

# ADC MODULE BUILT FOR AN OCEAN BOTTOM SEISMOMETER (OBS)

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*Abstract- This paper presents the new data acquisition system designed for autonomous Ocean Bottom Seismometers (OBS) to study the earth dynamics and internal structure. This part is the responsible to acquire the signals from two different sensors to be processed. The analog-to-digital converter module is based on input amplifiers, modulator and digital filter.*

*Keywords- Ocean Bottom Seismometer (OBS), seismometer, Analog-to-digital converter, Acquisition system, differential signal.*

## Introduction

The Ocean Bottom Seismometer (OBS) is an equipment specially designed for the acquisition of seismic data in the marine environment. OBSs are fully autonomous equipments that can be deployed up to 6000 meters depth on the seabed [1]. When the instrument reaches the sea bottom, a geophone is dropped to acquire the earth vibrations. At the same time, the OBS is equipped with a hydrophone to detect the water acoustic pressure. The data detected by the sensors are acquired by the ADC board.

The control unit is a Coldfire MCF54455 microcontroller that can operate at low power. This device manages all tasks performed in the system. After receiving data from the ADC board, performs data compression and stores the data in a Compact Flash memory card. When the experiment is over, data is downloaded to a computer. The acquisition system main clock is based on a Seascan module with a temperature stability of  $2 \times 10^{-8}$ . The OBS is recovered by sending an acoustic signal from the surface to detach the anchor weight, allowing the instrument to rise to the surface [2].



**Figure 1: Hydrophone (on top) and geophone (on bottom)**

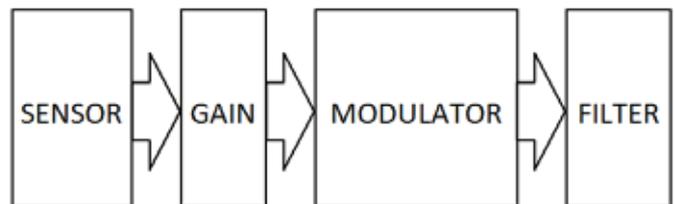
## The acquisition system

The OBS uses a Geophone module with three 4.5Hz geophones type SM-6 and it has a sensitivity of  $25.8 \text{ V/ms}^{-1}$ . In the case of the hydrophone, the OBS uses a Hightech HTI-90-U with a 1778 V/Bar sensitivity. In figure 1 we can see the sensors used to collect data in the OBS. The picture shows the hydrophone on top and shows the geophone on bottom.

To make preliminary tests on the ADC board, we have not been used the previously described sensors. To make this test we have simulated the sensors with a differential signal using a low-noise system, the low distortion function's generator DS360 of "Stanford Research System".

With this generator we can simulate the desired signal in frequency and voltage. In the case of our board, it accepts frequencies in the range from DC to 2 kHz, and a maximum variation voltage of 5 Vp-p. The most important issue of this generator is its capability to generate a differential signal with low distortion and low noise.

The analog-to-digital conversion module is divided into three stages. The first one consists on fully differential amplifiers; the second one is the modulator (ADC); and the third stage is the digital filter which takes care of the decimation. Figure 2 shows the data flow in the ADC board.

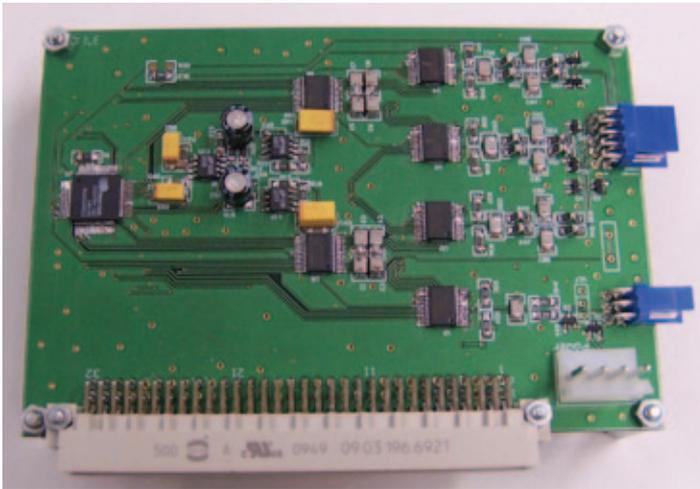


**Figure 2: Data flow in the ADC module**

In the first stage, which amplifies the signal, we use the CS3301 and CS3302 amplifiers for the geophone and the hydrophone respectively [3] [4]. The second stage is the CS5372 modulator. The Digital filter is the CS5376A, which carries out the decimation tasks too. This system provides a high dynamic range of 130 dB @ 103 Hz bandwidth, and lower total harmonic distortion than other modulators, while consuming significantly less power per channel. The modulators generate an oversampled serial bit stream at 512 kbits per second when operated from a clock frequency of 2048 MHz [5]. The CS5376A digital filter has decimation ratios that can support data output word rates between 1 sps and 4000 sps, although the designed datalogger can achieve programmable sampling rates ranging from 125 Hz to 1000 Hz, more than enough for any seismic application, while the power consumption is rated below 6 mW per channel [6].

The Figure 3 shows the analog to digital conversion module. The processed output signal through the elbow plug situated on bottom.

Figure 4 shows the interface between the ADC module and the MCF54455 microcontroller. Channel 1 corresponds to the hydrophone while channels 2 to 4 are the geophone channels (one for every axis). The ADC module interfaces with the microcontroller through and SPI bus. The ADC clock frequency is



**Figure 3: Analog-to-digital converter module**

32.768MHz while the sampling frequency is 250Hz. The power supply needed in the ADC module are a 3.3V, 2.5V and -2.5V. These will be generated by a DC-DC converter which generates the voltages from the main battery input.

**Tests and results**

In order to test the correct functionality of the system, the low noise and distortion DS360 function is used to generate the input signal. A sine wave is generated with 2 Vpp amplitude and 4 Hz frequency. Data is acquired by the acquisition system, compressed and stored in the Compact Flash memory card. A program in MATLAB extracts the data from each channel and represents them in separate graphs. Figure 5 shows the result of the acquisition.

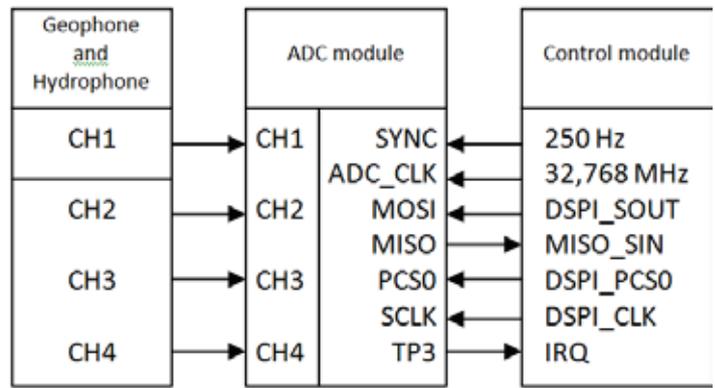
This test has also shown a power consumption of 250 mW for the ADC module.

**Conclusions**

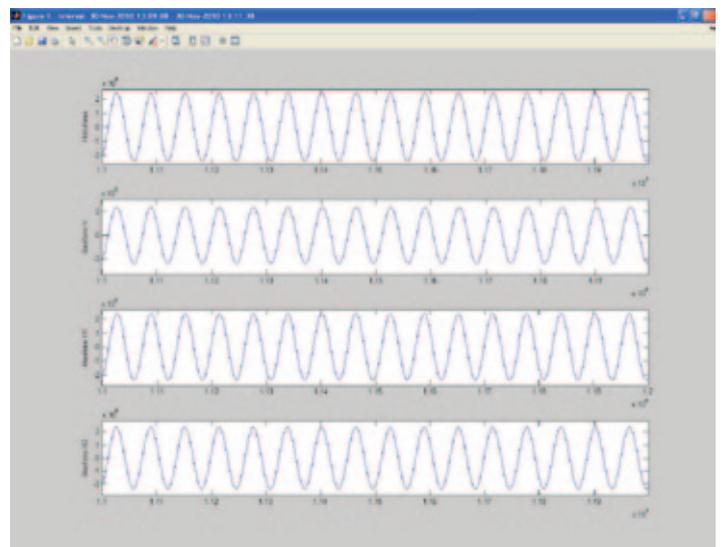
An ADC module was designed, built and tested in laboratory. The communication between the control module and the ADC module was carried out successfully, and the data was stored in the compact flash memory card. These results are conclusive with the simulation studies on real board. The acquisition system has to be tested in a real seismic refraction experiment in order to find the performance of the system in real environmental conditions.

**References**

[1] S. Shariat-Panahi, A. Mànuel, A. Bermudez, M. Ambros, V. Sal-lares, E. Molino, "Ocean Bottom Seismometer (OBS): An Instrument for Marine Seismic Data Acquisition". *Industrial Electronics, 2008. ISIE 2008. IEEE International Symposium on*. Cambridge, June 30 2008 - July 2 2008  
 [2] S. Shariat-Panahi, A. Mànuel, F. Alegria, X. Roset, A. Bermudez, V. Sallares, "Design, Characterization and Calibration of a Short-Period Ocean Bottom Seismometer (OBS)". *Instrumentation and Measurement Technology Conference Proceedings, 2008. IMTC*



**Figure 4: ADC module interface**



**Figure 5: Result of the acquisition with a signal amplitude of 2Vpp and 4Hz frequency.**

2008. IEEE. Victoria, BC. 12-15 May 2008.  
 [3] Cirrus Logic, "CS3301 Low-noise, programmable gain, differential amplifier". 2005  
 [4] Cirrus Logic, "CS3302 High-Z programmable gain differential amplifier". 2003.  
 [5] Cirrus Logic, "CS3371/72 Low-power, high-performance  $\Delta\Sigma$  modulators". 2005  
 [6] Cirrus Logic, "CS5376A low power multi-channel decimation filter". 2004