A TEOAE platform based on a sound card with high resolution

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Abstract

The paper describes some design aspect of an otoacoustic emissions (OAE) instrument for hearing assessment by using a personal computer and its affiliated sound card. The instrument functionality are achieved by means of virtual instrumentation programmed with LabVIEW utilities. Such OAE instrument is of high quality but relatively inexpensive, and has the potential for laboratory research and clinical practice.

1. Introduction

Otoacoustic emissions (OAEs) are the release of audio-frequency energy into the outer ear canal from the cochlea, transmitted through the auditory ossicles and the eardrum (Kemp, 1978). They can be recorded with a sensitive microphone placed in the ear canal. OAEs are generated spontaneously or evoked by acoustic stimuli. Transiently evoked otoacoustic emissions (TEOAEs) are evoked with transient acoustic stimuli. The measurement of TEOAEs has been widely used for many clinical applications.

2. Instrument Design

In the study, we designed an instrument to perform otoacoustic emissions (OAEs) testing which is a type of stimulus/response measurement to assess the cochlear performance. We built a TEOAE platform based on a notebook computer and its affiliated sound card (Creative Sound Blaster Extigy). The sound card processes the audio signals with very high quality. We selected such a sound card to develop the TEOAE platform due to two reasons. The sound card has audio quality of 24-bit resolution/96kHz sampling rate for its analog-to-digital (ADC) converter and digital-to-analog (DAC) converter ports. The performance of high resolution and high sampling rate ensure us to acquire the detail signal waveform of the tiny TEOAEs. Secondly, the sound card communicates with the notebook computer through an USB cable, and it can work as an external device to eliminate the noise effect induced by the notebook computer.

The functionality of the TEOAEs platform were achieved by the virtual instrument programs developed under LabVIEW’s graphical programming environment. LabVIEW’s graphical programming environment has several features that allow the developer to easily create the programmable OAE test-board. For spontaneous OAEs measurement, the platform should acquire the spontaneous emission and process lots of signal extraction and spectrum analysis. For the TEOAE testing, the instrument, furthermore, needs to create the complex trains of acoustic stimuli to evoke emission response. All these functionality need a flexible programming environment which is just the strength of Labview’s graphical programming.

3. Instrument Setup and Performance

As shown in Figure 1, the OAE platform included a personal computer (PC) equipped with Intel Pentium CPU, a Creative Sound Blaster Extigy sound card and an Etymotic Research’s ER-10C probe with a microphone and two speakers. The control program with friendly human-machine interface was programmed with the LabVIEW 6.0 software. The functionality of the TEOAE testing is executed as the following procedure. The PC runs the control program to generate the acoustic stimuli. The programmed acoustic stimuli are sent out through DAC of the sound card, and excite the speakers of the ER-10C probe. The stimuli evoke the TEOAEs that are sensed by the microphone, and are acquired into the PC through ADC of the sound card. The procedure is executed several hundred times to record sufficient TEOAE signals for later analysis.

With the human-machine interface in the PC, the operator’s commands such as experiment parameters, experiment procedures, and the data analysis could be fully controlled and transmitted to the Creative Sound Blaster Extigy sound card through the USB bus.

As shown in Figure 2, Human-Machine Interface consisted of initial value set of a TEOAE testing (ID number, right/left ear, stimulus control, average number, reject threshold), and output windows to display the final TEOAE measurement (reproduction ration, SNR, Accepted number, Rejected number, noise level, probe fit, wave pattern). About the algorithm for TEOAE analysis, we applied certain self-developed methods to process the TEOAEs [Li-Ping Yang]. A combination of derived nonlinear and linear methods is used to increase reproducibility of the TEOAEs. The results show that the average reproducibility of the TEOAE signals increased from...
78.1% to 88.7%. The analysis of noise influence on the TEOAEs is analyzed, and the modified wavelet method is also used to increase the accuracy of pass/fail criterions during the TEOAE testing.

Fig. 1 Block diagram of TEOAE acquisition system

Fig. 2 Human-Machine Interface

4. Conclusion

The study shows that a simple TEOAE platform can be easily built using a general notebook computer and its affiliated sound card. With the popular and familiar PC application, a user can easily adopt appropriate condition, procedure, and protocol to achieve the TEOAE testing and analysis under the proposed TEOAE platform. The TEOAE platform then exhibits its potential for laboratory research and clinical practice.

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6. References