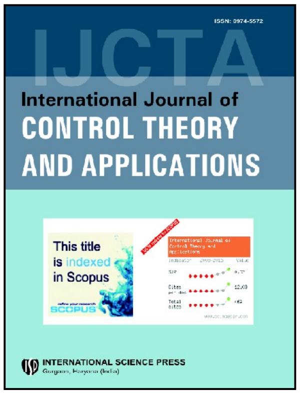

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Underwater Signal Processing Using ARM Cortex Processor

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Abstract: Acoustic signals are the important means of detecting underwater objects. Due to physical and chemical properties of propagation medium, underwater acoustic signals suffer from ambient noise and serve transmission loss. Underwater sensor signals are acquired through a data acquisition system. The data acquisition system contains an acoustic transducer, preamplifier, anti-aliasing filter and an ADC. The output of ADC i.e., the digitized data needs to be processed further to extract the information. Digital filters are used to filter out unwanted bands of frequencies to extract the required information from the digitized data. Digital filters are preferred to analog due to less hardware, re configurability and more accurate at low frequencies. In the proposed work, ARM cortex R processor based hardware is used for implementation of digital filters. This ARM processor based data acquisition system is used to observe the underwater environment and submerged objects like submarines during naval operations. These systems are also used to process seismic signals that are propagated through seabed to detect natural calamities such as tsunami.

Keywords: ADC, Digital filter, ARM cortex R Processor, Sensor, Low pass filter, Acoustics.

1. INTRODUCTION

Underwater is an interesting field of study since it has been used for diverse range such as detection of natural calamities, underwater environment and submerged objects in naval operations

This proposed work is about implementation of data acquisition system using ARM Cortex R4 processor. In underwater, Data acquisition system is used for acquiring data from sensor. The data received by sensor might be of ships, submarines, ocean climate and biological animals present in the water along with noise is also present [4]. Acoustic path is reliable, because wave can travel a very long distance with very low frequency underwater easily compare to electromagnetic waves and optical waves[4]

Acoustic sensor is used which is a low frequency hydrophone sensor. Senor output voltage in milli volts range is perhaps too low for ADC converter to process directly in this case brings the voltage level up to the level required by the ADC using preamplifier.

Amplifier output is analog signal the processing typically requires some form of filtering operation for best performance. To interface an embedded system with analog signal an Analog to Digital Converter must be employed. Before ADC the antialiasing filter is used, job of eliminating signal component with frequency greater than the nyquist frequency while allowing signal component at lower frequency.

In data acquisition system signal processing operation is designed for extract, enhancing, storing and transmitting useful information from a mix of conflicting information with the help of a processor[5].

2. PROPOSED SYSTEM

The perspective of proposed system explains how digital filter implementation by a software on processor for better performance and data acquisition system role to process the underwater signal

There are many types of digital filters such as FIR, IIR. FIR digital filter is implemented because it is conceptually simple to implement, possesses some attractive attribute and another important feature is these filters possesses linear phase. The entire signal frequency pass through the filter at same speed and phase distortion is avoided. Most other filter types generate some distortion due to non linear phase. The FIR filter structure is always stable and relatively simple compare to IIR structure[1].

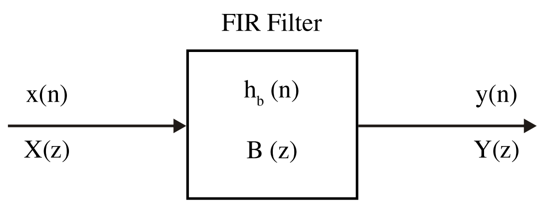

Figure 1: FIR Filter

The general difference equation for a FIR digital filter is

$$y(n) = \Sigma_{k=0}^{n-1} b_k \, x(n-k)$$

Where y(n) is the filter output at discrete time instance n.

b_k is the k_{th} feed forward tap or filter coefficients.

x(nk) is the filter input delayed by k samples.

Σ denotes summation from k=0 to k=n, where n is the no of feed forward taps in the FIR filter.

2.1. System Design of the Proposed Approach

Fig. 2 represents structure of implemented data acquisition system using ARM CORTEX R4 Processor.

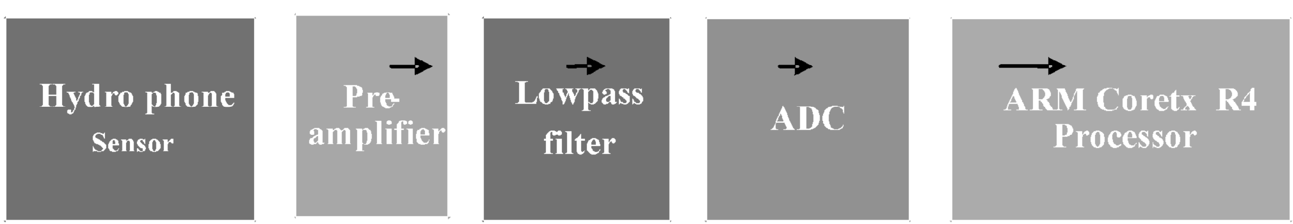

Figure 2: Block diagram of Data Acquisition system

The system uses the TMS570LS3137, was selected as the processor for this project. This was as ideal selection, as the ARM Cortex R4 Processor is extremely reliable because of processing functions are protected to high level of diagnostic coverage in hardware, greater accuracy, cheaper, ease of data storage and implementation of sophisticated algorithms[2]. An input voltage ranging from 0-5v is required for hardware kit, which corresponds with the hydrophone pressure sensor. An externally 16 bit analog to digital converter ADC7665, aids in the digitization of the analog signal acquired from sensor [3].

The preamplifier AD624 used to bring the signal up to the voltage range that is required by the input of analog to digital converter. The op amp ADA4084-2 is useful to implement low pass filter, before ADC to avoid aliasing.

3. DIGITAL FILTER ANALYSIS

To implement the proposed system, a digital filter algorithm is implemented by using mat lab and C.

In order to find the suitable digital filter for underwater applications. To evaluate, 50th order of the filter at different windowing techniques considering the characteristics are transitions width, minimum stop band attenuation, magnitude response, phase response, no of multipliers, adders, states, multi per input sample and add per unit sample using mat lab tool. Here hamming window is better approach to design FIR filter because of having better characteristics

Table 1
Filter different characteristics at various methods, Order = 50

Window name	*Transition width Approximate, exact value*	*Minstop band attenuation*	*Magnitude response (dB)*	*Phase response (radians)*	*No of multipliers adders, states, multi per input sample, add per unit sample*
Rectangular	4π/m 1.8π/m	21dB	+0.35	-15.78	51,50,50,51,50
Bartlett	8π/m 6.1π/m	25dB	-0.06	-15.85	49,48,50,49,48
Hanning	8π/m 6.2π/m	44dB	-0.004	-15.84	49,48,50,49,48
Hamming	8π/m 6.6π/m	53dB	0.02	-15.84	51,50,50,51,50
Blackman	12π/m 11π/m	74dB	-0.001	-15.82	51,50,50,51,50

4. EXPERIMENTAL RESULTS

The input wave form varies from mHz to KHz as shown in below figure 3.

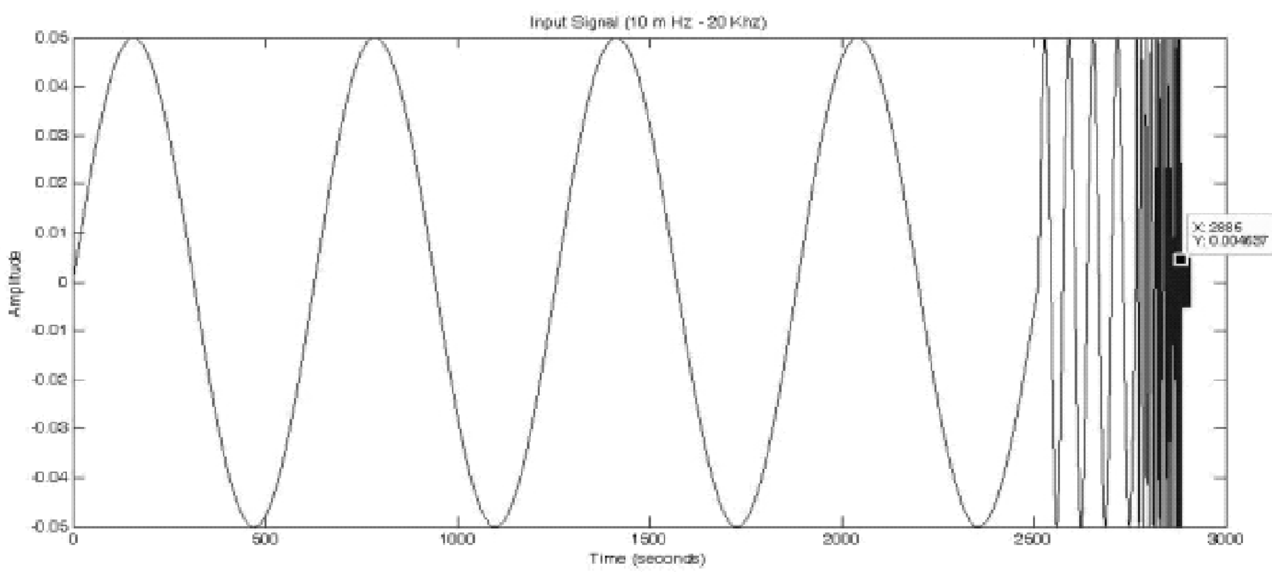

Figure 3: Input signal

The three channels are considered in the proposed work are: 0-2 Hz, 2-20 Hz and more than 20 Hz

0 to 2Hz channel specifications

The digital filter specification of channel 0 to 2 Hz is as shown in below.

Input voltage in terms of amplitude: 5V
Pass band frequency: 2Hz
Cut off frequency: 4Hz
Sampling frequency: 200Hz
Type of the filter: Direct form FIR
Order of filter: 50.

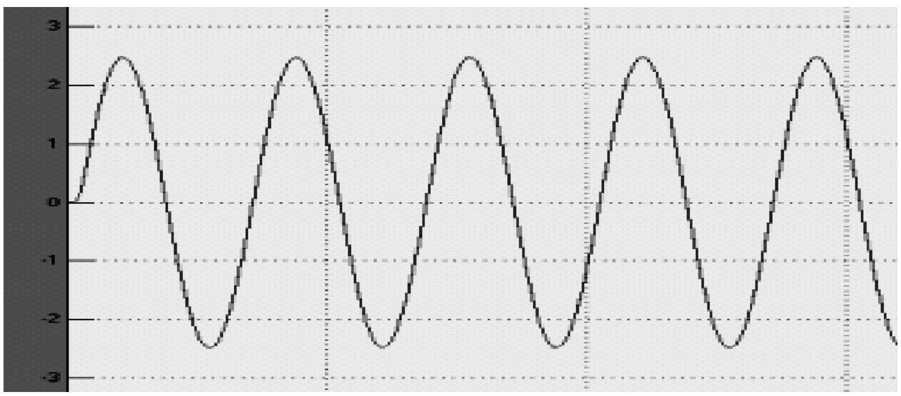

Figure 4: Output of the 0-2 Hz channel

The output of channel 1 is same as the input of the signal varying from 0 to 2Hz.

2 to 20Hz channel specifications

The digital filter specification of channel 2 to 20 Hz is as shown in below.

Input voltage in terms of amplitude: 5V
Input frequency: 16Hz
Cut off frequency: 4Hz
Sampling frequency: 200Hz
Type of the filter: Direct form FIR
Order of filter: 50.

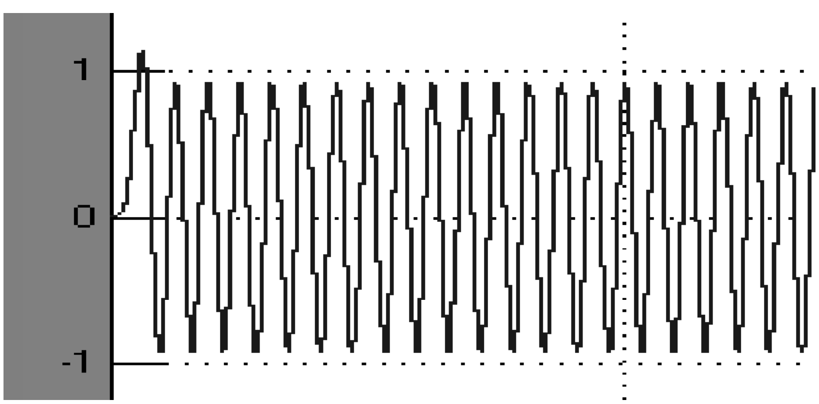

Figure 5: Output of the channel

More than 20Hz channel specifications

The digital filter specification of channel 2 to 20 Hz is as shown in below.

Input voltage in terms of amplitude: 5V

Input frequency: 35Hz

Cutoff frequency: 4Hz

Sampling frequency: 200Hz

Type of the filter: Direct form FIR

Order of filter: 50.

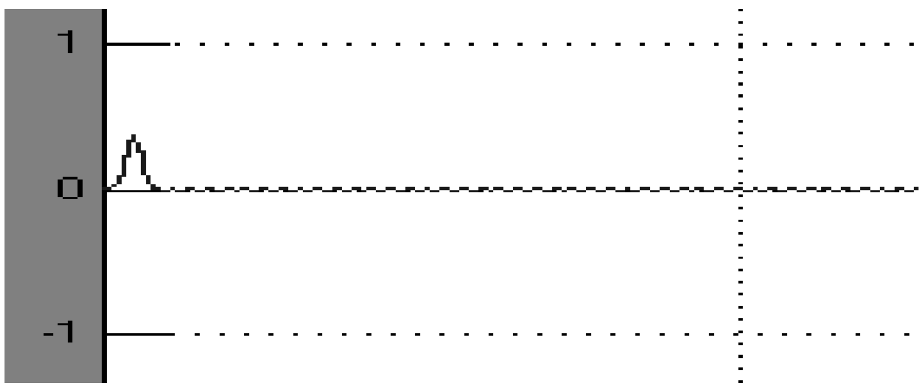

Figure 6: Output of the channel

When the input signal frequency increases the output signal get attenuate as shown in figures 4, 5 and 6.

5. CONCLUSION

The noise of underwater objects, noise made by cracks forming in the ice sheet and seismic signals travel with a low frequency. Hydrophone sensor measuring made over a frequency range extending from below Hz up to about 10 KHz signal , Based on hamming window technique FIR digital low pass filter is implemented in ARM Cortex R4 Processor, to process the signal and detection of objects with the help of data acquisition system.

6. ACKNOWLEDGEMENT

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