Performance Demonstration Kit for the ADS130E08

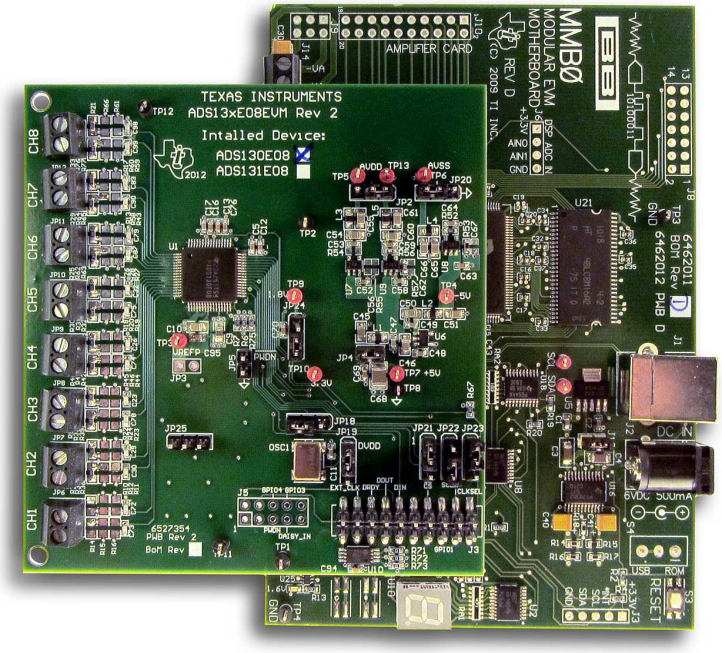

Figure 1. ADS130E08EVM-PDK

This user's guide describes the characteristics, operation, and use of the ADS130E08EVM-PDK. This performance demonstration kit is an evaluation module for the ADS130E08, an eight-channel, 16-bit, low-power, integrated analog front-end (AFE) designed for power protection circuits. The ADS130E08EVM-PDK is intended for prototyping and evaluation. This user's guide includes a complete circuit description, schematic diagram, and bill of materials.

Throughout this document, the terms ADS130E08EVM-PDK, demonstration kit, evaluation board, evaluation module, and EVM are synonymous with the ADS130E08EVM.

The following related documents are available through the Texas Instruments web site at www.ti.com.

Table 1. Related Documentation

Device	Literature Number
ADS130E08	SBAS574

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1 ADS130E08EVM Overview

1.1 Information about Cautions

This document contains caution statements. The information in a caution statement is provided for your protection. Be sure to read each caution carefully.

CAUTION

This is an example of a caution statement. A caution statement describes a situation that could potentially damage your software or equipment.

1.2 Introduction

The ADS130E08EVM-PDK is intended for evaluating the ADS130E08 low-power, 16-bit, simultaneously-sampling, eight-channel analog-to-digital converter (ADC). The digital SPI™ control interface is provided by the MMB0 modular EVM motherboard that connects to the ADS130E08 evaluation board. The ADS130E08EVM-PDK is designed to expedite evaluation and system development.

The MMB0 motherboard allows the ADS130E08EVM to be connected to the computer thorugh an available USB port. This manual shows how to use the MMB0 as part of the ADS130E08EVM-PDK, but does not provide technical details about the MMB0.

1.3 Supported Features

Hardware Features:

- Configurable for bipolar or unipolar supply operation
- Configurable for internal and external clock through jumper settings
- Analog test signals can be applied easily using screw terminals

Software Features:

- Analysis tools, including a virtual oscilloscope, histogram, and fast Fourier transform (FFT)
- Access to a variety of register contents, including PGA options and more.
- Set ADS130E08 register settings with easy-to-use, graphical user interface (GUI) software

1.4 ADS130E08EVM Hardware

Figure 2 shows the hardware included in the ADS130E08EVM kit. Contact the factory at http://e2e.ti.com if any component is missing. Also, it is highly recommended that you check the TI website at http://www.ti.com to verify that you have the latest software.

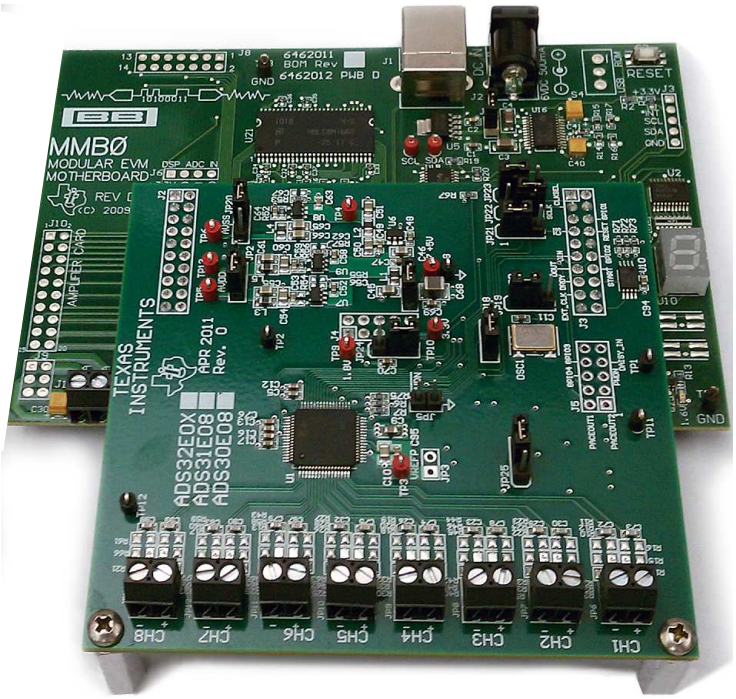


Figure 2. ADS130E08EVM-PDK Kit

The complete kit includes the following items:

- ADS130E08EVM printed circuit board (PCB)
- MMB0 (modular EVM motherboard)

An external power supply is required to power the MMB0 board. Any supply used to power the MMB0 board through the jack located at J2 must comply with the following requirements:

- Output voltage: 5.5 VDC to 15 VDC
- Maximum output current: ≥ 500 mA
- Output connector: barrel plug (positive center), 2.5-mm I.D. x 5.5-mm O.D. (9-mm insertion depth)
- Complies with applicable regional safety standards

2 Software Installation

2.1 Minimum Requirements

Before installing the software that is intended for use with the EVM kit, please verify that your PC-compatible computer meets the following minimum requirements:

- Pentium III® or Celeron® processor, 866 MHz or equivalent
- Minimum 256 MB of RAM (512 MB or greater recommended)
- USB 1.1-compatible input
- Hard disk drive with at least 200 MB free space
- Microsoft® Windows® XP operating system with SP2
- Mouse or other pointing device
- 1280 × 960 minimum display resolution

2.2 Installing the Software

CAUTION

Do not connect the ADS130E08EVM hardware before installing the software on a suitable PC. Failure to observe this caution may cause Microsoft Windows to not recognize the ADS130E08EVM.

Download the latest software from the TI website at www.ti.com/tool/ADS130E08EVM-PDK. To install the ADS130E08 software, unzip and run *setup.exe*. Figure 3 shows the initialization screen.

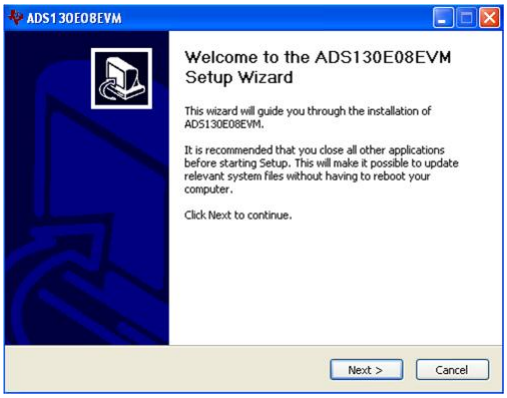


Figure 3. Initialization of ADS130E08EVM GUI

You must accept the two license agreements shown in Figure 4 and Figure 5 before the installation can proceed.

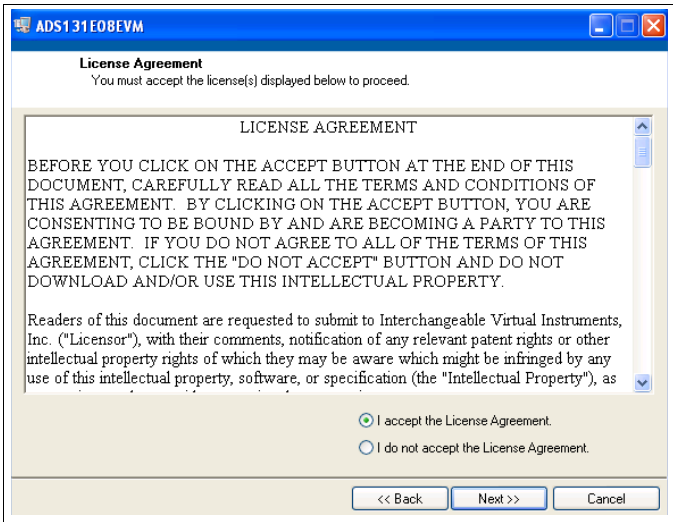


Figure 4. License 1

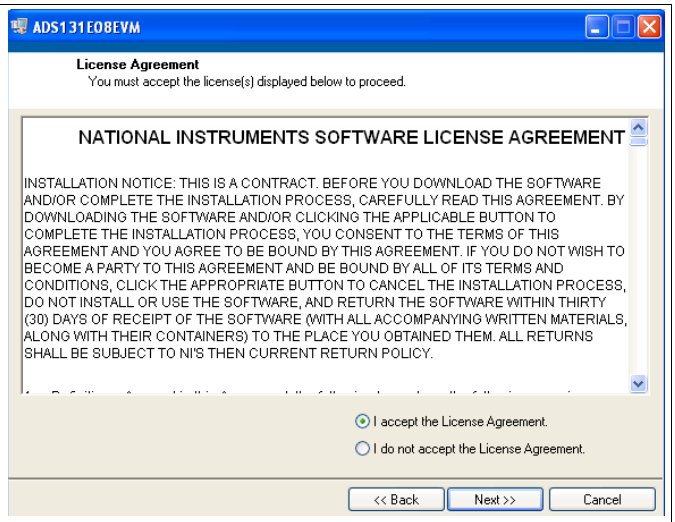


Figure 5. License 2

2.3 Installing the ADS130E08EVM-PDK Hardware Drivers

2.3.1 Installing the First USB Driver

Apply power to the MMB0 using a power supply as discussed in Section 1.4 and connect the MMB0 to your PC through any available USB port. The *Found New Hardware Wizard* window appears, as shown in Figure 6. Note that this is the first of two USB drivers that are installed. Click *Next* to continue driver installation.

Figure 6. New Hardware Wizard Screen 1

Click *Next* when the screen in Figure 7 appears.

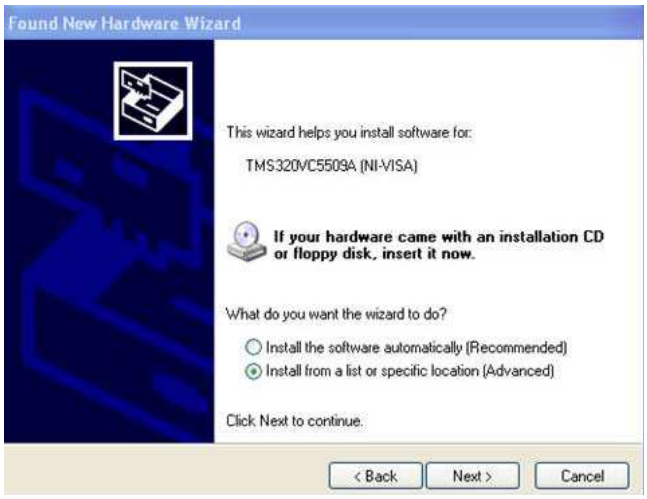


Figure 7. New Hardware Wizard Screen 2

Navigate to *C:\Program Files\ADS130E08EVM\USB Driver*, as shown in Figure 8.

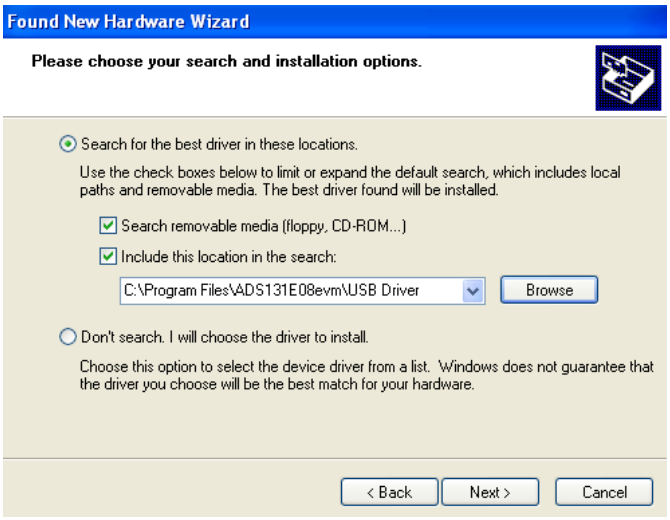


Figure 8. New Hardware Wizard Screen 3

Click *Next* to find and install the driver. When the wizard is complete, the screen in Figure 9 appears.

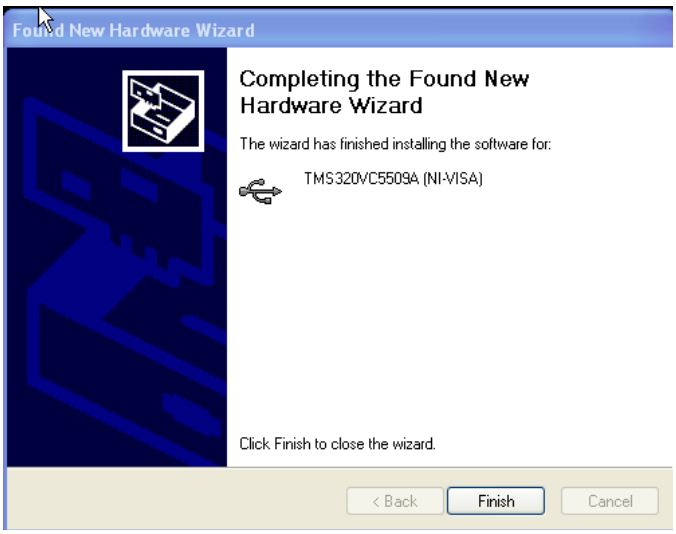


Figure 9. Completion of the First USB Driver

2.3.2 Installing the Second USB Driver

Launch the ADS130E08EVM-PDK software from the program menu. The software loads and begins downloading firmware to the processor on the MMB0. After the firmware is loaded and running, the *Found New Hardware Wizard* starts again, as shown in Figure 10.

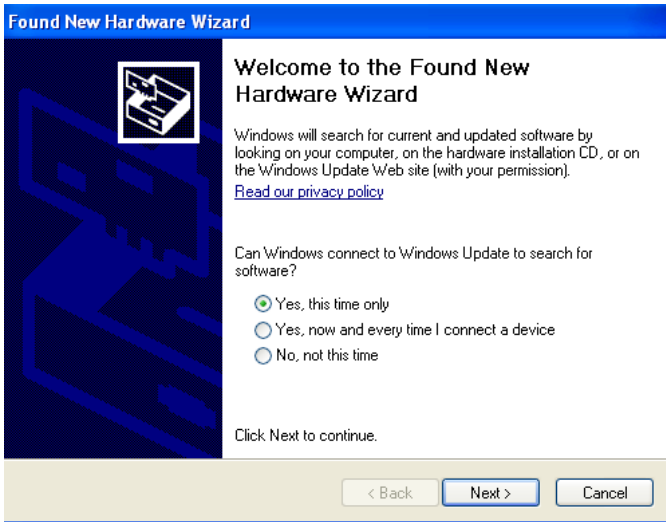


Figure 10. Second New Hardware Wizard Screen

Click *Next* and the screen in Figure 11 appears.

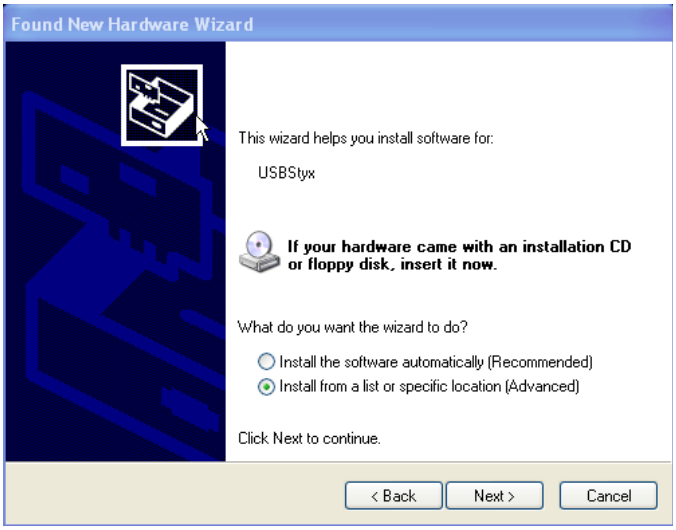


Figure 11. Installing the USBStyx Driver

Click *Next* to complete the installation. If the computer is unable to find the USBStyx driver, point to the installation directory of *C:\Program Files\ADS130E08EVM\USB Drivers*.

At this time, you may receive an error message because the ADS130E08EVM-PDK software has timed out. If so, click *OK*, close the GUI program, power cycle the ADS130E08EVM, and restart the newly installed ADS130E08 evaluation program. This process may need to be repeated if you plug the ADS130E08EVM-PDK into a different USB port on your computer.

3 ADS130E08EVM Daughter-Card Hardware Overview

CAUTION

Many of the components on the ADS130E08EVM are susceptible to damage by electrostatic discharge (ESD). Customers are advised to observe proper ESD handling procedures when unpacking and handling the EVM, including the use of a grounded wrist strap, bootstraps, or mats at an approved ESD workstation. An electrostatic smock and safety glasses should also be worn.

The ADS130E08EVM-PDK board is a four-layer circuit board. The board layout and schematics are appended to the end of this document.

The ADS130E08EVM-PDK is configured to be used with the TI MMB0 data converter evaluation platform. The key features of the ADS130E08 system on a chip (SOC) are:

- Eight integrated instrumentation amplifiers (INAs) and eight, 16-bit, high-resolution ADCs
- Low power consumption
- 3-V to 5-V unipolar or bipolar analog supply, and 1.8-V to 3.3-V digital supply
- SPI data interface

The following sections explain some of the hardware settings possible with the EVM for evaluating the ADS130E08 under various test conditions.

3.1 Power Supply

The ADS130E08EVM mounts on the MMB0 board with connectors J1, J2, and J3. The main power supplies (+5 V, +3.3 V, and +1.8 V) for the front-end board are supplied by the host MMB0 board through connector J3. All other power supplies required for the front-end board are generated onboard by power management devices.

The ADS130E08 operates in unipolar mode using a +3.0-V to +5.0-V analog supply (AVDD/AVSS) and a +1.8-V to +3.3-V digital supply (DVDD), or in bipolar mode using the onboard analog supply (±1.5 V to ±2.5 V). The power consumption of the front-end board is measured by using the JP3 jumper. Power down the ADS130E08 by shorting jumper JP4.

Test points TP4, TP5, TP6, TP7, TP8, TP9, TP10, and TP13 are provided to verify that the host power supplies are correct. The corresponding voltages are shown in Table 2.

Table 2. Power-Supply Test Points

Test Point	Voltage
TP7	+5.0 V
TP4	–4.96 V
TP9	+1.8 V
TP10	+3.3 V
TP5	+3.0 V
TP13	+2.5 V
TP6	–2.5 V
TP8	GND

The front-end board must be properly configured in order to achieve the various power-supply schemes. The default power-supply setting for the ADS130E08EVM is a bipolar analog supply of ±2.5 V, and there are onboard options to switch to a unipolar analog supply of +3 V. The digital supply (DVDD) is selectable to either +3.3 V or +1.8 V. Table 3 shows the board and component configurations for each analog power-supply scheme. Table 4 shows the board configurations for the digital supply. Note that the EVM is shipped with the analog supply set to ±2.5 V and digital supplies set to 3.3 V.

Table 3. Analog Supply Configurations

AVDD and AVSS	Unipolar Analog Supply		Bipolar Analog Supply	
	3 V	5 V	±1.5 V	±2.5 V
JP7	1-2	1-2	2-3	2-3
JP1	2-3	2-3	1-2	1-2
U6	TPS73230	TPS73250	Don't care	Don't care
U8	Don't care	Don't care	TPS73201	TPS73201
U7	Don't care	Don't care	TPS72301	TPS72301
R61	Don't care	Don't care	21 kΩ	47.5 kΩ
R62	Don't care	Don't care	78.7 kΩ	43.2 kΩ
R59	Don't care	Don't care	23.3 kΩ	49.9 kΩ
R60	Don't care	Don't care	95.3 kΩ	46.4 kΩ
C48, C54, C59	Not installed	Not installed	Not installed	Not installed

Table 4. Digital Supply Configurations (DVDD and DGND)

DVDD	3.3 V	+1.8 V
JP7	1-2	1-2
JP1	2-3	2-3
U6	TPS73230	TPS73250
U8	Don't care	Don't care
U7	Don't care	Don't care
R61	Don't care	Don't care
R62	Don't care	Don't care
R59	Don't care	Don't care
R60	Don't care	Don't care
C48, C54, C59	Not installed	Not installed

3.2 Clock

The ADS130E08 has an on-chip oscillator circuit that generates a 2.048-MHz clock (nominal). This clock can vary by ±5% over temperature. For applications that require higher accuracy, the ADS130E08 can also accept an external clock signal. The ADS130E08 provides an option to test both internal and external clock configurations. It also provides an option to generate the external clock from either the onboard oscillator or from an external clock source.

The onboard oscillator is powered by the DVDD supply of the ADS130E08. Care must be taken to ensure that the external oscillator can operate either with +1.8 V or +3.3 V, depending on the DVDD supply configuration. Table 5 shows the jumper settings for the three options for the ADS130E08 clocks.

Table 5. CLK Jumper Options

ADS130E08 Clock	Internal Clock	External OSC Clock	External Clock
JP5	Not installed	2-3	1-2
JP6	Don't care	1-2 (disable)	Don't care
J4 - pin 10	Don't care	Don't care	Clock source

A 2.048-MHz oscillator available for the +3.3-V DVDD supply is the FXO-HC735-2.048MHz. For a +1.8-V DVDD supply, use the SiT8002AC-34-18E-2.048. The EVM is shipped with the external oscillator enabled.

3.3 Reference

The ADS130E08 has an on-chip internal reference circuit that provides reference voltages to the device. Alternatively, the internal reference can be powered down and VREFP can be applied externally. This configuration is achieved with the external reference generators (U2 and U3) and driver buffer. These components (U2, U3, and U4) must be installed by the user; they are not installed at the factory. The external reference voltage can be set to either 4.096 V or 2.5 V, depending on the analog supply voltage. Measure TP3 to make sure the external reference is correct and stable. The settings for the external reference is described in Table 6. This table assumes REF5025 is installed at U2 and REF5040 at U3. A low-noise amplifier like the OPA350 can be installed at U4.

Table 6. External Reference Jumper Options

ADS130E08 Reference	Internal Reference	External Reference	
	VREF = 2.5 V	VREF = 4.096 V	VREF = 2.5 V
JP12	Don't care	2-3	1-2
JP2	Not installed	Installed	Installed

3.3.1 Accessing ADS130E08 Analog Supplies

Some ADS130E08 output signals are provided as test points for probing purposes using J4 (not installed on the board). Table 7 lists the various test signals with the corresponding test points.

Table 7. Auxiliary Connector Test Signals and Test Points

Signal	J4 Pin Number		Signal
Not connected	1	2	GPIO1
Not connected	3	4	GPIO2
PWDN	5	6	GPIO3
Dasiy in	7	8	GPIO4
AGND	9	10	Not connected

3.3.2 Accessing ADS130E08 Digital Supplies

The ADS130E08 digital signals (including SPI signals, some GPIO signals, and some control signals) are available at connector J1. These signals are used to interface to the MMB0 board DSP. The pinout for this connector is shown in Table 8.

Table 8. Serial Interface Pinout

Signal	J1 Pin Number		Signal
START/CS	1	2	CLKSEL
CLK	3	4	GND
NC	5	6	GPIO1
CS	7	8	RESET
NC	9	10	GND
DIN	11	12	GPIO2
DOUT	13	14	NC/START
DRDY	15	16	SCL
EXT_CLK	17	18	GND
NC	19	20	SDA

3.4 Analog Inputs

The ADS130E08 provides users the option to feed in signals from any arbitrary signal source directly. Analog signals can be applied at terminal blocks J5 through J12.

4 Using the Software

The software GUI contains a *Save to File* feature (located in the *Save* tab) that allows all data from any combination of channels, along with notes to describe the data, to be saved to a specified directory. This data can then be read back using a text editor. Saving the data in this format can be completed by clicking the *Save to File* button, as shown in Figure 12.

An additional option in the evaluation software allows register configurations to be saved to a file that can be reloaded to the GUI. To create a configuration file with all of the stored register settings, use the *Save Configuration Settings* option, found in the *File* menu at the top left-hand corner of the GUI. This configuration file can be reloaded to the GUI using the *Load Configuration Setting*s option found in the same *File* menu.

Figure 12 shows the options available in the *Save* tab.

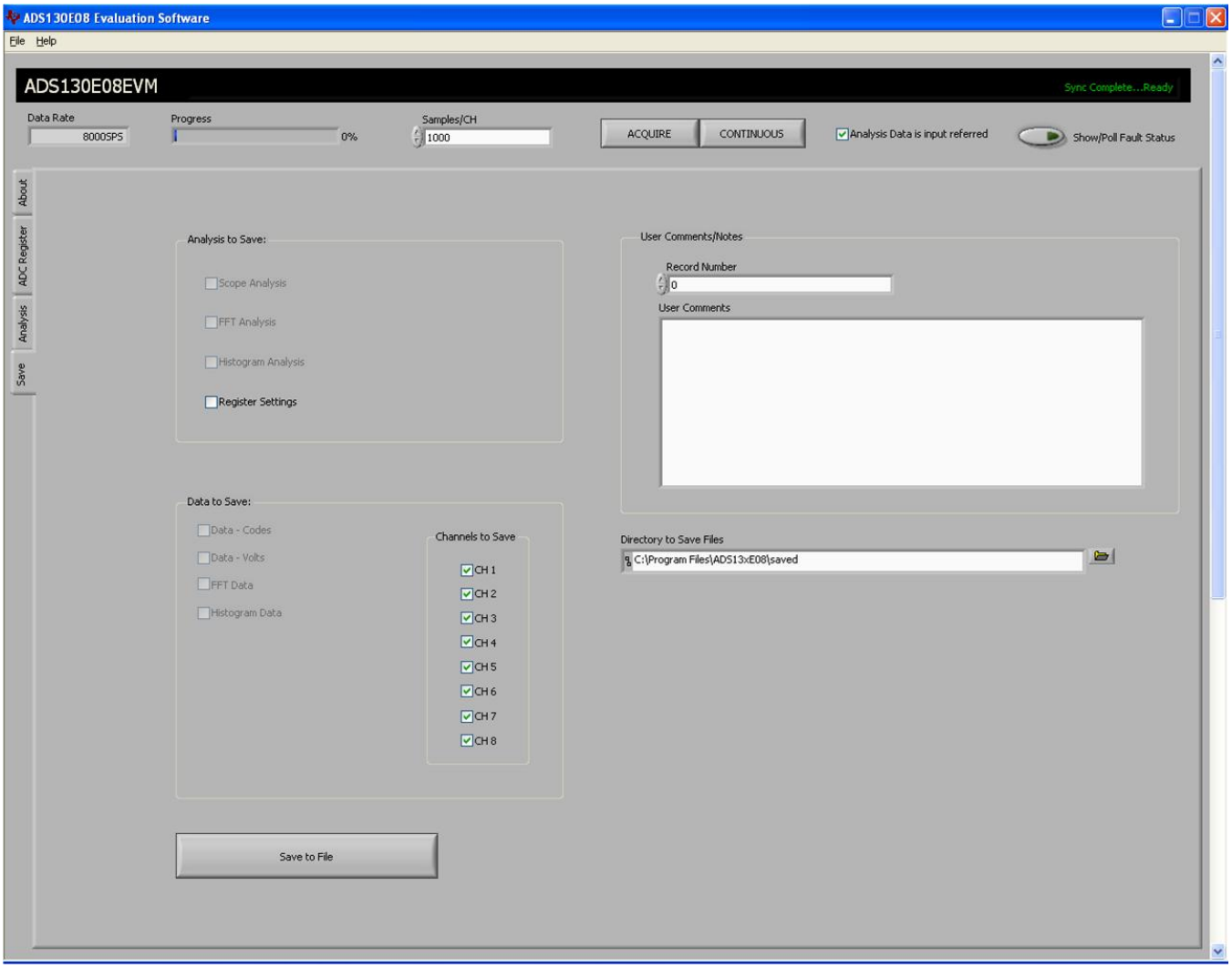


Figure 12. File Save Option Under Save Tab

4.1 Software Overview

This section provides a quick overview of the various features and functions of the ADS130E08EVM software package.

There are four tabs across the left side of the GUI; from top to bottom, they are:

- **About:** Provides information about the EVM and software version revisions.
- **ADC Register:** Includes all of the control registers for the ADS130E08 in a series of related subtabs:
  - Channel Registers
  - GPIO
  - Register Map
- **Analysis:** Provides different ways to analyze captured data, in the time or frequency domain, using the following subtabs:
  - Scope
  - Histogram
  - FFT
- **Save:** Provides options for saving acquired data

4.2 Global Channel Registers

The *Channel Registers* tab provides access to the ADS130E08 configuration and fault threshold registers. The Global Channel Registers tab has the following options:

- **Configuration Register 1:** Controls the CLKOUT option.
- **Configuration Register 2:** Controls the internal test source, along with the test-signal amplitude and frequency.
- **Configuration Register 3:** Controls the reference buffer power-down control, the reference voltage, and the op amp buffer control.
- **Fault Control Register:** Sets the comparator threshold level for fault.

Figure 13 shows the GUI panel to manipulate these registers and the respective settings for each.

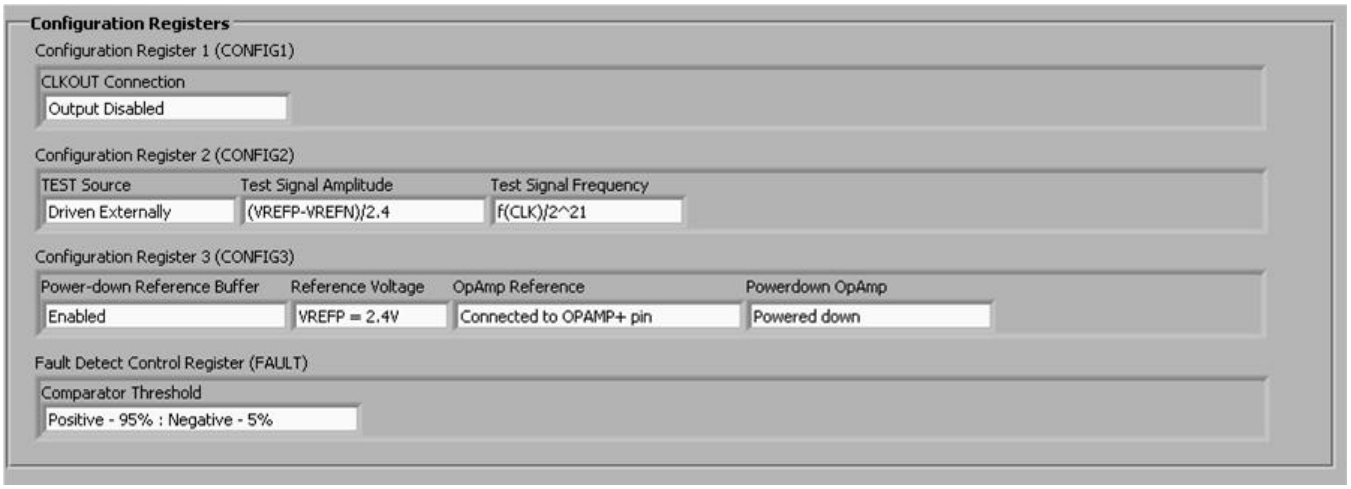


Figure 13. Channel Registers GUI for the Configuration Registers

4.3 Channel Control Registers

The second section under the Channel Registers tab is the Channel Control Registers box. This panel allows the user to uniquely configure the front-end multiplexer (mux) for each channel. Additionally, at the top of the Channel Control Registers box is the option to globally set all channels to the same setting. Table 9 lists the register map. The channel-specific mux is illustrated in Figure 14, and the all-channel-specific mux is shown in Figure 15.

Table 9. Register Assignments: Channel-Specific Settings

Address	Register	Reset Value	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Channel-Specific Settings										
05	CH1SET	00	PD1	GAIN12	GAIN11	GAIN10	0	MUX12	MUX11	MUX10
06	CH2SET	0	PD2	GAIN22	GAIN21	GAIN20	0	MUX22	MUX21	MUX20
07	CH3SET	0	PD3	GAIN32	GAIN31	GAIN30	0	MUX32	MUX31	MUX30
08	CH4SET	0	PD4	GAIN42	GAIN41	GAIN40	0	MUX42	MUX41	MUX40
09	CH5SET	0	PD5	GAIN52	GAIN51	GAIN50	0	MUX52	MUX51	MUX50
0A	CH6SET	0	PD6	GAIN62	GAIN61	GAIN60	0	MUX62	MUX61	MUX60
0B	CH7SET	0	PD7	GAIN72	GAIN71	GAIN70	0	MUX72	MUX71	MUX70
0C	CH8SET	0	PD8	GAIN82	GAIN81	GAIN80	0	MUX82	MUX81	MUX80

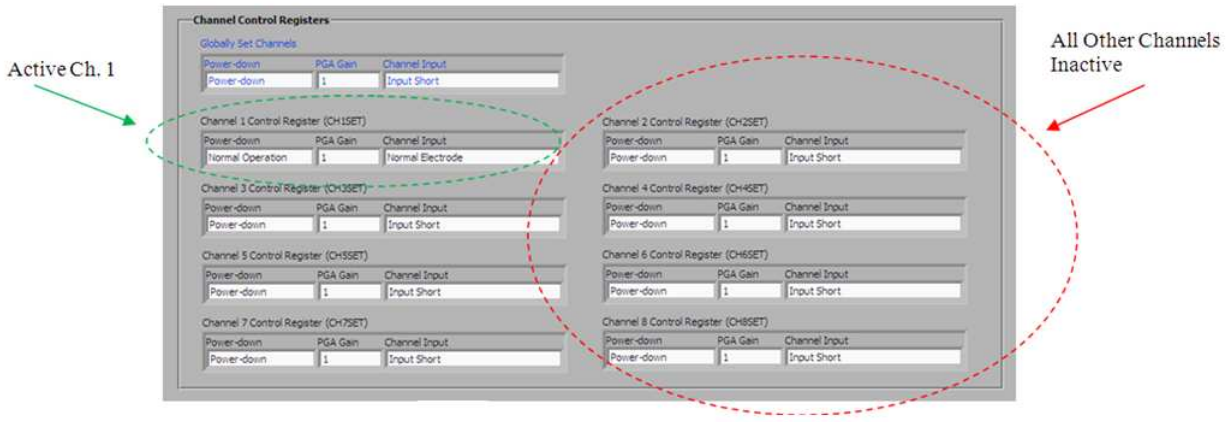


Figure 14. Channel Control Register GUI Panel: Single Channel Enabled

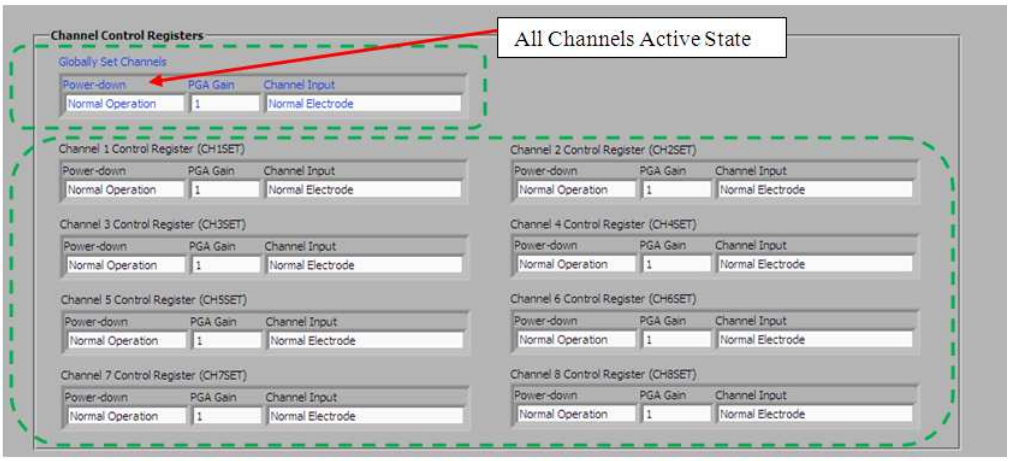


Figure 15. Channel Control Registers GUI Panel: All Channels Enabled

4.4 Internal Test Signals Input and the Scope Display Tab

Configuration Register 2 controls the signal amplitude and frequency of an internally-generated square wave test signal. The primary purpose of this test signal is to verify the functionality of the front-end mux, the programmable gain amplifier (PGA), and the ADC. The test signals may be viewed on the *Analysis→Scope Display* tab, as Figure 16 shows.

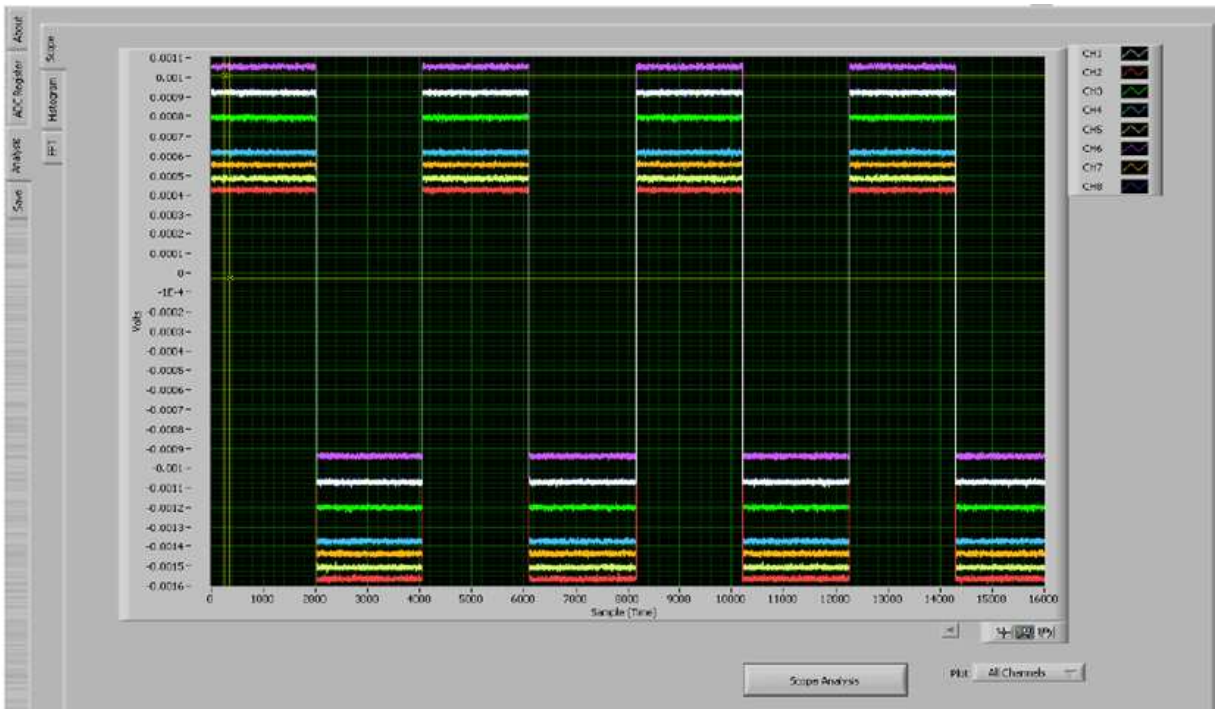


Figure 16. Example of Internal Test Signals Viewed on the Scope Display Tab

4.5 Temperature Sensor and the Scope Display Tab

The internal temperature sensor on the ADS130E08 is shown in Figure 22.

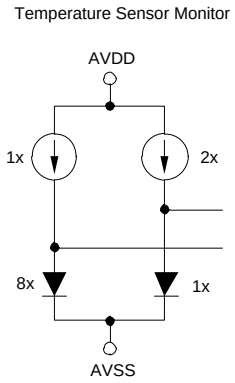


Figure 17. Internal Temperature Sensor

When the internal mux is routed to the temperature sensor input, the output voltage of the ADC may be converted to a temperature value using Equation 1:

$$\text{Temperature (°C)} = \left[\frac{\text{Temperature Readnig (}\mu\text{V)} - 145{,}300\ \mu\text{V}}{490\ \mu\text{V/°C}}\right] + 25°\text{C} \quad (1)$$

The output voltage corresponding to a given temperature can be read by running a data acquisition after the *Temperature Sensor* mux option is selected, as shown in the *Channel Control Registers* section. Figure 18 demonstrates an example of temperature sensor readings read back using the GUI.

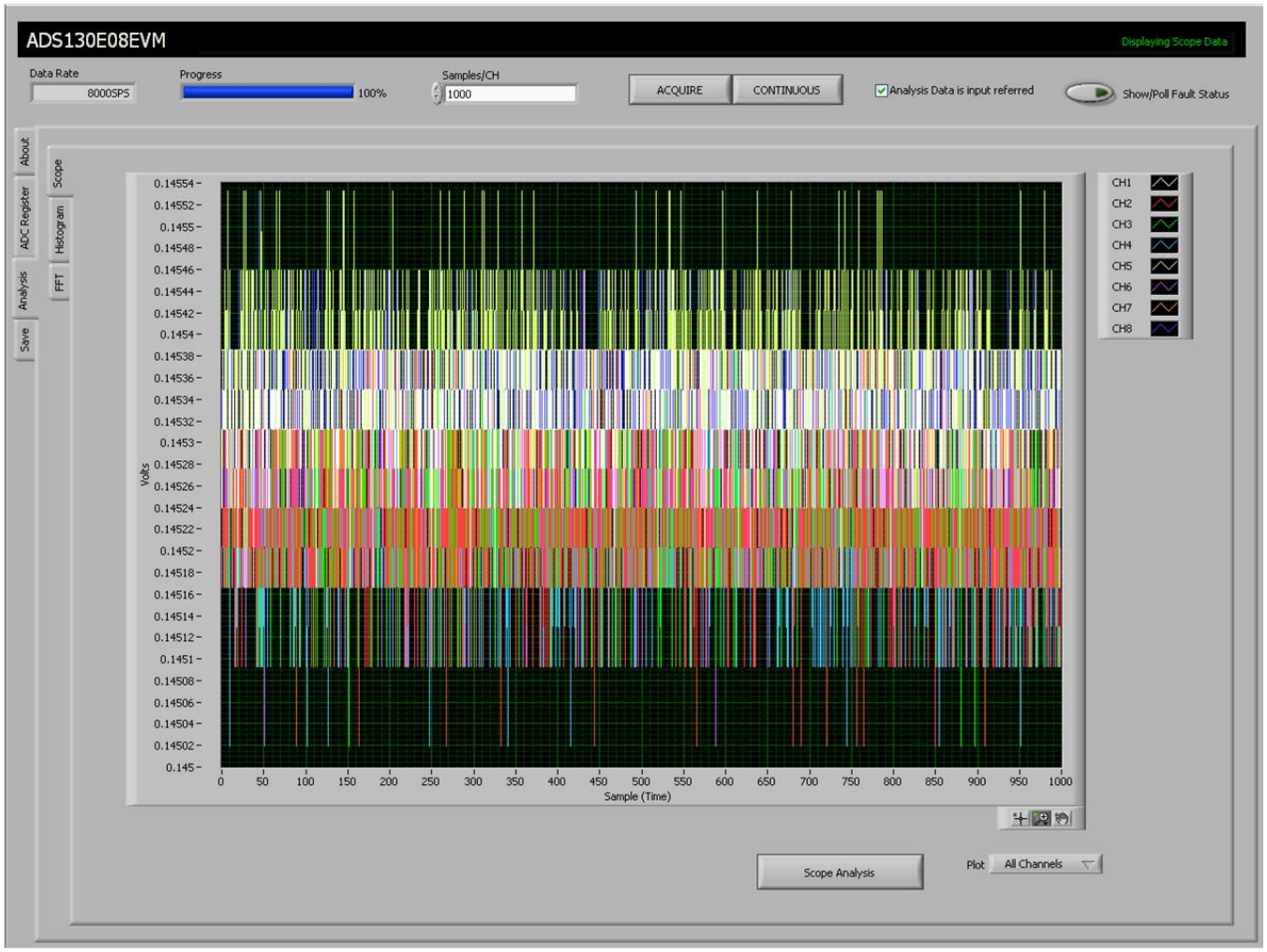


Figure 18. Eight-Channel Read of Internal Temperature Data

The number 0.1447 V (on the y-axis) can be calculated as a temperature using Equation 2:

$$\text{Temperature (°C)} = \left[\frac{0.1447 - 0.145300}{0.00049}\right] + 25 = 23.78°\text{C} \quad (2)$$

4.5.1 MV_{DD} Input and the Scope Tab

The MV_{DD} input option allows the measurement of the supply voltage V_S = (AVDD + AVSS) / 2 for channels 1, 2, 5, 6, 7, and 8; however, the supply voltage for channel 3 is DVDD / 2.

4.6 General-Purpose I/O Register (GPIO)

The GPIO registers control four general-purpose input and output (I/O) pins. Table 10 shows the respective register to control these pins. Figure 19 illustrates the GPIO Control Register GUI panel.

Table 10. GPIO: General-Purpose I/O Register

Address	Register	Reset Value	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
14h	GPIO	0Fh	GPIOD4	GPIOD3	GPIOD2	GPIOD1	GPIOC4	GPIOC3	GPIOC2	GPIOC1

Figure 19. GPIO Control Register GUI Panel

4.7 Fault Status Registers (FAULT_STATP and FAULT_STAIN)

The Fault Status registers store the status of whether the positive and/or negative input on each channel has a fault. This is a convenient feature to help pinpoint if any of the inputs are out of range. The GUI for this feature is enabled by clicking in the upper right-hand corner of the EVM software on the *Show/Poll Fault Status* button, as shown in Figure 20.

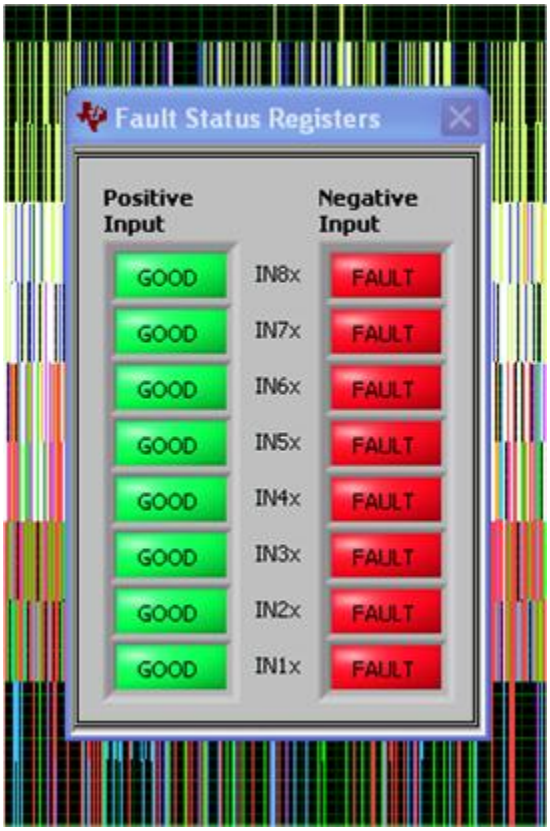
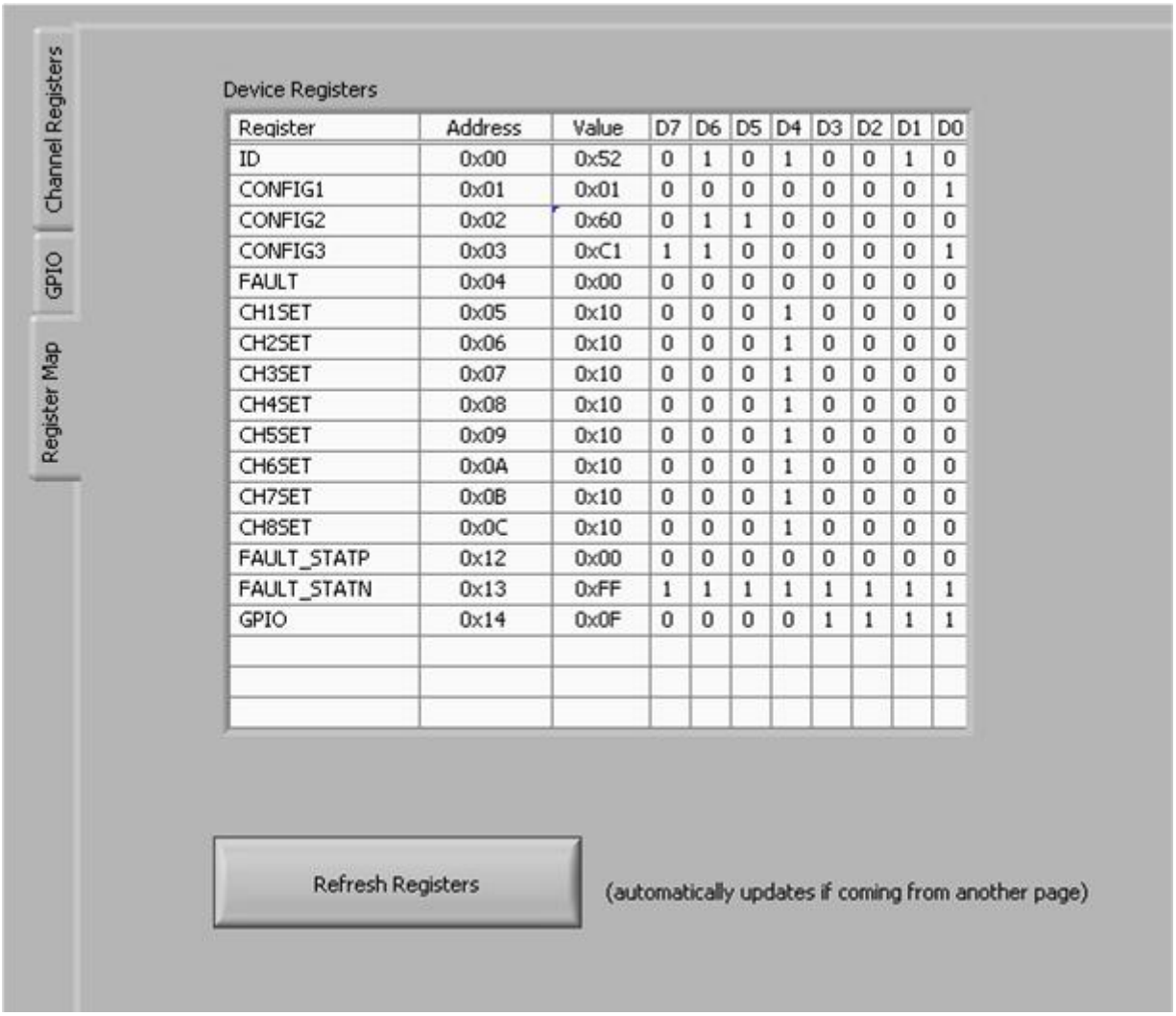


Figure 20. Fault Status Indicator

4.8 Register Map

The *Register→Device Register* tab is a helpful debug feature that allows the user to view the state of all the internal registers. This tab is shown in Figure 21.



Register	Address	Value	D7	D6	D5	D4	D3	D2	D1	D0
ID	0x00	0x52	0	1	0	1	0	0	1	0
CONFIG1	0x01	0x01	0	0	0	0	0	0	0	1
CONFIG2	0x02	0x60	0	1	1	0	0	0	0	0
CONFIG3	0x03	0xC1	1	1	0	0	0	0	0	1
FAULT	0x04	0x00	0	0	0	0	0	0	0	0
CH1SET	0x05	0x10	0	0	0	1	0	0	0	0
CH2SET	0x06	0x10	0	0	0	1	0	0	0	0
CH3SET	0x07	0x10	0	0	0	1	0	0	0	0
CH4SET	0x08	0x10	0	0	0	1	0	0	0	0
CH5SET	0x09	0x10	0	0	0	1	0	0	0	0
CH6SET	0x0A	0x10	0	0	0	1	0	0	0	0
CH7SET	0x0B	0x10	0	0	0	1	0	0	0	0
CH8SET	0x0C	0x10	0	0	0	1	0	0	0	0
FAULT_STATP	0x12	0x00	0	0	0	0	0	0	0	0
FAULT_STATN	0x13	0xFF	1	1	1	1	1	1	1	1
GPIO	0x14	0x0F	0	0	0	0	1	1	1	1

Figure 21. Device Register Settings

5 ADS130E08 Analysis Tools

Under the *Analysis* tab in the ADS130E08 GUI software, there are three different analysis tools available that enable a detailed examination of the signals selected by the front-end mux:

- Scope
- Histogram
- FFT

5.1 Scope Tool

The *Scope* tool, available under the *Analysis* tab, is a very useful means of examining the data results in the time domain. Users can decide if they would like their data displayed as input-referred or not, as well as review the details of the converted data to ensure that the data meets expectations. Figure 22 shows the scope tool features.

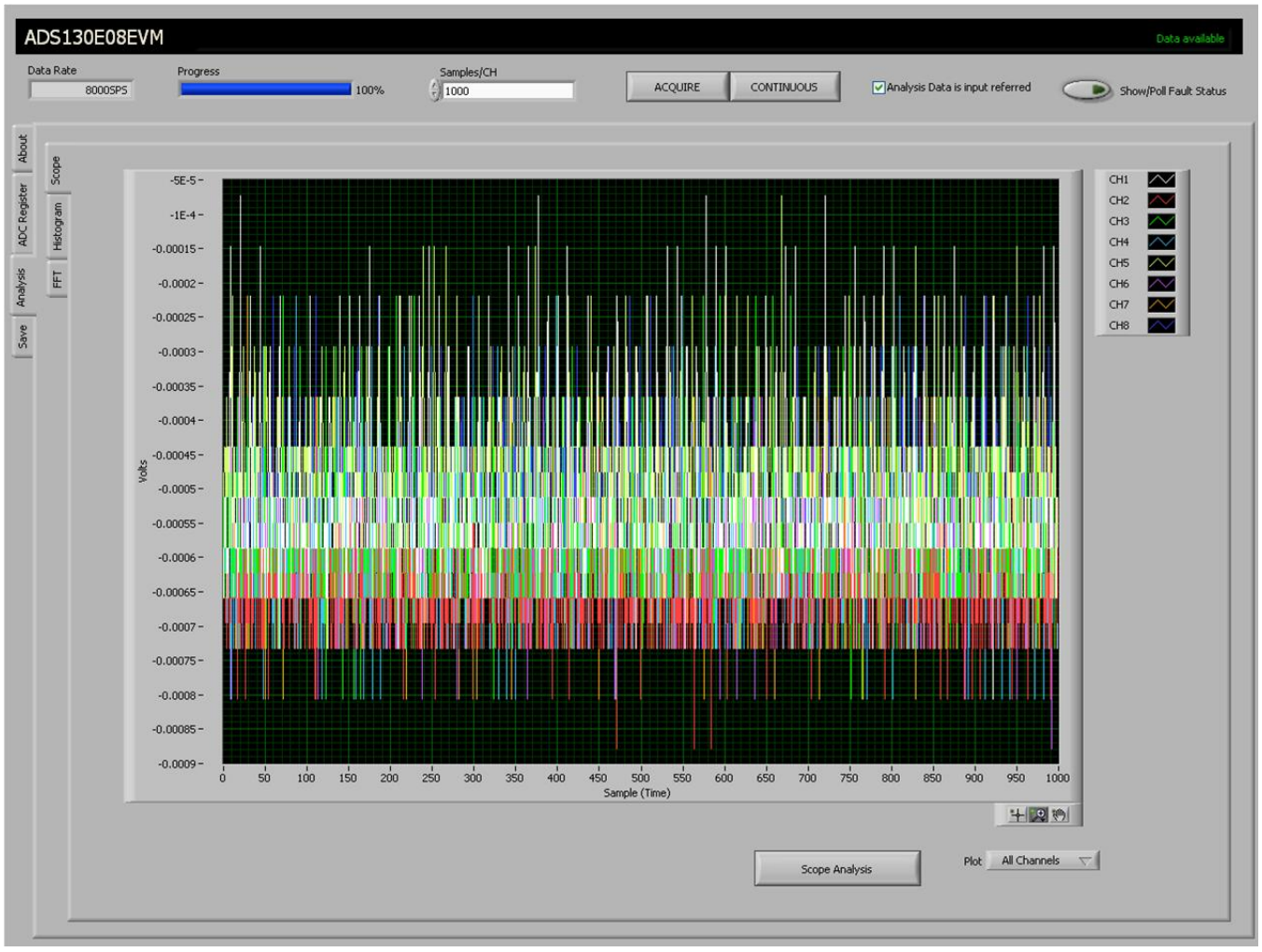


Figure 22. Scope Tool Features

5.1.1 Scope Analysis Button

The *Scope Analysis* button opens a pop-up window that displays the mean voltage, root mean square (RMS) voltage, and peak-to-peak voltage for noise analysis. Figure 23 shows an example of this window.

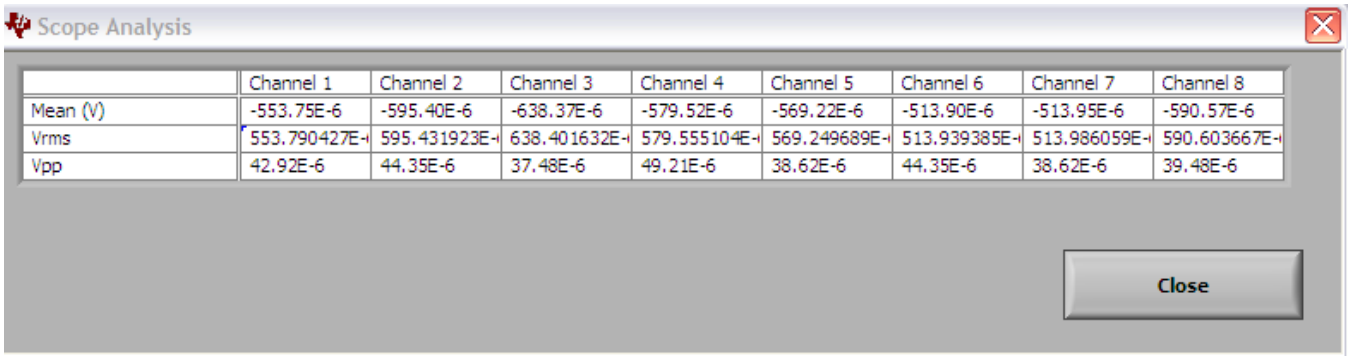


Figure 23. Scope Analysis Tab (Noise Levels for Each Channel Shown)

5.1.2 Waveform Examination Tool

The waveform examination tool allows the user to either zoom in on all channels simultaneously, or on just a single channel. Figure 24 shows an example of the waveform examination tool.

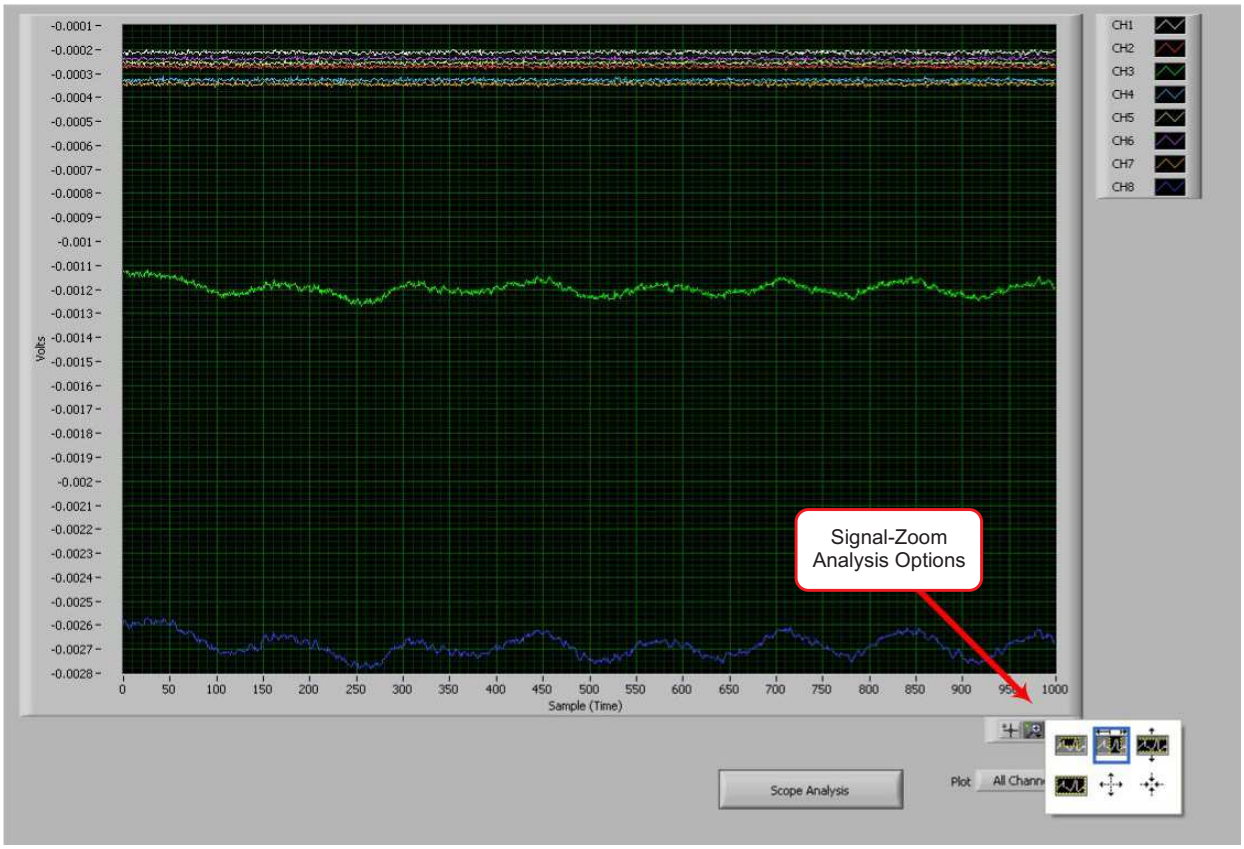


Figure 24. Zoom Option on the Waveform Examination Tool

5.2 Histogram Tool

The *Histogram* subtab displays the data in a histogram format for the eight channels. The data set is arranged in the total number of histogram bins set within the tab following acquisition. The screen shot shown in Figure 25 illustrates the histogram output for an input shorted signal. The same signal-zoom analysis shown in the previous section may be used on the histogram plots for a more detailed examination of the amplitude bins.

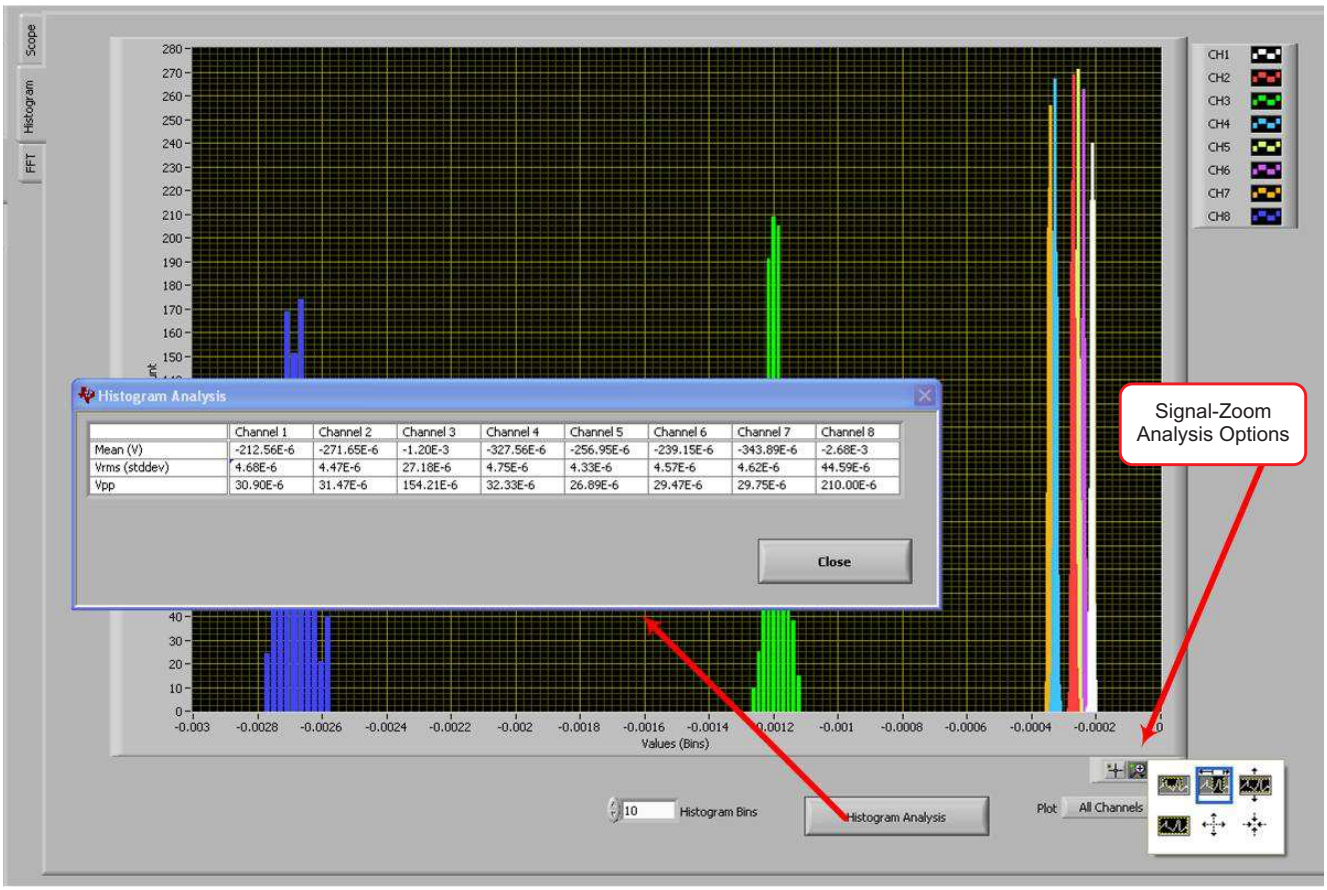


Figure 25. Histogram Bins

The *Histogram Analysis* button can be used to view the mean voltage, standard deviation used for the RMS voltage, and peak-to-peak voltage for analysis, as shown in Figure 26.

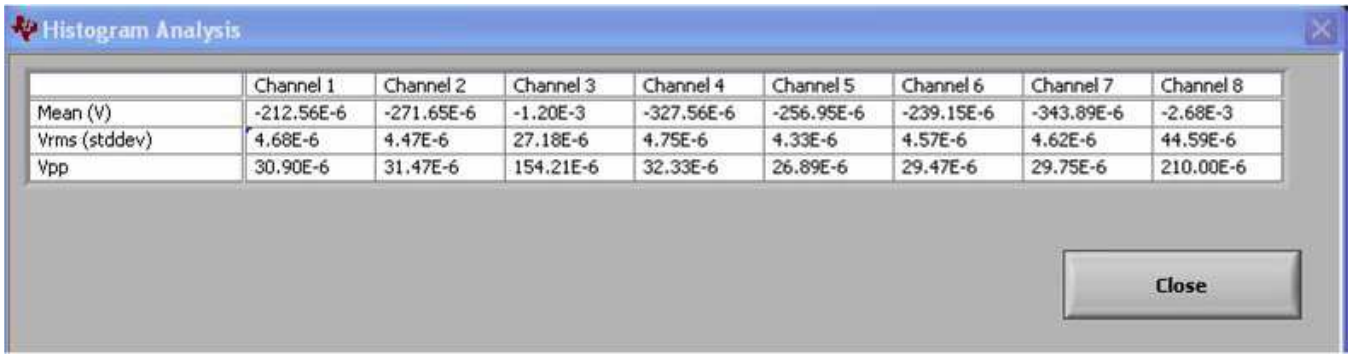


Figure 26. Statistics for the Signal Amplitude of Eight Channels

5.3 FFT Tool

The *FFT* subtab displays the data in the frequency domain by performing an FFT on the eight channels. Details of the FFT, including SNR, THD, and more, can be viewed using the *FFT Analysis* button located at the bottom of the display. Figure 27 shows the FFT display.

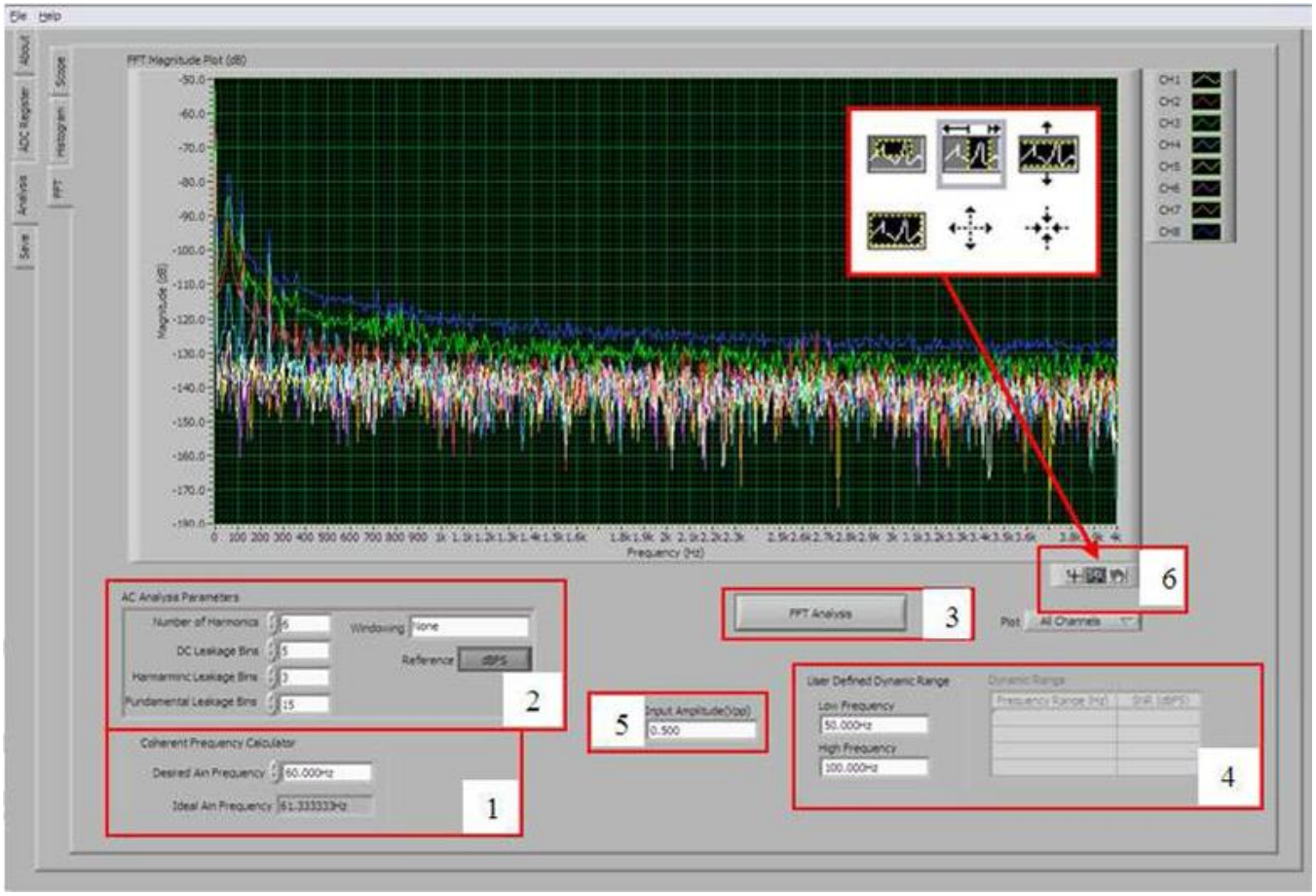


Figure 27. Analysis→FFT Graph of Normal Electrode Configuration

5.3.1 Coherent Frequency Calculator

The red box labeled *1* in Figure 27 shows the Coherent Frequency Calculator. Coherent sampling in an FFT is defined in Equation 3:

$$\frac{f_{AIN}}{f_{SAMPLE}} = \frac{N_{WINDOW}}{N_{TOTAL}} \quad (3)$$

where:

- f_{AIN} = input frequency
- f_{SAMPLE} = ADS130E08 sampling frequency
- N_{WINDOW} = number of odd integer cycles during a given sampling period
- N_{TOTAL} = number of data points (in power of 2) that is used to create the FFT.

If the conditions for coherent sampling can be met, the FFT results for a periodic signal are optimized. The ideal A_{IN} frequency is a value that is calculated based on the sampling rate so that the coherent sampling criteria can be met.

5.3.2 AC Analysis Parameters

The *AC Analysis Parameters* portion of the FFT tool (red box 2 in Figure 27) is used to dictate the number of harmonics, dc leakage bins, harmonic leakage bins, and fundamental leakage bins that are used in the creation of various histograms. Press the *Windowing* button, shown in in Figure 28, to evaluate the FFT graph under a variety of different windowing options. Pressing the *Reference* button toggles between dBFS (decibels, full-scale) and dBc (decibels to carrier).

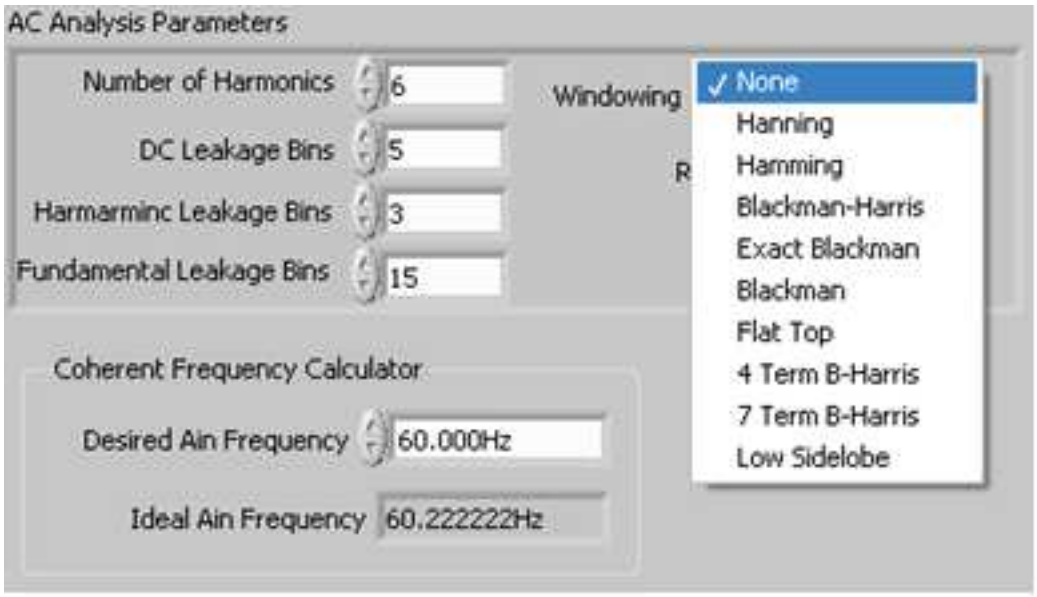
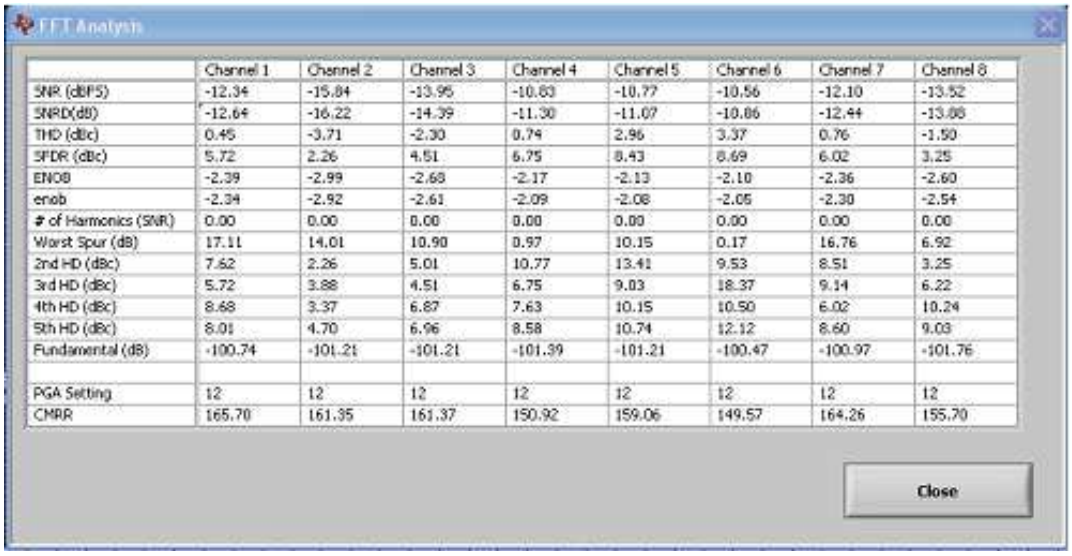


Figure 28. Analysis→FFT→AC Analysis Parameters: Windowing Options

5.3.3 FFT Analysis

The *FFT Analysis* button (red box 3, Figure 27) pulls up the window shown in Figure 29. This window displays the ac details of the data set after it is viewed in the frequency domain. The SNR, THD, and harmonic information is listed in a table format.



	Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6	Channel 7	Channel 8
SNR (dBFS)	-12.34	-15.84	-13.95	-10.83	-10.77	-10.56	-12.10	-13.52
SNRD(dB)	-12.64	-16.22	-14.39	-11.30	-11.07	-10.86	-12.44	-13.88
THD (dBc)	0.45	-3.71	-2.30	0.74	2.96	3.37	0.76	-1.50
SFDR (dBc)	5.72	2.26	4.51	6.75	8.43	8.69	6.02	3.25
ENOB	-2.39	-2.99	-2.68	-2.17	-2.13	-2.10	-2.36	-2.60
enob	-2.34	-2.92	-2.61	-2.09	-2.08	-2.05	-2.30	-2.54
# of Harmonics (SNR)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worst Spur (dB)	17.11	14.01	10.90	0.97	10.15	0.17	16.76	6.92
2nd HD (dBc)	7.62	2.26	5.01	10.77	13.41	9.53	8.51	3.25
3rd HD (dBc)	5.72	3.88	4.51	6.75	9.03	18.37	9.14	6.22
4th HD (dBc)	8.68	3.37	6.87	7.63	10.15	10.50	6.02	10.24
5th HD (dBc)	8.01	4.70	6.96	8.58	10.74	12.12	8.60	9.03
Fundamental (dB)	-100.74	-101.21	-101.21	-101.39	-101.21	-100.47	-100.97	-101.76
PGA Setting	12	12	12	12	12	12	12	12
CMRR	165.70	161.35	161.37	150.92	159.06	149.57	164.26	155.70

Figure 29. Analysis→FFT→FFT Analysis: Input Short Condition

5.3.4 User-Defined Dynamic Range

This portion of the FFT tool (red box 4, Figure 27) is used to examine the SNR of a specific channel within a given frequency band defined by the *Low Frequency* and *High Frequency* fields. The SNR displayed in this window also appears under the *Dynamic Range* heading, as shown in Figure 30.

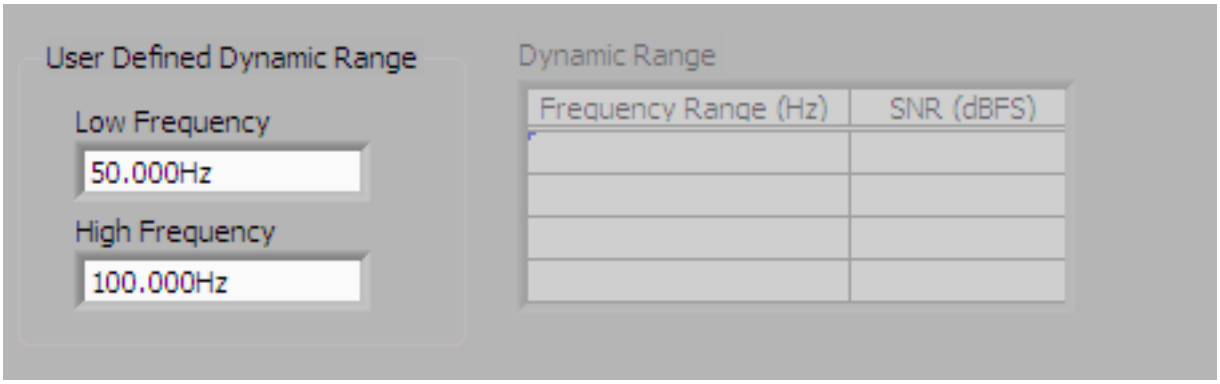


Figure 30. Changing the User-Defined Dynamic Range for Channel 1

5.3.5 Input Amplitude (V_{PP})

The *Input Amplitude* field (red box 5, Figure 27) is a user input that is important for accurately calculating the CMRR of each channel.

5.3.6 Waveform Zoom

This zoom function allows a closer examination of the FFT at frequencies of interest, as shown in Figure 31.

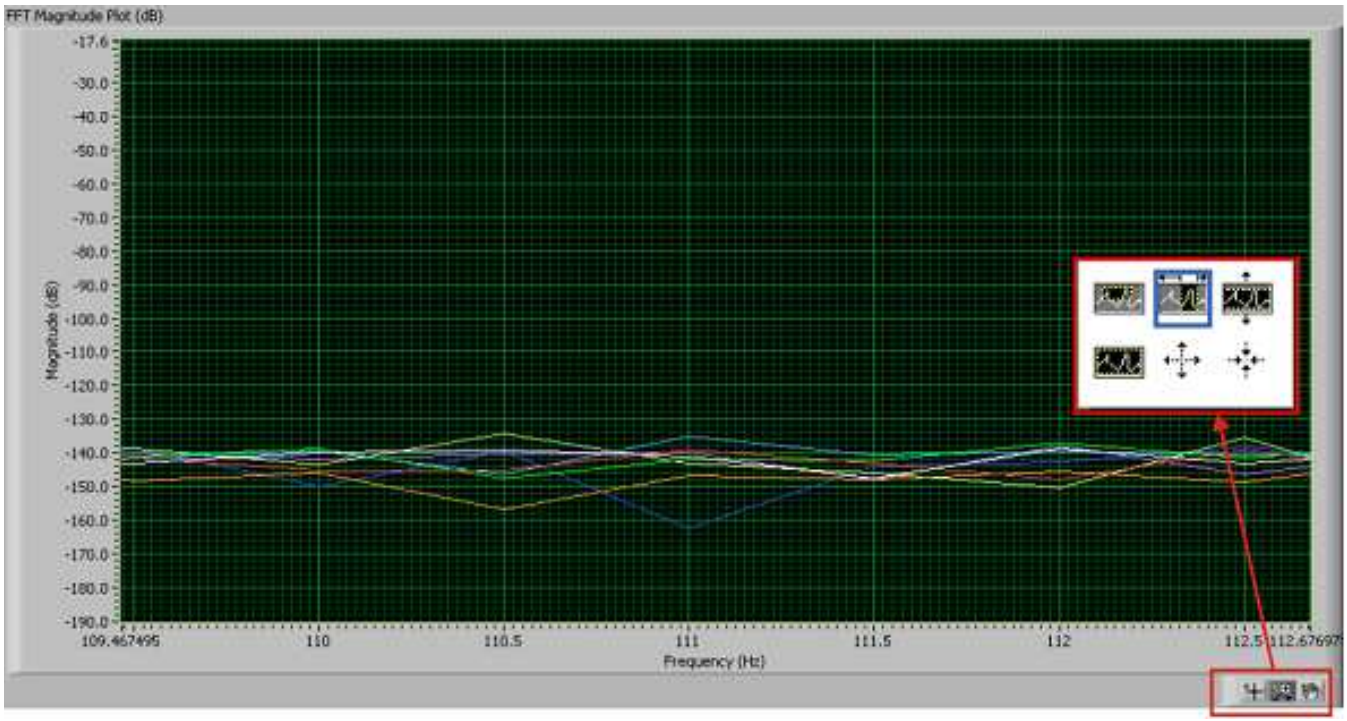


Figure 31. FFT Plot Using Waveform Zoom Function

6 Bill of Materials (BOM), Layout, and Schematic

This section contains the complete BOM, printed circuit board (PCB) layouts, and schematic diagrams for the ADS130E08.

NOTE: Board layouts are not to scale. These figures are intended to show how the board is laid out; they are not intended to be used for manufacturing ADS130E08 PCBs.

6.1 Bill of Materials

Table 11 lists the bill of materials for the ADS130E08.

Table 11. ADS130E08 Bill of Materials

Item	Qty	Ref Des	Description	Manufacturer	Part Number
1	1	N/A	Printed Circuit Board	TI	6527354
2	15	C1, C2, C3, C4, C5, C6, C11, C17, C39, C40, C41, C44, C50, C68, C69	CAP CER 1UF 25V 10% X5R 0603	Murata	GRM188R61E105KA12D
3	0	C7, C8, C15, C19, C26, C28, C30, C32, C33, C34, C35, C36, C48, C54, C59	Not Installed		
4	1	C9	CAP CER 22UF 6.3V 10% X5R 0805	Taiyo Yuden	JMK212BJ226KG-T
5	11	C10, C37, C38, C42, C43, C46, C47, C52, C53, C57, C58	CAP CER 10UF 10V 10% X5R 0805	Murata	GRM219R61A106KE44D
6	10	C12, C13, C14, C16, C18, C49, C61, C62, C75, C76	CAP CER 0.1UF 50V 10% X7R 0603	Murata	GRM188R71H104KA93D
7	16	C20, C21, C22, C23, C24, C64, C65, C66, C67, C70, C71, C72, C73, C74, C77, C78	CAP CER 470PF 50V C0G 5% 0603	TDK	C1608C0G1H471J
8	0	C25, C27, C29	Not Installed		
9	0	C31	Not Installed		
10	4	C45, C51, C55, C56	CAP CER 2.2UF 6.3V 10% X5R 0603	Murata	GRM185R60J225KE26D
11	2	C60, C63	CAP CER 100UF 10V 20% X5R 1210	Taiyo Yuden	LMK325BJ107MM-T
12	0	D1–D16	Not Installed		
13	1	J1 (Top side)	10 Pin, Dual Row, SM Header (20 Pos.)	Samtec	TSM-110-01-T-DV-P
14	1	J1, J2 (Bottom side)	10 Pin, Dual Row, SM Header (20 Pos.)	Samtec	SSW-110-22-F-D-VS-K
15	1	J3 (Bottom side)	5 Pin, Dual Row, SM Header (10 Pos.)	Samtec	SSW-105-22-F-D-VS-K
16	0	J4	Not Installed		
17	8	J5–J12	TERMINAL BLOCK 3.5MM 2POS PCB	On Shore	ED555/2DS
18	8	JP1, JP5–JP11	3 Position Jumper _ .1" spacing	Samtec	TSW-103-07-T-S
19	0	JP2	Not Installed		
20	2	JP3, JP4	2 Position Jumper _ .1" spacing	Samtec	TSW-102-07-T-S
21	0	JP12	Not Installed		

Table 11. ADS130E08 Bill of Materials (continued)

Item	Qty	Ref Des	Description	Manufacturer	Part Number
22	5	L1–L5	FERRITE BEAD 470 OHM 0805	Taiyo Yuden	BK2125HM471-T
23	5	R1, R67, R68, R69, R70	RES 0.0 OHM 1/10W 5% 0603 SMD	Yageo	RC0603JR-070RL
24	20	R2, R3, R4, R7, R10, R13, R16, R19, R22, R25, R28, R31, R34, R37, R40, R43, R46, R49, R63, R71	RES 10.0K OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-0710KL
25	0	R5, R6, R8, R9, R11, R12, R14, R15, R17, R18, R20, R21, R23, R24, R26, R27, R29, R30, R32, R33, R35, R36, R38, R39, R41, R42, R44, R45, R47, R48, R50, R51, R52, R53, R54, R55, R56, R57, R58, R64, R65, R66	Not Installed		
26	1	R59	RES 49.9K OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-0749K9L
27	1	R60	RES 46.4K OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-0746K4L
28	1	R61	RES 47.5K OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-0747K5L
29	1	R62	RES 43.2K OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-0743K2L
30	5	TP1, TP2, TP8, TP11, TP12	TEST POINT PC MINI .040"D BLACK	Keystone	5001
31	11	TP3, TP4, TP5, TP6, TP7, TP9, TP10, TP13, TP14, TP15, TP16	TEST POINT PC MINI .040"D RED	Keystone	5000
32	1	U1	Low-Cost, 8-Channel, 16-Bit Analog Front-End for Power Control	TI	ADS130E08IPAG
33	0	U2,U3, U4	Not Installed		
34	1	U5	IC UNREG CHRG PUMP V INV SOT23-5	TI	TPS60403DBVT
35	1	U6	IC LDO REG 250MA 3.0V SOT23-5	TI	TPS73230DBVT
36	1	U7	IC LDO REG NEG 200MA ADJ SOT23-5	TI	TPS72301DBVT
37	1	U8	IC LDO REG 250MA ADJ-V SOT23-5	TI	TPS73201DBVT
38	1	U9	IC EEPROM 256KBIT 400KHZ 8TSSOP	Microchip	24AA256-I/ST
39	1	OSC1	OSC 2.0480 MHZ 3.3V HCMOS SMT	Fox	FXO-HC735-2.048
40	9	N/A	0.100 Shunt - Black Shunts	3M	969102-0000-DA
41	1	N/A	Printed Circuit Board	TI	6462011 (MMB0)

6.2 PCB Layout

The ADS130E08 PCB layout is appended to this document.

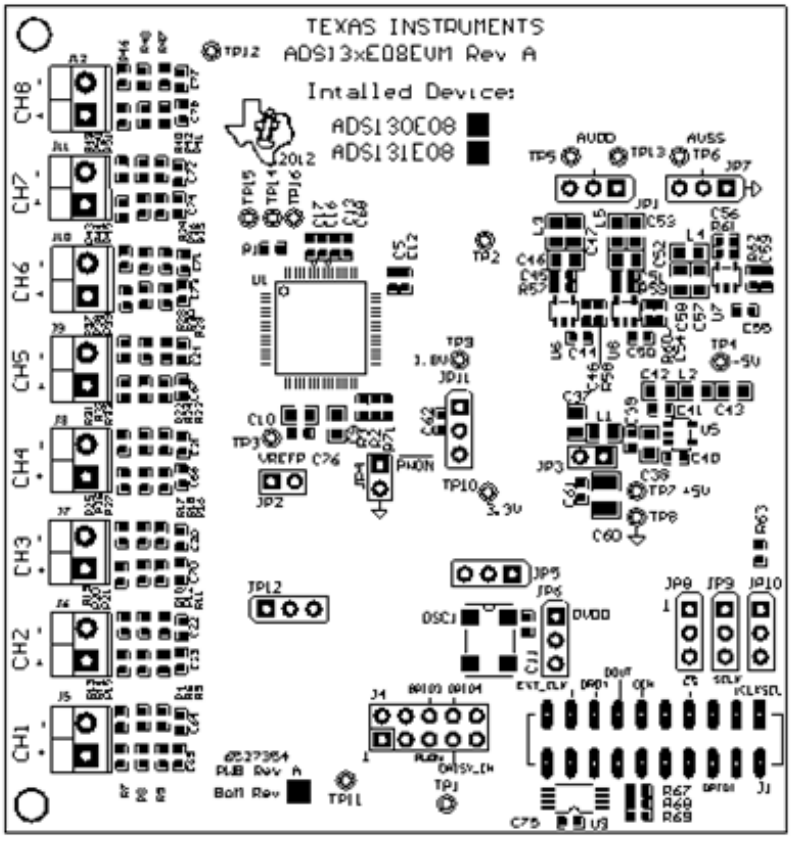
6.3 Front-End Board Schematic

The ADS130E08 schematic is appended to this document.

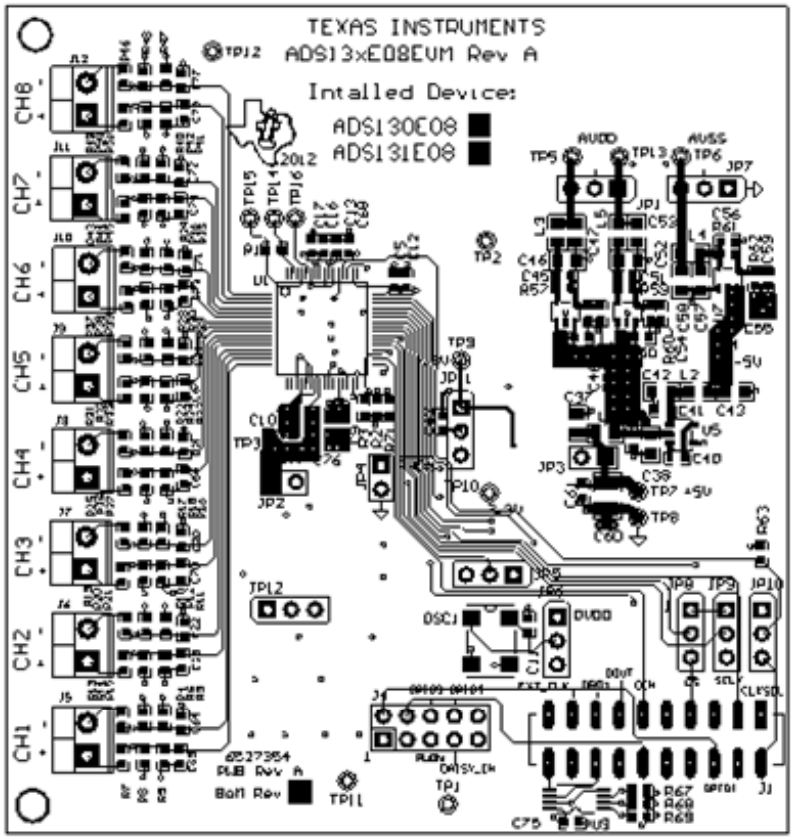
Revision History

Changes from Original (June 2012) to A Revision	Page
• Removed support for *included* power adapter for this EVM.	5
• Removed *supplied wall-mount power supply* from the *Installing the First USB Driver* section.	8

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.



Top Assembly



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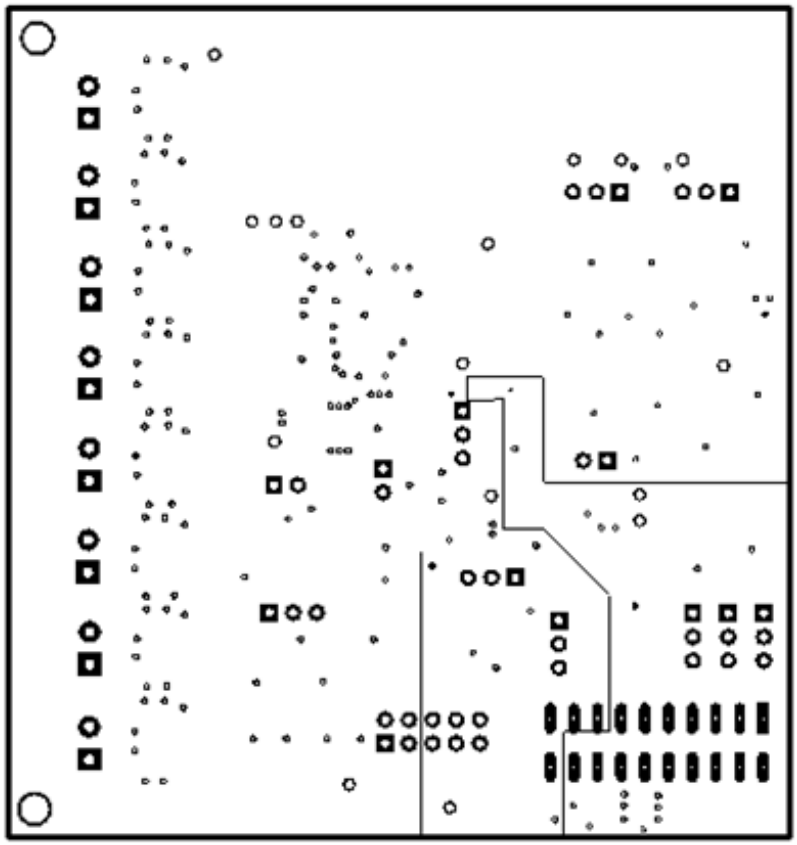
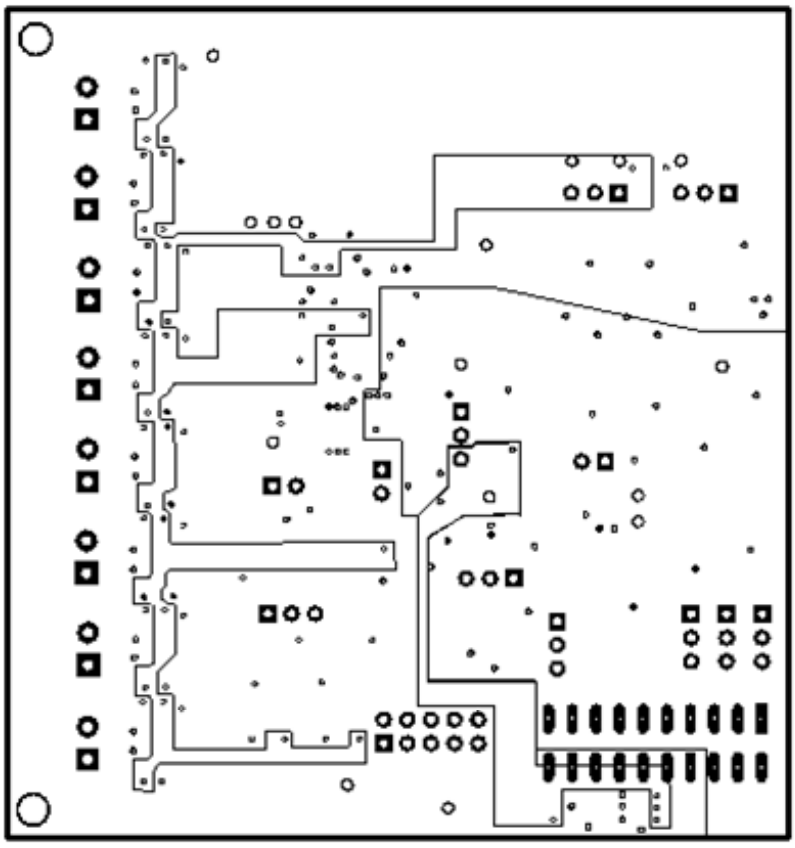
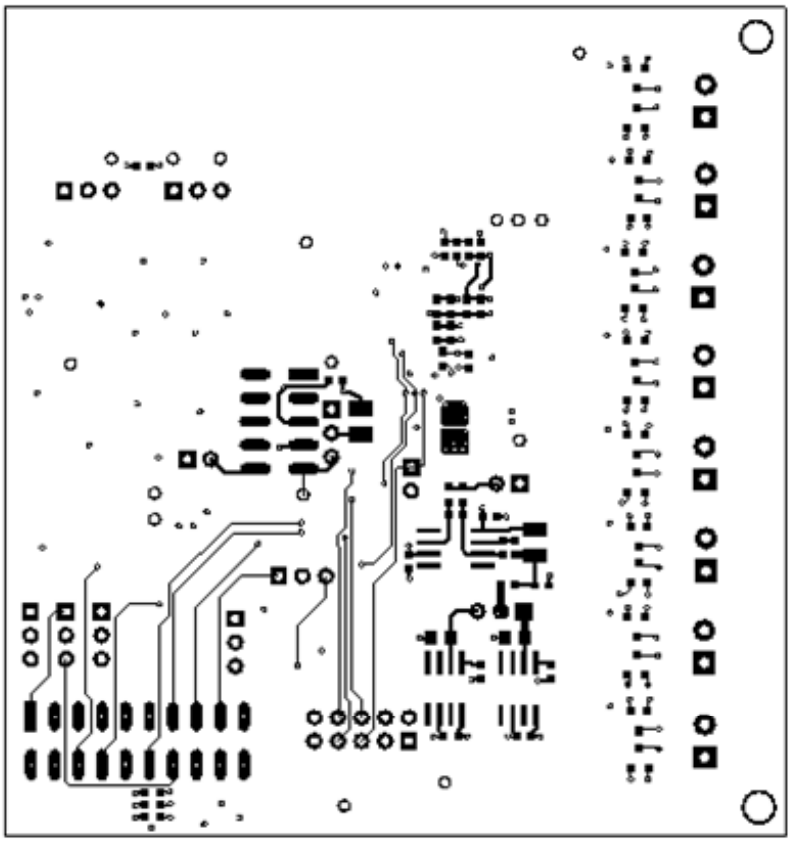


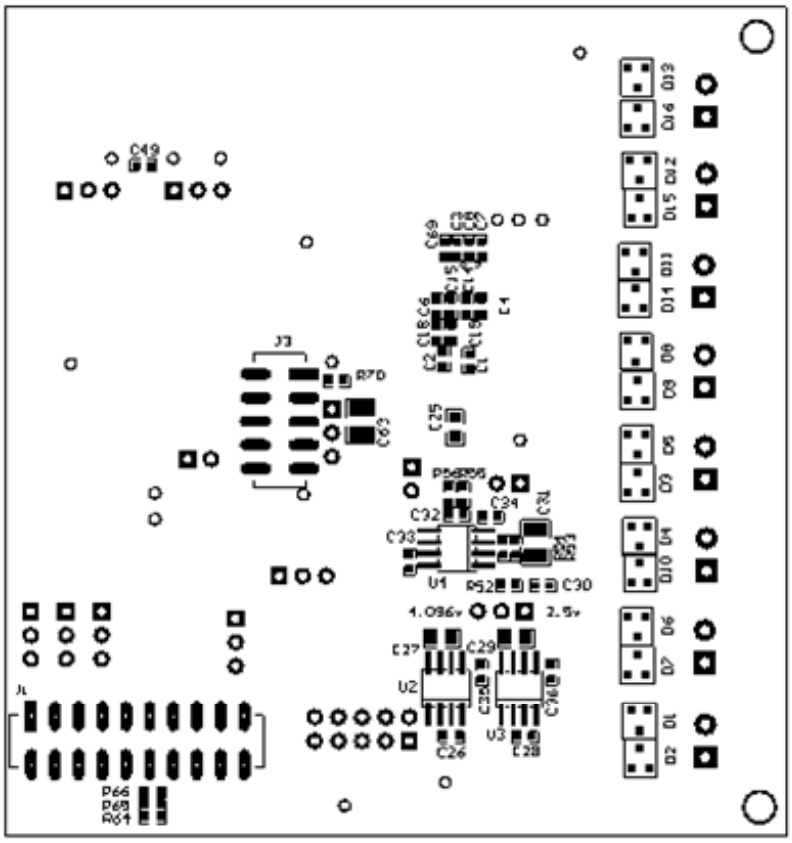
Internal Layer 1



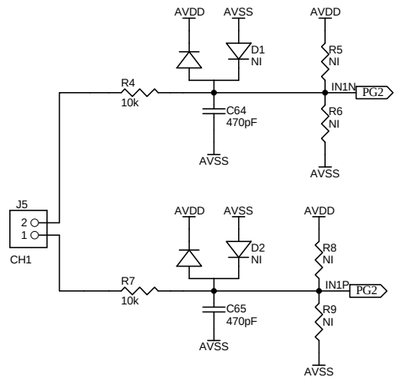
Internal Layer 2

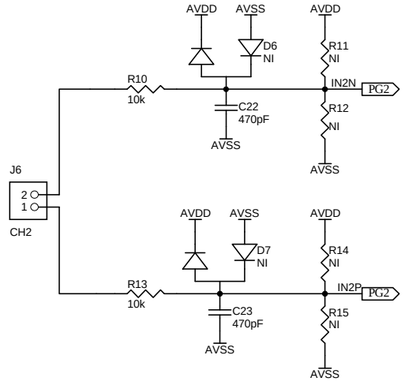


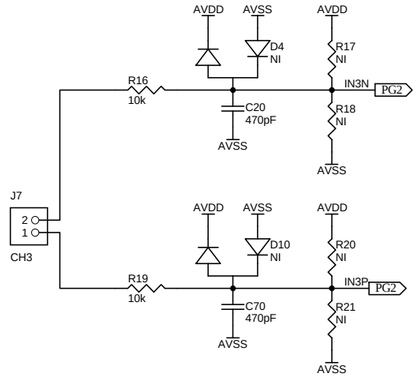
Bottom Layer

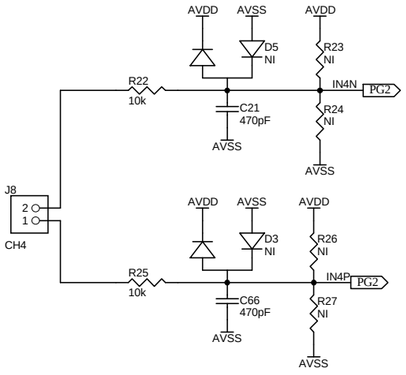


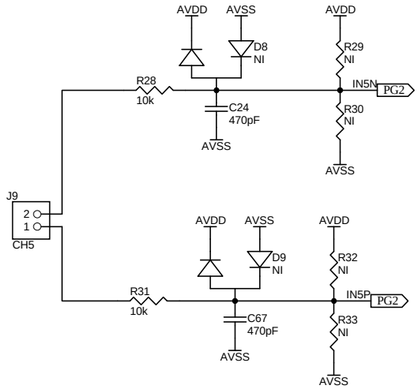
Bottom Assembly

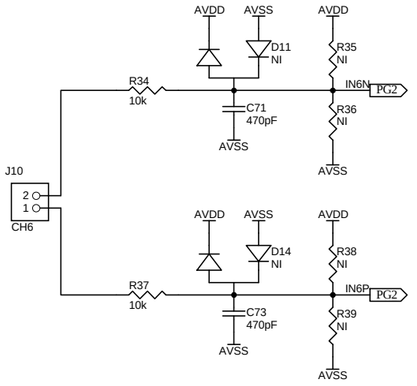


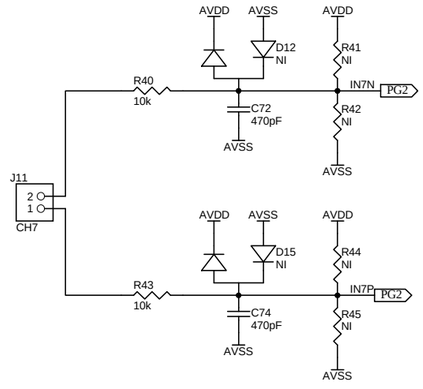


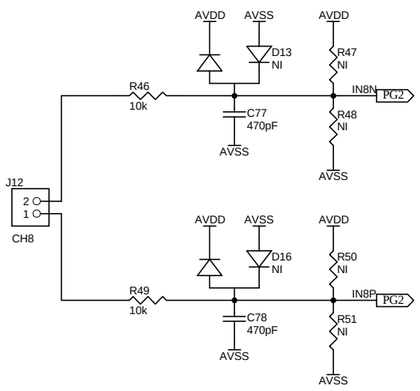












Engineer:	Tom Hendrick
Drawn By:	Tom Hendrick
FILE:	

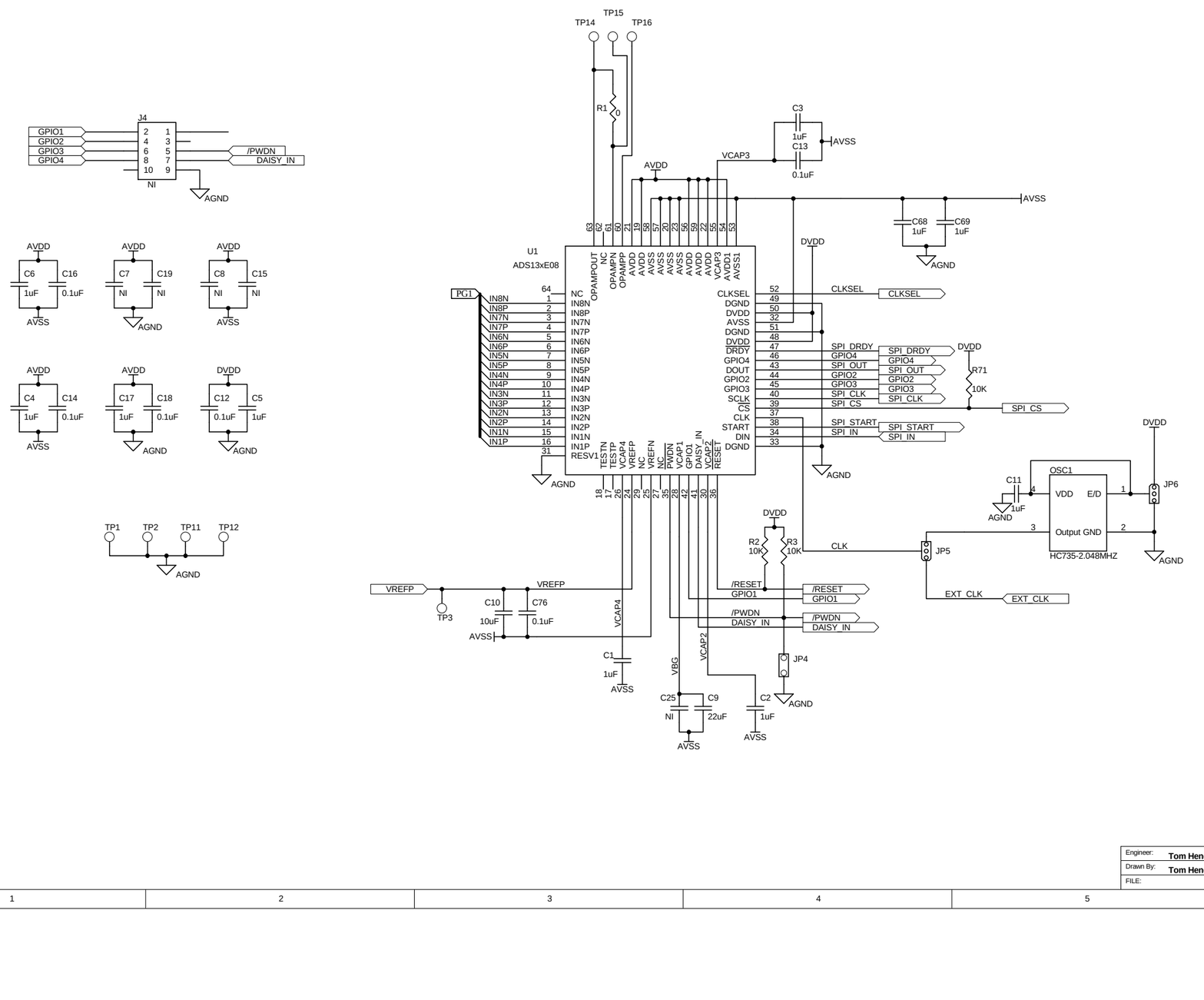
TEXAS INSTRUMENTS
12500 TI Boulevard. Dallas, Texas 75243

Title: **ADS13xE08**

DOCUMENTCONTROL #

REV: **A**

DATE: 2-May-2012 SIZE: SHEET: **1** OF: **5**



ADC Frontend

TEXAS INSTRUMENTS
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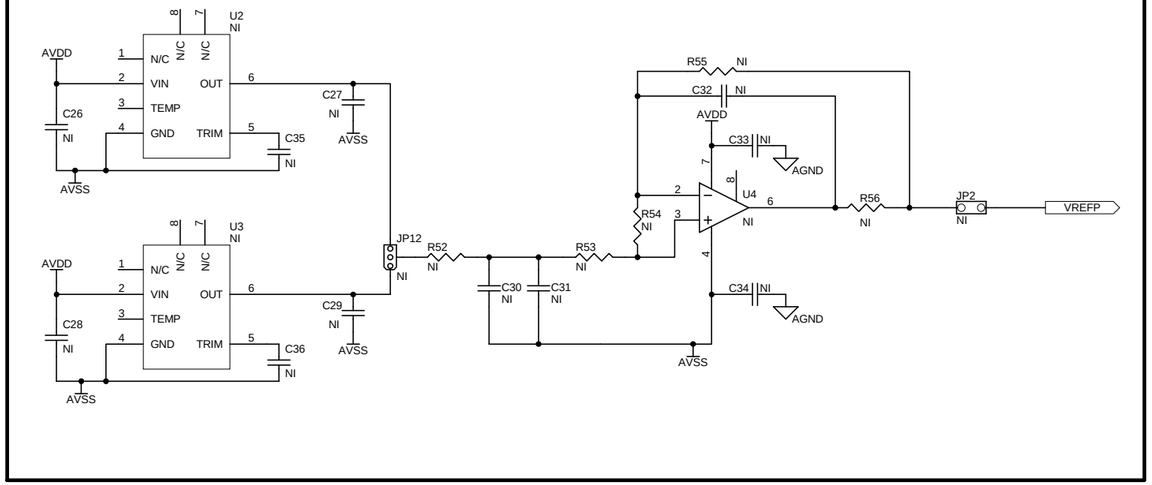
Title:	ADS13XE0X		
Engineer: Tom Hendrick	DOCUMENTCONTROL #	REV:	A
Drawn By: Tom Hendrick			
FILE:	DATE: 2-May-2012	SIZE:	SHEET: 2 OF: 5

External Reference

External Reference Drivers



NOT INSTALLED

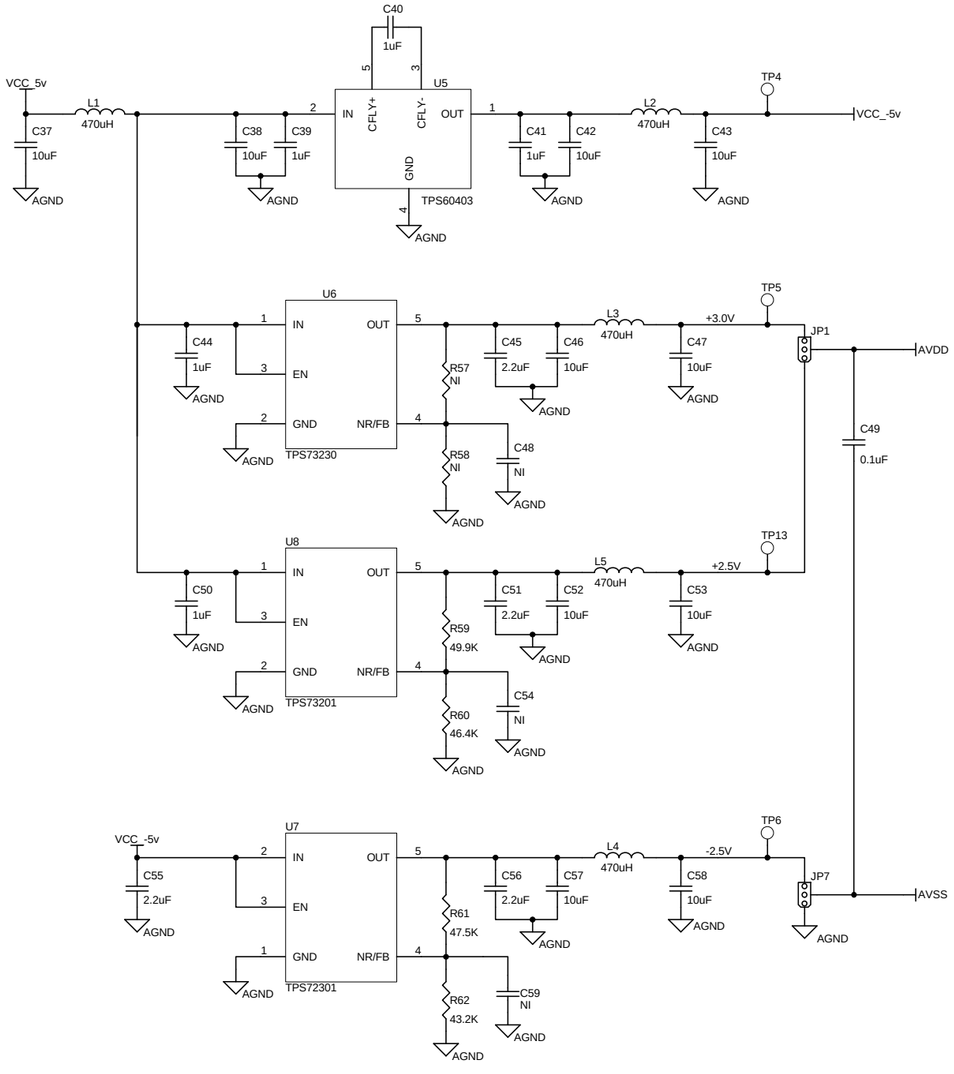
Engineer:	Tom Hendrick
Drawn By:	Tom Hendrick
FILE:	

TEXAS INSTRUMENTS
12500 TI Boulevard. Dallas, Texas 75243

Title: **ADS13xE08**

DOCUMENTCONTROL # | REV: **A**

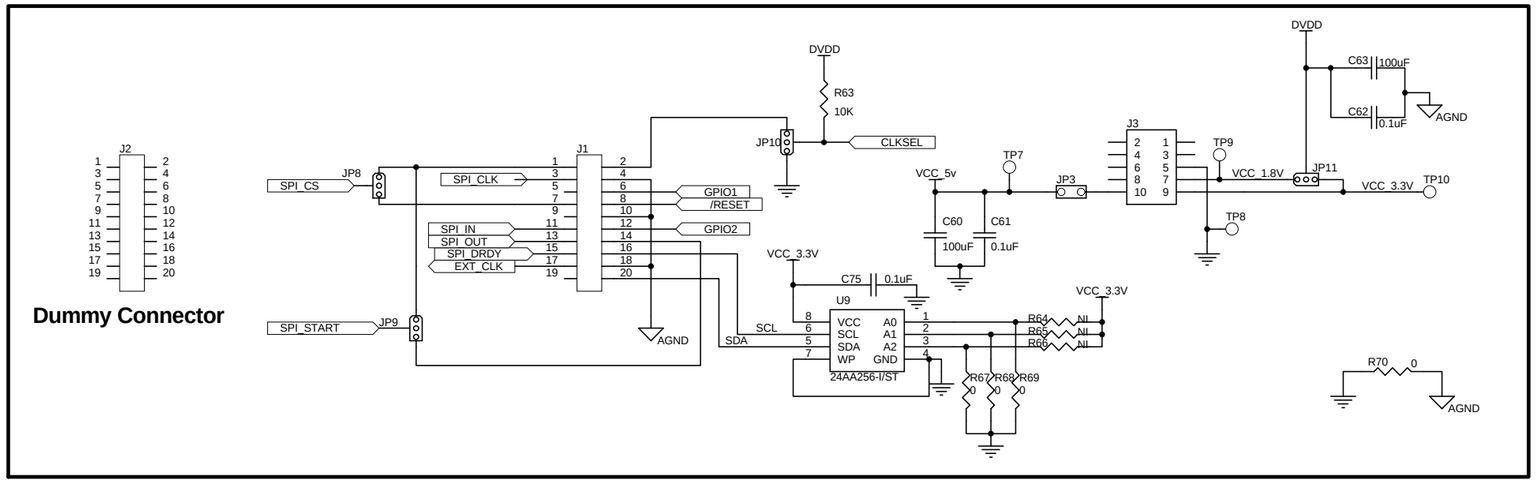
DATE: 2-May-2012 | SIZE: | SHEET: **3** OF: **5**



Power Supplies

TEXAS INSTRUMENTS
12500 TI Boulevard. Dallas, Texas 75243

Title:	ADS13xE08
Engineer:	Tom Hendrick
Drawn By:	Tom Hendrick
FILE:	
DOCUMENTCONTROL #	REV: A
DATE: 2-May-2012	SIZE:
SHEET: 4 OF: 5	



1	2	3	4	5	6

Engineer: **Tom Hendrick**
Drawn By: **Tom Hendrick**
FILE:

TEXAS INSTRUMENTS
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Title: **ADS13xE08**

DOCUMENTCONTROL #
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SHEET: **5** OF: **5**

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

3 *Regulatory Notices:*

   3.1 *United States*

      3.1.1 *Notice applicable to EVMs not FCC-Approved:*

      This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

      3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

      CAUTION

      This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

      Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

      FCC Interference Statement for Class A EVM devices

      NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社

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西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

   6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY WRITTEN DESIGN MATERIALS PROVIDED WITH THE EVM (AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

   6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS AND CONDITIONS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT MADE, CONCEIVED OR ACQUIRED PRIOR TO OR AFTER DELIVERY OF THE EVM.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS AND CONDITIONS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS ANDCONDITIONS OR THE USE OF THE EVMS PROVIDED HEREUNDER, REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN ONE YEAR AFTER THE RELATED CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY WARRANTY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS AND CONDITIONS, OR ANY USE OF ANY TI EVM PROVIDED HEREUNDER, EXCEED THE TOTAL AMOUNT PAID TO TI FOR THE PARTICULAR UNITS SOLD UNDER THESE TERMS AND CONDITIONS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM AGAINST THE PARTICULAR UNITS SOLD TO USER UNDER THESE TERMS AND CONDITIONS SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

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In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

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