

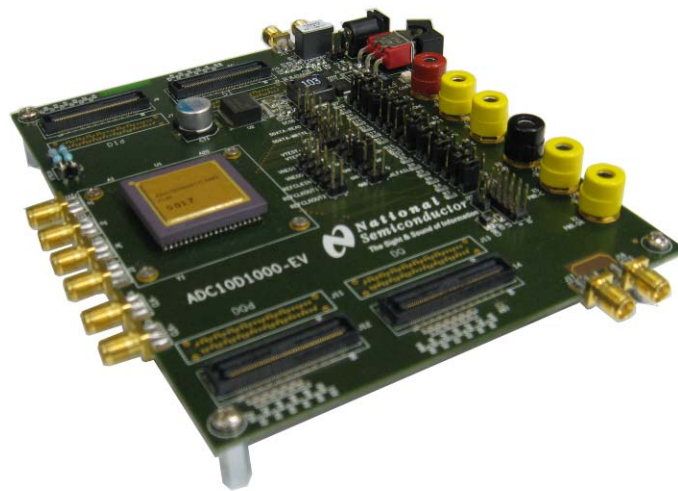


# **ADC10D1000CVL**

## **10-Bit, Dual 1.0 GSPS / Single 2.0 GSPS Signal Acquisition Evaluation Board**

### **Users' Guide**

Rev. 1.5 – January 28, 2009



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## 1.0 Introduction

The ADC10D1000CVAL Evaluation Board is designed to allow quick evaluation and design development of National Semiconductor's ADC10D1000CCMLS ultra high speed 10-bit Analog-to-Digital Converter.

This evaluation board is designed to function with Agilent's 16702B Logic Analysis System for fast evaluation. It requires only three connections to get started: a power supply, a Logic Analyzer Interface to PC, and a signal source.

## 2.0 Board Assembly

The ADC10D1000CVAL Evaluation Board schematic and BOM are included as additional documents.

## 3.0 Board Overview

Refer to Figure 1 for the ADC10D1000CVAL Evaluation Board block diagram.

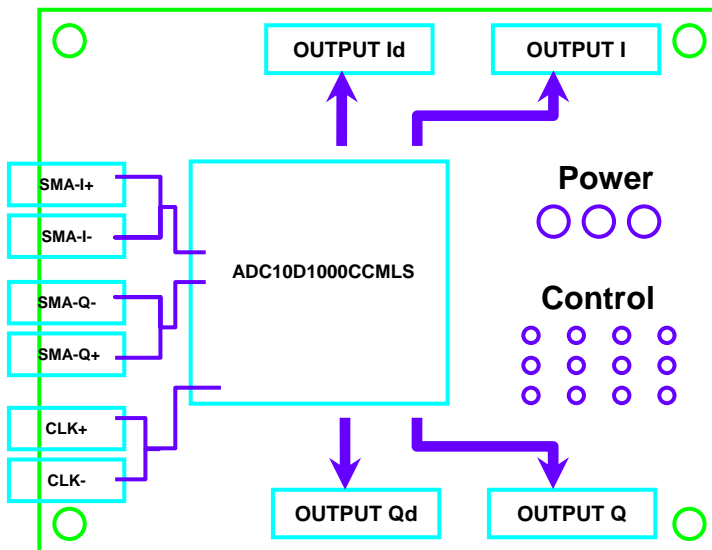


Figure 1. ADC10D1000CVAL evaluation board block diagram

### 3.1 Power Supply

Power to the board is supplied through the 6 banana jacks (4 yellow, 1 red, 1 black) located on the side opposite of the analog input SMA connectors. For best performance, it is recommended that each power (PWR-A, PWR-T, PWR-E, PWR-C, and PWR-DR) be tied together and connected via banana plugs to a 1.9V lab bench supply. If using separate supplies, the analog supply voltage must be turned on **BEFORE** the digital supply voltage (reverse the process with powering down). Failure to comply can result in damaging the device!

### 3.2 Clock Input

The SMA clock input on the board is connected directly to the ADC10D1000CCMLS clock inputs and is required to be AC-coupled. It is recommended to connect DC block to the evaluation board. The clock inputs are differential and a balun may be used to provide single-ended to differential conversion from a

single-ended clock source. For best performance, it is required to use a band-pass filter on the clock source.

### 3.3 Analog Inputs

The SMA analog input on the board is connected directly to the ADC10D1000CCMLS analog inputs and is AC-coupled. It is recommended to use DC blocks. Additionally, two more baluns may be used for S/E to differential conversion for the signal sources. For best performance, it is required to use a band-pass filter on the analog input source. If only one channel is being monitored, the other channel may be AC-grounded via 50ohm plugs for best performance.

### 4.0 Logic Analyzer

The ADC10D1000CVAL Evaluation Board allows the end user to power the ADC10D1000CCMLS, provide differential input signals I and Q plus clock, and capture the resulting 46 LVDS outputs from 4 contact foot-prints.

The evaluation board is designed to function with Agilent E5379A cables, which connect the data banks to the 16702B Logic Analyzer. At least two cables are required to monitor one channel (I or Q) at a time in Non-DES Mode and four cables are required to monitor DES Mode.

Both the I and Q sides have two output ports, each with two different connectors, however, only the 100-pin Samtec connectors are used. Refer to Appendix A for more information on recommended routing for flow-through routing for the 100-pin Samtec connector, footprint dimensions, and ordering information.

### 5.0 Functional Description

The ADC10D1000CVAL Evaluation Board schematic is included as an additional document. Refer to Figure 2 for photo of the ADC10D1000CVAL Evaluation Board setup.

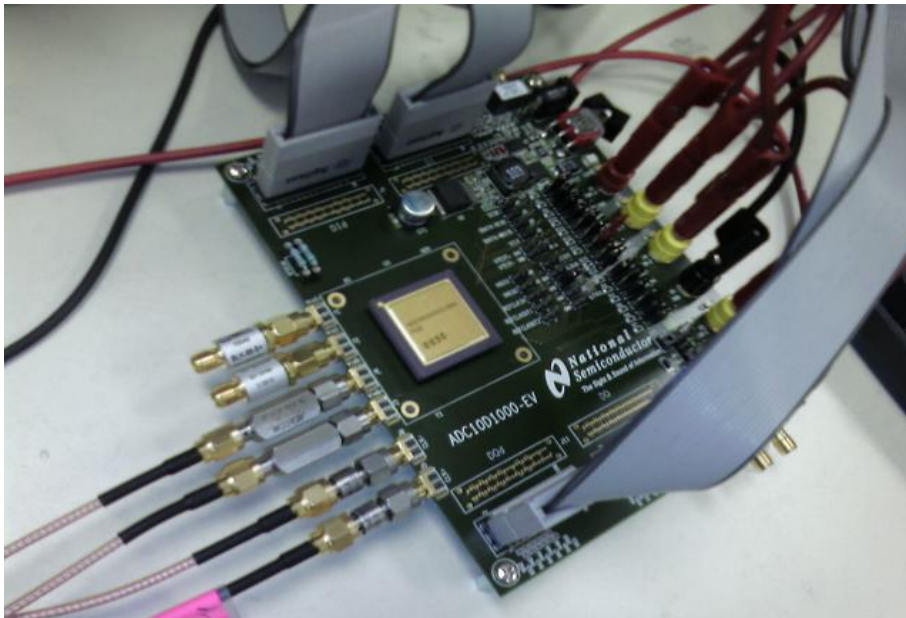


Figure 2. ADC10D1000CVAL Evaluation Board setup

## 5.1 Input Circuitry

The input signal(s) to be digitized should be applied to the SMA connectors labeled VinI+, VinI-, and/or VinQ+, VinQ-. The 50ohm inputs are intended to accept low-noise sine wave signals. To accurately evaluate the dynamic performance of this converter, the analog input signal(s) must be filtered by a high-quality bandpass filter.

This evaluation board is designed for operation with two differential analog inputs.

No other test equipment, such as an oscilloscope, should be connected anywhere in the signal path while gathering data because it will add noise to the signal.

## 5.2 Digital Data Output

Refer to ADC10D1000CVAl Evaluation Board schematic for digital out pin mapping (J8, J10, J12, J14).

## 5.3 Jumper Configuration

The ADC10D1000CVAl Evaluation Board comes configured in Non-DES Pin-Control Mode (Extended Control Enable bar, ECEb, jumper is high – Column B3 on the device). When operating in Pin-Control Mode, only the jumper settings must be used in order to configure the device. See Table 1 for jumper list and configuration. Refer to the product datasheet for more complete information.

<b>Name</b>	<b>Abbr.</b>	<b>Jumper Setting</b>
Scantest	Scantest	High
Extended Control Enable bar	ECEb	High
Test Pattern Mode	TPN	Low
Non-Demuxed Mode	One-to-One	Low
SelBit	SelBit	High
POR Enable	POR_En	High
Calibrate Cycle Initiate	Cal	See Section 5.4 Calibration
Differential Clock Reset -	DCLK_RST-	High
Differential Clock Reset +	DCLK_RST+	Low
Dual Edge Sampling	DES	Low
CALDLY	CALDLY	High
DDR Phase Select	DDR_PH	Low
Full Scale Input Range Select	FSR	High
Power Down Q-Channel	PDQ	Low
Power Down I-Channel	PDI	Low
VCMO	VCMO	Closed
*All other jumpers not listed above left floating		

**Table 1. ADC10D1000CVAl jumper settings for Non-DES Pin-Control Mode.**

If the ECEB jumper is low, then the chip may be controlled via the Serial Interface. This may be accomplished by using the Aardvark Total Phase I2C/SPI host adapter to write to the Control Registers. Refer to Appendix B for more information regarding the Aardvark (not included).

## 5.4 Calibration

In order to get the full performance of the ADC10D1000CCMLS, it is necessary to perform a calibration. This may be accomplished via the CAL jumper. With the CAL jumper tied high prior to power-on, after the chip has come to full operating temperature, set the CAL jumper low and then back to high.

## 6.0 Data Analysis

The data collected by the logic analyzer can be analyzed using National's WaveVision 4 software (see Appendix C, D) or a preferred analysis tool.

## 7.0 Appendix A – Hardware Information

### 7.1 Recommended Components

- Picosecond 5310 Phase Matched Balun
- MCL 15542 DC Bocks
- MCL 50ohm Terminators (for unused channels)
- Trilithic Tunable Bandpass Filters
- Aardvark Total Phase I2C/SPI host adaptor (for Extended Control Mode operation). See Appendix B for more information

### 7.2 Logic Analysis System

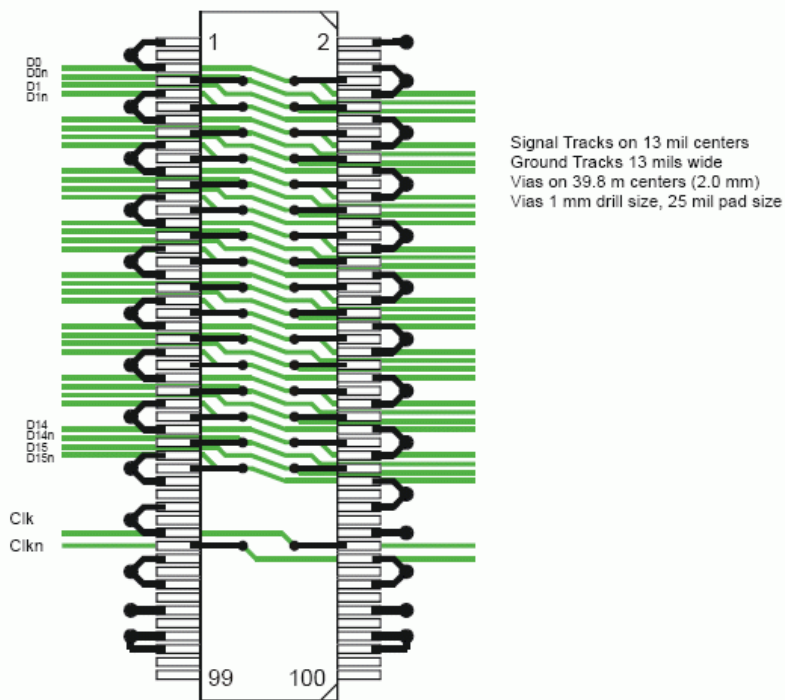
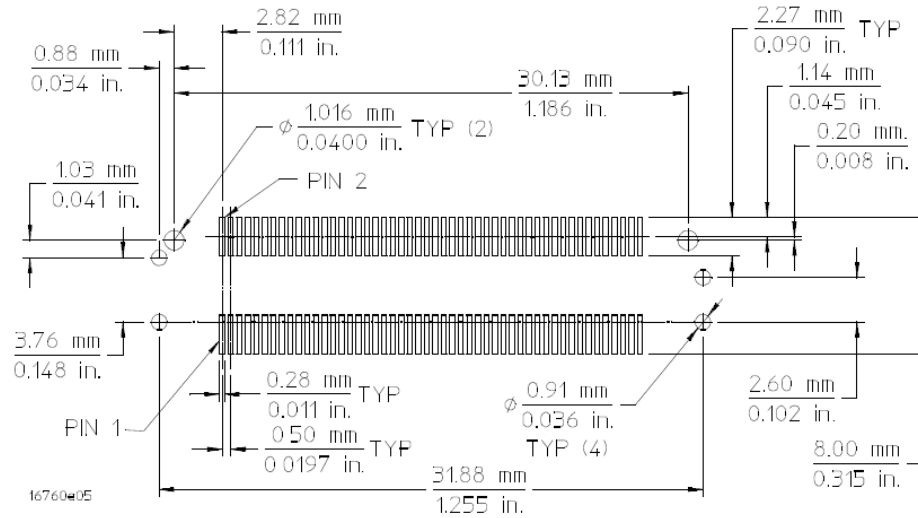


Figure 34 16-bit differential flow-through routing

Figure 3. Flow-through routing for the 100-pin Samtec connector

## Footprint dimensions

Use the following 100-pin **Samtec** connector footprint and support shroud mounting hole dimensions to design your target system board.



**Figure 8** 100-pin Samtec connector footprint and support shroud mounting hole dimensions

**Figure 4.** Footprint dimensions for 100-pin Samtec connector

### Ordering Probing Connectors and Shrouds

Connectors and shrouds may be ordered in kits or ordered separately. Select a support shroud appropriate for the thickness of your PC board. The following table lists the Agilent part numbers for each.

#### CAUTION

The support shrouds marked with an asterisk in the following table are made of conductive metal. Care should be taken to avoid shorting adjacent boards or components with the shrouds. For this reason it may be advisable not to connect the shrouds to ground.

For Probe Model #	Agilent Part Number	Consists of	For Target PC Board Thickness
E5378A & E5379A	16760-68702	5 Mating Connectors &	up to 1.57 mm (0.062 in.)
	16760-68703	5 Support Shrouds*	up to 3.05 mm (0.120 in.)

E5379A Differential Probe				E5379A Differential Probe			
Negative Signals		Positive Signals		Negative Signals		Positive Signals	
Signal Name	Pin#	Signal Name	Pin#	Signal Name	Pin#	Signal Name	Pin#
Ground	1	Ground	2	Ground	57	Ground	58
Do Not Connect	3	Do Not Connect	4	D13 n	59	D13 p	60
Ground	5	Ground	6	Ground	61	Ground	62
D0N	7	D0 p	8	D14 n	63	D14 p	64
Ground	9	Ground	10	Ground	65	Ground	66
D1 n	11	D1 p	12	D15 n	67	D15 p	68
Ground	13	Ground	14	Ground	69	Ground	70
D2 n	15	D2 p	16	NC	71	NC	72
Ground	17	Ground	18	Ground	73	Ground	74
D3 n	19	D3 p	20	NC	75	NC	76
Ground	21	Ground	22	Ground	77	Ground	78
D4 n	23	D4 p	24	D16/Clk n	79	D16/Clk p	80
Ground	25	Ground	26	Ground	81	Ground	82
D5 n	27	D5 p	28	NC	83	NC	84
Ground	29	Ground	30	Ground	85	Ground	86
D6 n	31	D6 p	32	NC	87	Ground	88
Ground	33	Ground	34	N/C	89	N/C	90
D7 n	35	D7 p	36	NC	91	NC	92
Ground	37	Ground	38	Ground	93	Ground	94
D8 n	39	D8 p	40	Ground	95	Ground	96
Ground	41	Ground	42	Do not connect	97	Do not connect	98
D9 n	43	D9 p	44	Do not connect	99	Do not connect	100
Ground	45	Ground	46				
D10 n	47	D10 p	48				
Ground	49	Ground	50				
D11 n	51	D11 p	52				
Ground	53	Ground	54				
D12 n	55	D12 p	56				

**Figure 5.** Ordering information

## 8.0 Appendix B – Aardvark I2C/SPI Host Adapter

### 8.1 Aardvark Description

The Aardvark I2C/SPI Host Adapter is a fast and powerful I2C bus and SPI bus host adapter through USB (see Figure 6). It allows a developer to interface a Linux or Windows PC to a downstream embedded system environment and transfer serial messages using the I2C and SPI protocols.

Part Number: TP240141

RoHS Compliant: Yes



Figure 6. Aardvark I2C/SPI Host Adapter

For more information please visit the manufacturer website at:

[http://www.totalphase.com/products/aardvark\\_i2cspi/](http://www.totalphase.com/products/aardvark_i2cspi/)

### 8.2 Aardvark to ADC10D1000CCMLS Interface

Level translation is required due to the different signaling levels (3.3V for the Aardvark vs. 1.9V for the ADC10D1000CCMLS). Refer to Figure 7 for interface overview.

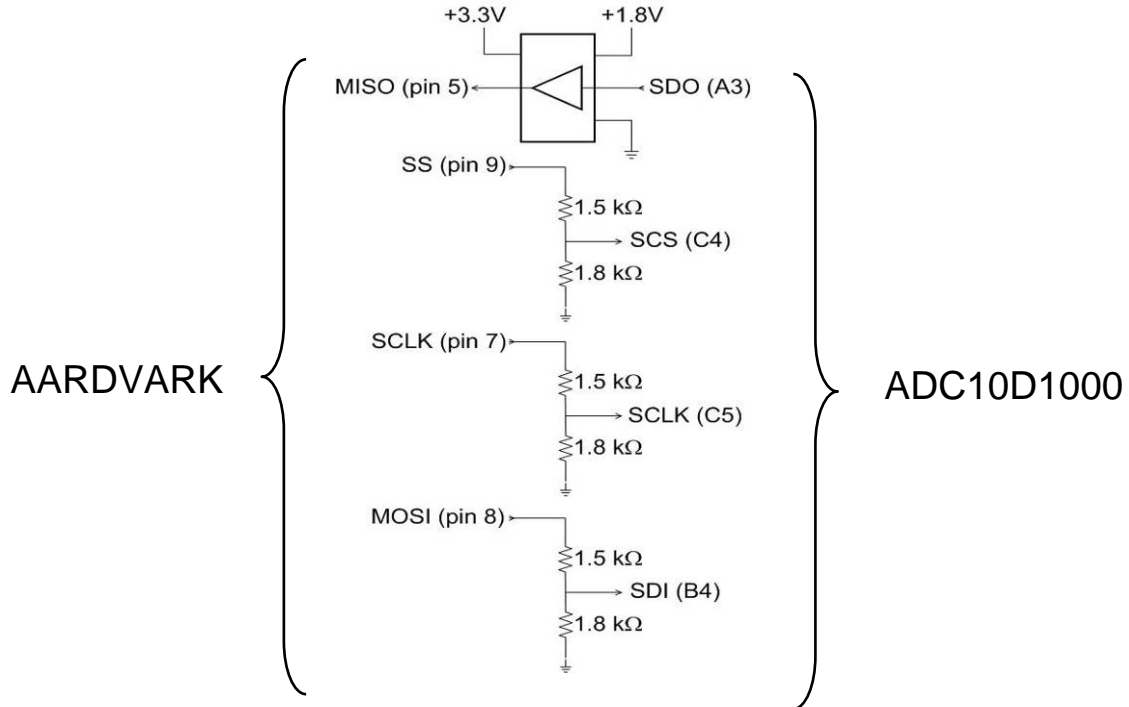


Figure 7. Aardvark to ADC10D1000CCMLS interface overview

### 8.3 Aardvark Setup

The software included with the Aardvark adapter is used to communicate with the ADC10D1000CCMLS. From the menu snapshot in figure 8 below, select **SPI to GPIO** mode on PC and then type SPI commands in **MOSI Message** window.

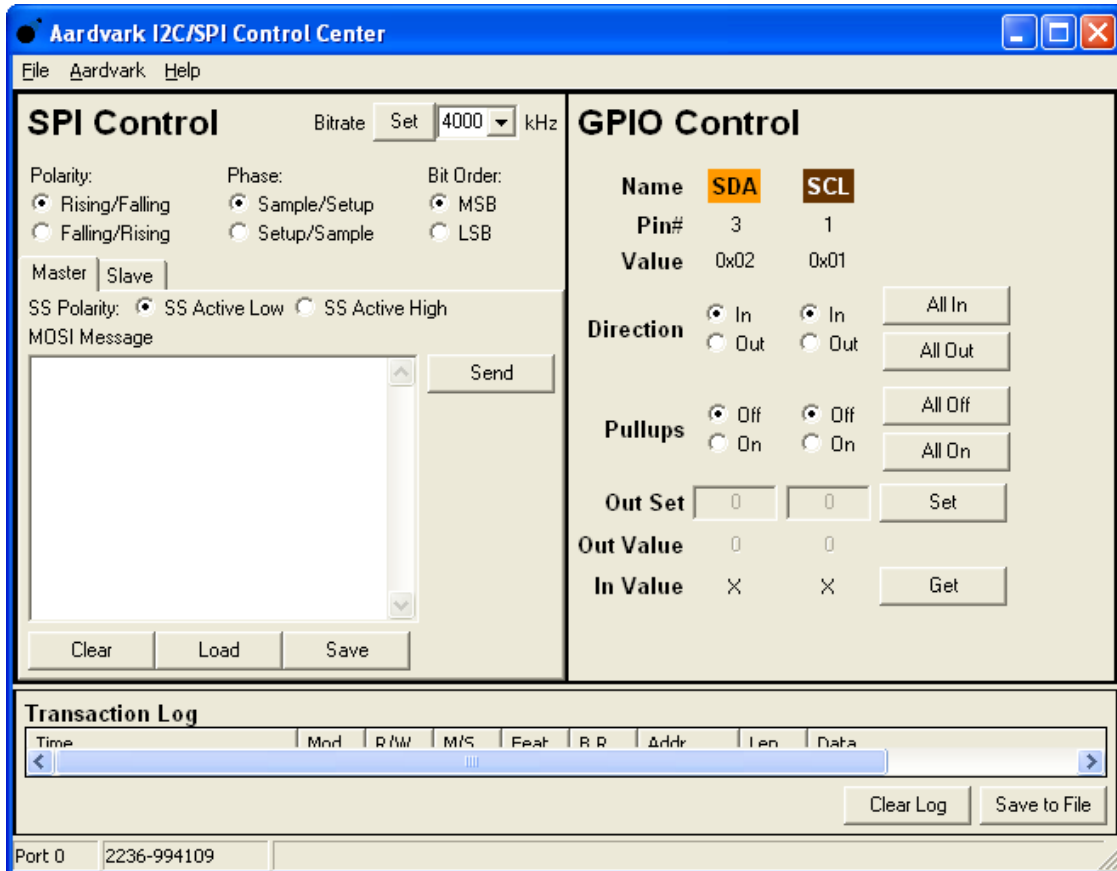


Figure 8. Aardvark software setup window



## 9.0 Appendix C – Installing and Running the WaveVision 4 Software

### 9.1 Installing the WaveVision Software

1. Insert the WaveVision CD-ROM into the computer's CD-ROM drive.
2. The WaveVision software requires a Java™ Runtime Environment or Java™ Development Kit, Version 1.4 or higher, from Sun Microsystems, Inc. For detailed information on WaveVision's use of Java™ technology, see Section 8.2. If the computer does not have this software, the WaveVision installer will instruct you on how to install it.
3. Locate and run the **WaveVision4Setup.exe** program on the CD-ROM.
4. Follow the on-screen instructions to finish the install

### 9.2 Java™ Technology

The WaveVision software uses Sun Microsystems® Java technology. The underlying Java software must be installed on the computer in order for the WaveVision 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 or higher. A suitable copy of the JRE is included on the WaveVision CD-ROM.

The WaveVision installer will first search for an existing copy of the JRE or JDK on the computer. If neither is found, the installer will prompt you to first install a JRE. To do this, run the **J2RE\*.exe** installer program which may be found on the CD-ROM. Follow the on-screen instructions to finish the install.

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

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

### 9.3 Automatic Device Detection and Configuration

The WaveVision system provides automatic hardware detection and configuration for the device under test. The FPGA is re-programmed automatically by the host PC when the evaluation board is turned on.

Normally, the configuration process is completely transparent to the user and requires no intervention. However, this process can be overridden, if required, by specifying a new Xilinx configuration image. To do this, select the **Xilinx Image Settings** button within the Capture Setting window (**Settings ? Capture Settings**).

### 9.4 Windows Driver

The WaveVision software communicates with the WaveVision hardware through the Windows device driver software. If you are unable to connect to the WaveVision board after installing the software, do the following to uninstall and reinstall the driver:

1. Find the Windows **Control Panel** and select **System**. If you are using Windows 2000/XP, select the **Hardware** tab.
2. Click on **Device Manager** and scroll down to the **Universal Serial Bus controllers**.
3. With the WaveVision board connected, an unknown device will be listed.
4. Right click on the unknown device and uninstall the driver.
5. Unplug the USB cable from the board.
6. Plug in USB cable to the board again to reinstall the driver.

## 10.0 Appendix D – Using WaveVision Plots

The WaveVision software provides several tools to manipulate the plot view. A toolbar appears above each plot, similar to Figure 11.



**Figure 11. WaveVision 4 toolbar menu**

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 it, 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 WaveVision software maintains default options for new plots. You may edit the default options by choosing **Default Plot Options** from the **Settings** menu.
- **FFT Options:** The toolbar shown in Figure 15 is from an FFT plot, and thus contains a button to edit the options for the FFT calculation. Depending upon the type of plot, various options will 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 the region of interest. 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 full 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 the appropriate end 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.

### 10.1 The Waveform Plot

The Waveform plot displays the raw samples collected from the hardware. This plot is primarily 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 how much of the ADC's dynamic range the analog input signal occupies.

## 10.2 The FFT Plot

The WaveVision software automatically computes a Fast Fourier Transform (FFT) of the sample set, and displays the results in an FFT plot. The resulting FFT plot is, in many respects, the heart of the software because it shows the frequency content of the analog input signal. It marks the fundamental frequency, and a selectable number of harmonics. It also labels their order and frequencies. It shows the power in the fundamental and harmonics. Hover the mouse cursor over a harmonic to display information about it.

The FFT may be used to diagnose common ADC problems such as input spectral impurity, clock phase noise, and clock jitter. The FFT plot also shows several statistics on the quality and purity of the collected samples including 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 five 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.

- **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

$$\text{ENOB} = \frac{\text{SINAD} - 1.76}{6.02}$$

and says that the converter is equivalent to a perfect ADC of this (ENOB) number of bits.

## 10.3 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. The default FFT options may be edited by choosing **Default FFT Options** from the **Settings** menu. The options are:

- **Windowing:** You may choose from one of five different window functions. The window function is applied to the samples before computing the FFT to compensate for the fact that the sample set may not be an integral number of wavelengths of the input signal. In general, Flat-Top will give the best results, 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 FFT 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.
- **IMD Calculations:** The WaveVision software is capable of performing Intermodulation Distortion calculations. When two fundamental frequencies within 3 dBFS 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 the 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.

## 10.4 Histogram Plots

Histogram plots are created by counting the number of times each ADC output code appears in a dataset. Histograms may be computed by software, or by hardware. A software histogram is computed from a dataset which is normally 128k samples or smaller. A hardware histogram is collected directly by the hardware, and may include millions of counts per code. 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.

## 10.5 Information Viewer

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

## 10.6 Data Import and Export

The WaveVision software provides a variety of means to share data with others, in both textual and graphical 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 single column of samples. You may open tab-delimited text files by choosing **Open** from the **File** menu; 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, if 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 into a spreadsheet 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.

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