TEXAS INSTRUMENTS

# TMS320C6000 Multichannel Vocoder Technology Demonstration Kit

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## ABSTRACT

This application report describes the content of the TMS320C6000 Multichannel Vocoder (MCV) Technology Demonstration Kit (TDK). The kit includes a GUI host program that allows the user to configure multiple channels of several vocoders being processed on a 'C6x EVM. The TDK also includes a number of application reports, which are listed in the References section of this report.

## Contents

# 1 Introduction

This application report describes the content of the TMS320C6000 Multichannel Vocoder (MCV) Technology Demonstration Kit (TDK). The kit includes a GUI host program that allows the user to configure multiple channels of several vocoders being processed on a 'C6x EVM. The audio source can be connected to the line-in jack on the EVM or a hard disk resident audio file. The output can be directed to a speaker/headphone via the line-out jack of the EVM, or it can be saved in a hard disk file.

The ADK also includes a number of application reports, which are listed in the References section of this report.

# 2 What is in the Demo?

This demo presents a fully functional multichannel voice coder application running on Texas Instruments (TI™) C6000 DSP. The demo consists of two distinctive parts, the DSP application and the host application.

The host application is responsible for sending commands to the DSP for run-time channels and I/O configuration and for streaming data between the host and the DSP. It is a Win32 application built for both Windows 95™ and Windows NT™.

The DSP application consists of up to 10 concurrently active *channels*. Each active *channel* has at least one input I/O port, one output I/O port and up to 3 different algorithms. For each channel, the underlying framework is responsible for acquiring input data from assigned I/O input port, using assigned algorithm/algorithms to process those data, and sending the outputs to assigned I/O output port. All assignments of I/O ports and algorithms to a certain channel are performed by the host. The DSP application is built using the *DSP BIOS* kernel and TI's *Multichannel Run Time Environment (MCRTE)* technology, including *Chip Support Library (CSL), Board Support Library (BSL)* and *Channel Manager Library (CM)*.

Currently, 4 I/O ports are supported in the demo, each port has 10 channels.

- Host Port Input 0 – 9
- Host Port Output 0 – 9
- Serial Port Input 0 – 9
- Serial Port Output 0 – 9

In total, eight algorithms are supported in the demo. They are:

- G.729. 8 kbps/s CS-ACELP speech coder and G.729 Annex A, a reduced complexity CS-ACELP speech coder, fully interoperable with G.729

- Enhanced Full Rate GSM speech coder

- EVRC. IS-127 Enhanced Variable Rate Speech Coder

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- G.723.1. Dual rate speech coder transmitted at 5.3 and 6.3 kbps

- G.726. 40/32/24/16 kbps Adaptive Differential Pulse Code Modulation (ADPCM)

- G.165 Echo Cancellation algorithm

- Echo Simulation algorithm dedicated to add simulated echoes into voice signal

- Dummy voice coder: does nothing but copy data in input buffer to output buffer

Table 1 summarizes the algorithms in the MCV TDK demo.

**Table 1. Multichannel Vocoder TDK Algorithm Summary**

| Algorithm | Frame Size (ms) | Bit Rate (kbps) | Stack Size (Bytes) | Code Size (Bytes) | Context Size (Bytes) | | Table Size (Bytes) | C6201 MHz |
|-----------|-----------------|-----------------|---------------------|-------------------|---------------------|------|---------------------|-----------|
| | | | | | Enc. | Dec. | | |
| G.723.1 | 30 | 5.3/6.3 | 7964 | 73600 | 1488 | 452 | 19000 | 14.4/23.2 |
| G.729/A | 10 | 8 | 2764 | 86720 | 1948 | 1644 | 6032 | 25.6/16.3 |
| G.726 | Configurable | 16/24/32/40 | 196 | 24384 | 1188 | 1188 | 232 | 3.2 |
| GSM EFR | 20 | 12.2 | 5664 | 65536 | 3320 | 1740 | 10204 | 13.1 |
| EVRC | 20 | Variable Rate | 5748 | 91232 | 2772 | 1412 | 14312 | 26.0 |
| G.165 LEC (32ms) | Configurable | NA | 256 | 4512 | 2092 | | 0 | 3.2 |

NOTE: The above algorithms are compiled from their respective C codes, some without any hand optimization. The program is running from off-chip memory using the internal program memory as cache.

# 3 Getting Started

## 3.1 Hardware Requirements

- An IBM compatible PC with a Pentium 200MHz CPU or better, at least 24 Mbytes RAM

- TMS320C6201/C6701 EVM board* plugged into one of the PC's PCI connectors, with dip switch 3,5,7,9 off, all others on

- A splitter connected to the stereo line-in jack of the EVM board. The splitter has two stereo inputs and one stereo output and can be bought at Radio Shack

- A pair of audio cables connected to the 2 inputs of the splitter

- Two audio sources for left and right inputs of the codec, each connected to one of the audio cables. For example, a CD player and a cassette player

- A pair of speakers connected to stereo line-in jack of the EVM board, for example, Radio Shack AMX-16 speakers, CAT. NO 40-1363

## 3.2 Software Requirements

- EVM Support Software for TMS320C6x DSP correctly installed in your PC. It can be verified by running the EVM confidence test.

- Code Composer Studio 1.0 and up with DSP BIOS support

- The multichannel vocoder TDK demo software installed

To launch the demo, double click host.exe from Windows Explorer. A dialogue window will then pop up asking for a DSP coff file. Select target.out and click OK.

## 3.3 GUI Overview (Host)



**Figure 1. Main GUI Window**
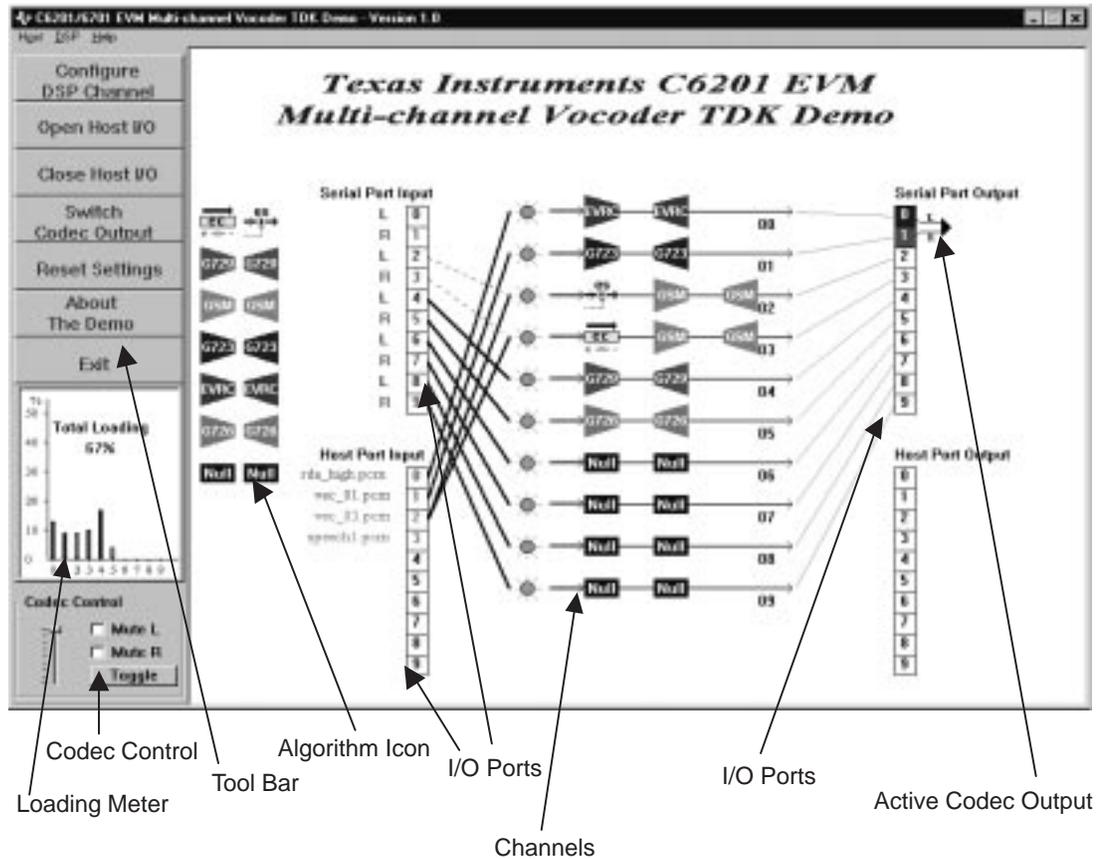
**Algorithm Icons:**

| | | |
|---|---|---|
| | Coder | Decoder |
| Speech Coders | | |
| Echo Cancellor + Echo Simulator | ec | es |
| G.729 | G729 | G729 |
| GSM EFR | GSM | GSM |
| G.723.1 | G723 | G723 |
| EVRC | EVRC | EVRC |
| G.276 | G726 | G726 |
| Dummy | Null | Null |

L: Codec Left Channel Input/Output

R: Codec Right Channel Input/Output

**Legends:**

——— **Channel Input**

——— **Channel Output**

– – – **Echo Source**

# 4 Code Composer Studio Window with DSP BIOS Real Time Analysis (Target)
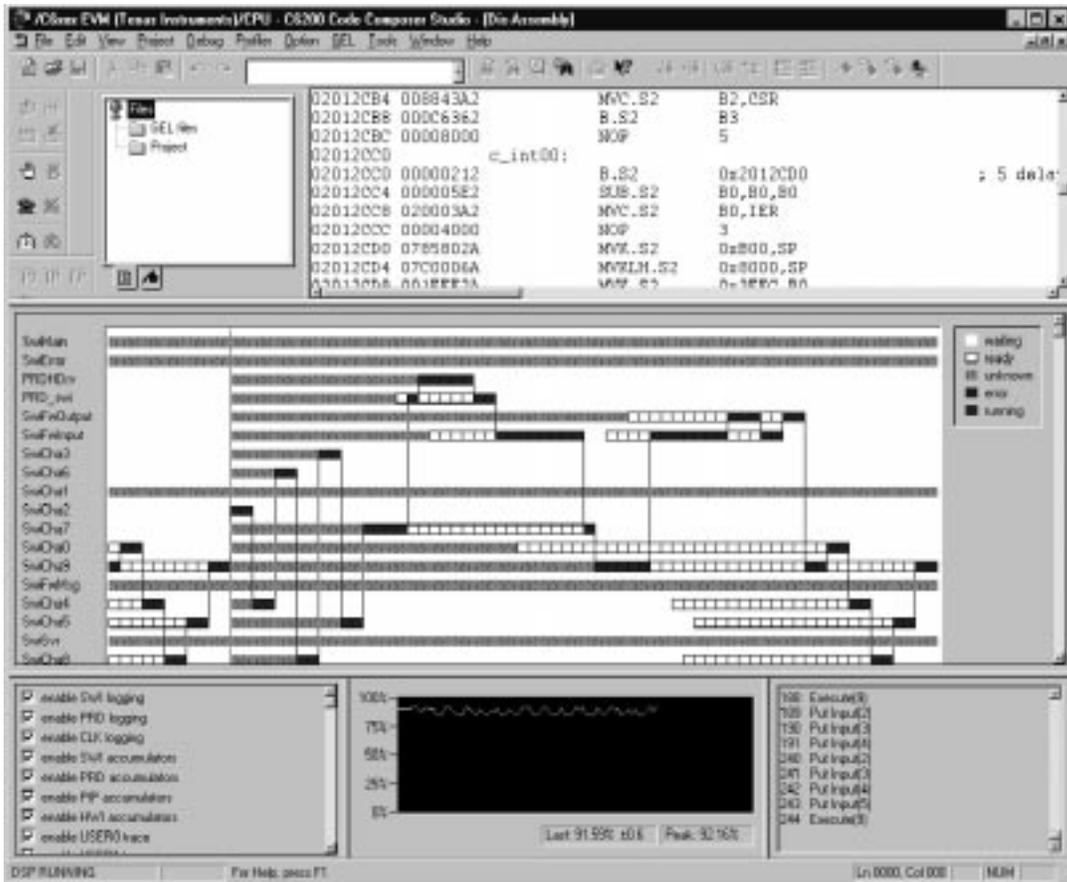


**Figure 2. Code Composer Studio Window with DSP BIOS Real Time Analysis**

# 5 Configuring Channel Components

To configure algorithm components of a channel, the following method can be used:

- "Drag and Drop" is the simplest way to make changes to the channel components setting. Move the mouse to the desired component icon located at the leftmost part of the client window. Push the left mouse button down to select that component, drag it to the target channel, and drop it there by releasing the left mouse button. This operation may add a component to that channel or replace old ones, depending on the previous settings and the component selected.

- If more than one component needs to be selected, for instance, encoder + decoder, you can select both of them by drawing a rectangle encompassing the components. Hold the left mouse button down, draw the rectangle, and after finishing drawing, release the button. The color of the selected components will be inverted. Drag the components to the target channel and drop them there. This replaces the old components regardless of the previous settings, except for echo canceler and echo simulator.

- Double-click on the desired channel. This brings up the *Channel Configuration Dialogue Box.* You can go through the dialog box and configure channel components and channel I/Os as well as all other parameters. This is the only way to completely configure all settings of a channel at one shot.

- Either click the "Configure DSP channel" button in the tool bar, or select DSP in the menu bar and then select the "Configure DSP Channel" item under it. This brings up the same *Channel Configuration Dialogue Box* as in previous case. However, now you must specify the desired channel number.
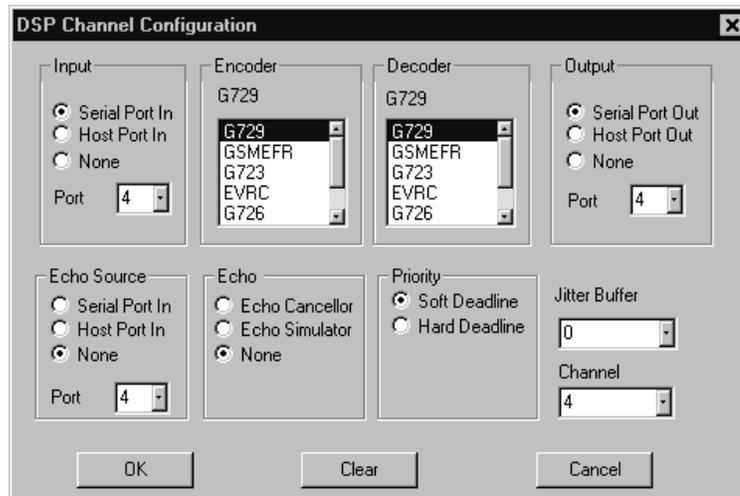


**Figure 3.  Channel Configuration Dialog Box**

# 6    Configuring Channel I/O

To configure channel I/O, use the following method:

- Move the mouse to the selected I/O port and select it by pushing down the left mouse button. Hold the button down while moving mouse to the desired channel, and release the mouse button to link the I/O port with the channel.

- Double-click the desired channel. This brings up the *Channel Configuration Dialogue Box.* You can go through it and configure channel components, channel I/Os and all other parameters. This is the only way to completely configure all settings of a channel with one action.

- Either click the "Configure DSP channel" button in the tool bar, or select DSP in the menu bar. Then select the "Configure DSP Channel" item under it. This brings up the same *Channel Configuration Dialogue Box* as in the previous case, except you must specify the desired channel number.

- Double-click left mouse button at either the left or right end of the desired channel.  This disconnects the input or output I/O port previously associated with the channel.

# 7  Displaying and Configuring xDAIS Algorithm Parameters

There are two sets of parameters for each DAIS-compliant algorithm. One is called creating parameters, and the other is called status parameters. The two are usually different from each other.

- To display and configure the *creating parameters* of a xDAIS algorithm, for example, Line Echo Cancellor, follow these steps:

  1. Move the mouse cursor on top of the icon of the echo cancellor located in the upper left corner of the client window.

  2. Click the right mouse button. After a *menu* appears on the screen, select the item "properties" from it.

  3. A dialogue box pops up on the screen with all the configurable parameters for the algorithm.

  4. Modify the parameters and then click OK. The creating parameters of that algorithm are now updated.

If the algorithm is already up and running in a channel, its *status parameters* can be displayed and configured similarly by moving mouse cursor on top of that algorithm in the channel. Follow the steps described above.
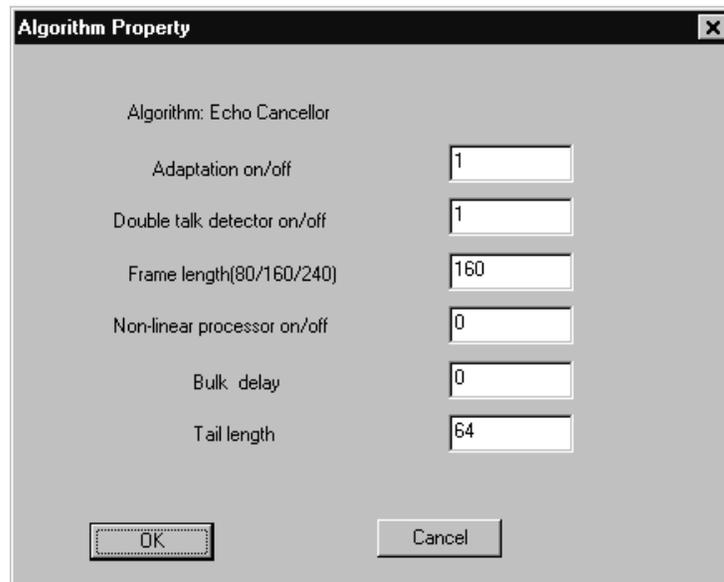


**Figure 4.  xDAIS Algorithm Parameter Configuration Dialog Box**

# 8 Opening Host I/O Ports

To open a host channel, use the following methods:

- Move mouse cursor to the desired host channel, select it by double-clicking the left mouse button, the *Open Host I/O Dialogue Box* will come up. You must specify the type of file to be opened as well as file name. To locate the file, push the browse button. This demo supports six types of files:
  - Raw PCM
  - G.729/G.729A bit stream
  - GSM EFR bit stream
  - G.723 6.3 kbps and 5.3 kbps bit stream
  - G.726 16 kbps, 24 kbps, 3two kbps, and 40 kbps bit stream
  - EVRC bit stream

  After all the information is provided, click "OK". If the file is opened successfully, the file name appears beside that host channel and the channel is highlighted.

- Either click the "Open Host I/O" button in the tool bar, or select "Host" in the menu bar and then select the "Open Host I/O" item under it. The same *Open Host I/O Dialogue Box* will be brought up as in the previous case, except that you must specify the desired I/O port as well as channel number.
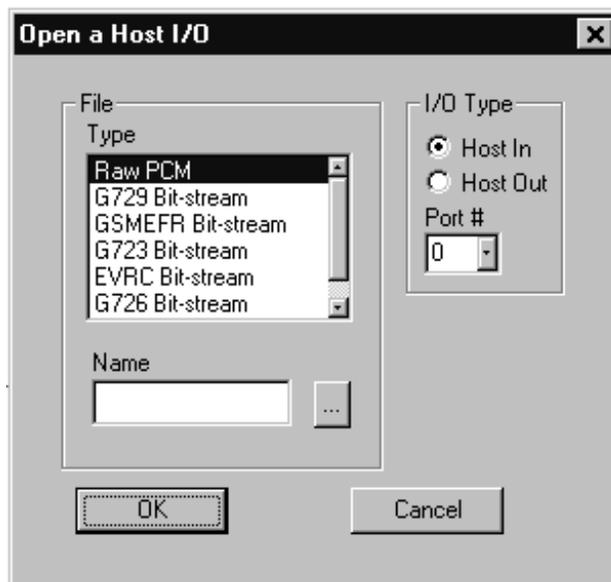


**Figure 5.  Open Host I/O Dialog Box**

# 9 Closing Host I/O Ports

To close a host channel, use the following methods:

- Move mouse cursor to the desired host channel, select it by clicking the *Right* mouse button, a *Close Host I/O Dialogue Box* will come up. Click to close this I/O port.

- Either click the "Close Host I/O" button in the tool bar, or select "Host" in the menu bar and then select "Close Host I/O" item under it, the same *Close Host I/O Dialogue Box* will be brought up as in the previous case, except user has to specify the desired I/O port as well as channel number.
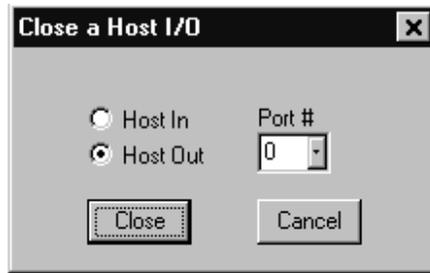
**Figure 6.  Close Host I/O Port Dialog Box**

## 10    Resetting Settings for all Channels

To clear all settings for all channels, click the " Reset Settings" button in the tool bar. A *Reset All Settings Dialogue Box* will come up to ask for confirmation. Click "OK" and all channels will be disabled with no affiliated algorithm components and I/O ports. You can also select the menu item "Reset Settings" under DSP to do the reset.
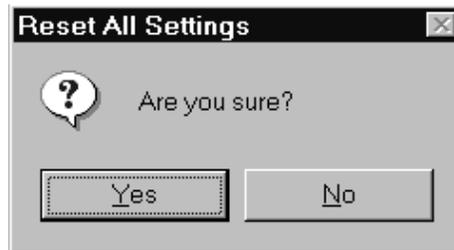


**Figure 7.  Reset All Settings Dialog Box**

## 11    Switching Codec Output

The current pair of codec output ports that connected with the codec is highlighted in blue and red colors. To change the output pair, select the desired output port by moving the mouse cursor onto it. Double-click the left mouse button. The selected pair of output ports is now highlighted.

## 12    EVM Stereo Audio Codec Control

The *Codec Volume Control Box* is located at the lower left corner of the GUI window, below the loading meter. The sliding bar on the left controls the output volume of both left and right channels of the codec. The two check boxes on the right control whether the outputs of either the left or right channel or both are muted. The button underneath the check boxes toggles the selection in the two boxes.
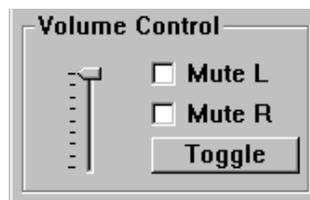


**Figure 8.  Volume Control Box**

## 13 Target (DSP) CPU Loading Meter

Each vertical bar in the loading meter indicates the percentage of the target (DSP) CPU loading in processing a channel. The total CPU loading is also displayed.
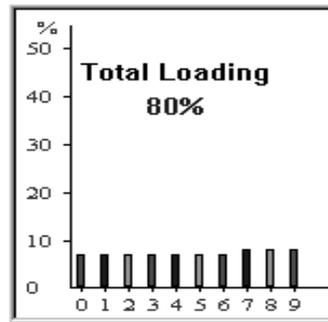


**Figure 9. DSP Loading Meter**

## 14 References

Refer to the following application reports to learn more about the MultiChannel/Algorithm System on TMS320C6000.

1. Xiangdong Fu and Zhaohong Zhang, *TMS320C6000 DSP Multichannel Vocoder Technology Demonstration Kit Host Side Design*, SPRA558.

2. Xiangdong Fu, *TMS320C6000 DSP Multichannel Vocoder Technology Demonstration Kit Target Side Design*, SPRA560.

3. Chiouguey Chen, *G.726 ADPCM Speech Coder: Multichannel TMS320C62x Implementation*, SPRA563.

4. Chiouguey Chen, *G.729 CS_ACELP Speech Coder: Multichannel TMS320C62x Implementation*, SPRA564.

5. Min Wang, *GSM Enhanced Full Rate Speech Coder: Multichannel TMS320C602x Implementation*, SPRA565.

6. Min Wang, *IS-127 Enhanced Variable Rate Speech Coder: Multichannel TMS320C62x Implementation*, SPRA566.

7. Thomas J. Dillon, Jr., *G.723.1 Dual Rate Speech Coder: Multichannel TMS320C62x Implementation*, SPRA562.

8. Peter Dent, *Implementation of Echo Control for G165/DECT on Texas Instruments TMS320C62xx Processors*, Application Report, May 1998.

9. Zhaohong Zhang, *Performance Analysis of Line Echo Cancellation Implementation using TMS320C6201*, SPRA421.

10. Zhaohong Zhang, *Analysis of Filter Coefficient Precision on LMS Algorithm Performance for G.165/G.168 Echo Cancellation*, SPRA561.

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