BROADBAND, UNDERWATER ACOUSTIC DEVICES FOR AMBIENT NOISE MEASUREMENTS

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1 INTRODUCTION

The market of preamplified hydrophones is currently dominated by either professional measurement devices (e.g., [1,2,3]) or commercial devices [4], which are generally not easy to use, in particular to connect to a commercial acquisition system. In addition, they suffer:

- signal decay on the cable, which can be significant particularly at high frequency, and
- external electromagnetic interference (e.g., cross-talk, etc.).

A recent solution has been proposed by SMID Technology [5] which consists of digital hydrophones, having the digitalization module close to the hydrophone. They overcome the main drawbacks of the analog hydrophones related to signal loss along cable and influence by electromagnetic interferences, but require dedicated receiving boxes, dedicated acquisition software tools, possibly proprietary protocols; hence they may be not so user friendly.

This work addresses the design and development of high-tech, passive, broadband, either analog or digital underwater acoustic measurement devices, which are cost-effective, straightforward to use, robust, and are able to cover a very wide range of noise measurement applications such as monitoring of: marine mammals, ambient noise, ship traffic noise, piling operations during wind farm building, and wind farm noise, seismic activities, etc.
Advanced technological solutions, in particular *(a)* the design of preamplifiers with low self-noise and *(b)* the use of $\Sigma\Delta$ A/D converters, allow these systems to achieve:

- ✓ Very wide dynamic ranges
- ✓ Low equivalent input noise
- ✓ Simultaneous sampling frequency, in the case of more input channels
- ✓ High data flow rate
- ✓ Low power consumption
- ✓ Portability (very small size and light weight).

2 PROPOSED ACOUSTIC DEVICES

If one considers the variety of applications above mentioned, they imply to provide systems able to measure:

- Frequency ranges from infrasonic to ultrasonic
- Possibly very loud sound levels along with very weak emitted signals.

2.1 Preamplified hydrophones

The fundamental characteristics of appropriate hydrophone pre-amplifiers in order to meet the demanding requirements cited above are:

- Low self noise
- High input signal level
- Protection against input over-voltage
- Wide frequency range
- Single-ended or differential output, capable to drive up to 100 m of dedicated cable without signal loss.

A “scientific”, a “general-purpose” and a cheaper, “commercial” preamplified hydrophones are proposed here, which together are able to cover the requirements of most of noise monitoring applications. The technical characteristics of these products are summarized in Table 1. The choice of the best device for a certain application is mainly driven by the frequency range one wishes to privilege, and by the equivalent input noise in that range, compared to the minimum signal level of interest, and maximum input level.

Table 1.The scientific, general-purpose and commercial preamplified hydrophones.

Parameter	**Scientific**	**General-Purpose**	**Commercial**
Linear frequency range (Hz)	5 – 80k	0.5 – 80k	5 – 30k
Usable frequency range (Hz)	1 – 150k	0.1 – 130k	2.5 – 60k
Receiving Sensitivity (dB re 1V/μPa)	-165 @ 1 kHz -167 @ 110 kHz	-165 @ 1 kHz -175 @ 110 kHz	-171 @ 1 kHz -181 @ 50 kHz
Equivalent Input Noise (dB re 1μPa/√Hz)	+28 @ 1 kHz +21 @ 30 kHz	+28 @ 1 kHz +27 @ 30 kHz	+42 @ 1 kHz +41 @ 30 kHz
Max Input Pressure Level (dB re μPa)	+177 @ 1kHz	+177 @ 1kHz	+180 @ 1kHz
Max Operating Depth (m)	4000	600	2000

2.2 Digitalization modules

The design approach is the same adopted in recent works for SMID Technology [6,7,8] and mainly consists of using only ΣΔ, 24-bit A/D converters with ≥ 110 dB of dynamics. This has led AGUAtech to develop a new line of digitalizers, as reported in Table 2.

Table 2.Proposed DAQ modules.

Number of input channels	**Bandwidth**	**Sampling Frequency**	**Used for**
Two	4 Hz – 100 kHz	Up to 212 kHz	Double-gain single hydrophone
			Fixed-gain hydrophone pair
Four	4 Hz – 100 kHz	Up to 212 kHz	Fixed-gain hydrophones
Four to Eight	0.1 Hz – 70 kHz	Up to 144 kHz	Variable-gain hydrophones

Their main characteristics are:

- Very limited size of the underwater box
- Working depth up to 600 m (optional: 4000 m)
- Low power consumption
- Digital data transmission through up-to 300m-long cable

2.3 Receivers

An ***analog receiver*** has been built for any application which includes the use of traditional analog hydrophones and pre-existing acquisition/storing systems.
With respect to existing receivers, AGUAtech’s analog receiver includes a dedicated signal conditioning unit and allows the user to:

- change filters (VGF) and gains (VGA) among a predefined set of values
- listen to the received signals in the audio band on headphones for monitoring and perceptual analysis purposes
- get either direct or conditioned analog signal, and hence possibly feed the audio interface of a computer for monitoring and/or acquisition purposes
- provide power supply to the hydrophone via external supplier or internal battery.

In addition, AGUAtech proposes a ***digital receiver*** able to receive from 1 to 4 digital hydrophones and to allow the user to have digital outputs but also corresponding analog outputs.
For example, the version for two digital input channels allows the user to:

- have digital data available through audio protocol
- have two analog outputs via 24 bit D/A converters
- change filters and gains among a predefined set of values
- listen to the signals on a stereo headphone
- provide power supply to the hydrophones via external supplier or internal battery.

The signals from the digital output can be sent to either an audio interface board, a digital receiver by SMID Technology [5] with Ethernet output port, or a netbook with its own digital audio interface. Figure 1 shows the block diagram of AGUAtech's two-channel system, consisting of a pair of hydrophones, a pan-tilt-compass-depth sensor, a digitalizer and a digital receiver.

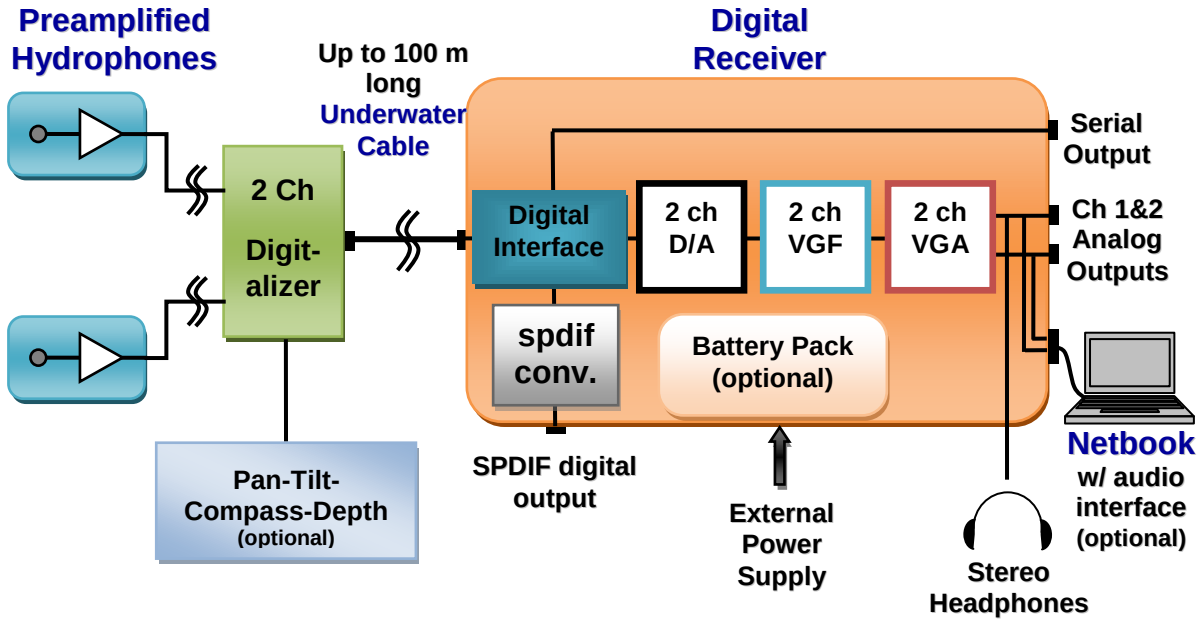

Figure 1. Block diagram of AGUAtech's two-hydrophone digital device.

3 CONCLUSIONS

This paper has proposed a bench of solutions of analog and digital underwater acoustic measurement devices which can cover most of noise measurement applications. The new line of products proposed includes analog preamplified hydrophones, analog receivers, digitalizers, and digital receivers with one or more (up to eight) channels.

4 REFERENCES

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