Transducer Interface for DSP Ultrasound Picture Processing

Aleksander Bekjarski[1]

Abstract - **The transducers are now very useful in medical echographic devices. It is most important to reduce the hardware of these devices and to improve the software performances and possibilities. The goal of this article is to present solution of a transducer interface coupled directly with a digital signal processor (DSP).**
Keywords:-**Transducers, echographs, digital signal processors.**

I. INTRODUCTION

The transducers are the parts of echographic devices for medical diagnostic and are very hardware specific blocks. They emit the ultrasound waves, receive the reflected ultrasound waves, transform the ultrasound waves in an electrical signal. There are two principal types of the transducers in accordance with the method of scanning: mechanical end electronical [1]. The electronical types transducers are most useful, because they haven the advantages: little dimensions, missing of mechanical moving parts, software control of the scanning and resolution. Software control give the possibility to involve with the law of scanning some effectively methods of signal preprocessing. These processing's make easier the rest of the signal processing and echographic image construction from the processed echographic signal.

II. THE FUNCTIONAL DESCRIPTION

The functional schema of a electronic ulrtasound transducer consist of an array of quartz ultrasound transmitters/receivers, high voltage switches for pulse quartz driving, the low voltage control register and output signal multiplexer. The connections between these functional blocks are shown in Fig.1.

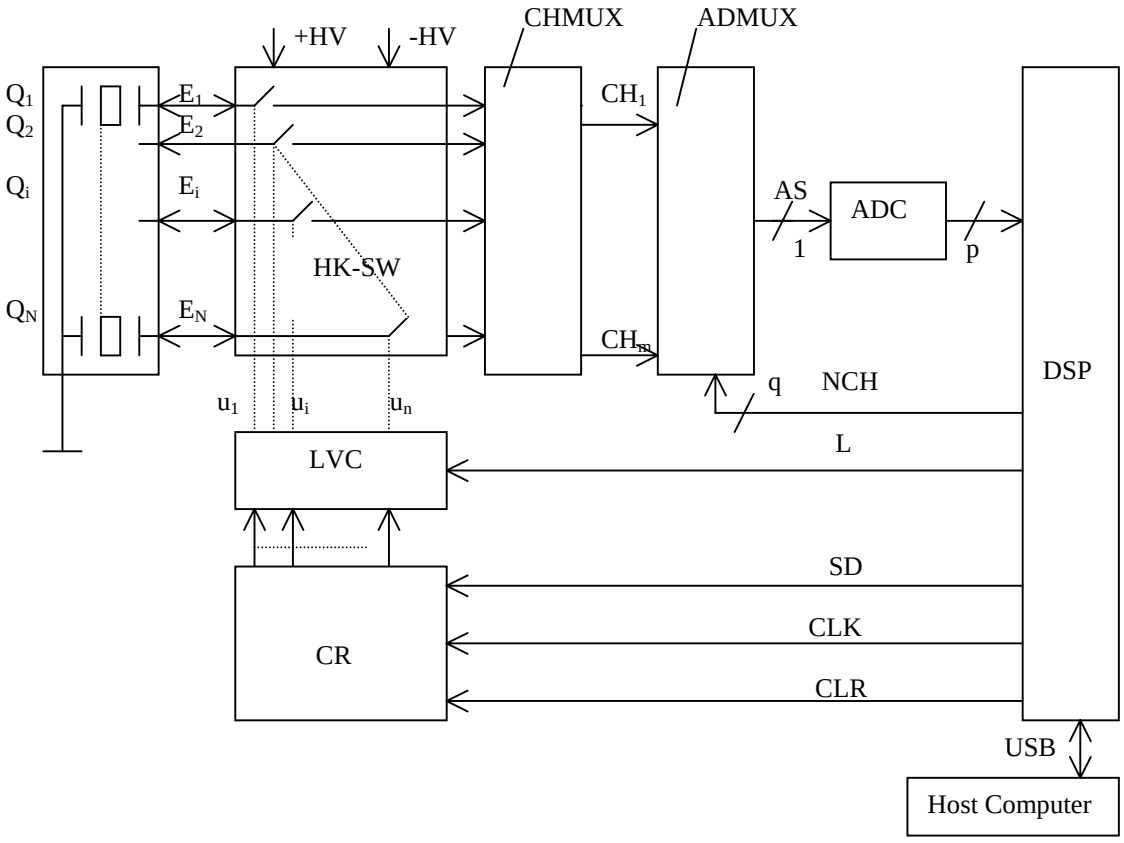

Fig.1. Functional block schema

[1]Aleksander B. Bekjarski is with the Faculty of Communications and Communications Technologies, TechnicalUniversity, Kliment Ohridski 8, 1000 Sofia, Bulgaria, E-mail: aabbv@vmei.acad.bg

The array of N-number of quartz ultrasound transducers Q_1, Q_2, …, Q_i, …, Q_n are connected with the n-numbers of high voltage pulse signals E_1, E_2, …, E_i, …, E_n. These signals are outputs of the high voltage switches HV-SW, which are with a high voltage +HV and –HV supplied. The other side of high voltage switches connected to channel multiplexer CHMUX, which decrease the number of lines from the quartz array to a number m (CH_1, CH_2, …, CH_i, …, CH_m):

$$m<n. \quad (1)$$

The value of *m* depend from the step *s*, with which the lines E_1, E_2, …, E_i, …, E_n are connected together. If for example E_1 is connected with E_i, Ei_{+1} with E_{2i+1}, etc. the value of the step is

$$s=i \quad (2)$$

and the value of *m*, which satisfy the condition (1) is:

$$m=n/s. \quad (3)$$

Very often *s* is chosen s=4 for a typical n=128.

The signals CH_1, CH_2, …, CH_i, …, CH_m are inputs for the analog to digital converter multiplexer ADMUX, which give at output AS in a moment only one of the input analog signals CH_1, CH_2, …, CH_i, …, CH_m. The control of the multiplexer ADMUX is made with the digital value NCH of the channel number *m*. The number of bits *q* for channel number NCH is:

$$q=\log_2 m. \quad (4)$$

The output AS of the multiplexer ADMUX is connected with the analog to digital converter ADC. The number of bits of analog to digital converter is chosen

$$p=\log_2 B, \quad (5)$$

where:

B is the number of gray scale levels for echographic picture (usually B=256, respectively p=8).

The low voltage control signals u_1, u_2, …, u_i, …, u_n for control of high voltage switches are outputs of the logic circuit LVC. This circuit is connected with the control register CR. The values of logical control signals u_1, u_2, …, u_i, …, u_n are stored in control register CR and is loaded in logic circuit LVC with the load signal L. This done the possibility to change the content of the control register independent from the values, which are loading in logic circuit LVC. The speed of control register CR changes is not match high. Therefore it is possible to load the values of control signals u_1, u_2, …, u_i, …, u_n in control register CR from a serial bus. This bus is two wire: SD – data and CLK – clock. There is a possibility to stop quickly all transducers activating without loading the control register CR. This is done with a clear signal CLR connected to the control register CR.

It is seen from fig.1, that all of the signals from and to the ultrasound transducer can be prepared in digital form:

- data bus with p-bits for input of the samples of reflected ultrasound signal from each channel CH_1, CH_2, …, CH_i, …, CH_m;
- control bus with q-bits for output of current value of channel number (usually q=5 for m=32);
- serial bus with two wire SD and CLK for data and clock;
- control signals L and CLR for load and clear low voltage signals u_1, u_2, …, u_i, …, u_n.

These digital lines can be connected and control from a digital signal processor or an universal microcontroller. The advantages for using a microcontroller are a simple hardware and software design and low cost, but the microcontroller have not the abbility for a complex signal processing. Therefore it is necessary to use a host computer for all steps of signal processing. In this article it is proposed to involve a digital signal processor (DSP) inside of ultrasound transducer block and interfacing the transducer hardware directly with digital signal processor (DSP). The adwantages of this proposition are, that it is possible to use the powerfull capabilities of digital signal processors (DSP) for some steps of ultrasound signal preprocessing and to transmit to the host computer the processed ultrasound signal in a compact form. The transmission can be made with a universal bus, for example USB (Universal Serial Bus).

A practical transducer interface is build with one of the popular digital signal processors TMS320C542 [2]. As an exemplary design it is used the DSK plus Starter Kit [3]. The rest hardware of transducer interface is designed with several 8 – channel High Voltage Analog Switches HV20220 [4].

CONCLUSION

It is proposed in this article a direct coupling of specific ultrasound transducer hardware to a universal digital signal processor (DSP). It is found in the practical hardware and software design, that this proposition is most flexible, compact and free the host computer from the time consuming preprocessing.

REFERENCES

1. Rumack C.M., S.R.Wilson, J.W.Charbonean. Diagnostic Ultrasound, Hardcover, New York, 1991.
2. TMS320C54x Fixed Point Digital Signal Processor. Data Sheet. Texas Instruments, 1999.
3. TMS320C54x DSK plus. DSP Starter Kit. User's Guide, Texas Instruments, 1996.
4. HV20220 Data sheet. Supertex Inc.