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First approach to bidirectional acoustic tag's software. PPM modulation and threshold demodulation scheme

Gerard Batet [1], Ivan Masmitjà[2], David Sarrià[3], Spartacus Gomariz[4], Joaquín del Rio[5]

[1] SARTI (UPC, gerard.batet@upc.edu), [2] ICM (CSIC, masmitja@icm.csic.es), [3] SARTI (UPC, david.sarria@upc.edu), [4]SARTI (UPC, spartacus.gomariz@upc.edu),[5] SARTI (UPC, joaquin.del.rio@upc.edu)

***Abstract* – In the development of a novel bidirectional acoustic tag, choices have to be made regarding its usability and system characterization to rapid prototype and to get a test accessible system. It is important to approach the development of each step in an easy error-detection to not interfere with the others. In this work, a walk-through of the first version of the software implementation is made, where a threshold and a timer have been used to detect and demodulate a pulse position modulation signal.**

Keywords – Bidirectional acoustic tag, Biotelemetry, Underwater Acoustics.

I. INTRODUCTION

Novel technology development and rapid prototyping is a challenge. Especially, for underwater environments, which is the case for the design of a bidirectional acoustic tag for marine animal monitoring. Several systems must be designed to interlock together, to work to their full potential, and to accomplish the maximum transmission and reception range.

The microcontroller system, which manages all the circuitry, plays a significant role in achieving the optimum system's operation point with the minimum power consumption. Thus, a good software implementation will help ease both the hardware development and its systematic management.

In this work, a brief explanation of the software development and approach will be presented together with preliminary results and future work on this topic.

II. SOFTWARE DESIGN RESTRICTIONS

Acoustic telemetry has different protocols (e.g., Binary Shift Keying), but the most used is pulse position modulation (PPM) [1]. The PPM protocol encodes the information in the time spaces between acoustic pulses with a determined duration and tone frequency (see fig. 2) (e.g., 69 kHz tone of 5 ms).

The software should encode and transmit the tag's assigned unique ID in the Open protocol (OP) PPM format, by the European tracking network (ETN) association.

As the tag must be bidirectional, the reception also will be done decoding a PPM format, in this case, there are no restrictions in protocol usage, although OP decoding will be implemented.

As a consequence, and adding power consumption into the equation, the software must achieve different points while remaining simple, in structure and functioning, to allow failure and error detection in the hardware development.

These points are: (i) encoding and managing the transmission circuitry; (ii) managing the reception circuitry and decoding the message; and (iii) maintaining the low power consumption through all modes.

III. BASE SOFTWARE DESIGN

The proposed algorithm topology takes into account the current electronic design, that marks a base power consumption when activated. A choice in functionality is conducted based on this conditioning, as shown in fig. 1, resulting in a transmit, receive, sleep scheme.

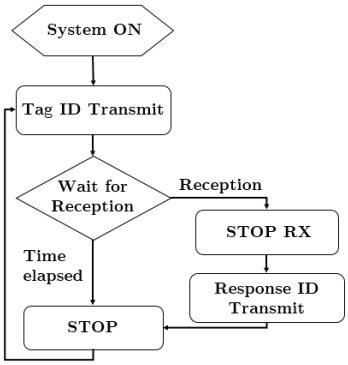

Fig 1. Algorithm base scheme

IV. IMPLEMENTATION

The software achieves bidirectionality thanks to the shown cycle (see fig. 1). First, the transmission is done, to maintain low power on the microcontroller's side, via timer pulse width modulation (PWM) and entering STOP mode while waiting for the next pulse generation (i.e. the waiting time encoding phase).

After transmitting, it opens a short waiting-for-reception time, given that the power consumption of the input

analogue amplification stage is relatively high. If detection has been accomplished, a wait time to separate messages is implemented and a response is emitted.

As seen in fig. 2, once the reception phase starts, a comparator is activated (c_{wait}). When a laboratory-tested threshold (***th***) is reached, it deactivates the comparator for a known time given by a timer, and reactivates the comparator again. This cycle (c_{wait}) is repeated for *n+1* times (in c_{det}), where *n* is the expected interruptions created by the comparator to understand the pulse as good (i.e. in fig. 2, n = 5). After that, a guard time (t_g) is implemented, and the microcontroller remains in stop mode to avoid power consumption, thus, the protocol establishes a minimum time where no pulses are emitted. This process repeats until the full message is decoded (m_d) or a timeout is reached.

As the algorithm relies on the active electronic filter to avoid noise being recognized as a pulse, three different checks are implemented: (i) if a pulse has a duration greater than *n+1* or (ii) less than *n-1*, it is discarded (p_d); and (iii) if the encoding time (t_e) is greater than the expected maximum, the pulse count is reinitialized.

V. TESTING

Tests have been done on dry-laboratory environment and on field, using new iterations over the first implementation of the tag's electronics [2]. The tests done include a bidirectionality test, power consumption study and battery characterization with two in-series LR44 silver-oxide cells, laboratory discharge testing have been done with a higher software time cycle rate over 4 days.

Further tests must be done utilizing the data acquisition testbed [3] on the OBSEA Underwater cabled observatory facilities [4], with the modular system [5] developed.

VI. CONCLUSIONS AND FUTURE WORK

The tests done over the air, in a water tank, and in-field, showed great results of receive detection and bidirectionality response.

Battery durations of up to 110 days when used in pinger mode and 72 days when bidirectionality is implemented.

The software was conducted in a first-approach fashion using a simple threshold method for the detection of the pulses, which will be used as a baseline comparison for benchmark other implementations. Future work will develop more robust algorithms to check the correct frequency and increase the signal-to-noise tolerance of the system.

VII. ACKNOWLEDGEMENTS

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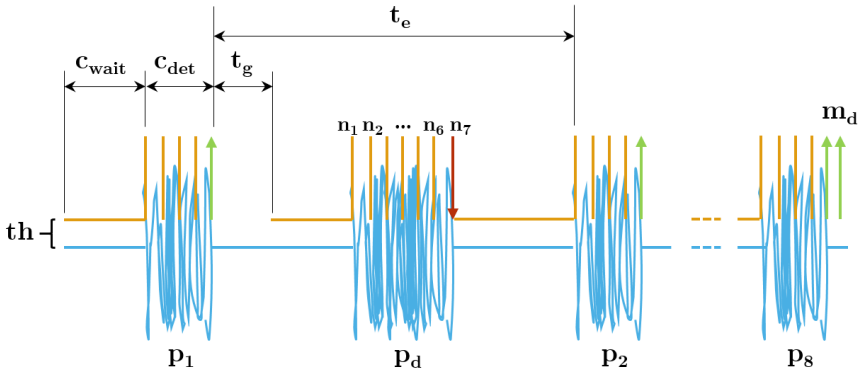

Fig 2. PPM protocol with pulse detection and message decoding scheme

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