inter.noise 2000
The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE

I-INCE Classification: 7.8

DESIGN OF A CLINIC AUDIOMETER BASED ON PERSONAL COMPUTER

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Keywords:
AUDIOMETER, DSP, PCI, PMC

ABSTRACT
In this paper the hardware architecture of a new clinic audiometer based on personal computer will be presented. The use of state-of-the-art technologies will add new features to the system such as communications capabilities that will enhance actual audiometers. The system is made of: i) A digital signal processor based card with PCI interface that would be connected directly to the PC bus. ii) An analog-to-digital and digital-to-analog module compatible with the mezzanine standard. iii) A module with the analog electronics needed to accommodate the electro-acoustic sensor signals.

1 - INTRODUCTION

Most of the actual audiometers found in the market are autonomous. Thus, they run independently from a personal computer. The tendency has been to add to these audiometers communications capabilities that enables the user to use the data obtained from the audiometric tests realized. The possibility of developing an audiometer based on a personal computer permits to add new and enhanced capabilities to this instruments (data processing, storage, communication, etc) that could be highly difficult to implement in a classical version. In this sense the research study developed in the last few years has been focused to implement an audiometer completely integrated in the personal computer. The different phases that had been followed to achieve this objective are the following:

- Development of a precision attenuator with digital control and capability for generating signal levels from −10 dBHTL to 120 dBHTL free of clicks.
- Development of a hardware platform that generates the necessary signals for the audiometer (sinusoidal signals, broadband and narrowband noise for aerial and boned noise). This hardware communicates with the main system processor that controls the audiometric process.
- Development of a software application that handles the process and storages the results of the audiometric tests.

In the following paragraphs the two different audiometers that have been developed based on these aspects are presented.

1.1 - Type IV audiometer based on personal computer

Figure 1 shows the block diagram corresponding to this audiometer. The audiometer consist of the following blocks:

- The DSPS block contains the digital signal processors and the CODECS. It deals with the communication process with the host receiving the commands and generating all the necessary signals involved in the audiometric test. It also processes the signals coming from a microphone and from the patient's button.
- The signal conditioning block is the responsible for adapting and controlling the signal levels through the use of the attenuator. It has all the control logic for acquiring the patient's signal and configuring the attenuator. The precision attenuator has the mission of providing the required levels for the headphones with the highest precision. It is a self-calibrating attenuator.

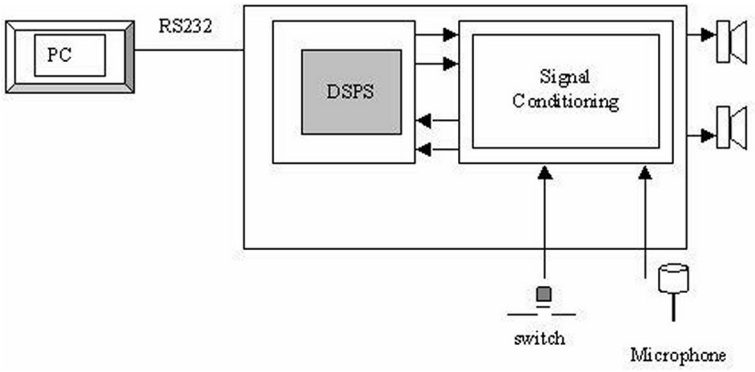

Figure 1: Block diagram of the Type IV audiometer.

The main advantages of this audiometer are:

- It conforms with IEC645 standard requisites [1].
- It is fully programmable from a personal computer.
- It has software developed for the computer that makes possible to storage and manage the results from the audiometric tests.

The main disadvantages are:

- The use of a one DSP per channel complicates system management.
- The restricted processing capability limits the number of operations to implement.
- The low speed communication interface between the personal computer and the DSP module.

1.2 - Clinic audiometer based on personal computer

Figure 2 shows the block diagram corresponding to this audiometer. The audiometer consist of the following blocks:

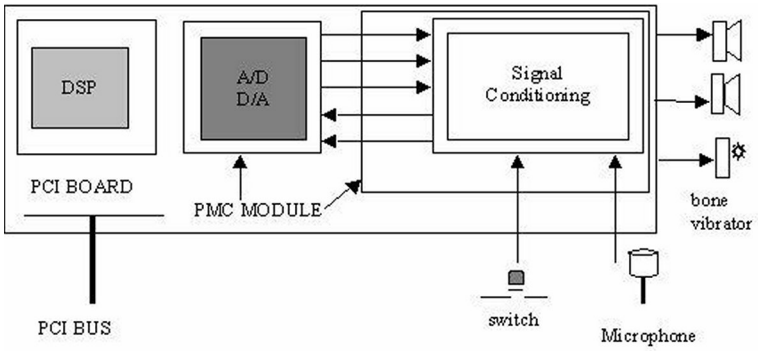

Figure 2: Block diagram of the clinic audiometer.

- A PCI card based on a 166 MHz version of the TMS320C6701 digital signal processor that generates the various signals for each channel, acquires the signal from the microphone and the patient's button and controls the audiometric test process. The software executed in the digital signal processor has been developed with the real time system DSPBIOS and the data interchange system RTDX, both from Texas Instruments.
- A PCI card in mezzanine format (PMC block [2]) that implements the analog to digital (A/D) and digital to analog (D/A) conversions needed in the system. Three D/A channels are used for the headphones and the bonded vibrator and one A/D channel is used for the microphone.

- Another PMC module that implements the signal conditioning elements for the signals of the microphone, headphones, bonded vibrator and patient's button. This module is based on the use of CS3300 programmable attenuators and low noise amplifiers.

The actual prototype is based on a commercial PCI card (PCIC6600) and an acquisition module (Q20DS) from Blue Wave System Inc.
The advantages of the system developed are:

- The audiometer is fully integrated in the personal computer.
- High space reduction has been obtained due to the use of the mezzanine standard.
- Easy upgradeable capabilities due to the use of the PMC modular technology that is based on a well developed standard (PCI).
- Increased system performance due to the use of a state-of-the-art digital signal processor and boost in communication speed as a result of the use of the PCI bus.
- Possibility of integrating the audiometer in more complicated software and hardware systems and adding new features using personal computer technologies: OLE, ActiveX, TCP/IP, etc.

The main disadvantage could be a high manufacture cost due to the use of state-of-the-art components with high scale integration technologies. This disadvantage will be overcome in the near future with its massive commercialization.

2 - CONCLUSIONS AND FUTURE RESEARCH

The main conclusion of this work is that it is possible to develop clinic audiometers that fully integrate in the personal computer and thus they can benefit from all the technologies present on the personal computer. One of the most important benefits in this aspect would be the one derived from the communications capabilities of the computer and all the related technologies that are being discussed nowadays such as the Internet. This aspect would be of real interest in the area of assisted care and telemedicine. Future research is focused in developing a single PCI card that contains the three complete modules with the aim of reducing final market price. This would also allow faster upgradeable capabilities for improving performance with new components available. The main goal is developing a modular structure based on the PMC technology that allows implementing different types of acoustic instruments. It is important to highlight that a patent has been obtained for the Type IV audiometer developed and a commercialization agreement has been signed with Bruel and Kjaer.

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