An Anchor Mooring Profile Monitoring Buoy based on Underwater Non-contact Wireless Communication

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***Abstract*- The anchor mooring profile monitoring buoy can obtain the long-term, fixed-point and high vertical resolution vertical profile monitoring data of the specific sea area. To guarantee the communication reliability and the safety of the profiler, an underwater non-contact wireless communication system based on electromagnetic induction coupling is presented in this paper. This system can realize the low cost, low power consumption, low directionality demand, reliable and short-distance data transmission between the underwater profiler and the floating body. The underwater experimental results show that the system can realize the reliable half-duplex non-contact wireless communication at 9600bps when the distance and the axial direction between the two coupling coils are less than 20cm and 60 degree respectively.**

I. INTRODUCTION

The anchor mooring profile monitoring buoy is a kind of advanced sea monitoring buoy in recent years. It has both the long-term and fixed-point property of the anchor mooring buoys and the self-lifting property of the drifting profile buoys (ARGO buoys), so it can obtain the long-term, fixed-point and high vertical resolution vertical profile monitoring data of the specific sea area. For the anchor mooring profile monitoring buoy, however, the two-point mooring design is usually used, i.e. the top end is pulled by floating body and the bottom is the anchorage, the underwater profiler can reciprocate upward and downward between the floating body and the anchorage to acquire the profile monitoring data. After the monitoring data acquired by profiler transmitted to the floating body by a certain transmission mode, the same monitoring data will be retransmitted to the onshore data center by data radio station or communication satellite.

The data transmission between the underwater profiler and the floating body can be realized by wired communication or wireless communication. If the wired communication is selected, since the communication distance will constantly change with the reciprocating motion of the profiler, the design of the transmission lines will be very difficult. At the same time, the communication reliability and the safety of the profiler will also be difficult to guarantee. So the wireless mode will be more suitable than the wired mode used in the data transmission between the underwater profiler and the floating body. In all of the underwater wireless communication modes, the underwater acoustic communication has the merits of long transmission distance and high transmission rate etc, but the underwater acoustic communication device is expensive and the power consumption is too high to meet the demand of the long-term underwater observation considering the profiler is usually self-contained; the underwater laser communication system also has the merits of long transmission distance and higher transmission rate, but the structure of the laser communication device is very complex and the cost is also very high, especially, the directionality demand of the laser communication is so high that the communication performance will largely reduce and even interrupt if there is no device to assure its probes' alignment in a small range; although the LED-based underwater optical communication has the advantage of low cost and power consumption, the problem of the communication directionality remains the same.

To resolve the above problem in the data transmission between the underwater profiler and the floating body by using the underwater wireless communication, an underwater non-contact wireless communication system based on electromagnetic induction coupling is presented in this paper. This system can realize the low cost, low power consumption, low directionality demand, reliable and short-distance data transmission between the underwater profiler and the floating body, on this basis, an anchor mooring profile monitoring buoy based on the underwater wireless communication is further put forward. The buoy presented in this paper can realize the profile monitoring data's underwater acquisition and self-contained storage during the process of profiler's reciprocating motion, profile monitoring data's short-distance non-contact wireless transmission between the profiler and floating body when the profiler floating up to the bottom of the floating body, profile monitoring data's storage on the floating body and the retransmission by data radio station or communication satellite.

This paper is organized as follows: in section 2 the overall structure of the system is given; and then we make a detailed introduction to the key technology of the system, i.e. underwater non-contact wireless communication system based on electromagnetic induction coupling in section 3. Next we illustrate the experimental results and finally conclusion and future work are presented.

II. SYSTEM OVERVIEW

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The anchor mooring profile monitoring buoy presented in this paper is composed of antenna, floating body, profile data retransmission system on the floating body, underwater non-contact wireless communication system based on electromagnetic induction coupling, underwater profiler, sensor group, underwater profile data acquisition and storage system, unidirectional switch, mooring cable and matching block. The structure diagram of the buoy is shown in figure 1.

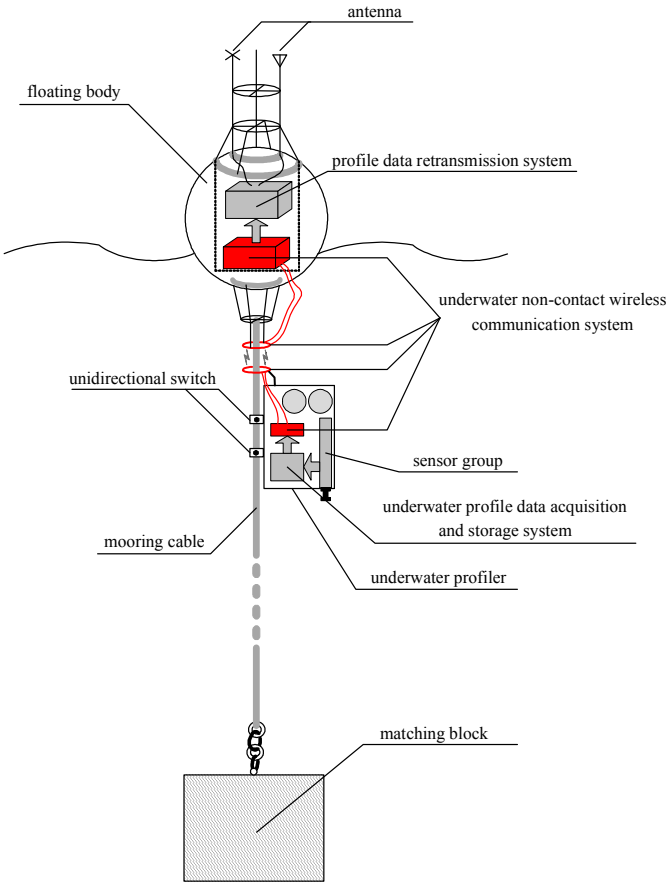

Figure 1. The structure diagram of the anchor mooring profile monitoring buoy presented in this paper.

The workflow of the system is as follows: the profile monitoring data will be transmitted to the underwater profile data acquisition and storage system for self-contained storage by sensors' specific interface in the profiler's rising or falling process; when the profiler floats up to the bottom of the floating body and a stable communication link is established between the underwater non-contact wireless communication system based on electromagnetic induction coupling (short for coupling signal transceiver modules) in the profiler and floating body respectively, the profiler will stop floating, meanwhile, the profile monitoring data stored in the underwater profile data acquisition and storage system will be transmitted to the profile data retransmission system on the floating body by the coupling signal transceiver modules; the underwater profile data will firstly be stored in the SD card or USB storage device on the profile data retransmission system and then the retransmission will be performed by the data radio station or communication satellite; the profiler will sink again after the retransmission of the profile data and a new round of the data acquisition starts.

III. COUPLING SIGNAL TRANSCEIVER MODULE

Coupling signal transceiver module can be divided into three parts, i.e. coupling signal transmitter, coupling signal receiver and coupling coil. The structure diagram of the coupling signal transceiver module is shown in Fig. 2.

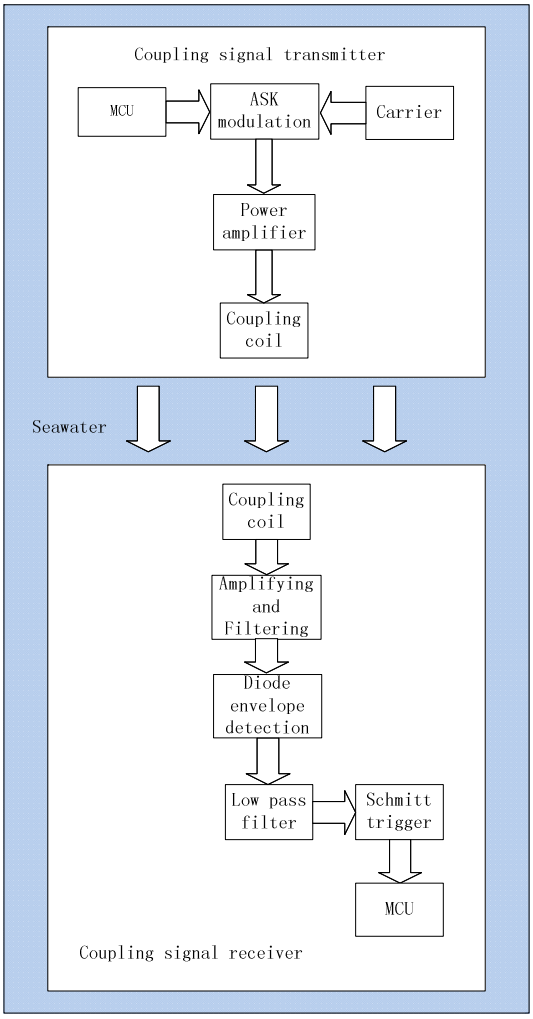

Figure 2. The structure diagram of the coupling signal transceiver module

Coupling signal transmitter

Coupling signal transmitter is composed of data interface, modulation circuit and power amplifier circuit. The data interface in the coupling signal transmitter is serial port RS232, its main function is to receive the profile data from the underwater profile data acquisition and storage system. The modulation circuit is used to modulate the profile data on the carrier signal by ASK mode and the carrier frequency is about 200 kHz according to the electromagnetic transmission characteristics of sea water. The class B push-pull power

amplifier circuit is used to amplify the modulated profile data for coupling transmission.

Coupling signal receiver

Coupling signal receiver is composed of amplifying and filtering circuit, demodulation circuit, digital signal recovery circuit and data interface. Voltage Amplifier based on Integrated Operational Amplifier (short for IOA) is used to amplify the micro voltage signal received from the receive coil. The noise whose frequency is higher than carrier frequency will be removed by the active low pass filter based on IOA. Diode envelope detection circuit combined with active low pass filter is used as demodulation circuit to recover the baseband signal. Schmitt trigger is used to recover the digital signal from baseband signal. The data interface in the coupling signal receiver is also RS232 to send the recovered profile data to the profile data retransmission system.

Coupling coil

L-C Parallel resonance circuit is selected in this paper to receive the electromagnetic induction signal which is shown in Fig. 3. In Fig. 3, C has been fixed on the coupling signal transmitter and coupling signal receiver, so L matched with C can be changed to any shape as the coupling coil. After various testing, the shape of the coupling coil is determined as circle whose photo is shown in Fig. 4.

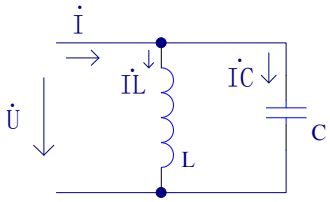

Figure 3. L-C Parallel resonance circuit

Figure 4. The photo of the coupling coil

IV. Experimental Results

To simulate the field circumstance, coupling signal transmitter and coupling signal receiver are integrated with profile data retransmission system and underwater profile data acquisition and storage system respectively. The integrated electronic system is shown in Fig.5. The integrated electronic system is put underwater to test after waterproof package. Underwater experimental results show that the coupling signal transceiver module can realize the reliable half-duplex non-contact wireless communication at 9600bps when the distance and the axial direction between the two coupling coils are less than 20cm and 60 degree respectively. The power consumption of the coupling signal transceiver module is about 250mW.

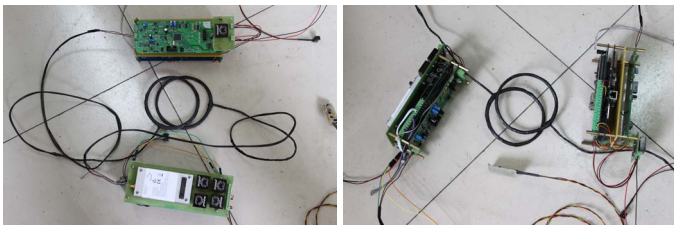

Figure 5. The integrated electronic system

In addition, the integrated electronic system should be fixed on the profiler or floating body at last to realize the anchor mooring profile monitoring buoy. Final assembly of the buoy is shown in Fig. 6 and the sea test of the buoy will be performed as soon.

Figure 6. Final assembly of the buoy

V. Conclusion and Future Work

An anchor mooring profile monitoring buoy is presented in this paper based on the realization of the coupling signal transceiver modules. Low cost, low power consumption, low directionality demand, reliable and short-distance data transmission between the underwater profiler and the floating body is established by means of the coupling signal transceiver module. At the same time, the safety of the profiler will also be guaranteed because of the selection of the wireless communication mode.

Many problems will appear when the buoy is used in field sea test. The solution of these problems will promote the underwater signal transmission technology based on electromagnetic induction coupling to being mature. Considering the importance of the profile data transmission, the underwater non-contact wireless communication must became the key technology of the future anchor mooring profile monitoring buoy.

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