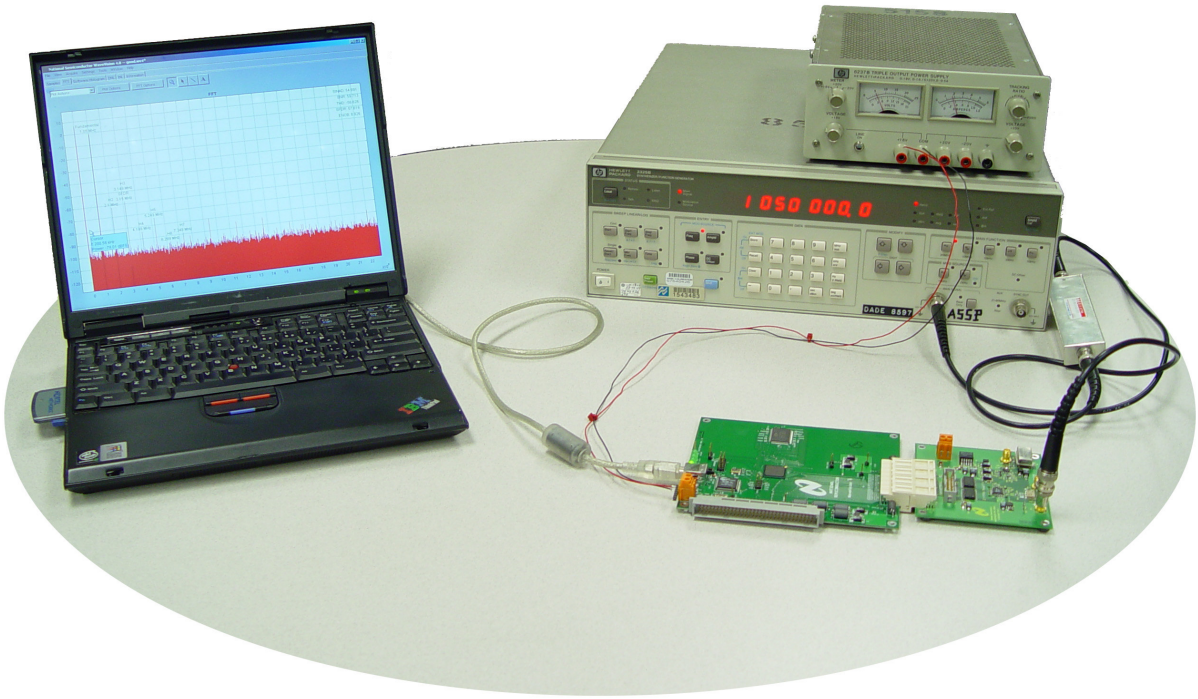
National Products
from Texas Instruments

National Semiconductor's

WaveVision4

Data Capture System



User's Guide

October 2006

Table of Contents

Table of Contents 2
1 WaveVision4 System 3
1.1 What is the WaveVision4 System? 3
1.2 WaveVision4 System Features 3
1.3 Packing List 3
1.4 Board Layout Overview 4
1.5 Component Description 5
1.6 WaveVision4 Data Capture Board Test Points 5
2 System Functionality 6
2.1 System Block Diagram 6
2.2 General System Overview 6
2.3 Automatic Device Detection & Configuration 7
2.4 Modes of Operation & LED Indicators 7
2.5 Memory 8
2.6 Computer Interface 8
2.7 Power Requirements 8
3 Quick Start Guide 8
3.1 Install the WaveVision4 Software. 8
3.2 Install the WaveVision4 Hardware. 8
3.3 Launch the WaveVision4 Software 9
4 Use with Older WaveVision System ADC Boards. 9
4.1 Wave Vision 1/2/3 device board with WaveVision4 Hardware and Software 9
4.2 WaveVision 1/2/3 Capture and Device board with WaveVision4 Software 10
5 Java™ Technology 11
6 Troubleshooting 12
7 Windows Driver 14
8 WaveVision4 Software Basics 15
8.1 Basic Features 15
8.2 Board Settings 15
8.3 Capturing Data for ADCs 15
8.4 Viewing Data 16
8.5 Running a DAC board 16
9 Using WaveVision4 Plots 16
9.1 The Waveform Plot 17
9.2 The FFT Plot 17
9.3 FFT Options 18
9.4 Histogram Plots 18
9.5 Information Viewer 19
10 Data Import and Export 19
11 Driving a DAC 19
11.1 Waveform type: Sine, SineX/X, Sawtooth, and Triangle 20
11.1.1 Clock Selection 20
11.1.2 Waveform Selection 20
11.1.3 Waveform Data Adjust 21
11.1.4 Start/Stop 22
11.1.5 Close 22
11.2 Waveform type: Pulse 23
11.3 Waveform type: DC 24
11.4 Waveform type: File 25
11.4.1 Open File 25
11.4.2 Scale/Crop Data 25

1 WaveVision4 System

This User's Guide primarily describes version 4.1 of the WaveVision Data Capture Board and its use. However, reference is made to version 4 where it differs from version 4.1. Generically, the system is referred to as "WaveVision4", regardless of the version. Accordingly, wherever "WaveVision4" is mentioned, it means both "WaveVision4" and "WaveVision4.1", unless otherwise stated or implied.

1.1 What is the WaveVision4 System?

The WaveVision4 system is National Semiconductor's platform for evaluating analog-to-digital and digital-to-analog converters. It is composed of three core components:

- A WaveVision4 Data Capture Board
- A software program that runs on a Microsoft® Windows® XP/2000 based personal computer, herein referred to as simply the "WaveVision4 software."
- A National Semiconductor ADC or DAC Evaluation Board

This manual describes the features and operation of the WaveVision4 Data Capture Board and software only. Each ADC and DAC evaluation board comes with its own User's Guide, which documents its specific features.

1.2 WaveVision4 System Features

- Transfers data rapidly with full-speed USB 2.0 (USB1.1 for version 4).
- Provides jumperless, plug-and-play configuration.
- Supports a wide variety of ADC and DAC Evaluation Boards.
- Fast data capture (up to 200 MHz) with wide (36 bit) data bus.
- Capable of performing FFT analysis and hardware histograms.

1.3 Packing List

The WaveVision4 kit (National order number WAVEVSN BRD 4.1) consists of the following components:

- WaveVision Data Capture Board
- WaveVision4 software on CD-ROM
- USB cable
- User's Guide (This Document)

1.4 Board Layout Overview

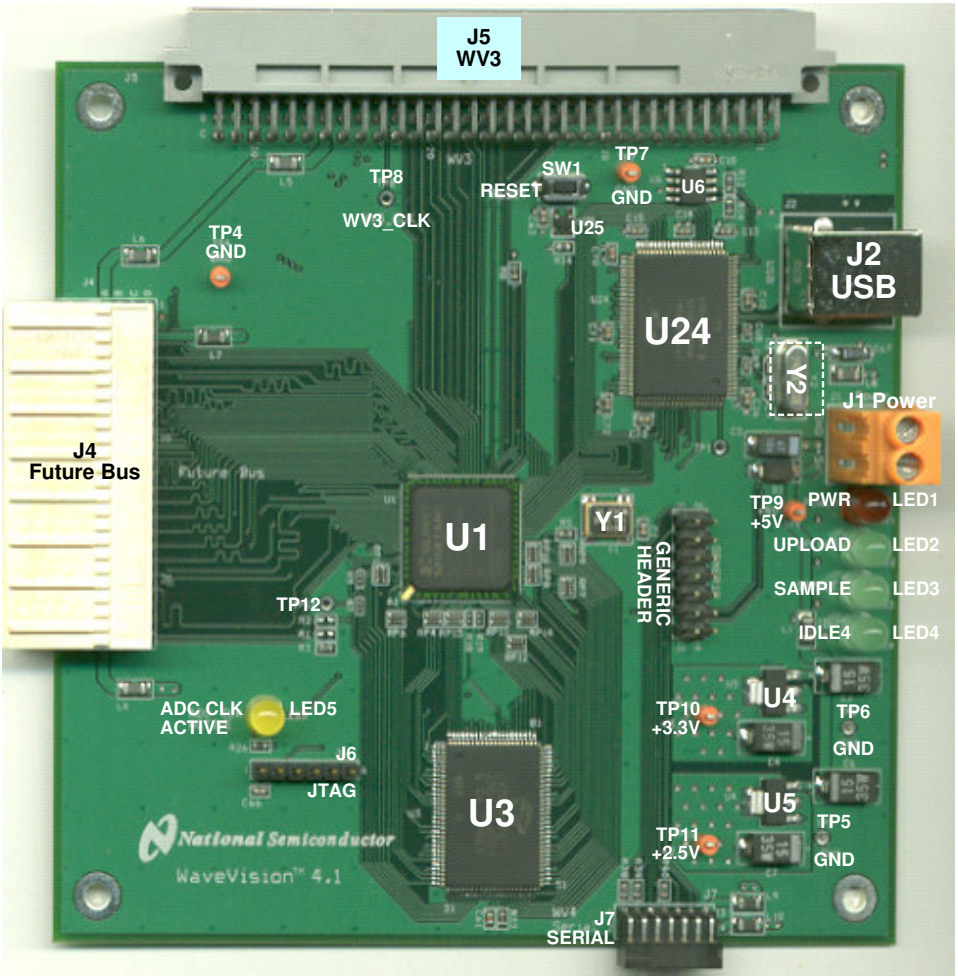


Figure 1 WaveVision4 (version 4.1) Data Capture Board Layout

1.5 Component Description

The following table describes both the on-board connectors and the main components used in the WaveVision4 System shown in Figure 1.

Component	1.5.1.1 Description
J1 (POWER)	+5V Power Supply Connection (See Section 3.2)
J2 (USB)	USB cable Connection.
J3 (GENERIC)	General-use header connected to the FPGA (U1). Consult the ADC/DAC evaluation board user's guide for more information.
J4 (Future Bus)	Future Bus Connector
J5 (WaveVision3)	WaveVision 3/2/1 System (96-pin Euro header)
J6 (JTAG)	JTAG Header
J7 (Serial)	Serial DUT Board Interface (ver. 4.1 only)
U1	FPGA
U3	Synchronous SRAM (200MHz)
U4	National LM1117MPX-2.5 (2.5V Regulator)
U5	National LM1117MPX-3.3 (3.3V Regulator)
U6	Configuration EEPROM
U24	USB microcontroller
U25	LM3722 (Power-On Reset)
LED1-4	Status LEDs. (See section 2.4)
LED5	ADC/DAC Clock Present LED (See section 2.4)

1.6 WaveVision4 Data Capture Board Test Points

The following table describes the main Test Points available.

Test point	Description
TP8 (WV3_CLK)	Test Point for the clock coming across the WV3 connector
TP10	+3.3V (Regulated) test point.
TP11	+2.5V (Regulated) test point.
TP4,5,6,7 (GND)	Ground test points.
TP9	+5V Power Input

2 System Functionality

2.1 System Block Diagram

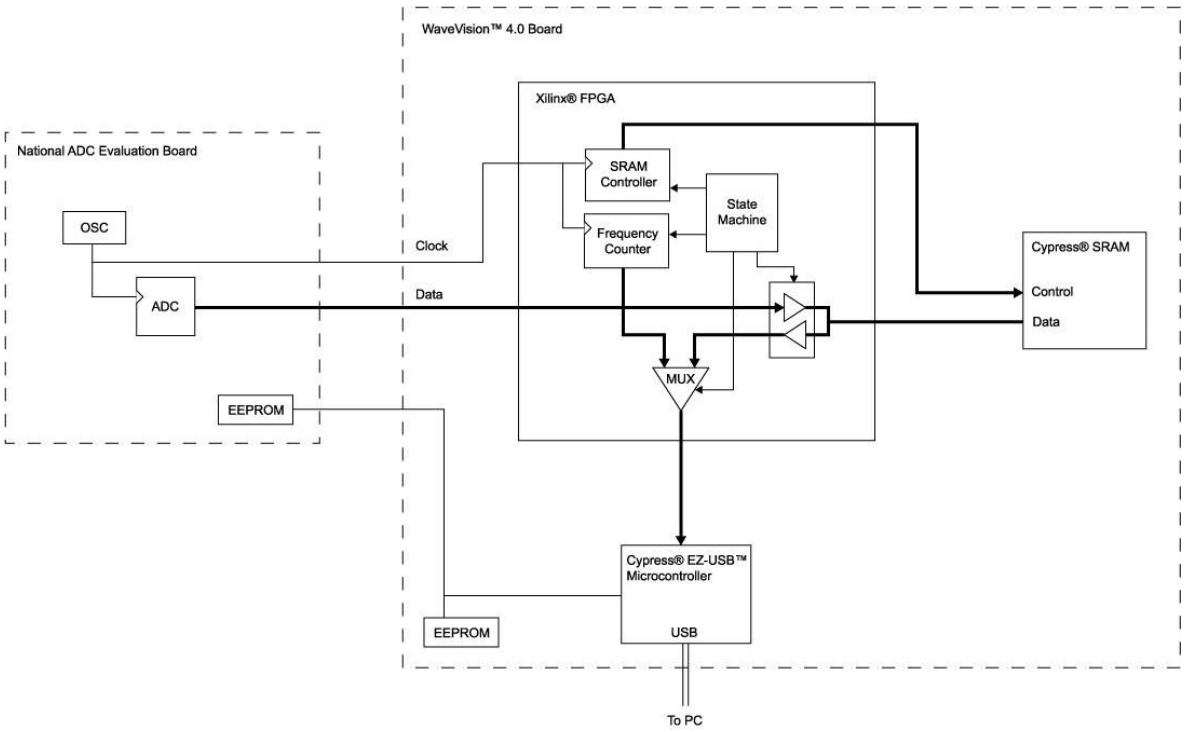


Figure 2: WaveVision4 System Block Diagram

2.2 General System Overview

2.2.1.1.1 ADC Evaluation Boards

The ADC evaluation board (shown in Figure 2) delivers conversion data along with a source-synchronous clock to the Future Bus connector (J4) or to the serial connector (J7). The data and clock signals are connected directly to the FPGA Device (U1) on the WaveVision4.1 Data Capture Board. During data capture, the FPGA acts as a Synchronous SRAM controller, which is clocked by the ADC Evaluation Board. The ADC data flows through the FPGA and is stored to the SRAM (U3). After data is uploaded to the PC for analysis, the SRAM controller is clocked by an onboard 100 MHz oscillator (Y1). The data is presented to the USB microcontroller (U24), which routes it across the USB bus to the host PC.

A frequency counter function in the FPGA measures the frequency of the incoming ADC clock. This value is used during the FFT calculation to provide accurate and meaningful signal analysis.

2.2.1.1.2 DAC Evaluation Boards

For DAC evaluation boards, data capture is not provided; instead waveform data is downloaded from the PC into the USB microcontroller, which transfers it into the FPGA. The FPGA then places the data into SRAM. The FPGA reads the SRAM and feeds the data continuously to the DAC through the serial connector (J7), which generates a waveform output. The rate at which the data is fed to the DAC is determined by a user selectable clock divisor passed from the PC to the USB microcontroller to the FPGA. The FPGA divides the 100MHz clock by this divisor to determine the DAC update rate.

2.3 Automatic Device Detection & Configuration

The WaveVision4 system provides automatic hardware detection and configuration for the device under test. The FPGA is re-programmed on the fly by the host PC when the WaveVision4 Data Capture Board is turned on, or whenever the ADC or DAC evaluation boards are exchanged.

Normally, the configuration process is totally transparent to the user, and requires no intervention. However, this process can be overridden if required. Refer to the device evaluation board manual for more information.

Important Note: Many of our evaluation boards ***do*** require jumper configurations to select channels, voltages, or other options. Please consult the manual that came with the evaluation board for specific information.

2.4 Modes of Operation & LED Indicators

ADC Evaluation Boards

Data acquisition by the WaveVision4 System is divided into three phases:

1. **Frequency Count**: The clock frequency of the ADC or DAC under test is measured and sent back to the host PC.
2. **Sample**: ADC Data Samples are clocked into the SRAM.
3. **Upload**: Sample data is transferred to the host PC.

LEDs on the WaveVision4 Data Capture Board indicate each of these phases. During the frequency counting phase, LED2 “UPLOAD” will be lit momentarily. The frequency count should take about a tenth of a second to complete.

During the collection phase, LED3 “SAMPLE” will be illuminated. The collection should generally take less than a quarter second, but may be longer for low-speed devices.

During the upload phase, LED2 “UPLOAD” will be illuminated. The upload takes approximately 10 seconds to transfer the entire SRAM contents (2^{17} samples). For many purposes, 2^{15} samples are adequate.

When no action is being taken by the WaveVision4 System, LED 4 “IDLE” will be illuminated. This LED also indicates that the FPGA has been programmed correctly. This LED should be “ON” before attempting to start a data acquisition.

LED5 “ADC_CLOCK” is used to determine whether an ADC Evaluation Board clock is active. This LED flashes to indicate that the FPGA is receiving a clock signal from the Evaluation board.

DAC Evaluation Boards

For the DAC evaluation boards, the phases are **download** waveform data/frequency and **run**. LED3 “SAMPLE” indicates the download is occurring. LED2 “UPLOAD” indicates that the DAC is running. LED4 and LED5 have equivalent functions as for the ADC evaluation boards.

2.5 Memory

The WaveVision4 Data Capture Board comes with at least 128k x 36, or 4 Mbit, of 200 MHz SRAM. Some versions may have SRAM of different speed or capacity – the amount present on your board can be queried in the WaveVision4 software through the Capture Board Settings menu.

2.6 Computer Interface

The WaveVision4 Data Capture Board communicates with a PC via standard USB 1.1 for ver 4 and USB 2.0 for ver 4.1 at full speed.

2.7 Power Requirements

The WaveVision4 Data Capture Board requires only a single +5V power supply. However, many ADC and DAC evaluation boards require additional power supplies. The WaveVision4 Data Capture Board consumes approximately 200 mA of current (1 W of power) when fully configured, with no part evaluation board attached. ADC and DAC evaluation boards differ widely in their power consumption – please consult the manual that came with your evaluation board, and ensure that your power supply is capable of adequately supplying the load.

3 Quick Start Guide

3.1 Install the WaveVision4 Software.

1. Insert the WaveVision4 CD-ROM into your computer's CD-ROM drive.
2. The WaveVision4 software requires a Java™ Runtime Environment or Java™ Development Kit, version 1.4 or higher, from Sun Microsystems, Inc. For detailed information on WaveVision4 system use of Java technology, please see Section 5. If your computer does not have this software, the WaveVision4 software installer will instruct you on how to install it.
3. Locate and run the **WaveVision4* Setup.exe** program on the CD-ROM. Follow the on-screen instructions to complete the installation.

3.2 Install the WaveVision4 Hardware.

4. Place the WaveVision4 Data Capture Board on a clean, static-free surface.
5. Connect a +5V supply and ground to power block J1, observing the polarity indicated on the board silk screen.
6. Connect the WaveVision4 Data Capture Board to your personal computer with the supplied USB cable.
7. Connect the ADC/DAC Evaluation Board to the WaveVision4 Data Capture Board by mating it to the appropriate connector. Consult the manual that came with your Evaluation Board and supply any additional power supplies or clock sources needed. Also ensure that DIP switches and/or jumpers on the product evaluation board are set correctly.
8. Turn on the +5V power supply, being sure to apply power to the WaveVision4 Data Capture Board before or simultaneously with power to the ADC/DAC Evaluation Board.
9. Verify that the RED LED (labeled "POWER", near the USB connector) is lit.
10. You will see a Windows™ message concerning the installation of the WaveVision4 driver software. Under Windows XP, you will be prompted by the New Hardware Wizard to enter `Next`, `Continue Anyway` (you should ignore the Windows Logo warning), and `Finish`. If for some reason the installation fails, read the Windows Driver section 7.

3.3 Launch the WaveVision4 Software.

Start the WaveVision4 software on your computer by selecting the desktop icon “WaveVision4” or by clicking on the Start button, and selecting

`Programs -> WaveVision -> WaveVision4`

Once the WaveVision4 software is running;

11. Select “**`Board Settings`**” from the **`Settings`** pull down menu.

12. Select “**`WaveVision4 (USB)`**” from the **`Board Type`** pull-down menu button to tell the WaveVision4 software that you are using the USB-compatible WaveVision4 Data Capture Board.

13. The firmware should automatically load. If not, click the “**`Test`**” button in the **`Communication`** section of the window. A small status window will appear. If you do not see a status window, or receive an error message, please see the “Troubleshooting” Section 6.

14. Finally, Check that LED4 “IDLE” has been illuminated on the WaveVision4 Data Capture Board. If LED4 remains in the “OFF” state, please see the “Troubleshooting” section 6.

4 Using with Older WaveVision System ADC Boards.

The WaveVision4 system may be interfaced to ADC evaluation boards designed for older versions of the WaveVision system and the WaveVision4 software may be used to interface to older versions of the WaveVision Data Capture Board.

4.1 Wave Vision 1/2/3 device board with WaveVision4 Hardware and Software

The WaveVision4 Data Capture Board may be used to capture data from most of the older WaveVision system ADC evaluation boards (DUT boards). Those older boards that can be used with the WaveVision4 Data Capture Board are those that have a three-pin header to select whether clock source from the DUT board or a divided clock from the older WaveVision 1/2/3 board is being used. When using these older DUT boards with a WaveVision4 Data Capture Board, it is necessary to short together all three pins of the clock select header. See the schematic in the DUT board Manual or User’s Guide to locate this header.

Upon running the WaveVision4 software, click on the “Settings” pull-down menu and, on the right side of the open panel, click on “Configure as WaveVision3 compatible”, as shown in Figure 3(a). The WaveVision4 system will measure the clock frequency from the DUT board and report it as indicated in Figure 3(b)

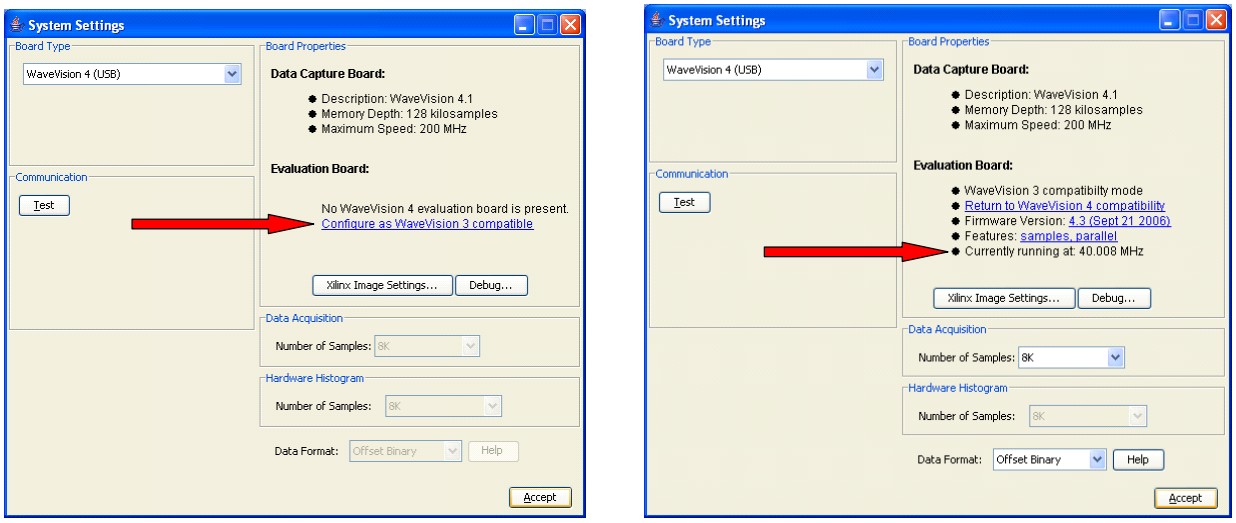


Figure 3: WaveVision4 System Settings Panel – Older DUT Boards

4.2 WaveVision 1/2/3 Capture and Device board with WaveVision4 Software

Connect the older WaveVision capture board to the computer through an RS-232 port and connect the DUT board to the capture board. Upon running the WaveVision4 software, click on the “Settings” pull-down menu and, on the left side of the open panel, click on “Configure as WaveVision3 compatible”, as shown in Figure 4(a). The result is shown in Figure 4(b). The WaveVision4 system cannot measure the clock frequency in this configuration, so it is necessary to enter it into the “Sample Rate” box. It is also necessary to select the COM Port that is used and to select the desired number of samples and the data format of the ADC. See the WaveVision3 Capture Board User’s Guide for information on using that board. That User’s Guide can be found at http://www.national.com/appinfo/adc/evalboards_datacapture.html.

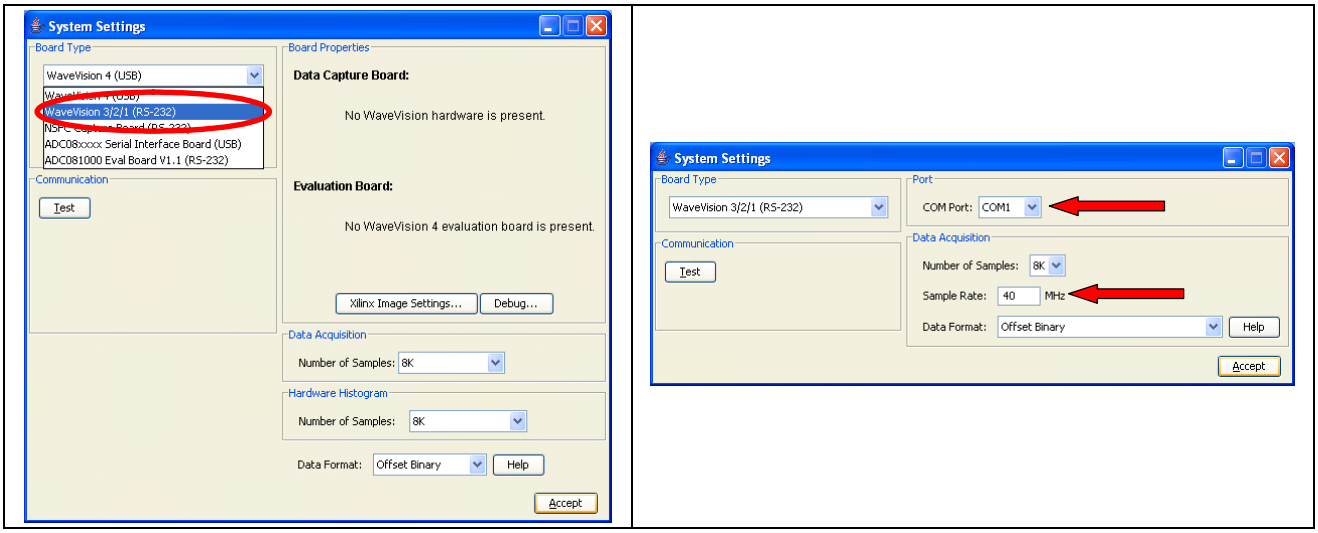


Figure 4: WaveVision4 System Settings Panel – Older Capture Boards

Once these connections and selections are made, the WaveVision4 software is used a similar manner as with the WaveVision4 Data Capture and DUT boards.

5 Java™ Technology

The WaveVision4 software uses Sun Microsystems® Java technology. The underlying Java software must be installed on your computer in order for the WaveVision4 software to run. The software can run on top of either the Java Runtime Environment (JRE) or the Java Development Kit (JDK), version 1.4.2 or later. A suitable copy of the JRE is included on your WaveVision4 CD-ROM.

The WaveVision4 installer will first look for an existing copy of the JRE or JDK on your computer. If neither is found, the installer will instruct you to first install a JRE. To do this, run the **`J2RE*.exe`** installer program off the CD-ROM. Follow the on-screen instructions to finish the install.

After a suitable JRE or JDK is installed, run the WaveVision4 installer again. The installer will detect the Java software and configure the WaveVision4 software to use it.

Java technology can allow software to run on different platforms. However, the WaveVision4 software contains Windows specific hardware interface code and, therefore, is only currently supported under Windows.

6 Troubleshooting

National Semiconductor's WaveVision4 System provides one of the easiest and fastest ADC and DAC evaluation products on the market. If you're having trouble using the system, please work through the troubleshooting flowchart below. Remedies for each of the possible failure modes are listed after the flowchart. The flowchart is targeted for the ADC evaluation boards, but problems 1-3 also apply to the DAC boards. Be sure to refer to your evaluation board manual for solutions also. If you continue to have problems, please contact the National Semiconductor Customer Support Center listed on the last page of your National Semiconductor datasheet.

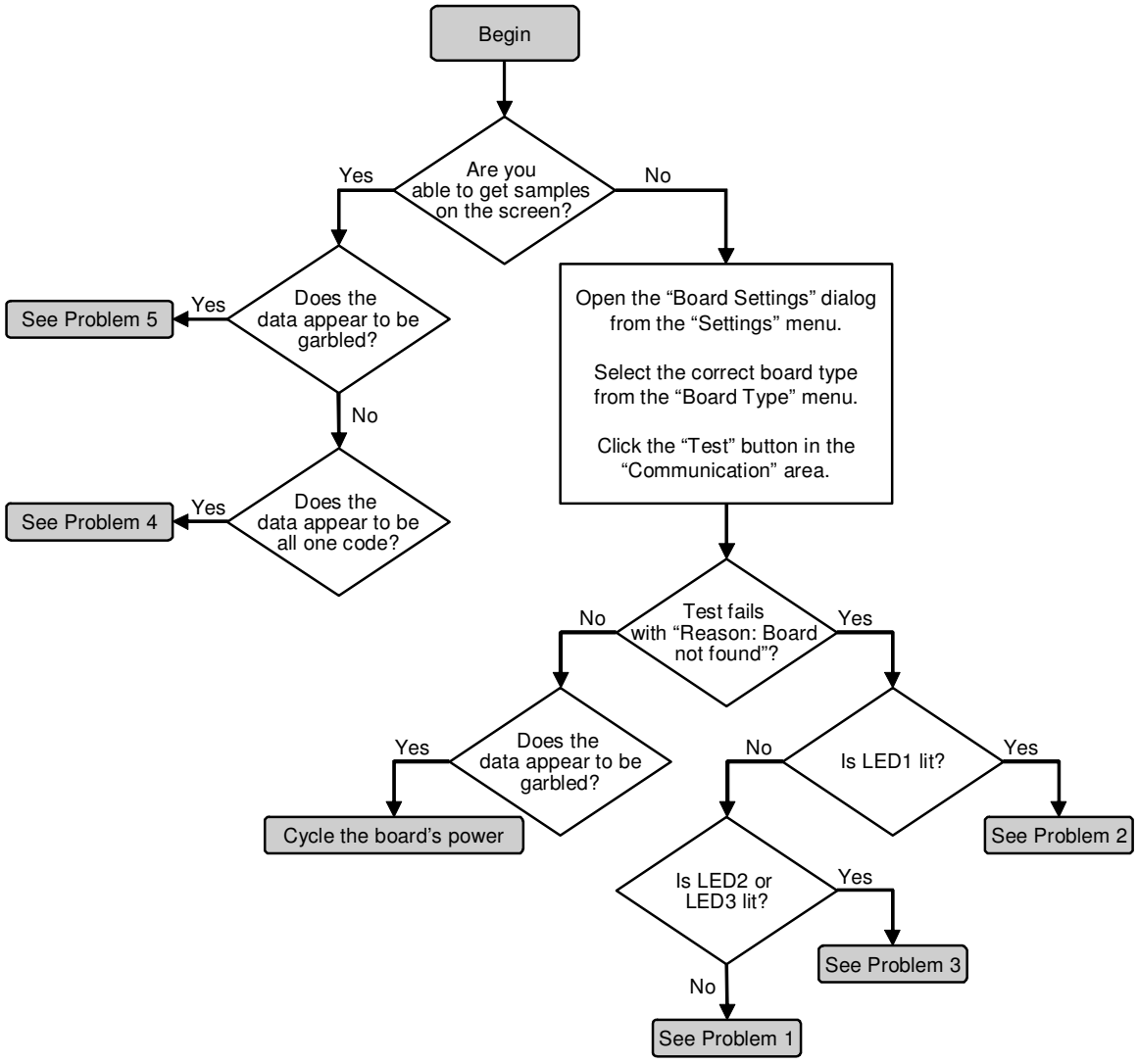


Figure 5: Troubleshooting Flowchart

Problem 1: The board is powered, but no LEDs are lit, and the host PC is unable to communicate with it.

Solutions:

1. Ensure that your power supply is able to source enough current for both the WaveVision4 Data Capture Board and your part evaluation board. See Section 2.7 for more information about power requirements. You may need to power the WaveVision4 Data Capture Board and the part evaluation board separately.
2. Ensure that the power supply is connected with the correct polarity. Consult the board's silkscreen.
3. Probe test points TP10 and TP11 and verify that +3.3V and +2.5V are present on each, respectively. If these voltages are incorrect, despite the +5V supply being properly applied, your board may be defective.

Problem 2: The board is powered and LED1 is lit, but the WaveVision4 software does not detect it.

Solutions:

1. Ensure that the USB cable is firmly connected to both the WaveVision4 Data Capture Board and the host computer.
2. Ensure that the WaveVision4 software was properly installed with the WaveVision4 installer – not simply copied from another computer system.
3. Open the Device Manager (**`Start -> Control Panel -> System -> Device Manager`**), and look under the **`Universal Serial Bus Controllers`** node.
4. Verify that your PC's USB controller and root hub are functioning properly. If they are not, please consult the documentation for your operating system.
5. Verify that the **`National Semiconductor WaveVision4`** device appears under the **`Universal Serial Bus Controllers`** node when turned on. If it is not present, check to see if an unknown **`USB Device`** appears under the **`Other devices`** node. If the hardware appears this way, your driver software is not installed. Turn off the board, re-run the WaveVision4 installer to install the driver software, and then turn the board back on. If you continue to have problems with driver software, please see Section 7 for more information.

Problem 3: The board responds to communication tests, but hangs during data collection or upload (LED2 or LED3 lit).

Solutions:

1. Check that LED5 "ADC_CLK ACTIVE" is flashing to verify that the ADC board's clock is making it across the edge connector.
2. If the clock is not present, the LED will not flash and the SRAM controller will not be able to function.
3. Probe the oscillator module or signal generator connected to the ADC Evaluation board to ensure it is functioning properly.
4. Ensure that the WaveVision4 software is automatically selecting firmware appropriate for your evaluation board.

    - Open the **`Board Settings`** dialog from the **`Settings`** menu.
    - Ensure that **`WaveVision4 (USB)`** is selected from the **`Board Type`** menu.
    - Click the **`Xilinx Image Settings`** button.
    - Verify that the **`Select images automatically`** checkbox is checked.

5. Cycle the power to the WaveVision4 Data Capture Board.

Problem 4: Data is collected from the board, but is all one code.

Solutions:

1. Check the Information panel for the dataset to see what clock frequency was measured. If zero frequency was measured, it most likely means your ADC clock is not making it onto the WaveVision4 Data Capture Board. Check the oscillator module or signal generator to ensure it is functioning properly.

2. Ensure that your signal generator is properly configured, and the jumpers on the ADC Evaluation Board are set appropriately

3. Ensure that the WaveVision4 software is automatically selecting firmware appropriate for your evaluation board. Open the **`Board Settings`** dialog from the **`Settings`** menu. Ensure that **`WaveVision4 (USB)`** is selected from the **`Board Type`** menu. Click the **`Xilinx Image Settings`** button, and verify that the **`Select images automatically`** checkbox is checked.

Problem 5: Data is collected from the board, but is garbled.

Solutions:

1. Ensure that the WaveVision4 software is automatically selecting firmware appropriate for your evaluation board. Open the **`Board Settings`** dialog from the **`Settings`** menu. Ensure that **`WaveVision4 (USB)`** is selected from the **`Board Type`** menu. Click the **`Xilinx Image Settings`** button, and verify that the **`Select images automatically`** checkbox is checked.

2. Ensure that your signal generator is properly configured, and the jumpers on the ADC Evaluation Board are set appropriately. Signal conditioning circuitry on the part evaluation board may be distorting your input signal if configured improperly.

7 Windows Driver

The WaveVision4 software communicates with the WaveVision4 hardware through the Windows device driver software. If you are unable to connect to the WaveVision4 Data Capture Board after installing the software, do the following to uninstall and reinstall the driver. Go to the Windows Control Panel and select System and then the Hardware tab. Then click on Device Manager and go down to the Universal Serial Bus controllers. With the WaveVision4 Data Capture Board connected, you will see it (or an unknown device) listed. Right click on it and uninstall the driver. Then unplug and plug in the board again to reinstall the driver.

8 WaveVision4 Software Basics

Please note: The following sections are a brief tour to highlight all of the basic abilities of the WaveVision4 software. More specific documentation is also available within the WaveVision4 software, from the `Help` menu.

8.1 Basic Features

- Operates with a variety of data capture boards, including the WaveVision4 Data Capture Board.
- Allows inspection of sampled waveforms.
- Calculates FFTs and histograms.
- Provides a wide variety of data import and export abilities.

8.2 Board Settings

Before you can collect samples or drive a DAC, the WaveVision4 software must know what kind of hardware you're using. To configure the WaveVision4 software's interaction with your hardware, open the **`Board Settings`** dialog from the **`Settings`** menu.

Select the type of board you have from the **`Board Type`** pull-down menu.

Depending upon what type of hardware you're using, you will see a variety of options on the right-hand side of the window. For WaveVision4 Data Capture Board, the following settings are available:

- Xilinx Image: These settings determine which firmware is used on the WaveVision4 Data Capture Board.
- Samples collected during data acquisition (for ADCs): This is the number of samples to be uploaded to the host PC. In general, 8k samples are adequate for most measurements, while 32k samples are better suited for precision comparisons.

The Board Settings window also provides a **`Test`** button for testing communication between the PC and WaveVision4 Data Capture Board. Please see Section 3 for more information about setting up a WaveVision4 evaluation system.

8.3 Capturing Data for ADCs

To collect a set of samples from the hardware, choose **`Samples`** from the **`Acquire`** menu. If you do not have any data capture hardware, you may open a sample dataset by choosing **`Simulated Samples`** from the **`Acquire`** menu. You may, of course, also open a file.

8.4 Viewing Data

Some definitions are in order:

A **dataset** is a set of samples.

A **view** is a way of looking at a dataset; time domain plot ("normal" waveform), frequency domain plot (FFT), and histogram are all different ways of looking a sample dataset.

Each window in the WaveVision4 software can contain only one dataset. If you'd like to examine more than one dataset simultaneously, you must open more than one WaveVision4 window. You can open additional windows by choosing **`New Window`** from the **`File`** menu.

Each WaveVision4 window can contain multiple views of the same dataset. By default, a waveform, FFT, and histogram view are shown for each dataset.

8.5 Running a DAC board

Refer to section 11 for the details of using a DAC board.

9 Using WaveVision4 Plots

The WaveVision4 software provides several tools to help you interact with plots. A toolbar appears above each plot, similar to Figure 6.

Figure 6: WaveVision4 Plot Tools

Seen from left to right, the following tools are available:

Plot Actions menu: This menu contains commands that pertain to this particular plot. You may export the plot data to a file, print the plot, save it as a graphic, or change the plot's colors.

Plot Options: This button opens a dialog box with options that pertain to this particular plot. You may turn off labels, annotations, or other elements in this dialog. The WaveVision4 software maintains default options for new plots. You may edit the default options by choosing **`Default Plot Options`** from the **`Settings`** menu. Each time new data is acquired, the default plot and FFT options are used. A change in the default options results in a permanent change of these defaults.

FFT Options: The toolbar shown in Figure 6 is from an FFT plot, so contains a button to edit the options for the current FFT calculations. Depending upon the type of plot, various options may be present on the toolbar. Please consult the appropriate section below for more information about these options.

Magnifying glass tool: This tool allows you to zoom in and out to see fine details in the plot. Click and drag a box from upper-left to lower-right to zoom in on a particular region of your plot. Click and drag a box from lower-right to upper-left to zoom out. **With the magnifying glass tool selected, click the right mouse button to return to a normal, 100% view.**

Arrow Tool: The arrow tool is used to select, move, and edit annotations. To edit an annotation, double click it with the arrow tool. To delete an annotation, select it with the arrow tool and press the `Delete` key on your keyboard.

Line Annotation Tool: To draw lines on the plot, select this tool. Drag to draw new lines. To add arrowheads, or fix the endpoints of the line, double-click it with the arrow tool.

Text Annotation Tool: To draw labels on the plot, select this tool and click at the desired location in the plot. To edit the justification, location, or text of an annotation, double-click it with the arrow tool.

9.1 The Waveform Plot

The Waveform plot shows you the raw samples collected from the hardware. This plot is mainly used to verify the integrity of collected data – the waveform is the best view in which to diagnose a distorted signal, an irregular clock, a low-amplitude signal, and many other common ADC system problems.

The Waveform plot also quickly shows you how much of the ADC's dynamic range your signal occupies.

9.2 The FFT Plot

The WaveVision4 software automatically computes a Fast Fourier Transform (FFT) of the sample set, then displays the results in a frequency domain (FFT) plot. This plot is, in many respects, the heart of the software. The frequency domain plot shows you the frequency content of your input signal, marking the fundamental frequency, the highest spur, and a selectable number of harmonics. It also labels their order and frequencies and shows the power in the fundamental and harmonics. Allow your mouse cursor the hover over a harmonic to get information about it.

The frequency domain plot can be used to diagnose common ADC problems such as input spectral impurity, clock phase noise, and clock jitter. This plot also shows several statistics on the quality and purity of the collected samples, such as SNR, SINAD, THD, SFDR, and ENOB. These statistics are to be interpreted with the following definitions (which are repeated in every National Semiconductor ADC datasheet):

Signal to Noise Ratio (SNR) is the ratio, expressed in dB, of the RMS value of the input signal to the RMS value of the sum of all other spectral components below one-half the sampling frequency, not including harmonics or DC.

Signal to Noise Plus Distortion (S/N+D or SINAD) Is the ratio, expressed in dB, of the RMS value of the input signal to the RMS value of all of the other spectral components below half the clock frequency, including harmonics but excluding DC.

Total Harmonic Distortion (THD) is the ratio, expressed in dBc, of the RMS total of the first specified number of harmonic levels at the output to the level of the fundamental at the output. THD is calculated as

$$\mathrm{THD} = 20\log\sqrt{\frac{f_2^{\,2} + \cdots + f_N^{\,2}}{f_1^{\,2}}}$$

where f_1 is the RMS power of the fundamental (output) frequency and f_2 through f_N are the RMS power in the first N harmonic frequencies. The default number of harmonics, "N", in the WaveVision4 software is initially set to five.

Spurious-Free Dynamic Range (SFDR) is the difference, expressed in dB, between the RMS values of the input signal and the peak spurious signal, where a spurious signal is any signal present in the output spectrum that is not present at the input.

Effective Number of Bits (ENOB, or Effective Bits) is another method of specifying Signal-to-Noise and Distortion or SINAD. ENOB is defined as (SINAD - 1.76) / 6.02 and says that the converter is equivalent to a perfect ADC of this (ENOB) number of bits.

9.3 FFT Options

FFT plots can be configured in many different ways. Clicking the "FFT Options" button at the top of the plot will display a dialog showing the options for that particular plot. The software also maintains default options for new FFT plots, which are editable. You can edit the default FFT options by choosing **`Default FFT Options`** from the **`Settings`** menu. The options are:

Windowing: You may choose from one of five different window functions, one of which is the rectangular window, which is often, but incorrectly, referred to as "No Windowing". The window function is applied to the samples before executing the FFT to compensate for the fact that the sample set may not be an integral number of cycles of the input signal. In general, the Flat-Top window will give the best results for evaluating data converters, but it may be easier to compare data with other systems when the windowing functions are the same.

dB Scale: You may select to represent power on the frequency domain plot in dBc (decibels relative to carrier), in which 0 dB is taken to be the fundamental (carrier) power, or dBFS (decibels relative to full-scale), in which 0 dB is taken to the be power contained in a signal which uses the entire dynamic range of the ADC.

Harmonics: You may select the number of harmonics recognized (and labeled) by the software. You may also select the number of FFT bins excluded around harmonics in, for example, SNR calculations. The exclusion region around each harmonic will be shown in a different color than the rest of the data points.

N.B.: The FFT algorithm can not determine whether any harmonics included are in the noise floor or not. To enhance the accuracy of your THD readout, set the number of harmonics to include in THD to be those that are above the noise floor and set the "bins excluded" to just include those bins that are the harmonic frequency bin width.

IMD Calculations: The WaveVision4 software is capable of performing Intermodulation Distortion (IMD) calculations. When two fundamental frequencies within 3 dBFS of each other are present in the waveform, the software will normally perform IMD calculations. You may inhibit this behavior by deselecting the "Allow IMD calculation" checkbox. When IMD calculation is enabled, you may also select whether the software will include only 2^{nd} order or both 2^{nd} and 3^{rd} order terms.

9.4 Histogram Plots

Histogram plots are created by counting the number of times each ADC output code appears in a dataset. A software histogram is computed from a dataset which is normally 128k samples or smaller. The resulting histogram will show discontinuities between comparators, gain or offset errors, and other common ADC system problems.

The Histogram plot also displays the number of codes that were never counted (missing codes), followed by the first ten such missing codes.

N.B.: The Histogram will indicate missing codes when an insufficient number of samples is taken. For example, a 12-bit ADC has 4096 possible output codes, but a histogram of 4k samples will show some codes missing in the data set because many of the codes in the data set will be present more than once. The fact that these codes are not present in the data set does not necessarily mean that the converter itself exhibits a missing code characteristic.

9.5 Information Viewer

The information viewer is not a plot, but it displays a variety of useful information about the dataset, such as the sample rate, and any warnings generated by the software. You may also change the sample rate for the dataset in memory and input comments about the dataset here, to be saved in a WaveVision4 file.

10 Data Import and Export

The WaveVision4 software provides a variety of means to share data with others, in both text and graphic formats.

The most flexible way to import data into the software is from a tab-delimited ASCII text file. The contents can be either a sample set or a histogram, provided with or without time information. The simplest example of this would be a file with a single column of samples. You can open tab-delimited text files by choosing **`Open`** from the **`File`** menu and you can interleave data from multiple columns and/or files. You can choose **`ReOpen`** to reopen the same file later with the same settings (for example when you update the file with new data),

There are a variety of ways to export data from the software:

- Save the file as a normal WV4 (*.wv4) file. WV4 files are ASCII, tab-delimited text files. Samples are stored one per line in a single column. You can open a WV4 file directly in a spreadsheet or text editor program.
- Save the file as a TXT (*.txt) file. You will produce a one- or two-column tab-delimited ASCII text file of samples or histogram information, without the header information that is contained in a WV4 file.
- You can export the contents of an individual plot by choosing **`Export Data`** from the plot's **`Plot Actions`** menu. The format of the data is always tab-delimited ASCII text.
- You can export a plot as either a GIF (*.gif) or Encapsulated Postscript (*.eps) graphic by choosing **`Export Plot as Graphic`** from the plot's **`Plot Actions`** menu. GIF files are suitable for the web or for emails. Encapsulated Postscript files are high-resolution scalable files suitable for direct publication.

11 Driving a DAC

Driving a DAC with WaveVision4 is fairly straightforward. After the board has been connected and automatically recognized by the WaveVision4 software, the DAC Control Panel will appear. This Control Panel gives you the flexibility to drive various waveforms from the DAC.

To evaluate the performance of your DAC, connect an oscilloscope or other signal analyzer to your device evaluation board's analog output. With the proper analysis equipment, you will be able to evaluate your device's performance.

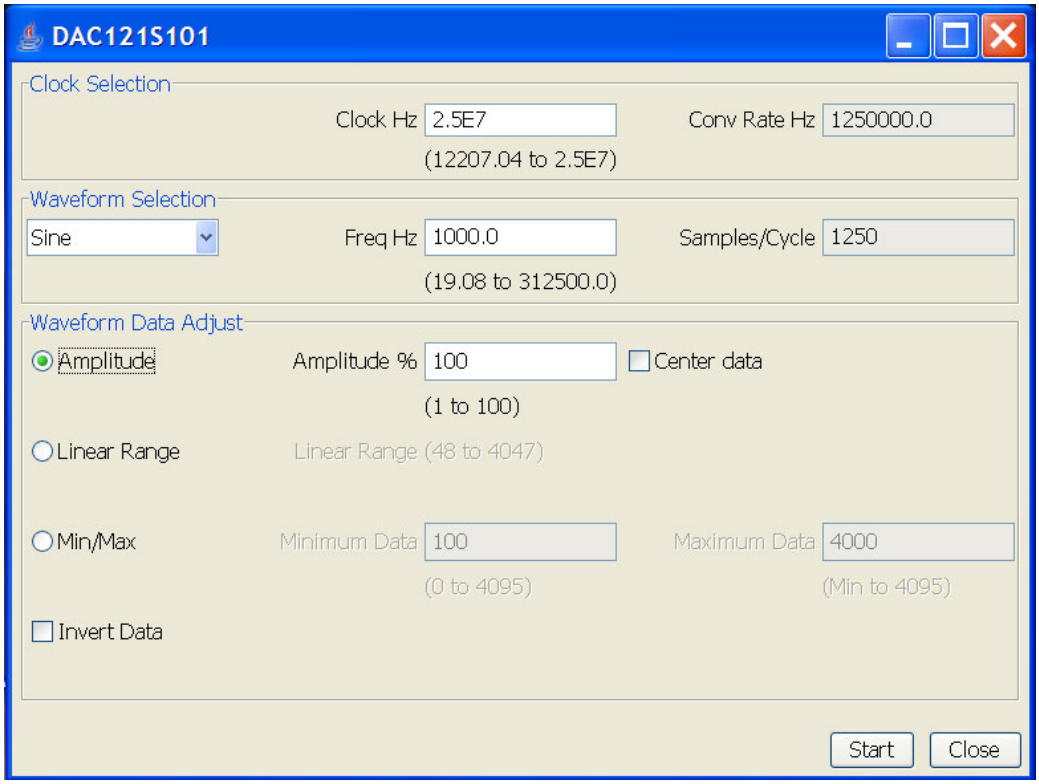
To drive your DAC, simply select a waveform as described later in this section and press the start button.

The digital data generated by the WaveVision4 software will be displayed in the main WaveVision4 window when you press the start button. **Note**: In some cases, limitations of the part (i.e. settling time) will prohibit the DAC from generating an exact analog representation of the digital waveform that is seen in on your computer screen. Refer to the device's Data Sheet for details on its limitations.

The DAC Control Panel enables the selection of either predefined waveforms or user defined waveforms. The options for some waveform types vary, so these are described individually below.

11.1 Waveform Type

The predefined waveform types (sine, sineX/X, sawtooth, pulse and triangle) have the following control panel.



11.1.1 Clock Selection

The “Clock Selection” section allows selection of the clock frequency used to send data to the DAC. The valid values of “Clock Hz” are 100MHz divided by even integer values from 4 to 8192 (this frequency range is shown under the entry box); the software adjusts the entry to the nearest valid value. The “Conv Rate Hz” display is the conversion rate at which the DAC receives and outputs a new data word, which is the clock frequency divided by 20 for many of our serial DACs, but can very with the DAC type.

11.1.2 Waveform Selection

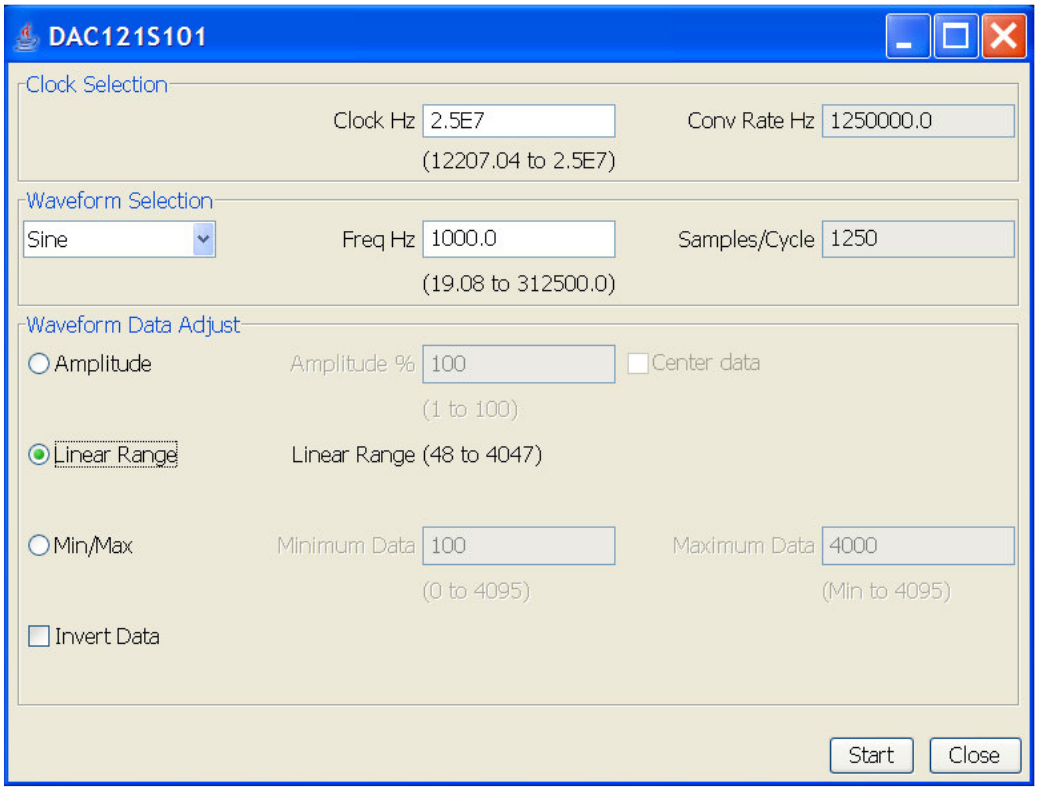
The “Waveform Selection” options allow selection of the waveform type and the frequency of the waveform (note that the allowable range of the frequency is given below the “Freq Hz” entry box; the range varies depending on the “Clock Hz” value selected). The “Samples/Cycle” display is the integer number of data samples/waveform cycle and is equal to the “Conv Rate Hz” divided by the “Freq Hz” value. Note that at high waveform frequencies the samples/cycle decreases to a small number and gives a poorer representation of the waveform. Note also that the waveform frequency value is forced to the closest actual value; the selection of high frequency values is limited because the samples/cycle is an integer.

11.1.3 Waveform Data Adjust

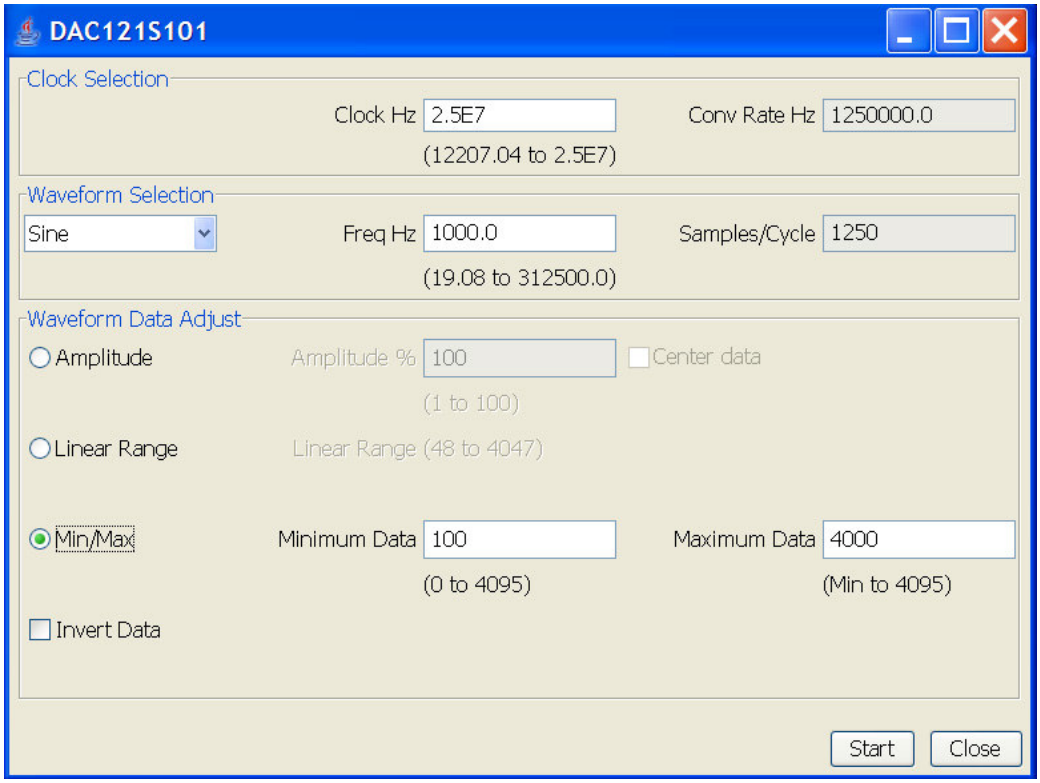
The “Waveform Data Adjust” options allow scaling of the waveform. One of three radio buttons is selected, as well as an option to invert the data.

The amplitude of the data can be set from 1 to 100%. Small amplitudes can result in a poor representation of the waveform. If the amplitude is less than 100%, the data can be selected to either start at zero or be centered at the mid range value.

The data can be scaled into the noted linear range for a better representation of the waveform.



The data can be scaled into any desired range. The allowable range for the min and max values is given. Note that if the range is small, the representation of the waveform may be poor.



The data is inverted if the box is checked.

11.1.4 Start/Stop

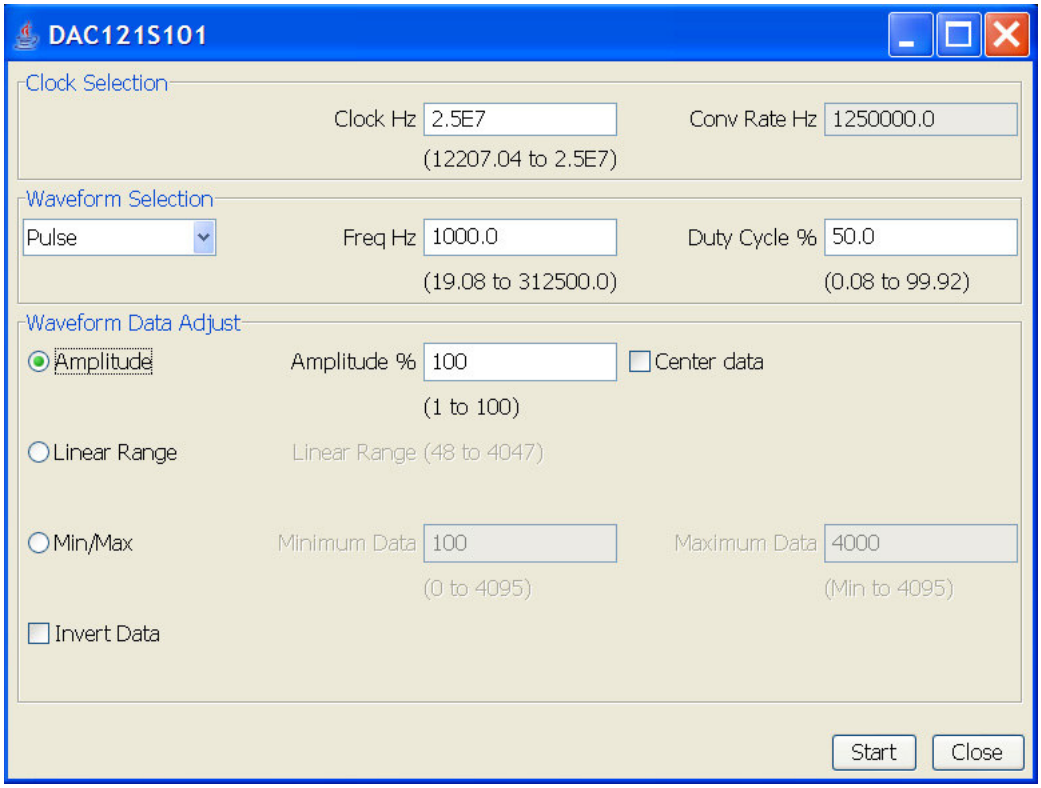
When the “Start” button is pressed, the waveform is displayed on the PC screen, and at the DAC output. Changing of all options is disabled until the waveform is stopped. Note that if you close the WaveVision4 software while the DAC is running, the DAC continues to run until the WaveVision4 software is started again.

11.1.5 Close

The “Close” button closes the window. It is reopened by selecting the “Settings->Product Settings” menu in the WaveVision4 program. When the WaveVision4 software is closed, all the options are saved and restored upon startup.

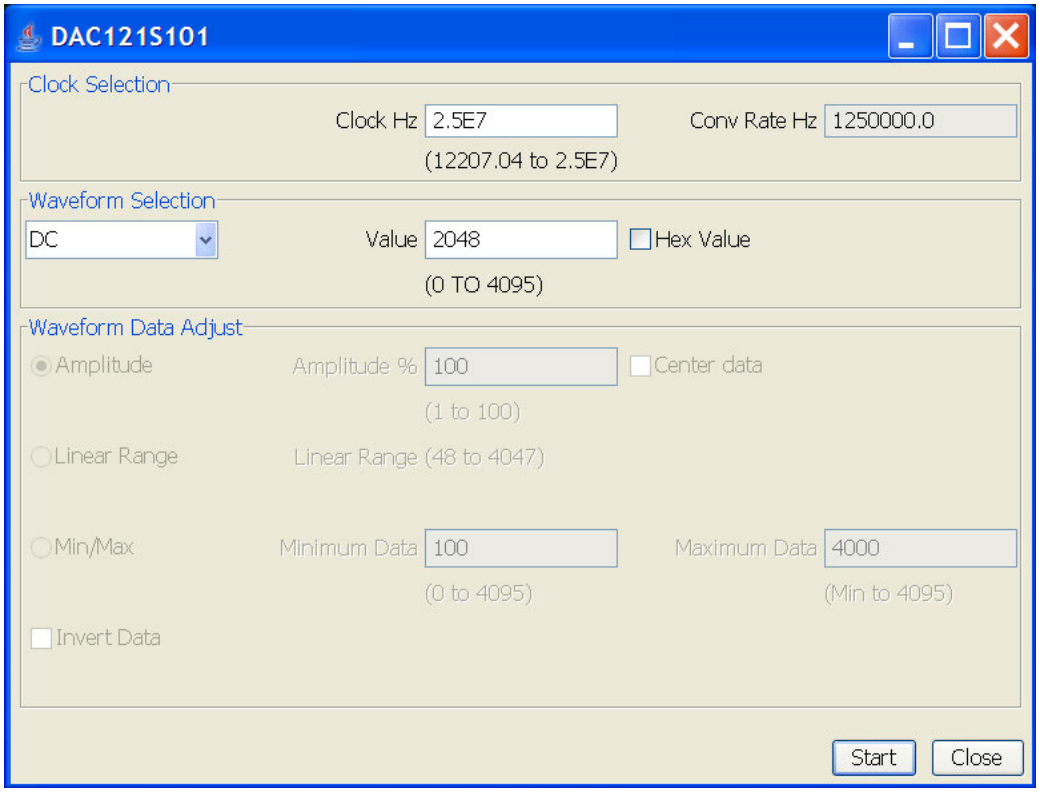
11.2 Waveform type: Pulse

The pulse waveform has the following control panel. The only change from the prior control panel is an option to select the duty cycle of the pulse (in place of displaying the samples/cycle). The valid duty cycle values are determined by the integer value samples/cycle (which is equal to “Conv Rate Hz” divided by “Freq Hz”). Assuming the samples/cycles is equal to “n”, then the value duty cycles are 100/n, 100*2/n, … 100*(n-1)/n. For example, if the samples/cycle is 6, the valid duty cycles are 16.67%, 33.33%, 50.00%, 66.67%, 83.33%. The “Duty Cycle” entry is forced to the nearest valid value.



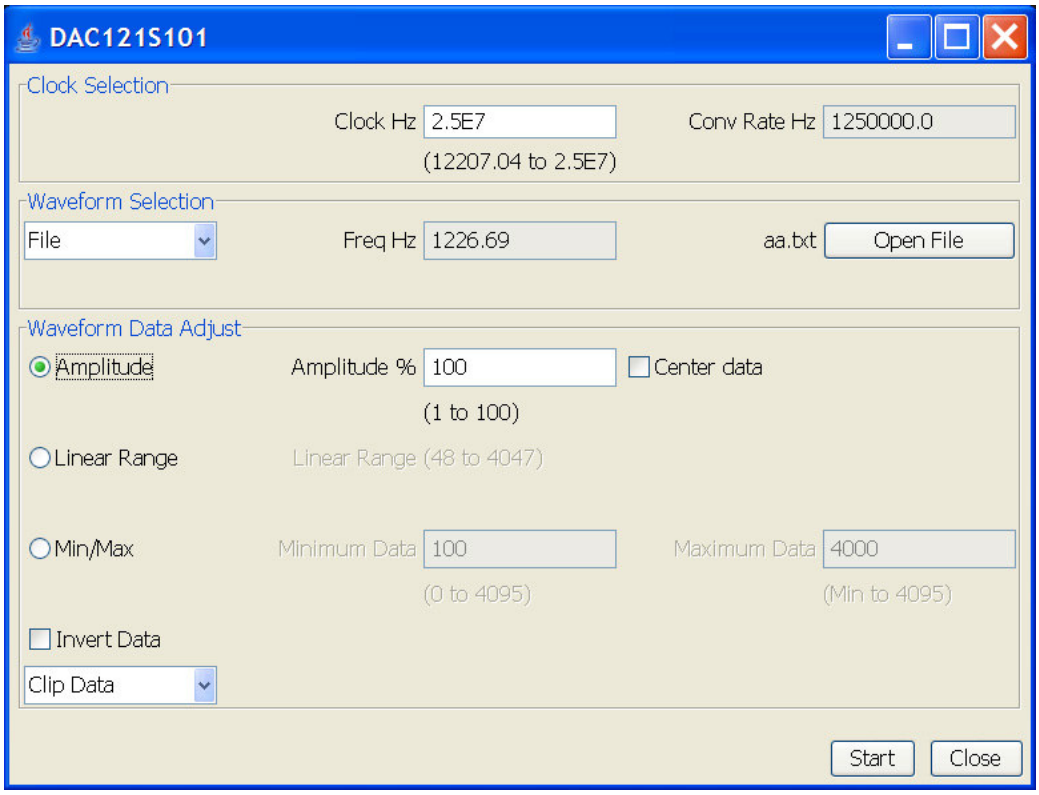
11.3 Waveform type: DC

The DC waveform is a fixed value output by the DAC. All the waveform options are disabled, except for a single “Value” which is entered in either decimal or hex depending on the checkbox. The “Conv Rate Hz” shows the rate at which the DAC data is updating, even though the data is constant. This allows a fixed output that can be measured



11.4 Waveform type: File

The final waveform type is a user defined text file that contains the integer data representation of the waveform. Most of the options have been described above, so only the additional options are noted below.



11.4.1 Open File

When the “Open File” button is clicked, a file name is selected and the user is prompted through a series of dialogs to select the desired data column from the text file. The data must be integer values in decimal or hex (as selected by the user). The number of data values must be from 16 to 65500. Note that more data values mean a better representation of a waveform, but limit the maximum frequency of the waveform. Since the samples/cycles is fixed, the waveform frequency is dependent on the clock frequency (“Freq Hz” = “Conv Rate Hz”/# data samples).

Note that until a filename is selected for the first time, all the options are disabled.

11.4.2 Scale/Crop Data

The user uses the combo box either to scale file waveform data into the waveform data adjust range or to crop file waveform data outside the data adjust range.

BY USING THIS PRODUCT, YOU ARE AGREEING TO BE BOUND BY THE TERMS AND CONDITIONS OF NATIONAL SEMICONDUCTOR'S END USER LICENSE AGREEMENT. DO NOT USE THIS PRODUCT UNTIL YOU HAVE READ AND AGREED TO THE TERMS AND CONDITIONS OF THAT AGREEMENT. IF YOU DO NOT AGREE WITH THEM, CONTACT THE VENDOR WITHIN TEN (10) DAYS OF RECEIPT FOR INSTRUCTIONS ON RETURN OF THE UNUSED PRODUCT FOR A REFUND OF THE PURCHASE PRICE PAID, IF ANY.

The WaveVision4 Data Capture Board is intended for product evaluation purposes only and is not intended for resale to end consumers, is not authorized for such use and is not designed for compliance with European EMC Directive 89/336/EEC, or for compliance with any other electromagnetic compatibility requirements.

National Semiconductor Corporation does not assume any responsibility for use of any circuitry and/or software supplied or described. No circuit patent licenses are implied.

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

National Semiconductor Corporation Americas
Tel: 1-800-272-9959
Fax: 1-800-737-7018
Email: support@nsc.com

National Semiconductor Europe
Fax: +49 (0) 1 80-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 699508 6208
English Tel: +49 (0) 870 24 0 2171
Français Tel: +49 (0) 141 91 8790

National Semiconductor Asia Pacific Customer Response Group
Tel: 65-2544466
Fax: 65-2504466
Email:sea.support@nsc.com

National Semiconductor Japan Ltd.
Tel: 81-3-5639-7560
Fax: 81-3-5639-7507

www.national.com

National does not assume any responsibility for any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Mobile Processors	www.ti.com/omap		
Wireless Connectivity	www.ti.com/wirelessconnectivity		
	TI E2E Community Home Page		e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2012, Texas Instruments Incorporated