

## CDB5529 Evaluation Board and Software

### Features

- RS-232 Serial Communication with PC
- On-board 80C51 Microcontroller
- On-board Voltage Reference
- Lab Windows/CVI™ Evaluation Software
  - Register Setup & Chip Control
  - FFT Analysis
  - Time Domain Analysis
  - Noise Histogram Analysis
- Integrated RS-232 Test Mode

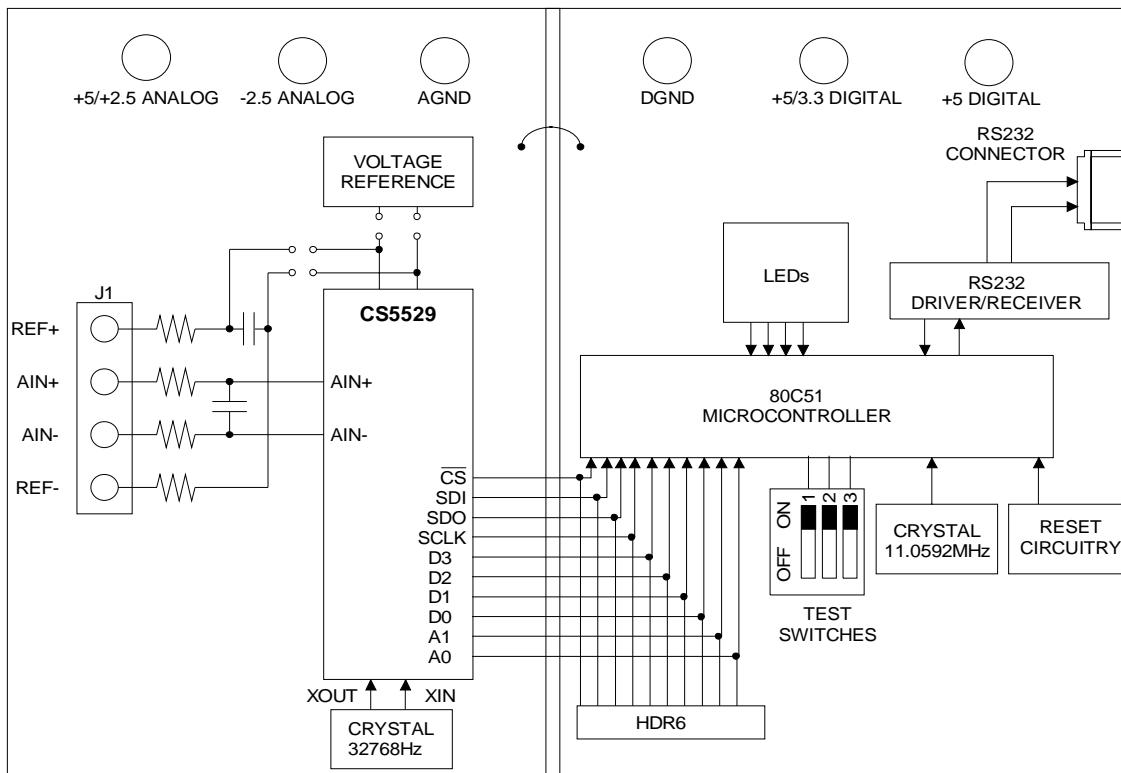
### General Description

The CDB5529 is an inexpensive tool designed to evaluate the performance of the CS5529 16-bit Analog-to-Digital Converter (ADC).

The evaluation board includes an LT1019 voltage reference, an 80C51 microcontroller, an RS232 driver/receiver, and firmware. The 8051 controls the serial communication between the evaluation board and the PC via the firmware, thus, enabling quick and easy access to all of the CS5529's registers.

The CDB5529 also includes software for Time Domain Analysis, Histogram Analysis, and Frequency Domain Analysis.

**ORDERING INFORMATION: CDB5529**



## **PART I: HARDWARE**

### ***Introduction***

The CDB5529 evaluation board provides a quick means of testing the CS5529 Analog-to-Digital Converter (ADC). The board interfaces the CS5529 to an IBM<sup>TM</sup> compatible PC via an RS-232 interface while operating from either a single +5 V supply or dual  $\pm 2.5$  volt supplies. To accomplish this, the board comes equipped with an 80C51 microcontroller and a 9-pin RS-232 cable which physically interfaces the evaluation board to the PC. Additionally, analysis software provides easy access to the internal registers of the converter, and provides a means to display the converter's time domain, frequency domain, and noise histogram performance. The evaluation board's software includes debug algorithms to trouble shoot the evaluation board. Refer to the *Trouble Shooting the Evaluation Board* section for more details.

### ***Evaluation Board Overview***

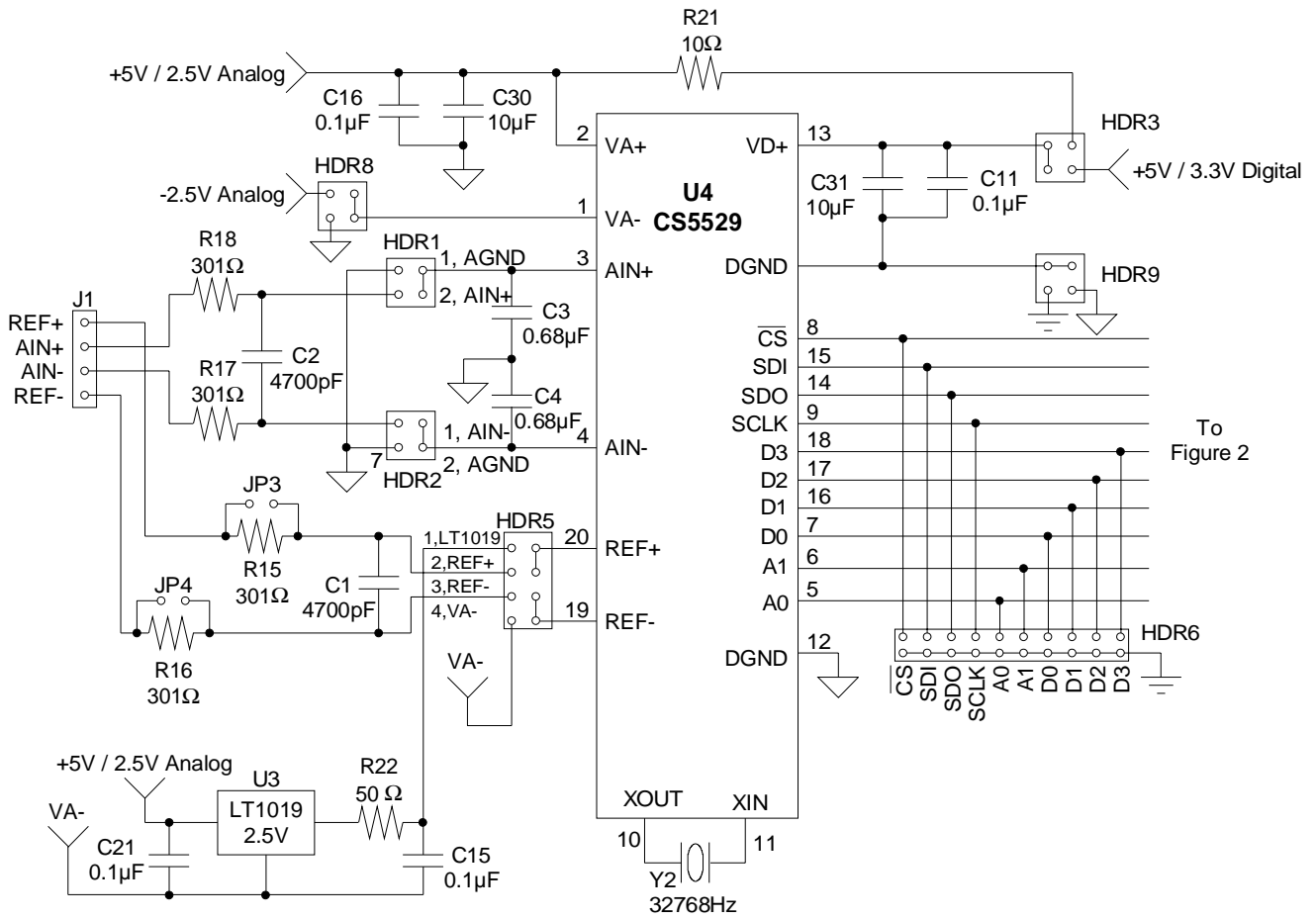
The board is partitioned into two sections: analog and digital. The analog section consists of the CS5529 and a precision voltage reference. The digital section consists of the 80C51 microcontroller, the hardware test switches, the reset circuitry, and the RS-232 interface.

The CS5529 is designed to digitize signals while operating from a 32.768 KHz crystal. As shown in Figure 1, a signal can be connected to the converter's inputs via J1's AIN+ and AIN- inputs. Note that a simple RC network filters the input to reduce broadband noise.

The evaluation board provides two voltage reference options, on-board and external. With HDR5's jumpers in positions 1 and 4, the LT1019 provides an absolute voltage level of 2.5 volts (the LT1019 was chosen for its low drift, typically 5ppm/°C). By setting HDR5's jumpers to position 2 and 3, the user can supply an external voltage reference to J1's REF+ and REF- inputs (Application Note 4 on Crystal Semiconductor's web site details various voltage references).

The ADC serial interface is *SPI*<sup>TM</sup> and *MICROWIRE*<sup>TM</sup> compatible. The interface control lines ( $\overline{CS}$ , SDI, SDO, and SCLK) are connected to the 80C51 microcontroller via port one. To interface an external microcontroller, these control lines are also connected to HDR6. However to accomplish this, the evaluation board must be modified in one of three ways: 1) cut the interface control traces going to the microcontroller, 2) remove resistors R1-R8, or 3) remove the microcontroller.

Figure 2 illustrates the schematic of the digital section. It contains the microcontroller, a Motorola MC145407 interface chip, and test switches. The test switches aid in debugging communication problems between the CDB5529 and the PC. The microcontroller derives its clock from an 11.0592 MHz crystal. From this, the controller is configured to communicate via RS-232 at 9600 baud, no parity, 8-bit data, and 1 stop bit.



**Figure 1. Analog Schematic Section**



Register	Read Command Byte	Write Command Byte
Offset Register	0x90 (H)	0x80 (H)
Gain Register	0x92 (H)	0x82 (H)
Configuration Register	0x94 (H)	0x84 (H)
Conversion Data Register	0x96 (H)	---

**Table 1. Microcontroller Command via RS-232**

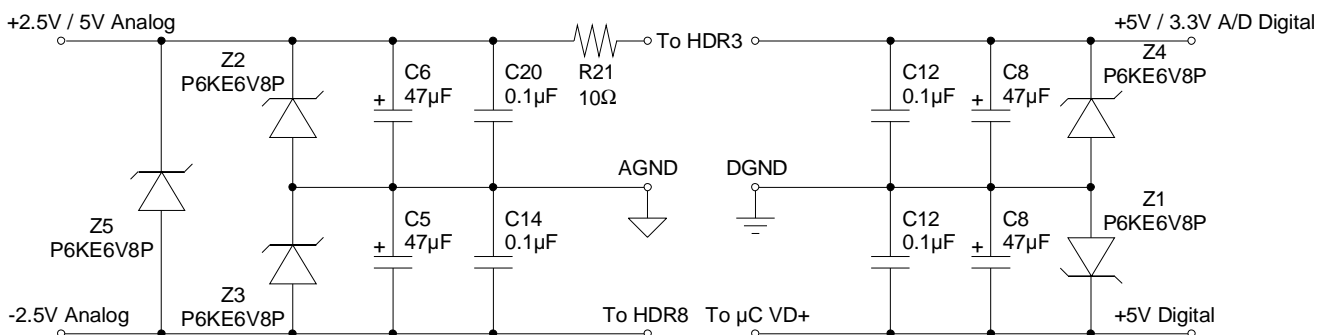
Table 1 lists the RS-232 commands used to communicate between the PC and the microcontroller. To develop additional code to communicate to the evaluation board via RS-232, the following applies: to write to an internal ADC register, choose the appropriate write command byte (See Table 1), and transmit it LSB first. Then, transmit the three data bytes, lowest order byte (bits 7-0) first, with the LSB of each byte transmitted first. These three data bytes provide the 24-bits of information to be written to the desired register. To read from an internal register, choose the appropriate read command byte and transmit it LSB first. Then, the microcontroller automatically acquires the ADC's register contents and returns the 24-bits of information. The returned data is transmitted lowest order byte first with the LSB of each byte transmitted first.

The CS5529 A/D converter is designed to operate from a single +5V or a dual  $\pm 2.5V$  analog supply. Figure 3 illustrates the power supply connections to the evaluation board. The +2.5/5V Analog supplies the positive analog section of the evaluation board,

the LT1019 and the ADC. The -2.5V Analog supplies the negative. HDR8 (see Figure 1) can be used to bypass VA- to ground. The +5V Digital supplies the digital section of the evaluation board. It powers the 80C51, the reset circuitry, and the RS-232 interface circuitry.

### Using the Evaluation Board

The CS5529 is a highly integrated ADC. It contains coarse/fine charge buffers and programmable output word rates (OWR). The buffers provide charge to the modulator reducing the dynamic current demand from the signal being digitized and from the external reference. The ADC's digital filter allows the user to select output word rates (OWR's) from 1.88 Hz up to 101.1 Hz (assuming a 32.768 kHz clock). 303 Hz output word rates can be attained when a 100kHz clock source is used. Since the CS5529 has such a high degree of integration and flexibility, the CS5529 data sheet should be read thoroughly before and consulted during the use of the CDB5529.


**Figure 3. Power Supplies**

Name	Function Description
HDR1	Used to switch AIN+ between J1 input and AGND.
HDR2	Used to switch AIN- between J1 input and AGND.
HDR3	Used to switch digital power for the converter (VD+) from positive analog supply header (+5V/2.5V Analog) to the positive digital supply header (+5V/3.3V Digital).
HDR4	Does not exist.
HDR5	Used to switch VREF+ and VREF- pins from external J1 connection header to the on board LT1019 reference.
HDR6	Used to connect external micro-controller.
HDR7	Used in conjunction with the self test modes to test the UART communication between the microcontroller and the PC.
HDR8	Used to switch the analog component's (LT1019 and converter) negative potential between the -2.5V Analog header and AGND.
HDR9	Used in conjunction with HDR3 to switch the digital ground of the converter (DGND) from the AGND header to the DGND header.
HDR10	Used to switch the A0 and A1 output switches of the converter into the microcontroller. These shunts must be disconnected when the converter powered from bipolar supplies.

## Software

The evaluation board comes with software and an RS-232 cable to link the evaluation board to the PC. The executable software was developed with Lab Windows/CVI™ and meant to run under Windows™ 3.1 or later. After installing the software, read the readme.txt file for last minute changes in the software. Additionally, **Part II: Software** further details how to install and use the software.

**Schematic & Layout Review Service**

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## **PART II: SOFTWARE**

### ***Installation Procedure***

To install the software:

- 1) Turn on the PC.
- 2) At DOS prompt type WIN to Launch Windows 3.1™ or later.
- 3) Insert the Installation Diskette into the PC.
- 4) From within the Windows Program Manager, pull down File from the menu bar and select the Run option.
- 5) At the prompt  
type: A:\SETUP.EXE <enter>.
- 6) The program will begin installation.
- 7) After a few seconds, the user will be prompted to enter the directory in which to install the CVI Run-Time Engine™. The Run-Time Engine™ manages executables created with Lab Windows/CVI™ and takes approximately 1.5 megabytes of hard drive space. If the default directory is acceptable, select OK and the Run-Time Engine™ will be installed there.
- 8) After the Run-Time Engine™ is installed, the user is prompted to enter the directory in which to install the CDB5529 software. Select OK to accept the default directory.
- 9) The program takes a few minutes to install. After the program is installed, double click on the Eval5529 icon to launch it. After a few seconds, the user should be in the graphical user interface environment.

**Note:** *The software is written to run with 640 x 480 (standard VGA in Windows 3.1™) resolution; however, it will work with 1024 x 768 resolution. If the user interface seems to be a little small, the user might consider setting the display settings to the 640 x 480 standard (640x480 was chosen to accommodate a variety of computers).*

### ***Using the Software***

At start-up, the window START-UP CONFIGURATION appears first. This window contains information concerning the software's title, revision number, copyright date, etc. Additionally, at the top of the screen is a menu bar which displays user options. Notice, the menu bar item Menu is initially disabled. This eliminates any conflicts with the mouse or concurrent use of modems. Before proceeding any further, the user is prompted to select the serial communication port. To initialize a port, pull down option Setup from the menu bar and select either COM1 or COM2. Next, select the appropriate part under the Part menu. After a port is initialized and the part selected, it is a good idea to test the RS-232 link between the PC and the evaluation board. To do this, pull down the Setup menu from the menu bar and select the option TESTRS232. The user is then prompted to set the evaluation board's test switches to 011 and then reset the board. Once this is done, proceed with the test. If the test fails, check the hardware connection and repeat again. Otherwise, set the test switches to 000 (normal mode) and reset the board. The option Menu is now available and performance tests can be executed.

The evaluation software provides three types of analysis tests - Time Domain, Frequency Domain, and Histogram. The Time Domain analysis processes acquired conversions to produce a plot of Conversion Sample Number versus Magnitude. The Frequency Domain analysis processes acquired conversions to produce a magnitude versus frequency plot using the Fast-Fourier transform (results up to  $F_s/2$  are calculated and plotted). Also, statistical noise calculations are calculated and displayed. The Histogram analysis processes acquired conversions to produce a histogram plot. Statistical noise calculations are also calculated and displayed (see figures 4 through figure 9).

The evaluation software was developed with Lab Windows/CVI™, a software development package from National Instruments. More sophisticated analysis software can be developed by purchasing the development package from National Instruments (512-794-0100).

### ***Menu Bars Overview***

The menu bar controls the link between windows and allows the user to exit the program. It also allows the user to initialize the serial port and load presaved data conversions from a file. The five principal windows are the START UP CONFIGURATION (also referred to as the Setup Window), the Input / Output Window, the Histogram Window, the Power Spectrum Window (also referred to as the FFT window), and the Time Domain Window.

Specifically, the menu bar has the following control items:

**Menu:** To select, click on option Menu from the menu bar, or use associated hot keys. The items associated with MENU are listed and described below.

***Setup Window (F1)***

***Input/Output Window (F2)***

***Histogram Window (F3)***

***Power Spectrum Window (F4)***

***Time Domain Window (F5)***

These five menu items allow the user to navigate between the five windows. They are available at all times via the menu bar or hot keys.

**SETUP:** To select, click on option Setup from the menu bar. The functions available under Setup are:

**COM1:** When selected, COM1 is initialized to 9600 baud, no parity, 8 data bits, and 1 stop bit.

**COM2:** When selected, COM2 is initialized to 9600 baud, no parity, 8 data bits, and 1 stop bit.

**Load From Disk:** Used to load and display previously saved data conversions from a file. The file must comply with the CDBCAPTURE file save format. The format is: part number, number of bits, number of conversions, maximum range, and the data conversions. The user is prompted to enter the path and file name of previously saved data. To prevent hardware conflicts, this option is deactivated while in the Input/Output Window.

**TESTRS232:** This test mode tests the ability of the PC to communicate to the evaluation board. It consists of two subtests: 1) test the link between the PC and the RS-232 interface circuitry; and 2) test the RS-232 link between the PC and the microcontroller. HDR7 distinguishes these two subtests. Set HDR7 to Normal to test the complete communication link. Or set HDR7 to Loop Back to test the link between the RS-232 Circuitry and the PC. Then, set the test switches to 110 and reset the evaluation board. The LED's should indicate a binary six signifying that the hardware is ready to initiate the test. To complete the test, the user must initialize the PC. First, use the SETUP menu to select a communications port and then select the TESTRS232 option. From there, prompts navigate the user through the test. The PC indicates if the test passes or fails. Once either test is complete, the LED's toggle to indicate that the test mode is complete.

**QUIT:** Allows user to exit program.

### ***Input/Output Window Overview***

The Input/Output Window allows the user to read and write to the internal register of the converter in either binary or hexadecimal, and acquire real-time conversions. It has quick access control icons that quickly reset the converter, reset the converter's serial port, or self-calibrate the converter's offset and gain. The following are controls and indicators associated with this window.

**Acquire:** This is a control icon. When pressed, the PC transmits the collect single conversion command



to the microcontroller. The microcontroller in turn collects a conversion from the ADC and returns it to the PC. The PC stores the conversion and collects additional conversions to form a set. From the sample set collected, the high, the low, peak-to-peak, average, and standard deviation, are computed (the size of the data set is set by the Num To Average input) and then the display icons are updated. This process continues until the STOP button is pressed, or until another window is selected. Note: The quick access control icons are disabled once Acquire is selected. This eliminates potential hardware conflicts.

**BINARY:** Input icons set or clear the 24 individual bits in the gain, configuration, or offset registers. The bits are first set, then the control icon Write All Registers is selected to update the registers in the converter.

**CONFIGURATION REGISTER:** Text display box that displays the decoded meaning of each bit in the configuration register.

**DECIMAL:** Three display icons that display in decimal the contents of the gain, configuration, and offset registers.

**DIGITAL OUTPUT:** Display icon that displays the six states of the output latch. A0 and A1 are invalid when the converter is powered from bipolar supplies.

**GAIN REGISTER:** Display icon that displays the decimal equivalent of the bits set in gain register.

**HEX:** Three input/display icons that allow a user to set the 24 bits in the gain, configuration, or offset registers via 6 hexadecimal nibbles. If the upper nibbles in the registers are zero's, then leading zero nibbles need to be entered.

**Num To Average:** Input icon that sets the size of the data conversion set referred to when the Acquire button is pressed.

**Read All Registers:** This is a control icon. When pressed the gain, offset, and configuration registers contents are acquired. Then, the configuration text box and the register content icons are updated.

**Reinitialize:** This is a control icon. When pressed, 128 logic 1's followed by a logic '0' are sent to the ADC's serial port to reset its port. It does not reset the RS-232 link.

**Reset A/D:** This is a control icon. When pressed, the microcontroller sends the appropriate commands to return the converter to its initial default state.

**SELF Calibrate:** This is a control icon. When pressed, the appropriate commands are sent to the ADC to calibrate its own offset and gain.

**STOP:** Stops the collection of conversion data.

**Write All Registers:** This is a control icon. When pressed, the 72 binary input icons settings are acquired. This data is then transmitted to the ADC's gain, offset, and configuration registers. Then, the PC's display is updated to reflect the registers changes.

## ***Histogram Window Overview***

The following is a description of the controls and indicators associated with the Histogram Window. Many of the control icons are usable from the Histogram Window, the Frequency Domain Window, and the Time Domain Window. For brevity, they are only described in this section.

**BIN:** Displays the x-axis value of the cursor on the Histogram.

**CANCEL:** Once selected, it allows a user to exit from the COLLECT algorithm. If data conversion sample sets larger than 64 are being collected and the CANCEL button is selected, it is recommended that the user reset the evaluation board. The board will eventually recover from the continuous collection mode, but the recovery time could be as long as 10 minutes.

**COLLECT:** Initiates the data conversion collection process. COLLECT has two modes of operation: collect from file or collect from converter. To collect from a file an appropriate file from the SETUP-DISK menu bar option must be selected. Once a file is selected, its content is displayed in the graph. If the user is collecting real-time conversions to analyze, the appropriate COM port must be selected. The user is then free to collect the preset number of conversions (preset by the CONFIG pop-up menu discussed below). Notice, there is a significant acquisition time difference in the two methods.

**CONFIG:** Opens a pop-up panel to configure how much data is to be collected, and how to process the data once it is collected. The following are controls and indicators associated with the CONFIG panel.

**SAMPLES:** User selection of 64, 256, 512, 1024, 2048, 4096, or 8192 conversions.

**WINDOW:** Used in the Power Spectrum Window to calculate the FFT. Windowing algorithms include the Blackman, Blackman-Harris, Hanning, 5-term Hodia, and 7-term Hodia. The 5-term Hodia

and 7-term Hodia are windowing algorithms developed at Crystal Semiconductor. If information concerning these algorithms is needed, call technical support.

**AVERAGE:** Sets the number of consecutive FFT's to perform and average.

**LIMITED NOISE BANDWIDTH:** Limits the amount of noise in the converters bandwidth. Default is 0 Hz.

**OK:** Accept the change

**MAGNITUDE:** Displays the y-axis value of the cursor on the Histogram.

**MAXIMUM:** Indicator for the maximum value of the collected data set.

**MEAN:** Indicator for the mean of the data sample set.

**MINIMUM:** Indicator for the minimum value of the collected data set.

**OUTPUT:** Control that calls a pop-up menu. This menu controls three options: 1) save current data set to a file with the CDBCAPTURE format, 2) print current screen, or 3) print current graph.

**RESTORE:** Restores the display of the graph after zoom has been entered.

**STD. DEV.:** Indicator for the Standard Deviation of the collected data set.

**TEST:** Quick access control icon, similar to the hot keys, to allow user to quickly switch between a time domain, a frequency domain, or a histogram display.

**VARIANCE:** Indicates the Variance for the current data set.

**ZOOM:** Control icon that allows the operator to zoom in on a specific portion of the current graph. To zoom, click on the ZOOM icon, then click on the graph to select the first point (the 1st point is the top left corner of the zoom box). Then click on the graph again to select the second point (the 2nd point is the bottom right corner of the zoom box). Once an area has been zoomed in to, the OUTPUT functions

can be used to print a hard copy of that region. Click on RESTORE when done with the zoom function.

### ***Frequency Domain Window (i.e. FFT)***

The following describe the controls and indicators associated with the *Frequency Domain Window*.

**CANCEL:** See description in *Histogram Window Overview*.

**COLLECT:** See description in *Histogram Window Overview*.

**CONFIG:** See description in *Histogram Window Overview*.

**FREQUENCY:** Displays the x-axis value of the cursor on the FFT display.

**MAGNITUDE:** Displays the y-axis value of the cursor on the FFT display.

**OUTPUT:** See description in *Histogram Window Overview*.

**S/D:** Indicator for the Signal-to-Distortion Ratio, 4 harmonics are used in the calculations (decibels).

**S/N+D:** Indicator for the Signal-to-Noise + Distortion Ratio (decibels).

**SNR:** Indicator for the Signal-to-Noise Ratio, first 4 harmonics are not included (decibels).

**S/PN:** Indicator for the Signal-to-Peak Noise Ratio (decibels).

**TEST:** See description in *Histogram Window Overview*.

**ZOOM:** See description in *Histogram Window Overview*.

**# of AVG:** Displays the number of FFT's averaged in the current display.

### ***Time Domain Window Overview***

The following controls and indicators are associated with the *Time Domain Window*.

**CANCEL:** See description in *Histogram Window Overview*.

**COLLECT:** See description in *Histogram Window Overview*.

**CONFIG:** See description in *Histogram Window Overview*.

**COUNT:** Displays current x-position of the cursor on the time domain display.

**MAGNITUDE:** Displays current y-position of the cursor on the time domain display.

**MAXIMUM:** Indicator for the maximum value of the collected data set.

**MINIMUM:** Indicator for the minimum value of the collected data set.

**OUTPUT:** See description in *Histogram Window Overview*.

**TEST:** See description in *Histogram Window Overview*.

**ZOOM:** See description in *Histogram Window Overview*.

## ***Trouble Shooting the Evaluation Board***

This section describes special test modes incorporated in the microcontroller software to diagnose hardware problems with the evaluation board.

**Note:** *To enter these modes, set the test switches to the appropriate position and reset the evaluation board. To re-enter the normal operation mode, set the switches back to binary zero and reset the board again.*

**Test Mode 0, Normal Mode:** This is the default mode of operation. To enter this mode, set the test switches to 000 and reset the board. The evaluation board allows normal read/writes to the ADC's registers. All the LED's toggle on then off after reset, and then only when communicating with the PC.

**Test Mode 1, Loop Back Test:** This test mode checks the microcontroller's on-chip UART. To enter this mode, set test switches to 001, set HDR7 for loop back, and then reset the board. If the communication works, all the LED's toggle. Otherwise, only 1/2 of the LED's toggle to indicate a communication problem.

**Test Mode 2, Read/Write to ADC:** This test mode tests the microcontroller's ability to read and write to the ADC. To enter this mode, set the switches to 010 and reset the board. In this test mode, the ADC's configuration, offset, and gain registers are written to and then read from. If the correct data is read back, all the LED's toggle. Otherwise, only half of them toggle to indicate an error.

**Test Mode 3, Continuously Acquire Single Conversion:** This test mode repetitively acquires a single conversion. To enter this mode, set the test switches to 011 and press reset. A binary three is indicated on the LED's. By probing HDR6 and using  $\overline{CS}$  as a triggering pin, an oscilloscope or logic analyzer will display in real-time how the microcontroller reads conversion data.

**Test Mode 4:** Reserved for future modifications.

**Test Mode 5, Continuously Read Gain Register:** This test mode repetitively acquires the gain registers default contents (0x400000 HEX). To enter this mode, set the test switches to 101 and press reset. The LED's should indicate a binary five. By probing HDR6 and using  $\overline{CS}$  as a triggering pin, an oscilloscope or logic analyzer will display in real-time how the microcontroller acquires a conversion.

**Test Mode 6, PC to Microcontroller RS-232 Communication Link Test:** This test mode tests the ability of the PC to communicate to the evaluation board. It consists of two subtests: 1) test the link between the PC and the RS-232 interface circuitry; and 2) test the RS-232 link between the PC and the microcontroller. HDR7 distinguishes these two subtests. Set HDR7 to Normal to test the complete communication link. Or set HDR7 to Loop Back to test the link between the RS-232 Circuitry and the PC. Then, set the test switches to 110 and reset the evaluation board. The LED's should indicate a binary six signifying that the hardware is ready to initiate the test. To complete the test, the user must initialize the PC. First, use the SETUP menu to select a communications port and then select the TESTRS232 option. From there, user prompts navigate the user through the test. The PC indicates if the test passes or fails. Once either test is complete, the LED's toggle to indicate that the test mode is complete.

**Test Mode 7, Toggle LED's:** This test mode tests the evaluation board LED's. To enter this mode, set the test switches to 111 and reset the board. If the mode passes, the LED's toggle.

**Note:** *Remember, to return to the normal operating mode, set the test switches to binary zero, return HDR7 to Normal, and reset the evaluation board.*



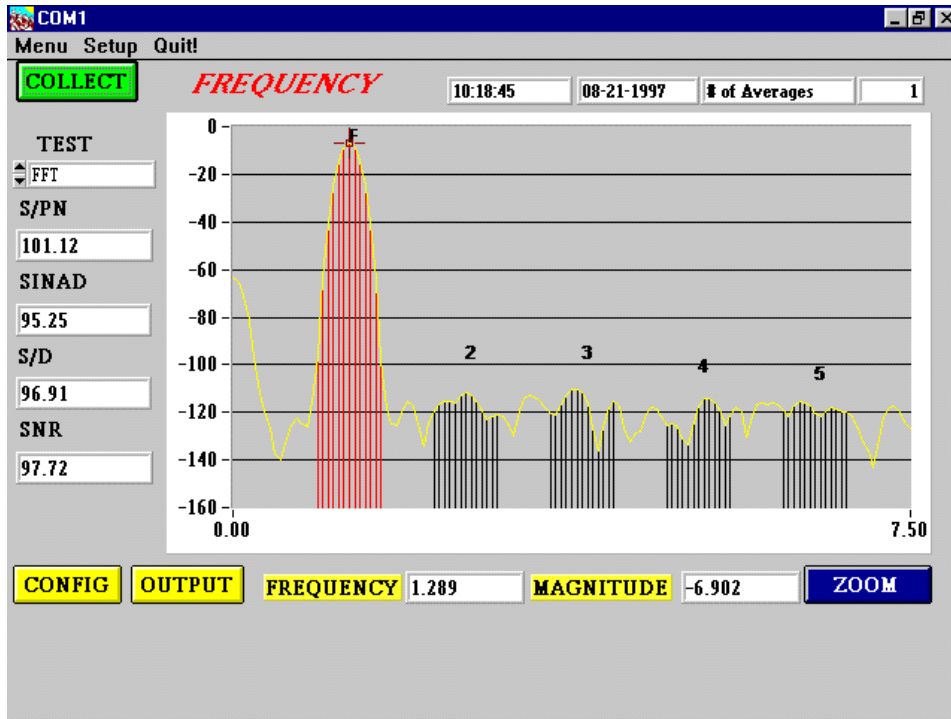


Figure 6. Frequency Domain Analysis

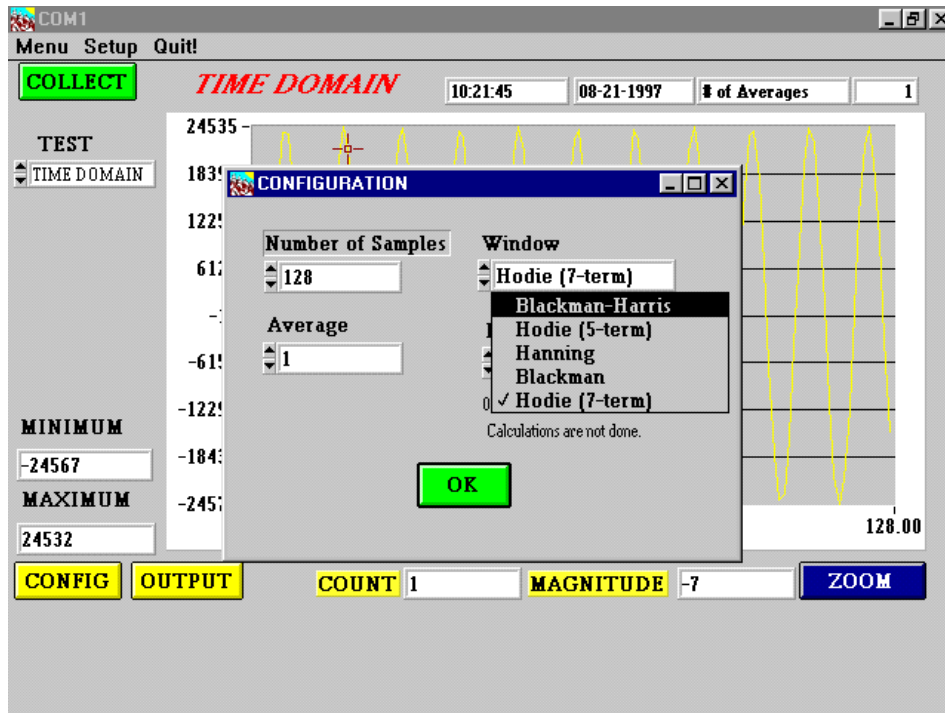


Figure 7. Configuration Menu

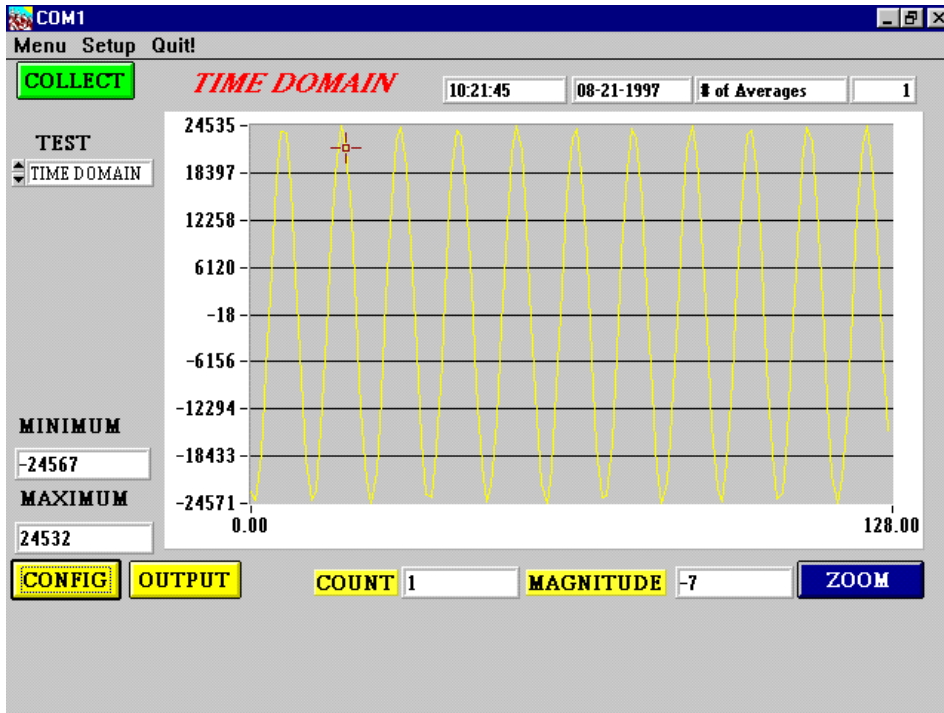


Figure 8. Time Domain Analysis

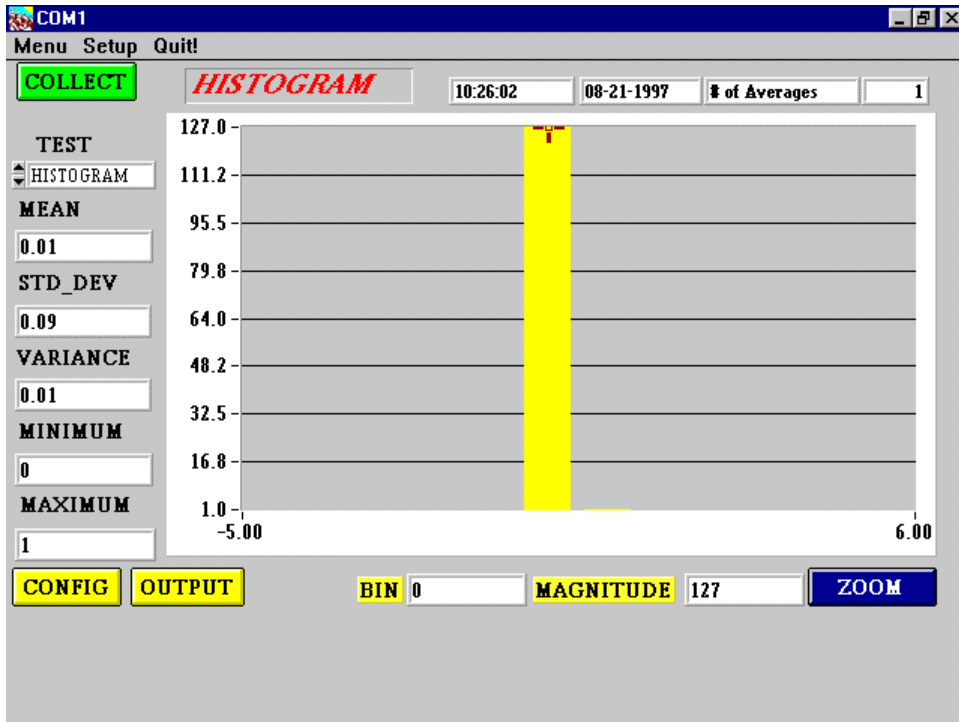
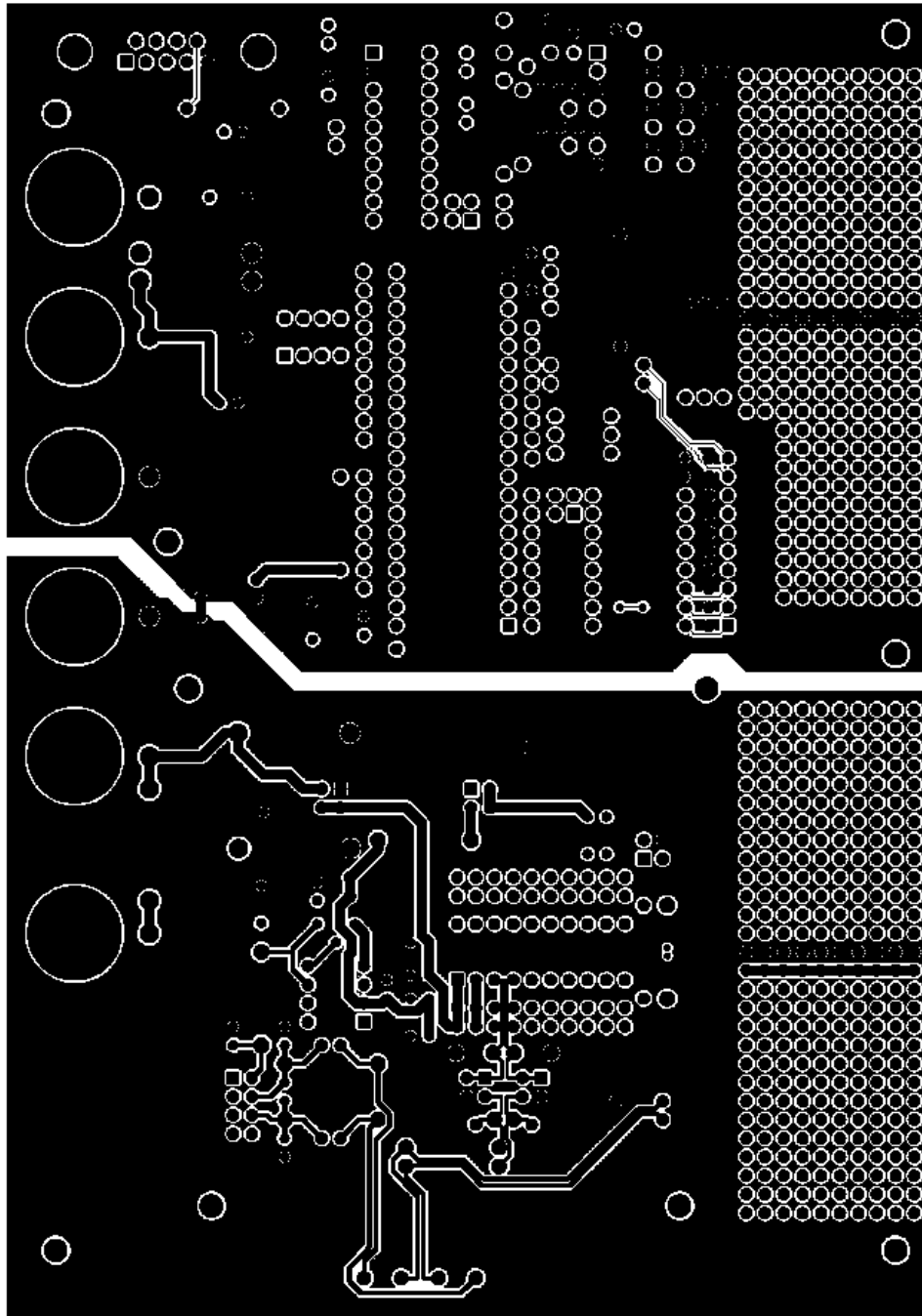


Figure 9. Histogram Analysis





CRYSTAL SEMICONDUCTOR  
CDB5529 Customer Demonstration Board  
CDB5529 Rev B

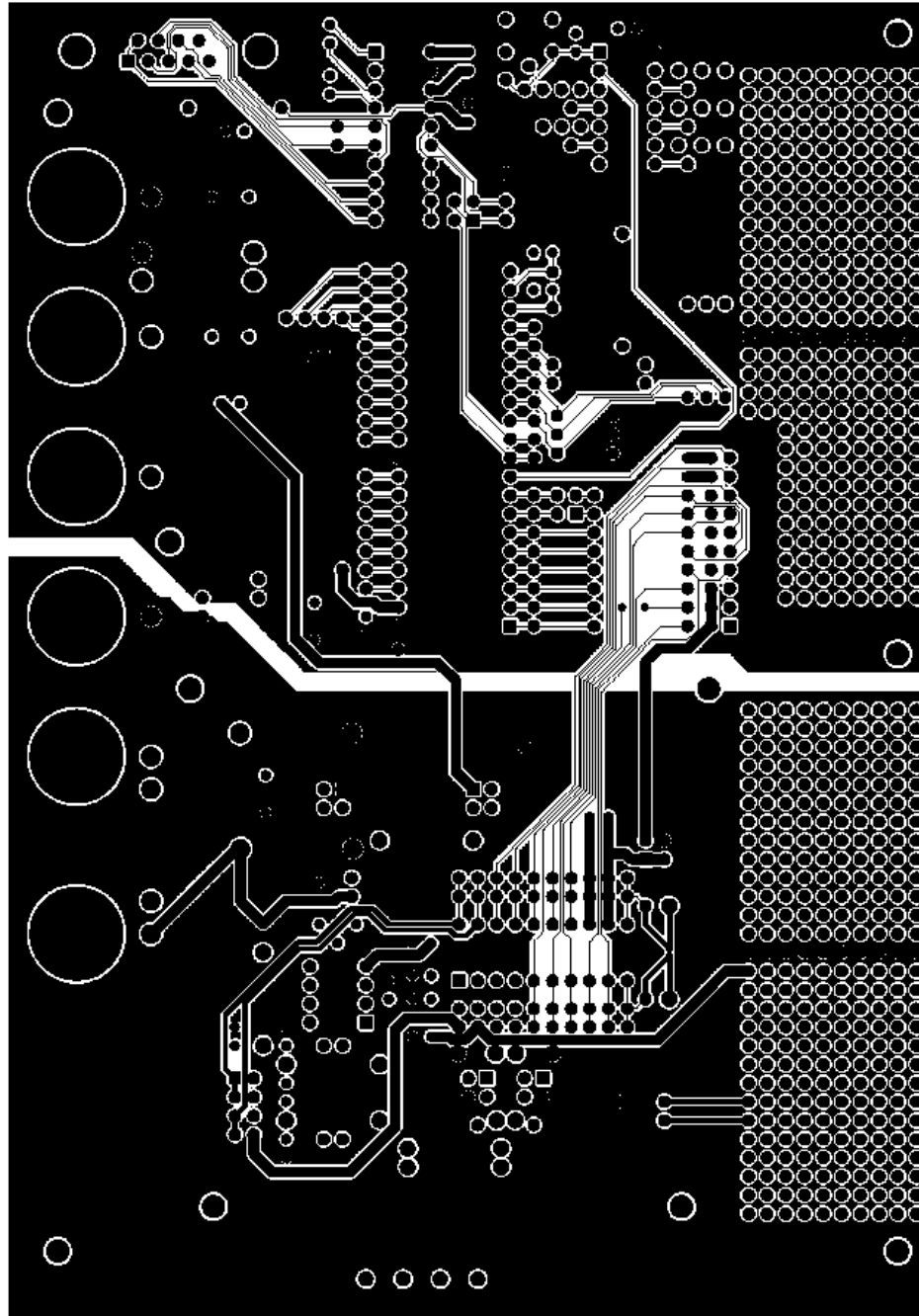


TOP SIDE



Figure 11. CDB5529 Component Side (top)

CRYSTAL SEMICONDUCTOR  
CDB5529 Customer Demonstration Board  
CDB5529 Rev B



BOTTOM SIDE



Figure 12. CDB5529 Solder Side (bottom)

• Notes •

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