Improvement of the MGAS Filter Damping Performance

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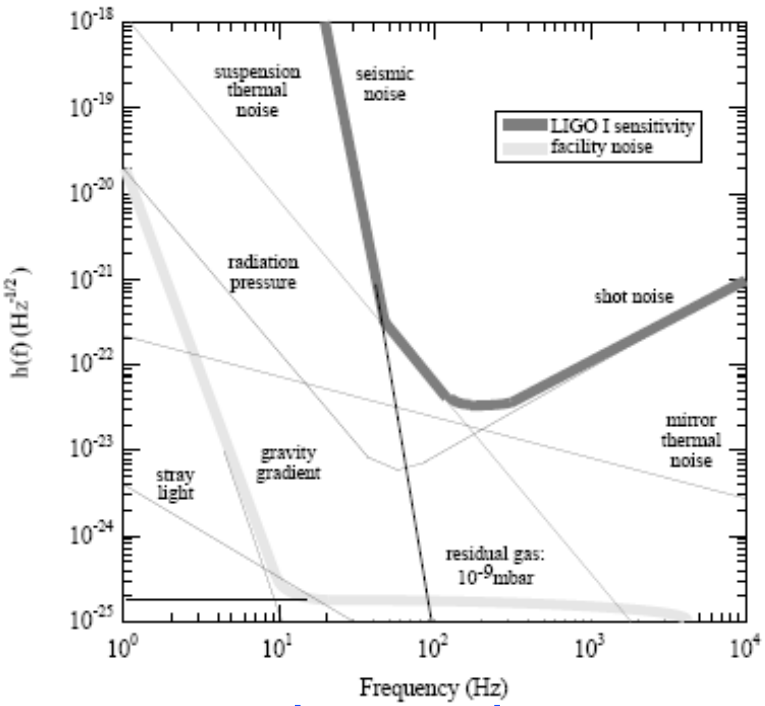
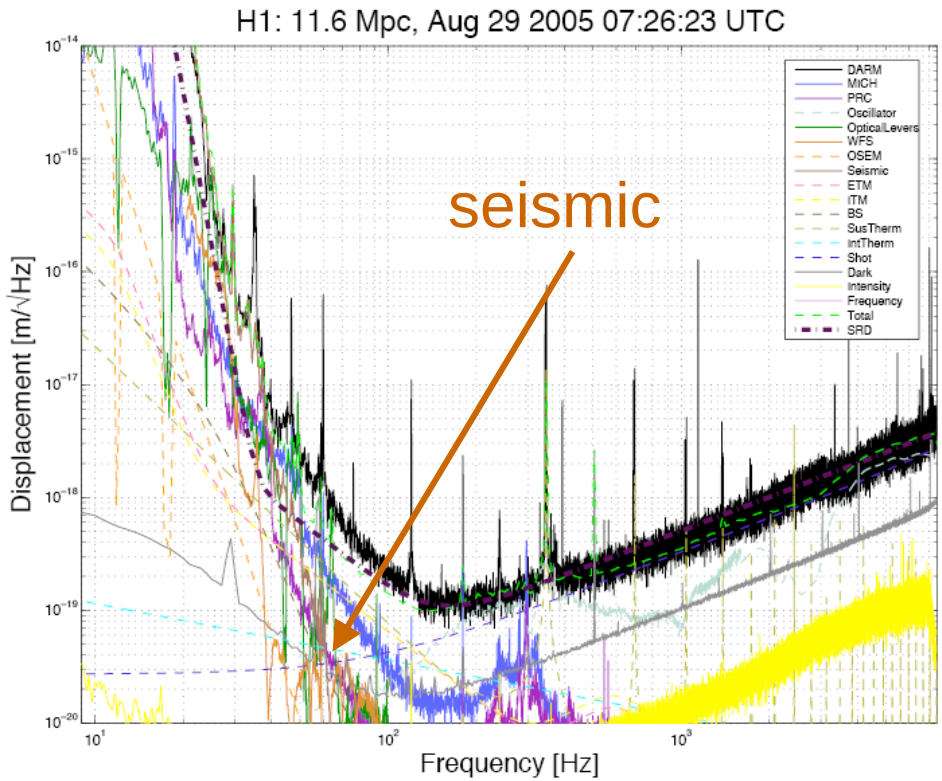
Seismic Noise

It is the disturbance resulting from the displacement of the mirrors due to the ground motion



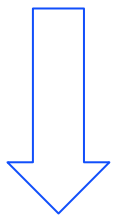
Noise Budget



Vertical Motion of the Mirrors

The vertical and horizontal degrees of freedom are not independent

- mechanical complexity
- non uniformity of the terrestrial gravitational field



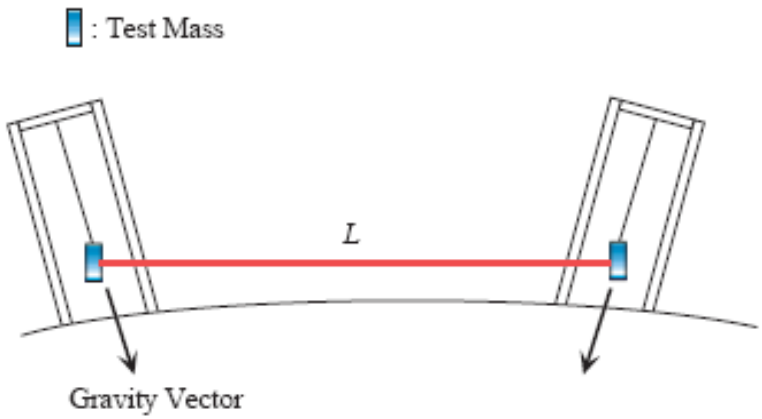
the motion of the mirrors in the vertical direction can change the arm length of the interferometer

Vertical Attenuation

- ground motion ~ 10^{-6} m
- expected GW signal ~ 10^{-18} m
- required attenuation factor ~ 10^{-12}

⇨ vertical to horizontal couplings must not be limiting factors to the horizontal sensibility

Gravitational Coupling



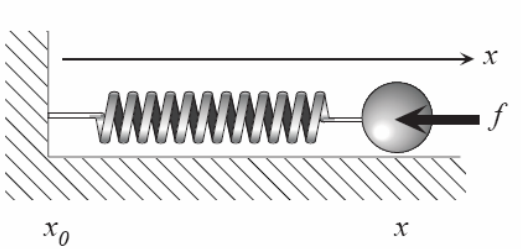
$$\Delta x = \alpha \Delta z$$

$\alpha = L/r_0$ ~< 10e-3

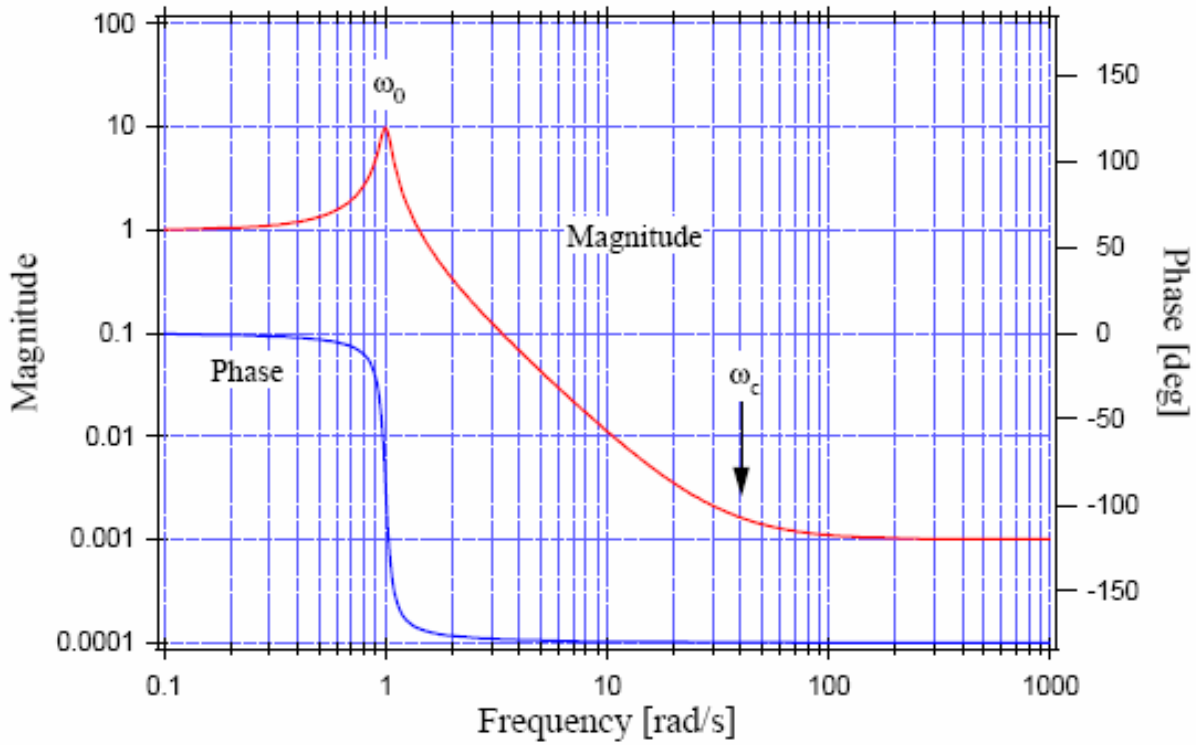
negligible respect to other couplings ~ 1%

Passive Mechanical Filters

Massive spring

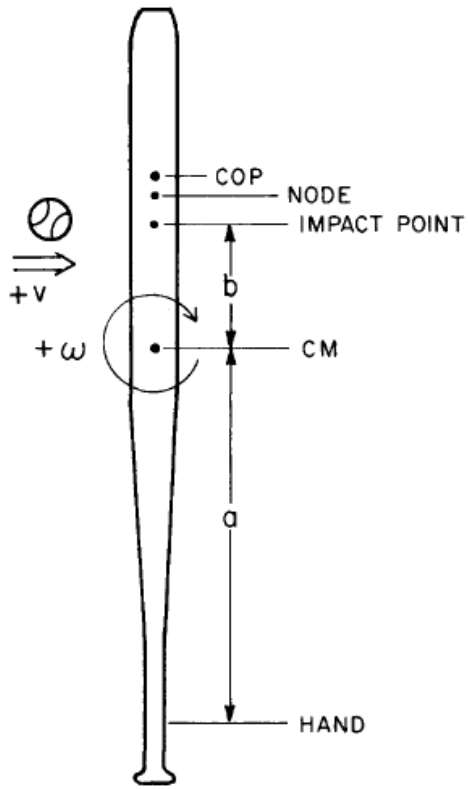


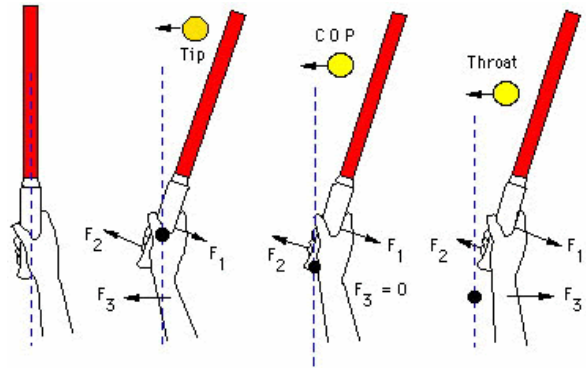
$$H_x \equiv \frac{\omega_0^2(1+i\phi)+\frac{M}{m}\omega^2}{\omega_0^2(1+i\phi)-\omega^2+i\frac{\gamma}{m}\omega}$$

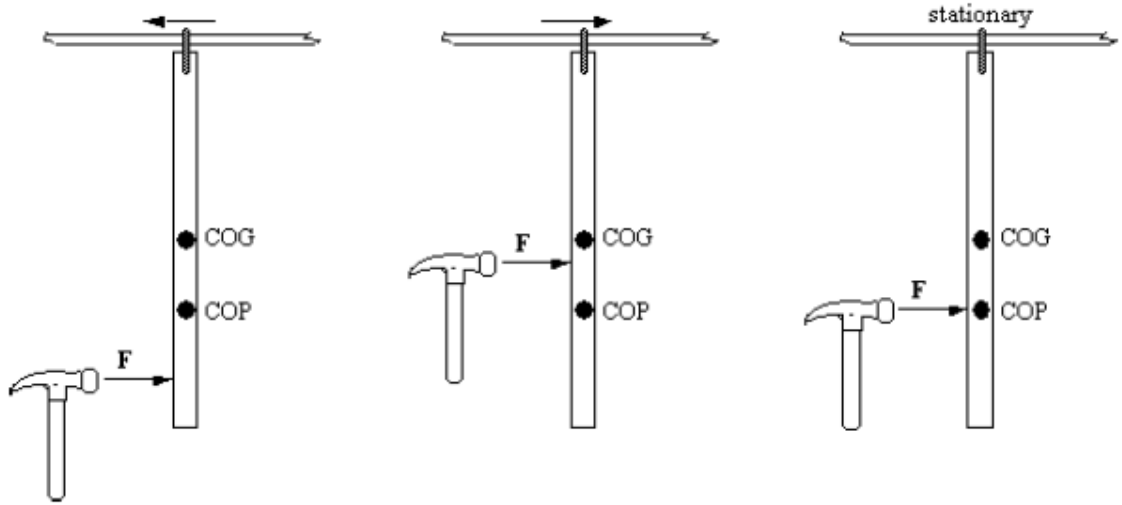


The C.O.P. Effect limitation on attenuation performance

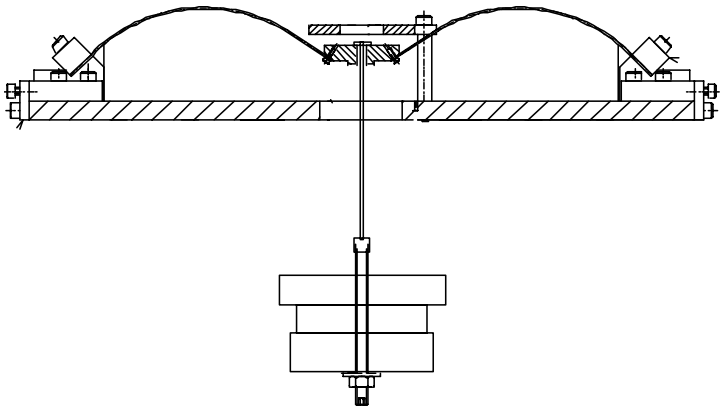
Center Of Percussion

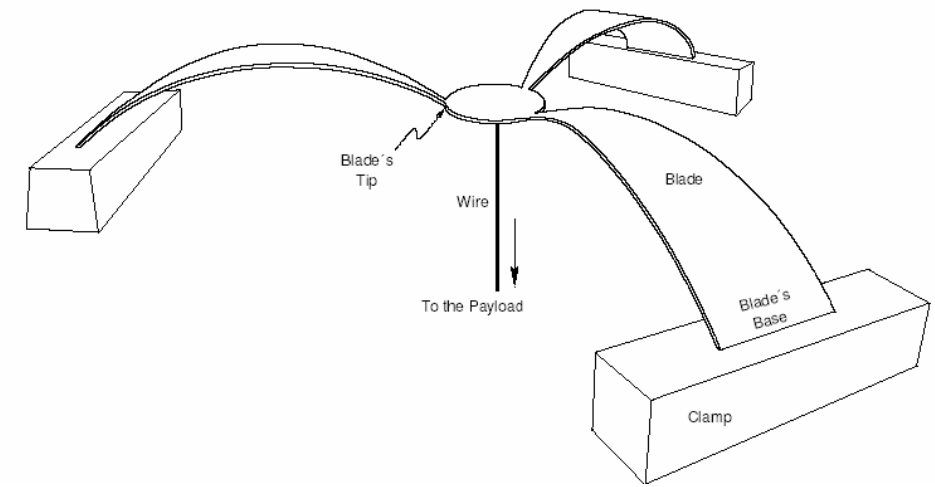




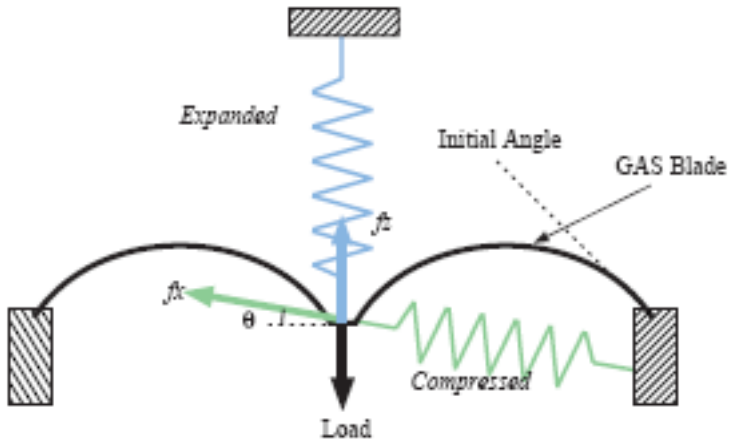


MGAS Filter



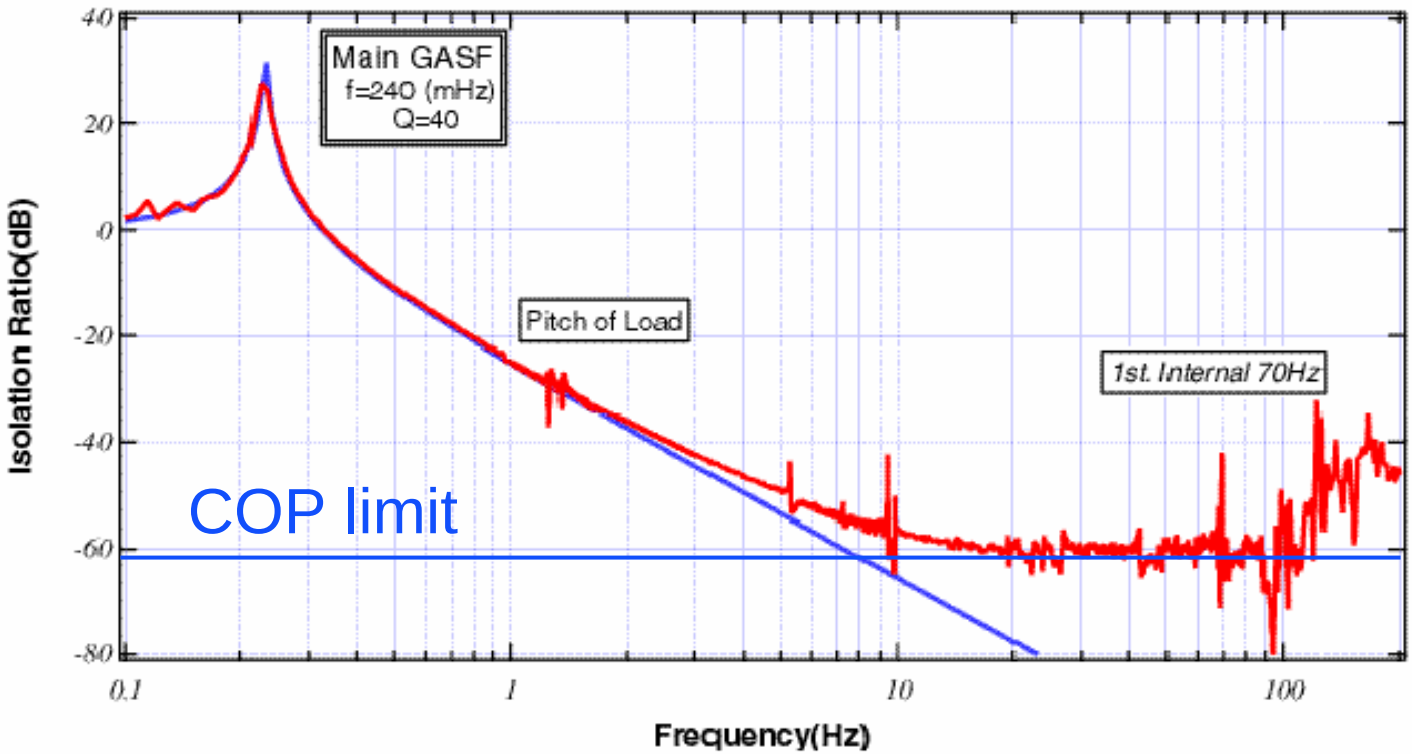


Linear Model for GAS Springs



GAS Filter Limit

Transfer Function

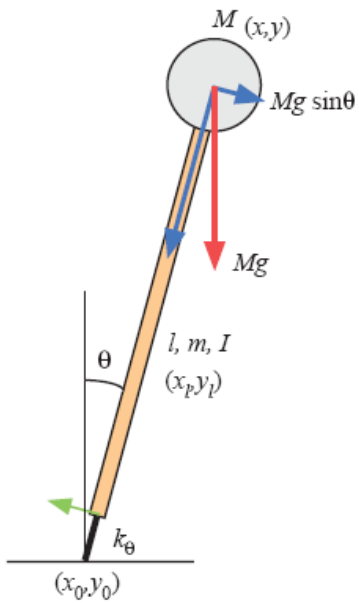


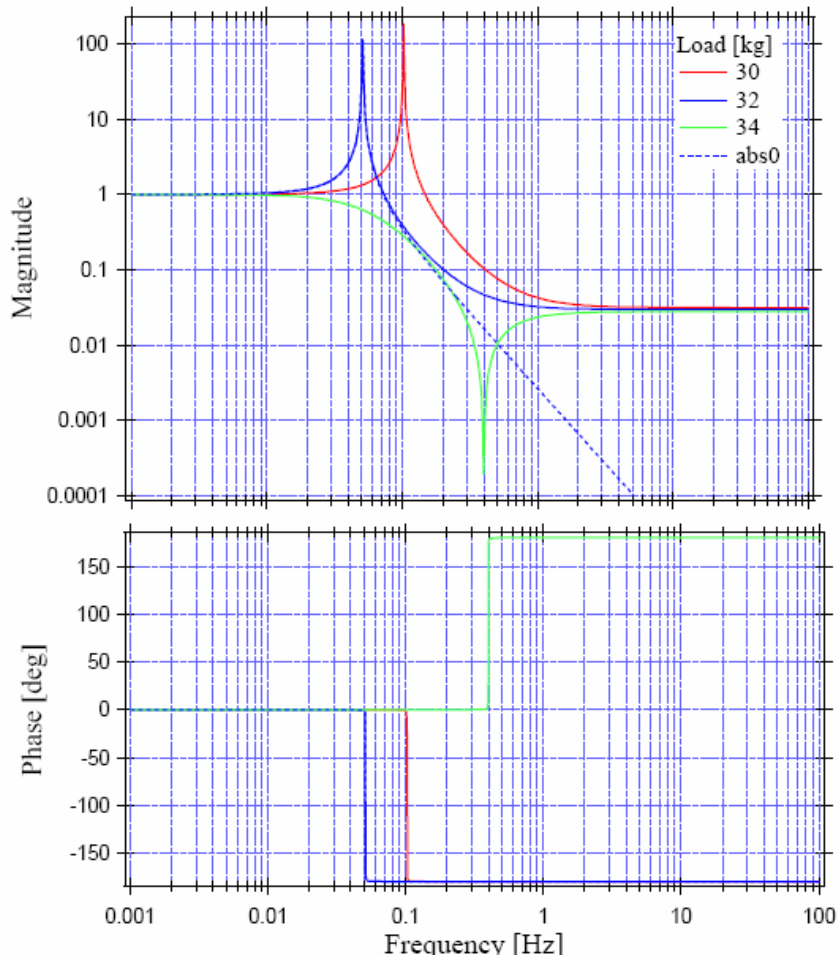
(Kenji Numata)

Inverted Pendulum

Transfer Function

$$H_{\mathrm{IP}}(\omega) = \frac{x}{x_0} = \frac{k_{\mathrm{eff}} + (\frac{m}{4} - \frac{I}{l^2})\omega^2}{k_{\mathrm{eff}} - (M + \frac{m}{4} + \frac{I}{l^2})\omega^2}$$

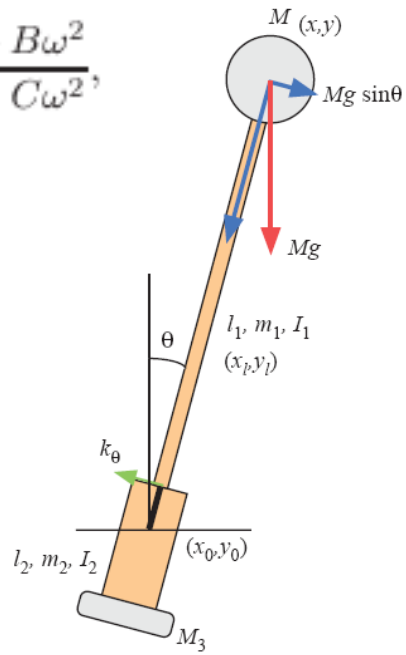


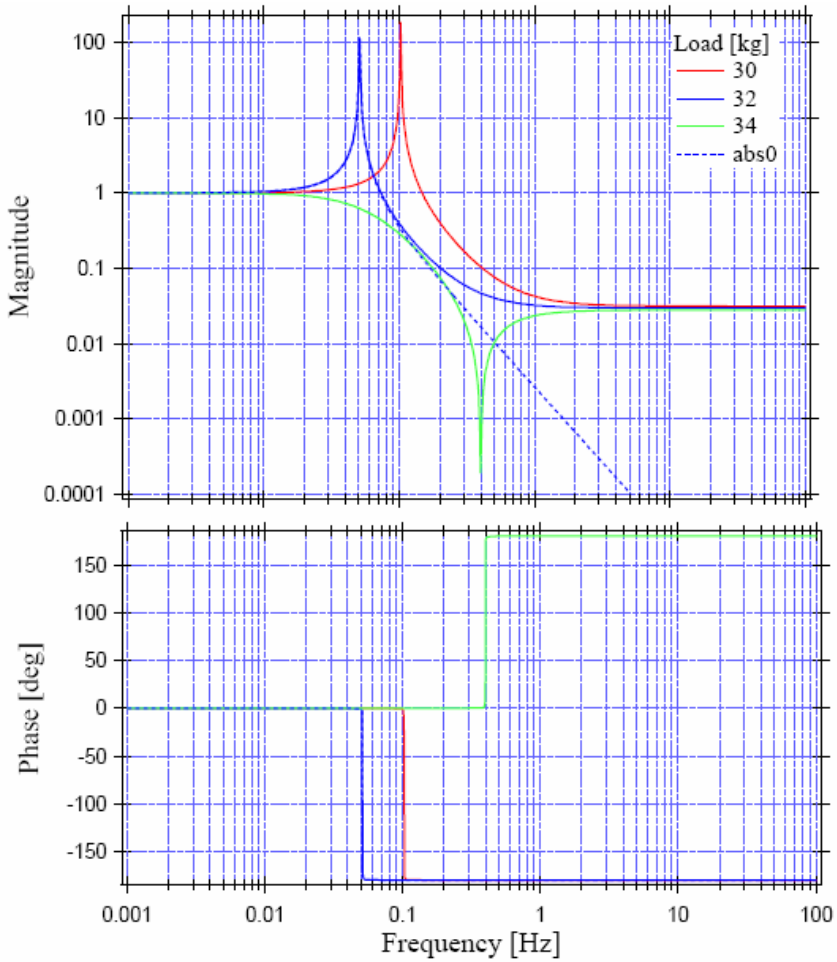


C.O.P. Displacement

Transfer Function for the counterweighted IP

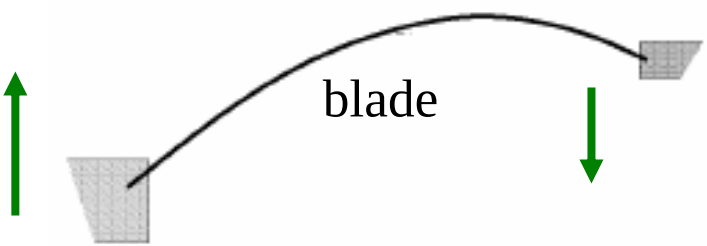
$$H_{IPCW}(\omega) = \frac{A + B\omega^2}{A - C\omega^2},$$



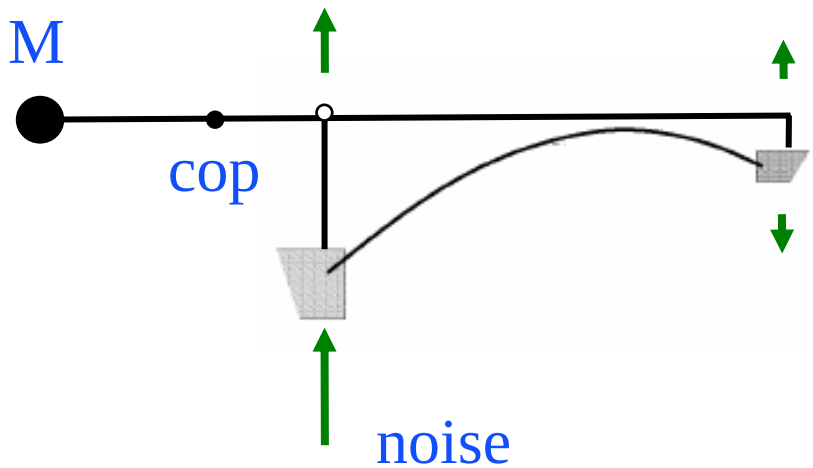


Extending the Idea to the GAS Springs

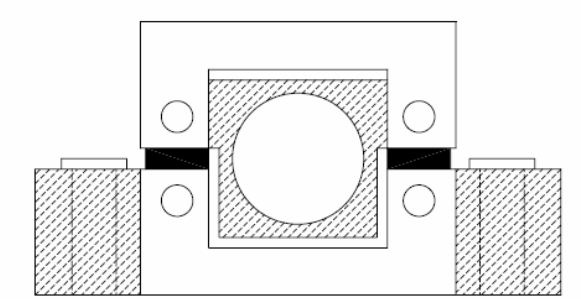
What we had before

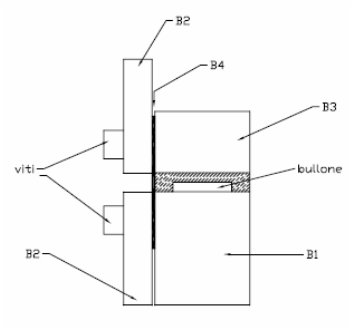


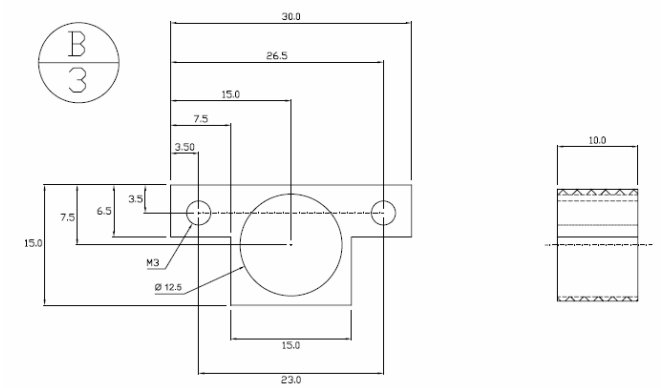
What we wanted to do

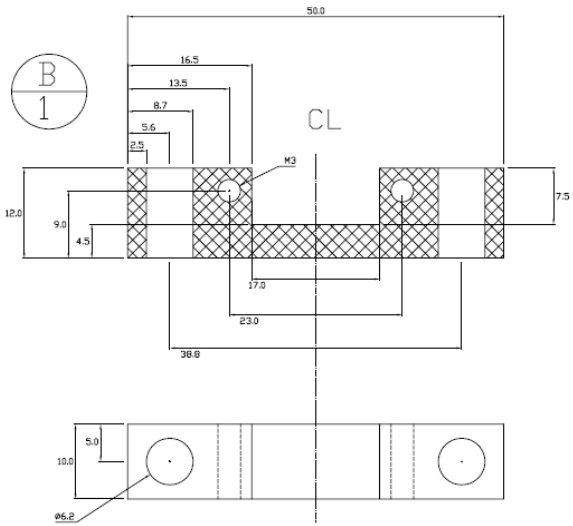


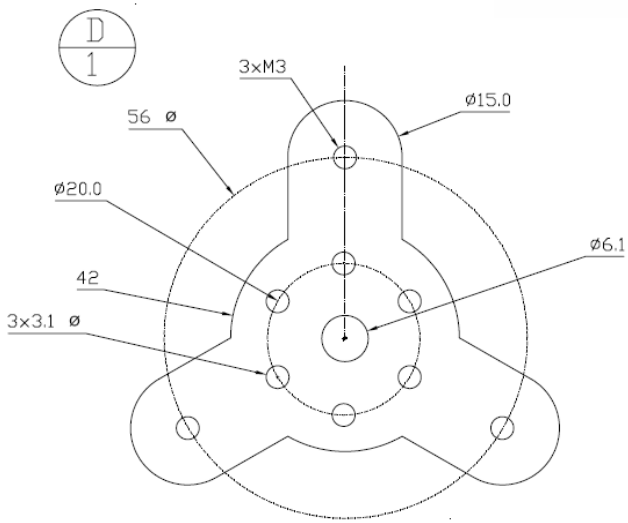
Prototype Design

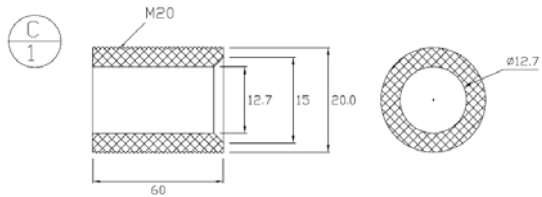




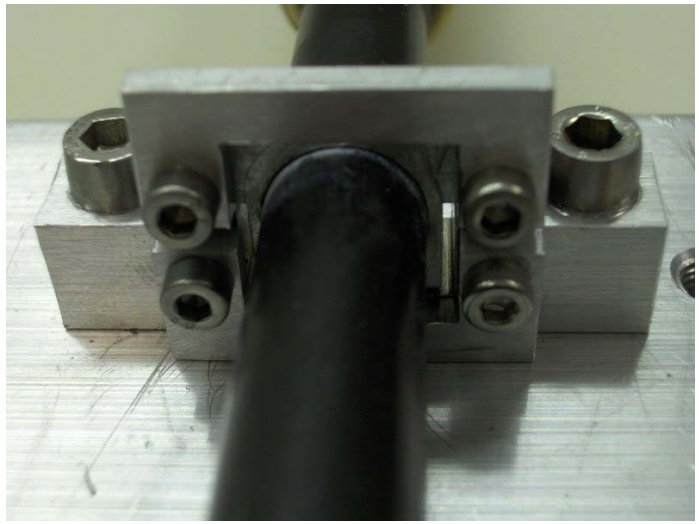


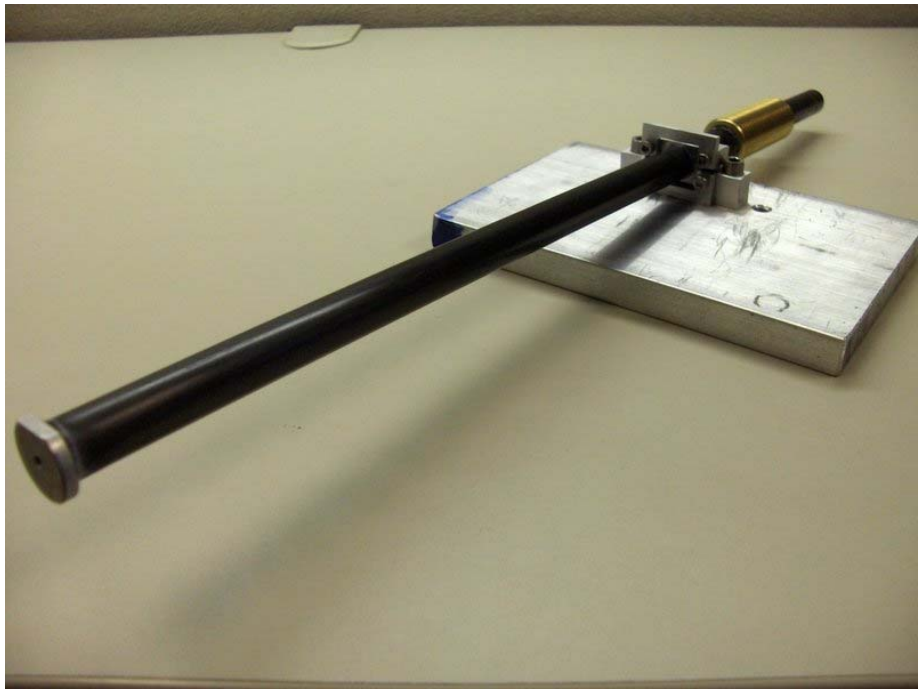




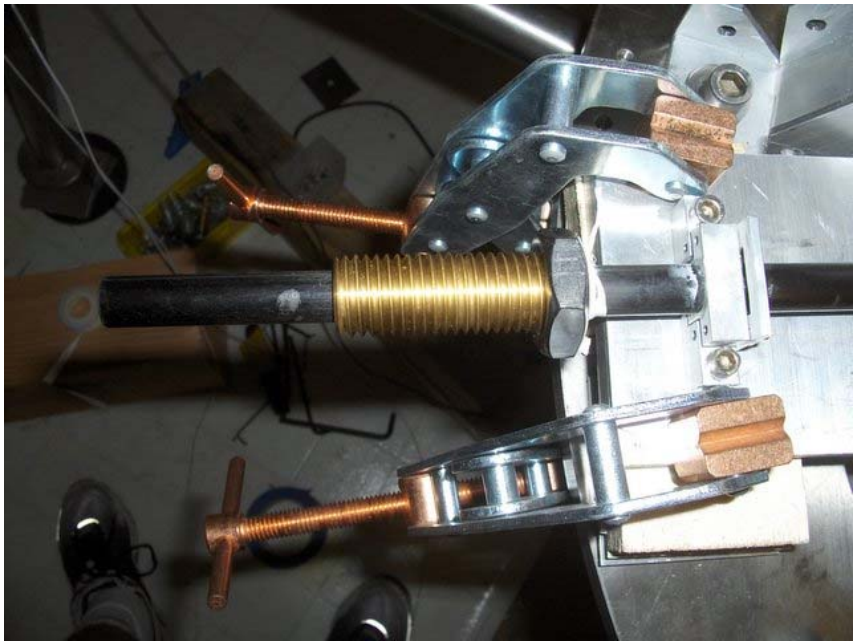


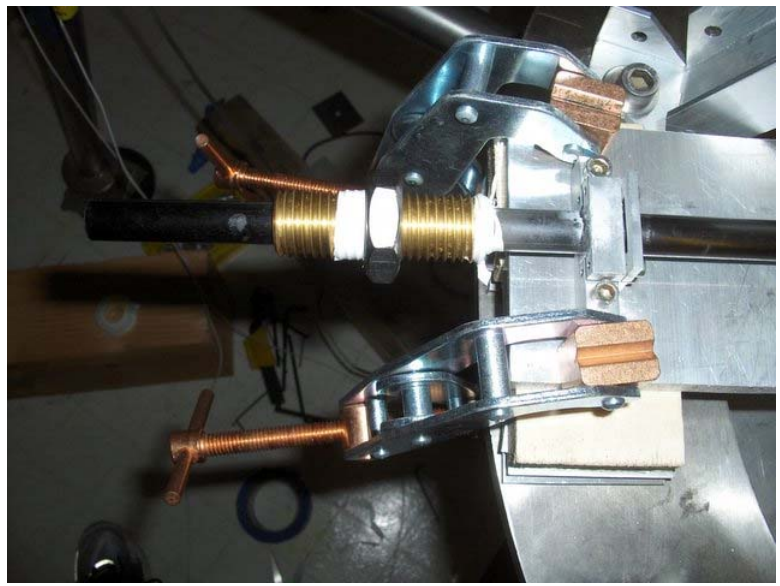
Making it Real



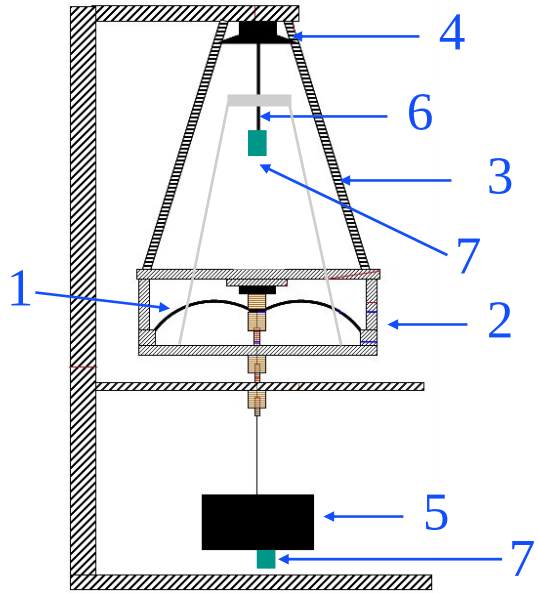


Tuning of the Counterweight

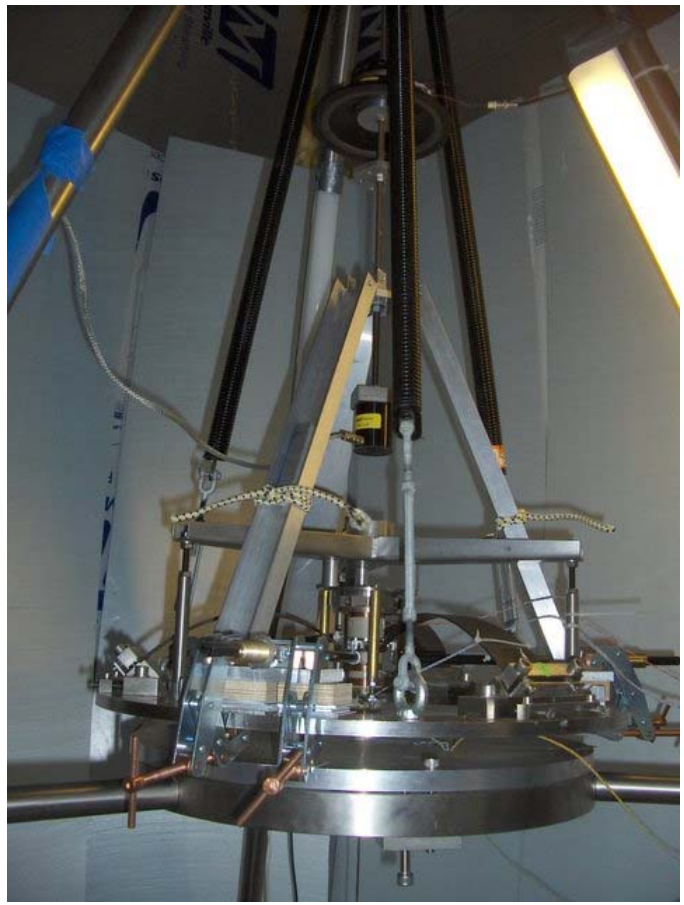


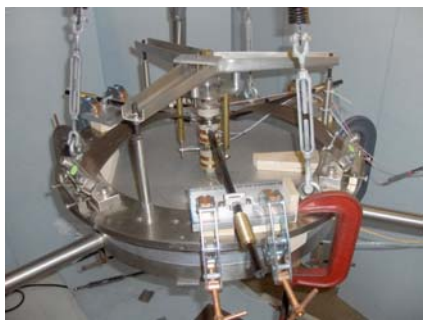


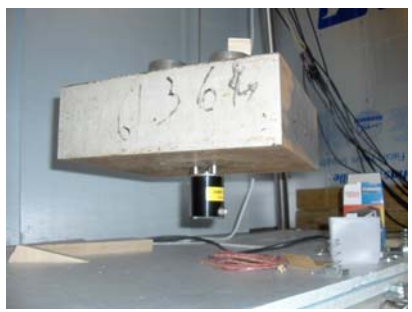
Experiment Setup



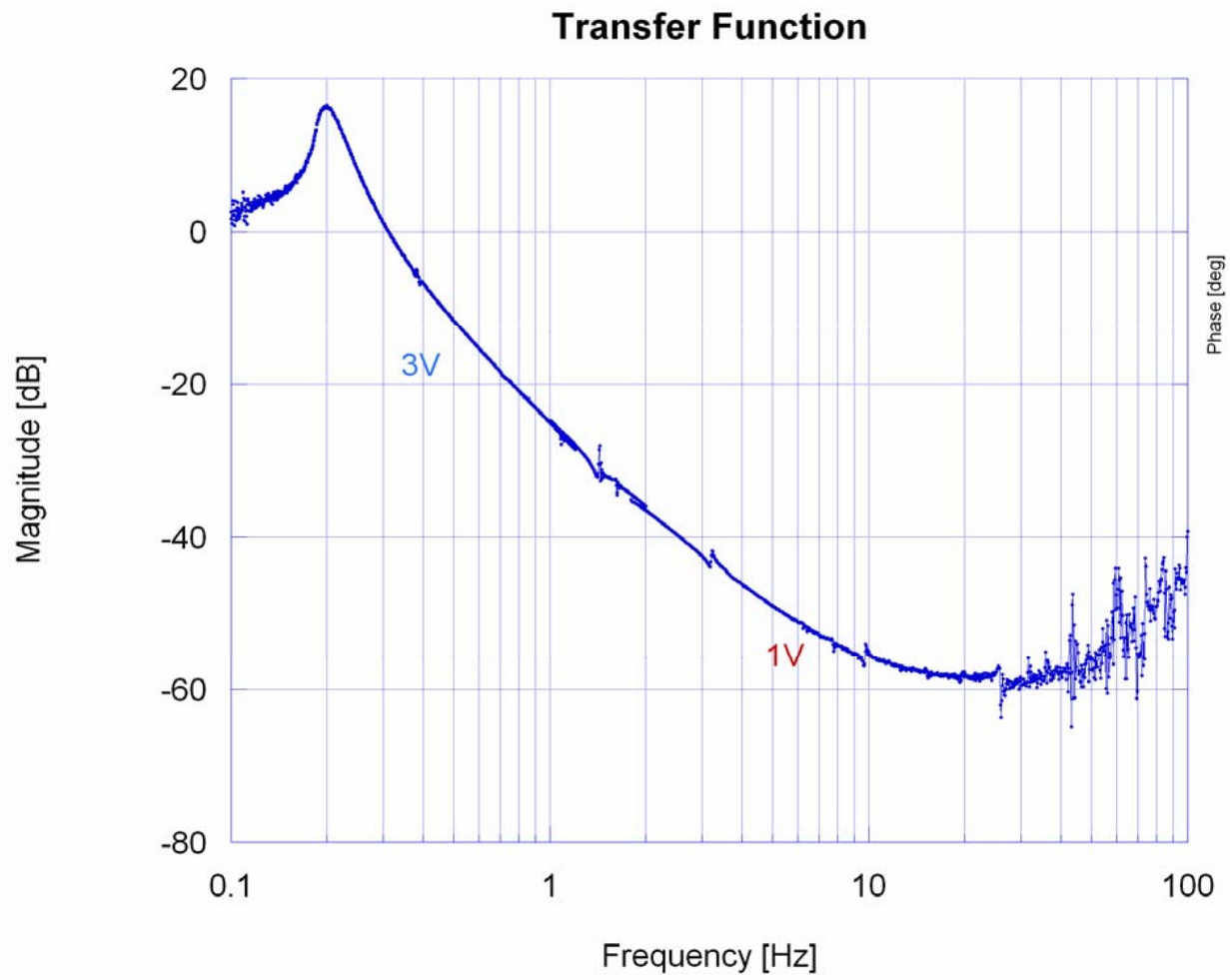
1) GAS blade
2) Filter body
3) Support spring
4) Voice-coil
5) Payload
6) Rigid connector
7) Accelerometer

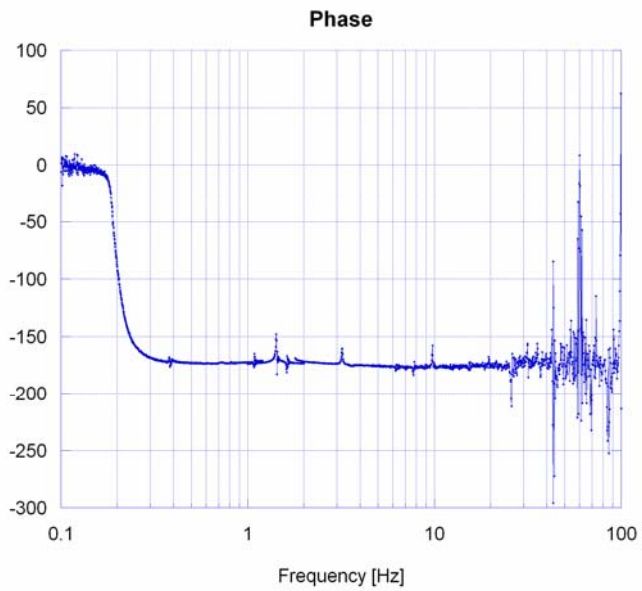




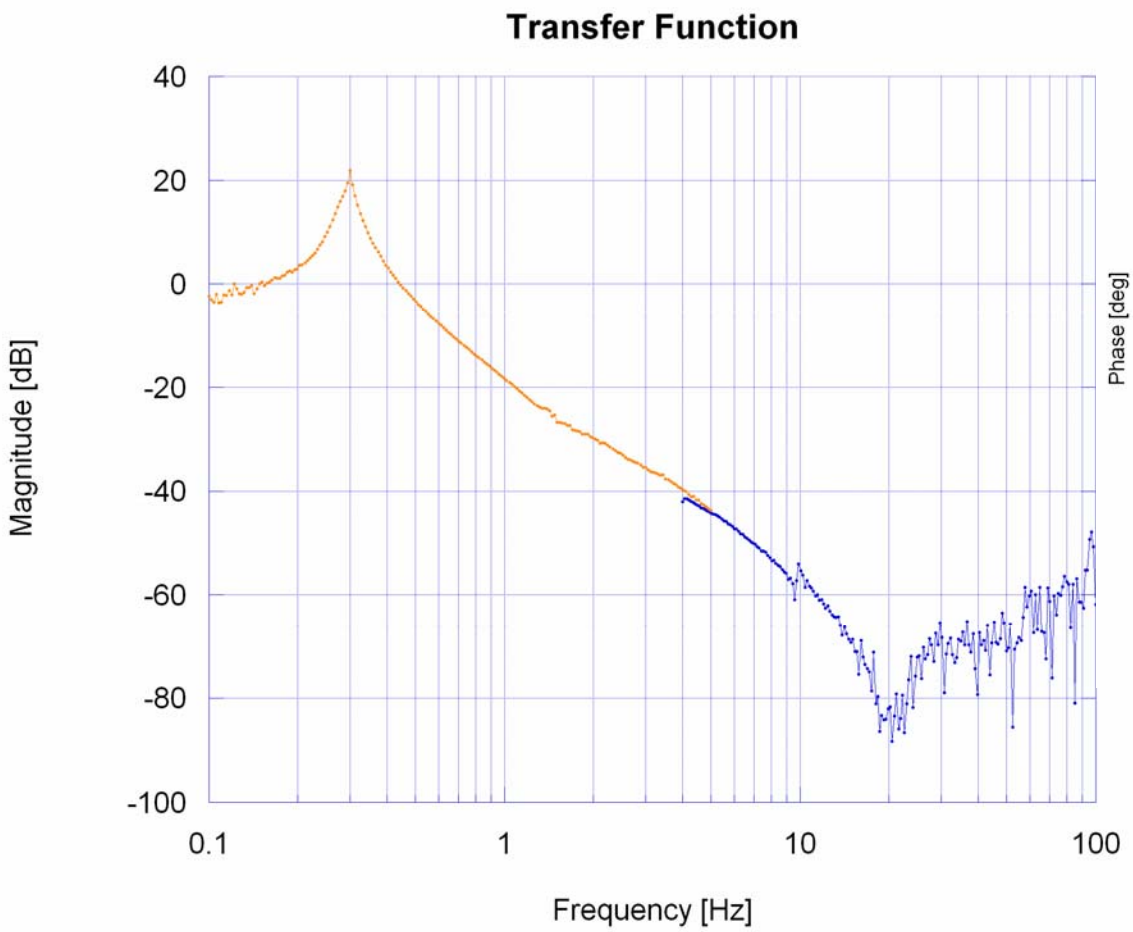


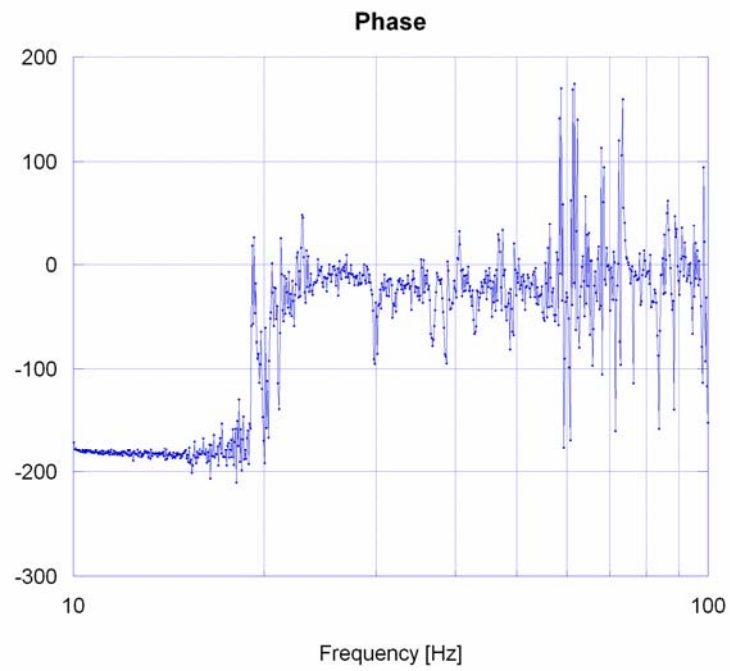
The Initial TF



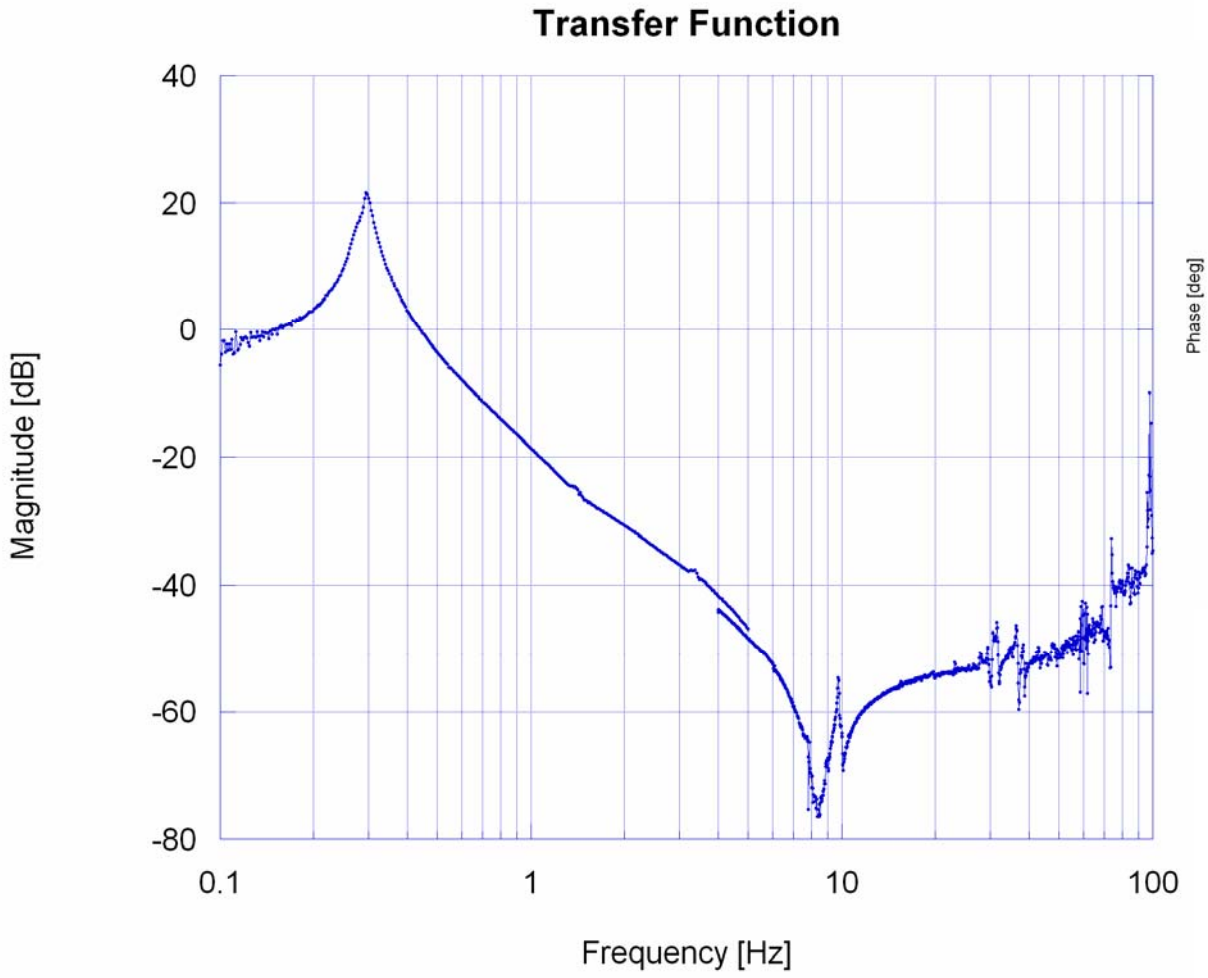


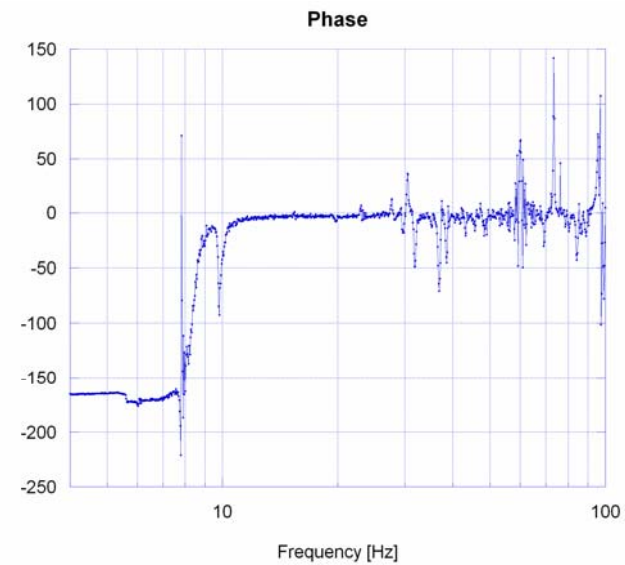
Overcompensation
Three Booms No CWs





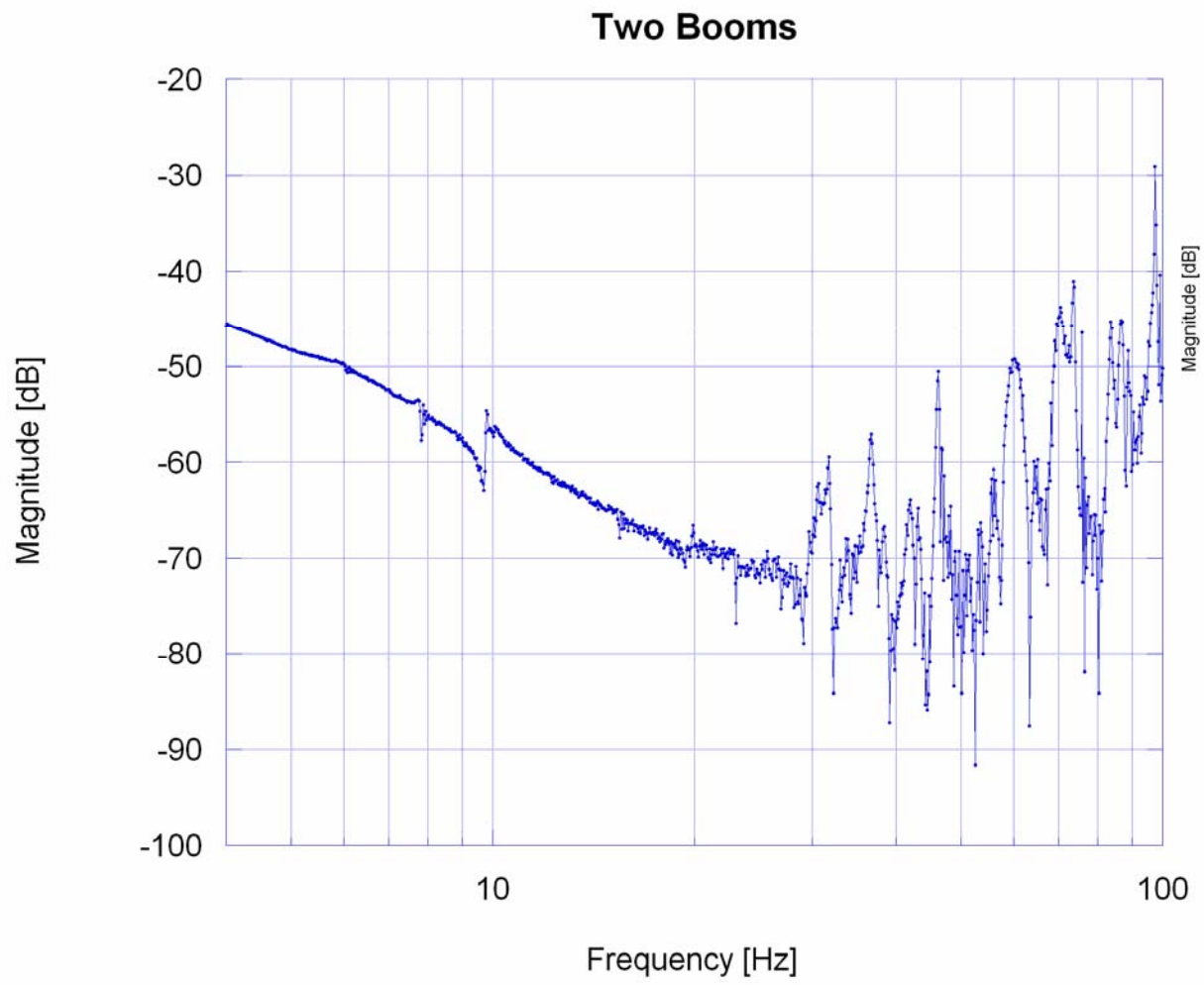
Three Booms + 2x3 CWs

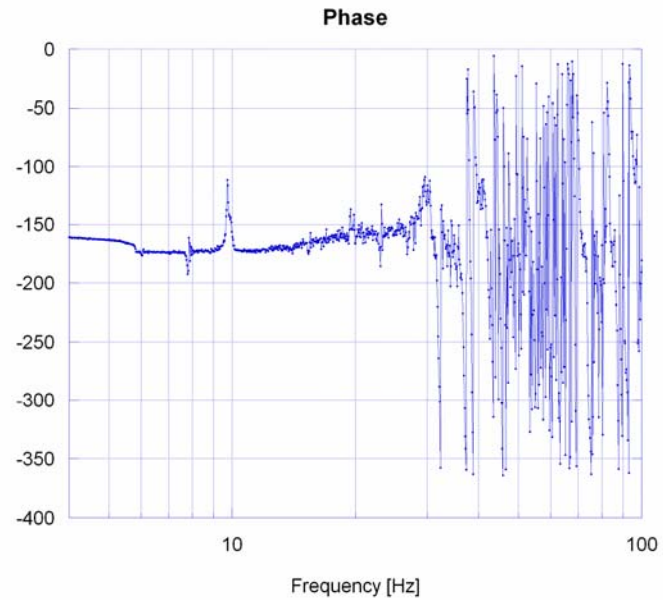




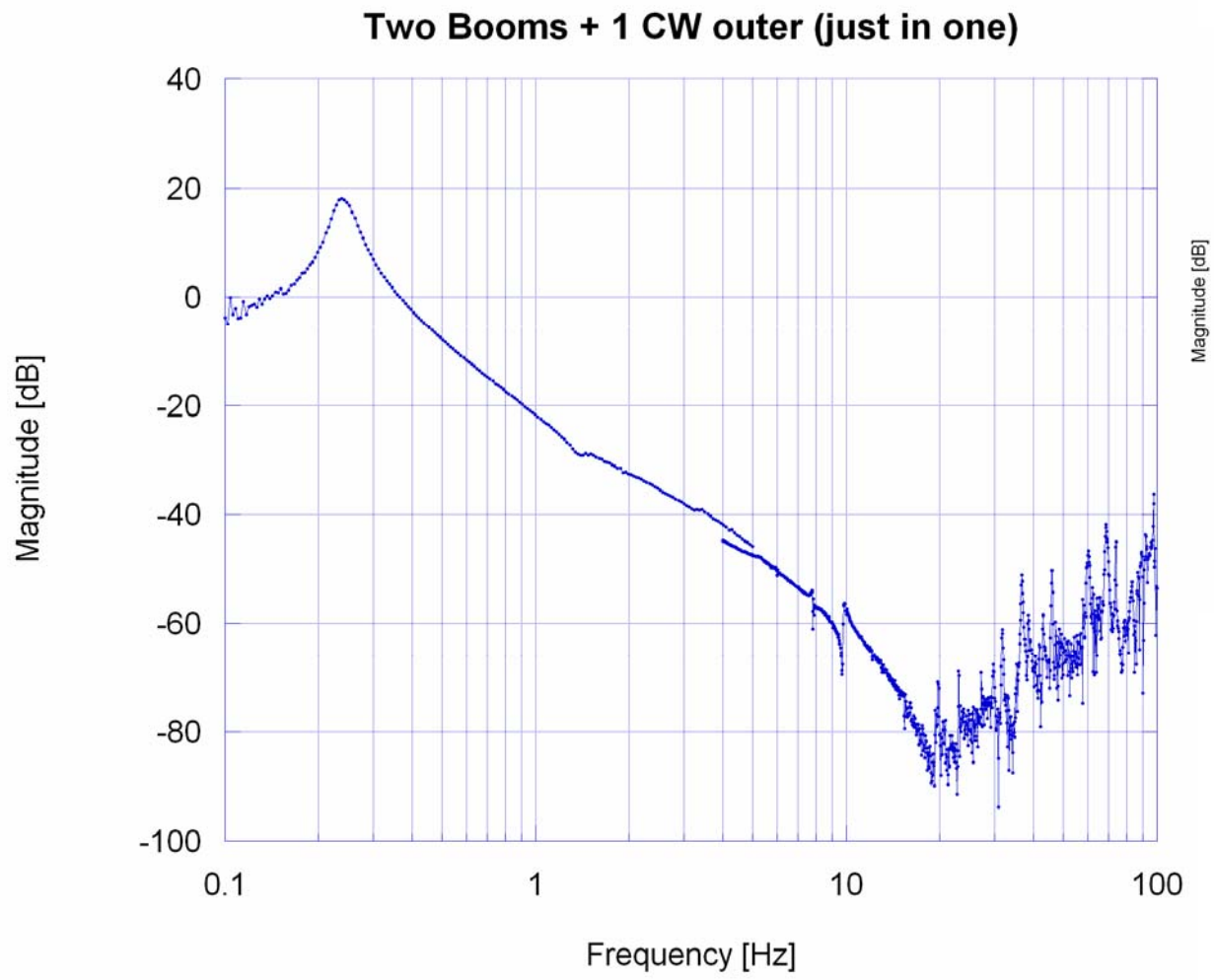
Note the phase advance

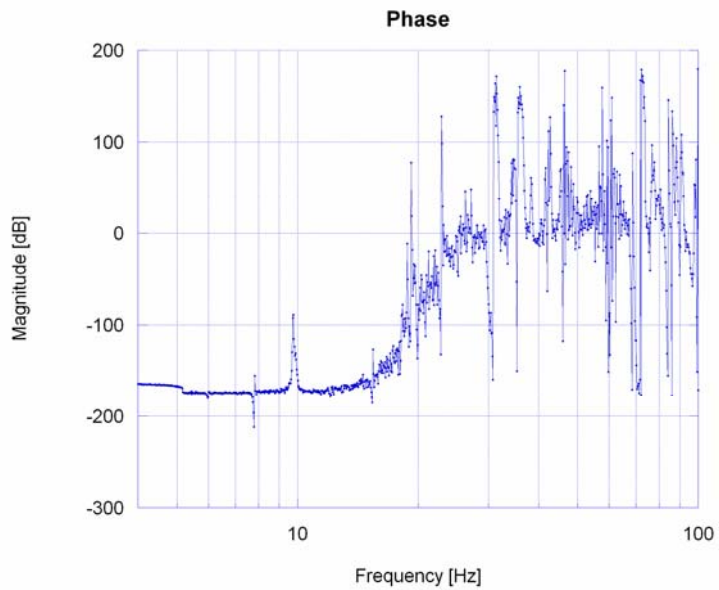
Undercompensation
Two Booms No CWs



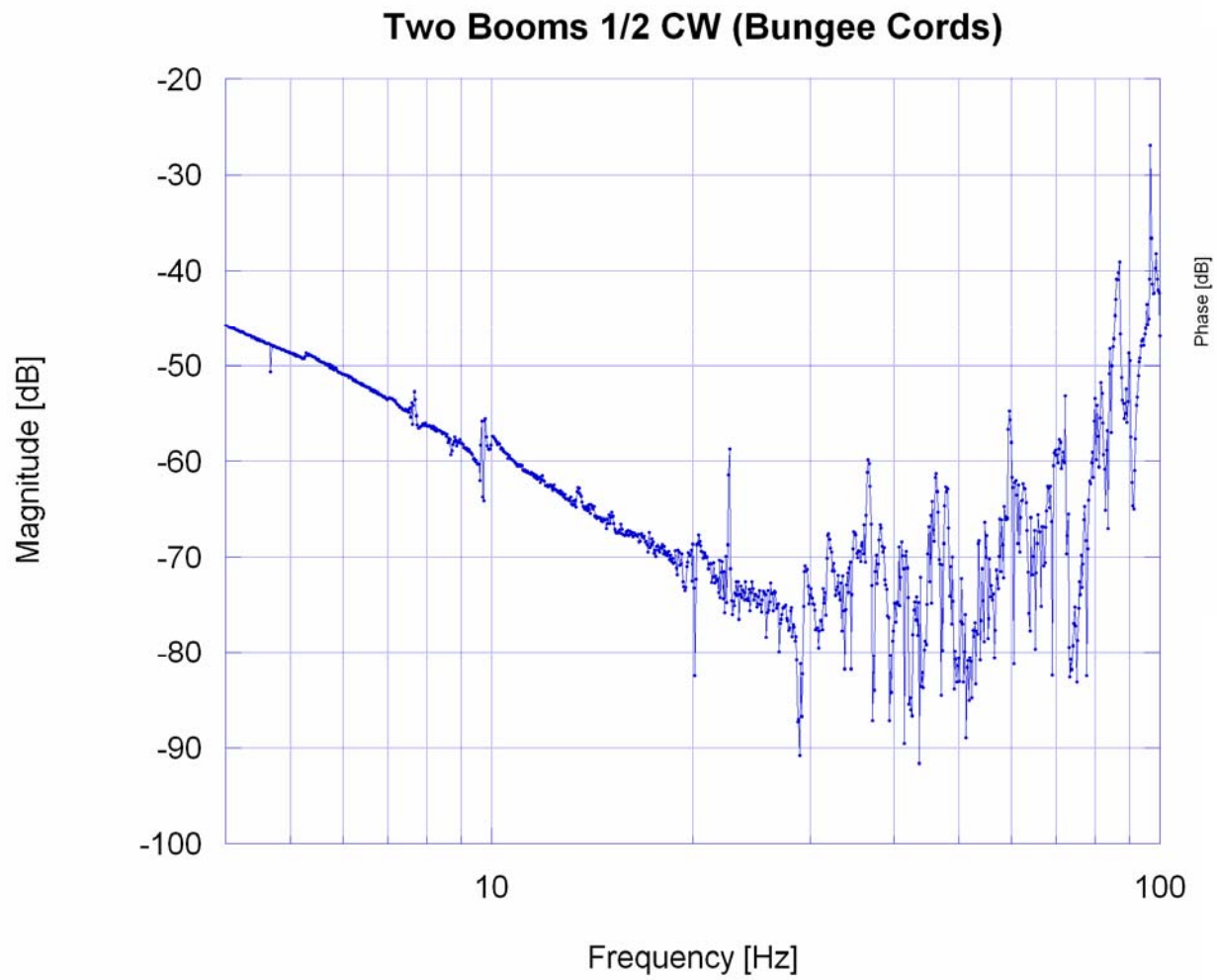


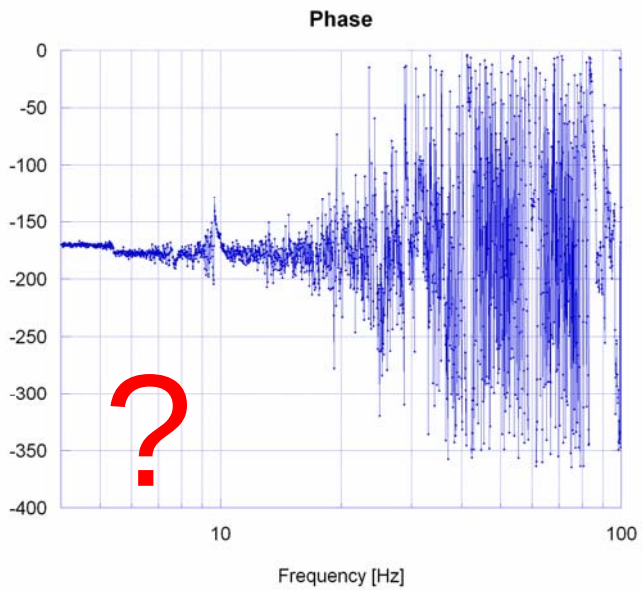
Two Booms + 1 CW



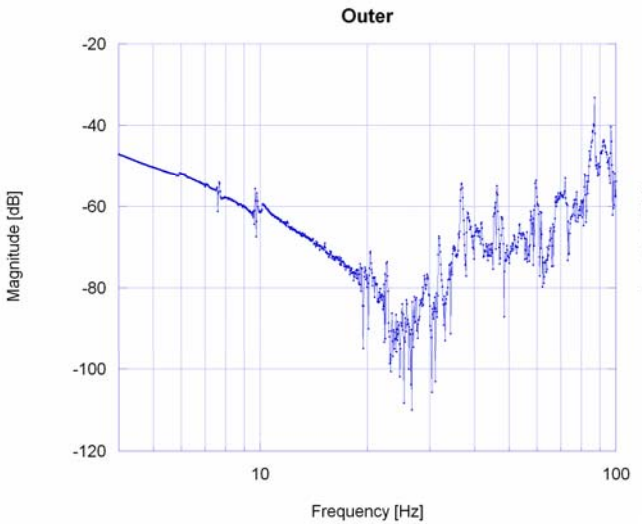


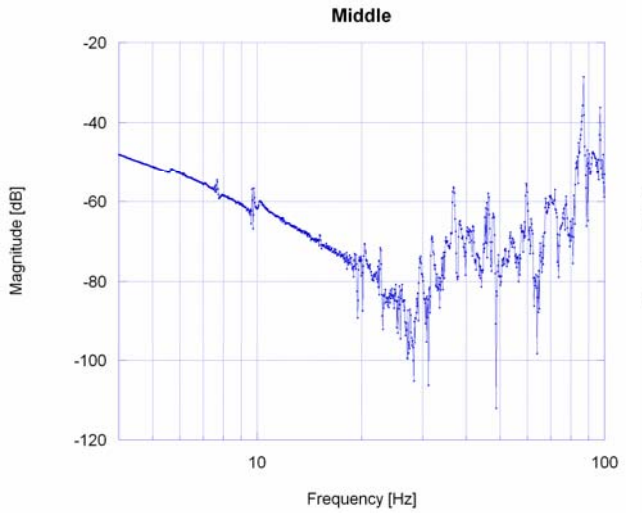
Two Booms + ½ CW

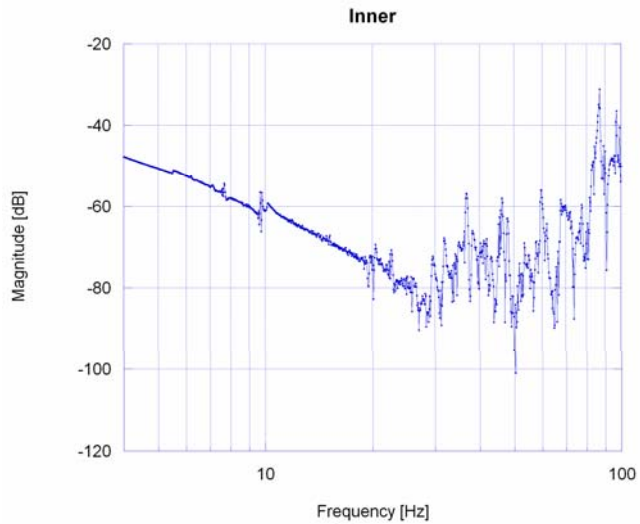


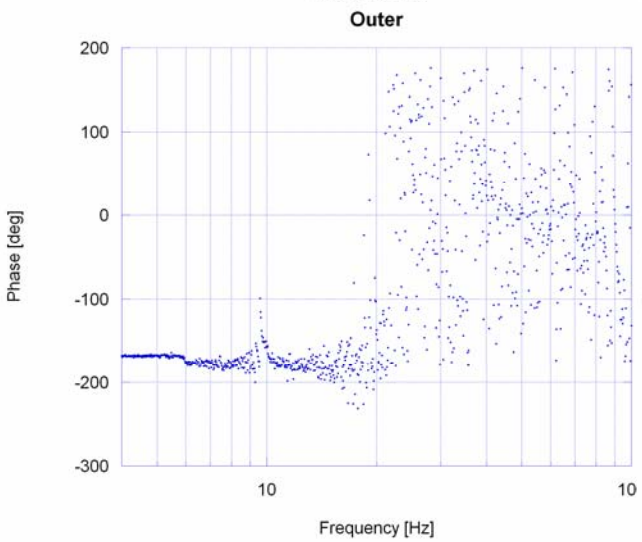


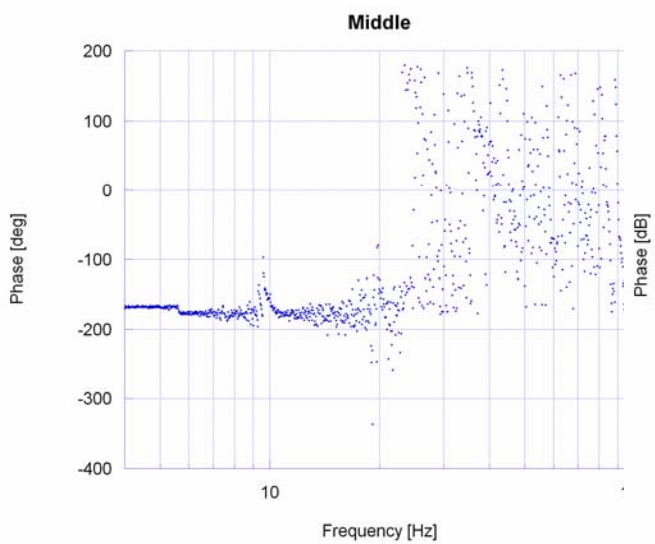
Two Booms 1 CW
CW positions comparison

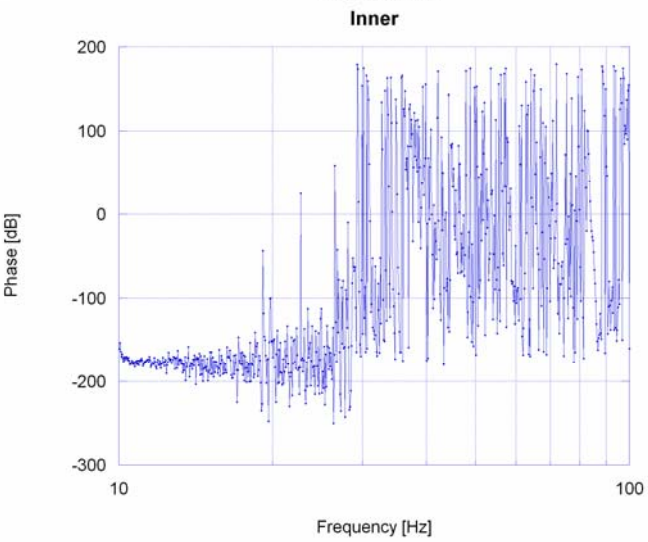




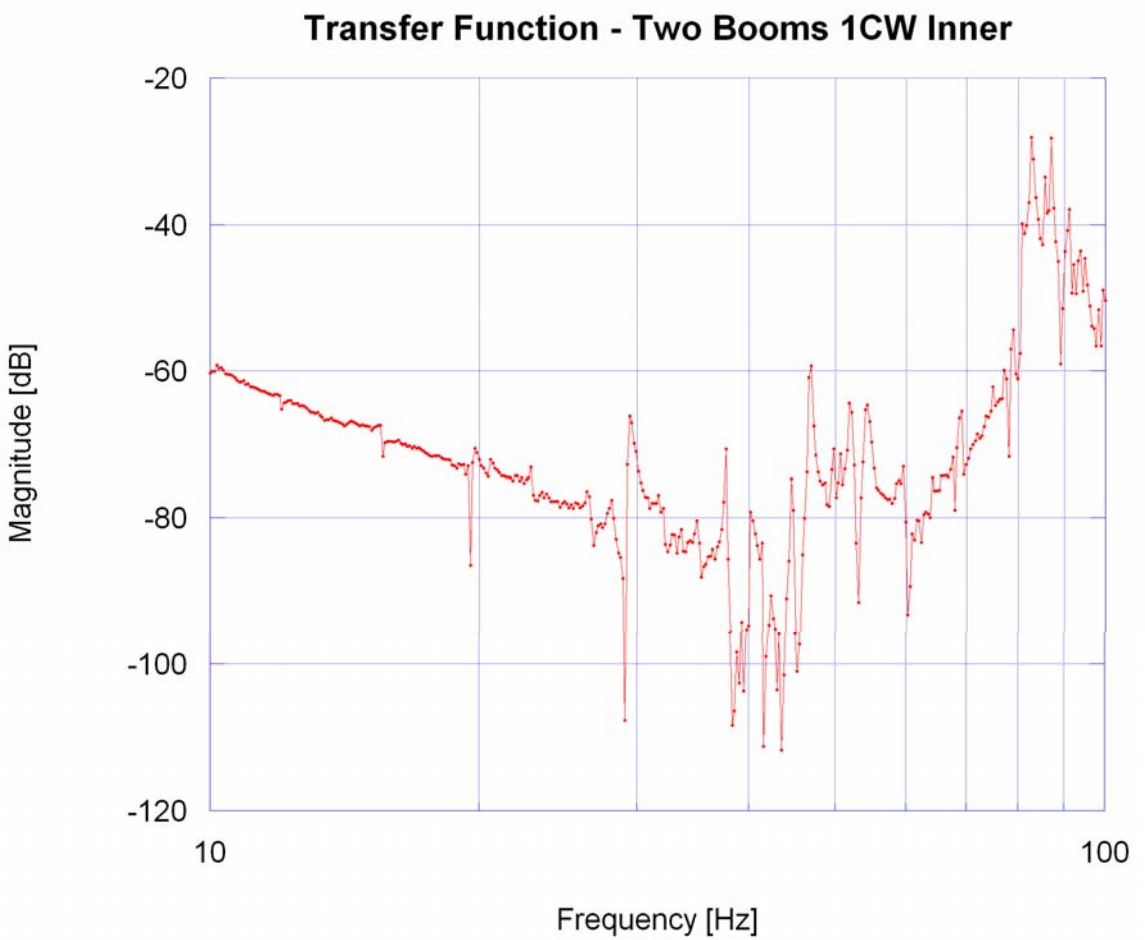


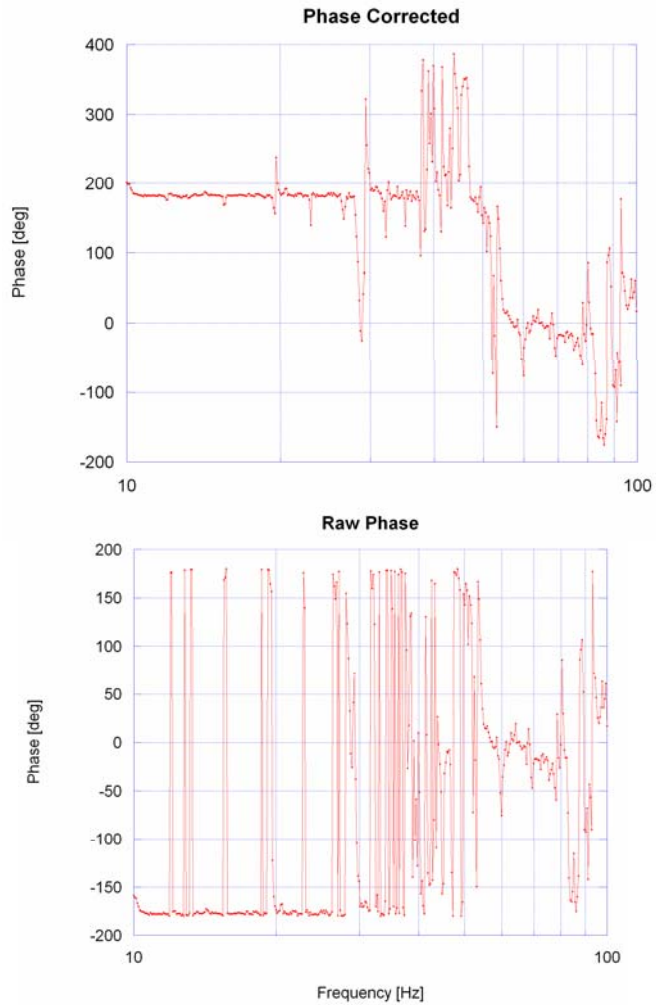




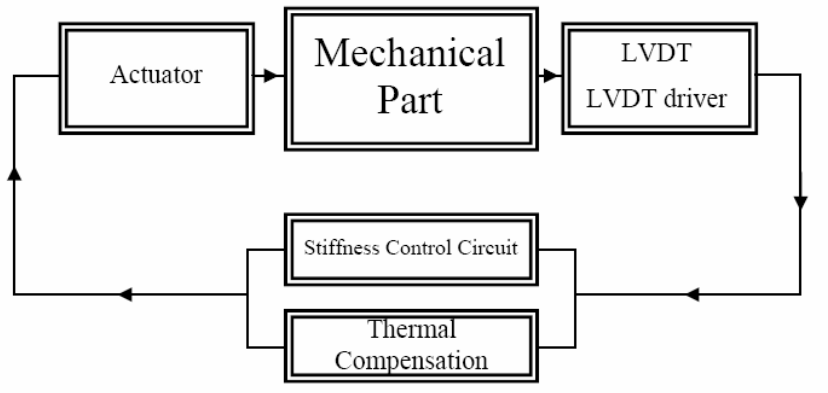


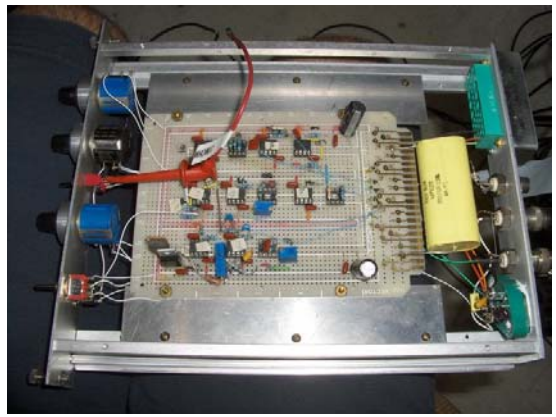
Two Booms 1 CW Inner

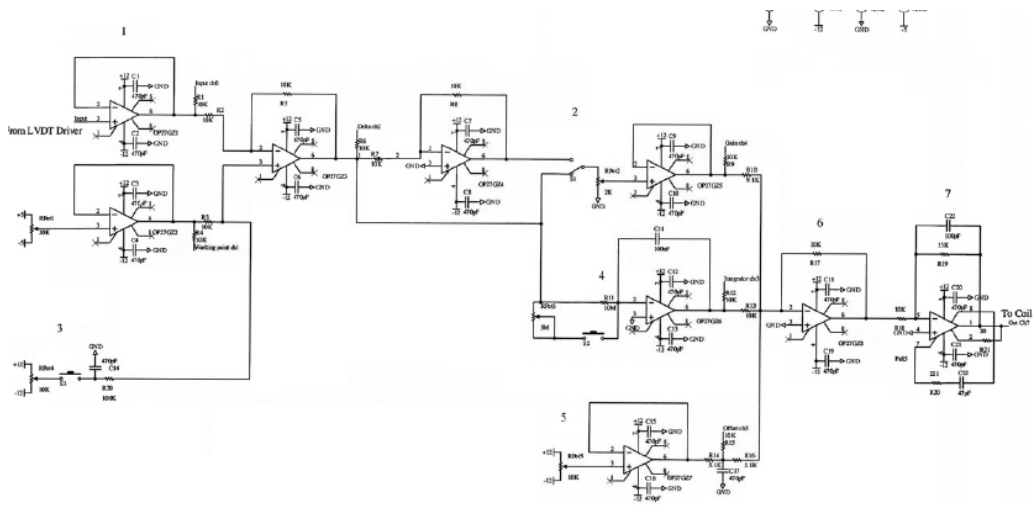




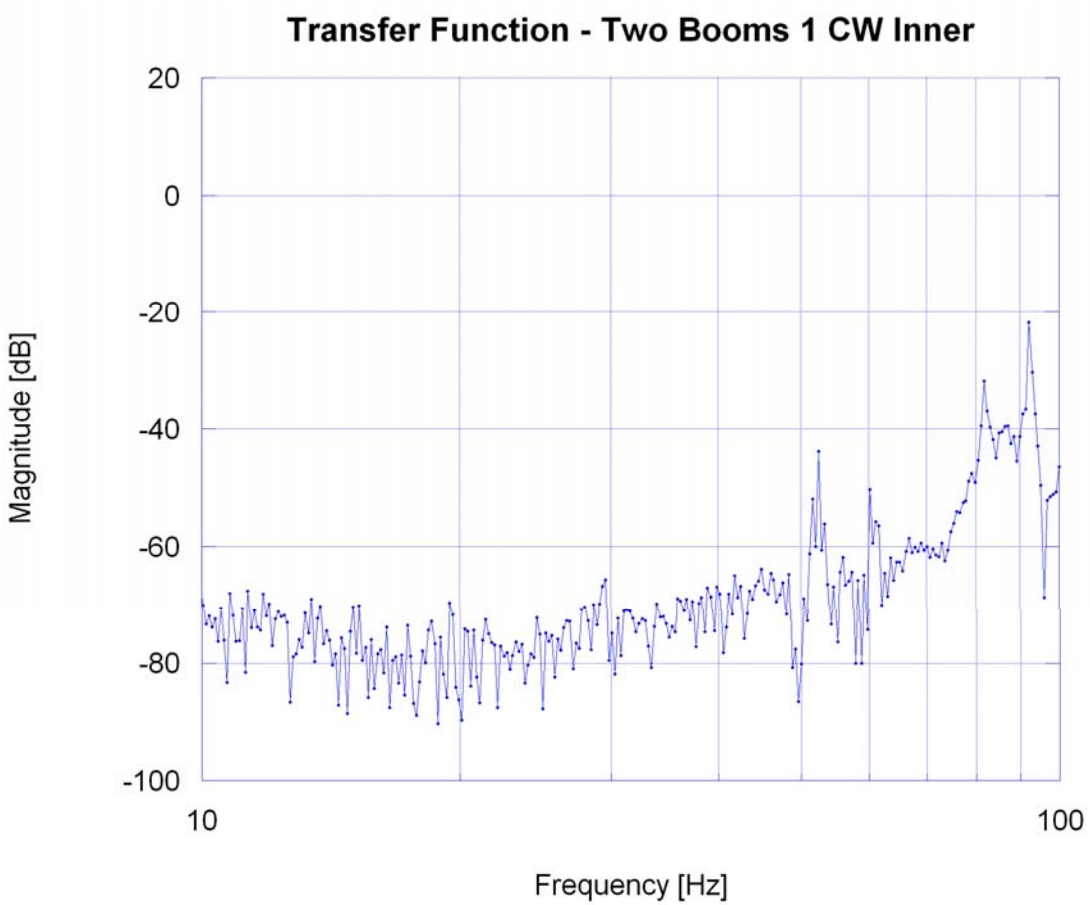
E.M. Antispring Circuitry

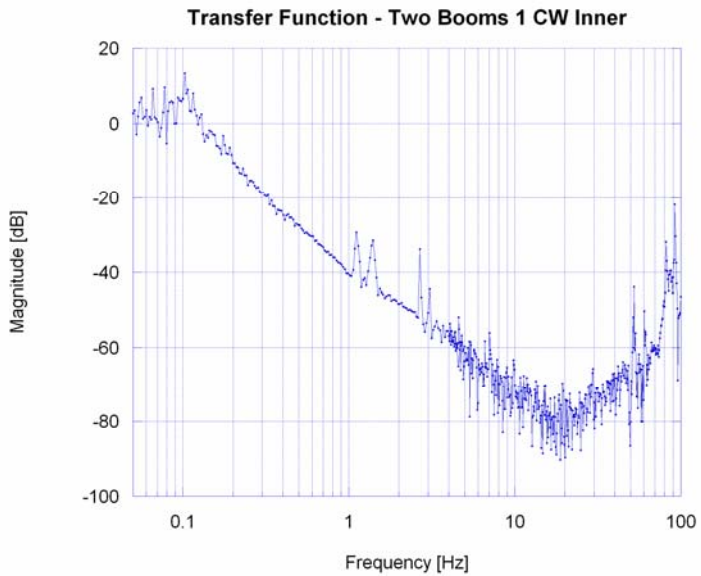


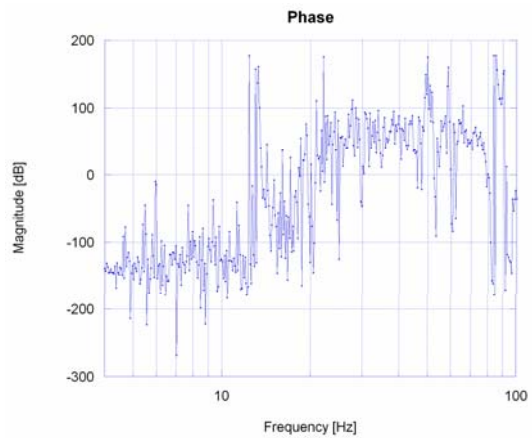




E.M. Antispring
Two Booms 1 CW Inner

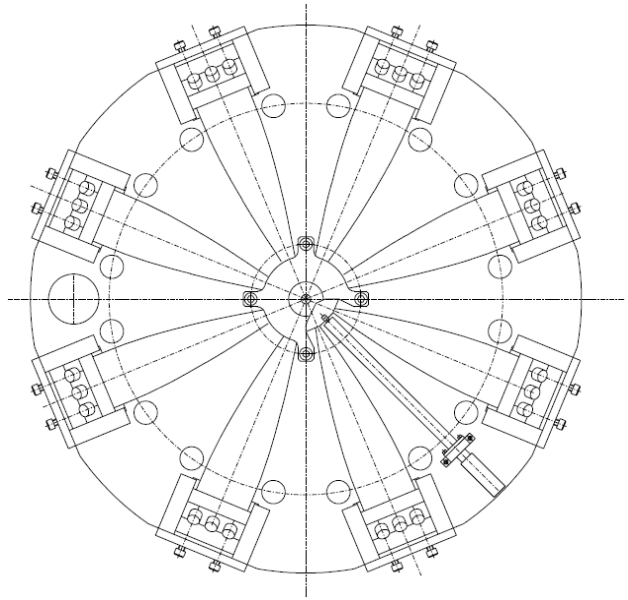


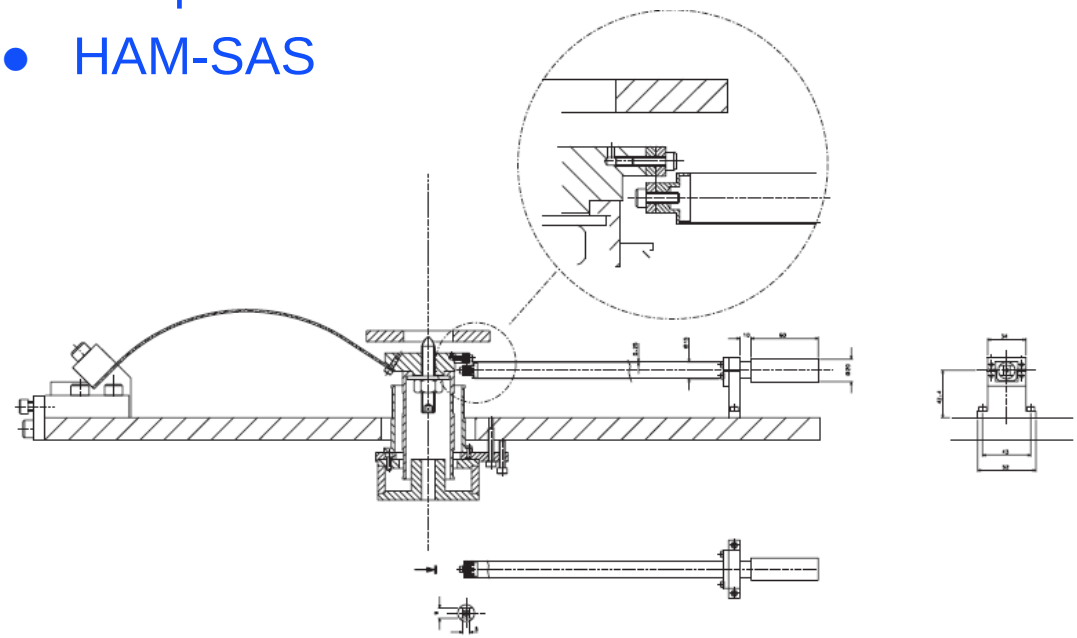




Next

- Lower the noise at high frequencies
- Deepen the TF and Phase data analysis
- Find the optimal setup for the best compensation
- HAM-SAS





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