Simulation and Testing of a Tunable Organ Pipe for Ocean Acoustic Tomography

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Abstract

Long-range, ocean acoustic tomography, require low frequency signals covering a broad frequency band. To meet this requirement, Teledyne Webb Research has developed a system which uses a tunable, narrow-band, high-efficiency sound resonator. The high-Q resonator tunes to match the frequency and phase of a reference frequency-modulated signal. The projector transmits a digitally synthesized frequency sweep signal and mechanically tunes an organ pipe to match the frequency and phase of a reference signal. The computer timing system uses high precision Cesium atomic clock. The resonator tube projector consists of a volume source in a form of pressure balanced symmetric Tonpilz driver and aluminum free flooded pipe. The actuator smoothly tunes the frequency of the resonator tube over the large frequency band. The transmission duration can vary from five seconds to a few minutes. The first sound source was built for the Naval Postgraduate School (Monterey, CA) for studying temperature variability in the California Current over the bandwidth 200-300 Hz. Since 2001, all ocean acoustic tomography experiments have used this type of TWR sound source. Modification with 140-205 Hz frequency sweep has been built. The transmission duration can vary from one second to a few minutes. This type of sound sources has been used in many experiments: Pacific Ocean, Pioneer Seamount (2001); MOVE Experiment (2004 - 2005); Pacific Ocean ,Hoke Seamount (2002-2004); NPAL04, SPICE04, Pacific Ocean (2004 -2005); Fram Strait 2008-2012; Philippine Sea (2009,2010-2011); Newfoundland, Canada (2014-2015). In 2013 the TWR specially designed a sound source for a sea floor deployment. The bottom-deployed swept frequency array can be used for high-resolution seismic imaging of deep geological formations. During its 15 years of operating history the Teledyne underwater tunable resonant sound source demonstrated exceptional performance. It is coherent, efficient, powerful, and had unlimited operational depth, as well as a minimum level of high frequency harmonic content. The analysis of a new high-Q resonant organ pipe with an octal band 500-1000 Hz is analyzed by the COMSOL Multiphysics® software. The finite analysis computer simulation gives the affectionate picture of tunable resonator acoustics. For clear interpretation of sound pressure levels (SPL) the analysis was done for the standard spherical piezo-ceramic driver. The finite element simulation shows the structural acoustics of the tunable resonator. The results are compared with the experimental test. Application of COMSOL® software analysis predicted optimal parameters of the resonator and avoided a long series of water tests with parameters adjustment. The parameters of the sound source were close to the COMSOL simulations.

Reference

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Figures used in the abstract

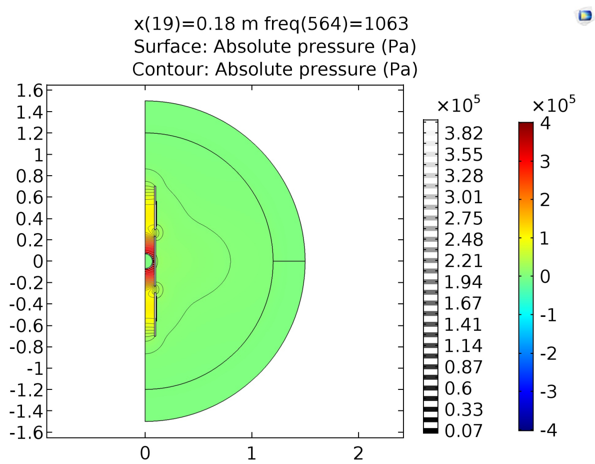

Figure 1: Absolute sound pressure in resonance, Pa.

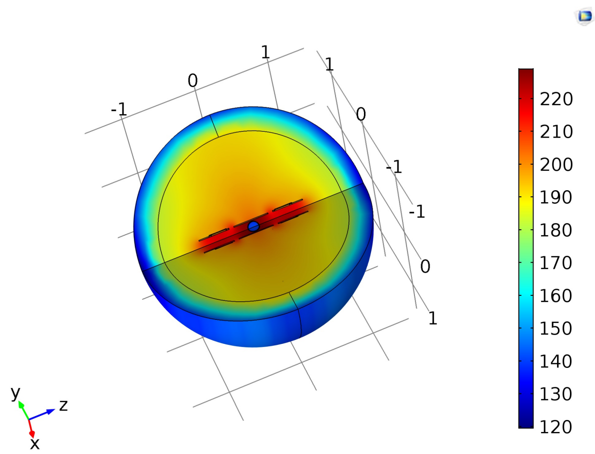

Figure 2: Sound pressure level in resonance, dB.

Figure 3: Sound source at Woods Hole Oceanographic dock.