winDSK6:
Using the Power of the C6X DSK

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Abstract

The TMS320C6X DSK is a versatile and powerful teaching tool, however, there are limited options to easily demonstrate its capabilities or conduct classroom demonstrations. By combining the real-time performance of the DSK with prepackaged applications that use the familiar graphical user interface on the host PC, ***winDSK6*** *opens new doors for using the DSK.* ***winDSK6*** *is a new version of the author's winDSK software for the C31 DSK, and includes numerous demonstration programs that give the educator prepackaged tools to illustrate and drive home signal processing concepts. These have proven invaluable in classroom and laboratory demonstrations in a variety of settings. The applications include an oscilloscope/ spectrum analyzer, audio graphic equalizer, arbitrary waveform generator, and tunable notch/bandpass filters.* ***winDSK6*** *also incorporates utility functions including a DSK confidence test and an application for creating and debugging real-time PC-host/DSK applications. The paper will discuss the architecture of the winDSK6 software, the interaction between the DSK program and the host PC application, and how both educators and students can use these capabilities to create new and exciting real-time PC-hosted DSK applications. The author freely distributes the software for educational use.*

I. Introduction

For the most effective learning, students need to be motivated to the point that they are excited about where a course will lead them, and have some vision of what new doors it will open to them. Simple in concept, but often difficult in execution. As digital signal processing (DSP) becomes ever more present in our curricula (and in the workplace), there is a constant need to motivate students to *want* to work through the mathematics by showing them the power of what they are learning, in a way that they can relate to *before* they can completely comprehend the theory involved. As teachers, we need to be able to grab our students' interest, we need to be able to provide interesting and significant demonstrations of DSP capabilities, and we need provide continuing support to our students' efforts once we get them started. Unfortunately, in subjects like digital signal processing and computer engineering, we often seem to spend more time teaching how to use the tools then we do teaching the material. This seemingly endless series of tools students (and faculty) have to learn, be they programming languages, user interfaces, new hardware, new instruction sets, and so on, continues to constitute a significant roadblock to student progress and our innovation as teachers.

To combat this problem, the author previously developed the **winDSK** [1] software for the Texas Instruments TMS320C31 DSP Starter Kit (DSK), which continues to be used around the world. **winDSK6** is the next evolution in that process, harnessing the much more potent TMS320C6211 DSK, and providing an intuitive, turn-key solution for demonstrating signal processing concepts and supporting student efforts to develop meaningful real-time DSP projects. It provides students (and teachers) with an immediate, substantive, and engaging demonstration of the DSK's capabilities.

winDSK6 is a Windows 9X/NT application intended to provide a positive "out of box" experience to students, and to provide additional utilities and functions to make the DSK even more accessible to them. It contains numerous demonstration programs that emphasize audio and visual interaction, including an oscilloscope/spectrum analyzer, graphic equalizer, audio effects, DTMF generator, and arbitrary waveform generator. Help files for each application introduce the underlying theory at work in producing the effect. **winDSK6** also provides a DSK Confidence Test, and a Host Port Interface testing and debugging tool.

II. Software Architecture and Operation

winDSK6 is a stand-alone application consisting only of the executable and support files. The application is written in C++, and is centered on an object that encapsulates the DSK and its physical interface to the host computer. Communications between the host PC and the DSK are based on the API supplied by Texas Instruments, with the host PC mastering all communications. To provide the most versatility, only a single memory location in the DSK software, which contains the address of the shared data table the host accesses, is required to be in a fixed location. Individual applications are dialog-based, and each performs a similar task sequence to execute the appropriate DSK application;

> Reset the DSK, load the DSK application code, and start it running,
> Determine the location of the DSK application's shared data table, and
> Synchronize the host user interface and the DSK state.

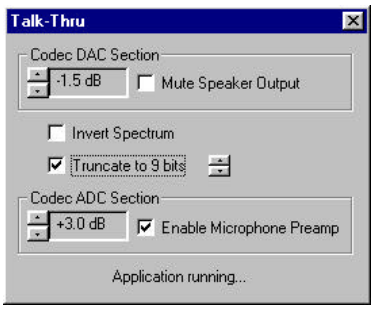
All this occurs immediately upon selecting an application from the menu or toolbar. Once the application is running, the host computer controls the DSK application's behavior by modifying memory locations within the DSK application shared data table in response to the user changing control settings in the dialog window. This real-time interactivity provides immediate results on the DSK in response to user actions.

III. DSK Applications

The demonstration applications showcase a number of audio signal processing operations. All programs only require the basic DSK in order to operate, no additional circuitry is required. Several new applications have been added in response to specific requests from professors who needed to demonstrate certain effects. Each application is supported by a short theory section in the application=s help files that explains the operation of the application.

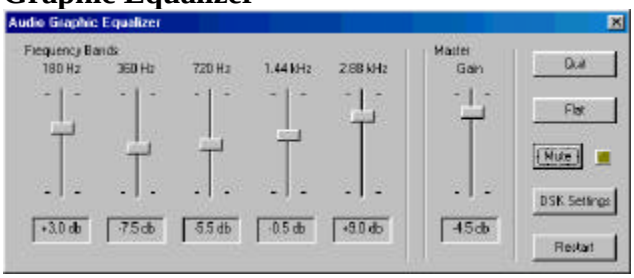
A ADSK Settings@ button on most applications allows the user to reconfigure the analog interface circuit gains on the fly. A "Restart" button allows restarting each application at its default settings. The demonstration applications include;

Talk-Thru



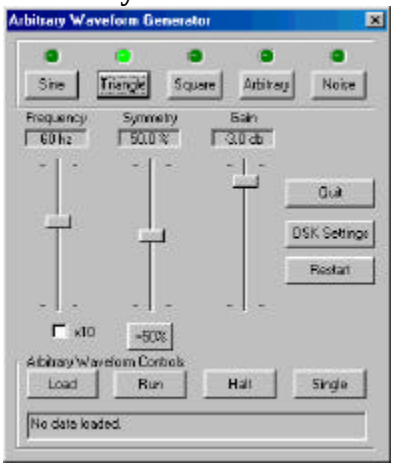
This application takes audio input from the ADC and passes it back out through the DAC. All aspects of the TLC320AD535 CODEC on the DSK can be controlled. The user can also vary the effective number of bits from the full 15-bit range of the AIC down to a single bit, demonstrating the relationship between quantization and signal-to-noise ratio. The concept of spectral inversion can also be demonstrated.

Graphic Equalizer



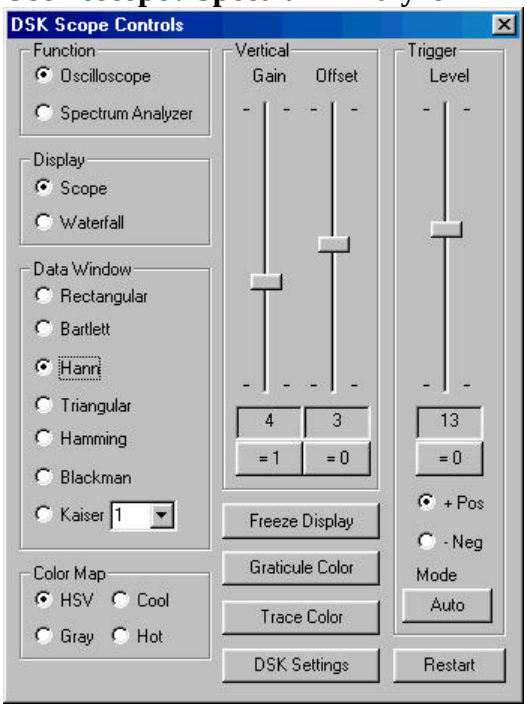
The five-band graphic equalizer uses five parallel 128th order FIR filters, with the gain of each filter independently controlled by a slider control. A master gain control, mute button, and flat button provide additional control.

Arbitrary Waveform Generator

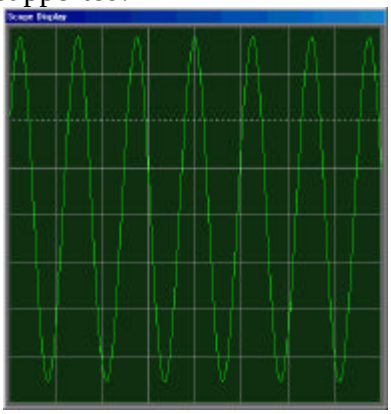


The arbitrary waveform generator generates sine, square, and triangle waves at frequencies between 1 Hz and 1 kHz, with selectable symmetry for the triangle and square waves. A noise generator function is also available. In addition, it can load up to 1 million sample values from an ASCII file and then operate as an arbitrary waveform generator. The data is automatically scaled to the full range of the DAC. Continuous and single pass arbitrary signal generation is supported. A sample chirp file is included with the software.

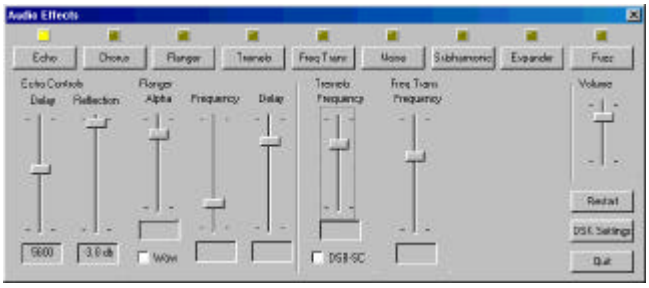
Oscilloscope / Spectrum Analyzer



The oscilloscope / spectrum analyzer can operate as a standard oscilloscope or as a spectrum analyzer. The resizable display window can be viewed as a conventional oscilloscope, or a waterfall display can be selected with various colormaps. For spectral analysis, a number of different data windows can be selected. Standard oscilloscope triggering methods are also supported.

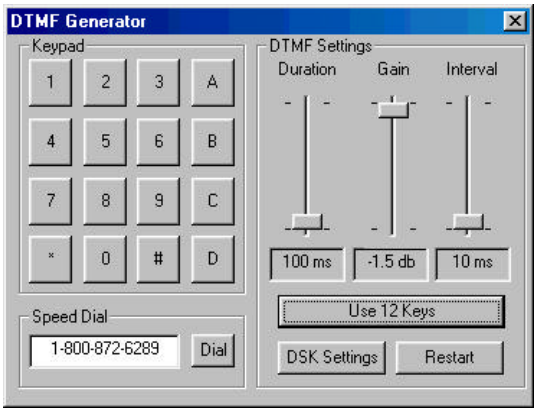


Audio Effects



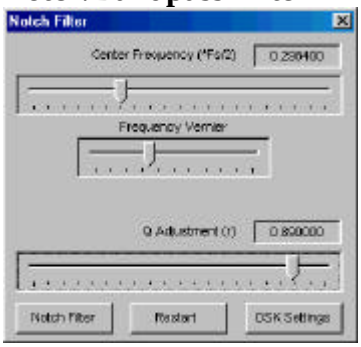
The audio effects application demonstrates a variety of signal manipulations possible using DSP, including echo, chorus, flanging, tremelo (amplitude modulation), noise, and frequency translation. Many of the effect parameters can be varied well beyond the customary values used with music to produce unusual effects.

DTMF Generator



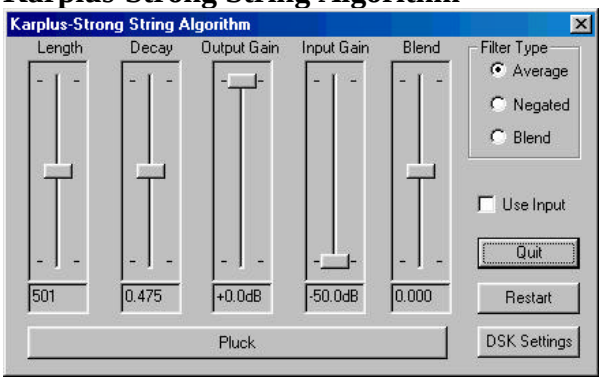
The DTMF generator can generate all 16 DTMF tone pairs. The duration of each tone, as well as the interval between tones, can be adjusted. A 12-key or 16-key keypad can be selected. A speed dial feature operates in the same way as a typical telephone.

Notch/Bandpass Filter



This application implements a single stage IIR filter acting as a notch or bandpass filter. The filter center frequency and Q can be adjusted.

Karplus-Strong String Algorithm

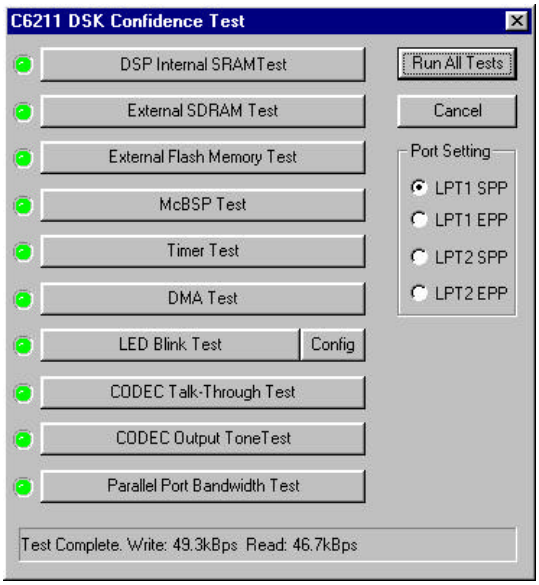


Implements the Karplus-Strong string algorithm [2] to synthesize a plucked string. The delay buffer length, decay coefficient, and the filter type are all user adjustable. Additionally, the ADC input can be processed through the algorithm by using it to excite the string buffer on a continuous basis.

IV. DSK Utilities

The DSK utilities provide support for testing and debugging DSK applications. A flash programming utility will be added in a future version to facilitate using the DSK in bootable embedded system projects.

DSK Confidence Test



The DSK Confidence Test is an easy way to test the basic functionality of the DSK, providing a graphical interface to the confidence test supplied with DSK. Visual indicators show test progress and status. Each test may be run individually, or all can run in an automatic sequence. In addition, the DSK Confidence Test also tests and reports the speed of the parallel port connection between the host PC and the DSK in both directions.

Host Port Interface (HPI) Test

The Host Port Interface (HPI) Test application tool includes a COFF/DSK/HEX program loader, and permits reading/writing selectable memory locations while a DSK program is executing. Memory locations can be selecting by entering the appropriate value, or by picking program labels from a list. The data can be viewed, edited, and written in floating point or integer forms. The HPI Test is particularly useful for modifying memory when reading and writing must be done independently, a function that is not available under Code Composer.

V. Future Enhancements

The most exciting planned enhancement to **winDSK6** will be added support for a low cost daughtercard under development that will provide a two-channel analog interface capable of 16-bit operation at 48 KHz. This will greatly enhance the capabilities of the DSK, and open the door to many more interesting applications. Optimized native support for the TMS320C6711 DSK will also be incorporated in future versions. Additional applications and demonstrations will be incorporated as well, and updated versions will be made available as discussed below.

VI. Conclusions

winDSK6 has proven extremely useful in numerous DSP, signal and systems, and other courses, and provides an excellent platform to demonstrate DSP concepts. It provides a strong audio-visual demonstration and exploration tool to help motivate students, and enhances the capabilities of a powerful hardware tool. We also routinely use it to good effect at various open-house events to demonstrate interesting audio signal processing effects and show the concepts of spectral analysis, since it requires so little equipment, is so easy to set-up and use, and promotes interaction between the presenter and the audience.

The author freely distributes this software for educational, non-profit use, and invites user comments and suggestions for improvement. At the time of publication, the final distribution site was unavailable. Interested parties are invited to contact the author via e-mail at *morrow@ieee.org*.

References

[1] M. G. Morrow and T. B. Welch, “winDSK: A Windows-based DSP Demonstration and Debugging Program,” in *Proceedings of the IEEE International Conference on Acoustics, Speech, and Signal Processing*, (Istanbul, Turkey), June 2000

[2] Karplus, K., and Strong, A., “Digital Synthesis of Plucked-String and Drum Timbres,” *Computer Music Journal*, Vol. 7, No. 2, Summer 1983

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