

INA260EVM-PDK

INA260 Evaluation Module and Product Demonstration Kit

User's Guide



Literature Number: SBOU180
November 2016

1	Overview	5
1.1	INA260EVM-PDK Contents.....	6
1.2	INA260EVM-PDK Features.....	7
1.3	Related Documentation from Texas Instruments.....	8
2	INA260EVM-PDK Hardware	8
2.1	SM-USB-DIG Platform Description.....	9
2.2	INA260EVM PCB Description.....	10
2.3	EVM Digital Inputs and Outputs.....	12
3	INA260EVM-PDK Setup	12
3.1	One-Time GUI Software Installation.....	13
3.2	INA260EVM Jumper Settings.....	15
3.3	Connecting the Hardware.....	16
3.4	System Power-Up.....	18
4	INA260EVM GUI Software	19
4.1	Configuration Tool.....	20
4.2	Results Bar.....	23
4.3	Graph Tool.....	23
4.4	Registers Tool.....	24
5	INA260EVM Documentation	24
5.1	Schematic.....	25
5.2	PCB Layout.....	26
5.3	Bill of Materials.....	27

List of Figures

1	Hardware Included with the INA260EVM Kit.....	6
2	Placeholders for TVS Devices	7
3	INA260EVM-PDK Hardware Setup.....	8
4	SM-USB-DIG Platform Block Diagram.....	9
5	INA260EVM Block Diagram.....	10
6	Recommended Display Settings	13
7	INA260EVM GUI Installation.....	14
8	INA260EVM Default Jumper Settings	15
9	INA260EVM and SM-USB-DIG Connected in Proper Orientation	16
10	SM-USB-DIG Powers on When Connected to a Computer	17
11	INA260EVM Powers Up following the GUI Launch.....	18
12	V _{DUT} Selection	19
13	Configuration Page.....	20
14	Slave Address Setting	21
15	Operating Mode Menu	21
16	Configuring Conversion Times	22
17	Configuring the Alert Pin	22
18	INA260 Results Bar	23
19	Graph Tool Page	23
20	Registers Tool Page	24
21	INA260EVM Schematic.....	25
22	INA260EVM PCB Top Layer (Component Side).....	26

List of Tables

1	INA260EVM Kit Contents	6
2	Related Documentation	8
3	Signal Definition of J4 on INA260EVM Board	10
4	INA260 I ² C Address Configuration	12
5	INA260EVM Test Board Jumper Functions.....	16
6	Bill of Materials: INA260EVM	27

INA260EVM-PDK and Software Tutorial

This user's guide describes the characteristics, operation, and use of the INA260EVM-PDK. This user's guide discusses how to set up and configure the software and hardware, and reviews various aspects of device operation. Throughout this document, the terms *evaluation board*, *evaluation module*, *EVM PCB*, and *EVM* are synonymous with the INA260EVM PCB. The terms *PDK*, *kit*, and *EVM kit* are synonymous with the INA260EVM-PDK. This user's guide also includes information regarding operating procedures and input/output connections, an electrical schematic, printed circuit board (PCB) layout drawings, and a parts list for the EVM.

1 Overview

The [INA260](#) is a high- or low-side current sensor, power, and voltage monitor with a 2-m Ω precision integrated shunt resistor and I²C™ interface. The INA260 offers programmable conversion times and averaging modes, enabling high resolution measurements of the current, voltage, and power dissipation of the source being monitored. The INA260EVM-PDK, which consists of the INA260EVM and SM-USB-DIG controller board, is a platform for evaluating the features and performance of the INA260 under various signal and supply conditions. This document gives a general overview of the INA260EVM-PDK, and describes the features and functions to be considered when using it.

1.1 INA260EVM-PDK Contents

Table 1 summarizes the contents of the INA260EVM kit. Figure 1 shows all included hardware. Contact the [Texas Instruments Product Information Center](#) nearest you if any component is missing.

NOTE: This EVM kit requires the INA260EVM GUI software, which is available for download through the [INA260 Tools & Software](#) folder. Downloading the latest version of the GUI software is recommended.

Table 1. INA260EVM Kit Contents

Item	Quantity
INA260EVM PCB test board	1
SM-USB-DIG platform PCB	1
USB extender cable	1

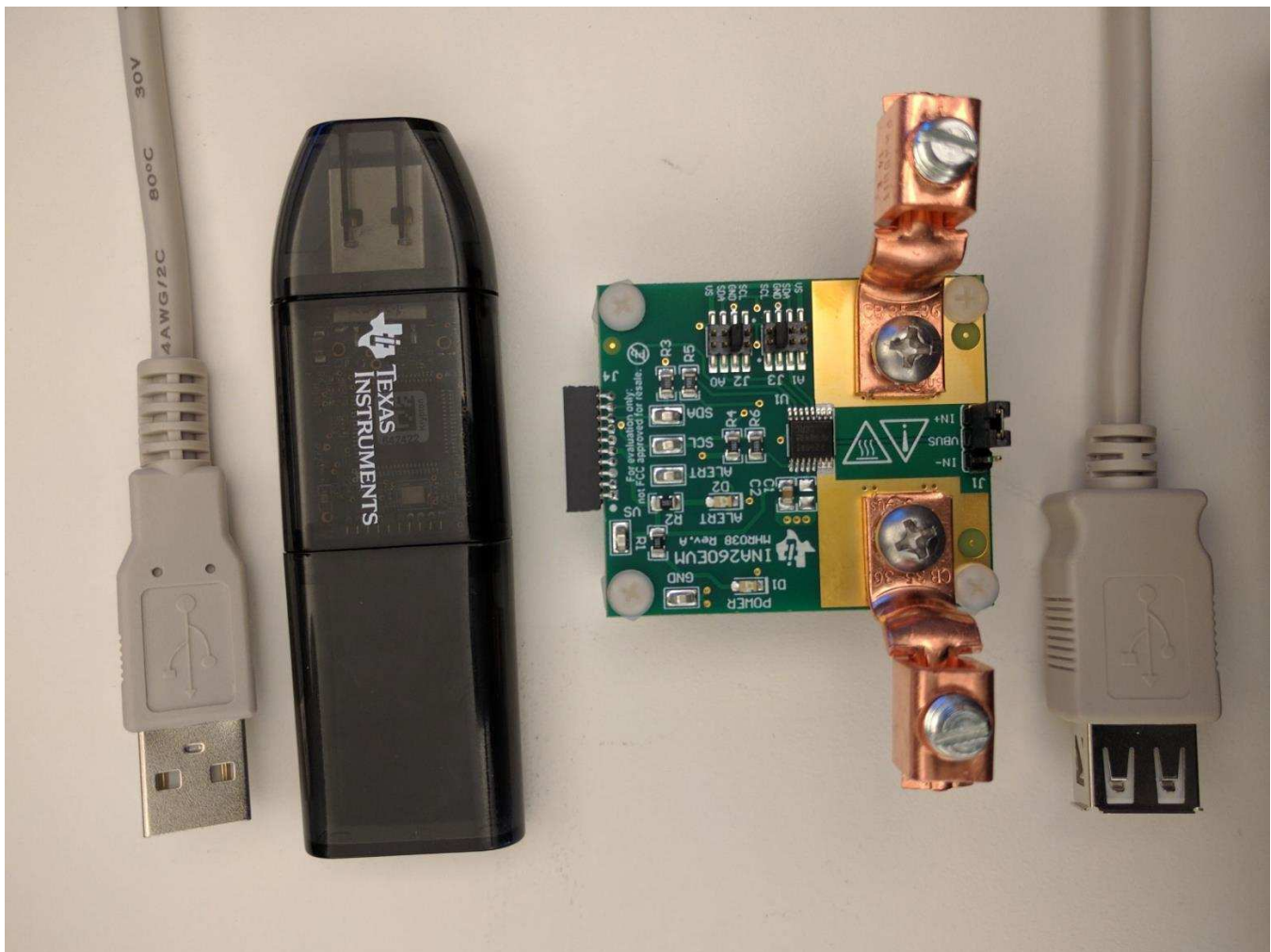


Figure 1. Hardware Included with the INA260EVM Kit

1.2 INA260EVM-PDK Features

- USB-powered; no external power supply is required
- Support for full $\pm 15\text{-A}$ input current range and 36-V common-mode voltage range of the INA260
- EVM includes placeholders for transient voltage suppression (TVS) devices to protect the INA260 inputs from excessively high common-mode voltages
- Digital host controller included
- Intuitive GUI software supports all major INA260 functional modes and simplifies device configuration

NOTE: To protect against voltage transients that may exceed the absolute maximum ratings, TI highly recommends installing the TVS devices (D3 and D4, as shown in [Figure 2](#)) with a minimum power rating of 1000 W to clamp the input voltages to less than 36 V.

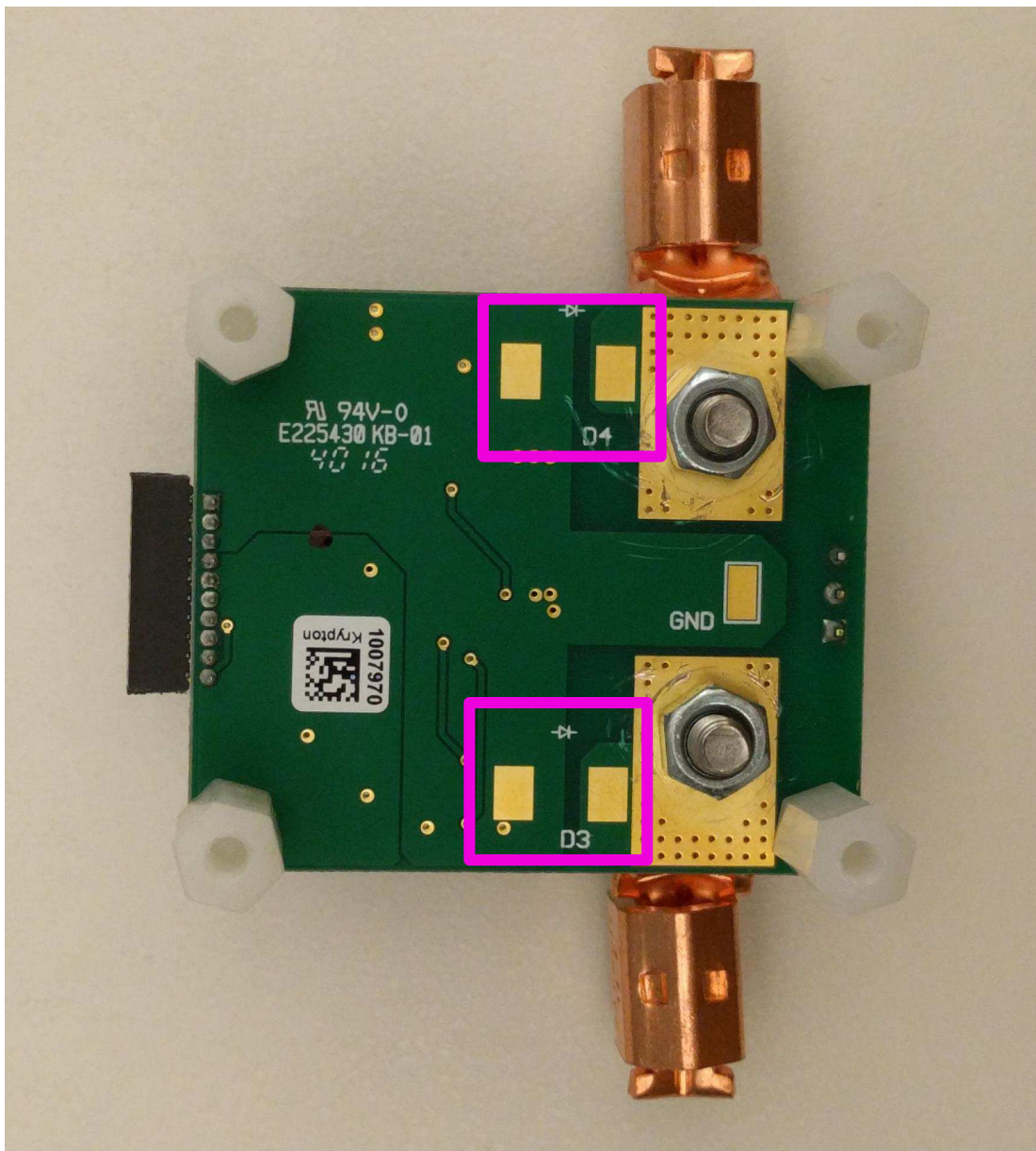


Figure 2. Placeholders for TVS Devices

1.3 Related Documentation from Texas Instruments

The following documents provide information regarding Texas Instruments' integrated circuits used in the assembly of the INA260EVM. This user's guide is available from the TI web site under literature number **SBOU180**. Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. Newer revisions may be available from the [TI web site](#), or call the Texas Instruments' Literature Response Center at (800) 477-8924 or the Product Information Center at (972) 644-5580. When ordering, identify the document by both title and literature number.

Table 2. Related Documentation

Document	Literature Number
INA260 product data sheet	SBOS656
SM-USB-DIG platform user guide	SBOU098

2 INA260EVM-PDK Hardware

Figure 3 shows the overall system setup for the INA260EVM-PDK. The power source to be monitored is connected to the EVM input terminals. The computer runs the GUI software through which the user can enable power to the INA260 and communicate with the device. User commands are sent through the computer's USB port to the SM-USB-DIG board that translates these commands into I²C format, before sending them to the EVM. With power enabled, the INA260 responds to these I²C commands by sending the requested data back to the SM-USB-DIG board over the I²C. The SM-USB-DIG converts the received data to USB format and sends the data back to the computer, where it is then appropriately processed and displayed to the user.

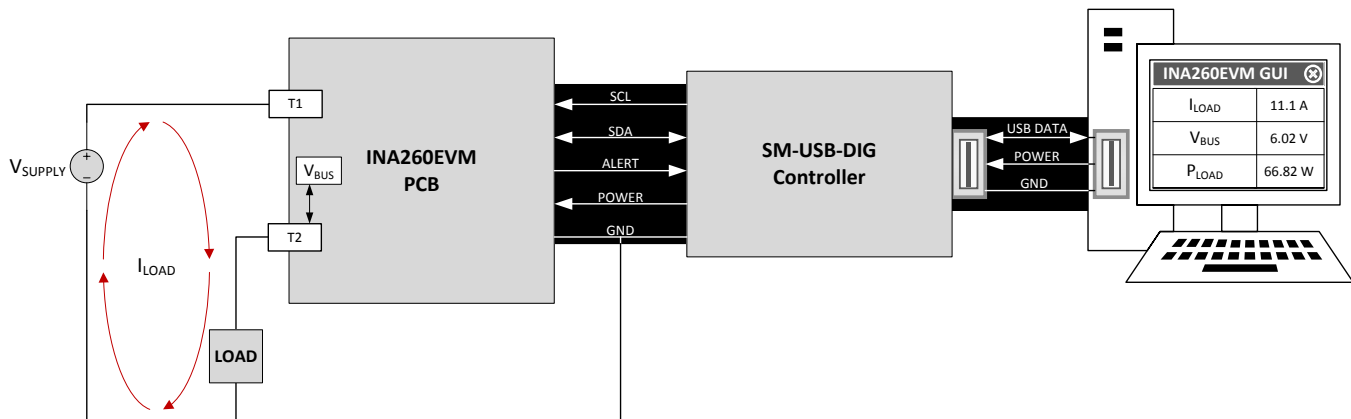


Figure 3. INA260EVM-PDK Hardware Setup

2.1 SM-USB-DIG Platform Description

Figure 4 shows the block diagram for the SM-USB-DIG platform. This platform is a general-purpose data acquisition system that is used on several different Texas Instruments' evaluation modules. The details of operation are included in a separate document, [SBOU098](#) (available for download at [www.ti.com](#)).

The primary control device on the SM-USB-DIG platform is the [TUSB3210](#). The TUSB3210 is an 8052 microcontroller that converts data received on the built-in USB interface to the I²C, SPI, and other serial digital I/O patterns. This EVM uses the I²C interface of the TUSB3210 to control the INA260.

Power supply for the SM-USB-DIG is derived from the USB interface. The SM-USB-DIG includes an onboard low dropout (LDO) regulator that uses the 5-V USB supply from the computer to generate a 3.3-V supply, which is then used to power all the active circuitry on board. The 3.3-V regulated supply can also be used to power the EVM PCB. In fact, the raw 5-V USB supply as well as the 3.3-V regulated supply are routed to a 2-input power MUX on the SM-USB-DIG, the [TPS2115A](#), whose output terminates at the V_{DUT} pin of the 10-pin EVM connector, intended to be used as the EVM power supply. The user can select between the 5-V and 3.3-V options for V_{DUT} through the INA260EVM GUI software.

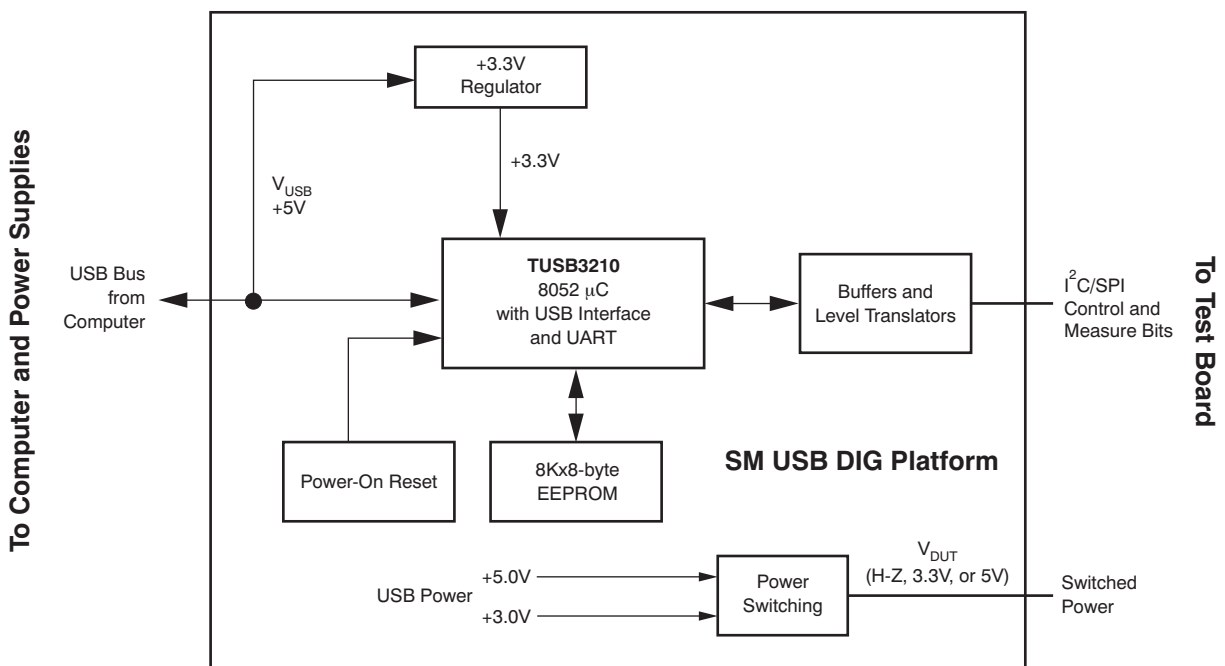


Figure 4. SM-USB-DIG Platform Block Diagram

2.2 INA260EVM PCB Description

Figure 5 depicts a block diagram of the INA260EVM PCB highlighting the power supplies, analog inputs, and digital I/O signals.

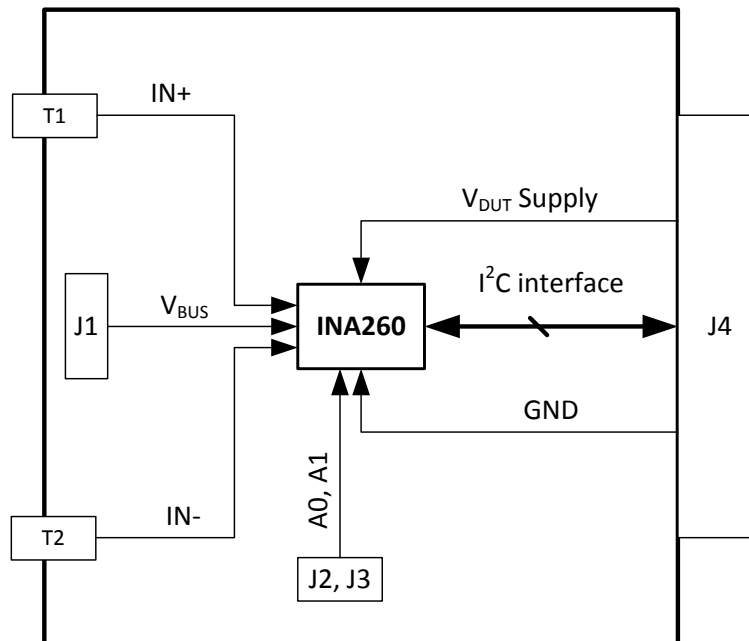


Figure 5. INA260EVM Block Diagram

The EVM PCB requires minimal instrumentation to be operated. In fact, the only pieces of required equipment not included in the kit are a (Windows® 7) computer and an input current source. All other inputs are supplied by the SM-USB-DIG board, via the 10-pin connector socket, J4. Table 3 lists the pinout for J4.

Table 3. Signal Definition of J4 on INA260EVM Board

Pin on J4	Signal	Description
10	I2C_SCL	I ² C clock signal (SCL)
9	CTRL/MEAS4	GPIO: control output or measure input
8	I2C_SDA1	I ² C data signal (SDA)
7	CTRL/MEAS5	GPIO: control output or measure input
6	SPI_DOUT1	SPI data output (MOSI)
5	V _{DUT}	Switchable DUT power supply: 3.3 V, 5 V, Hi-Z (disconnected) ⁽¹⁾
4	SPI_CLK	SPI clock signal (SCLK)
3	GND	Power return (GND)
2	SPI_CS1	SPI chip-select signal ($\overline{\text{CS}}$)
1	SPI_DIN1	SPI data input (MISO)

⁽¹⁾ When V_{DUT} is Hi-Z, all digital I/Os are Hi-Z as well.


2.2.1 EVM Power Supply

The INA260EVM PCB uses the V_{DUT} and GND lines from the SM-USB-DIG (via J4) as the high and low supply voltages for the INA260. As noted in Table 3, the available supply voltages for V_{DUT} are 5V and 3.3V. The EVM supply voltage is user-selectable through the GUI. The 1 μ F ceramic capacitor, C2, placed in close proximity to the INA260 (U1) supply pin provides adequate decoupling to V_{DUT} for power supply rejection at higher frequencies.

2.2.2 EVM Analog Inputs

The INA260 accepts two kinds of analog inputs: namely, a current through the internal shunt resistor and a voltage between the V_{BUS} pin and GND. The GUI allows the INA260 to be configured for digitizing either one or both of these inputs in serial order. The high current lug connectors designated T1 and T2 are the terminations of the internal 2-m Ω shunt resistor. Therefore, connect T1 and T2 in series with the input current source and load; see [Figure 3](#). The INA260 is a bidirectional device and thus current can flow through the shunt resistor in either direction.

CAUTION




Do Not Exceed the Absolute Maximum Ratings (see the [INA260 datasheet](#))!

To help ensure safe operating conditions, the following electrical ratings must not be exceeded:

- 15 A between connectors T1 and T2 in either direction
- 36 Vdc between T1 and GND
- 36 Vdc between T2 and GND

WARNING



Potential Burn Hazard!

To minimize risk of burn, do not touch U1 (the INA260 device) when input current is present. Temperatures higher than 50°C are possible.

The V_{BUS} input of the INA260 is accessible through pin 2 of header J1. Pins 1 and 3 of J1 are connected to IN+ and IN-, respectively. Note that the V_{BUS} input is independent of the current input (that is, the V_{BUS} input can be applied with or without a load), and the INA260 provides an accurate voltage reading. However, the device also passively multiplies the measured values of V_{BUS} and input current to generate a power value. For the power calculation to be meaningful, V_{BUS} must represent the voltage drop created by the input current across the load. Therefore, for accurate load power measurements, short the V_{BUS} pin to IN+ or IN- (on header J1) depending on the location of the load. For example, for the arrangement in [Figure 3](#), short V_{BUS} to IN- for an accurate load power calculation.

The EVM PCB also includes placeholders for the TVS devices to protect the INA260 inputs from excessively high common-mode voltages. The pads for these uninstalled devices, D3 and D4, are located on the bottom side of the EVM PCB and are suitable for DO-214AB package.

2.3 EVM Digital Inputs and Outputs

The only digital input signals required to operate the INA260 are the 2-bit I²C device address (A[1:0]), serial clock (SCL), and serial data (SDA), which is a bidirectional pin and thus also an output. The device address bits can each assume one of four values: GND, V_{S+}, SDA or SCL, resulting in 16 possible slave addresses summarized in Table 4. The values of A0 and A1 must be set using jumpers J2 and J3, respectively.

Table 4. INA260 I²C Address Configuration

A1	A0	Slave Address
GND	GND	1000000
GND	V _{S+}	1000001
GND	SDA	1000010
GND	SCL	1000011
V _{S+}	GND	1000100
V _{S+}	V _{S+}	1000101
V _{S+}	SDA	1000110
V _{S+}	SCL	1000111
SDA	GND	1001000
SDA	V _{S+}	1001001
SDA	SDA	1001010
SDA	SCL	1001011
SCL	GND	1001100
SCL	V _{S+}	1001101
SCL	SDA	1001110
SCL	SCL	1001111

SCL and SDA are driven by the SM-USB-DIG via J4. These are open-drain inputs and the EVM contains pullup resistors to drive these inputs high when the corresponding SM-USB-DIG digital outputs are in tri-state. Both fast (1 kHz to 400 kHz) and high-speed (1 kHz to 2.94 MHz) I²C modes are supported.

The outputs of the INA260 include SDA and ALERT, both of which are routed to J4 and are readable from the GUI. The GUI includes support for both over- and underlimit as well as conversion ready indicator modes of the ALERT pin. The state of the ALERT pin can be read from either the GUI or the onboard LED indicator.

3 INA260EVM-PDK Setup

CAUTION

Components of the INA260EVM-PDK are susceptible to damage by electrostatic discharge (ESD). Customers are advised to observe proper ESD handling precautions when unpacking and handling the EVM, including the use of a grounded wrist strap at an approved ESD workstation.

Setting up the INA260EVM-PDK involves the following sequence of operations:

1. Perform a one-time GUI software installation
2. Configure the EVM jumpers
3. Connect the hardware
4. Power-up the EVM and input source

3.1 One-Time GUI Software Installation

The GUI software must be installed on a computer running Windows XP or later. Windows 7 is the recommended operating system.

NOTE: For the GUI text to be rendered correctly, the text size under *Control Panel >> Appearance and Personalization >> Display* (shown in [Figure 6](#)) must be set to **Smaller - 100%**.

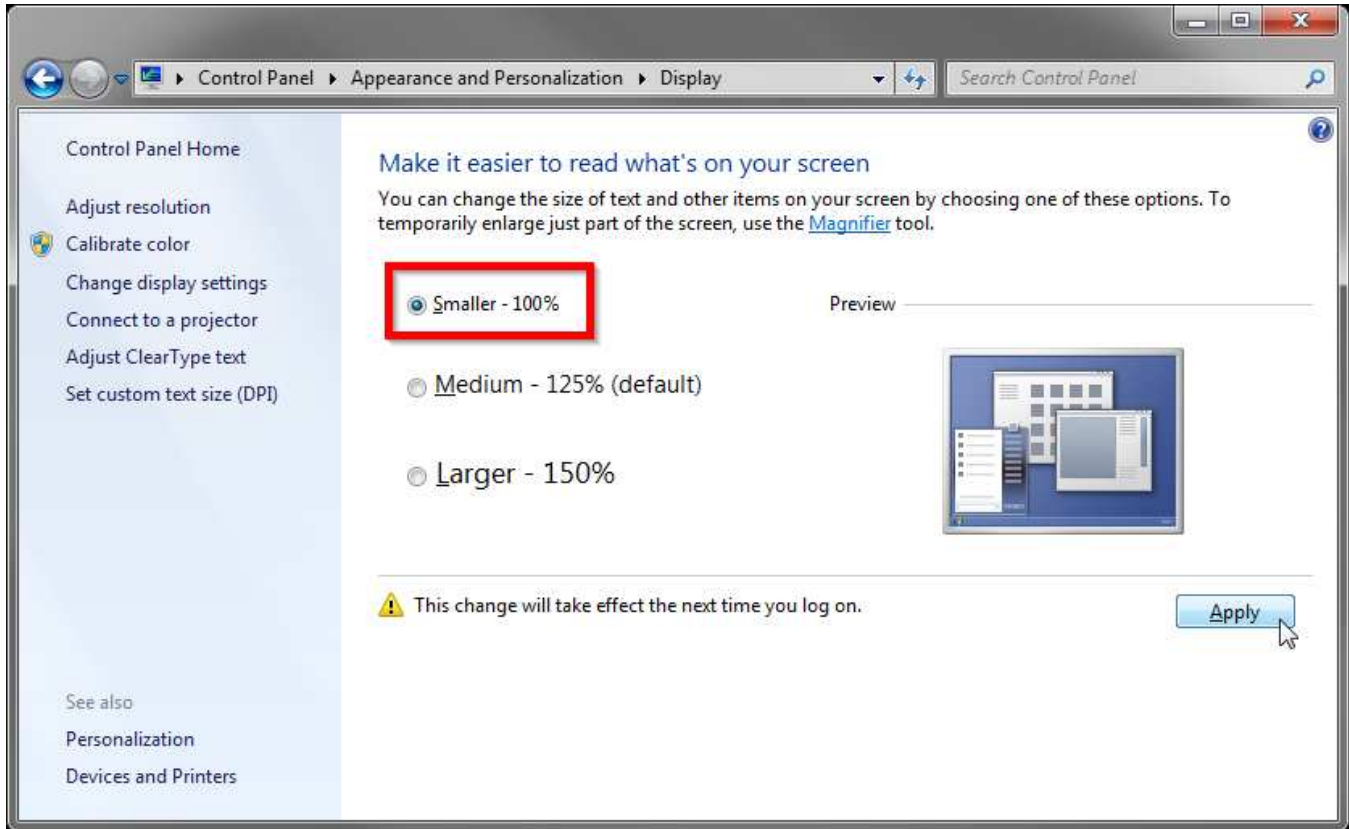


Figure 6. Recommended Display Settings

Make sure the hardware is not connected to the computer. Download the INA260EVM GUI from the [INA260 Tools & Software](#) folder. Extract the contents of the downloaded .zip file and run *Setup_INA260EVM.exe*. Follow the on-screen instructions provided in [Figure 7](#) to complete the software installation.

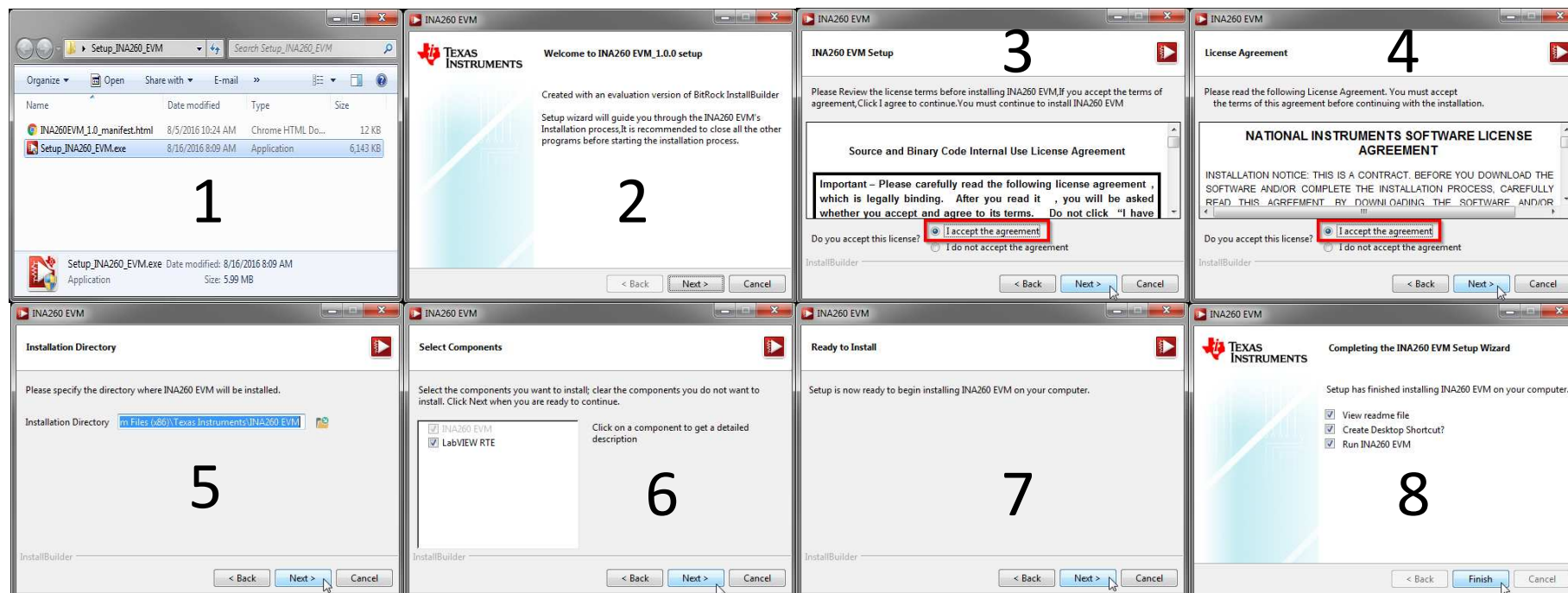


Figure 7. INA260EVM GUI Installation

3.2 INA260EVM Jumper Settings

Figure 8 shows the default jumper configuration for the INA260EVM and Table 5 explain the purpose of each jumper. Ensure that the jumpers are installed in the correct positions, based on the required test conditions.

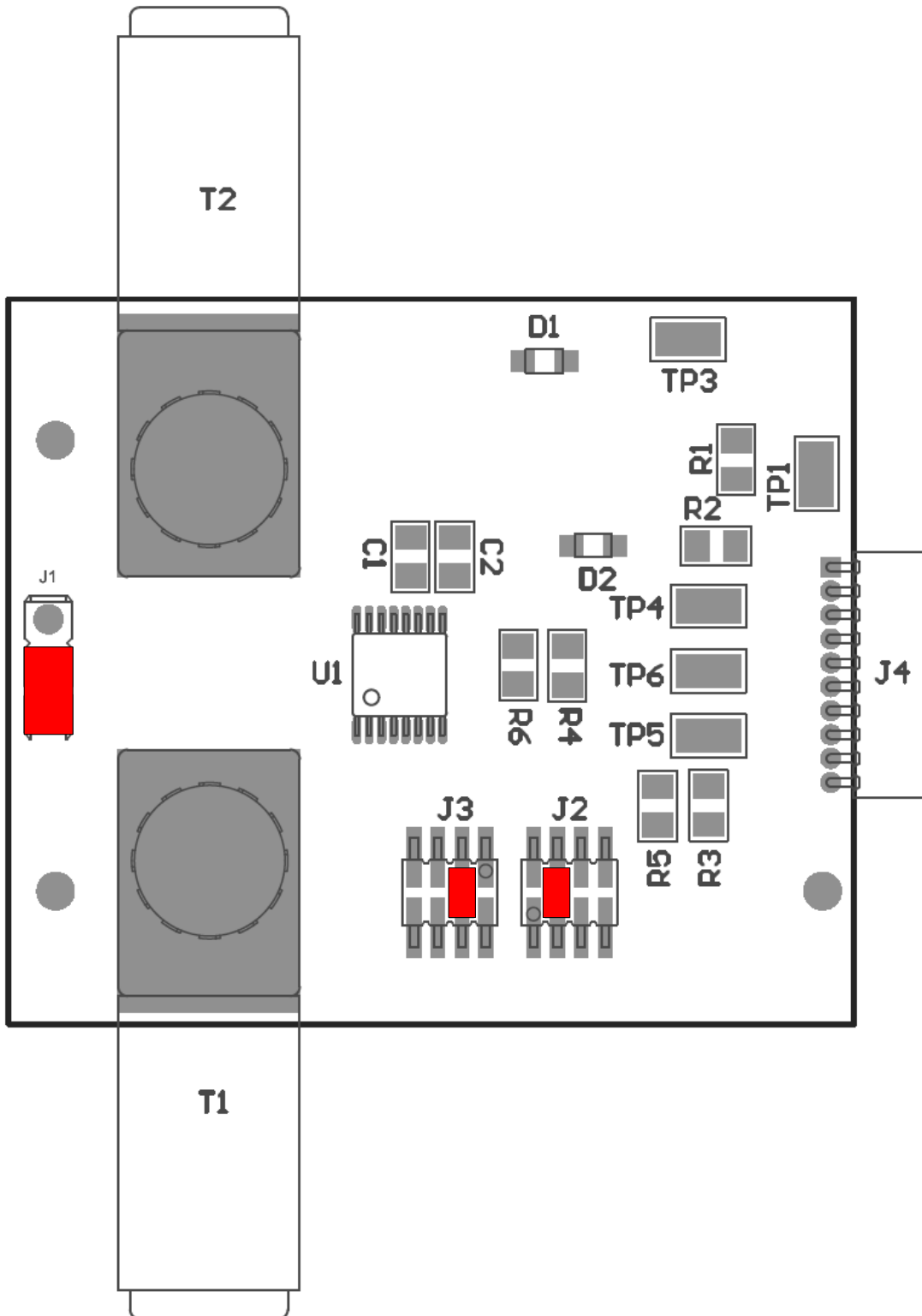


Figure 8. INA260EVM Default Jumper Settings

Table 5. INA260EVM Test Board Jumper Functions

Jumper	Default	Purpose
J1	IN+	This jumper selects whether the V_{BUS} pin on the INA260 is connected to the IN+ or IN- pin; see Section 2.2.2 for details.
J2	GND	This jumper sets the A0 character of the 2-character I ² C device address; see Section 2.3 for details.
J3	GND	This jumper sets the A1 character of the 2-character I ² C device address; see Section 2.3 for details.

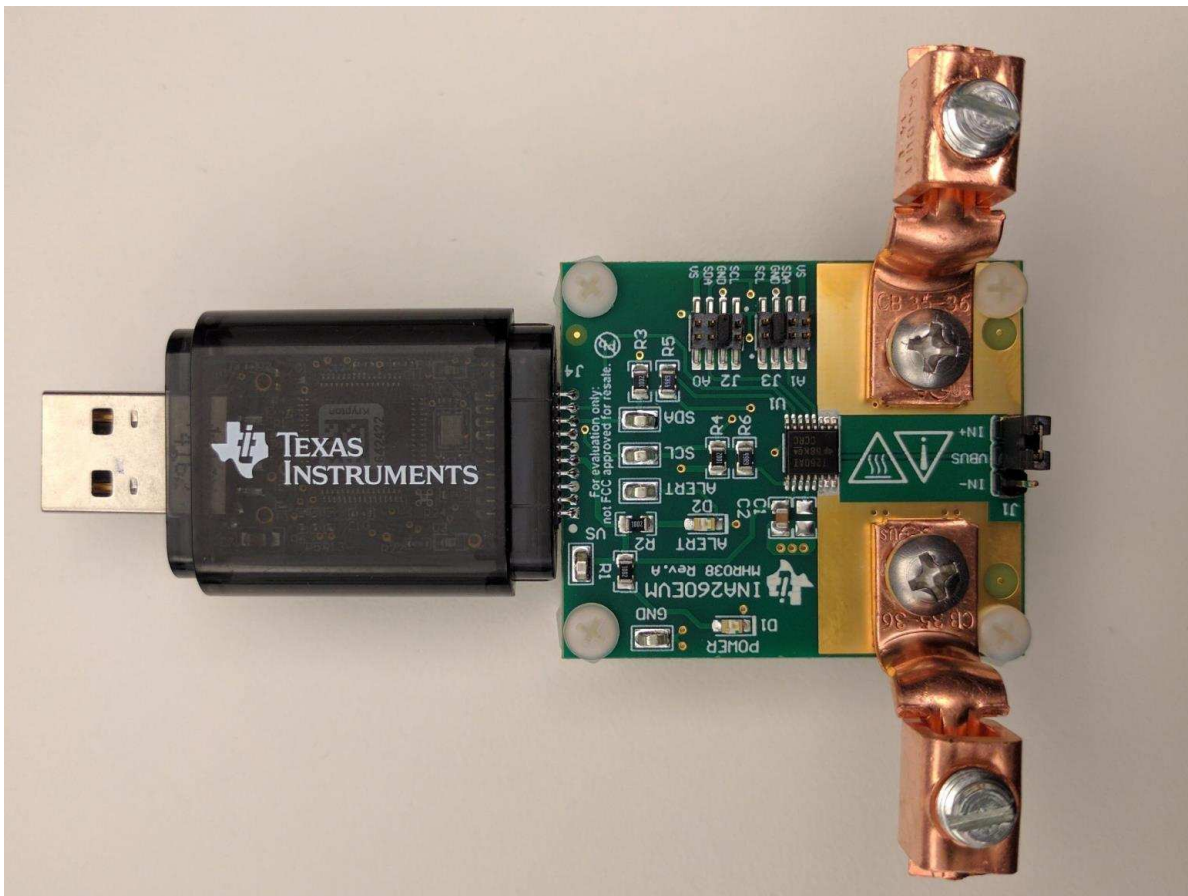
3.3 Connecting the Hardware

To minimize risk of potential electrical shock hazard, be sure EVM is full deenergized.

Before connecting the boards, make sure the high current lug connectors (T1 and T2) are tightly secured to the EVM PCB for low contact resistance. To minimize risk of potential electrical shock hazard, deenergize EVM followed by use of a screw-driver, while clasping the nut on the PCB bottom side with a crescent wrench.

NOTE: It may be necessary to uninstall the nylon standoffs near the lug connectors before manipulating the fasteners to avoid damaging them.

Connect the INA260EVM to the SM-USB-DIG board in the proper orientation, as shown in [Figure 9](#). Make sure that the two connectors are completely pushed together; loose connections can cause intermittent operation.


Figure 9. INA260EVM and SM-USB-DIG Connected in Proper Orientation

Next, with the output disabled, connect the input current source to the EVM via T1 and T2, as shown in Figure 10.

NOTE: The lug connectors can accommodate wire sizes up to #6-AWG.

Also be sure to connect the low-side terminal of the input current source to EVM ground (GND) using one of the test points. This step is important to obtain accurate V_{BUS} measurements.

Lastly, connect the SM-USB-DIG to the computer, using the included USB extender cable if necessary. At this point the SM-USB-DIG powers on, but the EVM does not.

The power supply to the EVM must be enabled from the GUI.

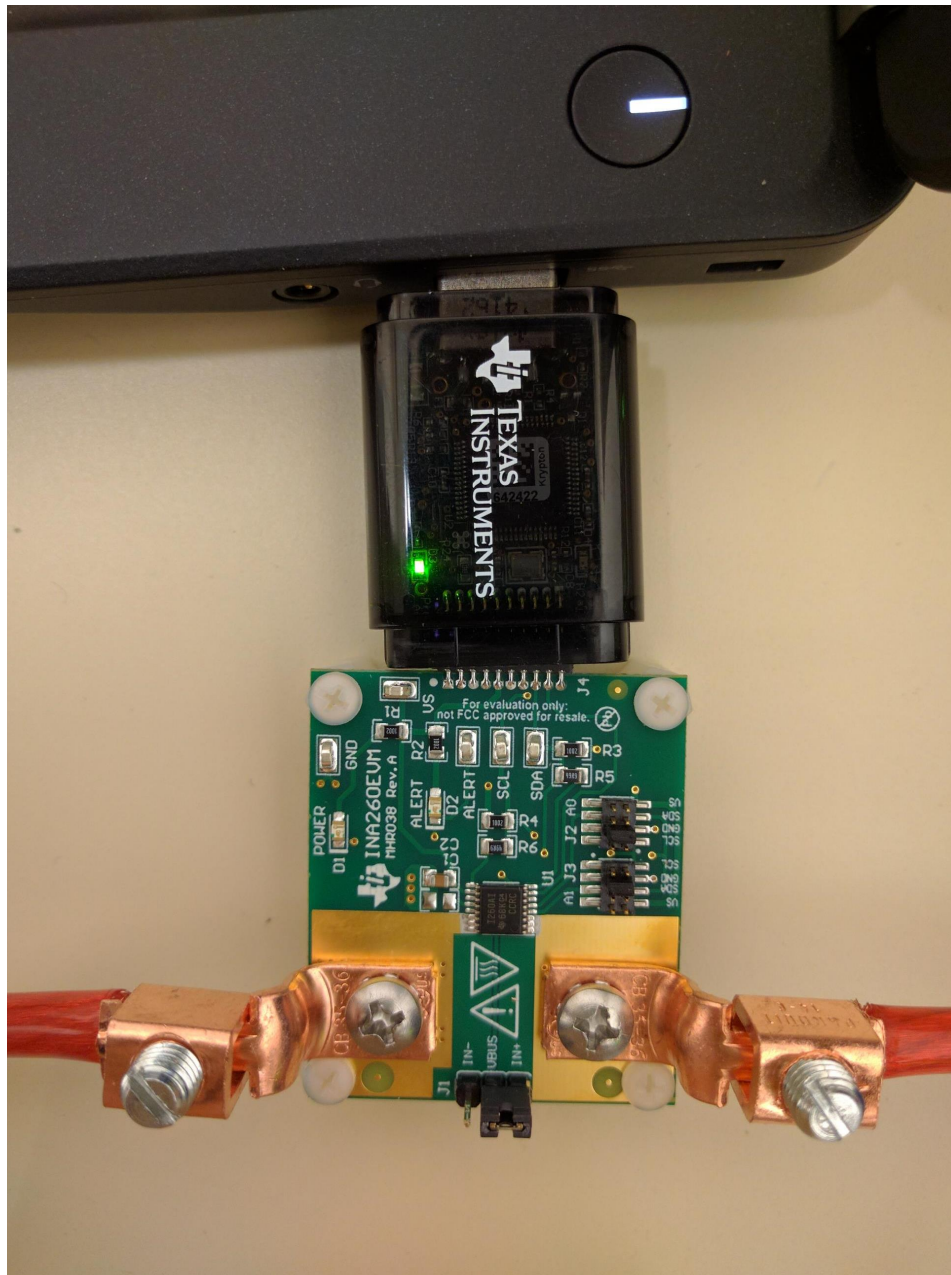


Figure 10. SM-USB-DIG Powers on When Connected to a Computer

3.4 System Power-Up

Launch the INA260EVM GUI software. By default the **Power** button on the GUI is enabled so the **POWER** LED on the EVM immediately lights up, indicating that the EVM PCB is receiving power, as shown in Figure 11.

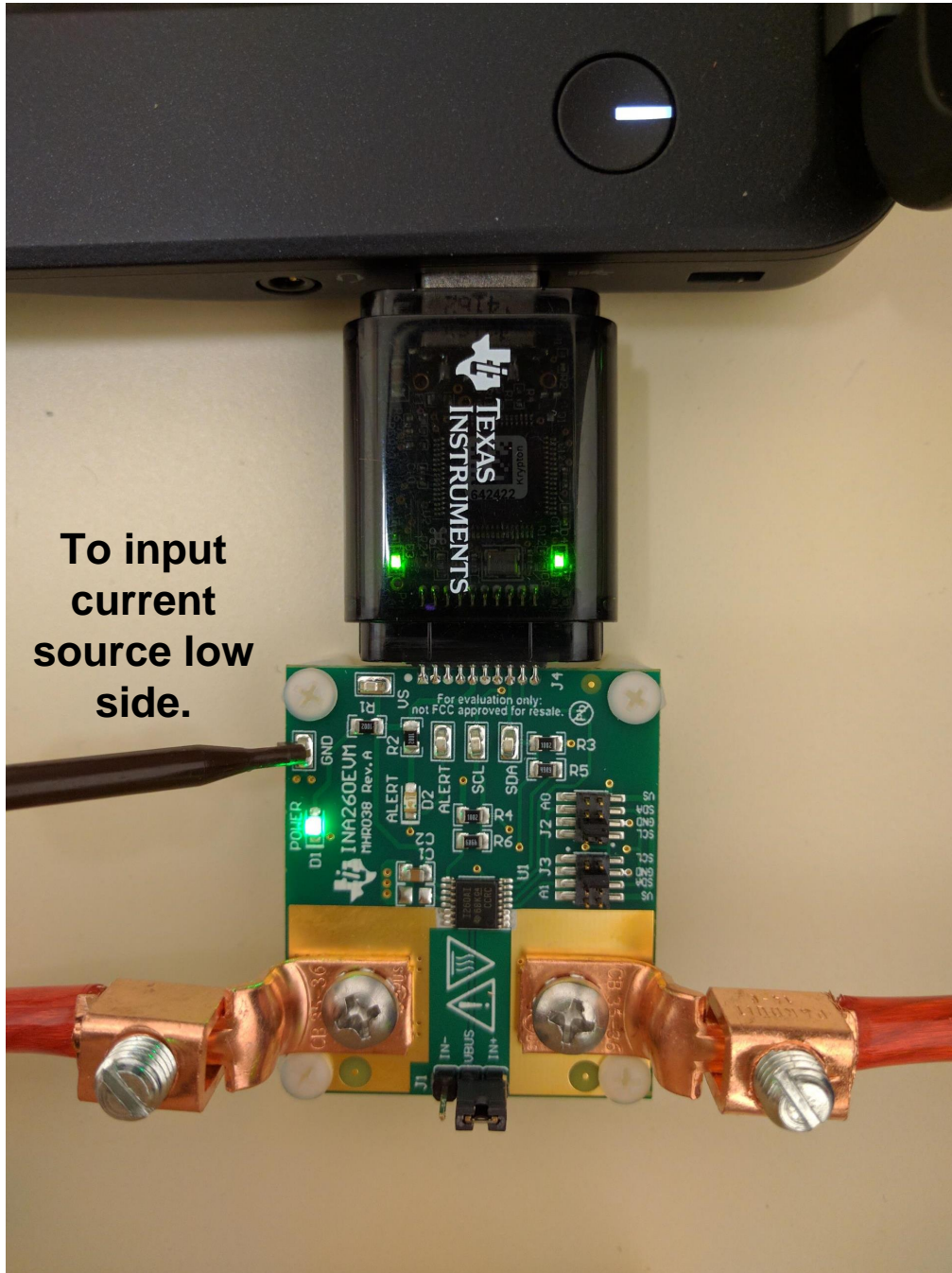


Figure 11. INA260EVM Powers Up following the GUI Launch

Additionally, the supply voltage (V_{DUT}) is set to 3.3 V by default, but if necessary the 5-V option can be selected, as shown in [Figure 12](#).

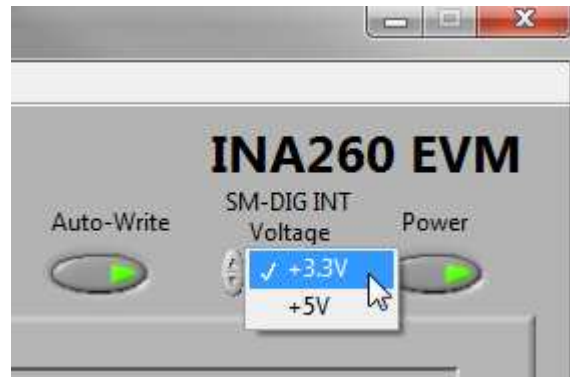


Figure 12. V_{DUT} Selection

With the INA260 powered on, the analog input sources can now be enabled.

[Section 4](#) discusses the GUI configuration and data collection using this setup.

4 INA260EVM GUI Software

The INA260EVM GUI is a collection of software tools that make it easy for the user to explore the key behaviors of the INA260. The following tools are available:

- The *Configuration* tool simplifies the INA260 setup prior to evaluation testing
- The *Graph* tool plots the acquired data and exports to a file if necessary
- The *Registers* tool displays and modifies the contents of the user-accessible registers

Each tool has a dedicated page that can be accessed by clicking on the corresponding tab on the GUI. The tabs are organized intuitively from left to right in the proper order, and the GUI always displays the *Configuration* page immediately after startup. Measurement data can be monitored using the *Results Bar* at the bottom of the GUI window. In most cases (gross) testing can be performed using just the *Configuration* tool and the *Results Bar*; the *Graph* and *Registers* tools may only be needed in special situations.

4.1 Configuration Tool

The Configuration tool allows the user to modify the operating conditions of the INA260 as required. User-specified settings are translated to I²C frames and written to the appropriate device registers whenever the user clicks the **Write All Reg** button. Equivalently, enabling the **Auto-Write** button causes immediate register updates whenever changes are detected. The Configuration page of the GUI is shown in Figure 13.

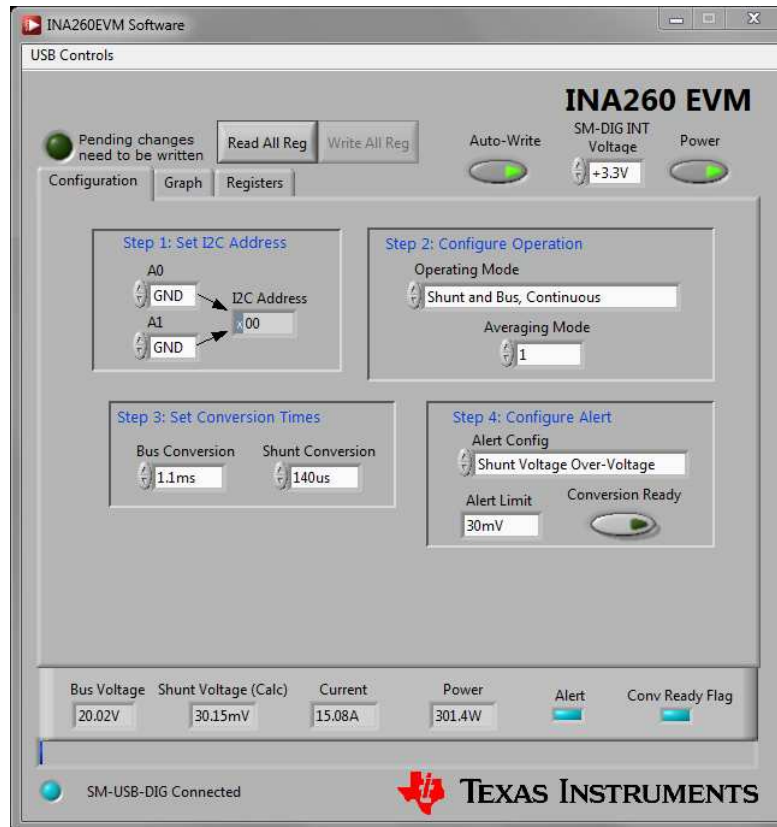


Figure 13. Configuration Page

4.1.1 Step 1: Set the I²C Address

The first step to configuring the INA260 from the EVM GUI is to be able to communicate with it. As indicated by [Table 4](#), the address bits A0 and A1 may represent up to 16 different INA260 devices communicating over a single I²C bus, where each device is identified by a unique slave address. Therefore, step 1 involves selecting the correct A0 and A1 values that represent the slave address of the INA260 installed on the EVM. In other words, the states of A0 and A1 in the GUI must match the jumper settings chosen for J2 and J3 on the EVM. The equivalent hexadecimal value of the slave address is displayed in the box labeled I²C Address in [Figure 14](#).

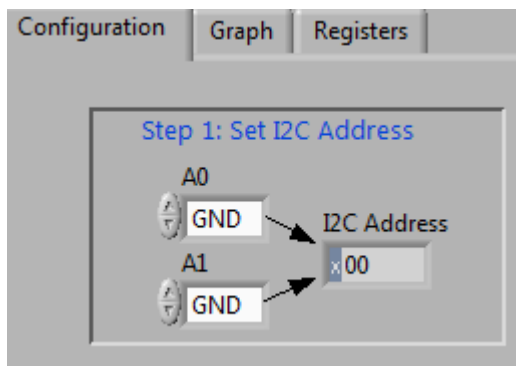


Figure 14. Slave Address Setting

4.1.2 Step 2: Configure Operation

The INA260 offers multiple options for controlling the measurement process, including sequencing, triggering, averaging as well as a power-down function. The associated control parameters can be specified in this section of the GUI.

[Figure 15](#) shows the options available under the *Operating Mode* menu. The default operating mode is *Shunt and Bus, Continuous*, which configures the INA260 to continuously measure the shunt current and bus voltage in serial order. The INA260 can also be set up to measure only the shunt current or bus voltage, but most applications benefit from measuring both signals.

NOTE: For maximum functionality, select a *Shunt and Bus* operating mode, as shown in [Figure 15](#).

Selecting any of the manual trigger modes sets up the INA260 to take a measurement only when the user clicks the **Write All Reg** button.

The *Power Down* mode stops all measurements from taking place until the operating mode changes again. The device remains attached to power but draws minimal supply current.

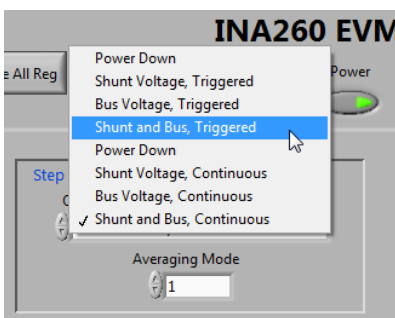


Figure 15. Operating Mode Menu

The *Averaging Mode* menu allows the user to select a desired number of samples for the INA260 averaging feature. This step configures the INA260 to compute and store the average value of the specified number of samples in the output register. The default value is 1.

4.1.3 Step 3: Set Conversion Times

Conversion time determines the sample rate of the INA260 internal ADC and can be programmed depending on the bandwidth of the input signal. The INA260 offers independent control of the conversion time for bus and shunt measurements. Step 3 provides drop-down menus from which suitable values can be selected, as shown in [Figure 16](#).

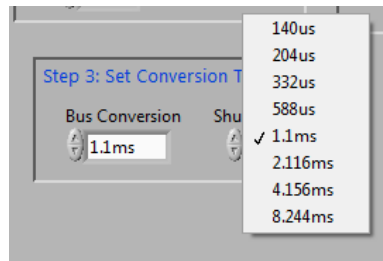


Figure 16. Configuring Conversion Times

4.1.4 Step 4: Configure Alert

The Alert pin allows the user to set limits on the value of the output register corresponding to the parameter selected from the drop-down menu, as shown in [Figure 17](#). If at any time the register value violates the user-specified limit, a flag is triggered on the Alert pin. Note that, by default, the Alert pin is set to active low. The limit value can be specified in the *Alert Limit* box.

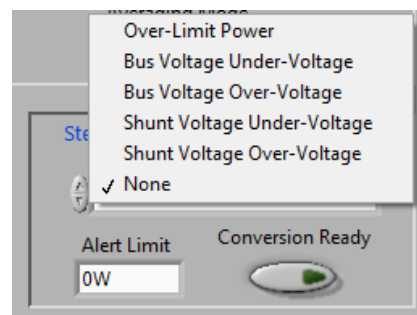


Figure 17. Configuring the Alert Pin

In addition to the INA260EVM software alert configuration, the *Alert Configuration* box includes the **Conversion Ready** button that allows for a special functionality on the Alert pin. When the INA260 completes the conversions for the current operation, it triggers the Alert pin and notifies the user that another conversion can be performed. In most cases, the INA260 conversion ready flag is not visible because of the speed of the INA260 conversion process.

4.2 Results Bar

The contents of the INA260 output registers are appropriately scaled and displayed on the *Results Bar* located at the bottom of the GUI window, as shown in [Figure 18](#). The data displayed includes the states of the Alert and Conversion Ready flags. Results are updated every time the output registers of the INA260 are read by clicking the **Read All Reg** button. Alternatively, data can be read continuously by enabling the **Continuously Poll Data** button on the *Graph* tool page.

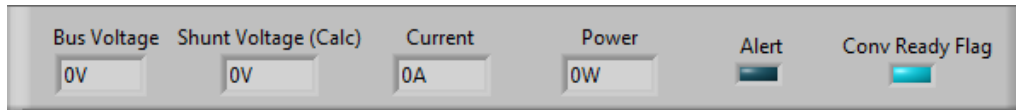


Figure 18. INA260 Results Bar

4.3 Graph Tool

The *Graph* tool buffers and plots measurement data over time, similar to an oscilloscope, as shown in [Figure 19](#). The Y-axis variable can be changed from the drop-down menu. The plot is updated by clicking on the **Read All Reg** button or enabling the **Continuously Poll Data** button to read the output registers continuously. Note that the output registers do not update until a new set of samples are acquired either by clicking **Write All Reg** or with the INA260 configured in a continuous trigger mode.

NOTE: The recommended operating mode for using the *Graph* tool is *Shunt and Bus, Continuous*.

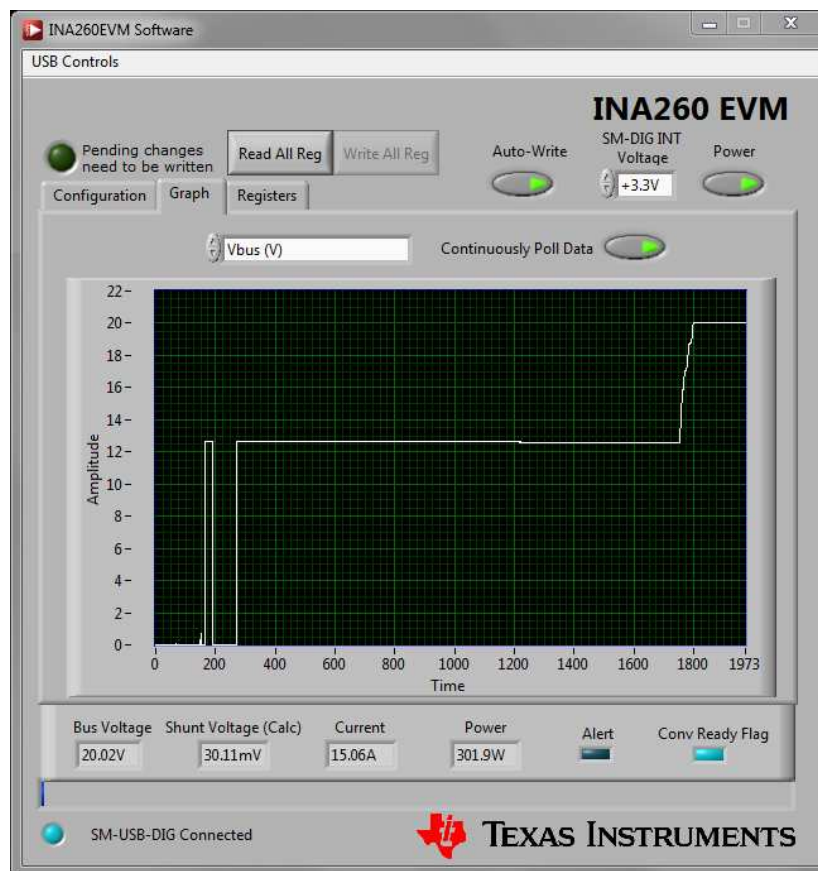


Figure 19. Graph Tool Page

4.4 Registers Tool

The *Registers* tool (as shown in [Figure 20](#)) allows the user to monitor and even change the contents of the internal user-accessible registers of the INA260 on a bit-by-bit basis. Bit names for the selected register are displayed on the lower panel of the page, but the user is advised to consult the [INA260 datasheet](#) for detailed bit definitions that may be necessary when modifying the contents of the input registers.

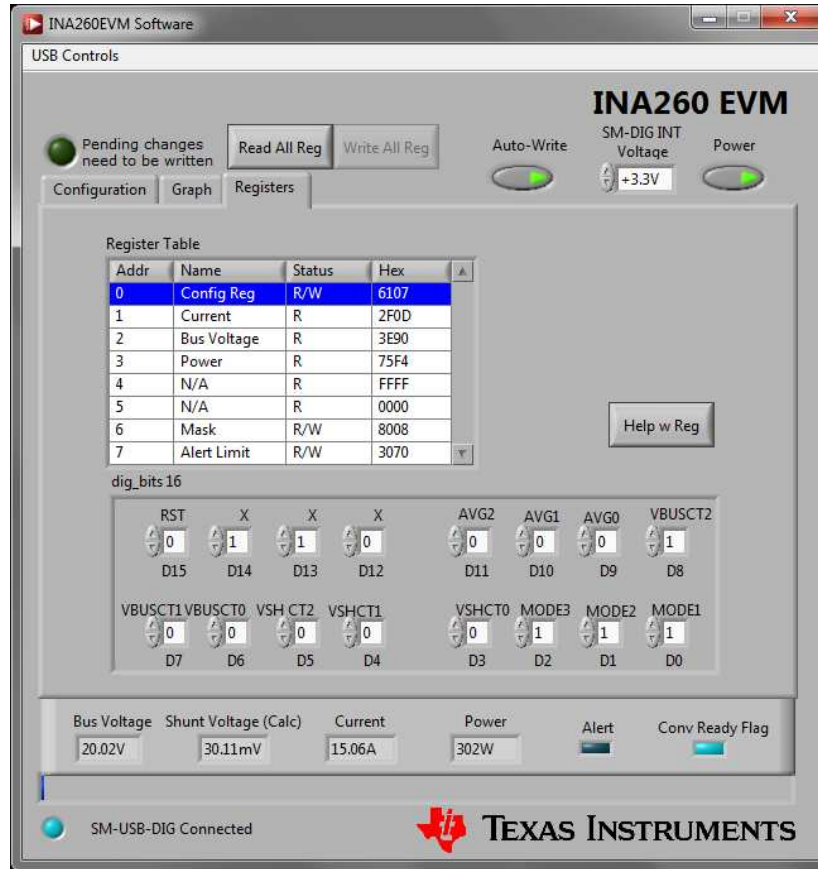


Figure 20. Registers Tool Page

5 INA260EVM Documentation

This section contains the complete bill of materials, schematic diagram, and PCB layout for the INA260EVM.

NOTE: The board layout is not to scale. This image is intended to show how the board is laid out and is not intended to be used for manufacturing INA260EVM PCBs.

5.1 Schematic

Figure 21 shows the schematic for the INA260EVM.

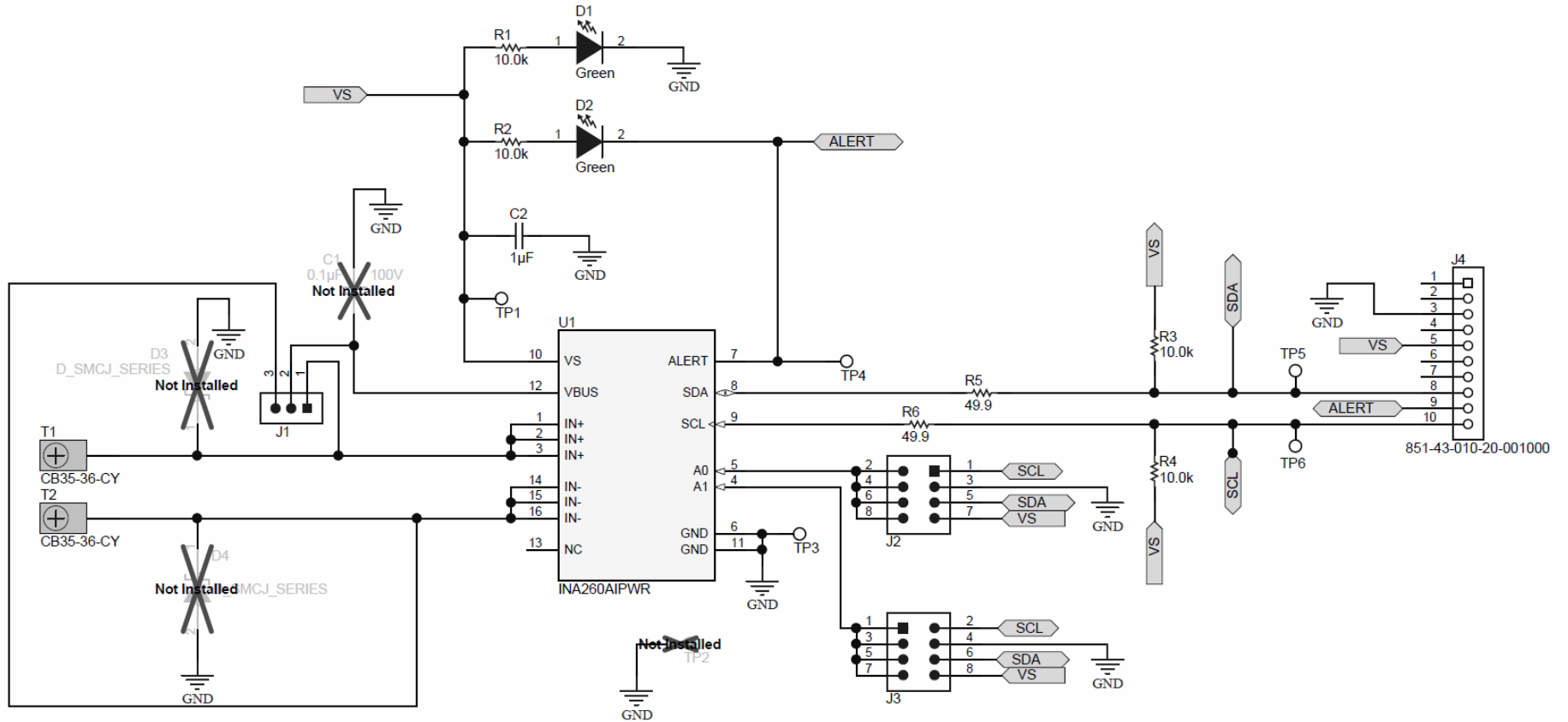


Figure 21. INA260EVM Schematic

5.2 PCB Layout

Figure 22 shows the component layout for the INA260EVM PCB.

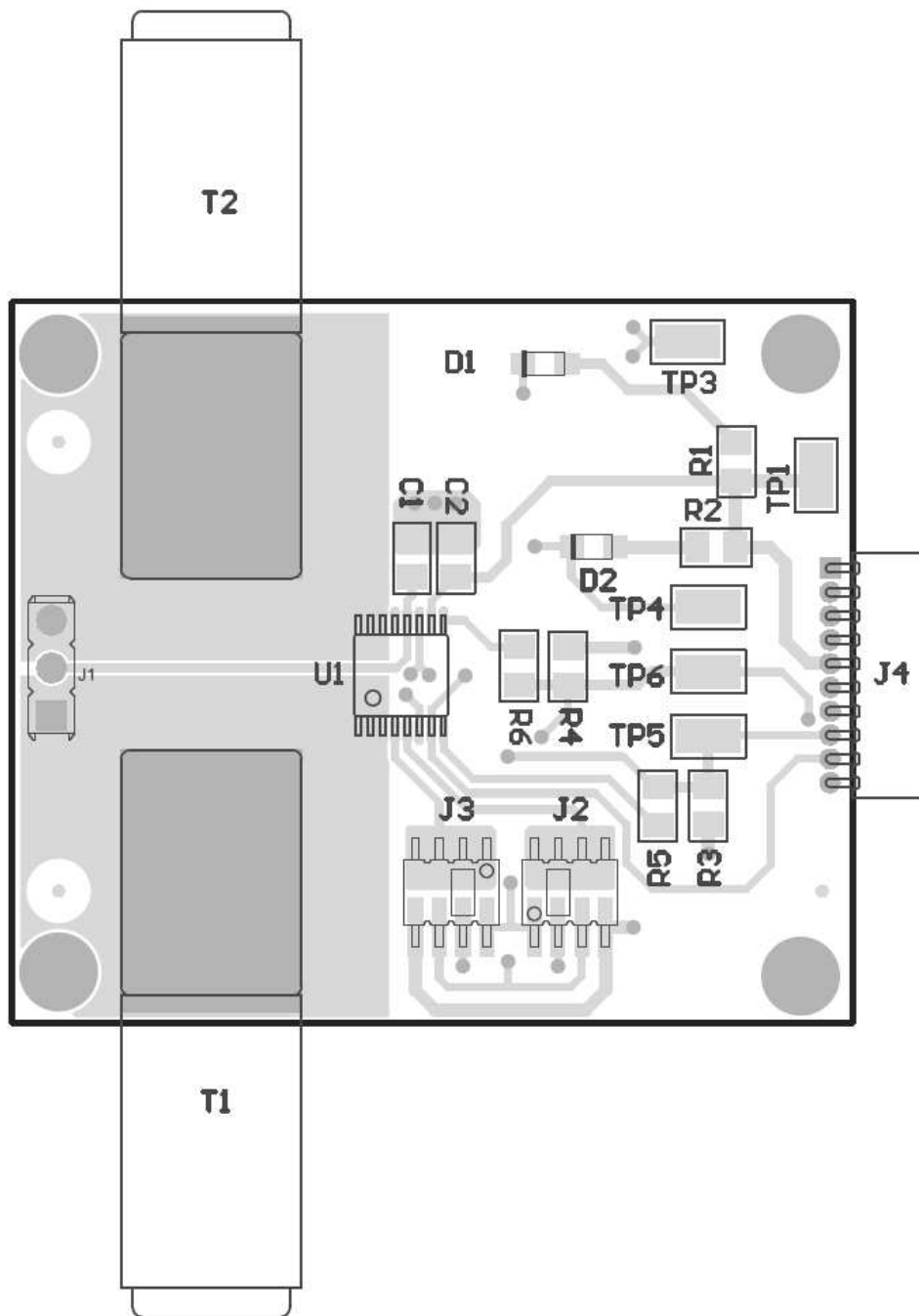


Figure 22. INA260EVM PCB Top Layer (Component Side)

5.3 Bill of Materials

Table 6 lists the bill of materials for the INA260EVM.

Table 6. Bill of Materials: INA260EVM

Item No.	Ref Des	Description	Vendor/Mfr	Part Number
1	C2	CAP, CERM, 1 μ F, 50 V, +/- 10%, X7R, 0805	MuRata	GRM21BR71H105KA12L
2	D1, D2	LED, Green, SMD	Kingbright	APT2012LZGCK
3	J1	Header, 2.54mm, 3x1, Tin, TH	Harwin Inc	M20-9990345
4	J4, J5	Header, 50mil, 4x2, Gold, SMT	Amphenol FCI	20021121-00008C4LF
5	J6	Receptacle, 50mil, 10x1, Gold, R/A, TH	Mill-Max	851-43-010-20-001000
6	R1, R2, R3, R4	RES, 10.0 k, 1%, 0.125 W, 0805	Vishay-Dale	CRCW080510K0FKEA
7	R5, R6	RES, 49.9, 1%, 0.125 W, 0805	Vishay-Dale	CRCW080549R9FKEA
8	T1, T2	Terminal 50A Lug	Panduit	CB35-36-CY
9	TP1, TP3, TP4, TP5, TP6	Test Point, Miniature, SMT	Keystone	5015
10	U1	Integrated Shunt High-Side or Low-Side Measurement, Bi-Directional Current and Power Monitor with I2C Compatible Interface, PW0016A	Texas Instruments	INA260AIPWR

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including demonstration software, components, and/or documentation which may be provided together or separately (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/llds/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/llds/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

東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lstds/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/lstds/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 AND CONDITIONS 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.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

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.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com