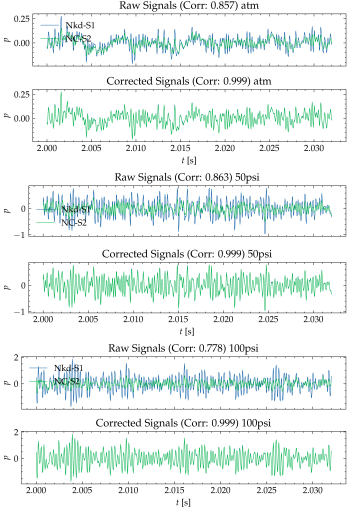
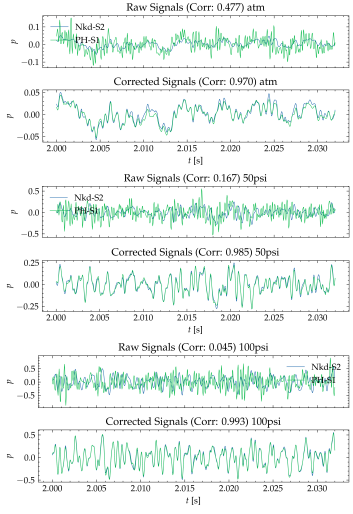
Corrected signals

Corrected NC trace



Corrected PH trace



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Calibration algos

Algorithm 1 H Transfer-Function Estimation

Require: $x[n]$ (ref), $y[n]$ (treated), f_s, Welch $(N_{\text{seg}}, N_{\text{ov}}, w)$
Ensure: $f[k]$, $H[k]$, $\gamma^2[k]$
1: Compute $S_{xx}[k], S_{yy}[k]$ (Welch)
2: Compute $S_{xy}[k]$ (same settings)
3: $H[k] \leftarrow S_{xy}[k] / S_{xx}[k]$
4: $\gamma^2[k] \leftarrow |S_{xy}[k]|^2 / (S_{xx}[k] S_{yy}[k])$
5: **return** $(f[k], H[k], \gamma^2[k])$

Algorithm 2 Coherence-weighted Wiener inverse

Require: y_r, f_s, grid f, $H(f)$, $\gamma^2(f)$
Ensure: y
1: $y_r \leftarrow y_r - \text{mean}(y_r)$
2: $\hat{y}_r \leftarrow \mathcal{F}(y_r, N_{\text{fft}})$
3: $m \leftarrow |H|, \quad \phi \leftarrow \text{unwrap}(\angle H)$
4: Interp m, ϕ, γ^2 to FFT grid $\Rightarrow m_i, \phi_i, \gamma_i^2$
5: $H_i \leftarrow m_i \, e^{j\phi_i}$; $\quad \varepsilon \leftarrow$ machine epsilon
6: $H_{inv} \leftarrow \gamma_i^2 \, H_i^* / \max(m_i^2, \varepsilon)$
7: $H_{inv}[0] \leftarrow 0 \quad$ (& Nyquist if present)
8: $y \leftarrow \Re\{\mathcal{F}^{-1}(\hat{y}_r \cdot H_{inv})[0{:}N]\}$
9: **return** y

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References

Tsuji, Y., Fransson, J. H. M., Alfredsson, P. H. & Johansson, A. V. 2007 Pressure statistics and their scaling in high-Reynolds-number turbulent boundary layers. *J. Fluid Mech.* **585**, 1–40.

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