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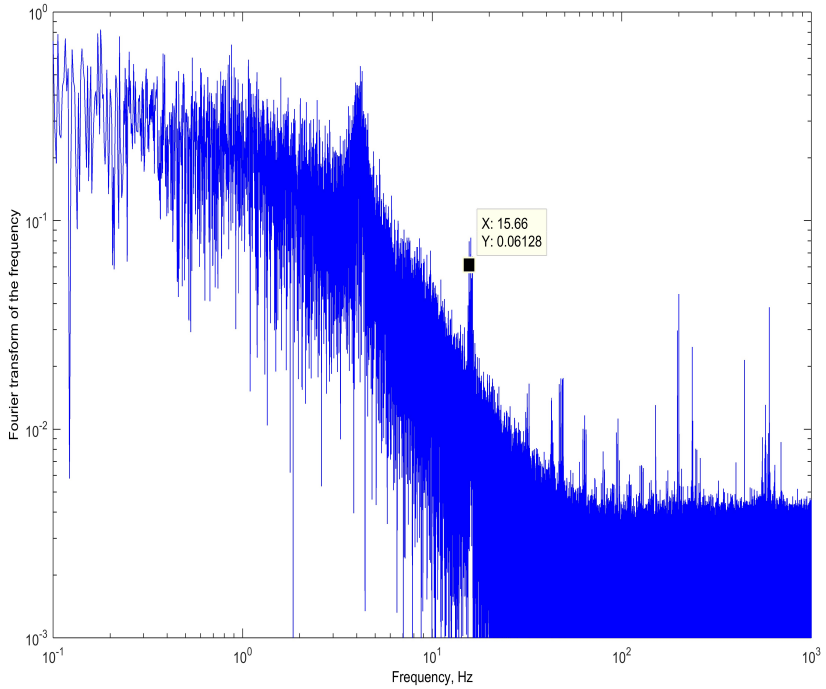


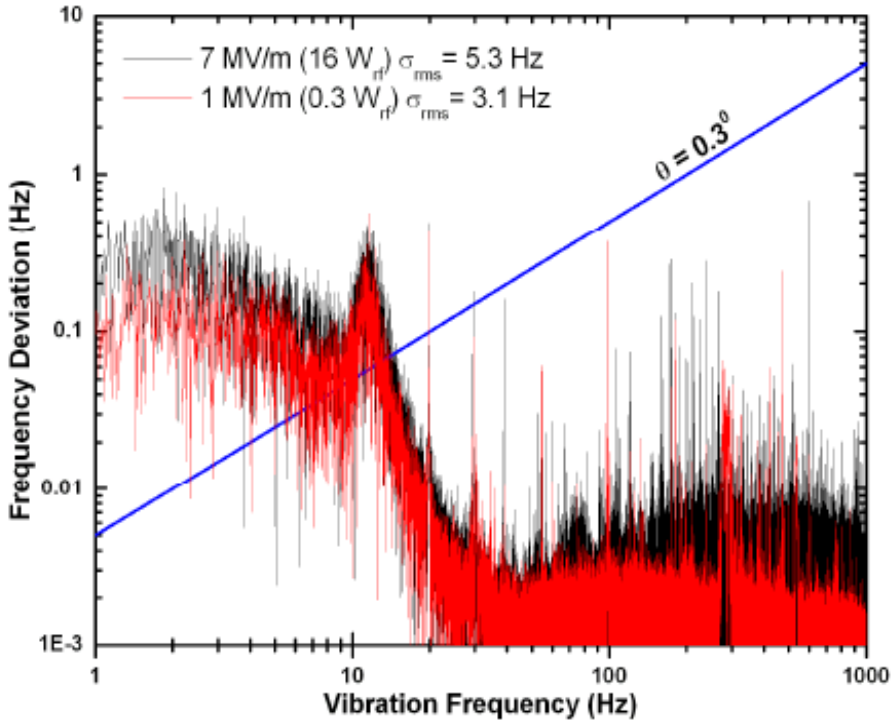
Power requirement increase from detuning

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Microphonics indicate spoke cavity resonance near 14 Hz





- ESS will operate at 14 Hz, could excite the resonance.
- The detuning of the cavity frequency could then get large, increasing power requirements
- Detuning given by: $\ddot{\delta w_n^2} + \frac{\Omega_n}{Q}\delta\dot{w}_n + \Omega_n^2\delta w_n = 2\Omega_n^2(-k_n)V^2$
- Detuning amplitude ω, frequency Ω, mechanical Q, driven by V. k is coupling.
- V is idealized as square wave (train of pulses)

- Since V is periodic, it is reasonable to assume the detuning will be too.
- Can then expand into fourier series. First harmonic of detuning will depend on first harmonic of driving square wave

- To get a numerical estimate, we will assume worst case where the cavity mode has same frequency as driving voltage.

- Detuning amplitude is then: $Q k V_1$

- V1 is first harmonic of V^2 and has amplitude $A^2 \cdot (duty\ cycle)$ where A amplitude of V

- Calculating power with

$$P_g^{opt} = \frac{V_c^2}{2R_{sh}}\left[(b+1)+\sqrt{(b+1)^2+\left(2Q_0\frac{\delta\omega_m}{\omega_0}\right)^2}\right]$$

$$b = \frac{R_{sh} I \cos(\psi)}{V_c}$$

- Gives with numbers taken from measurements and specification that the necessary power increases by as much as 40% for worst case scenario.

- Reality probably a good deal less problematic

References/Sources

- Delayens Seminar presentation at FREIA 2nd June
- Z. A. Conway. ELECTRO-MECHANICAL INTERACTIONS IN SUPERCONDUCTING SPOKELOADED CAVITIES". PhD thesis. 2007
- ESS Technical Design Report (ESS-doc-274-v15)