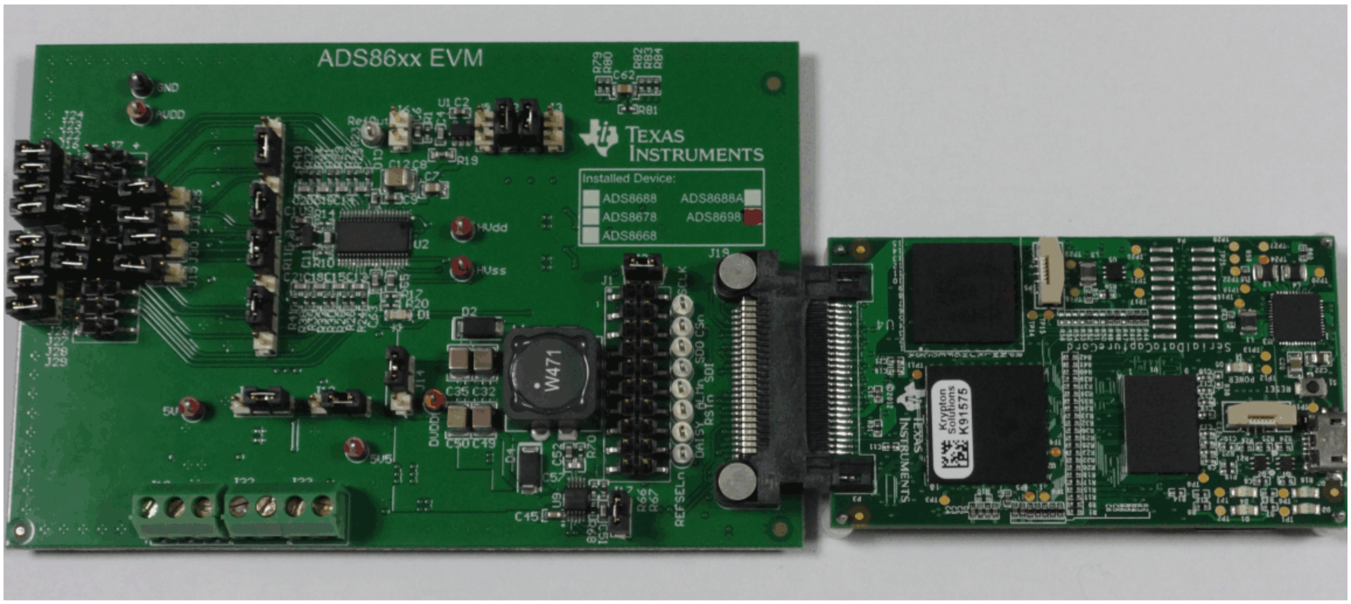
User's Guide

SBAU245A–June 2015–Revised July 2015

ADS86xxEVM-PDK Evaluation Module



ADS86xxEVM-PDK

This user guide describes the operation and usage of the ADS86xx evaluation module (EVM). The ADS86xx are a family of pin-compatible successive approximation (SAR) analog-to-digital converters (ADCs) with varying resolution and channel counts designed for integrated data acquisition systems. Table 1 lists the devices available in the ADS86xx family that are supported by the ADS86xxEVM.

Table 1. Devices Supported By the ADS86xxEVM

Device	Description
ADS8698	8-channel, integrated, 18-bit SAR ADC with ALARM
ADS8688A	8-channel, integrated, 16-bit SAR ADC with ALARM
ADS8678	8-channel, integrated, 14-bit SAR ADC with ALARM
ADS8668	8-channel, integrated, 12-bit SAR ADC with ALARM

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1 Related Documents

Table 2 lists the related documents that are available through the Texas Instruments web site at www.ti.com.

The ADS86xxEVM is designed to demonstrate true performance of these devices. Each input channel on the selected device can support true bipolar input ranges of ±10.24 V, ±5.12 V, and ±2.56 V as well as unipolar input ranges of 0 V to 10.24 V and 0 V to 5.12 V. The ADS8688A, ADS8678, and ADS8668 devices support additional true bipolar input ranges of ±1.28 V and ±0.64 V as well as unipolar input ranges of 0 V to 2.56 V and 0 V to 1.28 V. The input range selection is done by software programming the device internal registers. This selection is independent for each channel. The device offers a 1-MΩ, constant resistive input impedance irrespective of the selected input range. This user guide includes circuit description, a schematic diagram, and a bill of materials for the ADS86xxEVM circuit board.

Table 2. Related Documentation

Device	Literature Number
ADS8698	SBAS686
ADS8688A	SBAS680
ADS8678	SBAS627
ADS8668	SBAS492
OPA376	SBOS406
OPA2209	SBOS426
OPA320	SBOS513
REG71055	SBAS221
TPS7A4901	SBVS121
TPS54060	SLVS919
TPS7A3001	SBVS125

2 ADS86xxEVM-PDK Overview

The ADS86xxEVM-PDK is a platform for evaluating the ADS86xx series of devices. Throughout this document, the terms *ADS86xxEVM*, *demonstration kit*, and *evaluation board* are synonyms with the ADS8698EVM-PDK, ADS8688AEVM-PDK, ADS8678EVM-PDK, and ADS8668EVM-PDK. The ADS86xxEVM-PDK consists of an ADS86xxEVM board and a simple capture card. The simple capture card is a field-programmable gate array (FPGA)-based controller card that functions as a serial peripheral interface (SPI™) host and transfers data to the ADS86xxEVM graphical user interface (GUI) via a USB interface. The ADS86xxEVM GUI collects, analyzes, and records data from the ADS86xxEVM board. The ADS86xxEVM GUI is capable of collecting data from the ADS86xxEVM in auto and manual modes, configuring the ADC program registers, and performing FFT analysis of data captured from the ADC.

ADS86xxEVM Features:

- Includes support circuitry as a design example to match ADC performance.
- 3.3-V slave SPI.
- Serial interface header for easy connection to the simple capture card.
- Designed for a 5-V analog supply.
- Integrated 4.096-V voltage reference.
- Bipolar (±10.24 V, ±5,12 V, ±2.56 V, ±1.28 V, and ±0.64 V) or unipolar (0 V to 10.24 V, 0 V to 5.12 V, 0 V to 2.56 V, and 0 V to 1.28 V) input ranges for each channel.
- Onboard, second-order, Butterworth, low-pass filters for four channels.
- Onboard regulator for generating a ±15-V bipolar supply for second-order, Butterworth, low-pass filters.
- Accepts a ±100-mV signal on the negative analog inputs (AIN_xGND).

ADS86xxEVM GUI Features:

- Captures data from the ADS86xxEVM in auto and manual modes.
- Configures the ADS86xx device program registers.
- Enables and disables channels in auto mode.
- Provides FFT analysis and calculates the SNR, THD, and SINAD ac performance parameters.
- Provides single and multiple graph views for captured data.
- Includes a dc histogram for dc inputs.
- Logs ADC data.

3 EVM Analog Interface

The ADS86xxEVM is designed for easy interfacing with analog sources. The Samtec™ connector provides a convenient 10-pin, dual-row header at J7. Figure 1 and Figure 2 show the ADS86xxEVM analog input connections for channels AIN0 to AIN3 and channels AIN4 to AIN7, respectively. Table 3 lists the analog interface connections for J7.

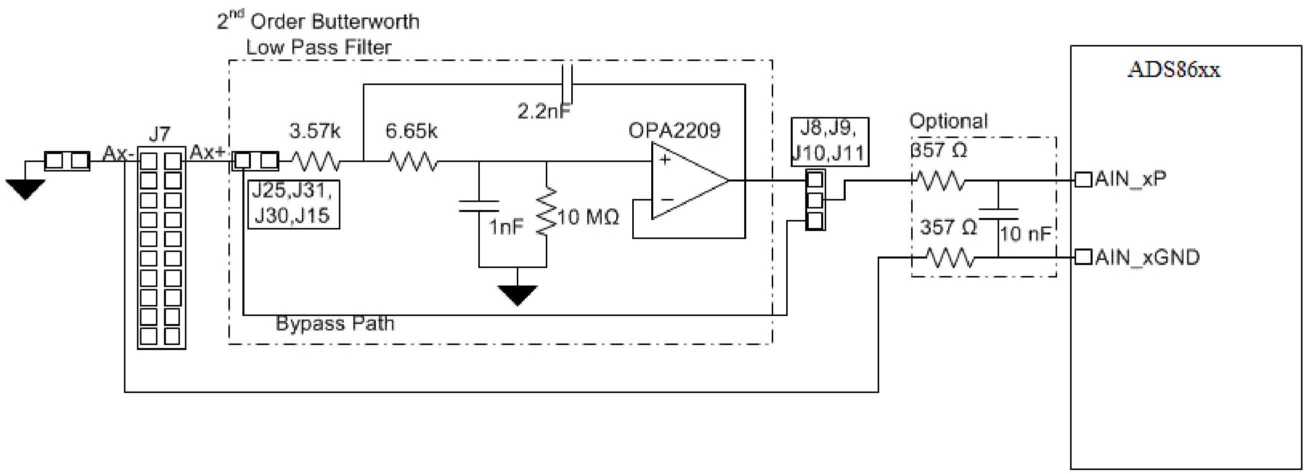

Figure 1. ADS86xxEVM Analog Input Connections for Channels AIN0, AIN1, AIN2, and AIN3

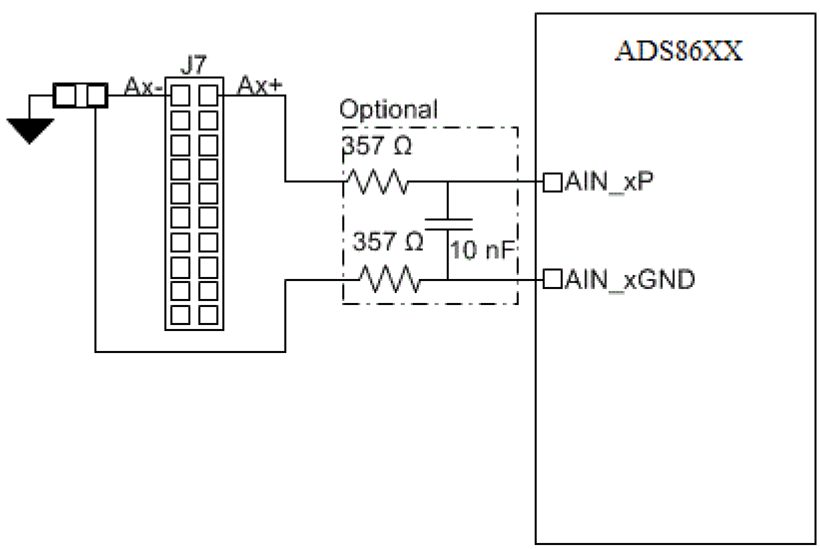

Figure 2. ADS86xxEVM Analog Input Connections for Channels AIN4, AIN5, AIN6, and AIN7

Table 3 summarizes the J7 analog interface connector.

Table 3. J7: Analog Interface Connections

Pin Number	Signal	Description
J7.2	A6+	Positive analog input for channel AIN6
J7.4	A7+	Positive analog input for channel AIN7
J7.6	A0+	Positive analog input for channel AIN0
J7.8	A1+	Positive analog input for channel AIN1
J7.10	AUX+	Positive analog input for AUX channel
J7.12	A2+	Positive analog input for channel AIN2
J7.14	A3+	Positive analog input for channel AIN3
J7.16	A4+	Positive analog input for channel AIN4
J7.18	A5+	Positive analog input for channel AIN5
J7.20	GND	Analog ground connection
J7.1	A6–	Negative analog input for channel AIN6
J7.3	A7–	Negative analog input for channel AIN7
J7.5	A0–	Negative analog input for channel AIN0
J7.7	A1–	Negative analog input for channel AIN1
J7.9	AUX–	Connected to analog ground
J7.11	A2–	Negative analog input for channel AIN2
J7.13	A3–	Negative analog input for channel AIN3
J7.15	A4–	Negative analog input for channel AIN4
J7.17	A5–	Negative analog input for channel AIN5
J7.19	GND	Analog ground connection

3.1 Connecting Negative Inputs to Ground

The negative analog inputs for all channels (except for the AUX channel) are capable of accepting a ±100-mV signal. The negative analog inputs can either be connected to the analog ground or a ±100-mV signal can be applied on these inputs. Table 4 describes the appropriate jumper settings for connecting these inputs to analog ground.

Table 4. Connecting Negative Analog Inputs to Ground

Signal	Jumper	Position for Connecting to Analog Ground	Position for Applying a ±100-mV Signal
A0–	J22	Closed	Open
A1–	J16	Closed	Open
A2–	J26	Closed	Open
A3–	J27	Closed	Open
A4–	J28	Closed	Open
A5–	J29	Closed	Open
A6–	J24	Closed	Open
A7–	J23	Closed	Open
AUX–	NA	Always connected to GND	NA

3.2 Using Onboard, Second-Order, Butterworth, Low-Pass Filters

The ADS86xxEVM includes second-order, Butterworth, low-pass filters with a cutoff frequency of 22 kHz for channels AIN0, AIN1, AIN2, and AIN3. There is also a provision to bypass these filters. See Figure 1 for an analog input circuit for channels AIN0, AIN1, AIN2, and AIN3. Table 5 lists the jumper settings for using onboard, second-order, Butterworth, low-pass filters and Table 6 lists the jumper settings for bypassing these filters.

Table 5. Using Onboard, Second-Order, Butterworth, Low-Pass Filters

Channel	Jumper	Position	Jumper	Position
AIN0	J25	Closed	J8	Closed between pins 1 and 2
AIN1	J31	Closed	J10	Closed between pins 1 and 2
AIN2	J30	Closed	J11	Closed between pins 2 and 3
AIN3	J15	Closed	J9	Closed between pins 2 and 3

Table 6. Bypassing the Onboard, Second-Order, Butterworth, Low-Pass Filters

Channel	Jumper	Position	Jumper	Position
AIN0	J25	Open	J8	Closed between pins 2 and 3
AIN1	J31	Open	J10	Closed between pins 2 and 3
AIN2	J30	Open	J11	Closed between pins 1 and 2
AIN3	J15	Open	J9	Closed between pins 1 and 2

3.3 Selecting the Reference Mode for the ADS86xxEVM

The ADS86xxEVM can either operate on an internal or external reference. Table 7 lists the jumper settings for selecting the reference. Table 8 describes the connections for the external reference.

Table 7. Selecting the Reference for the ADS86xxEVM

Jumper	Position for Using Internal Reference	Position for Using External Reference
J2	Closed	Open

Table 8. External Reference Connections

Pin Number	Signal	Description
J5.1	REFIN	Input for external reference
J5.2	GND	Analog ground connection

4 Digital Interface

Connector J19 (Samtec part number ERF8-025-01-L-D-RZ-L-TR socket strip connector) provides the digital I/O connections between the ADS86xxEVM board and the simple capture card. Consult Samtec at www.samtec.com or call 1-800-SAMTEC-9 for a variety of mating connector options. Table 9 summarizes the pin outs for connector J19.

Table 9. Connector J19 Pin Out

Pin Number	Signal	Description
J19.1	DAISY	Daisy input for the ADC
J19.4	$\overline{\text{EVM\_PRESENT}}$	EVM present, active low (connected to GND)
J19.5	$\overline{\text{REFSEL}}$	Reference selection input for the ADC
J19.6	$\overline{\text{RST/PD}}$	Reset or power-down input for the ADC
J19.8	$\overline{\text{A}}$	No connection
J19.11	EVM_ID_SDA	I^{2}C data for the onboard EEPROM
J19.12	EVM_ID_SCL	I^{2}C clock for the onboard EEPROM
J19.13	3V3_SDCC	3.3-V digital supply from the simple capture card
J19.14	5V_SDCC	Unregulated 5-V supply from the simple capture card
J19.33, J19.34	SCLK	Clock input for the ADC
J19.35	$\overline{\text{CS}}$	Chip-select input for the ADC
J19.38	SDI	Data input for the ADC
J19.39	SDO	Data output from the ADC
J19.45-49	EVMSDxxxxx	Digital connections for the onboard micro secure digital (microSD) card
J19.2, J19.10, J19.16, J19.50	GND	Ground connections

4.1 Serial Interface (SPI)

The ADS86xx device uses SPI serial communication in mode 1 (CPOL = 0, CPHA = 1) with clock speeds up to 18 MHz. The ADS86xxEVM offers 49.9-Ω resistors between the SPI signals and J19 to aid with signal integrity. Typically, in high-speed SPI communication, fast signal edges can cause overshoot; these 49.9-Ω resistors slow down the signal edges in order to minimize signal overshoot.

4.2 I^{2}C Bus for the Onboard EEPROM

The ADS86xxEVM has an I^{2}C bus that records the board name and assembly date to communicate with the onboard EEPROM. The bus is not used in any form by the ADS86xx converter.

4.3 microSD Card

The ADS86xxEVM has a microSD card that contains the software files for the simple capture card. The contents of the microSD card must not be deleted or altered.

5 Power Supplies

The ADS86xxEVM can be powered from the simple capture card if onboard buffers for active low-pass filters are not being used. The onboard regulator (U9) for generating high-voltage supplies (HVDD and HVSS) is disabled by closing jumper J17. The HVDD and HVSS supplies are only required for buffers U4 and U5.

CAUTION

Do not open jumper J17 if the ADS86xxEVM must be powered only from the simple capture card and an external 5-V supply is not provided on J32.

High-voltage supplies (HVDD and HVSS) for buffers U4 and U5 can be generated using the onboard regulator (U9) if an external 5-V dc supply is provided on J32. The external 5-V dc supply must be at least 200 mV above the unregulated 5-V supply of the simple capture card. The external 5-V dc supply must be capable of providing at least 500 mA of current. Table 10 provides jumper settings for generating HVDD and HVSS using the onboard switching regulator U9.

Table 10. Jumper Settings for Generating HVDD and HVSS Using an Onboard Switching Regulator

Jumper	Position for Using an Onboard Switching Regulator
J12	Closed between pins 1 and 2
J14	Closed between pins 1 and 2
J17	Open

HVDD and HVSS for buffers U4 and U5 can also be generated by providing external high-voltage supplies on J18, as shown in Table 11. Table 12 and Figure 3 illustrate the power-supply connections for external supplies.

Table 11. Jumper Settings for Generating HVDD and HVSS from External High-Voltage Supplies

Jumper	Position for Generating HVDD and HVSS from External Voltage Supplies
J12	Closed between pins 2 and 3
J14	Closed between pins 2 and 3
J17	Closed

Table 12. Power-Supply Connections

Voltage Supply	Signal	Voltage Range	Pin Number	Note
External 5 V	EXT_5V	5 V to 5.5 V	J32.2	Required only for generating HVDD and HVSS using the onboard switching regulator
—	GND	GND	J32.1	—
External HVDD	EXT_HVDD	16 V to 25 V	J18.3	Required only for generating HVDD and HVSS from external high-voltage supplies. Make sure HVDD + |HVSS| < 36 V.
External HVSS	EXT_HVSS	–16 V to –25 V	J18.1	Required only for generating HVDD and HVSS from external high-voltage supplies. Make sure HVDD + |HVSS| < 36 V.
—	GND	GND	J18.2	—

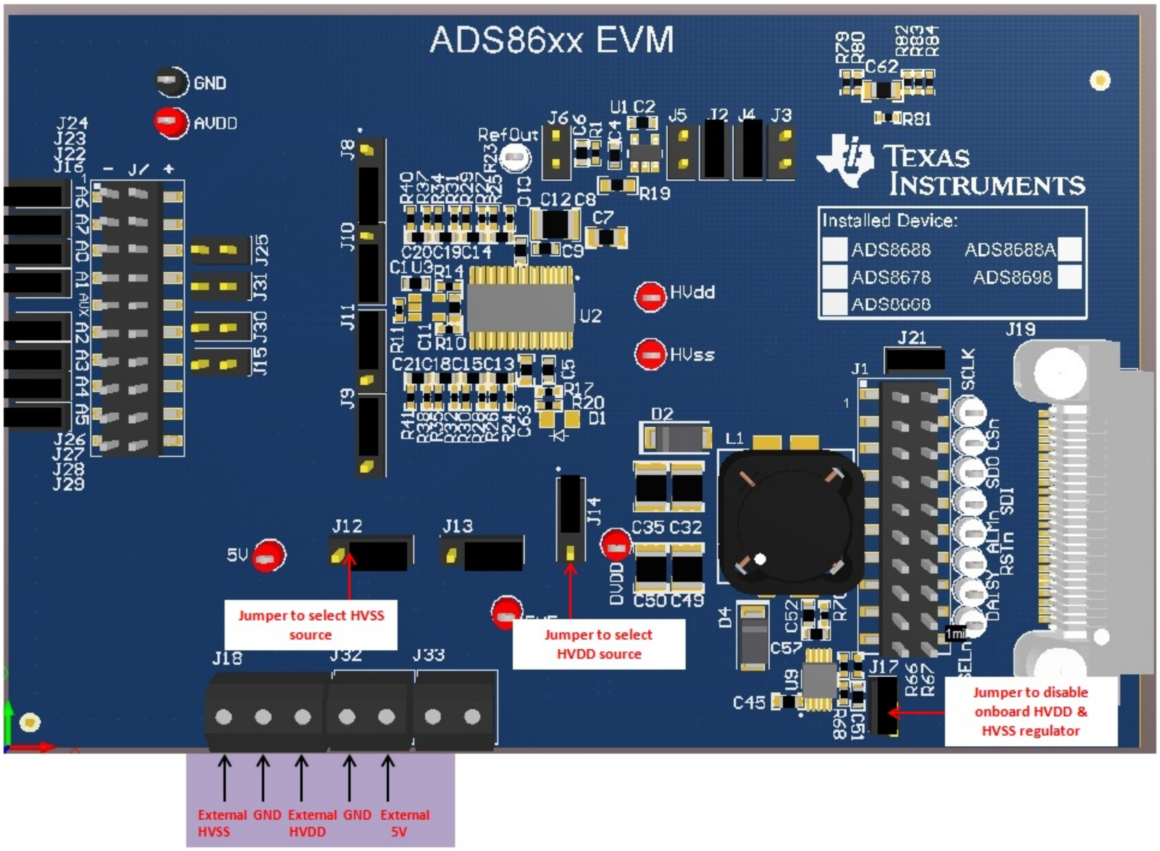

Figure 3. Power-Supply Connections Diagram

The AVDD analog supply for the ADS86xx is generated by converting an unregulated 5-V supply from the simple capture card or by converting an external 5-V supply to a regulated 5-V supply by using the REG71055 charge pump and the TPS7A4901 linear regulator. The DVDD digital supply for the ADC is derived from a 3.3-V supply from the simple capture card.

6 ADS86xxEVM-PDK Initial Setup

This section presents the steps required to setup the ADS86xxEVM-PDK kit prior to operation.

6.1 Default Jumper Settings

Figure 4 details the default jumper settings. Table 13 provides the configuration for these jumpers.

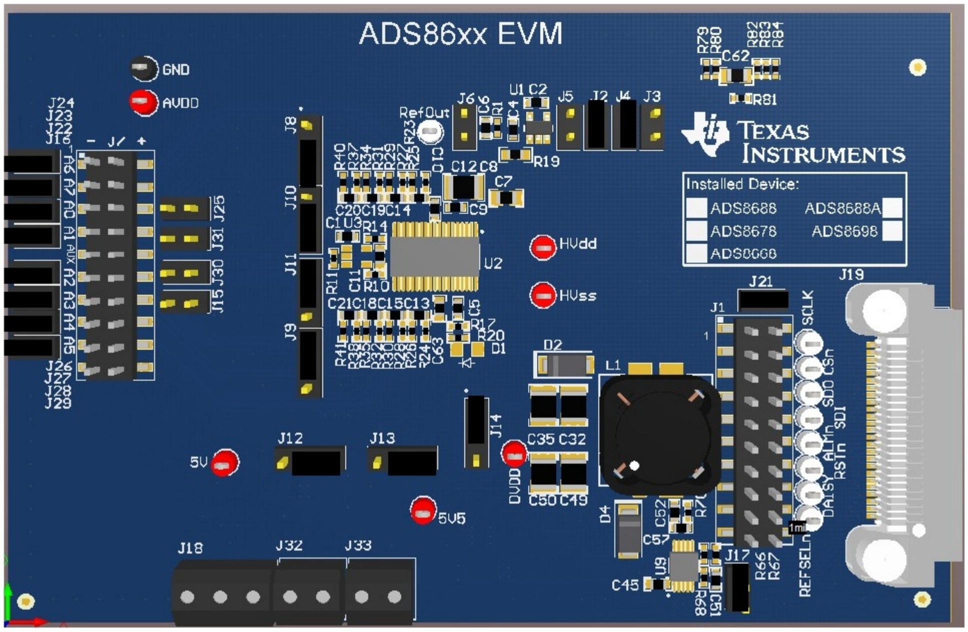

Figure 4. ADS86xxEVM Default Jumper Settings

Table 13. Default Jumper Configuration

Jumper	Default Position
J2	Closed
J3	Open
J4	Closed
J5	Open
J6	Open
J8	Closed between pins 2 and 3
J9	Closed between pins 1 and 2
J10	Closed between pins 2 and 3
J11	Closed between pins 1 and 2
J12	Closed between pins 1 and 2
J13	Closed between pins 2 and 3
J14	Closed between pins 1 and 2
J15	Open
J16	Closed
J17	Closed
J21	Closed
J22	Closed
J23	Closed
J24	Closed
J25	Open
J26	Closed
J27	Closed
J28	Closed
J29	Closed
J30	Open
J31	Open

6.2 Software Installation

This section presents the steps required to the install the software.

NOTE: Ensure the microSD memory card included in the kit is installed in the microSD socket (P6) on the back of the simple capture card before connecting the EVM to the computer. Otherwise, as a result of improper boot up, Windows® cannot recognize the ADS86xxEVM-PDK as a connected device.

Complete the following steps to install the software:

1. Verify the microSD memory cards are installed on the simple capture card and the ADS86xxEVM board.
2. Verify jumpers are in the factory-default position and are properly connected to the hardware.
3. Install the ADS86xxEVM-PDK software.
4. Complete the *simple capture card* device driver installation.

Each task is described in the following subsections.

6.2.1 Verify the microSD Memory Card is Installed on the Simple Capture Card

The ADS86xxEVM-PDK includes microSD memory cards that contain the EVM software and simple capture card firmware required for the EVM operation.

NOTE: Ensure the microSD memory cards that contain the software are installed in the microSD socket on the back of the simple capture card and on the back of ADS86xxEVM board. Figure 5 and Figure 6 show the bottom view of the simple capture card and the ADS86xxEVM, respectively, with the microSD card installed.

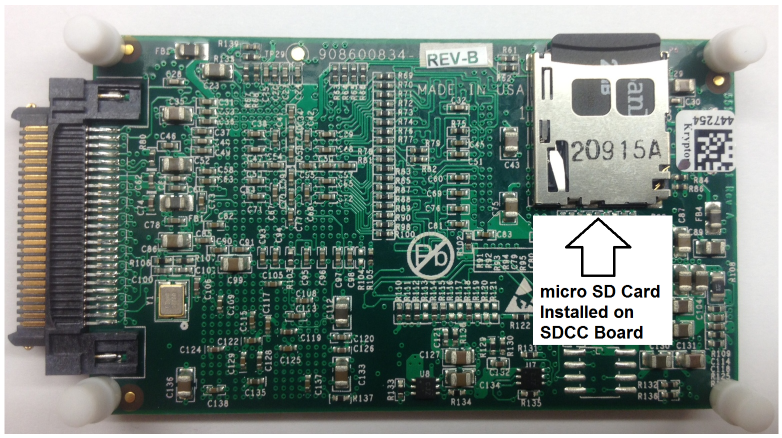

Figure 5. Bottom View of the Simple Capture Card with the microSD Memory Card Installed

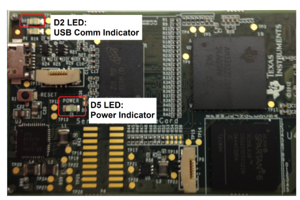

Figure 6. Bottom View of the ADS86xxEVM Board with the microSD Memory Card Installed

The microSD memory cards are formatted at the factory with the necessary firmware files for the simple capture card to boot properly. In addition to the simple capture card firmware files (application and MLO files), the microSD memory cards contain the ADS86xxEVM-PDK software installation files.

6.2.2 Verify Jumpers are in the Factory-Default Position and Connect the Hardware

The ADS86xxEVM-PDK includes both the ADS86xxEVM and the simple capture card; however, the devices are shipped unconnected. Follow these steps to verify the configuration and connectivity of the ADS86xxEVM-PDK.

1. Ensure that he microSD card is installed on the back of the Simple Capture card and ADS86xxEVM respectively, as shown in Figure 5 and Figure 6.
2. Ensure that the ADS86xxEVM jumpers are configured as illustrated in Figure 4.
3. Connect the ADS86xxEVM board to the simple capture card; see Figure 7.

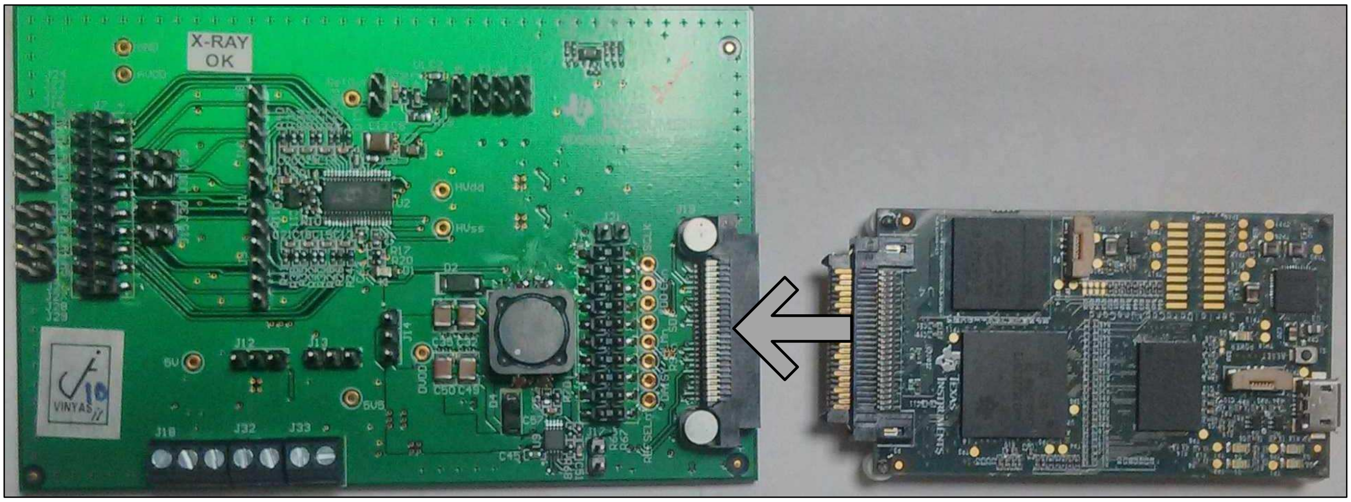

Figure 7. Connecting the ADS86xxEVM Board to the Simple Capture Card

4. Connect the simple capture card to the computer through the micro USB cable.
5. Verify that the LED D5 power-good indicator is illuminated. Wait approximately ten seconds and verify that diode D2 blinks, indicating that USB communication with the host computer is functioning properly. Figure 8 shows the location of the LED indicators in the simple capture card.

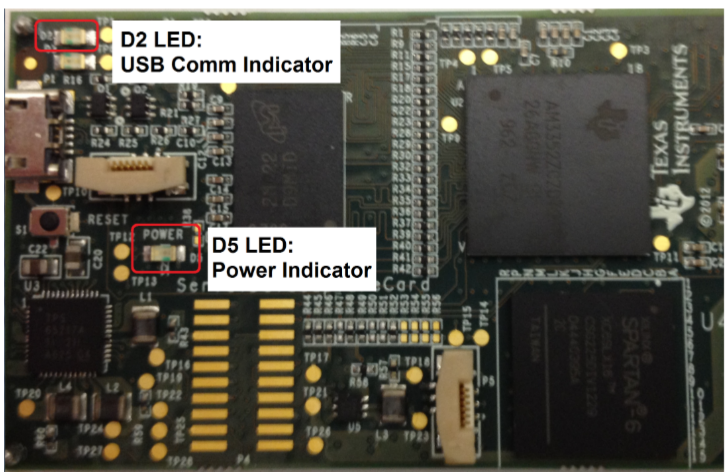

Figure 8. LED Indicators on the Simple Capture Card

6.2.3 Install the ADS86xxEVM-PDK Software

The ADS86xxEVM software must be installed on the computer. This software supports the ADS86xxEVM-PDK. The user must have administrator privileges to install the EVM software. The following steps list the directions to install the software.

1. Open the Windows explorer and locate the microSD memory card labeled *ADS86xxEVM* in the browser as a removable storage device.
2. Navigate to the *...\ADS86xxEVMGUI\Version x.x\Volume* folder.
3. Run the installer by double-clicking the *setup.exe* file. This action installs the EVM GUI software and required simple capture card device driver components.
4. After the installer begins, a welcome screen is displayed. Click **Next** to continue.
5. Select the default directory under: *...\Program Files(x86)\Texas Instruments\ADS86XX EVM GUI*; see Figure 9 and Figure 10. One or more software license agreements appear.

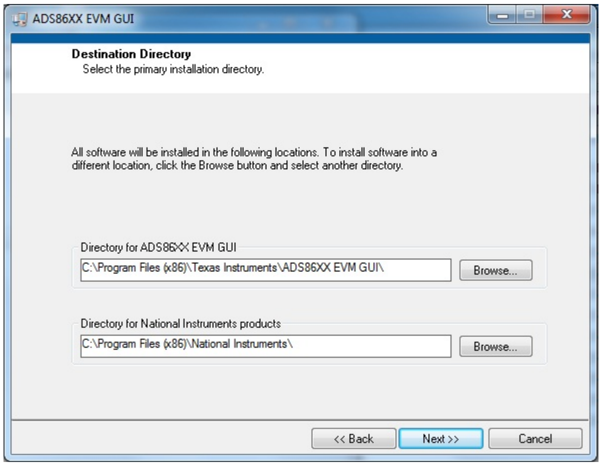

Figure 9. Destination Directory Screen

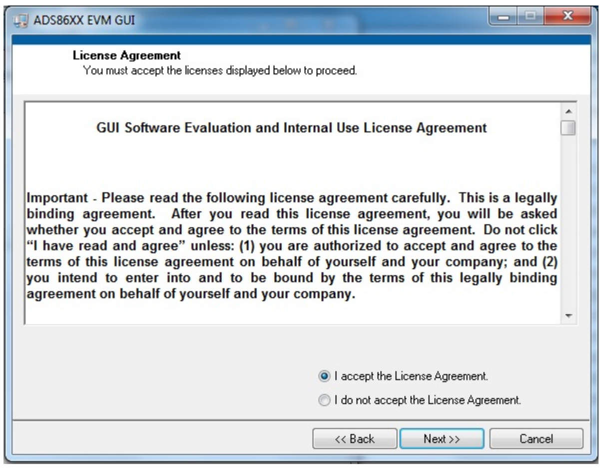

Figure 10. License Agreement Screen

6. Select the *I Accept the License Agreement* radial button and click **Next**.

7. The start installation screen appears, as shown in Figure 11. Click **Next**.

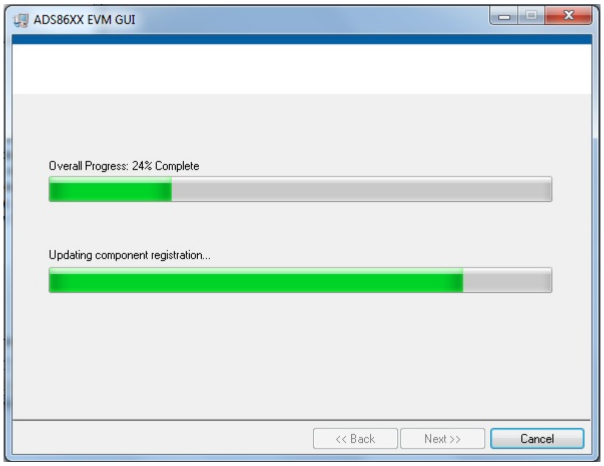

Figure 11. Start Installation Screen

8. A progress bar appears, as shown in Figure 12; this step takes a few minutes.

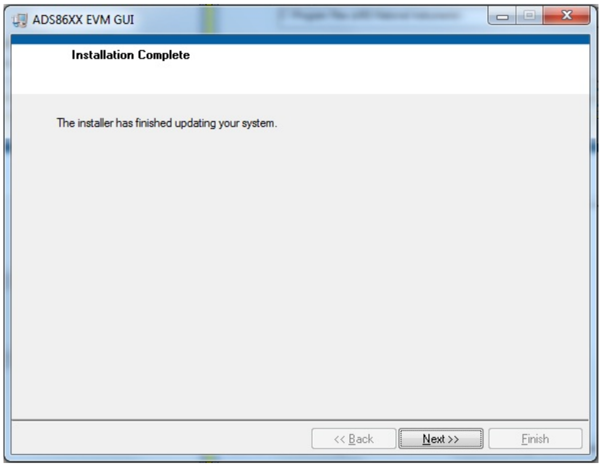

Figure 12. Progress Bar Screen

9. The progress bar is followed by an installation complete notice.

6.2.4 Complete the Simple Capture Card Device Driver Installation

During installation of the simple capture card device driver, a prompt may appear with the Windows security message shown in Figure 13. Select *Install this driver software anyway* to install the driver required for proper operation of the software. The drivers contained within the installers are safe for installation in your system.

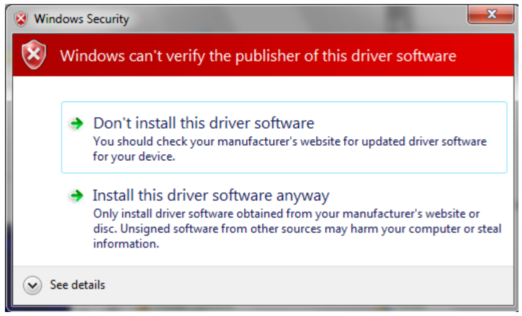

Figure 13. Windows 7 Driver Installation Warning

NOTE: Driver installation prompts do not appear if the simple capture card device driver is already installed on your system.

Following are the steps required to install the simple capture card device driver.

1. Immediately after the ADS86xxEVM software installation is complete, prompts appear to install the simple capture card device driver; see Figure 14 and Figure 15.
2. A computer restart may be required to finish the software installation. If prompted, restart the computer to complete the installation.

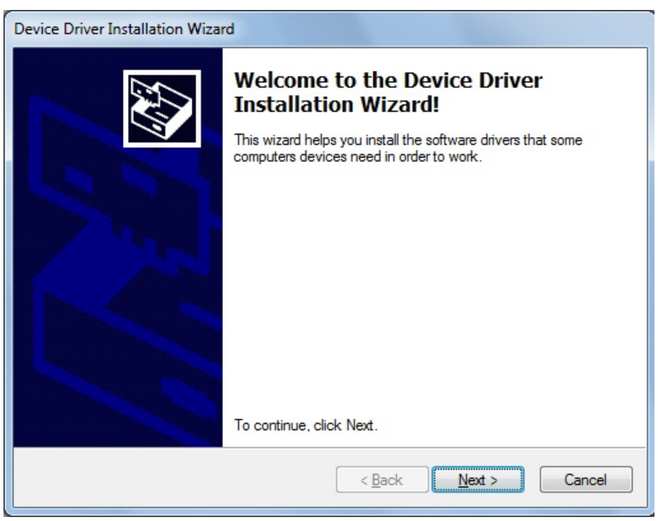

Figure 14. Installation Wizard Screen

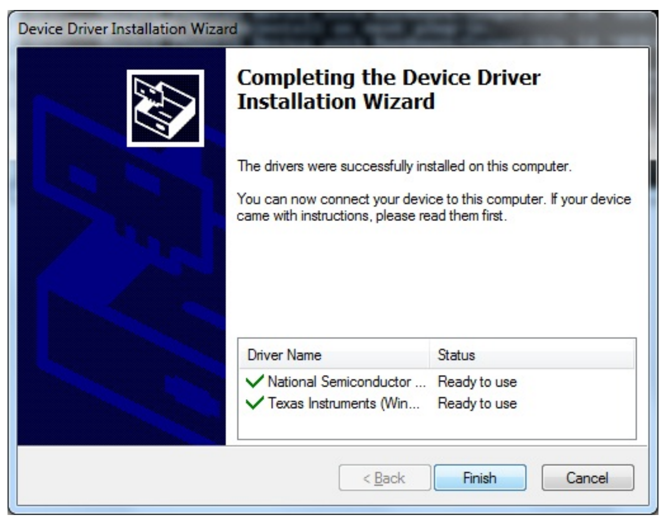

Figure 15. Simple Capture Card Device Driver Completion

7 ADS86xxEVM-PDK Kit Operation

This section describes how to use the ADS86xxEVM-PDK and ADS86xxEVM GUI to configure the EVM and acquire data.

7.1 About the Simple Capture Card

The simple capture card provides the USB interface between the computer and the ADS86xxEVM. The controller board is designed around the AM335x processor, a USB 2.0, high-speed capability, 32-bit, ARM core. The simple capture card incorporates an onboard FPGA subsystem and 256MB of onboard DDR SRAM memory.

The simple capture card is not sold as a development board, and is not available separately. TI cannot offer support for the simple capture card except as part of this EVM kit.

7.2 Loading the ADS86xxEVM GUI

The ADS86xxEVM GUI provides control over the settings of the ADS86xx family of devices mentioned in Table 1. Adjust the ADS86xxEVM settings when the EVM is not acquiring data. During acquisition, all controls are disabled and settings cannot be changed.

When you change a setting on the ADS86xxEVM GUI, the setting immediately updates on the board.

Settings on the ADS86xxEVM correspond to settings described in the ADS86xx product data sheet (available for download at www.ti.com); see the product data sheet for details.

To load the ADS86xxEVM GUI, follow these steps:

Step 1. Make sure the PDK kit is configured and powered up as explained in Section 6.2.2.

Step 2. Start the ADS86xxEVM GUI. Go to Start→All Programs→Texas Instruments→ADS86xx EVM GUI and click **ADS86xx EVM GUI** to run the software.

Step 3. Verify that the software detects the ADS86xxEVM. The GUI identifies the device on the EVM that is connected to the controller and loads the settings. After the settings are loaded, the GUI displays the device name followed by EVM on the top of the GUI window, as shown in Figure 16.

Step 4. Verify that the *Connect to Hardware* box is checked on the top right corner and *HW CONNECTED* is displayed with a green background on the bottom edge of the GUI window.

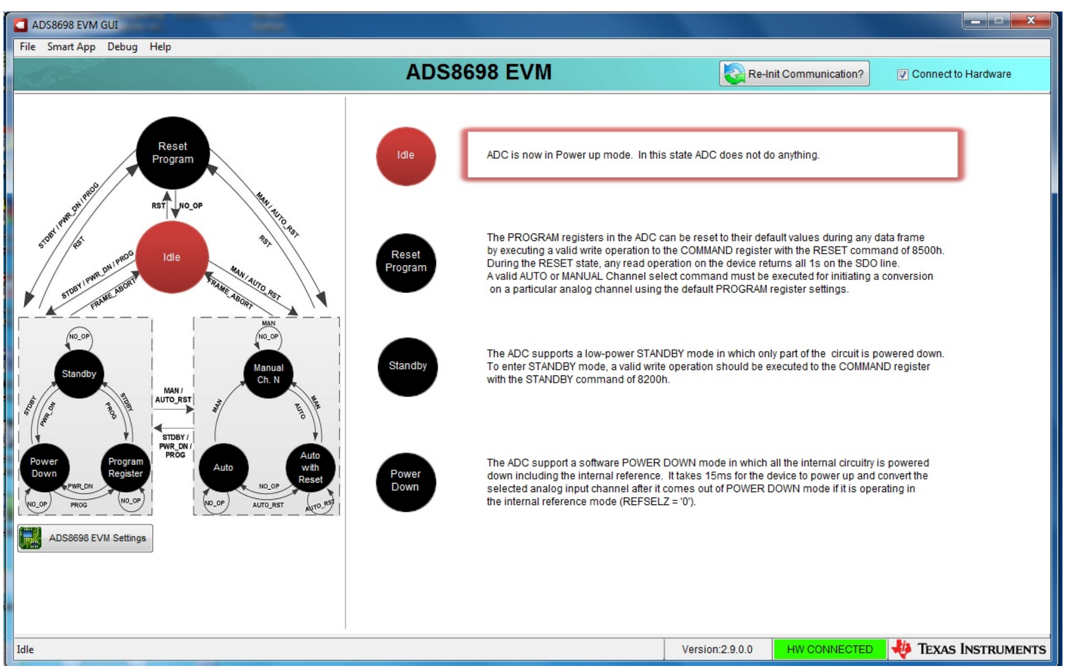

Figure 16. Start Page of the ADS86xxEVM GUI

7.3 *Configuring the ADS86xxEVM*

7.3.1 System Block Diagram View

The ADS86xx channels can be configured by the system block diagram view in the GUI. The system block diagram can be activated by clicking on the **Program Register** button on the left side of the GUI window. A channel can be powered down by checking the *AINx_PD* box. if a channel is powered down, that channel turns grey in system block view. The voltage range for each channel can be selected from a drop-down menu corresponding to each channel in the system block diagram view, as shown in Figure 17. The window for selecting the input voltage range is displayed in Figure 18.

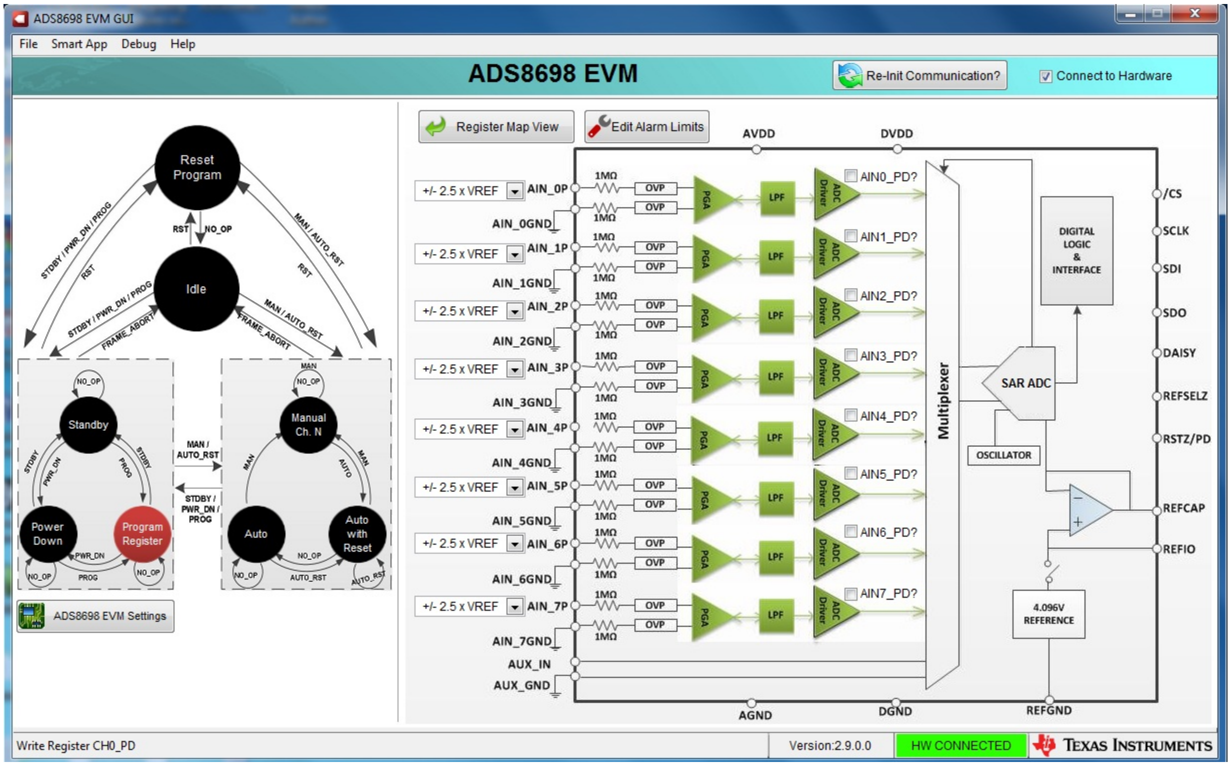

Figure 17. System Block Diagram View

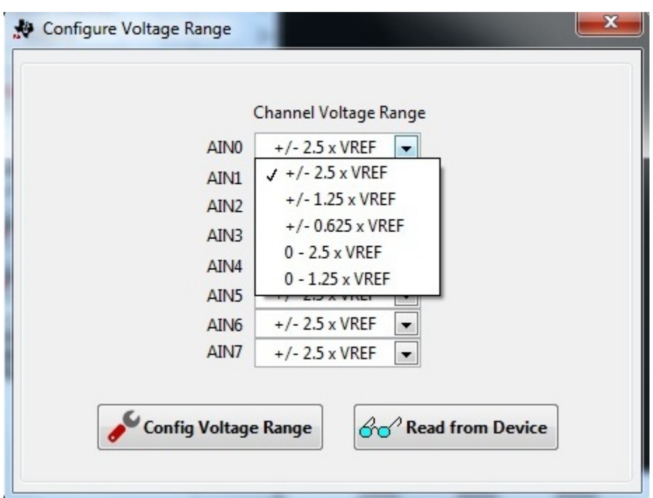

Figure 18. Selecting the Input Range for the Channels

7.3.2 Register Map View

All registers can be read or written by the register map view in the GUI. The register map view can be activated by clicking the **Register Map View** button in the system block diagram view; see Figure 17. The register map table provides a complete list of program registers present in the ADS86xx device. The user must provide data in hexadecimal for writing registers. The user also must select the register in the register map, provide data in the *Write Data* box, and click the **Write Register** button to write the register. For reading a register, the user must select the register in the register map and click the **Read Register** button. All registers can be read by clicking the **Read All** button. The values for all registers can be saved in a configuration file (.cfg) by the **Save Config** button. The saved configuration can be loaded back by using the **Load Config** button. Changes made in the register map view are reflected in the system block view and vice-versa. For details on the ADS86xx program registers, refer to the program register map in the respective device data sheet. Figure 19 shows the register map view.

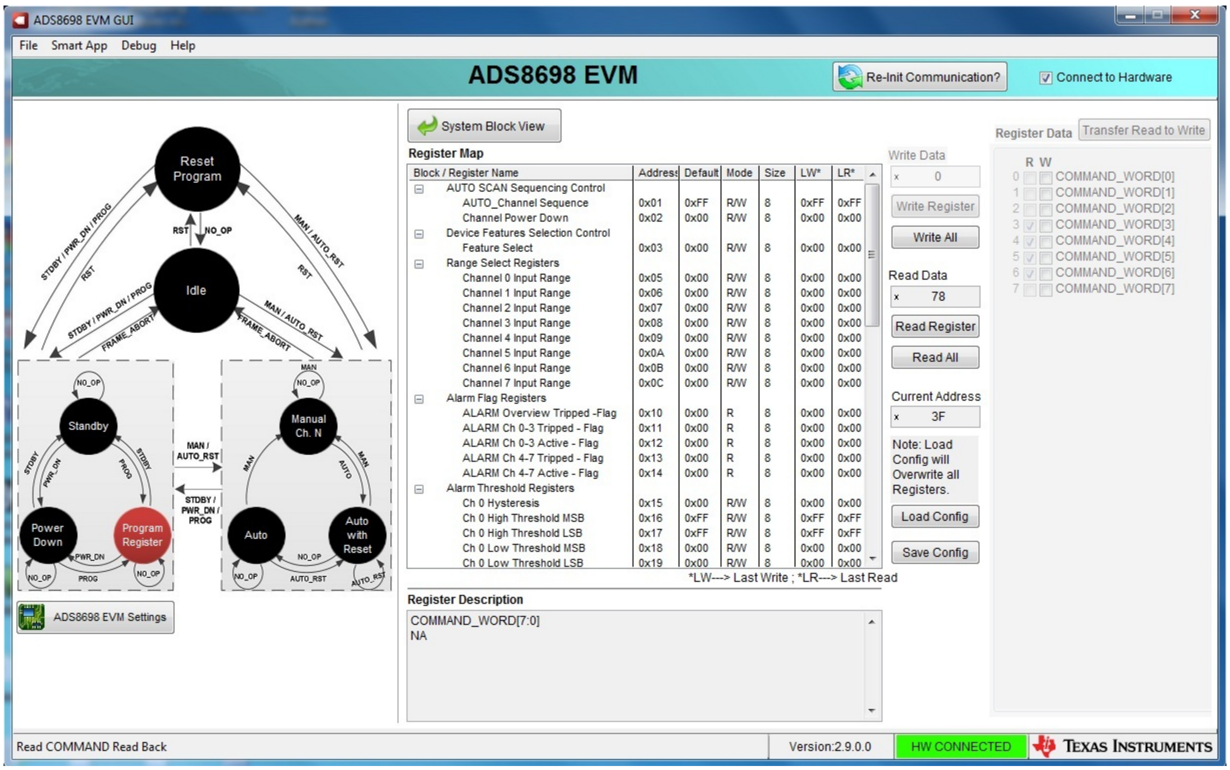

Figure 19. Register Map View

7.3.3 Jumper Settings for the ADS86xxEVM

The **ADS86xxEVM Settings** button on the left side of the GUI window describes the jumper settings on the ADS86xxEVM. The reset and REFSEL jumpers are monitored by the GUI. If the reset jumper (J3) is open, the GUI switches to the reset Program mode in the start page of the GUI. For details on different jumper settings; see *Section 3* and *Section 5*. Figure 20 shows the ADS86xxEVM GUI window for the jumper settings.

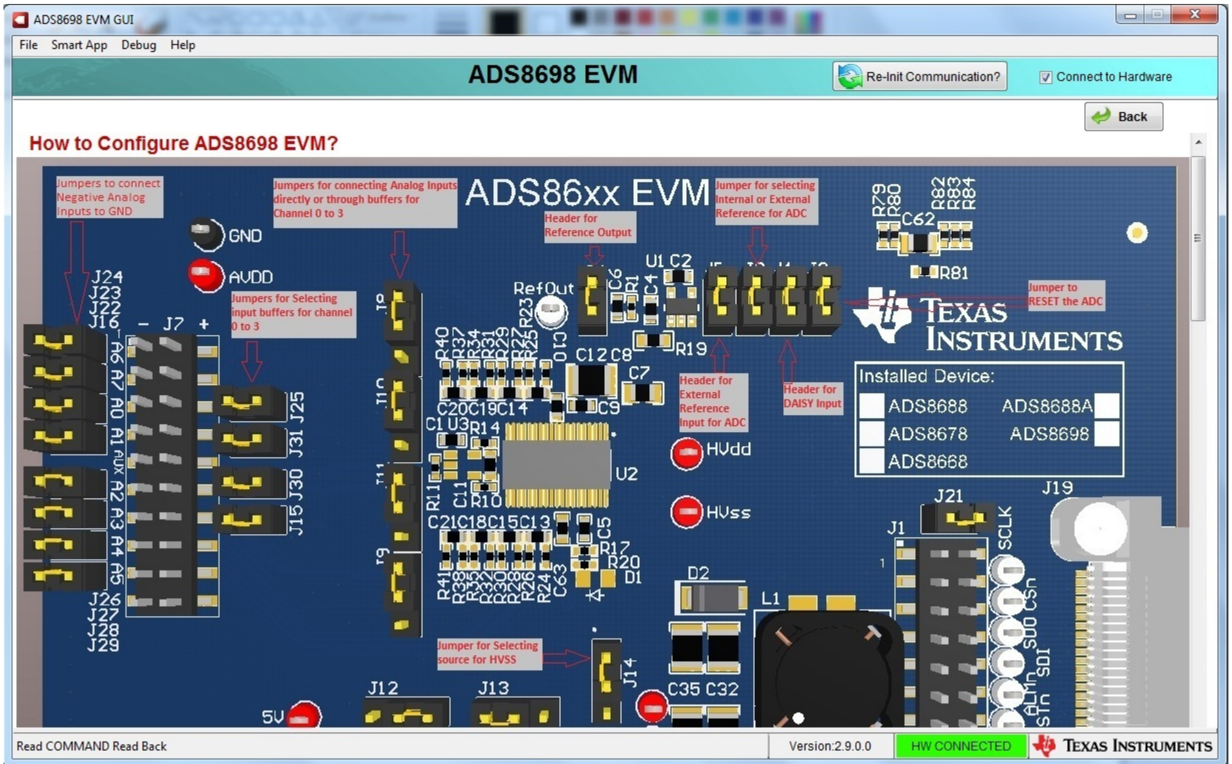

Figure 20. ADS86xxEVM Jumper Settings

7.4 Capturing the Data

Data can be captured from the ADS86xxEVM either in manual mode or in auto mode. Manual mode captures data from one of the device channels whereas auto mode captures data from the channels that are powered up and selected in the auto channel sequence. *Section 7.4.1* and *Section 7.4.2* provide details for manual and auto mode, respectively.

7.4.1 Manual Mode

Manual mode can be activated by clicking on the **Manual Channel N** button on the left side of the GUI window and by selecting *Data Capture* from the drop-down menu; see Figure 21. In manual mode, data are captured for the channel selected by the *Channel Name* drop-down menu. The sampling rate and number of samples for the data capture can be entered in the *ADC Capture Settings* box. The ADS86xxEVM GUI supports a sampling rate from 20 kSPS to 500 kSPS. The sampling rate is adjusted to the closest value obtained from Equation 1.

$$\text{Sampling Rate (kSPS)} = 17000 / [34 + K] \text{ .... for the ADS8688A, ADS8678, and ADS8668 Devices} \quad (1)$$

$$\text{Sampling Rate (kSPS)} = 18000 / [36 + K] \text{ .... for the ADS8698 device}$$

where

- $0 \le K \le 816$, and K is an integer. (2)

The GUI supports a capture of 1024 samples to 8,388,608 samples. For sampling rates less than 100 kSPS, the maximum number of samples are limited to 131,072 per capture. The number of samples are adjusted to the closest power of 2. The data captured are displayed in a graph in the GUI window.

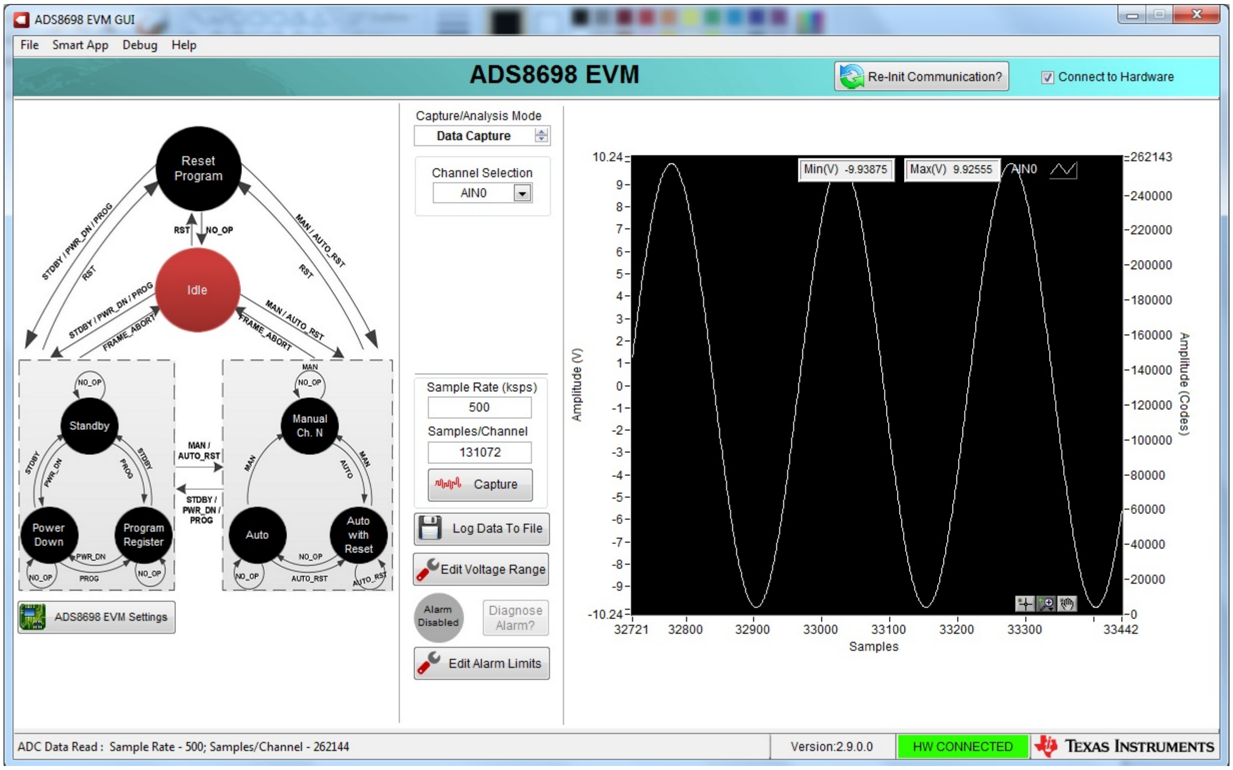

Figure 21. Manual Mode Data Capture

7.4.2 Auto Mode

Auto mode can be activated by clicking on the **Auto with Reset Mode** button and selecting *Data Capture* from the drop-down menu. In auto mode, data are captured sequentially for the channel selected in the auto channel sequence. The channels can be enabled or disabled by the check boxes corresponding to the channels. In auto mode, the sampling rate entered is an aggregate of the sampling rate for all channels enabled in the auto channel sequence. The effective sampling rate for a channel is the sampling rate for the device divided by the number of channels enabled. The sampling rate for the device must be entered in the *Sample Rate (ksps)* box. Also in auto mode, the sampling rate follows the calculation of Equation 1.

The number of samples to be captured per channel must be entered in the *ADC Capture Settings* box. The number of samples per channel value is adjusted to the closest power of 2 by the GUI. The GUI supports a maximum capture of 8,388,608 samples per capture. The maximum number of samples per channel that can be captured in auto mode is determined by Equation 3.

$$(\text{Number of Samples per Channel}) \times (\text{Number of Channels Enabled}) \leq 8{,}388{,}608 \quad (3)$$

Data captured in auto mode can be viewed in single graph view or in multi graph view. In single graph view, data for an individual channel are displayed in a single graph. The channel for a single graph can be selected from the channel drop-down menu. In multi graph view, data for all enabled channels are displayed in multi graph view. Figure 22 and Figure 23 illustrate the data captured in auto mode.

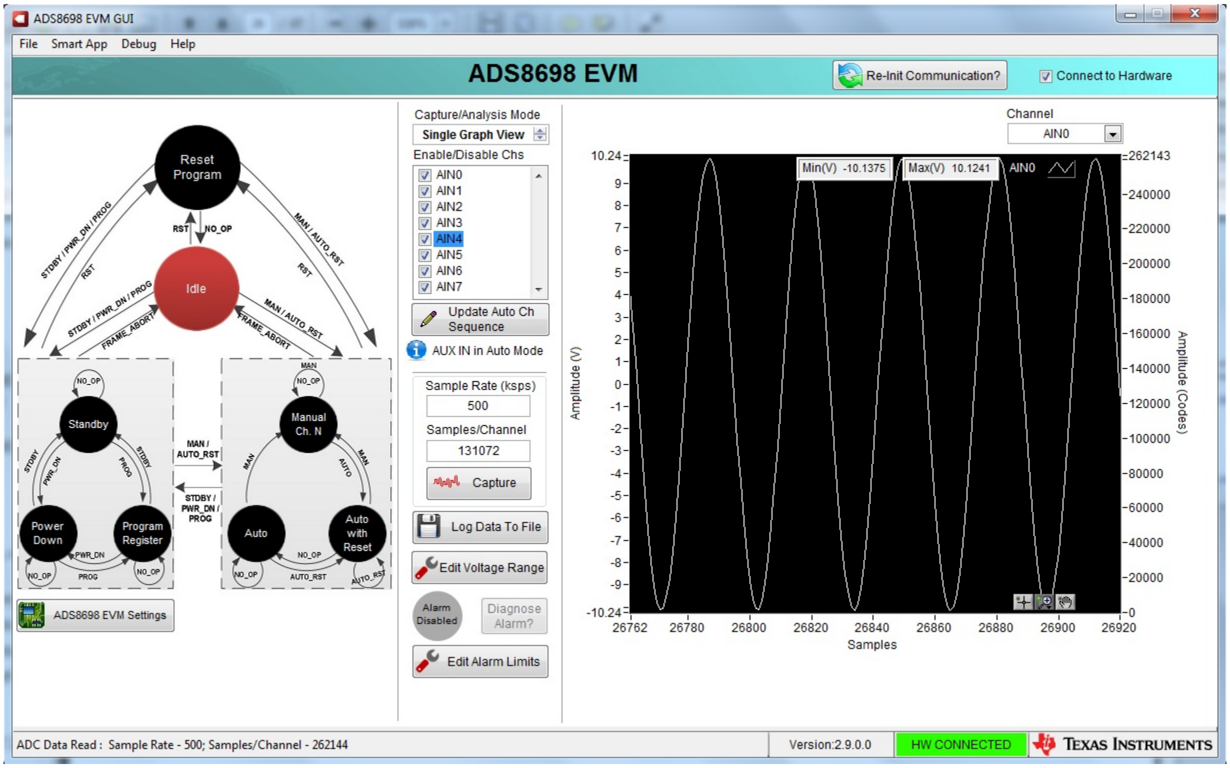

Figure 22. Data Capture in Auto Mode with Single Graph View

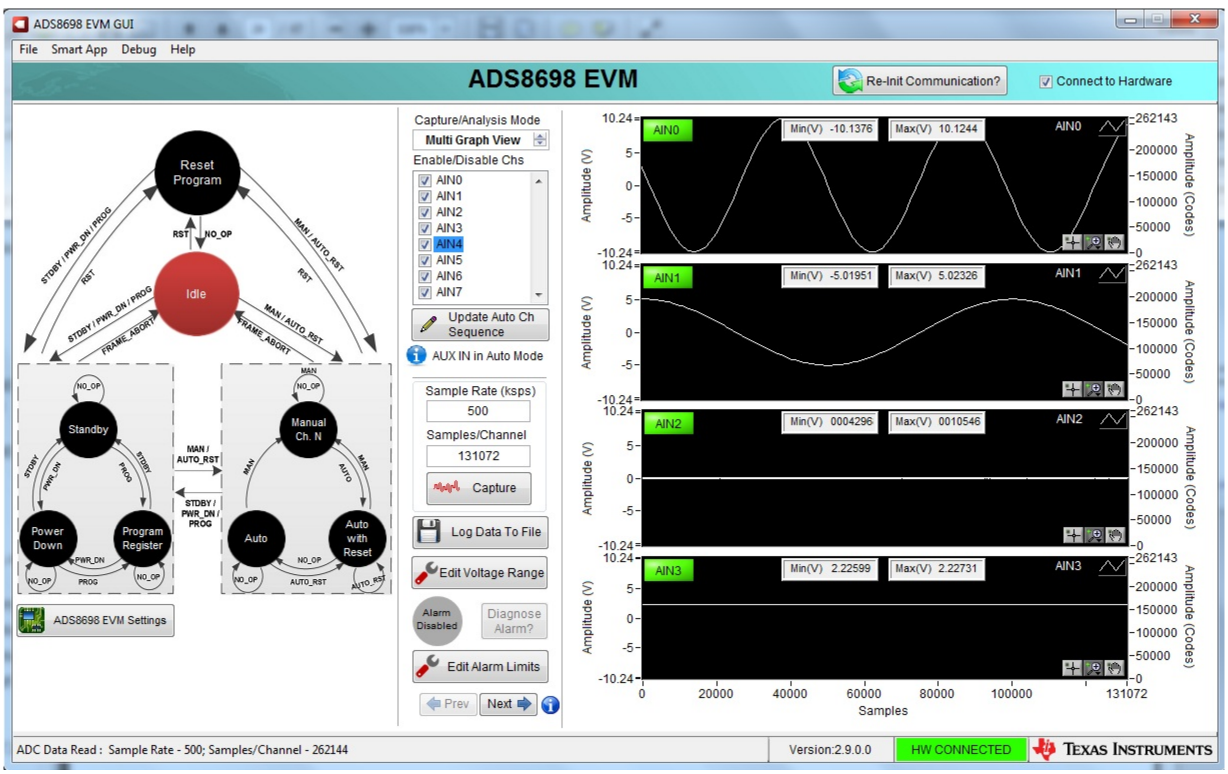

Figure 23. Data Capture in Auto Mode with Multi Graph View

7.4.3 Saving the Captured Data

The data captured from the EVM can be stored in a .csv file by clicking the **Log Data To File** button, as shown in Figure 24. A window appears for selecting the location and entering the name of the file for saving the captured data.

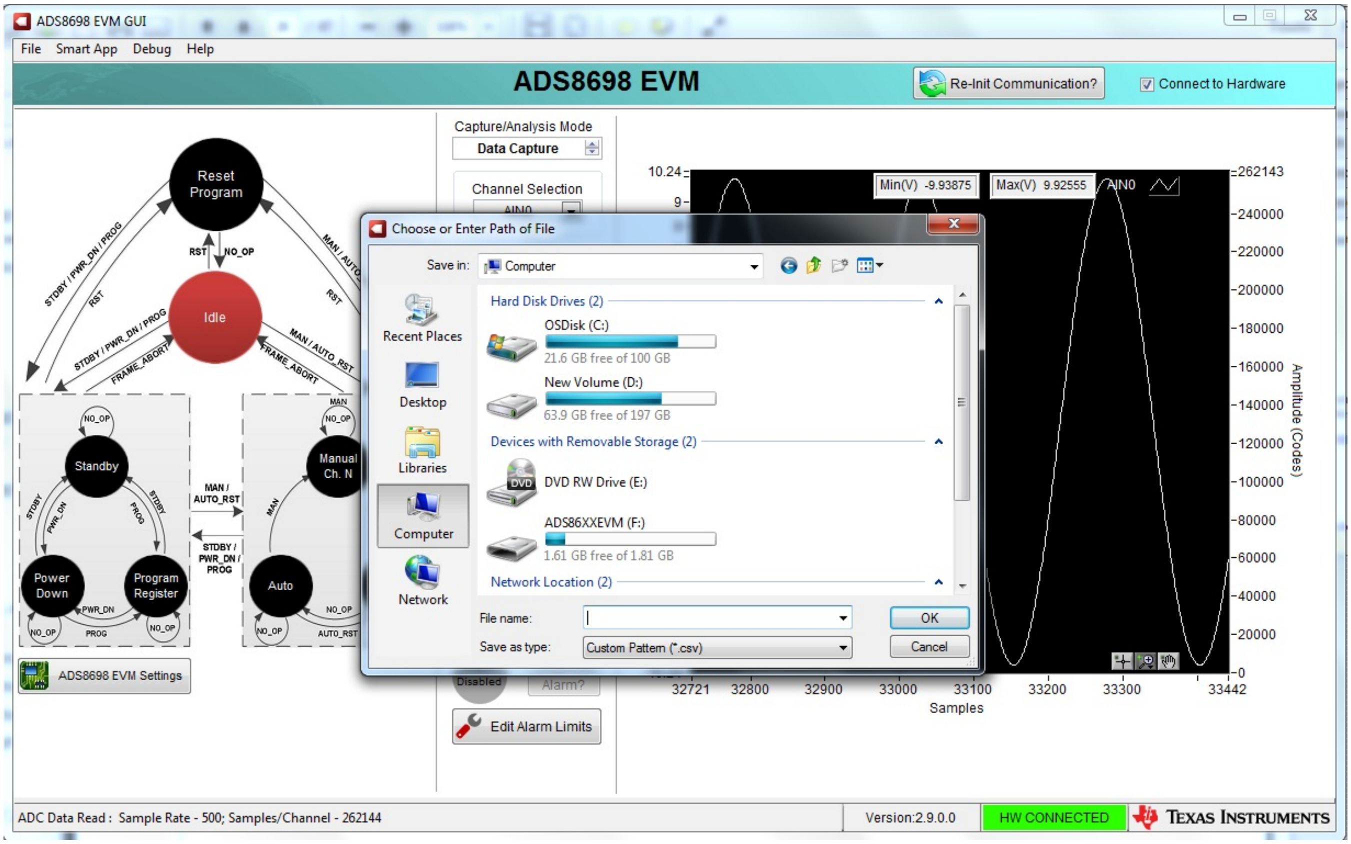

Figure 24. Saving the Captured Data

7.5 Analyzing the Data

The ADS86xxEVM GUI includes the histogram analysis and FFT analysis for data captured from the ADS86xxEVM in auto or manual mode. Data can be analyzed with the selected analysis from the drop-down menu in the ADC capture settings.

7.5.1 Histogram Analysis

Histogram testing is commonly used when testing ADCs. A histogram is merely a count of the number of times a code occurs in a particular data set. The histogram analysis page of the GUI creates a histogram of the data of the acquired data set and displays that data. The input channel (AINx) for the histogram analysis can be selected from the channel drop-down menu and the data capture settings can be entered in boxes on the left side of the graph. Figure 25 shows the histogram analysis page.

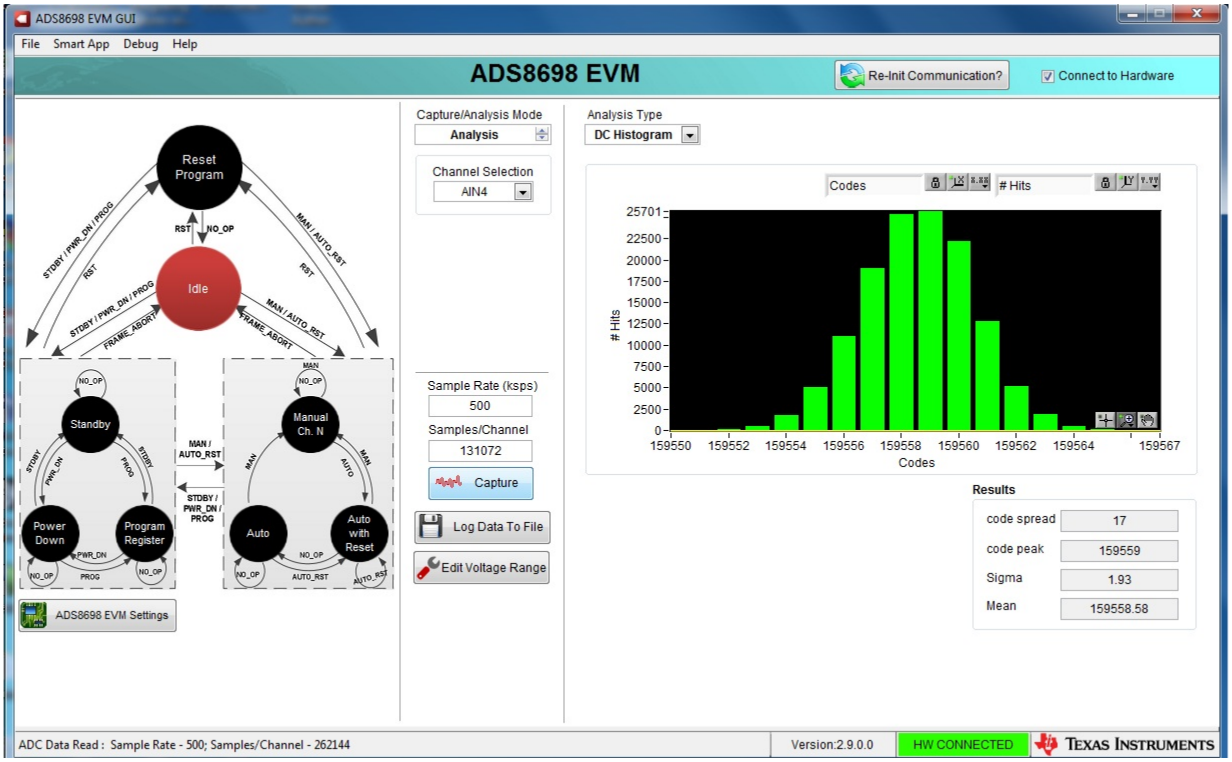

Figure 25. Histogram Analysis

The following parameters are calculated using the histogram analysis.

- Code Spread: Is the number of different codes captured for a certain input.
- Code Peak: Is the code with the maximum number of hits.
- Sigma: Is the standard deviation of all the codes captured.
- Mean: Is the average of all the codes captured for a certain input.

7.5.2 FFT Analysis

The FFT analysis page in the GUI performs the fast fourier transform (FFT) of the captured data and displays the resulting frequency domain plots. This page also calculates key ADC dynamic performance parameters, such as signal-to-noise ratio (SNR), total harmonic distortion (THD), signal-to-noise and distortion ratio (SINAD), and spurious-free dynamic range (SFDR). Figure 26 shows the FFT performance analysis display. The input channel (AINx) for FFT analysis can be selected from the channel drop-down menu and the data capture settings can be entered in boxes on the left side of the graph. The FFT calculated parameters are shown on the bottom side of the graph.

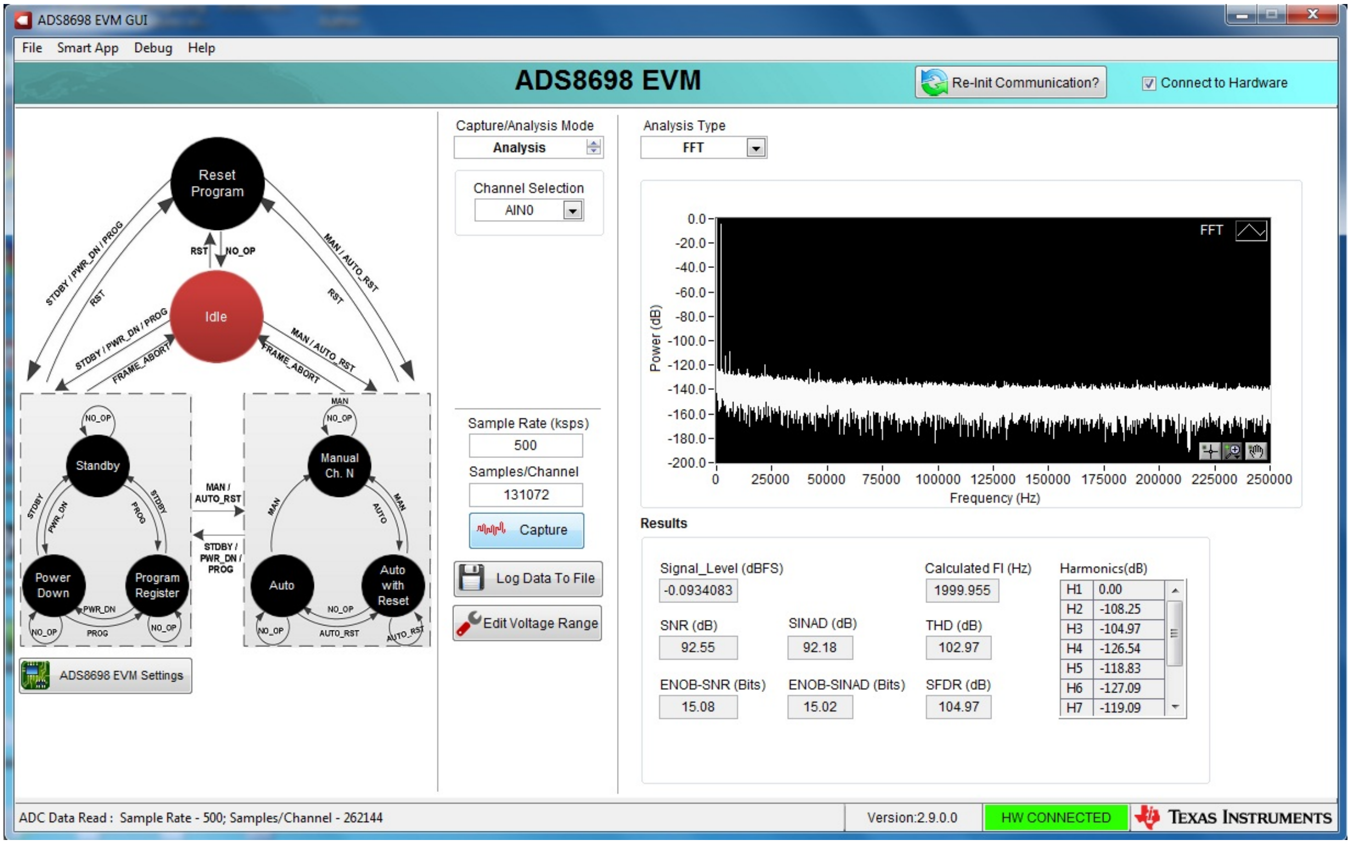

Figure 26. FFT Analysis

Input signal frequency for FFT analysis:

- The GUI analyses the FFT to provide signal power (dBFs), SNR, SINAD, THD, SFDR, and ENOB numbers.
- The GUI uses a 7-term Blackman-Harris window to minimize spectral leakage.

7.6 Alarm Feature

7.6.1 Alarm Functionality

The ADS86xx series of devices support an elaborate set of ALARM functionality. The detail of the ALARM functionality and operation is available in respective device data sheets. The ADS86xxEVM and GUI support the required hardware and software features to demonstrate the ALARM functionality of the device.

The ALARM feature of the device can be activated by clicking the **Edit Alarm Limits** button when in manual or auto mode. Individual channel threshold levels and hysteresis levels can be programmed in the *Configure Alarm Settings* pop-up window. The ALARM feature can be enabled or disabled by checking or unchecking the **Alarm Enable?** check box. Click the **Config Alarm Settings** button to program device registers with correct data, as shown in Figure 27.

The user can also program these values by individually programming each register from register map view, as described in *Section 7.3.2*.

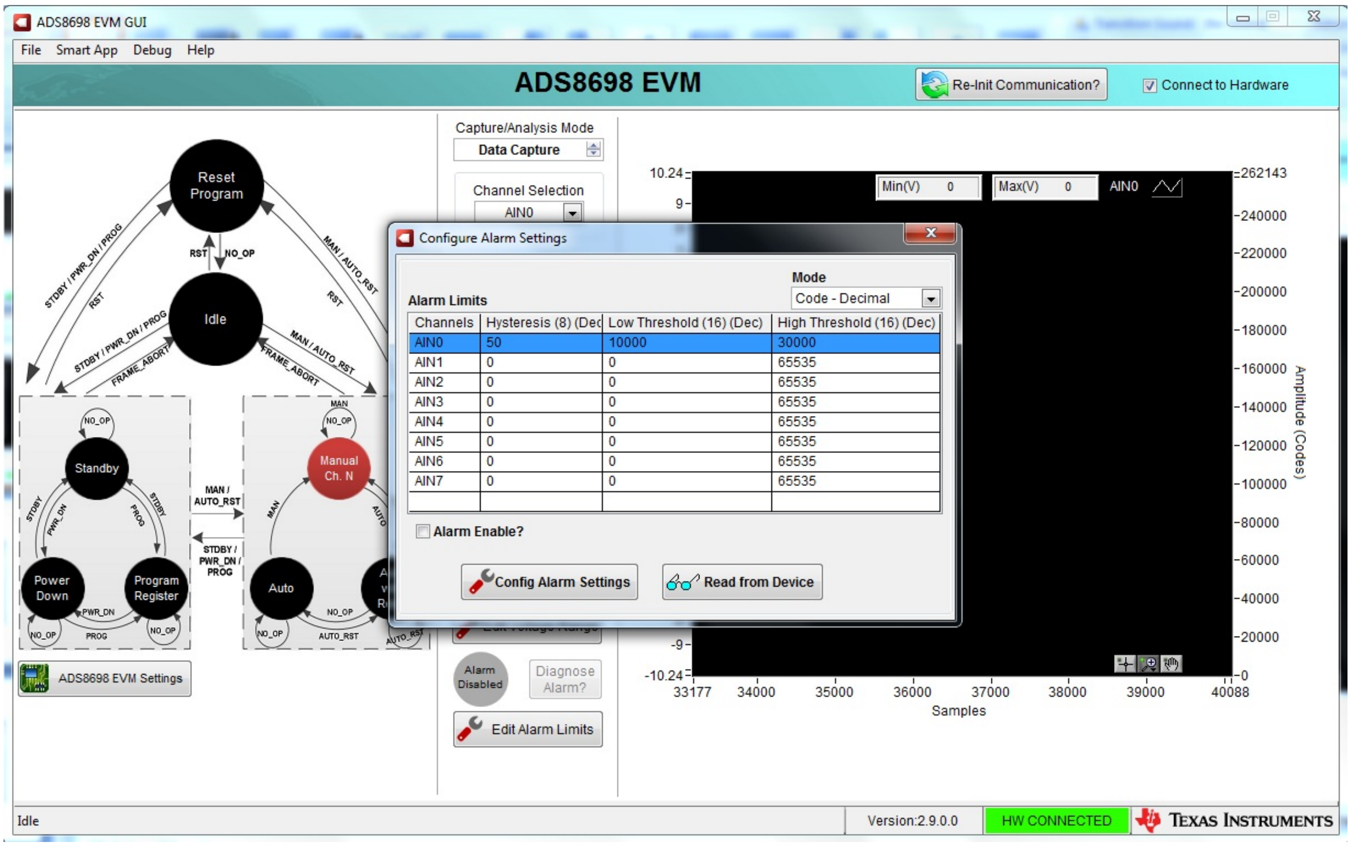

Figure 27. Alarm Enable Settings

When the ALARM feature is enabled, the capture data window shows the indicators for high and low thresholds based on the values programmed. After data capture, if the device detects an ALARM event, EVM diode D1 turns on with a red indicator light. The GUI monitors the status of the ALARM pin on the device. When an ALARM is detected, the ALARM indicator on the GUI starts flashing.

The user can read the status of tripped alarms by clicking the **Diagnose Alarm?** button. The user can also read the ALARM register contents from register map view to detect the state of tripped and active alarms.

7.7 Phase Compensation

The ADS86xxEVM GUI includes an analysis page for compensating the phase of signals captured in auto mode. When the signals on different channels are sampled in auto mode, a deterministic phase difference between signals is introduced resulting from the time difference between sampling instants. The phase difference is dependent on sampling rate, input signal frequency, number of channels, and initial phase difference. The phase compensation analysis page compensates for the introduced phase difference and provides the results after phase compensation. For details on phase compensation, see the reference guide *Phase Compensated 8-CH Multiplexed Data Acquisition System for Power Automation* (TIDU427). The phase compensation analysis page can be activated from the *Smart App* menu. Figure 28 displays the phase compensation analysis page.

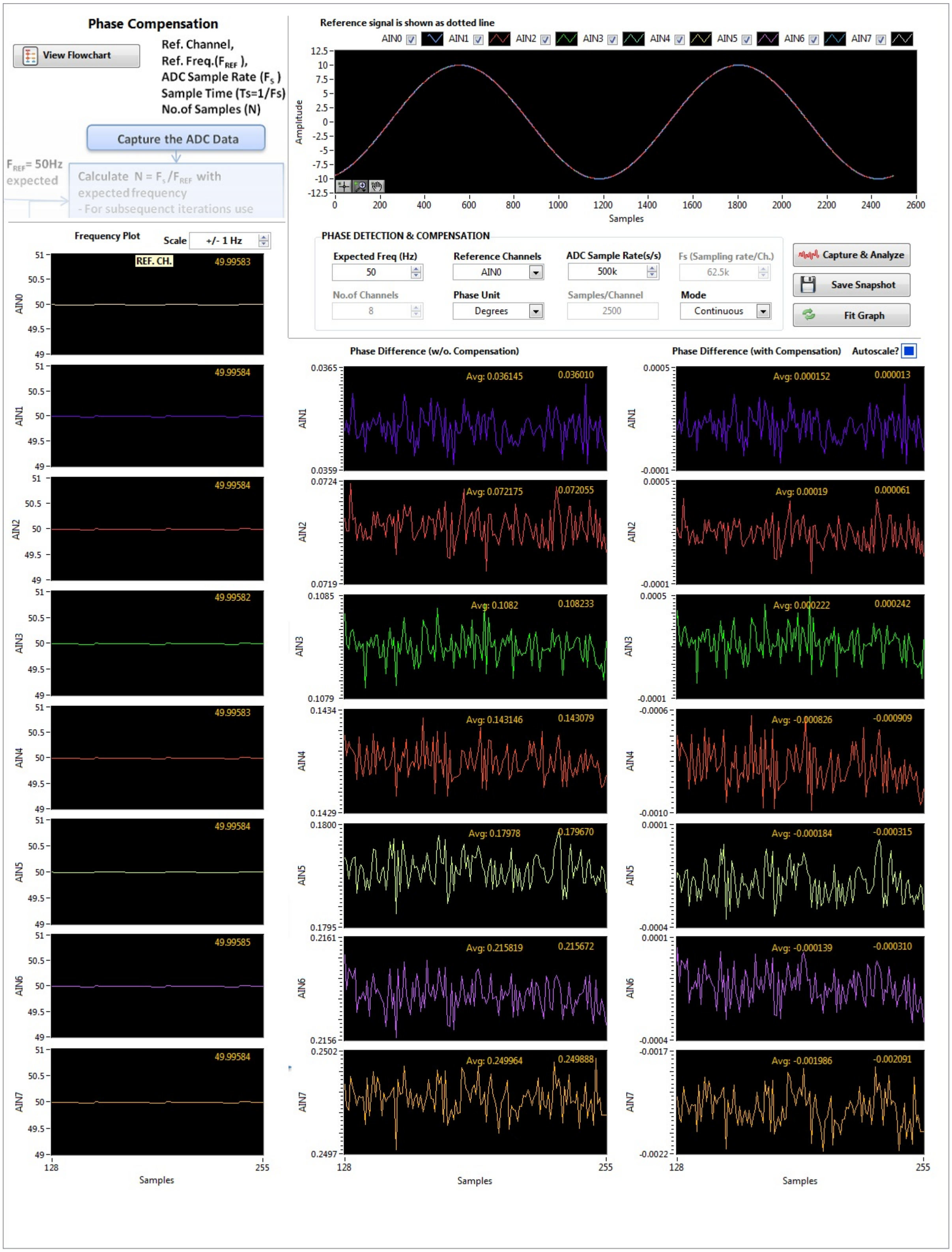

Figure 28. Phase Compensation Analysis

7.8 ADS86xxEVM GUI Simulation Mode

The ADS86xxEVM GUI can be run in simulation mode by unchecking the *Connect to Hardware* check-box on the top right side of the GUI window. In simulation mode, the GUI does not connect to the ADS86xxEVM board and only displays the results for one set of captured data stored in the computer. Figure 29 shows the ADS86xxEVM GUI running in simulation mode.

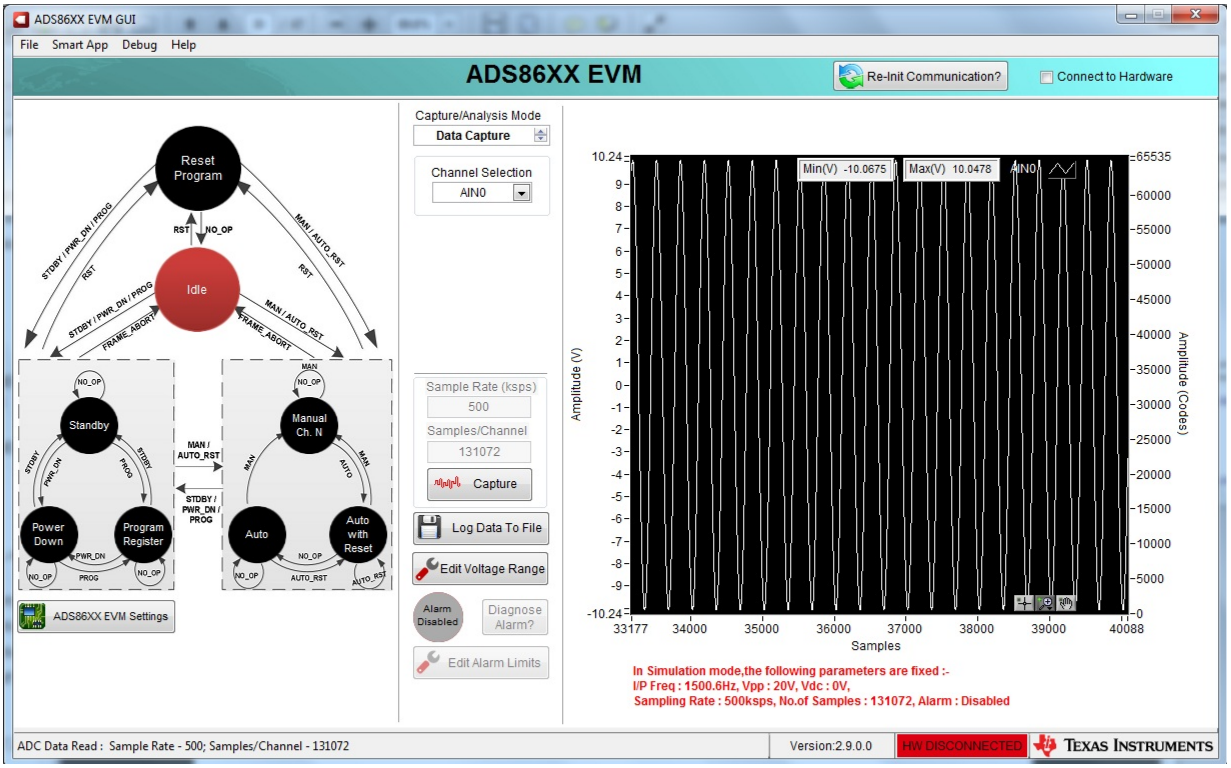

Figure 29. Simulation Mode

8 Bill of Materials, Layout, and Schematics

Schematics for the ADS86xxEVM are appended to this user's guide. The bill of material is the same for all devices in the ADS86xx family. The device U2 varies based on the device chosen for evaluation. The bill of materials is provided in Table 14. Section 8.2 shows the PCB layouts for the ADS86xxEVM with the ADS8688IDBT device installed on the EVM. Section 8.3 provides the schematics for the ADS86xxEVM and ADS8688IDBT.

8.1 Bill of Materials

NOTE: All components are compliant with the European Union Restriction on Use of Hazardous Substances (RoHS) Directive. Some part numbers may be either leaded or RoHS. Verify that purchased components are RoHS-compliant. (For more information about TI's position on RoHS compliance, see www.ti.com.)

Table 14. ADS8688EVM Bill of Materials

Item No.	Qty	Ref Des	Description	Vendor	Part Number
1	1	!PCB	Printed Circuit Board	Any	PRJ_Number
2	4	C1-C3, C6	CAP, CERM, 0.1uF, 25V, +/-5%, X7R, 0603	AVX	06033C104JAT2A
3	1	C10	CAP, CERM, 1uF, 16V, +/-10%, X5R, 0603	Kemet	C0603C105K4PACTU
4	1	C11	CAP, CERM, 3000pF, 50V, +/-5%, C0G/NP0, 0603	MuRata	GRM1885C1H302JA01D
5	6	C16, C24, C26, C30, C45, C64	CAP, CERM, 0.1uF, 50V, +/-10%, X7R, 0603	AVX	06035C104KAT2A
6	4	C17, C22, C27, C28	CAP, CERM, 2200pF, 50V, +/-5%, C0G/NP0, 0603	TDK	C1608C0G1H222J
7	4	C23, C25, C29, C31	CAP, CERM, 1000pF, 50V, +/-5%, C0G/NP0, 0402	MuRata	GRM1555C1H102JA01D
8	4	C32, C35, C49, C50	CAP, CERM, 22uF, 25V, +/-10%, X7R, 1210	MuRata	GRM32ER71E226KE15L
9	3	C34, C36, C53	CAP, CERM, 10uF, 25V, +/-10%, X7R, 1206	MuRata	GRM31CR71E106KA12L
10	2	C37, C54	CAP, CERM, 10uF, 35V, +/-10%, X7R, 1206	Taiyo Yuden	GMK316AB7106KL
11	15	C4, C12-C15, C18-C21, C38-C41, C56, C58	CAP, 10000pF, 0603, 5%, 50V, C0G	TDK	C1608C0G1H103J080AA
12	1	C42	CAP, CERM, 0.22uF, 16V, +/-10%, X7R, 0603	TDK	C1608X7R1C224K
13	2	C44, C46	CAP, CERM, 2.2uF, 10V, +/-10%, X7R, 0603	MuRata	GRM188R71A225KE15D
14	1	C48	CAP, CERM, 10uF, 50V, +/-20%, X7R, 2220	TDK	C5750X7R1H106M
15	1	C5	CAP, CERM, 10uF, 6.3V, +/-20%, X5R, 0603	Kemet	C0603C106M9PACTU
16	1	C51	CAP, CERM, 0.1uF, 25V, +/-5%, X7R, 0603	Kemet	C0603C104J3RAC
17	1	C52	CAP, CERM, 0.39uF, 16V, +/-10%, X7R, 0603	MuRata	GRM188R71C394KA88D
18	1	C57	CAP, CERM, 470pF, 50V, +/-10%, X7R, 0603	TDK	C1608X7R1H471K
19	2	C59, C60	CAP, CERM, 10uF, 35V, +/-10%, X7R, 1210	MuRata	GRM32ER7YA106KA12L
20	7	C7, C33, C43, C47, C55, C61, C62	CAP, CERM, 10uF, 10V, +/-10%, X7R, 0805	MuRata	GRM21BR71A106KE51L
21	1	C8	CAP, CERM, 22uF, 16V, +/-20%, X7R, 1210	TDK	C3225X7R1C226M
22	2	C9, C63	CAP, CERM, 1uF, 16V, +/-10%, X7R, 0603	TDK	C1608X7R1C105K
23	1	D1	Diode, LED, RED, 2.1V, 14.2-mcd, 20 mA, 0805	Lite On	LTST-C170UKT

Table 14. ADS8688EVM Bill of Materials (continued)

Item No.	Qty	Ref Des	Description	Vendor	Part Number
24	2	D2, D4	Diode, Schottky, 60V, 2A, SMA	Diodes Inc.	B260A-13-F
25	2	D3, D5	Diode, Zener, 5.6V, 500mW, SOD-123	ON Semiconductor	MMSZ4690T1G
26	2	D6, D8	Diode, Zener, 27V, 500mW, SOD-123	Vishay-Semiconductor	MMSZ4711-V
27	1	D7	Diode, Zener, 3.9V, 500mW, SOD-123	ON Semiconductor	MMSZ4686T1G
28	2	D9, D10	Diode, Schottky, 30V, 0.2A, SOT-23	Diodes Inc.	BAT54C-7-F
29	6	FID1-FID6	Fiducial mark. There is nothing to buy or mount.	N/A	N/A
30	4	H1-H4	Bumpon, Hex, 0.063mil, 11mm Dia, Lt Brn	3M	SJ5202
31	2	J1, J7	Header, 100mil, 10x2, SMD	Samtec, Inc.	TSM-110-01-T-DV-P
32	1	J18	Terminal Block, 6A, 3.5mm Pitch, 3-Pos, TH	On-Shore Technology, Inc.	ED555/3DS
33	1	J19	Receptacle, Micro High Speed Socket Strip, 0.8mm, 25x2, R/A, SMT	Samtec, Inc.	ERF8-025-01-L-D-RA-L-TR
34	19	J2-J6, J15-J17, J21-J31	Header, TH, 100mil, 2x1, Gold plated, 230 mil above insulator	Samtec, Inc.	TSW-102-07-G-S
35	1	J20	MicroSD Memory Card Connector	Molex	502570-0893
36	2	J32, J33	Terminal Block, 6A, 3.5mm Pitch, 2-Pos, TH	On-Shore Technology, Inc.	ED555/2DS
37	7	J8-J14	Header, TH, 100mil, 3x1, Gold plated, 230 mil above insulator	Samtec, Inc.	TSW-103-07-G-S
38	1	L1	—	Wurth Electronics	744870471
39	1	Q1	Transistor, NPN, 45V, 0.1A, SOT-23	ON Semiconductor	BC847CLT1G
40	8	R1, R79-R85	RES, 10.0k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW040210K0FKED
41	5	R11, R21, R22, R74, R76	RES, 10.0Meg ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW040210M0FKED
42	1	R12	RES, 1.0k ohm, 5%, 0.125W, 0805	Vishay-Dale	CRCW08051K00JNEA
43	3	R13, R15, R18	RES, 47.0k ohm, 1%, 0.1W, 0603	Yageo America	RC0603FR-0747KL
44	1	R17	RES, 220k ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW0402220KJNED
45	1	R19	RES, 100 ohm, 1%, 0.1W, 0603	Vishay-Dale	CRCW0603100RFKEA
46	17	R2, R3, R5-R10, R14, R16, R86-R91, R93	RES, 49.9 ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW040249R9FKED
47	1	R20	RES, 100k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW0402100KFKED
48	16	R23-R32, R34, R35, R37, R38, R40, R41	RES, 357 ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW0402357RFKED
49	13	R36, R44, R48, R52, R94-R96, R98-R100, R102, R103, R107	Resistor, Uninstalled	NI	NI
50	16	R4, R33, R39, R47, R49, R61, R69, R77, R78, R92, R97, R101, R104-R106, R108	RES, 0 ohm, 5%, 0.063W, 0402	Yageo America	RC0402JR-070RL
51	4	R42, R46, R50, R54	RES, 3.57k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW04023K57FKED
52	4	R43, R45, R51, R53	RES, 6.65k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW04026K65FKED
53	1	R55	RES, 576k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW0402576KFKED
54	2	R56, R71	RES, 232k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW0402232KFKED
55	1	R57	RES, 182k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW0402182KFKED
56	4	R58, R60, R62, R72	RES, 499k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW0402499KFKED
57	2	R59, R73	RES, 20k ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW040220K0JNED
58	1	R63	RES, 33k ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW040233K0JNED

Table 14. ADS8688EVM Bill of Materials (continued)

Item No.	Qty	Ref Des	Description	Vendor	Part Number
59	2	R64, R75	RES, 82k ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW040282K0JNED
60	1	R65	RES, 15k ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW040215K0JNED
61	1	R66	RES, 1.1k ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW04021K10JNED
62	1	R67	RES, 44.2k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW040244K2FKED
63	1	R68	RES, 412k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW0402412KFKED
64	1	R70	RES, 20.5k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW040220K5FKED
65	1	SD1	SanDisk MicroSD Card, 2GB	SanDisk	SDSDQ-002G
66	26	SH-J2-SH-J6, SH-J8-SH-J17, SH-J21-SH-J31	Shunt, 100mil, Gold plated, Black	3M	969102-0000-DA
67	1	TP11	Test Point, Miniature, Black, TH	Keystone	5001
68	6	TP12-TP17	Test Point, Miniature, Red, TH	Keystone	5000
69	9	TP2-TP10	Test Point, Miniature, White, TH	Keystone	5002
70	2	U1, U3	Op Amp, Precision, 5.5MHz, Low-Noise, RRIO, with e-trim	Texas Instruments	OPA376AIDBVR
71	1	U10	IC, -3V to -36V, -200mA, Ultralow Noise, High-PSRR LDO Negative Linear Regulator	Texas Instruments	TPS7A3001DGN
72	1	U11	IC, 2K, Serial EEPROM	Atmel	AT24C02B
73	1	U2	16 bit 500KSPS 8 Channel SAR ADC	Texas Instruments	ADS8688IDBT
74	2	U4, U5	OpAmp, Low Noise, Low Power, 36V	Texas Instruments	OPA2209AIDGKR
75	2	U6, U7	IC, VIN 3V to 35V, 150mA, Ultralow Noise, High-PSRR, LDO Regulator	Texas Instruments	TPS7A4901DGN
76	1	U8	IC, SWITCHED CAP, BUCK BOOST CONVERTER 1.8V to 5.5V in 65uA	Texas Instruments	REG71055DDC
77	1	U9	Buck Inverting Buck-Boost Step Down Regulator with 3.5 to 60 V Input and 0.8 to 58 V Output, -40 to 150 degC, 10-Pin MSOP-PowerPAD (DGQ), Green (RoHS & no Sb/Br)	Texas Instruments	TPS54060DGQ

8.2 Board Layouts

Figure 30 through Figure 35 show the printed circuit board (PCB) layouts for the ADS86xxEVM.

NOTE: Board layouts are not to scale. These figures are intended to show how the board is laid out; these figures are not intended to be used for manufacturing ADS86xxEVM PCBs.

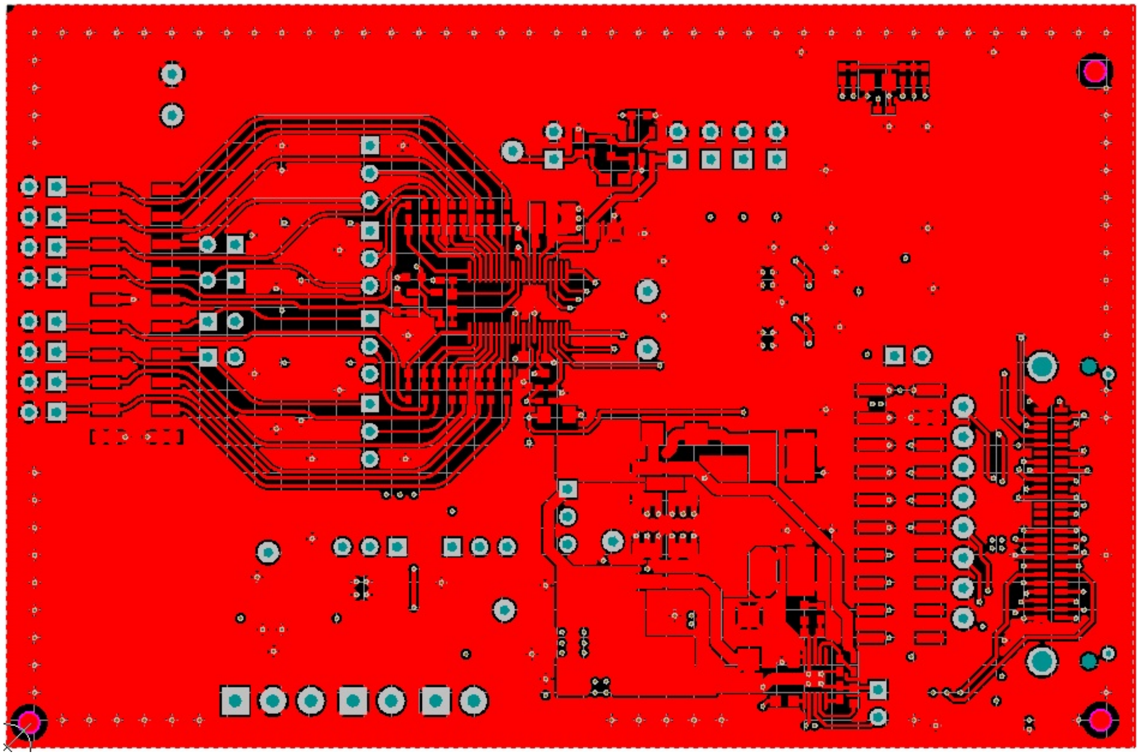

Figure 30. ADS86xxEVM PCB: Top Layer (L1)

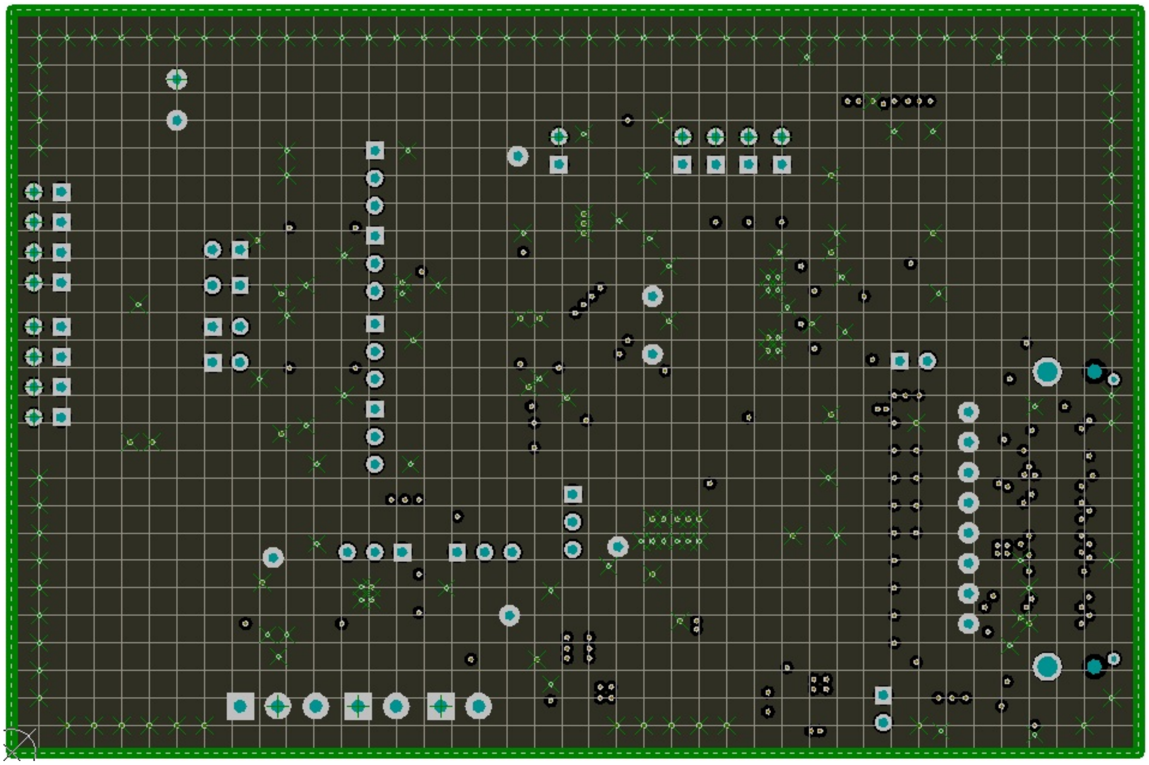

Figure 31. ADS86xxEVM PCB: Ground Layer (L2)

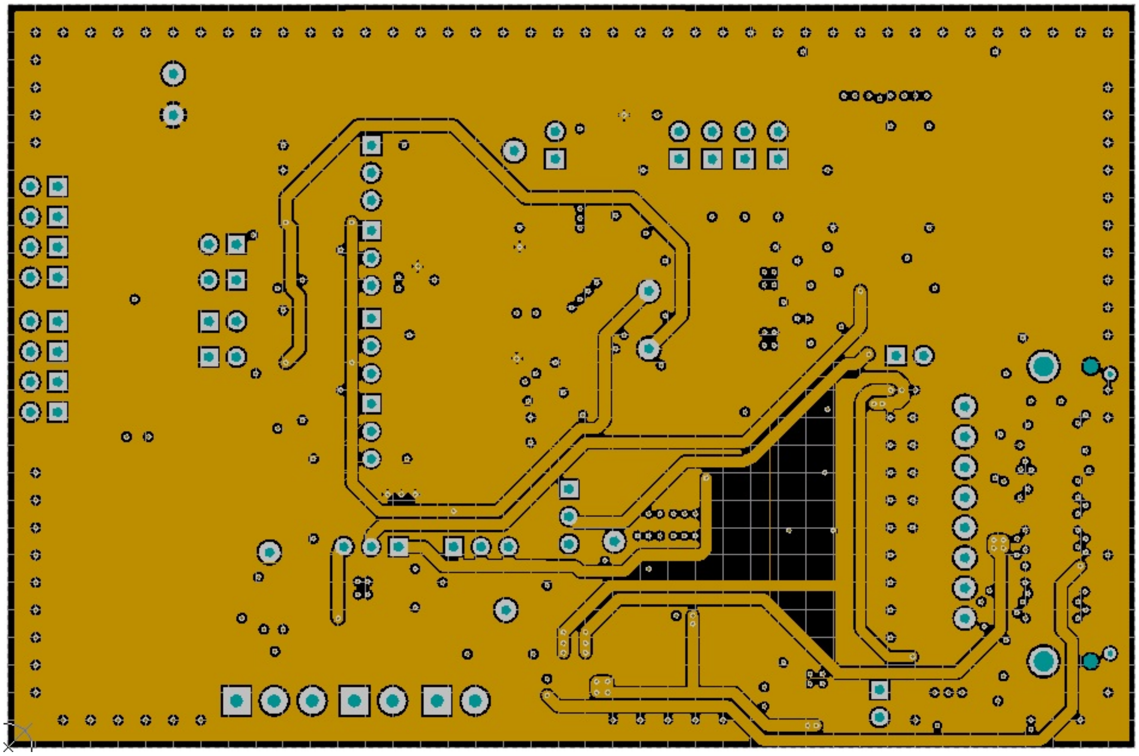

Figure 32. ADS86xxEVM PCB: Analog Power Layer (L3)

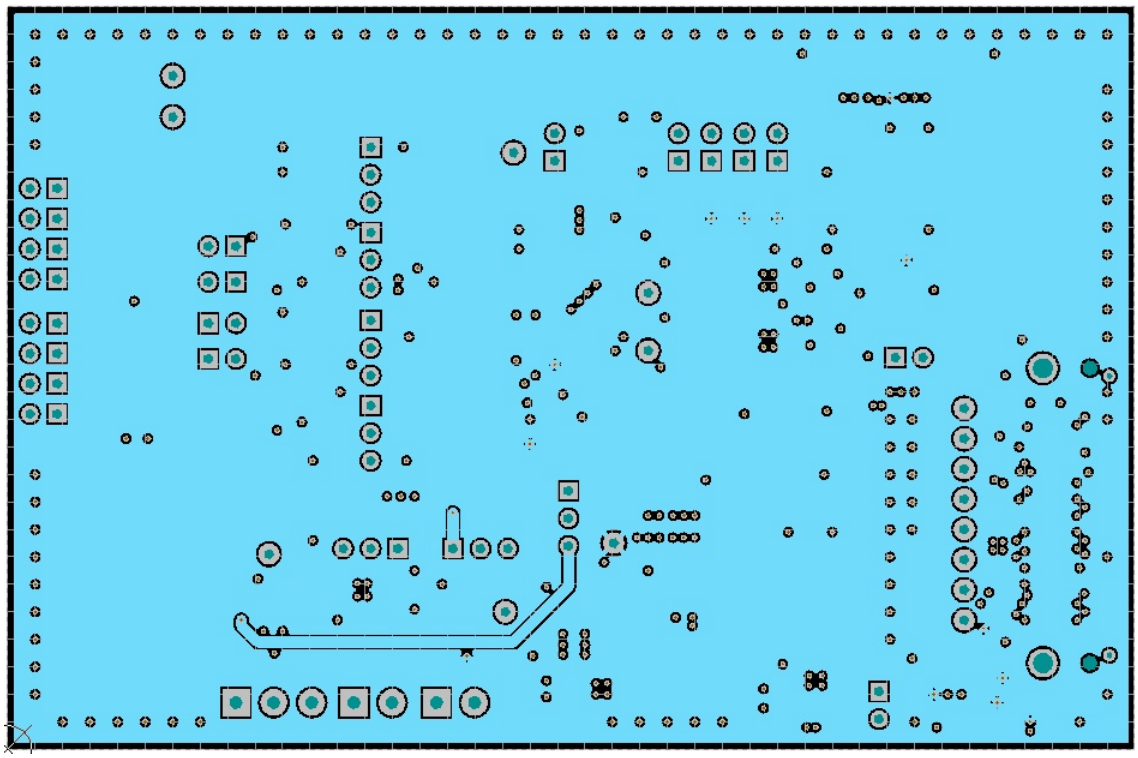

Figure 33. ADS86xxEVM PCB: Digital Power Layer (L4)

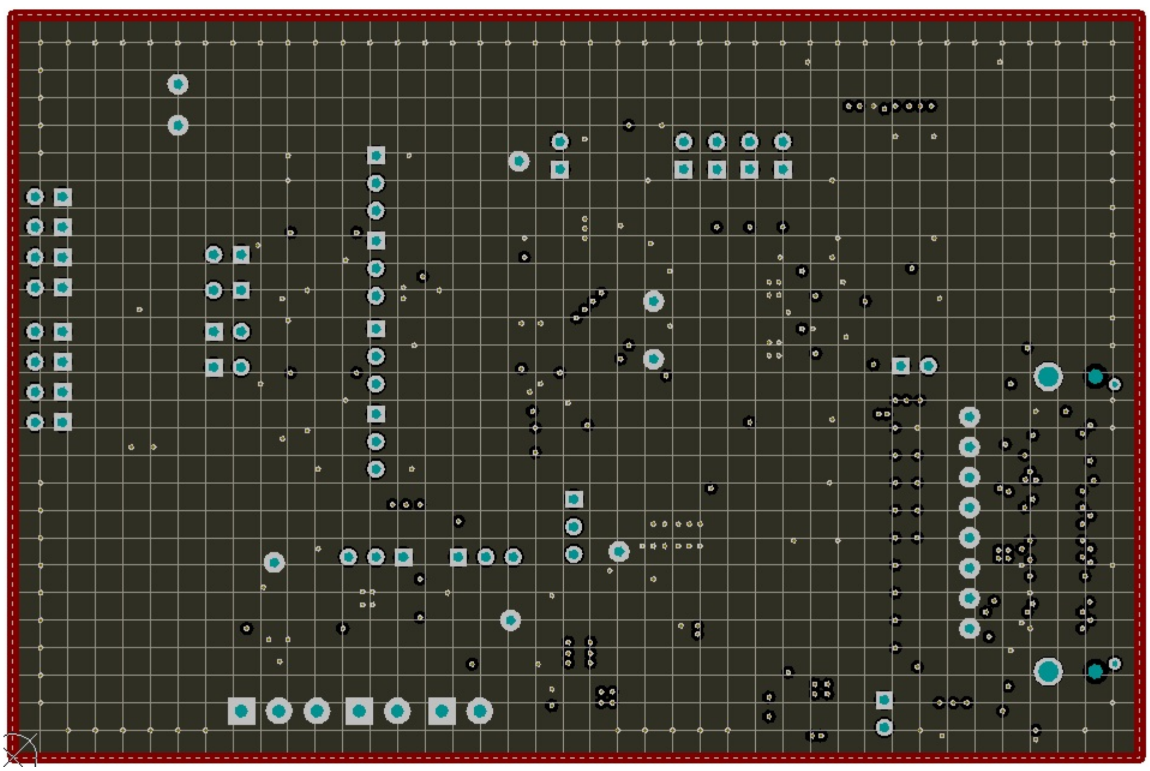

Figure 34. ADS86xxEVM PCB: Ground Layer (L5)

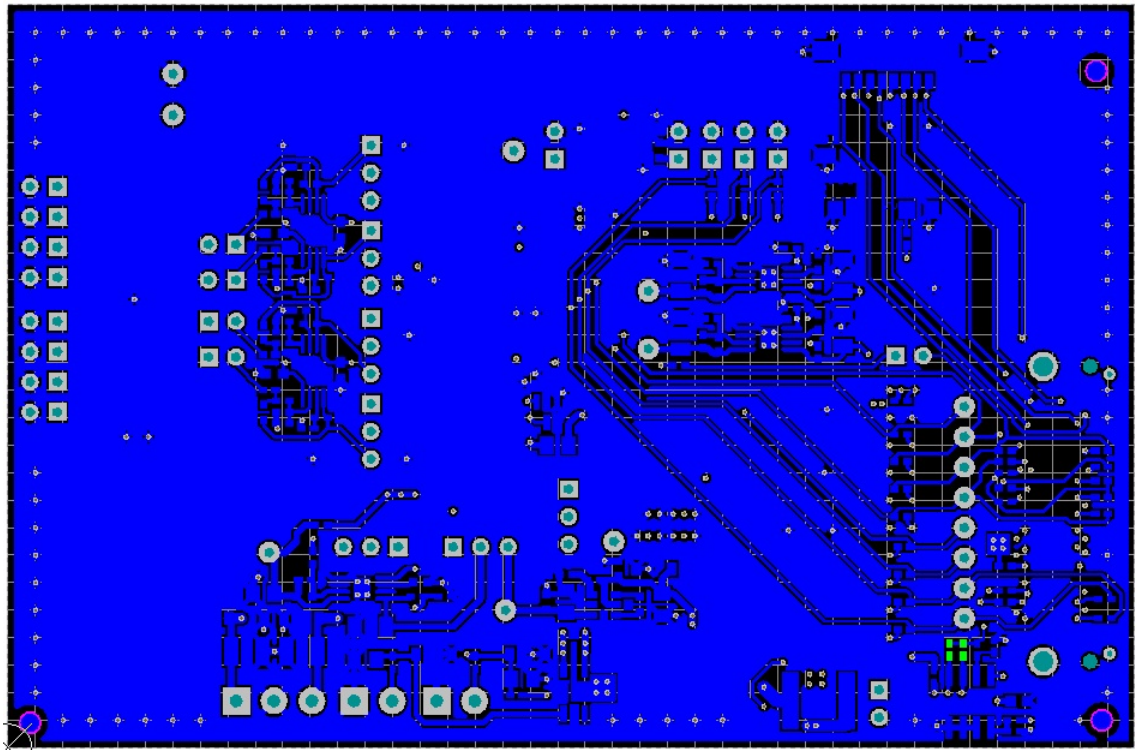

Figure 35. ADS86xxEVM PCB: Bottom Layer (L6)

8.3 Schematics

Figure 36 and Figure 37 illustrate schematics for the ADS86xxEVM-PDK.

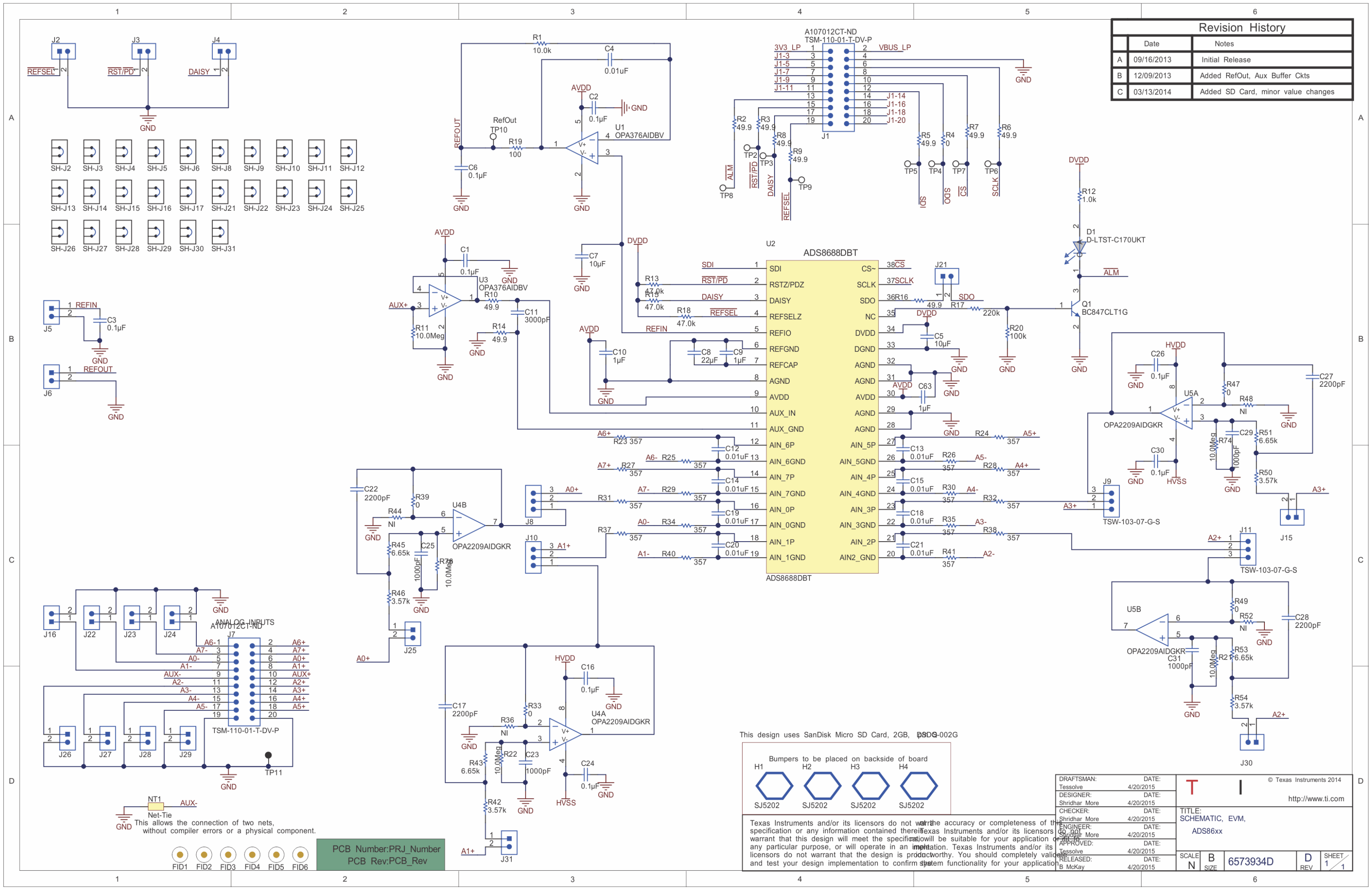

Figure 36. ADS86xx Interface Schematic

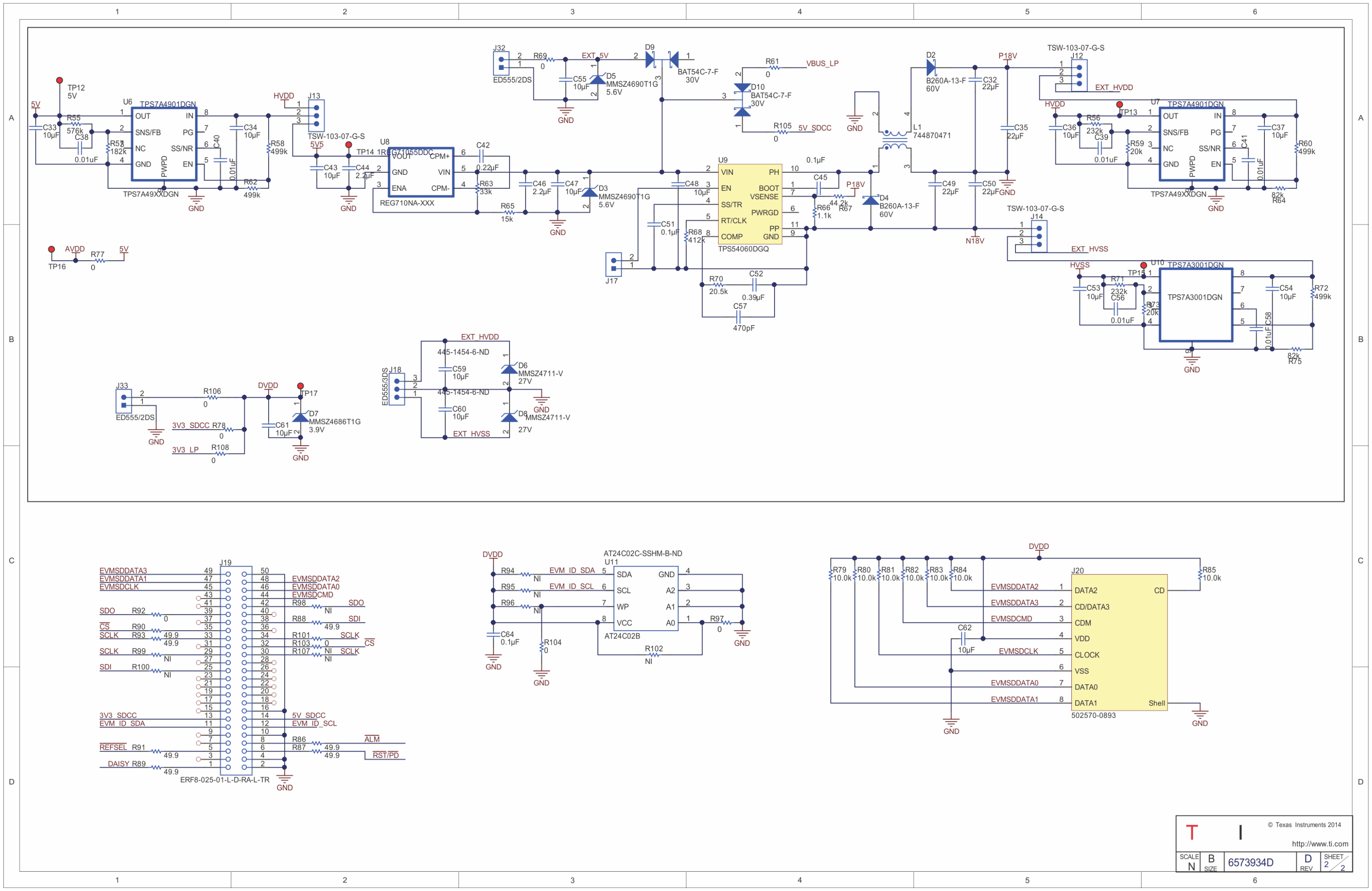

Figure 37. Power and SDCC Interface Schematic

Revision History

Changes from Original (June 2015) to A Revision	Page

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

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      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

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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.

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