DIGITAL AUDIO LABORATORY STATION

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Introduction

A new **Digital Audio Laboratory Station (DAL)** system (Fig. 1) was developed under **NeXTSTEP & UNIX** operating system. DAL system is available now on NeXT and IBM PC 486 /Pentium computers and will be soon available on HP, SUN, DEC and Canon computers. Research in the areas of acoustics, psychoacoustics, audio engineering, audiology etc, requires in many cases screening of the hearing abilities of the involved subjects and investigators. Required tests are often non-standard and need much better flexibility and precision than what is available from standard analog and digital equipment. With the DFG (Digital Function Generator) software [1,2], Digital Audiometer becomes a sophisticated Digital Audio Laboratory Station for performing any type of audio experiments. The fact that signal synthesis is implemented in software makes modifications very fast and simple, allowing for a rapid development of new experiments and testing procedures.

Fig. 1. Schematic Diagram of the Digital Audio Laboratory

Digital Audiometer

Audiometer.app was written for precise testing of hearing and advanced research in acoustics / psychoacoustics (Fig. 2). The quality of test signals is much higher than in the commercially available audiometers, since signal synthesis is performed in real time in digital domain and signals are dithered [3, 4]. This application is very useful for standard audiometric testing in the field of acoustics, psychoacoustics, music, sound engineering, audiology, speech pathology, etc. Signals are generated in real time according to algorithms developed by the authors [1, 2] and do not require a DSP processor (which is not available in some computers). Also the Digital Audiometer software works very well with the Digital Oscilloscope and Spectrum Analyzer (both applications come with the NeXT computer) and any recording / editing software. Playback and recording/analysis of the signal can be done simultaneously since DSP chip is not used and the main processor is used only 2->3% during signal reproduction.
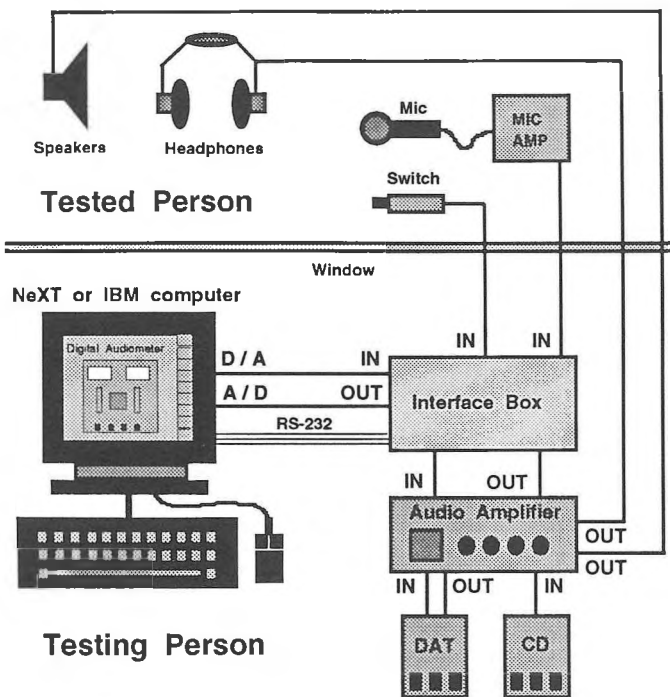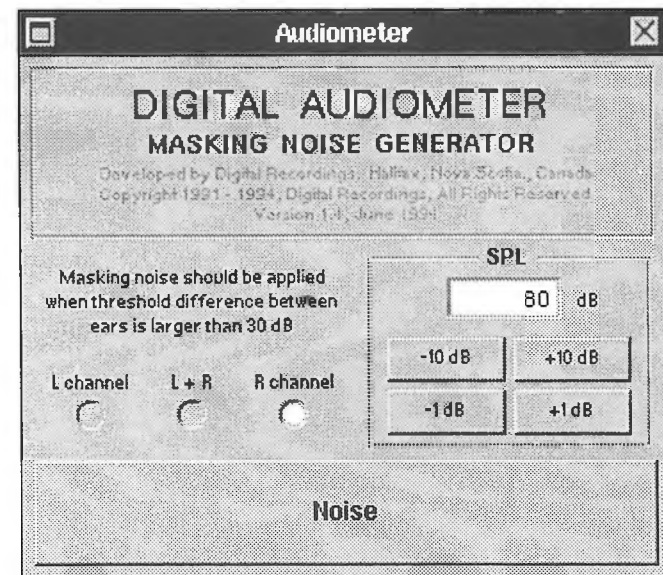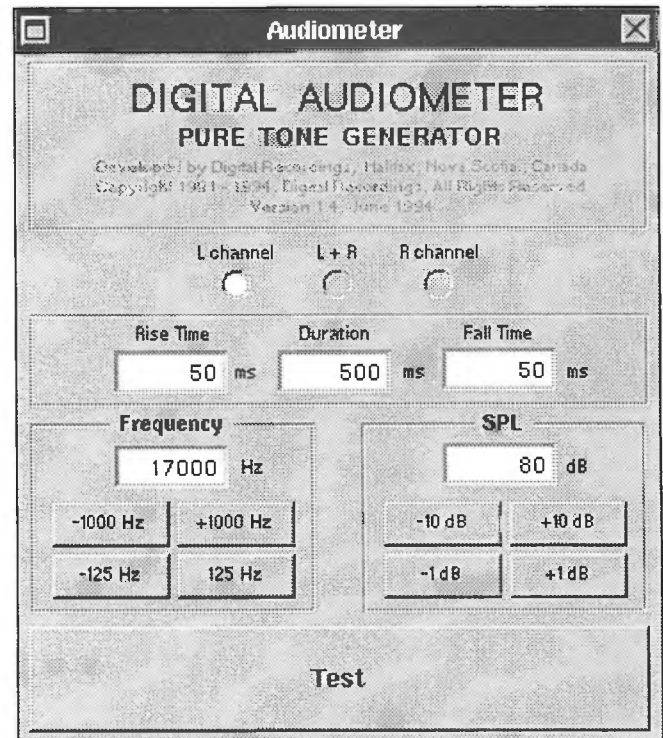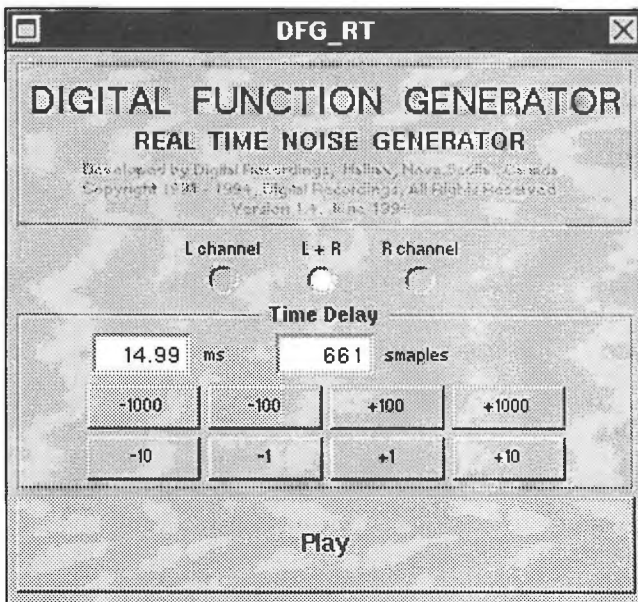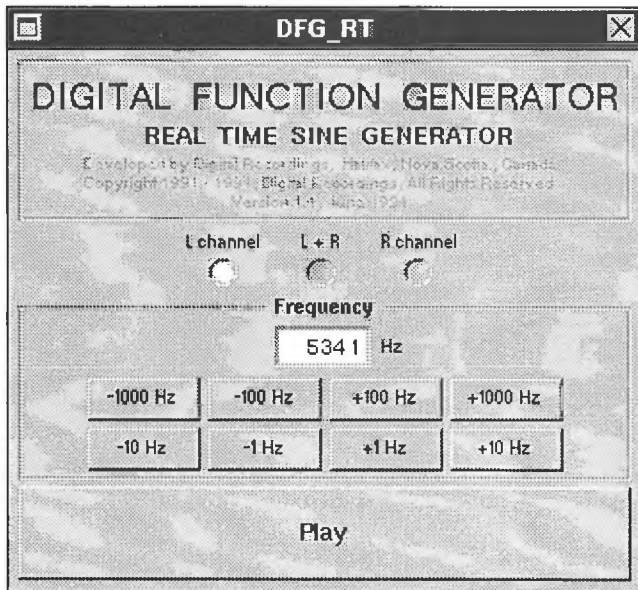
Fig. 2. Two software modules of Digital Audiometer

Below are listed main advantages of Digital Audiometer:

- frequency range: 20 Hz -> 20,000 Hz
- frequency stability +/- 0.001 Hz (at 1000 Hz)
- S/N = 95 dB (16 bit system)
- amplitude stability +/- 0.0003 dB (for 16 bit amplitude)
- no harmonic or intermodulation distortions (due to used algorithms and dithering)
- easy implementation of standard and non-standard tests
- easy modification of tests and procedures
- automatic and manual testing
- storage of all test signals in digital format
- high precision, consistency and no need for calibration
- archieving of test results on hard and optical disks
- further processing and statistical analysis of raw data
- display and printing of test results / data
- communication and exchange of results via E-mail / Ethernet
- low price, since this is software for popular computers
- easy upgrade and technical support, since it is software

Fig. 3. Two software modules of DFG_RT

Digital Function Generator

At the present time the DFG software [1, 2], which is part of DAL, consists of 8 modules.:

- **The Principles of Digital Audio module** allows synthesis of pure tones and white noise. It can also be used to illustrate concepts of signal amplitude, frequency, phase, interference, coherence, incoherence, signal ramping, additive synthesis, beats, virtual pitch as well as to demonstrate quantization, dithering, aliasing / hard clipping / harmonic / intermodulation distortions, etc.
- **The Modulation (AM, FM & AFM) module** allows synthesis of pure tones which can be Amplitude Modulated (AM), Frequency Modulated (FM) or Amplitude and Frequency Modulated (AFM).
- **The Additive Synthesis module** allows very flexible synthesis of complex sounds from their Fourier components.
- **The Sweep Generator (AS, FS & AFS) module** is a very flexible tool for generating arbitrary amplitude (AS), frequency (FS) or amplitude and frequency (AFS) sweeps.
- **The Function Generator module** can be used to synthesize sine, square, triangular, sawtooth, pulse and white noise signals.
- **The Sound Sequencer module** can be used for construction and playback of arbitrary sound sequences.
- **DFG_RTsine** module was written for real-time synthesis of the sinusoidal (pure tone) signals (Fig.3). Signals are generated in real time and do not require the DSP processor. Playback and recording/analysis of the signal could be done simultaneously since DSP chip is not used and main processor is used only 2->3% during signal production.
- **DFG_RTnoise** module was written for real-time synthesis of the noise signal (Fig.3).

DFG is used with great success in teaching of acoustics, psychoacoustics , audio engineering, and in various research projects at many universities in Canada, USA, Europe and Asia.

Conclusions

The most precise digital-domain method for the generation of arbitrary audio signals was successfully implemented on the NeXT and IBM-PC 486 computers [1, 2]. Since NeXTSTEP / UNIX is a multitasking environment, many software applications can run simultaneously.Digital Audiometer and DFG software by-design put very little demand on the hardware and do not require a DSP processor for sound synthesis. This allows the Digital Oscilloscope, Spectrum Analyzer and Sound Recording software to run simultaneously with DFG [1]. This in turn allows very sophisticated tests and demonstrations in acoustics,psychoacoustics, audiology, electronics, physics and engineering to be performed on a single NeXTSTEP / UNIX computer.

References

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