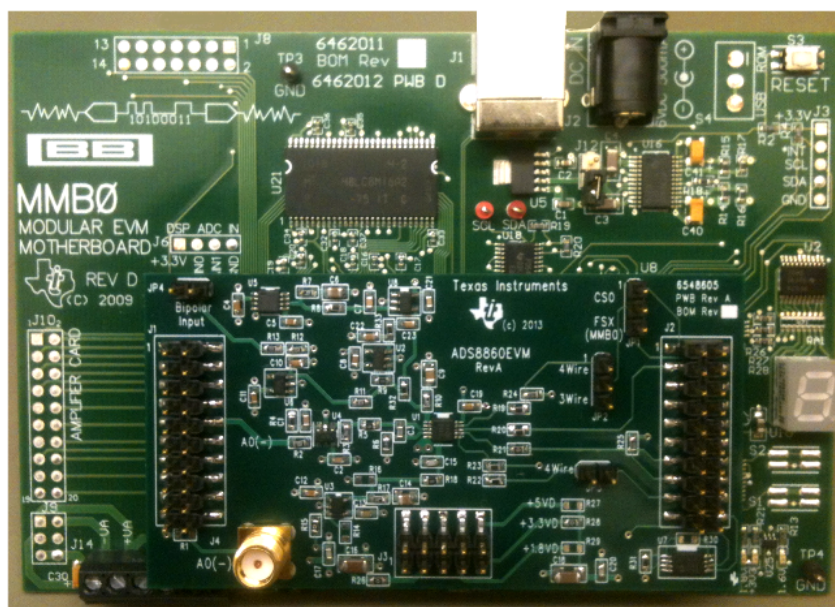


ADS8860EVM-PDK

This user's guide describes the operation and use of the [ADS8860](#) evaluation module (EVM). The ADS8860 is a 16-bit, pseudo-differential, unipolar, successive approximation register (SAR), analog-to-digital converter (ADC) with a maximum throughput of 1 MSPS. The device is a very low-power ADC with excellent noise and distortion performance for ac or dc signals. The performance demonstration kit (PDK) eases EVM evaluation with additional hardware and software for computer connectivity through a universal serial bus (USB). The [ADS8860EVM-PDK](#) includes the ADS8860EVM as a daughter card, MMB0 motherboard, A-to-B USB cable, and 6-V wall-adaptor power supply. This user's guide covers circuit description, schematic diagram, and bill of materials for the ADS8860EVM daughter card.



ADS8860EVM-PDK

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ADS8860EVM-PDK (continued)

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1 Related Documentation

Table 1 lists the related documents that are available for download from Texas Instruments at www.ti.com.

Table 1. Related Documentation

Device	Literature Number
ADS8860	SBAS547
OPA333	SBOS351
OPA376	SBOS406
OPA836	SLOS712
REF5045	SBOS410
THS4281	SLOS432
TPS78833	SLVS382

2 ADS8860EVM-PDK Overview

The ADS8860EVM is an evaluation module built to the TI Modular EVM system specifications. The EVM by itself has no microprocessor and cannot run software. Thus, the EVM is available as part of the ADS8860EVM-PDK kit that combines the ADS8860EVM as a daughter board with the digital signal processor (DSP)-based MMB0 motherboard using ADCPro™ software as a graphical user interface (GUI).

ADCPro software collects, records, and analyzes data from ADC evaluation boards. ADCPro also runs different plug-in programs to easily expand testing and data collection capabilities. In combination with the ADS8860EVM plug-in program, ADCPro offers a comprehensive evaluation environment for the ADS8860. For more details on ADCPro, see the *ADCPro Analog-to-Digital Converter Evaluation Software User's Guide* ([SBAU128](#)), available for download from www.ti.com.

ADS8860EVM Daughter Board Features:

- Includes support circuitry as a design example to match ADC performance
- 3.3-V slave serial peripheral interface (SPI)
- Serial interface header for easy connection to TI DSP-based communication systems
- Compatible with the TI Modular EVM system
- Designed for 5-V analog supply
- Onboard 4.5-V voltage reference
- Bipolar (–2.15 V to 2.15 V) or unipolar (0.1 V to 4.4 V) input range

ADS8860EVM-PDK Kit Additional Features:

- USB port for computer interfacing
- Regulated 5-V and 3.3-V supplies for powering EVM daughter board
- Easy-to-use evaluation software for Windows® operating system
- Data collection to text files
- Built-in analysis tools including scope, FFT, and histogram displays
- Easily expandable with new analysis plug-in tools from Texas Instruments

3 EVM Analog Interface

The ADS8860EVM is designed for easy interfacing to multiple analog sources. SMA connectors allow the EVM to have input signals connected through coaxial cables. In addition, the Samtec™ connector provides a convenient 10-pin, dual-row, header and socket combination at J1. Consult Samtec at www.samtec.com or call 1-800-SAMTEC-9 for a variety of mating connector options. The analog inputs are buffered by an OPA836 high-speed operational amplifier in order to properly drive the ADS8860 ADC input.

Use appropriate caution when handling these pins. Table 2 summarizes the pinout for analog interface J1.

Table 2. Analog Inputs

Connector	Pin Number	Signal	Description
Samtec 10 x 2	J1.10	A0(-)	CH0 inverted EVM input
SMA	J4	A0(-)	CH0 inverted EVM input

3.1 Unipolar Input Signal Configuration

With JP4 closed, the OPA836 positive input is biased with +1.125 V, created by dividing the 4.5-V onboard reference by four. This bias becomes a 2.25-V offset at the output of the OPA836 that allows input signals with a 0-V common mode. To keep the OPA836 distortion as low as possible, the input signal swing is limited from –2.15 V to +2.15 V, as shown in Figure 1.

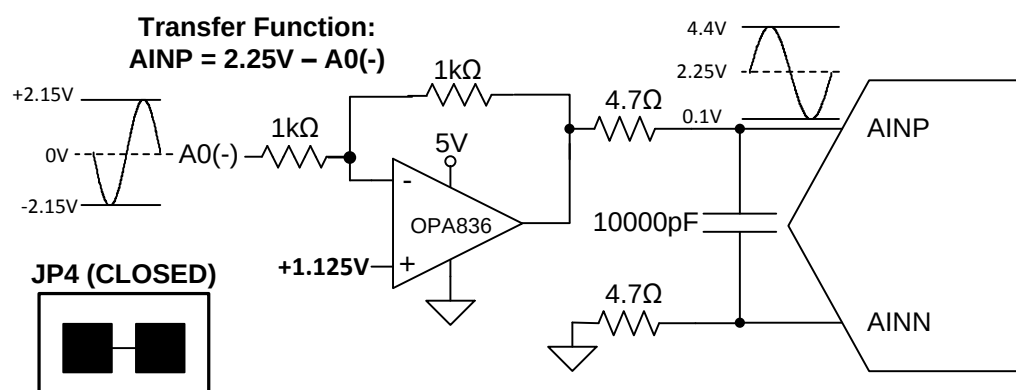


Figure 1. Differential Input Example

3.2 Bipolar Input Signal Configuration

With JP4 open, the OPA836 positive input is biased with +2.25 V, created by dividing the 4.5-V onboard reference by two. This bias becomes a 4.5-V offset at the output of the OPA836 that allows input signals with a 2.25-V common mode. To keep the OPA836 distortion as low as possible, the input signal swing is limited from +0.1 V to +4.4 V, as shown in Figure 2.

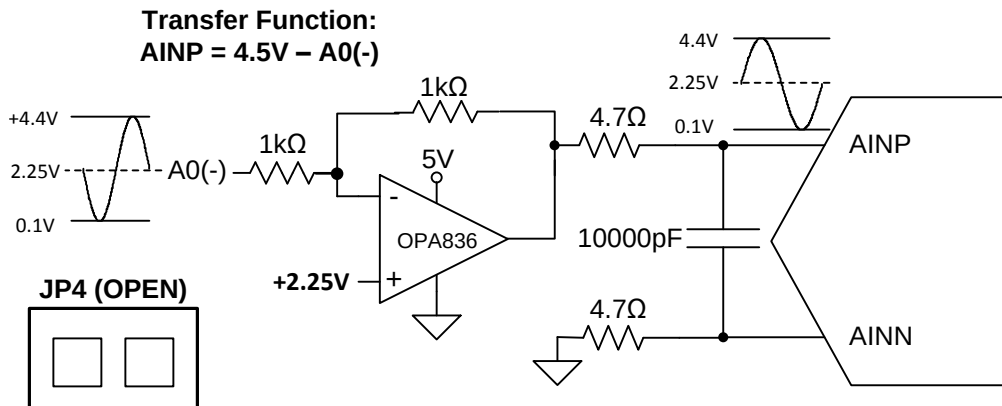


Figure 2. Single-Ended Signal Example

3.3 Voltage Reference

Because the EVM is powered by a 5-V analog supply, the reference should be a value below 5 V. This EVM uses 4.5 V, created by the onboard REF5045, as shown in Figure 3. Then, the EVM is filtered by an RC filter with a 160-Hz cutoff frequency to minimize noise contribution. Finally, the EVM is buffered by the THS4281, which can drive the 10 μF required at the ADC reference (with a 2-MHz effective bandwidth and 22-μVrms total noise). The OPA333 and the additional feedback is optional, but does complement the THS4281, minimizing offset and drift.

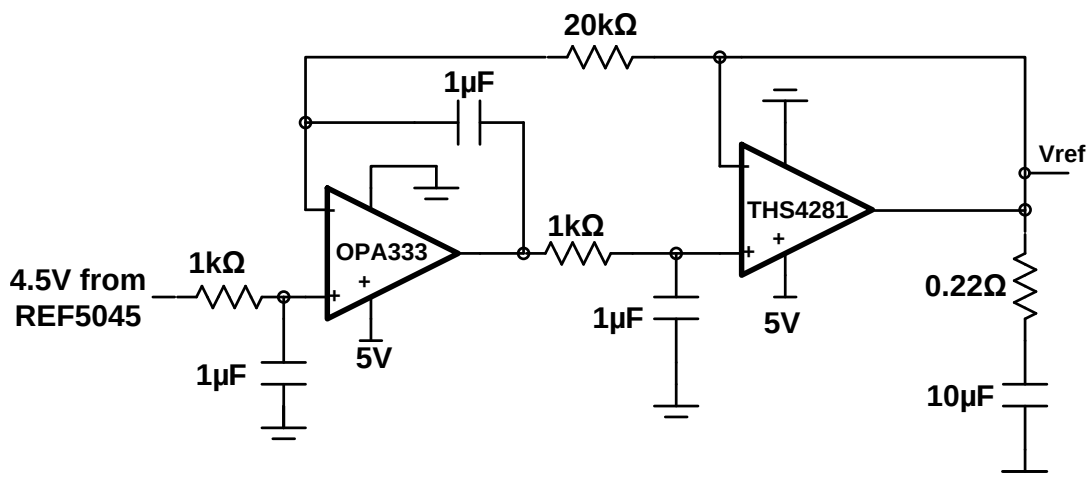


Figure 3. THS4281 Reference Driver with Complementary OPA333 for Drift and Offset Correction

4 EVM Digital Interface

Samtec part numbers SSW-110-22-F-D-VS-K and TSM-110-01-L-DV-P provide a convenient 10-pin, dual-row, header and socket combinations at P1. The header and socket provide access to the ADC digital control pins. Consult Samtec at www.samtec.com or call 1-800-SAMTEC-9 for a variety of mating connector options.

Table 3 summarizes the pinouts for digital interface J2.

Table 3. J2: Serial Interface Header

Pin Number	Signal	Description
J2.1	$\overline{\text{CS}}$ or CONVST	Chip-select input that can be used as a convert start
J2.3	SCLK	Serial clock input
J2.7	$\overline{\text{CS}}$ or CONVST	Chip-select input that can be used as a convert start meant for the MMB0 motherboard
J2:13	SDO or MISO	SDO or MISO output
J2.15	INT	20-k Ω pull-up resistor for detecting falling edges at the end of conversion
J2.17	CONVST	Direct connection to the convert start pin if JP3 is installed
J2.4, J2.10, and J2.18	GND	Digital ground connections
J2.16, J2.20	I ² C™ bus	I ² C bus; used only to program the U4 EEPROM on the EVM board
J2.2, J2.5-6, J2.8-9, J2.11-12, J2.14, and J2:19	Unused	Unused

4.1 Serial Interface (SPI)

The ADS8860 ADC uses SPI serial communication in mode 1 (CPOL = 0, CPHA = 1) with high-speed clocks higher than 30 MHz; for slower clocks, mode 0 is used (CPOL = 0, CPHA = 0). Because the serial clock (SCLK) frequency can be as fast as 80 MHz, the ADS8860EVM offers 47- Ω resistors between the SPI signals and J2 to aid with signal integrity. Typically, in high-speed SPI communication, fast signal edges can cause overshoot; these 47- Ω resistors slow down the signal edges in order to minimize signal overshoot.

4.2 I²C Bus for Onboard EEPROM

The ADS8860EVM has an I²C 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 ADS8860 converter.

5 EVM Power-Supply Inputs

J3 is the power-supply input connector. [Table 4](#) lists the configuration details for J3.

Table 4. J3: Power-Supply Interface Header

Pin Number	Pin Name	Function	Required
J3.3	+5VA	5-V analog supply	Yes
J3.5	GND	Digital ground input	Yes
J3.6	GND	Analog ground input	Yes
J3.7	1.8 VD	1.8-V digital supply	Optional
J3.9	3.3 VD	3.3-V digital supply	Yes
J3.10	5 VD	5-V digital supply	No
P3.1-2, P3.4, and P3.7-8	Unused	Unused	No

5.1 Analog Power Options

The ADS8860EVM board is designed to function with a 5-V analog power supply connected to J3.3. The ADS8860 is limited to 3.6 V for the analog supply, so the board regulates down the 5-V analog supply with an onboard 3.3-V low dropout receiver (LDO), such as the [TPS78833](#).

5.2 Digital Power Options

The ADS8860EVM connects the digital power supply of the ADS8860 to 3.3 VD (J3.10) with a 0-Ω resistor. This setting matches the logic level of the MMB0 motherboard.

5.3 Analog and Digital Grounds

The EVM only has one ground plane for all analog and digital supplies, thus, pins J3.5 and J3.6 are tied together to this ground plane. Therefore, both supply grounds should be connected to pins J3.5–6 so they share the same ground.

6 EVM Digital Configuration

The EVM offers two jumpers (JP2 and JP3) to configure the EVM in either 3-wire SPI mode or 4-wire SPI mode. By default, the EVM jumper settings are 3-wire. JP1 only establishes the pin that carries the chip-select signal from the J2 header.

6.1 SPI 3-Wire Mode (JP2:2–3 and JP3:OPEN)

The chip-select signal is used to bring the ADS8860 digital output out of 3-state and initializes conversions. The rising edge of the chip-select signal starts a conversion, then after the conversion time, the falling edge of the chip-select signal brings the digital output out of 3-state. Figure 4 shows the serial configuration for this mode.

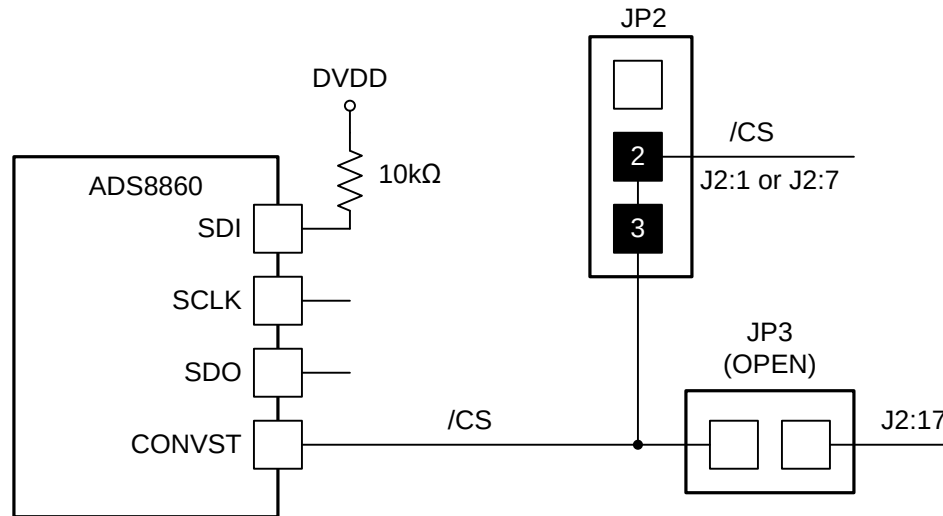


Figure 4. Serial 3-Wire Configuration

6.2 SPI 4-Wire Mode (JP2:1–2 and JP3:CLOSED)

The chip-select signal is used to bring the ADS8860 digital output out of 3-state. However, conversion is initialized from J3:17 as an independent signal. The rising edge of J3:17 (CONVST) starts a conversion, then after the conversion time, the falling edge of the chip-select signal brings the digital output out of 3-state. Figure 5 shows the serial configuration for this mode.

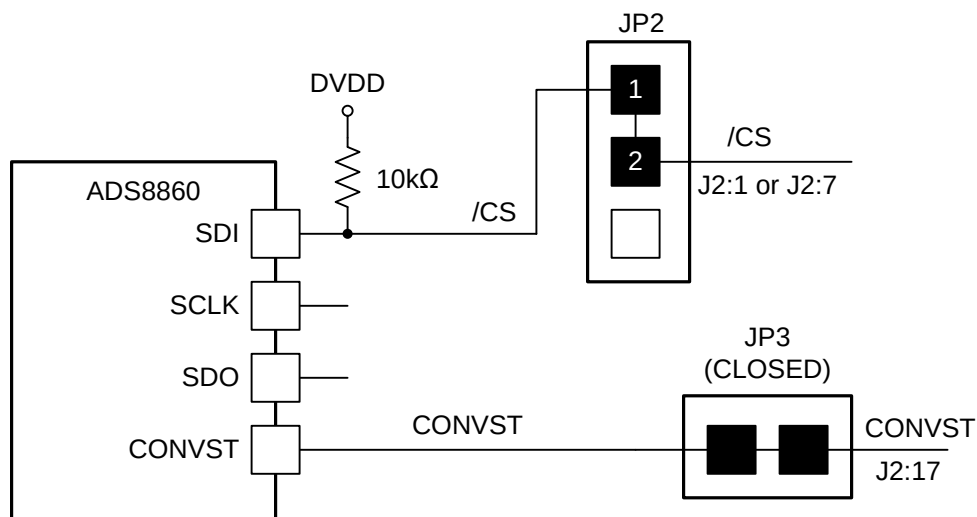


Figure 5. Serial 4-Wire Configuration

7 PDK Kit Setup

CAUTION

Do not connect the ADS8860EVM-PDK to a PC before completing [Section 7](#). Failure to observe this caution may cause Microsoft Windows to disregard the ADS8860EVM-PDK as a connected device.

This section presents the steps required to setup the ADS8860EVM-PDK kit before operation. [Section 8](#) explains how to operate the kit to acquire and analyze data.

The steps to setup the kit are as follows and must be completed before attempting to capture data:

- Step 1. Download and install the ADCPro software (if not already installed) on a PC.
- Step 2. Download and install the ADS8860EVM-PDK EVM plug-in software.
- Step 3. Configure the ADS8860EVM-PDK hardware.
- Step 4. Power-up the ADS8860EVM-PDK.

Each task is described in the subsequent sections of this document.

7.1 Installing the ADCPro Software

ADCPro is the primary program used to evaluate the ADS8860. ADCPro is available at www.ti.com/tool/adcpro. Refer to the *ADCPro User's Guide* ([SBAU128](#)) for detailed installation instructions.

7.2 Installing ADS8860EVM-PDK Plug-In Software

NOTE: ADCPro should be installed before attempting to install the ADS8860EVM-PDK plug-in software.

The installation file link for the PDK plug-in can be found in the ADS8860EVM-PDK product folder at www.ti.com/tool/ADS8860evm-pdk. In the software section, look for a link with a file named **ads886x-*adcpro*plugin-<version #>.exe** (<version #> refers to the installation file version number, and increments with software version releases). Download and double-click the file to run it; then follow the instructions as shown.

[Figure 6](#) shows the initial and completed installer screen shots.

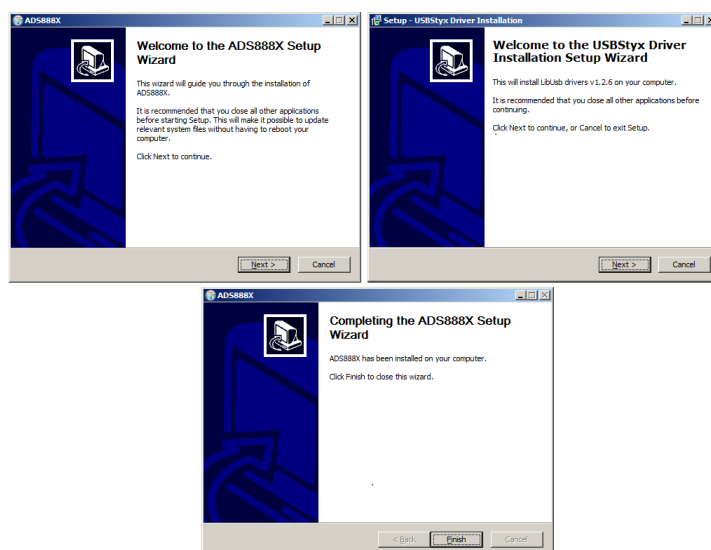


Figure 6. Plug-In Installer

7.3 Configuring the ADS8860EVM-PDK Hardware

The ADS8860EVM-PDK contains both the ADS8860EVM and the MMB0 motherboard; however, the devices may be shipped unconnected or configured incorrectly. Follow these steps to verify that the ADS8860EVM-PDK kit is properly configured and connected:

- Step 1. Unpack the ADS8860EVM-PDK kit.
- Step 2. Set J12 to closed, J13A to open, and J13B to closed on the MMB0, as shown in [Figure 7](#).
 - J12 must be closed. This setting allows the wall supply to power-up the MMB0 and ADS8860EVM through J2 (6-VDC input), and regulate down to 5 V, 3.3 V.
 - J13B must be closed. This setting connects the 5-V analog power supply with the 5-V digital power supply.
 - J13A must be open. This setting allows the 5-V analog power supply to be regulated on board.

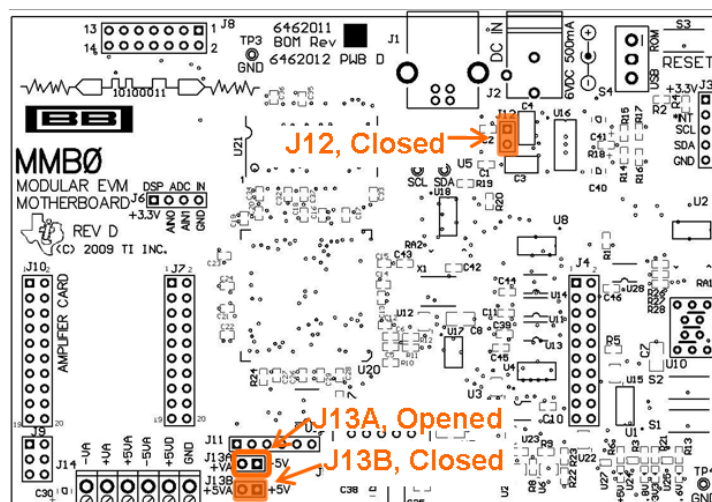


Figure 7. MMB0 Motherboard Jumper Configuration

- Step 3. Set JP1:2–3, JP2:2–3, JP3:open, and JP4:closed on the ADS8860EVM, as shown in [Figure 8](#).

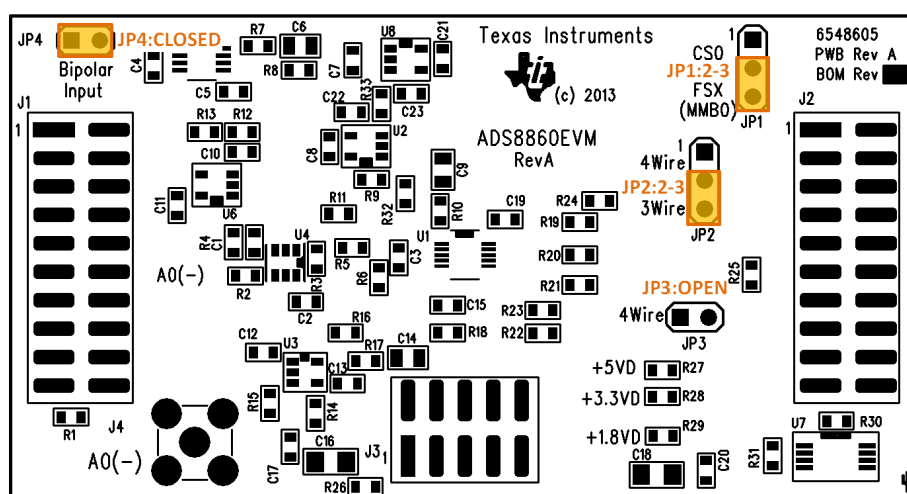


Figure 8. ADS8860EVM Jumper Configuration

4. Plug the ADS8860EVM into the MMB0.

CAUTION

Do not misalign the pins when plugging the ADS8860EVM into the MMB0. Check the pin alignment carefully before applying power to the PDK.

7.4 Powering up the ADS8860EVM-PDK

When the ADS8860EVM-PDK kit is configured, power can be applied to the MMB0. This power comes from a wall supply that delivers 6 VDC to the MMB0 through J2 on the MMB0 motherboard. This wall power supply is included with the PDK.

After the power supply is connected, four green light-emitting diodes (LEDs) in the bottom right-hand corner of the MMB0 motherboard should light up. If these LEDs do not light up, disconnect the power and verify that J12 is closed on the MMB0 motherboard.

8 PDK Kit Operation

The evaluation software is based on ADCPro. This program operates with a variety of plug-ins. To use ADCPro, load an EVM plug-in and a test plug-in (select these plug-ins from the EVM and test menus, respectively). To unload a plug-in, select the unload option from the corresponding menu.

The following sections describe how to use ADCPro and the ADS8860EVM plug-in to acquire data.

8.1 About MMB0

The MMB0 provides the USB interface between the PC and the ADS8860EVM. The MMB0 is a modular EVM system motherboard. The MMB0 is designed around the [TMS320VC5509](#), a DSP with an onboard USB interface from Texas Instruments. The MMB0 also has 16 MB of SDRAM installed.

The MMB0 is not sold as a DSP development board, and is not available separately. TI cannot offer support for the MMB0 except as part of an EVM kit. For schematics or other information about the MMB0, contact Texas Instruments.

8.2 Loading the ADS8860EVM-PDK Plug-in

- Step 1. Make sure the PDK kit is configured and powered up, as explained in [Section 7](#). Then, press the **Reset** button on the MMB0 (in the top right-hand corner) one time to clear the board memory.
- Step 2. Connect the MMB0 to a PC with the USB cable provided with the kit.
- Step 3. Start ADCPro from the Windows *Start* menu.
- Step 4. Load the ADS886XEVM plug-in from the ADCPro drop-down *EVM* menu, as shown in [Figure 9](#). Note that only one EVM plug-in can be loaded at a time. If a different plug-in is selected, the previous plug-in is unloaded.

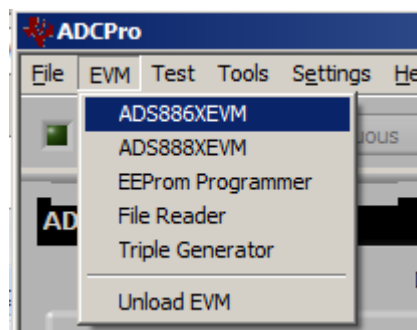


Figure 9. Loading EVM Plug-in

Step 5. When the plug-in is loaded, the plug-in searches for the board. A series of messages in the status area indicates this action, eventually displaying *Connected to EVM*.

Step 6. Change the device name from ADS8861 to ADS8860.

The plug-in is now loaded and ready to function with the ADS8860EVM.

8.3 Using the ADS8860EVM Plug-in

The ADS8860EVM allows the user to evaluate the ADS8860 ADC. Figure 10 shows the device configuration tab of the ADS8860EVM plug-in that is used to change acquisition parameters, such as sample rate and voltage reference.

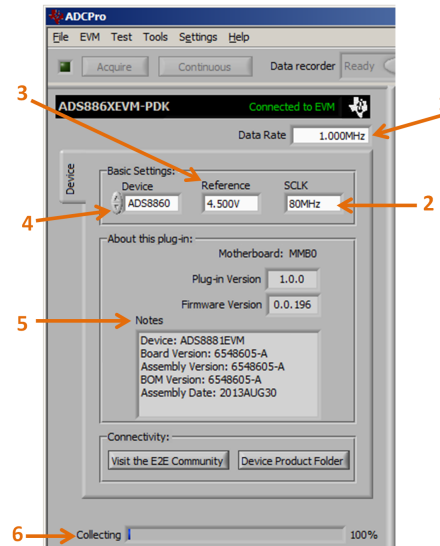


Figure 10. ADS8860EVM Plug-in: Device Configuration Tab

The device configuration tab contains the following controls:

1. **Data rate:** By default, data rate is at 1 MSPS. This control shows the data rate or sampling frequency used by the ADC to acquire data. With an SCLK frequency of 80 MHz, data rate can be set to a value from 19.536 kSPS to 1 MSPS. With an SCLK frequency of 10 MHz, data rate can be set to a value from 4 kSPS to 344.827 kSPS.
2. **SCLK:** By default, SCLK is at 80 MHz. SCLK sets the clock frequency used by the SPI interface to capture data. SCLK should be a value between 70 MHz to 80 MHz for 1 MSPS. For slow sampling rates, use 10 MHz. Do not use SCLK frequencies between 30 MHz and 50 MHz.
3. **Reference:** 4.5 V is the default reference value, which matches the onboard reference of the EVM. The value of this control should always match the reference used by the ADC to read accurate voltages.
4. **Device selection:** ADS8861 is the default device selected. Therefore, this value must be changed to ADS8860 in order to match the ADS8860EVM.
5. **About:** This control shows the plug-in version, MMB0 firmware version, assembly date, and board revision information. Note that the device name is ADS8881 because the software is based on the ADS8881EVM.
6. **Collection bar:** This feature shows the percentage of data collected during an acquisition session.

8.4 Loading Test Plug-in

When the ADS8860EVM plug-in is configured, one of the four test plug-ins must be loaded to acquire data by using the drop-down Test menu, as shown in [Figure 11](#). Note that only one Test plug-in can be loaded at a time. If a different plug-in is selected, the previous plug-in is unloaded.

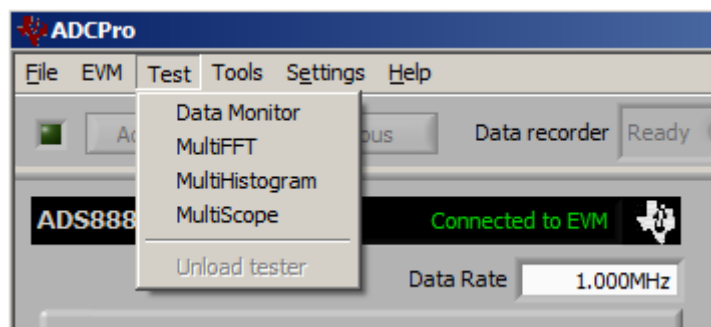


Figure 11. ADCPro Test Plug-ins

There are four different test options available for the ADS8860EVM:

- **Data monitor:** This test option acquires and exports data in a table format as hexadecimal data.
- **MultiFFT:** This test option allows the user to acquire data and create an FFT graph of power versus frequency to display data.
- **MultiHistogram:** This option acquires data and creates a histogram of code values.
- **MultiScope:** This feature acquires and displays data in a graph of voltage versus time.

For further details regarding how to set up and use the various test plug-ins, refer to the *ADCPro User's Guide* ([SBAU128](#)).

8.5 Acquiring Data

When the ADS8860EVM is configured for the desired test scenario, press the **Acquire** button to start the data collection process; the software collects the number of data points specified in the *Test* plug-in **Block Size** control. During data acquisition, the ADS8860EVM plug-in disables all front-panel controls and the collection process bar displays the completion progress.

8.6 Troubleshooting

If the ADS8860EVM plug-in cannot find the ADS8860EVM-PDK, press the **RESET** button on the MMB0 and try again.

If ADCPro stops responding while the ADS8860EVM-PDK is connected, shut down and restart the ADCPro software. Also, try unplugging the USB cable from the PDK.

9 Bill of Materials, Schematics, and Layout

The bill of materials is provided in [Table 5. Section 9.2](#) shows the PCB layouts for the ADS8860EVM. [Section 9.3](#) shows the schematic for the ADS8860EVM.

9.1 Bill of Materials

NOTE: All components should be 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, refer to www.ti.com.)

Table 5. ADS8860EVM Bill of Materials

Item No.	Qty	Value	Ref Des	Description	Manufacturer	Part Number
1	1	—		Printed Circuit Board, 3.2 in x 1.7 in. x 0.062 in.	Texas Instruments	6548605
2	9	1 μ F	C1, C4, C5, C7, C10, C12, C19, C22, C23	Capacitor, X7R Ceramic +/-10%, 25WV, 0603	Murata	GRM188R71E105KA12D
3	5	0.1 μ F	C2, C8, C11, C13, C21	Capacitor, X7R Ceramic +/-10%, 25WV, 0603	Murata	GRM188R71E104KA01D
4	1	10000 pF	C3	Capacitor, C0G Ceramic +/-5%, 50WV, 0603	TDK	C1608C0G1H103J
5	3	10 μ F	C6, C9, C14	Capacitor, X7R Ceramic +/-10%, 10WV, 0805	Murata	GRM21BR71A106KE51L
6	3	1000 pF	C15, C17, C20	Capacitor, C0G Ceramic +/-5%, 50WV, 0603	Murata	GRM1885C1H102JA01D
7	2	10 μ F	C16, C18	Capacitor, X7R Ceramic +/-10%, 16WV, 1206	TDK	C3216X7R1C106K
8	2	—	J1, J2 (Top)	Header 20 Pin SMT Plug, .100" Gold (2x10)	Samtec	TSM-110-01-L-DV-P
9	2	—	J1, J2 (Bottom)	Header 20 Pin SMT Socket, .100" Gold (2x10)	Samtec	SSW-110-22-F-D-VS-K
10	1	—	J3 (Top)	Header 10 Pin SMT Plug, .100" Gold (2x5)	Samtec	TSM-105-01-L-DV-P
11	1	—	J3 (Bottom)	Header 10 Pin SMT Socket, .100" Gold (2x5)	Samtec	SSW-105-22-F-D-VS-K
12	1	—	J4	CONN SMA JACK STRAIGHT PCB	Amphenol	132134
13	2	—	JP1, JP2	Header Strip, 3 pin .100" Gold (1x3)	Samtec	TSW-103-07-L-S
14	2	—	JP3, JP4	Header Strip, 2 pin .100" Gold (1x2)	Samtec	TSW-102-07-L-S
15	6	—	R1, R14, R16, R27, R29, R30	Not Installed	—	—
16	2	1k	R2, R3	Resistor, Metal Film Chip, 0.1%, 1/10W, 0603	Panasonic	ERA-3AEB102V
17	1	100	R4	Resistor, Thick Film Chip, 1%, 1/10W, 0603	Panasonic	ERJ-3EKF1000V
18	2	4.7	R5, R6	Resistor, Thick Film Chip, 1%, 1/10W, 0603	Vishay/Dale	CRCW06034R70FKEA
19	3	0.22	R7, R10, R17	Resistor, Thin Film Chip, 1%, 1/5W, 0603	Susumu	RL0816S-R22-F
20	2	1k	R8, R33	Resistor, Thick Film Chip, 1%, 1/10W, 0603	Panasonic	ERJ-3EKF1001V
21	2	10	R9, R18	Resistor, Thick Film Chip, 1%, 1/10W, 0603	Vishay/Dale	CRCW060310R0FKEA
22	3	20k	R11, R12, R32	Resistor, Metal Film Chip, 0.1%, 1/10W, 0603	Panasonic	ERA-3AEB203V
23	1	10k	R13	Resistor, Metal Film Chip, 0.1%, 1/10W, 0603	Panasonic	ERA-3AEB103V
24	4	0	R15, R21, R26, R28	Resistor, Thick Film Chip, 1/10W, 0603	Panasonic	ERJ-3GEY0R00V
25	5	47	R19, R20, R22, R23, R31	Resistor, Thick Film Chip, 1%, 1/10W, 0603	Panasonic	ERJ-3EKF47R0V
26	2	10k	R24, R25	Resistor, Thick Film Chip, 1%, 1/10W, 0603	Panasonic	ERJ-3EKF1002V
27	1	—	U1	IC ADC 16BIT 1MSPS PSEUDO-DIFF 10-MSOP	Texas Instruments	ADS8860IDGS
28	1	—	U2	IC OPAMP VFB R-R 95MHZ SOT23-5	Texas Instruments	THS4281DBV
29	1	—	U3	IC LDO RGLTR 3.3V LN SOT-23-5	Texas Instruments	TPS78833DBV
30	1	—	U4	IC OPAMP VFB RRO 205MHZ SOT23-6	Texas Instruments	OPA836IDBV
31	1	—	U5	IC VREF SERIES PREC 4.5V 8-MSOP	Texas Instruments	REF5045IDGK
32	1	—	U6	IC OPAMP GP 5.5MHZ SGL SOT23-5	Texas Instruments	OPA376AIDBV
33	1	—	U7	IC EEPROM 256KBIT 400KHZ 8TSSOP	Microchip	24LC256-I/ST
34	1	—	U8	IC OPAMP CHOP R-R 350KHZ SOT23-5	Texas Instruments	OPA333AIDBV

9.2 Board Layouts

Figure 12 through Figure 15 show the PCB layouts for the ADS8860EVM.

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 ADS8860EVM PCBs.

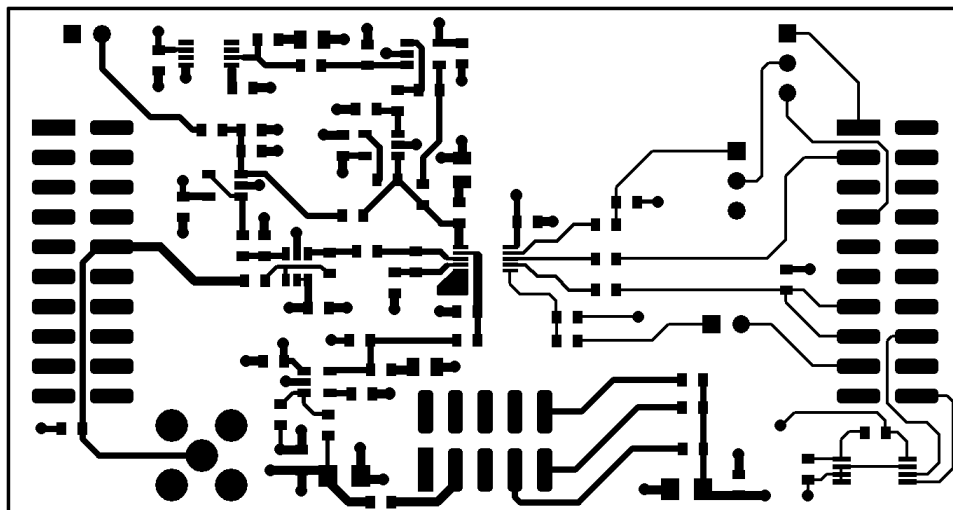


Figure 12. ADS8860EVM PCB: Top Layer

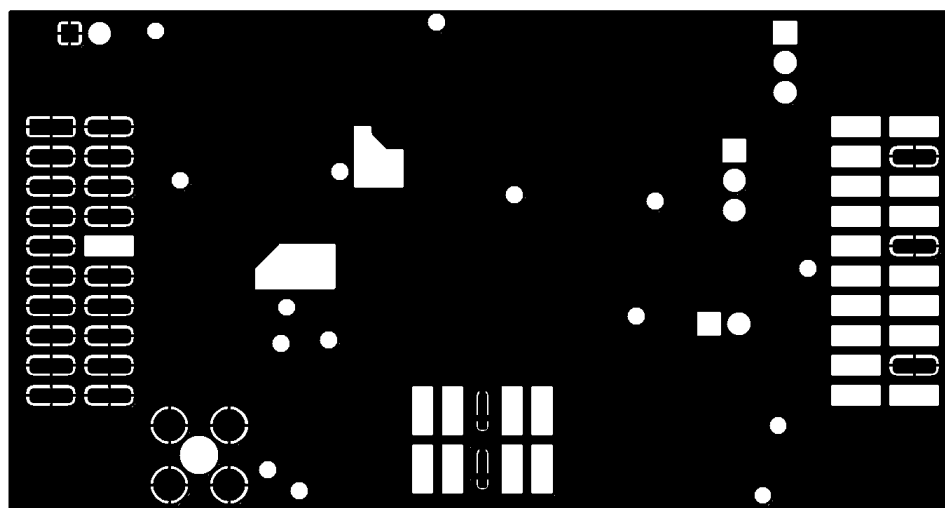


Figure 13. ADS8860EVM PCB: Ground Layer

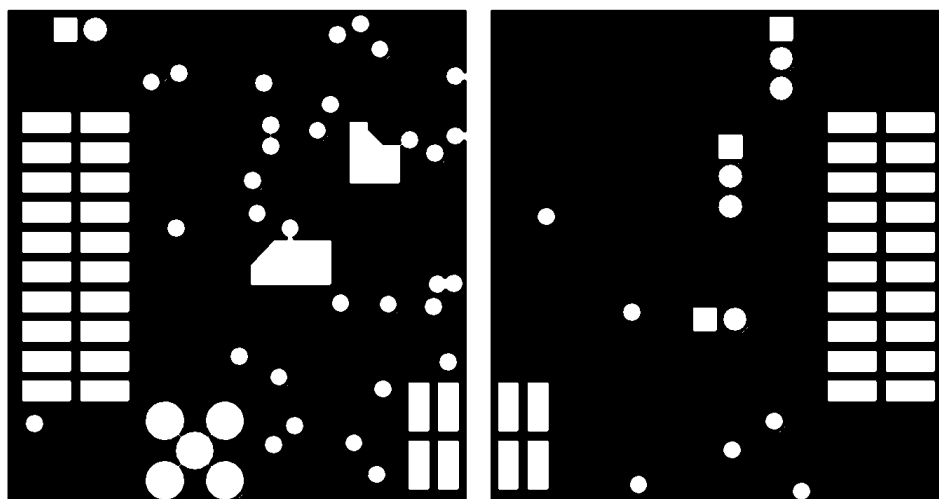


Figure 14. ADS8860EVM PCB: Power Layer

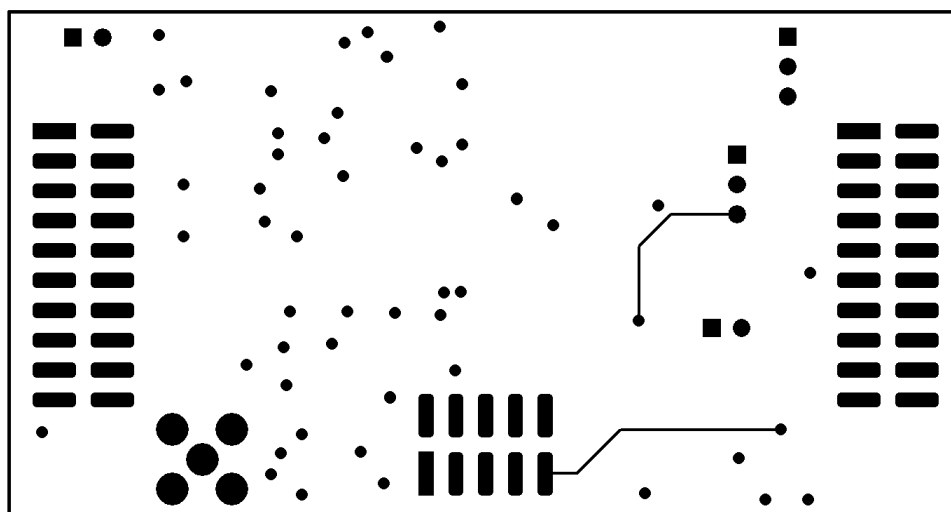
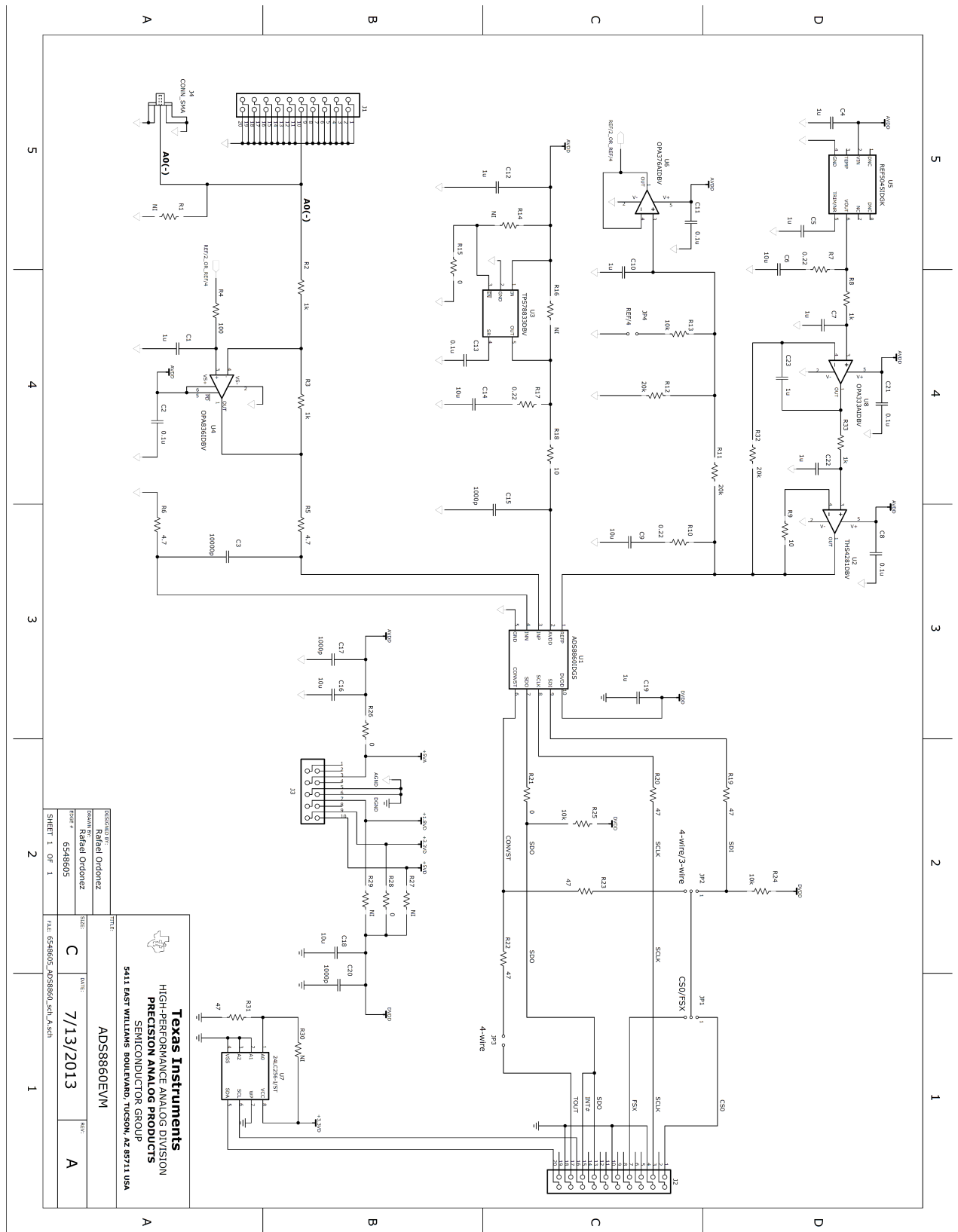


Figure 15. ADS8860EVM PCB: Bottom Layer

9.3 Schematic



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