The Auriga Ultracryogenic Test Facility: A New Capacitive Resonant Transducer.

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Abstract. Sensitivity of presently working gravitational wave resonant detectors is limited by the transduction chain – resonant transducer, impedance matching circuits and SQUIDs. For this reason the Auriga[1] collaboration has started in 1998 the construction of an ultracryogenic test facility where the entire transduction chain can be tested and improved. Mechanical isolation will easely allow for intrinsic thermal noise measurement. In this poster we present the design and first measurements of a new resonant capacitive transducer, intended to widen the detector bandwidth up to 50 Hz with the available new generation of SQUIDs.

The capacitive resonant transducer that we present here was the result of a long work of theoretical optimization of the transduction chain used in resonant bar gravitational wave detectors. In particular we built an equivalent electrical model of the system[2] that includes the bar, the transducer, a high Q RLC resonator for impedance matching and a DC-Squid. We could move parameters of the transducer like its effective mass[3] and resonant frequency, and of the electric resonator, like its central frequency and Q. We explored the space of these parameters using two different kind of Squid's, both available and beeing tested by the Auriga Group in Trento.

Calculations are algebraic. Bandwidth has been calculated using the following equations.

$$\begin{aligned}\Delta\nu &= \frac{I_1^2}{2\pi I_2}\\ I_1 &= \frac{1}{2\pi}\int_{-\infty}^{+\infty} SNR(\omega)\,d\omega \\ I_2 &= \frac{1}{2\pi}\int_{-\infty}^{+\infty} SNR^2(\omega)\,d\omega\end{aligned} \tag{1}$$

Bandwidth is the parameter we used most to rank possible configurations. This is because we found out that sensitivity is a much more tolerant parameter and it stays high in a much wider parameter area. Results of simulations are summarized here below, for what concerns the best transducer configuration and relative achievable bandwidth and sensitivity.

TABLE 1. Transducer Optimal Configuration.

Parameter	Optimal Value
Transducer Mass	3.5 kg
Transducer Frequency	887 Hz
Electrical Mode ($Q=10^5$)	952 Hz
Bandwidth	25 Hz

Based on results from simulations we designed and built a new capacitive transducer. We modified the usual 'mushroom' shape of the resonator in order to increase mass without moving frequencies too much. The model was simulated in detail using Pro/Mechanica[4] to make sure no dangerous resonance were introduced, that the central mode was were needed and that stresses were not too concentrated to avoid thermoelastic dissipations. Below is a picture showing the final transducer design.

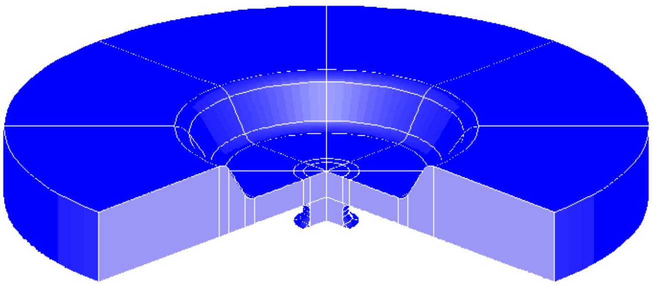

FIGURE 1. The final transducer design.

In a room temperature test we could measure the transducer central frequency at 885 Hz, which is more than satisfactory given our goal and all the numerical and mechanical error involved. Mechanical Q is less than 3000 and needs to be increased. More measure are scheduled as soon as the ultracryogenic facility will be operative.

REFERENCES

1 See J.P. Zendri et al., elsewhere in these Proceedings
2 M. Cerdonio et al., Physica B, 194-196 (1994) 3-4
3 P. Rapagnani, Y. Ogawa, Nuovo Cimento 7C, N.1 (1984), pg. 21
4 See http://www.ptc.com/