Abstract

Acoustic sensors that preferentially detect sound from a given direction over other directions are known as directional acoustic sensors. Several underwater directional acoustic sensors have been investigated in the thesis. Analytical, simulation and experimental studies have been conducted, and prototypes of first-order and second-order directional acoustic sensors have been developed. Additionally, an analytical expression has been derived to determine the weights of 8 and 10-channel receivers of third-order directional acoustic sensors to achieve the desired directivity index.

A first-order directional acoustic sensor is also known as an Acoustic Vector Sensor (AVS). We have done a comparative study of various types of underwater AVS in the form of analytical, computer simulation, and experimental studies for the underwater environment (by drawing on previous research). Analytical approaches are utilised to compare the P-P, P-U, and PAGE-based AVS in Signal-to-Self Noise Ratio (SSNR) and SNR. We also derive an analytical expression for the SNR of particle velocity in the presence of correlated and uncorrelated ambient noise scenarios for various inter-element spacings.

We investigate the design parameters for a P-U based directional acoustic sensor using Finite Element Method (FEM) modelling and experimental work to acquire a more in-depth comprehension of its capabilities. We have built a prototype of AVS at the Indian Institute of Technology, Delhi and carried out experimental research at the National Institute of Ocean Technology (NIOT), Chennai. We have shown the beampattern in addition to the DoA estimation utilising a hydrophone array and the P-U based AVS.

A second-order directional acoustic sensor estimates pressure, particle velocity, and

particle velocity gradient along three orthogonal axes. FEM analysis demonstrates the influence of mutual coupling and investigates the effect of misalignment of the sensitive axis of accelerometers on the beampattern. By adjusting the intersensor distance between the accelerometers along the sensitive axis, we examine the variation in the directivity index. We have also developed the prototype of a second-order directional acoustic sensor and tested it in an underwater tank at NIOT Chennai. We also obtained the beampattern and Directivity Index (DI).

A third-order directional acoustic sensor estimates the pressure, particle velocity, particle velocity gradient, and second-order velocity gradient along three orthogonal axes. We have derived the DI of a third-order directional acoustic sensor along with the weights of different channels for optimum DI. The DI of a third-order directional acoustic sensor varies from 7.7 dB to 12 dB. We also test the DI by varying the inter-sensor distance between the accelerometers positioned along the axis. We have also done a sensor misalignment study and found that the beampattern of second and third-order directional acoustic sensors highly depends on it. We also present various methods that can be used to make a third-order directional acoustic sensor by using hydrophones and accelerometers.