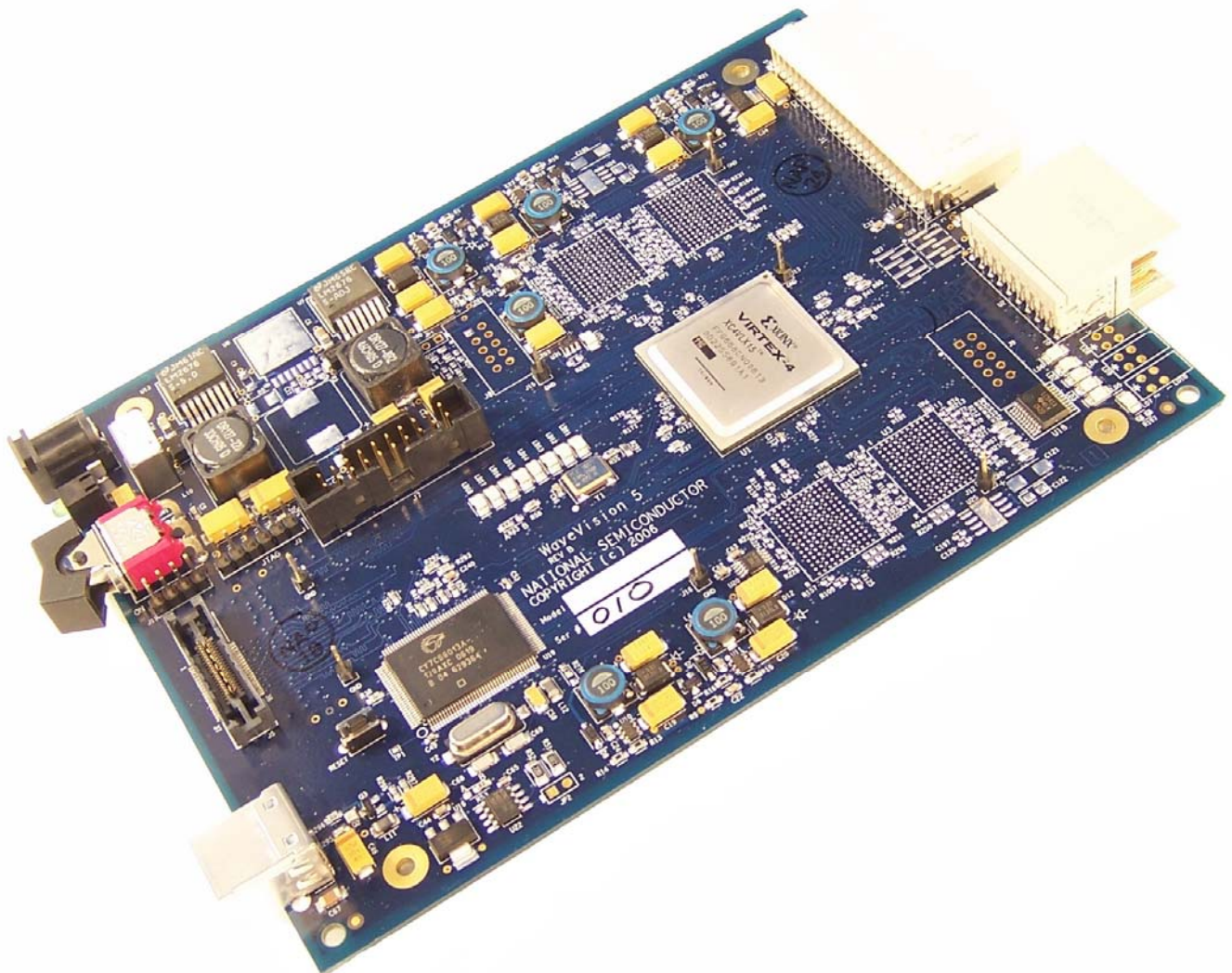




# WaveVision5

## Data Capture Board



Users' Guide  
June 2007

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## 1.0 The WaveVision System and its components

WaveVision is National Semiconductor's evaluation system designed specifically for lab evaluation of analog-to-digital and digital-to-analog signal-paths. It consists of two main components: the data capture hardware (the board) and the graphical user interface and control software. Both the board and the software have evolved through a few major generations. WaveVision5 Data Capture Board is the latest generation of said boards and is designed to offer the customer the ability work with the highest speed signal path ICs from National Semiconductor. It is not intended to replace the WaveVision4 capture board as the WaveVision4's performance is quite sufficient in many cases.

The WaveVision5 capture board will work with the current generation WaveVision4 software as well as the next generation of software currently in development. In this Users' Guide the operation with WaveVision4 software is described.

A third element that constitutes a complete evaluation setup is the device or signal-path evaluation board that plugs into the WaveVision5 capture board. This board is generically referred to as the "DUT board". Each ADC or signal-path evaluation board comes with its own User's Guide, which documents its specific features.

This User's Guide primarily describes the base version of the WaveVision5 Data Capture Board and its use. However, reference is made to the extended (EXT) version where it differs from the base version. The EXT version differs from the base version only in that it offers 8MBytes of additional buffer for imaging applications. Generically, the system is referred to as "WaveVision5", regardless of the version. Accordingly, wherever "WaveVision5" is mentioned, it means both base and EXT, unless otherwise stated or implied.

The latest version of this document may be obtained from National Semiconductor's web site at [www.national.com](http://www.national.com). The latest version of Wavevision-4 software too may be obtained there.

### 1.1 WaveVision5 System Features

- Transfers data rapidly at high-speed with USB 2.0 (USB1.1 compatible).
- Provides jumperless, plug-and-play configuration.
- Supports a wide variety of ADC Evaluation Boards through two separate connectors; one of which allows connection with many WaveVision4 board compatible evaluation boards.
- Fast data capture:
  - Through the FB (FutureBus) connector (compatible with the WaveVision4 board):
    - 36 parallel CMOS signals at up to 200 Mbps/signal (in DDR mode); or
    - 28 parallel LVDS pairs at up to 600 Mbps/signal (in DDR mode)
  - Through the new HMZd connector:
    - 12 differential serial pairs at up to 900 Mbps/signal (in DDR mode)
- High-speed auxiliary data connector allows alternate connection with logic analyzers.
- Base version capable of storing 64k, 16-bit wide samples from 1 or 2 DUT board channels.
- Extended version capable of storing up to 8MBytes of data for imaging type applications.
- DUT control through SPI interface.

### 1.2 Packing List

The WaveVision5 kit (National order number WAVEVSN BRD 5) consists of the following components:

- WaveVision5 Data Capture Board
- WaveVision4 software on CD-ROM

- USB cable
- +12V AC-DC Power Supply
- User's Guide (This Document)

### 1.3 Board Layout Overview

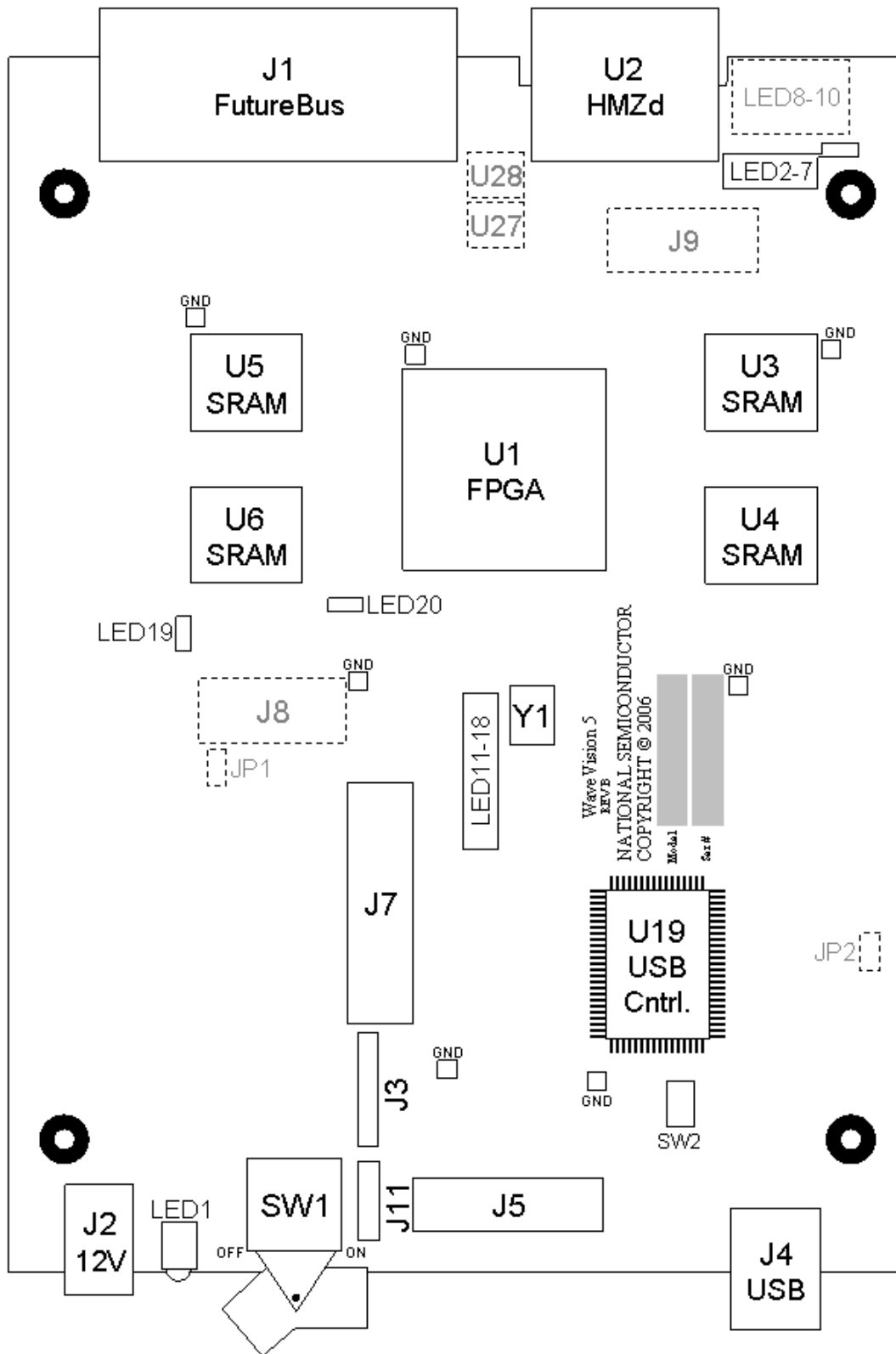


Figure 1a WaveVision5 Data Capture Board Layout - Component Side

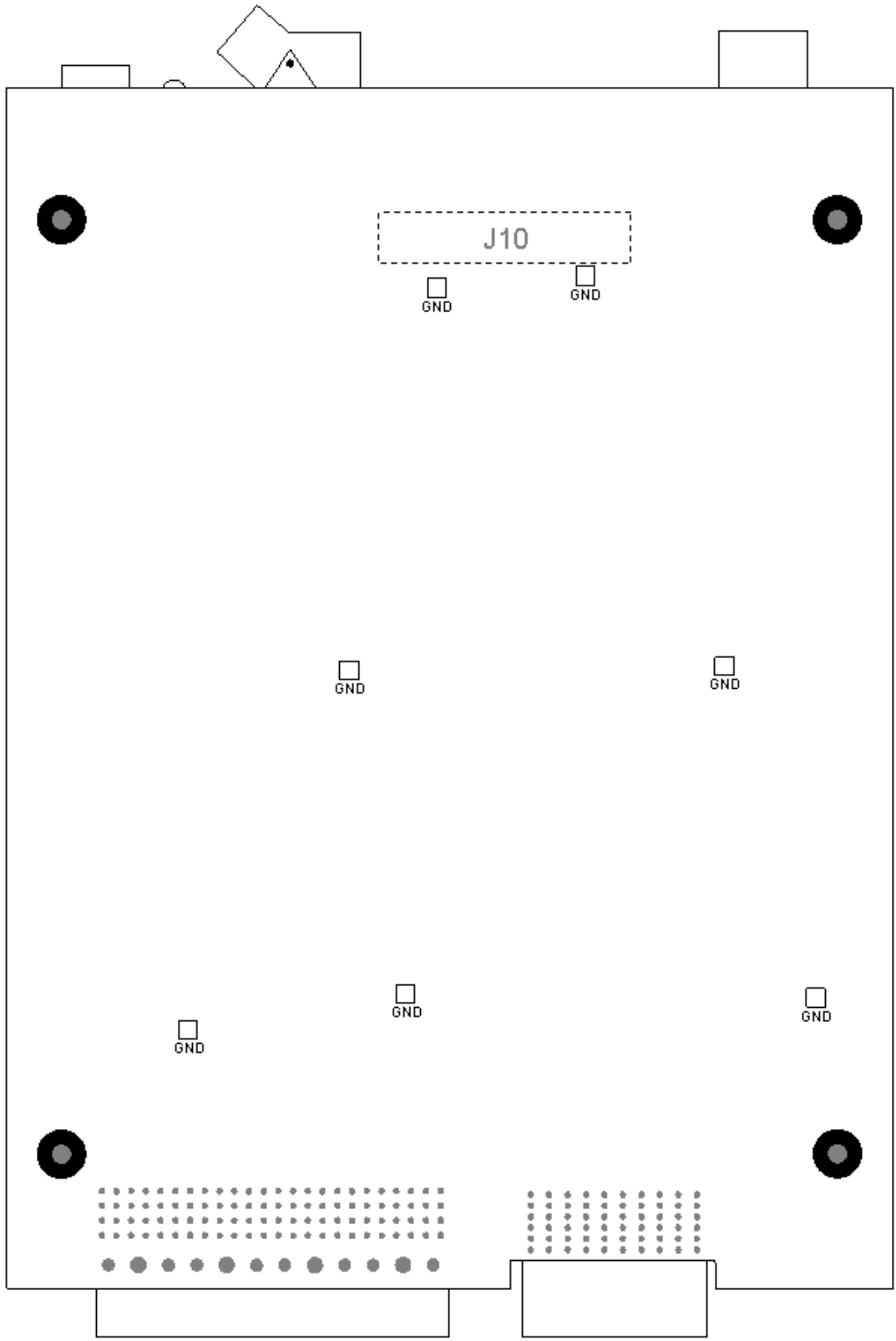


Figure 1b WaveVision5 Data Capture Board Layout – Solder Side

## 1.4 Component Description

The following table describes both the on-board connectors and the main components used in the WaveVision5 System shown in Figure 1.

Component	1.4.1.1 Description
J1 (Future Bus)	Future Bus Connector to DUT.
J2 (POWER)	+12V Power Supply Connection (See Section 3.2).
J3 (JTAG)	JTAG Header.
J4 (USB)	USB cable Connection.
J5 (Mictor)	Mictor Connector for connecting test equipment or other boards. (See section 2.6).
J7 (LSA)	Logic Analyzer Connector for lower frequency logic analyzers. (See section 2.6).
J10 (SoftTouch)	SoftTouch Connector for high frequency logic analyzers. (See section 2.6).
J11 (AUG)	Header for augmenting the I/O of J5
U2 (HMZd)	HMZd Connector to DUT for highest frequency signals.
J8, J9, U27, U28	Connectors for test purposes only.
JP1, JP2	Jumpers for test purposes only.
U1	FPGA
U3-6	DDR SRAM (200MHz)
U19	USB microcontroller
LED1	Right angle power LED.
LED6	Surface mount power LED.
LED2-5, LED7	Status LEDs (See section 2.4).
LED8-10	Right angle version of LED2-7 (not used).
LED11-15	DCM Status LEDs (See section 2.4).
LED16-18	Reserved for possible future use.
LED19	Warning light - DUT interface is at 2.5V.
LED20	Warning light – Aux. Test Equipment/Board interface is at 2.5V.
SW1	Power switch.
SW2	Reset switch.

## 1.5 WaveVision5 Data Capture Board Test Points

The following table describes the main Test Points available.

Test point	Description
J12-J18 (GND)	Ground test points.

## 2 System Functionality

### 2.1 System Block Diagram

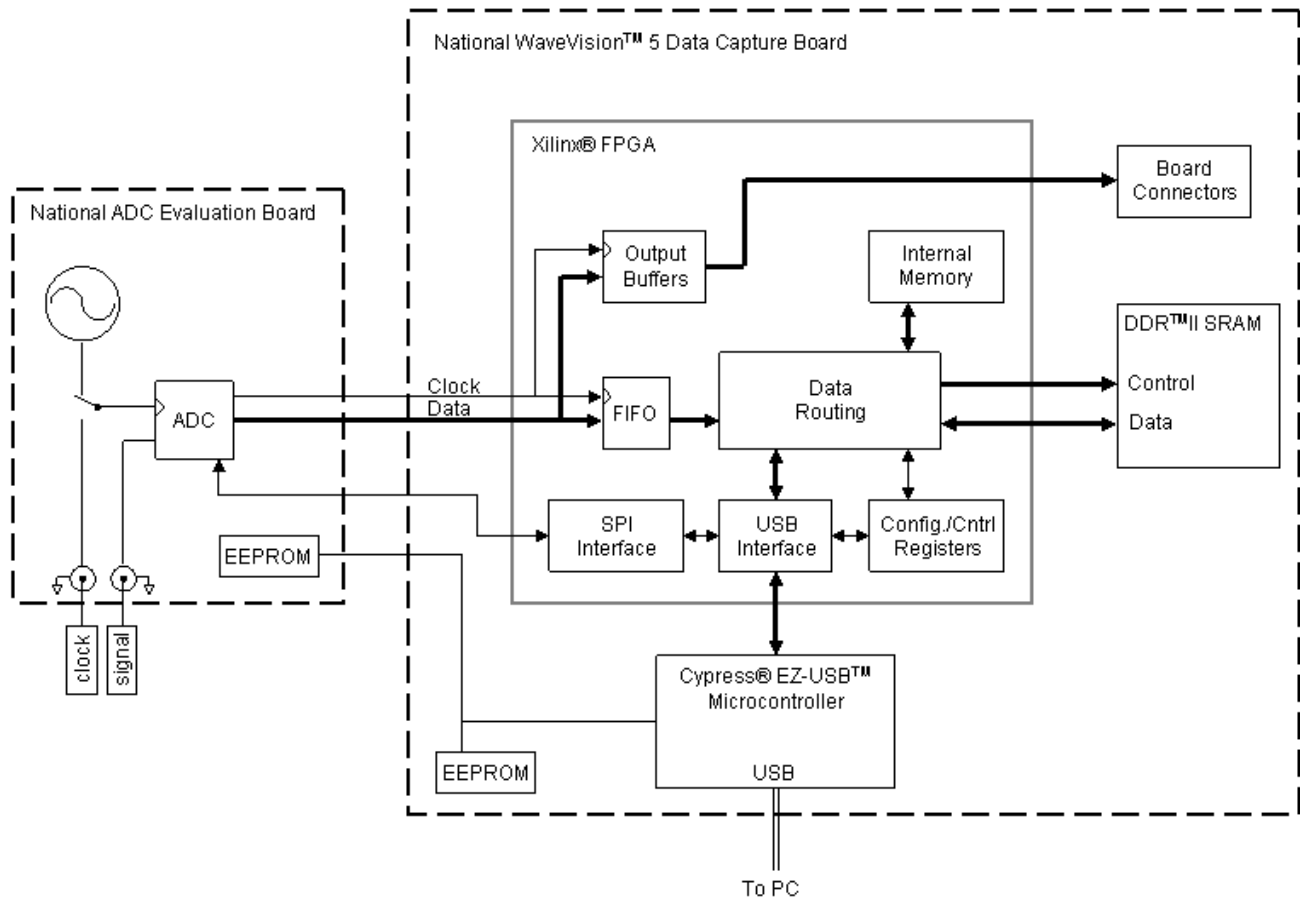


Figure 2: WaveVision5 System Block Diagram (For ADCs)

## 2.2 General System Overview

### 2.2.1 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 (J1) or to the high speed HMZd connector (U2). The data and clock signals are connected directly to the FPGA Device (U1) on the WaveVision5 Data Capture Board. During data capture, the FPGA captures the data from the ADC using the source-synchronous clock and routes it to the designated destination. As shown in the figure, there are three possible destinations. If the data is to be stored on the board before being forwarded to the PC, it first goes through a FIFO. After the FIFO, the data is routed to either the FPGA's internal memory or to external memory consisting of DDR SRAM ICs located on the WaveVision5 Data Capture Board. Once the requested amount of data has been stored in either memory location, it is uploaded to the PC through the FPGA's USB interface and the Cypress Microcontroller (U19) for analysis. The third path is to connectors on the board. Lower frequency data can be sent to the LSA connector (J7). Higher frequency data can be sent to either the Mictor connector (J5) or SoftTouch connector (J10), depending on the board's configuration.



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.

## 2.2.2 DAC Evaluation Boards

This interface is currently in development and is not available at this time. A later release of this board will support this feature.

## 2.3 Automatic Device Detection & Configuration

The WaveVision5 system provides automatic hardware detection and configuration for the device under test. The FPGA is re-configured on the fly by the host PC when the WaveVision5 Data Capture Board is powered on, or whenever ADC evaluation boards are exchanged.

Each DUT board has an FPGA configuration file unique to it. The PC, in conjunction with the USB micro-controller, determines which DUT board has been plugged in. It then loads a configuration file tailored for that DUT board into the FPGA.

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 evaluation board manual for more information.

**Important Note:** Many of our device 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.

**Important Note:** Please be aware that DUT boards are NOT how swappable. Please power down both the Wavevision-5 board and the DUT board prior to swapping DUT boards.

## 2.4 Modes of Operation & LED Indicators

### 2.4.1 ADC Evaluation Boards

Data acquisition by the WaveVision5 System is divided into three phases:

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

LEDs on the WaveVision5 Data Capture Board indicate each of these phases. During the frequency counting phase, LED5 "UPLOAD" will be lit momentarily. The frequency count should take about a tenth of a second to complete.

During the collection phase, LED7 "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, LED5 "UPLOAD" will be illuminated. The upload takes approximately 10 seconds to transfer the entire memory contents ( $2^{16}$ , 16-bit wide 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.

LED2 "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.

The status of each of the FPGA's DCMs is indicated by the LEDs in the middle of the board. LED11 displays the status of the DCM that generates the shifted clock used for writing to external RAM. LED12 and LED13 show the condition of the DCMs used for the reading access of SRAM bank 0 and bank 1, respectively, when they are installed on the board. The status of the DCM for the high-speed serial input clock is indicated by LED14. LED15 shows the status of the DCM used to generate a 2x clock from the FRAME signal, when it exists for a particular DUT.

**Important Note:** The operation of the LEDs may vary from DUT board to DUT board. Please read the DUT board manual for more pertinent information.

## 2.4.2 DAC Evaluation Boards

This interface is currently in development and is not available.

## 2.5 DUT Interface

The WaveVision5 Data Capture Board can be connected to the DUT through either the FutureBus (J1) connector or HMZd (U2) connector. The FutureBus connector is primarily for high speed, wide parallel single-ended data up to approximately 200 MSa/s while the HMZd is commonly used for higher speed differential data. The choice of the connector is based on the requirements of the DUT. The FutureBus is used whenever possible because of the larger number of pins and the cost of the mating connector. Both connectors can be used if the capture board is designed for that arrangement.

## 2.6 Auxiliary Test Equipment Interface

The WaveVision5 Data Capture Board can be connected to auxiliary test equipment through connectors located on the board. The Mictor connector is capable of operating up to 600 Mbits/sec signaling rate. It is capable of connecting the WaveVision5 Data Capture Board to other boards (see <http://catalog.tycoelectronics.com/TE/bin/TE.Connect?C=11473&F=0&M=CINF&GIID=1253&LG=1&I=13#content>).

Please be aware that the functionality to drive signals onto the auxiliary connectors is NOT provided in the default configuration. The purpose of these connectors is to allow customers to customize Wavevision's functionality for their specific requirements. This would, among other things, require the customer to design the FPGA logic for their specific application.

**Important Note:** The Mictor (J5) and SoftTouch (J10) connectors are designed to carry high frequency signals. As such, they are more susceptible than through-hole connectors (such as J7) to damage from rough handling. If either of these connectors is installed on the board, they should be handled with care. When attaching to these connectors, twisting, bending, and rotating of these connectors should be avoided in order to prevent damage to the surface mount leads. Only the pressure necessary to insert or extract connectors should be used. The board should be supported from the opposite side in order to prevent bowing of the board, which could possibly damage the solder connections.

## 2.7 Computer Interface

The WaveVision5 Data Capture Board communicates with a PC via standard USB 2.0 at high-speed (up to a 480 Mbits/sec signaling rate). It is fully backward compatible with USB 1.1 devices and cables.

## 2.8 Interface Voltage Levels And Warning

Both the DUT (J1) and Auxiliary Test Equipment Interfaces (J5, J7, J10, and J11) to the board can be set to either 2.5V or 3.3V levels. The higher speed serial interface (U2) is fixed at 2.5V levels. Knowing the correct voltage level for each interface is important to protecting the DUT and capture board. While some automatic protection is built into the DUT interface based on the system knowing which DUT is connected to the board, the same is not true of the Auxiliary Test Equipment interface. The default level for the Auxiliary Test Equipment interface is 3.3V, which could damage equipment connected to it if the equipment is expecting something lower.

## 2.9 Memory

The WaveVision5 Data Capture Board comes with at least 64k x 16-bits of memory. Versions of the board will be available with capacities up to 64Mb and capable of being reconfigured for different applications (e.g. as 4M x 16bits or as 1M x 64bits). The amount present on your board can be queried in the WaveVision4 software through the Capture Board Settings menu. This memory configuration will be determined Wavevision software at power up and the FPGA will be configured to optimize memory usage.

## 2.10 Power Requirements

The WaveVision5 Data Capture Board requires only a single +12V AC-DC power supply. However, many ADC evaluation boards require additional power supplies. The WaveVision5 Data Capture Board consumes approximately 200 mA of current (1 W of power) when fully configured, with no part evaluation board attached. ADC 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 1.4.2 or higher, from Sun Microsystems, Inc. For detailed information on WaveVision5 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 **WaveVision 4\* Setup.exe** program on the CD-ROM. Follow the on-screen instructions to complete the installation.

### 3.2 Install the WaveVision5 Hardware.

1. Place the WaveVision5 Data Capture Board on a clean, static-free surface.
2. Connect the +12V AC-DC power supply to the J2 power jack. Connect the other side of the power supply to an AC outlet (100-240 VAC, 50-60 Hz).
3. Connect the ADC Evaluation Board to the WaveVision5 Data Capture Board by mating it to the appropriate connector (either the J1 FutureBus or the U2 HMZd connector). Consult the manual that came with your evaluation board and connect any additional power supplies or clock sources needed. Also ensure that DIP switches and/or jumpers on the product evaluation board are set correctly.
4. Turn on the SW1 rocker power switch, being sure to apply power to the WaveVision5 Data Capture Board. Verify that the green LED (labeled LD1, near the J2 power jack) is lit. LD6 will also turn on at the same time.
5. Apply power to the DUT board.
6. Connect the WaveVision5 Data Capture Board to your personal computer with the supplied USB cable.
7. If this is the first time a WaveVision5 Data Capture Board has been connected to your computer, 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

#### 3.2.1 Power Sequencing

The Wavevision system does not require a mandatory power-up/down sequence. *The only requirement is that both the capture board and the DUT board be powered down prior to insertion/de-insertion of the DUT board* simply because the system is not designed for hot- swapping.

The recommended power-up sequence is as follows

- a. Power-up the Wavevision 5 capture board.
- b. Power-up the DUT board.
- c. Mate the USB connection between the capture board and the PC.

The power-down sequence is the exact reverse.

### 3.3 Launch the WaveVision4 Software.

Start the WaveVision4 software on your computer by selecting the desktop icon "WaveVision 4" or by clicking on the Start button, and selecting

All Programs -> WaveVision -> WaveVision 4

Once the WaveVision4 software is running;

1. A window should open that with the title "Downloading firmware ...". The progress bar should make it all the way to the right before the window closes.
2. Select **Capture Settings** from the **Settings** pull down menu.
3. Select **WaveVision 4 (USB)** from the **Board Type** pull-down menu button (if it is not already selected) to tell the WaveVision4 software that you are using the USB-compatible WaveVision4 Data Capture Board.
4. The firmware should have already been automatically loaded. If not, click the "**Test**" button in the **Communication** section of the window. A small status window will appear with the title "Downloading firmware ...". If you do not see this status window, or receive an error message, please see the "Troubleshooting" Section 6.

## 4 Using with Older WaveVision System ADC Boards.

The WaveVision5 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. The main requirements for interfacing to the WaveVision5 system are that the evaluation board has a FutureBus or an HMZd connector and an EEPROM. This means that WaveVision1/2/3 boards, since they use a Euro connector and do not have an on-board EEPROM, can not be used with the WaveVision5 Data Capture Board.

## 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 WaveVision5 System provides one of the easiest and fastest ADC 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. 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.

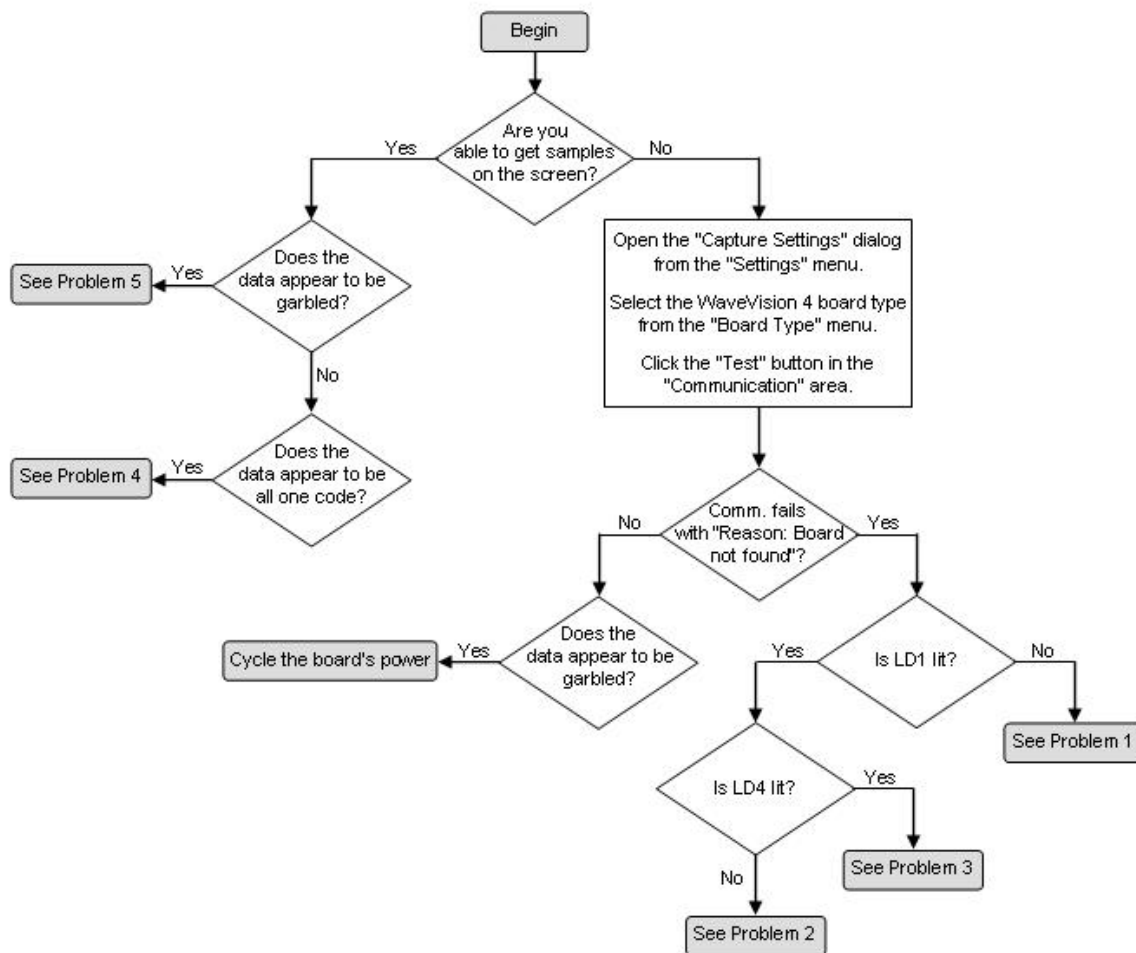


Figure 5: Troubleshooting Flowchart

**Problem 1:** The board is powered, but LD1 is not 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 WaveVision5 Data Capture Board and your part evaluation board. See Section 2.10 for more information about power requirements. You may need to power the WaveVision5 Data Capture Board and the part evaluation board separately.

**Problem 2:** The board is powered and LD1 is lit, but the WaveVision4 software does not detect it.

**Solutions:**

1. Ensure that the USB cable is firmly connected to both the WaveVision5 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 -> Hardware tab -> 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 by double clicking on them and checking the Device Status. If they are not, please consult the documentation for your operating system.
5. Verify that the **National Semiconductor WaveVision 5** device appears under the **Universal Serial Bus controllers** node when opened. If the device appears as **Cypress EZ-USB FX2LP - EEPROM missing**, then there is a problem with the programming of the EEPROM or it may be defective. 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.
6. Probe C44 (side closest to the USB connector) and L3 (either side, located near J7) and verify that +3.3V and +1.25V are present on each, respectively. If these voltages are incorrect, despite the +12V supply being properly applied, your board may be defective.

**Problem 3:** The board responds to communication tests, but hangs during data collection or upload (LD5 or LD7 stays lit during a capture).

**Solutions:**

1. Check that LD2 "ADC\_CLK" 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 FIFO and data routing controller inside the Xilinx FPGA 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 **Capture Settings** dialog from the **Settings** menu.
  - Ensure that **WaveVision 4 (USB)** is selected from the **Board Type** menu.
  - Click the **Xilinx Image Settings** button.
  - Verify that the **Select images automatically** checkbox is checked.

5. Disconnect the USB cable from the board. Cycle the power to the WaveVision5 Data Capture Board. Reconnect the USB cable to the board.

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

**Solutions:**

1. Click on the Information tab for the captured dataset to see what sample frequency was measured. If zero frequency was measured, it most likely means your ADC clock is not making it onto the WaveVision5 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 **capture Settings** dialog from the **Settings** menu. Ensure that **WaveVision 4 (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 **capture Settings** dialog from the **Settings** menu. Ensure that **WaveVision 4 (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 WaveVision5 hardware through the Windows device driver software. If you are unable to connect to the WaveVision5 Data Capture Board after installing the software, do the following to uninstall and reinstall the driver. Open the Device Manager (**Start -> Control Panel -> System -> Hardware tab -> Device Manager**), and look under the **Universal Serial Bus controllers** node. With the WaveVision5 Data Capture Board connected, you will see **National Semiconductor WaveVision 5** (or an unknown device) listed. Right click on the device and select Uninstall. Then unplug and plug the USB cable into the board again to start the process of reinstalling 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 WaveVision5 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, the WaveVision4 software must know what kind of hardware you're using. To configure the WaveVision4 software's interaction with your hardware, open the `Capture Settings` dialog from the `Settings` menu.

Select `WaveVision 4 (USB)` 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 the WaveVision5 Data Capture Board, the following settings are available:

- `Xilinx Image Settings` - These settings determine which firmware is used on the WaveVision5 Data Capture Board.
- `Number of Samples` - 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 WaveVision5 Data Capture Board. Please see Section 3 for more information about setting up a WaveVision5 evaluation system.

### 8.3 Capturing Data for ADCs

To collect a set of samples from the hardware, choose `Samples` from the `Acquire` menu or press F1. 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 to read samples from.

## 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 at a sample dataset.

Each WaveVision4 window 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 available for each dataset.

## 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.

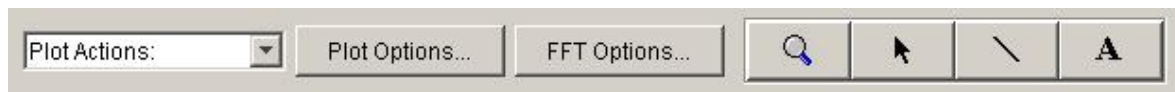


Figure 6: WaveVision4 Plot Tools

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 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 it 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. You may edit the default options by choosing **Default FFT Options** from the **Settings** menu. Each time new data is acquired, the default FFT options are used. A change in the default options results in a permanent change of these defaults. 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. The arrow tool also returns the cursor to reporting information about the point in the plot that it is on.

**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 add labels to 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 to 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

$$\text{THD} = 20 \log \sqrt{\frac{f_2^2 + \dots + f_N^2}{f_1^2}}$$

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. The value can be changed using the FFT Options button.

**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  $(\text{SINAD} - 1.76) / 6.02$  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”. That is why it appears in parentheses in the list of functions. 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 be the 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 be included in THD calculation to be those harmonics that are above the noise floor and set the “bins excluded” to just include those bins that are within the harmonic frequency’s 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. This can be useful in the unlikely event that a close-in spur is nearly as large as the input signal without a second input frequency actually being applied, since it is not really IMD that is being detected in that case. When IMD calculation is enabled, you may also select whether the software will include only 2<sup>nd</sup> order or both 2<sup>nd</sup> and 3<sup>rd</sup> 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 are taken to represent every possible ADC output code. For example, a 12-bit ADC has 4096 possible output codes, but a histogram of 4k samples will show some codes missing in the dataset because many of the codes in the dataset will be present more than once. The fact that these codes are not present in the dataset 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 frequency 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 WaveVision4 (\*.wv4) file. WaveVision4 files are ASCII, tab-delimited text files. Samples are stored one per line in a single column. You can open a WaveVision4 file directly in a spreadsheet or text editor program.
- Save the file as a Text (\*.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 WaveVision4 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.

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