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Development, Implementation and Verification of an Underwater Distance Measurement System based on Acoustic Transit Time Measurements.

ABSTRACT - Masterthesis

ATLAS ELEKTRONIK GmbH develops various passive sonar systems for submarines which, in addition to bearing, can also measure the distance to acoustic targets. For the sea trials, during which the installed sonar systems are tested and accepted by the customer, a reference system is required that is capable of providing reliable values for the target distance. The thesis deals with the redesign of an acoustic measurement system which measures the distance by determining the transit time of an acoustic pulse from a surface vessel to the submarine by means of two GPS synchronized clocks. Therefore, the theoretical basis for a pulse detection and transit time estimation algorithm based on a matched filter is first introduced. The system design is then presented and the practical implementation is described. In the subsequent test and verification phase, the reliable operation of the system is verified on the one hand and the measurement accuracy, which is a basic requirement for a reference system, is investigated on the other hand. For this purpose, the accuracy of the isolated estimation algorithm is investigated in a simulation. Subsequently, the fully integrated system is tested in practical tests at a sonar simulation facility and finally at a lake under almost real conditions. The resulting findings are incorporated into the estimation of the measurement uncertainty under real sea conditions, which is based on the Gaussian method. This also takes into account external influences such as the accuracy of the calibration, the decreasing synchronicity of the GPS clocks when the submarine is submerged, and the measurement uncertainty of the sound velocity. Furthermore, the increasing transmission loss with increasing distance, which leads to a decreasing SNR, is considered by applying the sonar equation. The result shows that it is realistic to meet the required relative measurement uncertainty of 1 % for the distance range of 2 - 15 km even under real conditions.