LOW-COST ACOUSTIC TRANSMITTER FOR UNDERWATER SENSOR NETWORKS

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Abstract
Currently, there is a lag in the proliferation of underwater sensors due to the lack of low cost acoustic transmitters. The high cost of acoustic modems and some of their characteristics, make them inappropriate for many scenarios where low power and short range communications are required. This paper presents the design and the details of a low-cost acoustic transmitter for underwater sensors.

INTRODUCTION

For many years, underwater sensor monitoring has been performed using autonomous data-loggers, which are subsystems that record data for a period of time. This offline monitoring has been widely used because the challenges that present the underwater environment related with communications: strong signal attenuation, transmission loss, multi-path propagation, Doppler spread, the time variation of the channel and the addition of background noise. The means more appropriate for transmit data under the sea is acoustically, and is currently an active research area. Nowadays, some commercial acoustic modems are in the market, but the prices -around 6000€- and the power consumption make them inappropriate for low cost underwater sensor networks [Sánchez]. On the other hand, most of them are not suitable for short distances -below 100m.

OBJECTIVES

Low cost, low size and low power consumption are desirable needs for underwater sensors. With these features sensors can be installed at different places and operate autonomously using a small battery. Incorporating an acoustic transmitter, they could transfer the data collected between nodes at short distances, but to allow growth of underwater sensors is necessary to maintain the low cost and the low power consumption requirements, and these are the objectives of the transmitter proposed.

PROPOSAL DESIGN

One of the major drawbacks in the design of acoustic transmitters is the cost of the transducer. Many commercial hydrophones can be used as projectors; however, the cost of them is on the order of thousands of euro. [Benson] has used a low-cost fish finder transducer, but the low beam width is not useful to transmit data in many scenarios.
We propose the use of piezoelectric ceramics as transducers since they are physically strong, chemically inert, immune to humidity or other atmospheric influences, and they can be manufactured relatively inexpensively [APC]. A ring piezoelectric ceramic was selected in order to transmit vibrations through the X/Y plane, avoiding rebounds with the surface and the bottom in shallow water environments.
To protect the piezoelectric ceramic from the contact with water, different resins were tried. A small balloon with mineral oil is another way to protect the ceramic, because oil is inert and has similar acoustical properties as water. After several tests we chose the resin instead oil because it allows a more robust encapsulation -piezo plus cable- although we observed a better performance with oil –less signal attenuation.
The communication system proposed is based on a low-power microcontroller. Nowadays, the modulations most used to date in this environment have been PPM and FSK, and both can be performed with this proposal. With this approach only two timers and two digital outputs are needed – the first for data output and the second for enable/disable the power amplifier stage. An analog input and ADC module integrated inside the microcontroller is required for sensor data acquisition. For low power consumption during idle operations, the microcontroller must be in sleep mode, and consequently the amplifier stage must be disabled. Only during data transmission the amplifier is enabled, thereby the system only uses energy when is required. This method time lengthens battery.
In this environment the frequencies commonly used to transmit data acoustically, are found between 40 up to 200 kHz. So the piezoelectric ceramic must work at the frequency or frequencies chosen on this range. Because the data signal -microcontroller pin output- is pulsed at the frequency chosen, a low-pass filter should be added to the design. Integrated filters such as the LTC1563-3 are good candidates for the design. Although, for some ceramics, the transmission and reception voltage response -TVR and RVR- could act as notch filters avoiding harmonics, and hence reducing the required components of the design.
The power amplifier stage for the piezoelectric can be implemented easily with a power operational amplifier. The considerations for choosing a correct amplifier that works at low voltages are reduced to have a moderately fast slew rate and remain stable when driving a large capacitive load. The piezoelectric ceramic ring chosen has a capacitive load of 4nF and could be driven by the OPA547 power operational amplifier. This amplifier can operate with a single supply of 8V and has an enable pin to disable the output stage reducing the quiescent current to conserve power, one of the requirements cited. In the following figure the structure of the low-cost acoustic transmitter is presented.

REFERENCES
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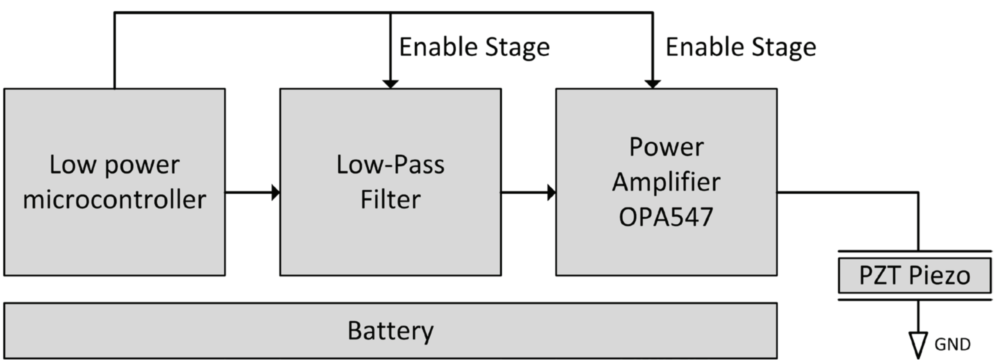

Figure 1. Low-cost acoustic transmitter