THE DEVELOPMENT OF A TELEMETRY AND POSITION INDICATING SYSTEM FOR A DIVER

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ABSTRACT

In a diving expedition safety is important both to the personnel on board the support boat and the divers. A diver needs to know their bearing and range to the support boat as diving progress to navigate freely in the water and to return to the boat immediately in time of emergency or after completing a task. Ideally, this may be achieved by computing the diver's bearing and range periodically using an underwater tracking system fitted on a support boat and transmitting the information back to them by acoustic means. However, despite the availability of electronic based diver tracking systems, no attempt was made to exploit this idea. The reason being the extensive and rapidly time-variant multipath echoes generated in a shallow water made it difficult to process the coded information if transmitted at high rates due to signal masking. Also, air bubble noise generated through breathing, physical movement and biological noise from snapping shrimps hinders effective propagation and reception of the data signals in the water.

In an attempt to inform a diver his position from a support boat and to send his depth to the boat, the authour has developed a unique low rate data telemetry technique using a new concept. The depth information is necessary for the positioning system to compute the diver track more precisely. The technique developed has the capability of resolving multipath echo problem and is, therefore, suitable for diver's application in shallow water.

This thesis concerns the developments of the telemetry technique and the hardware necessary for its implementation. The technique utilizes pulse position modulation (PPM) and uses time separations between pulses to exchange information between a support boat and a diver. To send bearing and range data

to a diver, the technique uses three modulated pulses (two time separations) while to send depth to the boat it requires two modulated pulses (one time separation). In the scheme, a time interval (or time separation) of 667μs is taken to represent one unit length (1m) for range and depth or one degree unit (1°) for bearing. A multipath echoes problem was successfully resolved by transmitting modulated pulses sequentially after allowing a time delay sufficient for the multipath echoes to subside at the receiver.

During the earlier stage of the project, the necessary hardware for testing the telemetry technique developed was designed and fabricated in the laboratory. Attention was given to the transmitter, receiver etc. to ensure that they met specifications and performed satisfactorily. During initial trials a personal computer was used to control the "diver unit" because a compact prototype diver unit was not yet available. The operation of the test system was achieved using a specially developed software written in assembly and BASIC languages. Several experiments were performed under different test conditions (in test tanks, in a swimming pool, in a brackish water channel and at sea) by telemetring numerical data representing bearing, range and depth to simplify data analyses. The recorded data were analyzed to assess the suitability of the technique and the system's performance.

Favorable results in tanks (almost 100% success rate) and in a brackish water channel experiments (over 90% success rate at 260m propagation range) indicated the capability of the technique to operate in confined areas and to resolve multipath echoes generated.

The effect of bubbles noise on underwater telemetry was investigated by conducting controlled experiments in a test tank with bubbles generated by a mechanical pump and in a swimming pool with bubbles generated by a diver. Data telemetry trials were also performed at sea, in Tateyama. The purpose were to study the characteristics and the quantitative effects of shrimps and other industrial noise on the decoding error rate in order to find suitable solutions. The bubbles and shrimps noise with pulse width of less than 4ms,

identified as the main cause of decoding error, was successfully resolved using a pulse width check circuit. However, for compactness the prototype diver unit uses software that filters those noise instead of the pulse width check circuit.

In September 1994, the prototype diver unit was finally fabricated using one-chip CPU, integrated circuits (IC) and components available in electronic stores. The one-chip CPU was programmed using structural assembly language and is ready for operation after the switch is turned on. It only requires modulated pulses transmitted by the boat unit to operate. The diver unit has a pressure sensor to determine water depth, a transmitter to transmit the depth information to the boat and a LCD panel for displaying range, bearing and depth data.

The trials using the prototype unit in the laboratory, in a round pond and at sea by two divers were successfully conducted with favorable results. In particular, the sea trials had demonstrated the usefulness of the system as implements for a diver to estimate their own position relative to the support boat. The author hopes that the telemetry technique and the system when used by a diver would not only contribute towards safety but also make diving more enjoyable both for research and leisure purposes.