Experimental Study of a Hydro-Acoustic Hybrid System for Simultaneous Underwater Communication and Positioning

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ABSTRACT Paper represents the results of a long-term experimental study on the performance of a hybrid system enabling simultaneous hydro-acoustic positioning of drifting underwater objects and hydro-acoustic communication between them and the nodes of the baseline nodes. This system does not require switching between modes, choosing between positioning and communication, whereas the data transfer between the underwater object and the nodes of the long-baseline antenna is carried out at high data rate and the determination of the object coordinates (positioning) is made with high accuracy. For example, using three-node bottom antenna with long-baseline (aperture of 40 meters), the positioning accuracy of the objects drifting 160 m over the bottom was less than 1 cm, and the data rate was on the order of kilobits per second.

KEY WORDS: Underwater positioning, underwater communication, AUV navigation, LBL.

INTRODUCTION

Underwater sensed data can only be interpreted meaningfully when referenced to exact location of the sensor, underwater vehicles must be navigated accurately to support docking, junction cable connections, switching equipment and so on, thus making underwater acoustic localisation, tracking and positioning to the tasks of high practical interest (Tan et al., 2011). Acoustic communication with moving and stationary underwater objects is often required and represents the only feasible mode of digital information transmission over large distances in sea water.

Typically, the task of positioning and the task of underwater communication require specialized devices: hydro-acoustic antennas (with long, short or ultra-short baselines) and hydro-acoustic modems. In particular, accurate estimation of the object moving in water column requires long-baseline antennas. In some cases, both communication and positioning can be executed by means of a combined system. For example, by means of a hydro-acoustic positioning system, in which the nodes of its long-baseline antenna are combined (integrated) with hydro-acoustic modems. Apart of exact positioning of moving objects, such systems can also accomplish data exchange with these objects transmitting usually small amounts of data, in particular, navigation and control information. One of the drawbacks of such combined systems consists in compulsory switching between modes (they are not able to operate for positioning and communication purposes simultaneously). Another disadvantage of the combined systems consists in low performance of their communication devices: the integrated hydro-acoustic modems provide usually very low data rates.

As an example the performance of a hybrid LBL positioning and communication system operating for underwater localisation and tracking of optical modules of a new (experimental) Baikal Neutrino Telescope cluster (Avrorin A.V. et al., 2012) is presented below. The sections below contain technology used in the experiments, as well as geometry LBL antenna and conditions of its operation. There is also demonstrated the functionality and performance of the hybrid LBL positioning and communication system under laboratory conditions and during a long-term test.

TECHNOLOGY

LBL acoustic positioning provides an opportunity for localisation of a transponder’s position with high accuracy. The accuracy depends on the spatial separation of the LBL nodes, as well as on the waveform of acoustic signals. Data transmission rate and immunity to bit errors depends on the waveform of acoustic signals as well, thus making the selection of signaling method responsible for performance of both the LBL positioning and communication systems.

While a spread-spectrum signal is characterized with a sharp main lobe of its autocorrelation function and also provides definite immunity to bit errors when carrying digital symbols in reverberant environments, devices based on the spread-spectrum technology were used in field