HYDROACOUSTICS
4, 169-172 (2001)

SMALL ANTENNA FOR A DIPPING SONAR

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The dome enclosing the antenna of dipping sonar should be of the smallest possible size. Presented in the paper is a concept of hydroacoustic antennas of active and passive sonar. The active antenna performs mechanical scanning while the passive antenna uses the orthogonal array of gradient hydrophones. In addition to that the antenna array includes ultrasonic transducers of a sound velocity profiler, a pressure sensor for measuring the depth of antenna submergence. With that many sources of signal in the sonar's case, a multiple fibre cable is required or signal modulation to transmit the signals over a limited number of wires. The sonar in question uses distribution over time and an original modulation method for simultaneous transmission of several signals using a cable channel. Block diagram and formulas describing the entire signal from the sonar's antenna are included.

INTRODUCTION

The antenna array presented in this article is an important element of the dipping sonar. The sonar is designed to detect underwater objects using the passive or active method. In addition to that, the sonar is equipped with a sound velocity profiler for matching the submergence of the antenna to the current hydrological conditions to ensure the best detection performance.

In the active mode the sonar uses the echolocation method with a chirp type sounding signal and scanning with mechanical revolution of the transmitting and receiving antenna. The sounding signal with chirp frequency modulation combined with digital matched filtration ensures an improved echo signal to noise ratio and reverberation.

In the passive mode, the sonar uses a bearing method using an antenna array with gradient hydrophones. The principle of operation of passive sonar with gradient hydrophones is based on the well-known principle of operation of radio bearing devices with a crossed frame antenna. In the system in question, the gradient antenna is built of four hydrophones placed in the corners of a square [1], [2], [3]. The subtractions of the signals from the opposite transducers are proportional to sine and cosine of the angle of the arrival wave. The improved version of the system is implemented in the sonar. Received signals are sampled and their discrete Fourier transforms are calculated. This method of signal processing significantly improves the detection capability and can better establish the bearing on the source of sound.

1. BLOCK DIAGRAM

The block diagram shows an antenna array placed in a submergible housing and the on-board receiver set. Both parts are connected with a cable line having a limited number of conductors. The diagram leaves out those elements that are involved in the steering of the active antenna and determining the position of the antennas to the north.

The antenna housing contains elements of the following three sub-subsystems:

- the sound velocity profiler,
- active echolocation system,
- passive noise bearing system.

The sub-systems work only one at a time. Selecting a specific relay connection chooses the working sub-system.

The sound velocity profiler sub-block measures sound velocity using the pulse method. It also measures the depth of submergence using a tensiometric hydrostatic pressure sensor. This sub-block consists of an ultrasonic transducer, transmitter, receiver, pressure sensor and a microprocessor measurement control. What is measured is the time acoustic pulses take to move from the ultrasonic transducer to the acoustic mirror and back. The results are converted in the microprocessor system into sound velocity in water values, which are then sent to the on-board operator control desk using an FSK modem.

The active receiving channel in the antenna case has a pre-amplifier for the active antenna signal, transmitting channel compensating elements and a transmission-reception switch. The pre-amplifier is there to ensure pre-amplification, the required signal to noise ratio and send the amplified signal through the cable line which is made possible by the low output impedance and high current efficiency. Through the relay contacts the receiving signal is taken to the cable line and further on, through the on-board wiring and the contacts of the relay of the receiver sub-block to the active antenna signal receiver. The receiver has a passive band filter, time variable gain amplifier, manual gain control amplifier and an active band filter.

The passive sub-system antenna consists of four hydrophones. The receiving channels – both for the active and passive mode – has one coaxial wire reserved in the cable line. Because of this the passive antenna signal transmission had to use additional modulation.

2. MODULATION

The signals from the passive sonar antenna are at a low level and have a very low frequency spectrum. Signals of this type are usually sent using modulation. The simplest method that requires a single cable connection only is to use amplitude modulation or a phase with several different carrier frequencies (frequency division of the line). Alternatively, we can use a time division of the line. This method is described below.

The block diagram in a simplified form shows how signals are sent from the four antenna hydrophones of the passive sonar. Following pre-amplification and filtration to reach the required frequency range, signals from the hydrophones are symmetrized and in this form brought to multiplexer inputs 8/1 (for reasons of transparency only four signals without symmetrization are shown). The symmetrization of source signals ensures better resistance to interference induced in the transmission channel. An additional effect of modulation is that he signal in the transmitting line does not contain low-band components that are mostly at risk of

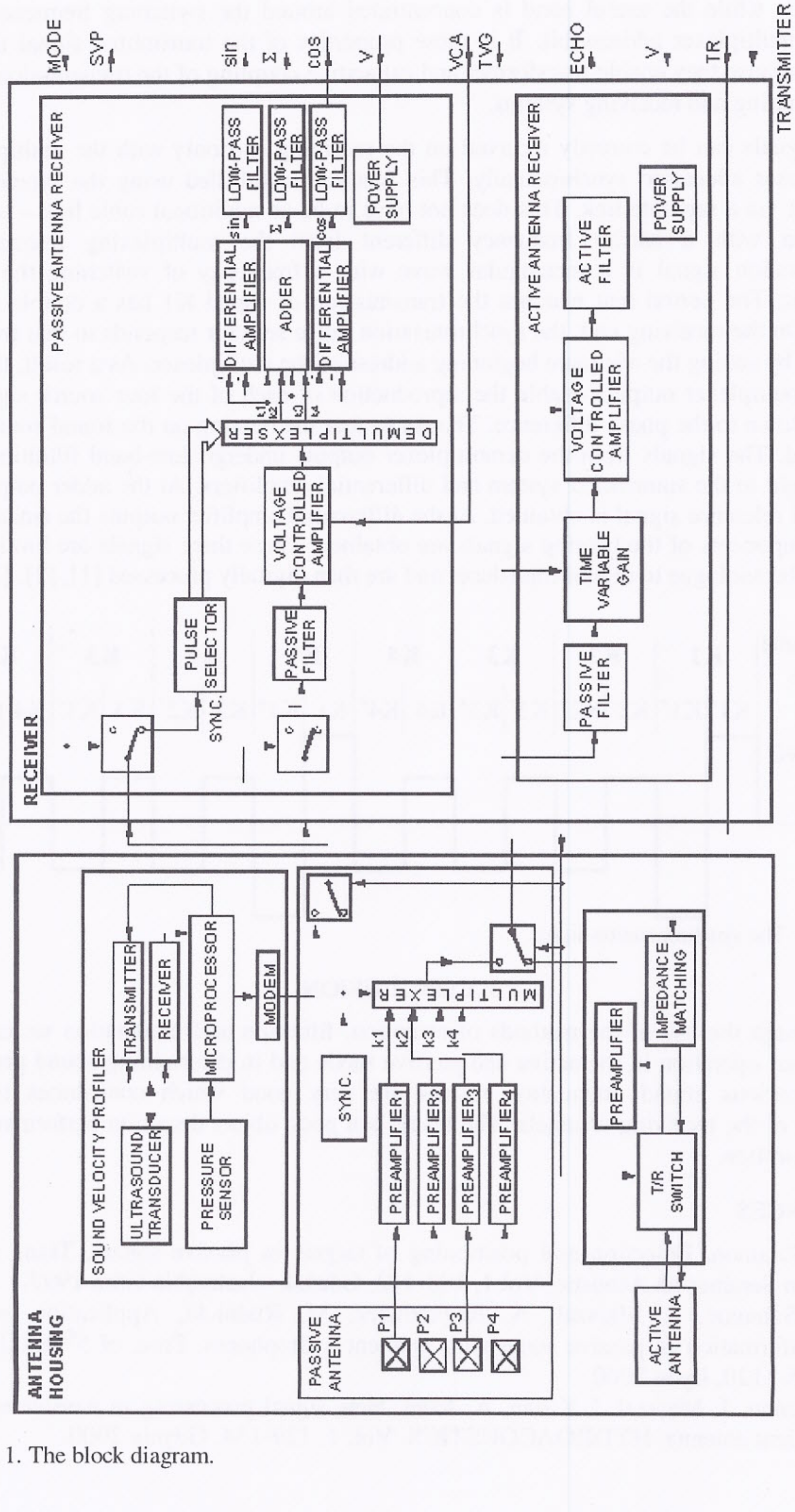

Fig. 1. The block diagram.

interference while the useful band is concentrated around the switching frequencies of the youngest multiplexer address bit. It is these properties of the transmitted signal that are in demand because they enable transformer and capacitive coupling of the transmission line with the transmitting and receiving systems.

Source signals can be correctly received on the receiving end only with the multiplexer and demultiplexer addressed synchronically. This function is fulfilled using the synchronisation signal sent via a separate link. This does not have to be an additional cable link – we can use modulation with a carrier frequency different from the multiplexing frequency. The synchronisation signal is a rectangular wave with a frequency of switching the youngest address bit. The period that matches the transmission of signal K1 has a double amplitude (fig. 2.). On the receiving end, the synchronisation pulse selector responds to that fragment of the signal by setting the adequate beginning address of the multiplexer. As a result, the signals at the demultiplexer outputs enable the reproduction of each of the four source signals with accuracy down to the phase difference. Thanks to that the bearing on the sound source can be established. The signals from the demultiplexer outputs undergo low-band filtration and are then brought to the summation system and differential amplifiers. At the adder output a non-directional reference signal is obtained. At the differential amplifier outputs the sinusoidal and cosine components of the bearing signals are obtained. These three signals are brought to the inputs of the analogue to digital transducer and are then digitally processed [1], [2], [3].

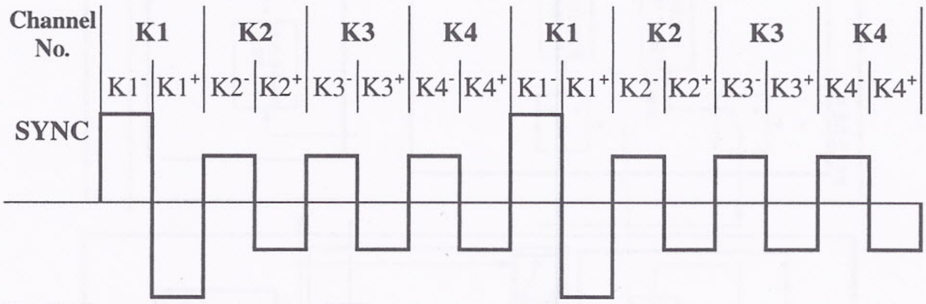

Fig. 2. The synchronisation signal.

3. CONCLUSION

Through the use of the methods of reception, filtration and modulation we can ensure proper sonar operation in the active and passive mode and in determining sound propagation routes. Spurious sound attenuation results are very good which contributes to a high sensitivity of the receiving channels. The result is a good object detection performance of the sonar in question.

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