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Firmware implementation for a bidirectional acoustic tag

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***Abstract* – Up until today, commercially available acoustic tags pose the inconvenience of lacking bidirectional communication capabilities. This implies that once deployed in the sea, they cannot be reconfigured in any way, limiting their potential applications and versatility. This paper aims to develop a firmware for an acoustic tag with bidirectional communication capabilities, enhancing its capabilities and versatility.**

***Keywords* –** *ADC, TAG,DAC, DMA, FSK, PPM, PGA.*

I. INTRODUCTION

This paper shows the firmware that has been developed for an acoustic tag with bidirectional communication capabilities. The hardware used as a foundation has been developed within the framework of the project SASES (Sistemas acústicos submarinos para la monitorización del comportamiento espacial de especies).

This hardware enables efficient management of bidirectional communications, minimizing the system's energy consumption, thanks to the use of a STM32L432KC low-power microcontroller [1]. Moreover, this platform is designed to support the integration of various sensors, providing greater capabilities to this system compared to commercially available tags today. Figure 1 illustrates the block diagram of the developed tag.

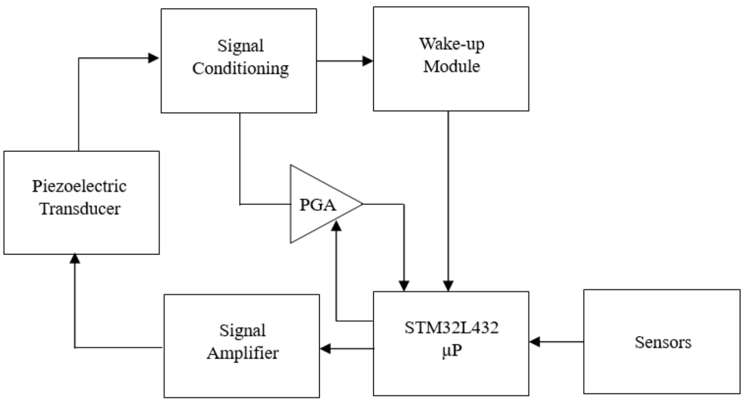

Fig 1. Hardware Architecture of SASES Tag [2][3]

II. FIRMWARE OPERATION

The system firmware has been developed following a modular structure based on different layers of abstraction. The developed modules are designed to be interchangeable, allowing the system to work with various modulations. It can seamlessly switch between them during runtime without causing disruptions. This structure also facilitates the straightforward and uniform development and integration of new modulations.

The firmware structure is divided into two layers or levels of abstraction. The low-level layer is called the transmission layer and is composed of the transmission and reception peripherals. In this layer, control of the various microcontroller peripherals is carried out to achieve an analog-to-digital front-end with the tag's hardware. This layer enables real-time analog-to-digital and vice versa conversion through the use of the microcontroller's ADC, DAC and DMA.

The intermediate level consists of the communication layer, which integrates the modulators and demodulators of the different developed modulation techniques. This layer communicates with the transmission layer through event-based signalling and data flow based on memory buffers. Having a homogeneous interface with the transmission layer greatly simplifies the development of new modulation and/or demodulation algorithms, as developers need only focus on algorithm development without worrying about hardware management.

Furthermore, the developed communication firmware has a simple and uniform interface for all modulators and demodulators. This allows them to be managed from the main program, which provides the tag with the rest of the functionalities to be developed. The entire structure is illustrated in Figure 2.

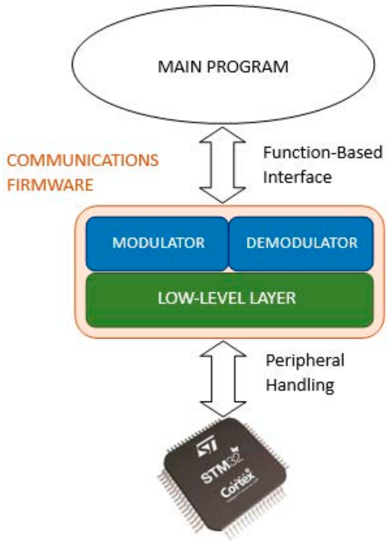

Fig 2. Communication Firmware Structure

III. IMPLEMENTED MODULATIONS

Once the firmware structure has been developed, and the transmission and reception modules belonging to the transmission layer have been implemented, various algorithms in the communication layer have been developed to provide the tag with bidirectional communication capabilities using different modulation techniques widely used in the industry. The acoustic tag has the ability to both emit and receive 32-bit packets using these algorithms, this is due to the limitations caused by the multipath propagation effect [4].

Modulators and demodulators have been developed for the 2-FSK and 2-PPM modulations, which serve as the foundation for the protocols of various commercial manufacturers [5]. This approach allows for potential compatibility with existing commercial devices in the future. Currently, efforts are underway to develop new modulation techniques that minimize the multipath propagation effect and enable more robust communications.

IV. CONCLUSIONS

The conclusions drawn from the development of this project demonstrate the feasibility of creating a bidirectional acoustic tag, paving the way for advancements in this technology. While it is true that further work is needed on the developed software to achieve optimal performance and integration with the hardware in order to let this project to evolve into a commercially viable technology.

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