# OPTIMIZING THE COST TO QUALITY RATIO IN ULTRASONIC IMAGING

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**Abstract**: The paper deals with a part of the grant and phd research of the authors in obtaining quality ultrasonic images with a simple electronic equipment. Having in mind the fact that the image resolution increases with the number of the transducers in the array, the methods that ensure performance will be presented. By simulating on a adequate software, the sampling and conversion methods are selected to obtain quality images with a minimum hardware structure. Conclusions are drown by the authors on the methods used to optimize ultrasonic investigation from the cost quality point of view.

**Keywords**: beam former, sigma-delta converter, ultrasonic imaging

## 1. INTRODUCTION

In figure number 1 is presented the general structure of an ultrasonic imaging system in B mode, which is the reference for this paper. The transducer array contains N elements (N=64, N=128, N= 256), arranged in a linear configuration. The value of N is application dependent.

The system is initialized by the digital controller, which give the start command for the generation of a frame of N pulses from the pulse generator. Every pulse of the frame is delayed by the emitting beam former in order to steer and focus the transducer array on the desired direction and distance. The resulting pulses are sent to the array through the emission-reception switch resulting in the emission of a ultrasonic beam.

The echoes resulting from the interaction of the ultrasonic wave with the propagating environment are received by the transducer array. The corresponding electrical signals are amplified by the time gain controlled amplifiers to compensate for the signal attenuation during the propagation process. The amplified signals are applied to the receiving beam former, which sums and generates a directional and focused beam. The signal processor processes this information and generates the image that results from the ultrasonic investigation.

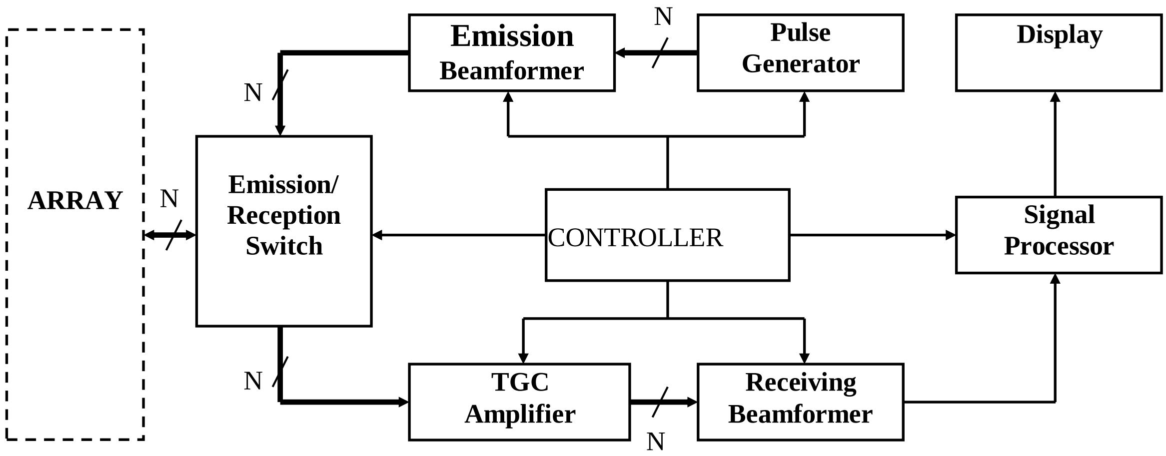


*Fig. 1 The block diagram of an ultrasonic imaging system in B mode*

For the two beam formers the following combination was chosen: fixed focusing at emission and dynamic focusing at reception. To achieve this, the digital implementation of the reception beam former is the best [3, 4]. Structural the digital beam former contains blocks for: dynamic focusing, sampling of the echo signals from the reception channels, for analog to digital conversion, for delay and for adding.

The sampling period can be uniform or not. It was chosen the non uniform sampling technique, which unlike at the constant sampling, the events happen synchronized with the delays [4]. Through this the hardware complexity is reduced substantially.

The analog to digital converter must have in view the sampling rate and the working speed especially for a large array of transducers. To obtain a quality ultrasonic image and at the same time to maintain a low complexity for the electronic equipment the digital beam former uses the over sampling sigma-delta converter [2, 4].

## 2. DISCUSSION AND EXPERIMENTAL RESULTS

The beam forming through delta-sigma conversion with non uniform sampling rate leads to the extraction of the nonlinear process of delaying from the modulator / demodulator assembly and the placement of it in front of the modulator. This way the synchronization of the modulator – demodulator is achieved, because in between the two it is only the adding operation. The block schematic with the structure of the receiving beam former is presented in figure 2.

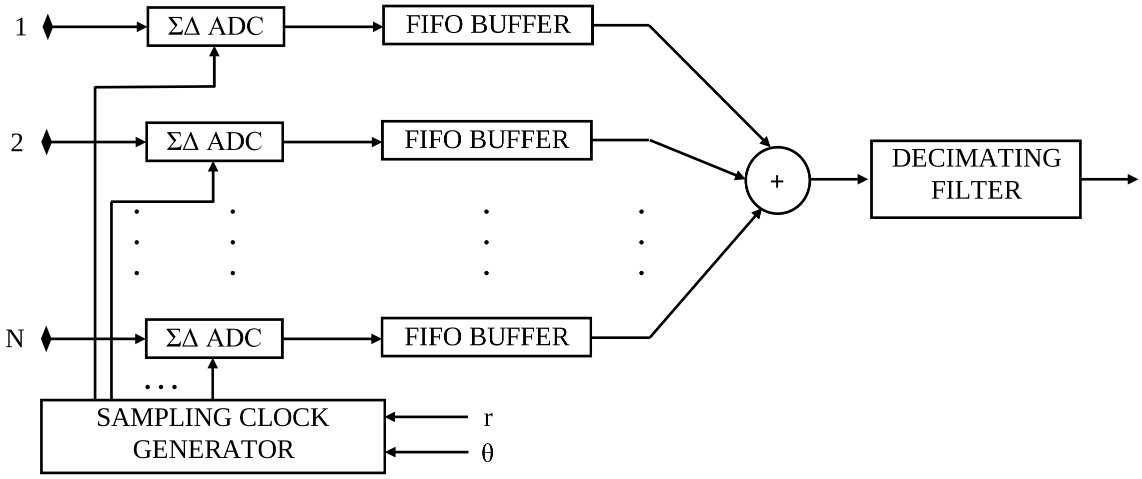


*Fig. 2 The structure of a non uniform delta-sigma modulation beam former*

The one bit coded samples that appear at different moments in time at the modulator outputs are aligned by the FIFO buffers on every channel and are transmitted synchronous to the adder. A rough version of the beam is generated that contains the error delay sum and the quantification noise. The beam is processed by the reconstruction/decimation filter; it eliminates the quantification noise and reduces the sampling rate close to the Nyquist sampling rate.

Through MATLAB simulation, based on real data from an array of 128 ultrasonic transducers, three types of beam formers were tested: the classical multi bit beam former, the sigma-delta with uniform modulation beam former and sigma-delta with non uniform modulation beam former. At the same time the performances of each beam former were tested through spectral analyses at beam level and the representation of the beam over time on a logarithmic scale.

In all three cases the quality of the ultrasonic image is basically the same the difference being at the hardware level. The delta-sigma implementation with non uniform sampling rate has the following advantages: a) the circuits for the delta-sigma analog to digital converter are far simpler leading in a reduction of resources for interconnection, space and consumption; b) precise delays are generated through the manipulation of the samples, obtained at a high sampling rate.

## 3. CONCLUSIONS

Using over sampling techniques images with quality similar to those generated with multi bit beam forming techniques can be obtained and at the same time the complexity of the circuits, the system size and the costs can be significantly reduced.

The considerable simplicity of the structure of the analog to digital converters allow for the structural redesigning of the receiving beam former in order to be implemented on two dedicated integrated circuits. The analog section that contains the delta-sigma converters will be implemented on an ASIC circuit. The digital section containing the digital delay lines, the adder, the decimating filter and the command and control block will be embedded in a single programmable circuit as a FPGA.

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