INA260EVM-PDK

INA260 Evaluation Module and Product Demonstration Kit

User's Guide

Literature Number: SBOU180
November 2016

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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-mΩ 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.

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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

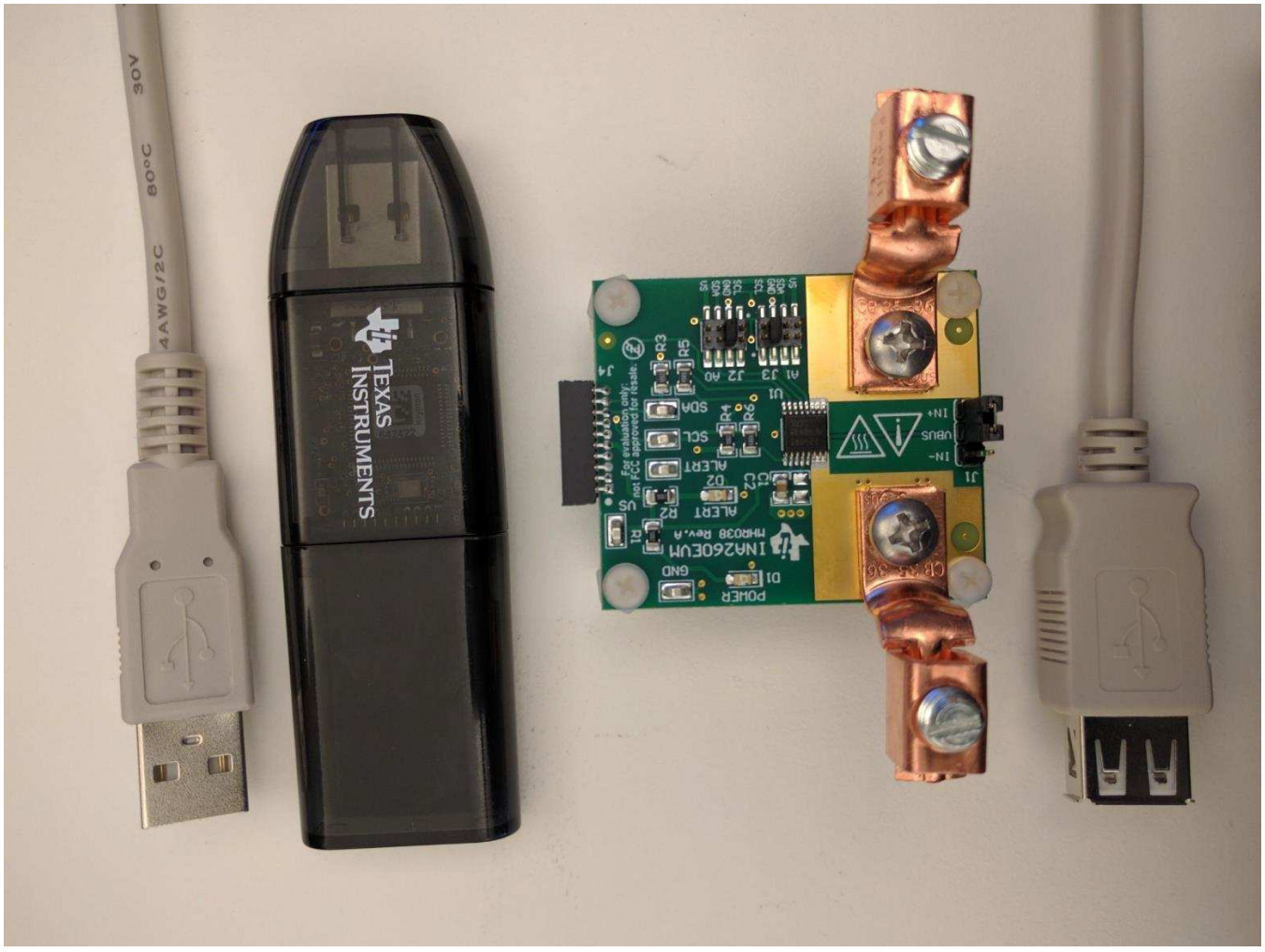


Figure 1. Hardware Included with the INA260EVM Kit

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1.2 INA260EVM-PDK Features

- USB-powered; no external power supply is required
- Support for full ±15-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.

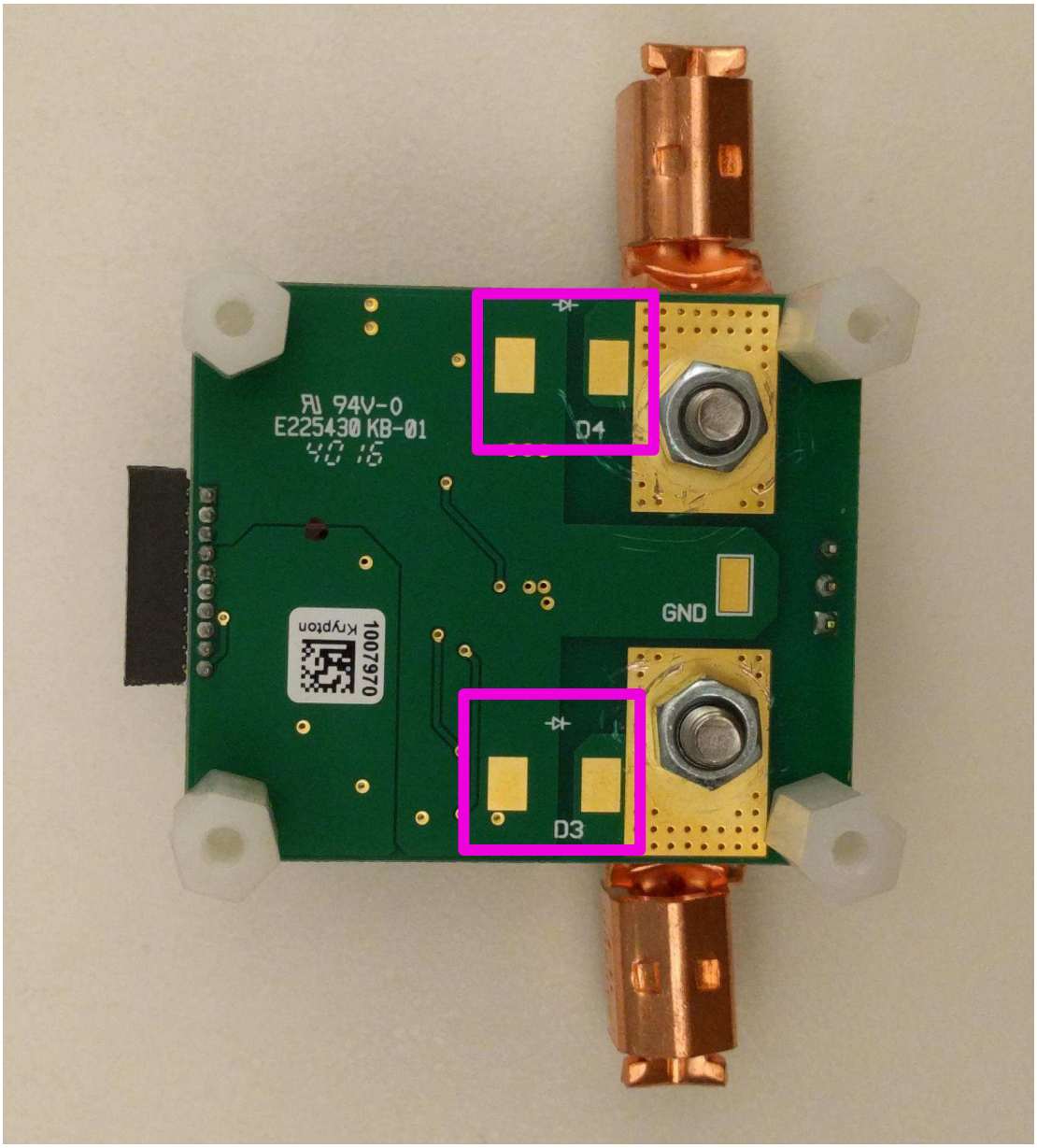


Figure 2. Placeholders for TVS Devices

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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 I^2C format, before sending them to the EVM. With power enabled, the INA260 responds to these I^2C commands by sending the requested data back to the SM-USB-DIG board over the I^2C. 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.

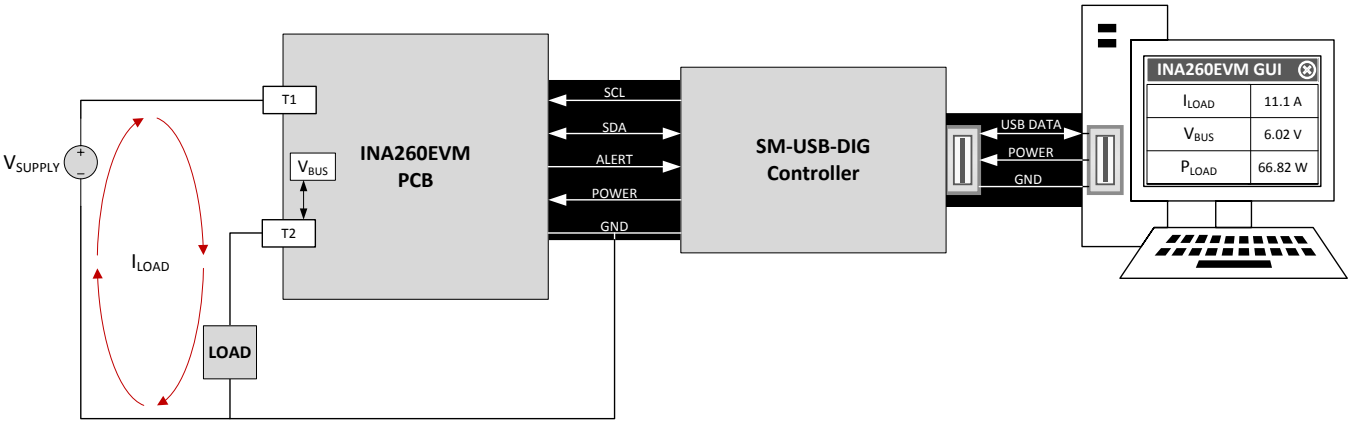


Figure 3. INA260EVM-PDK Hardware Setup

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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 I^2C, SPI, and other serial digital I/O patterns. This EVM uses the I^2C 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.

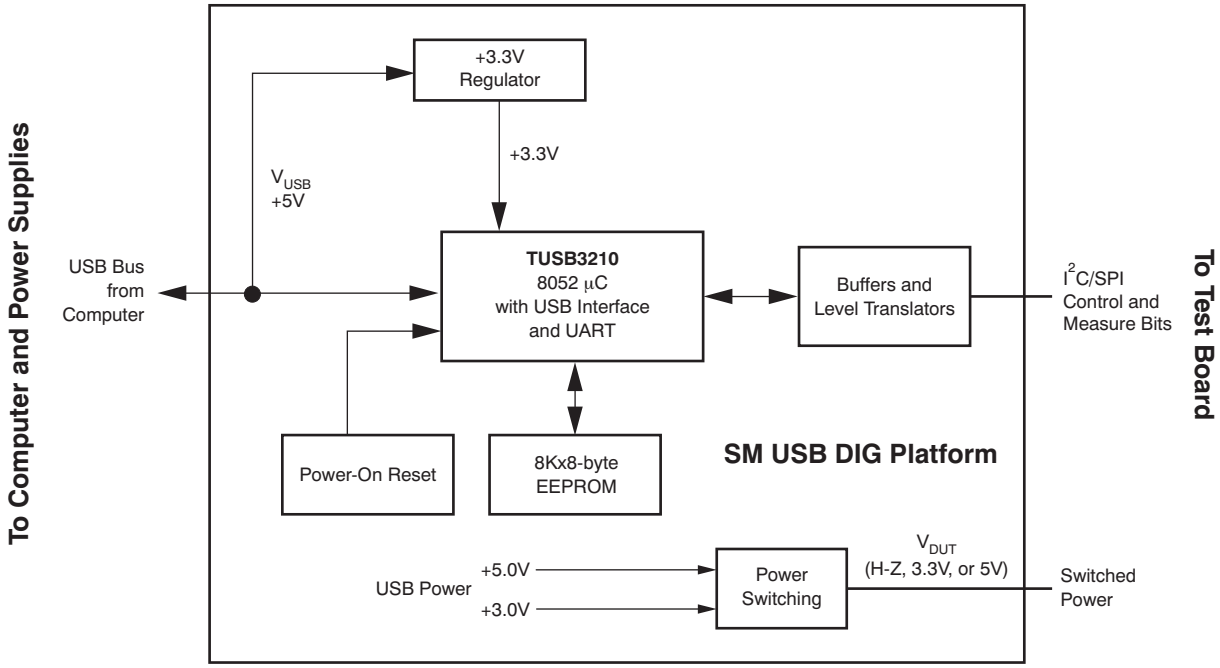


Figure 4. SM-USB-DIG Platform Block Diagram

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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.

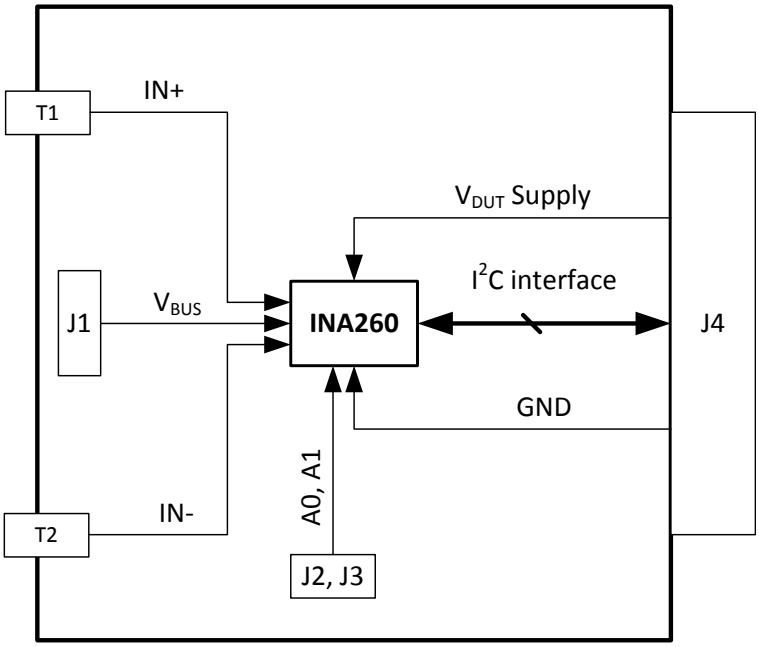


Figure 5. INA260EVM Block Diagram

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^2C clock signal (SCL)
9	CTRL/MEAS4	GPIO: control output or measure input
8	I2C_SDA1	I^2C 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 ($\overline{CS}$)
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 1µF 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.

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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-mΩ 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.

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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

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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%**.

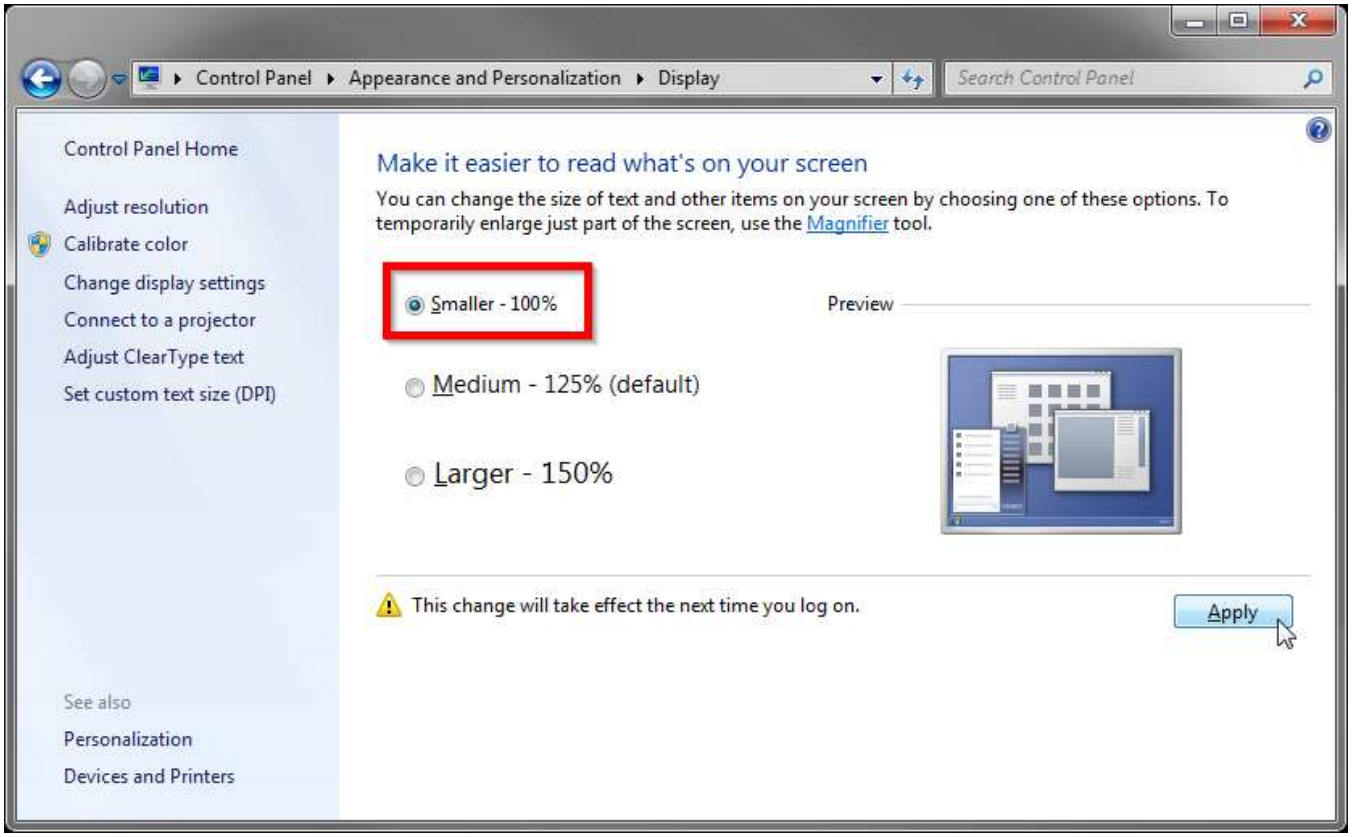


Figure 6. Recommended Display Settings

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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.

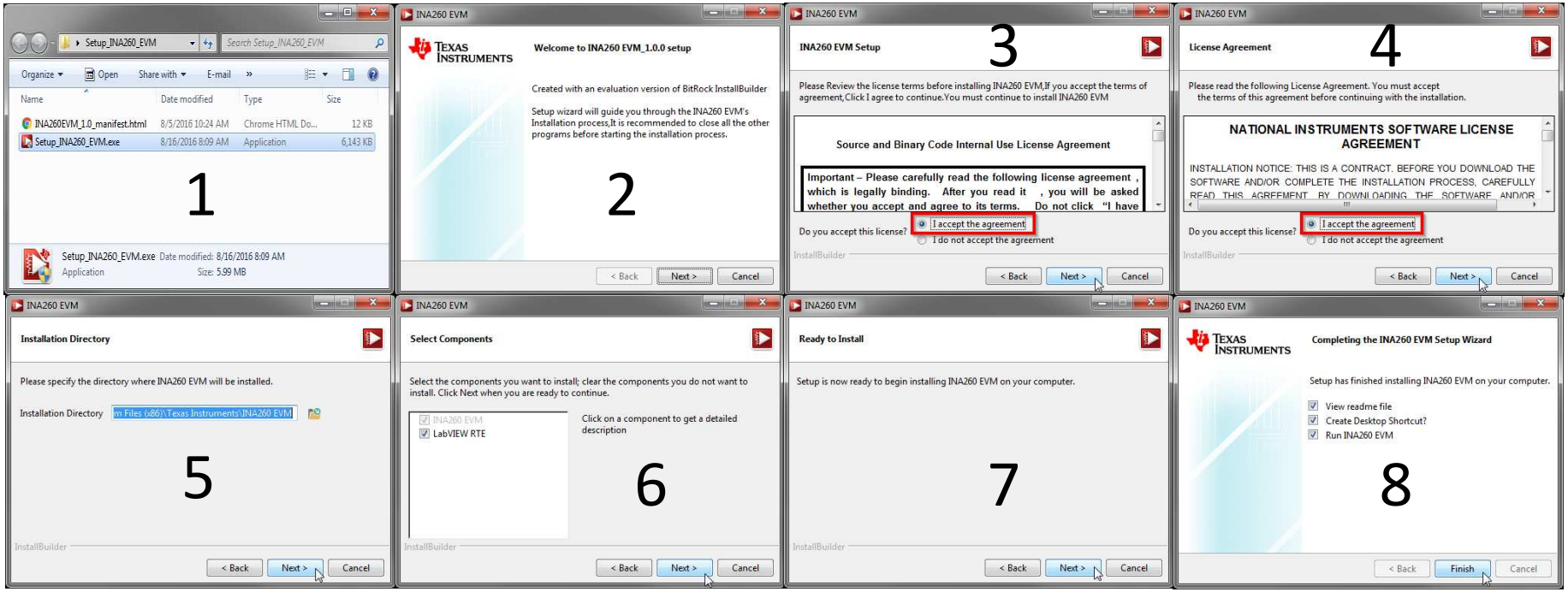


Figure 7. INA260EVM GUI Installation

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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.

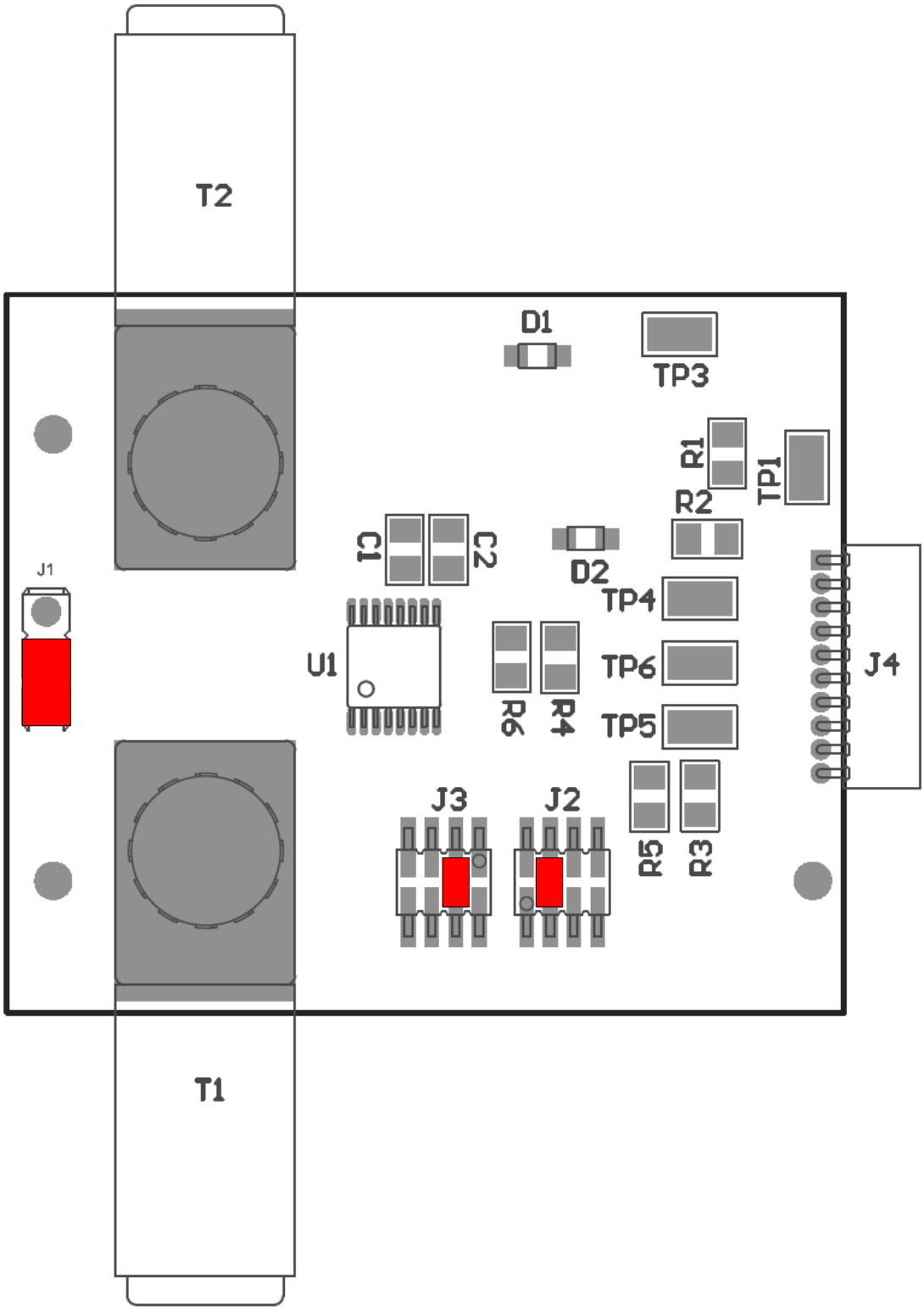


Figure 8. INA260EVM Default Jumper Settings

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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^2C device address; see Section 2.3 for details.
J3	GND	This jumper sets the A1 character of the 2-character I^2C 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.

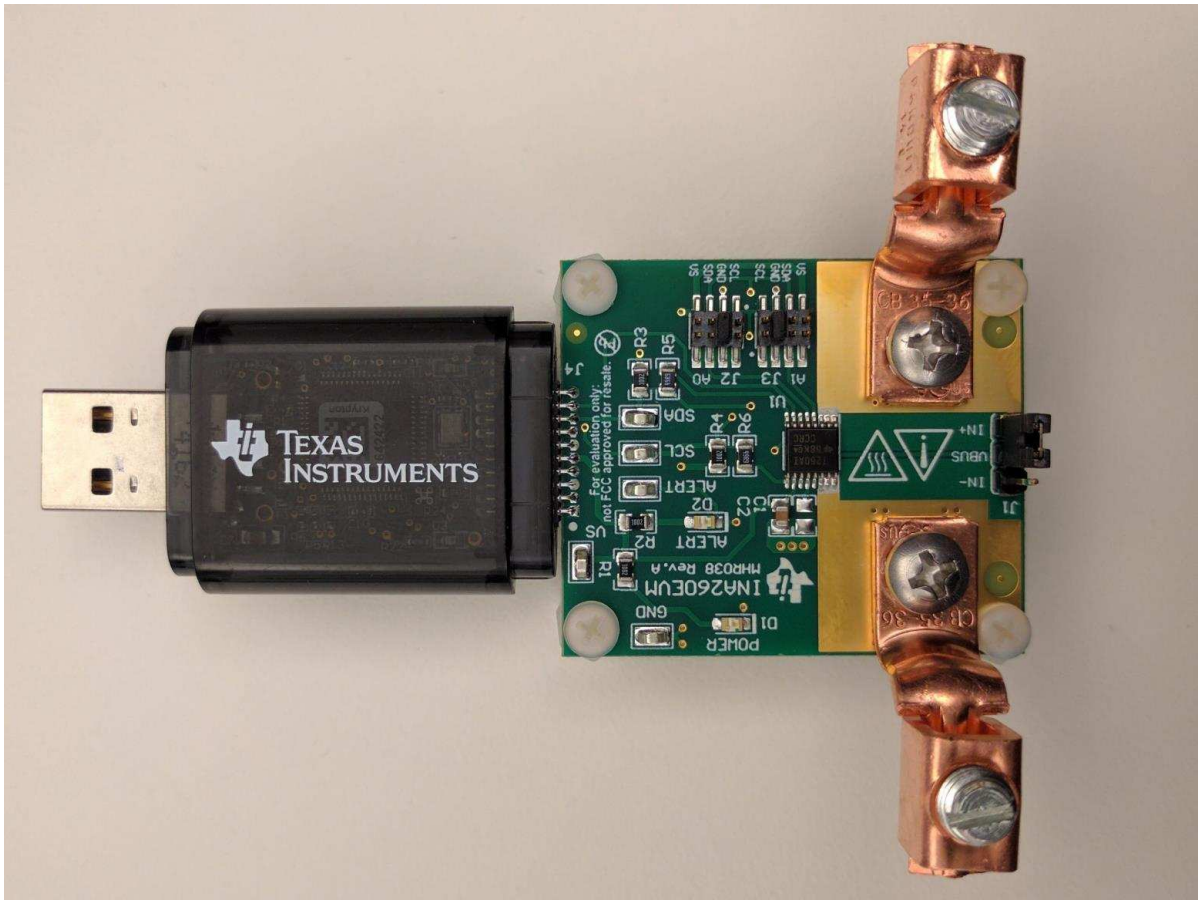


Figure 9. INA260EVM and SM-USB-DIG Connected in Proper Orientation

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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.

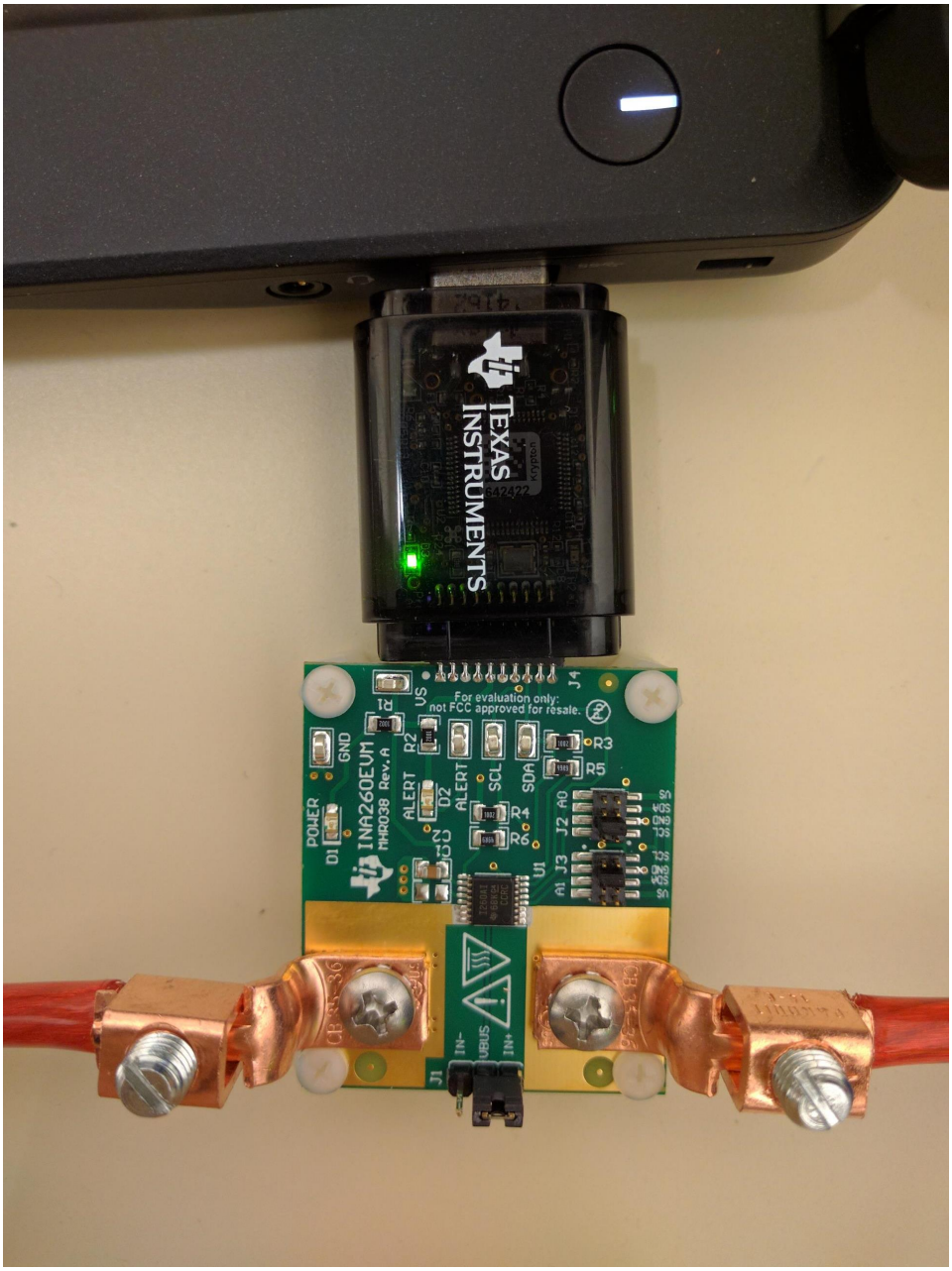


Figure 10. SM-USB-DIG Powers on When Connected to a Computer

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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.

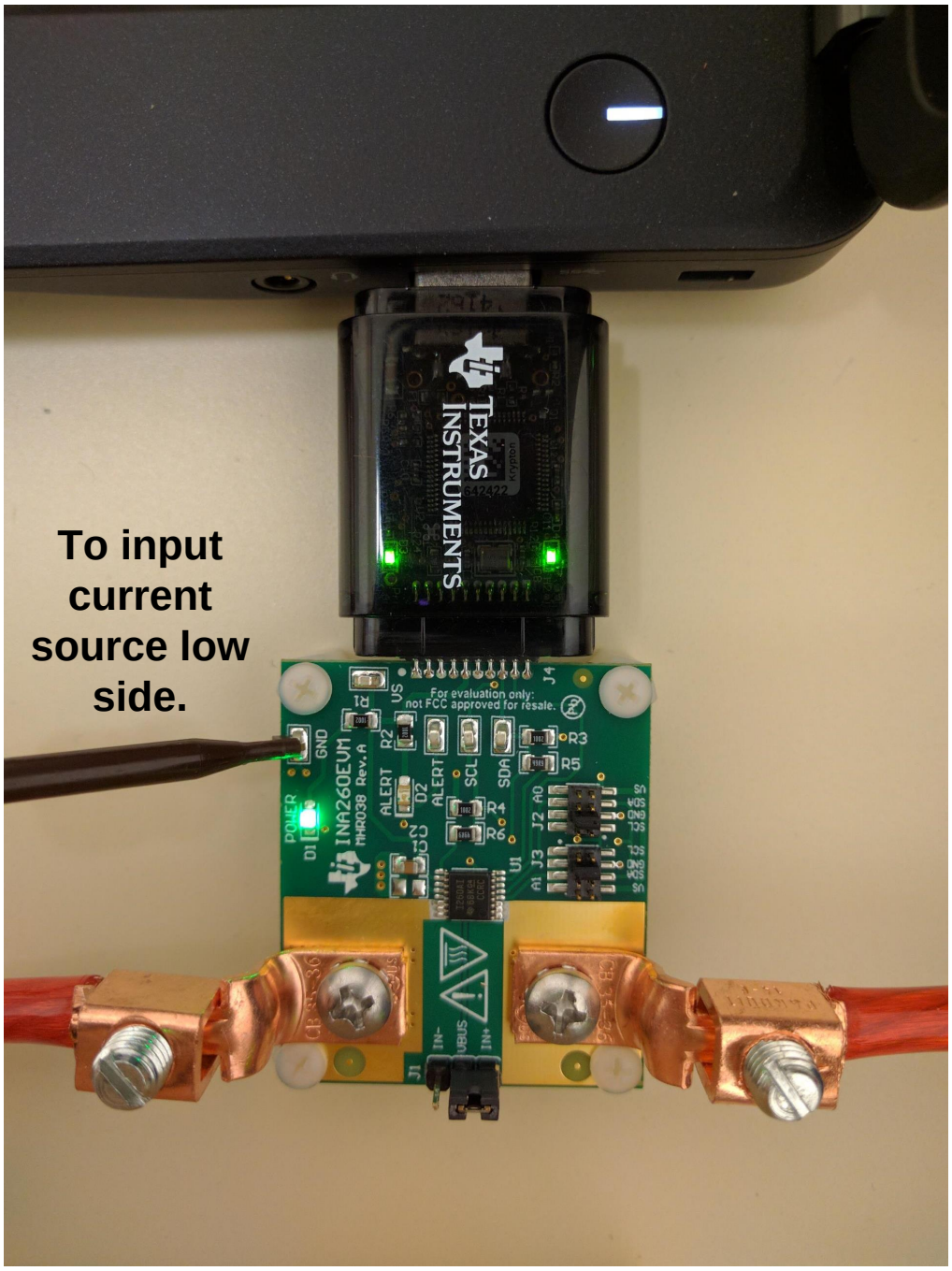


Figure 11. INA260EVM Powers Up following the GUI Launch

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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.

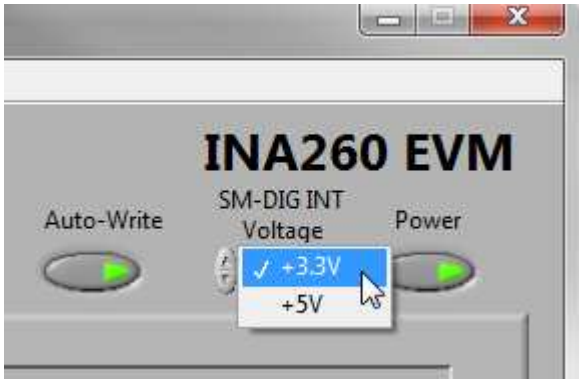


Figure 12. V_{DUT} Selection

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.

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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 I^2C 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.

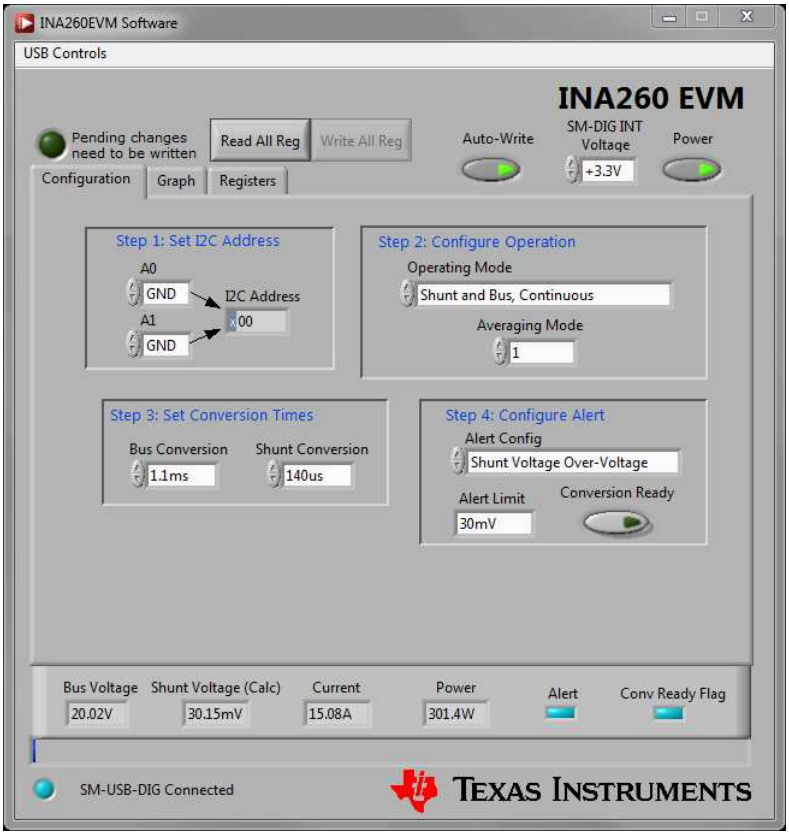


Figure 13. Configuration Page

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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.

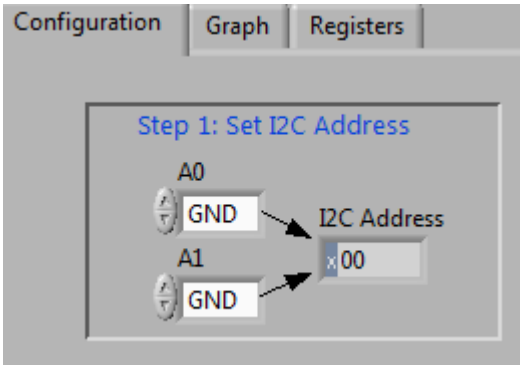


Figure 14. Slave Address Setting

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.

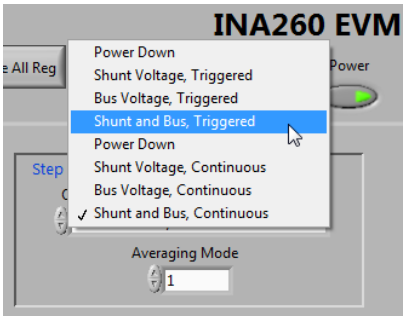


Figure 15. Operating Mode Menu

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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.

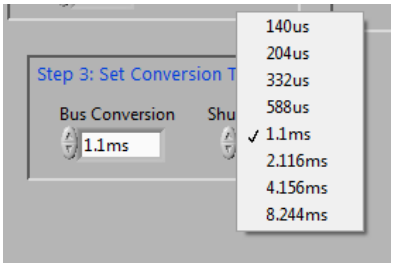


Figure 16. Configuring Conversion Times

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 can be specified in the *Alert Limit* box.

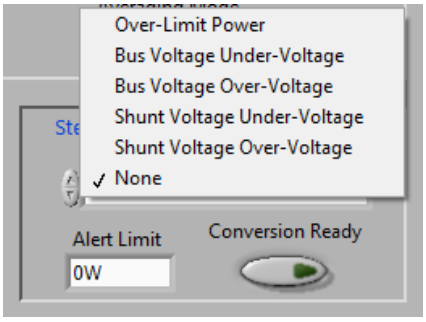


Figure 17. Configuring the Alert Pin

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.

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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.

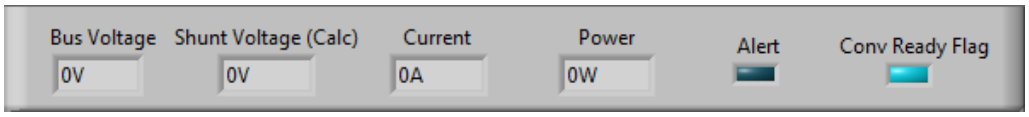


Figure 18. INA260 Results Bar

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*.

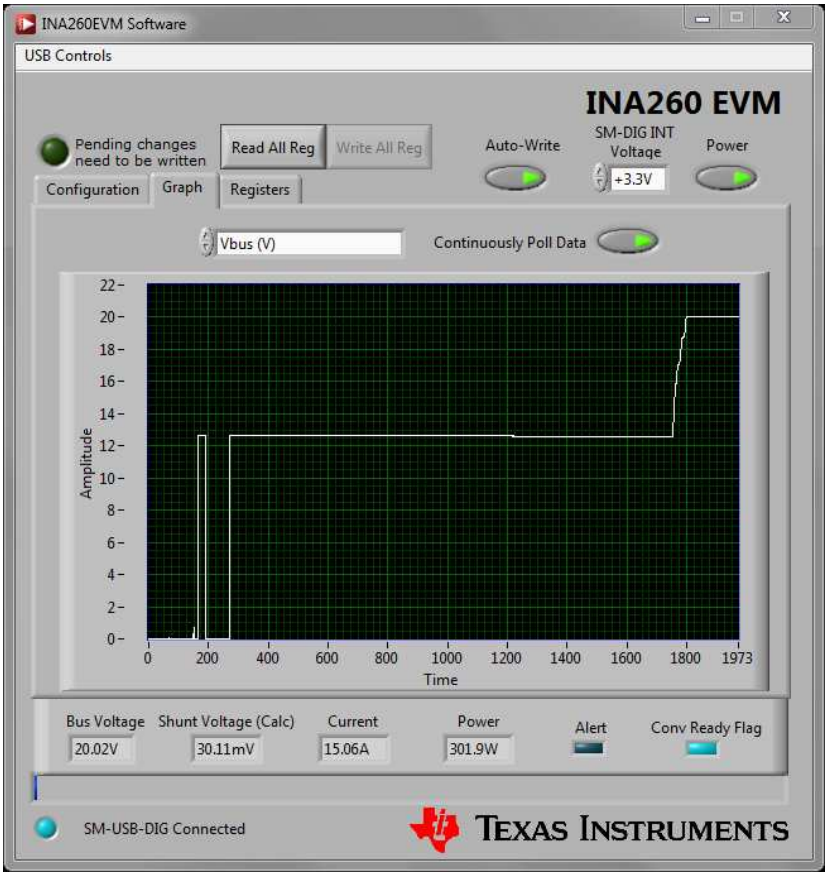


Figure 19. Graph Tool Page

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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.

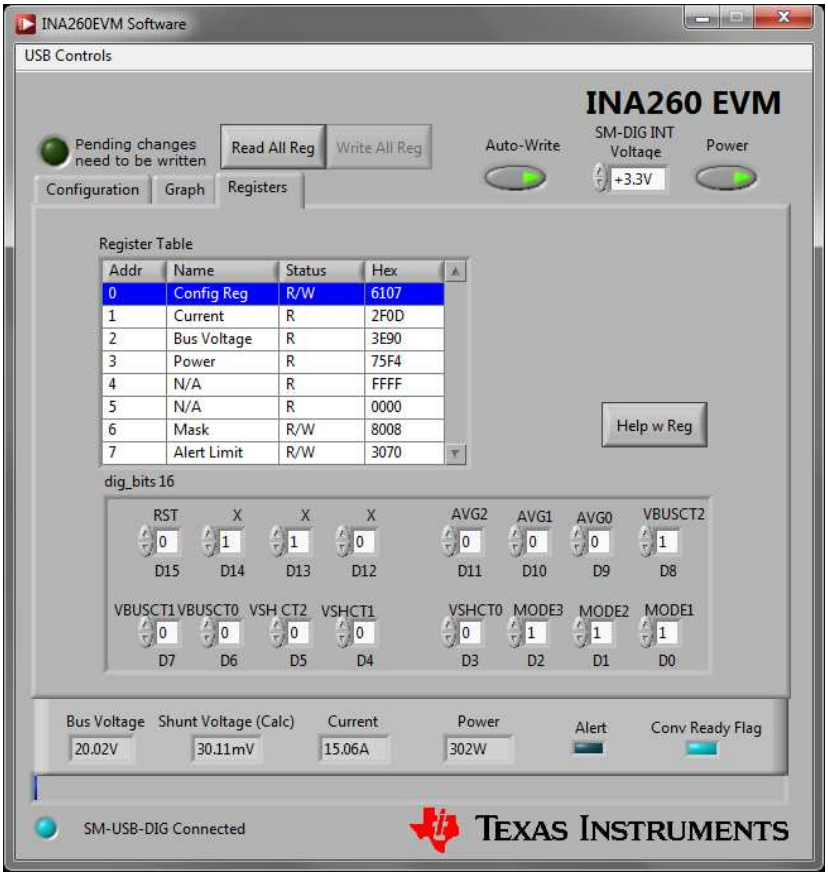


Figure 20. Registers Tool Page

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.

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5.1 Schematic

Figure 21 shows the schematic for the INA260EVM.

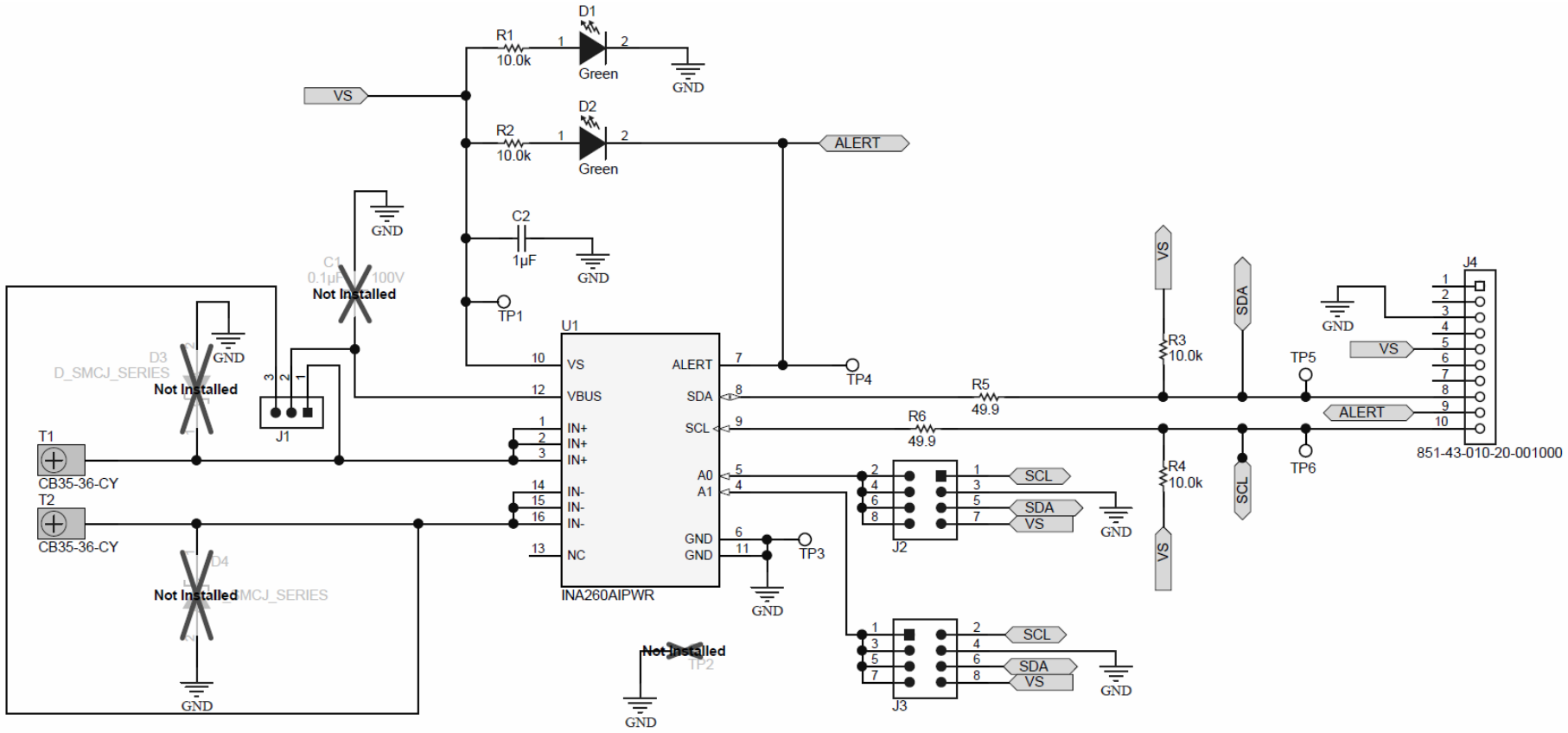


Figure 21. INA260EVM Schematic

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5.2 PCB Layout

Figure 22 shows the component layout for the INA260EVM PCB.

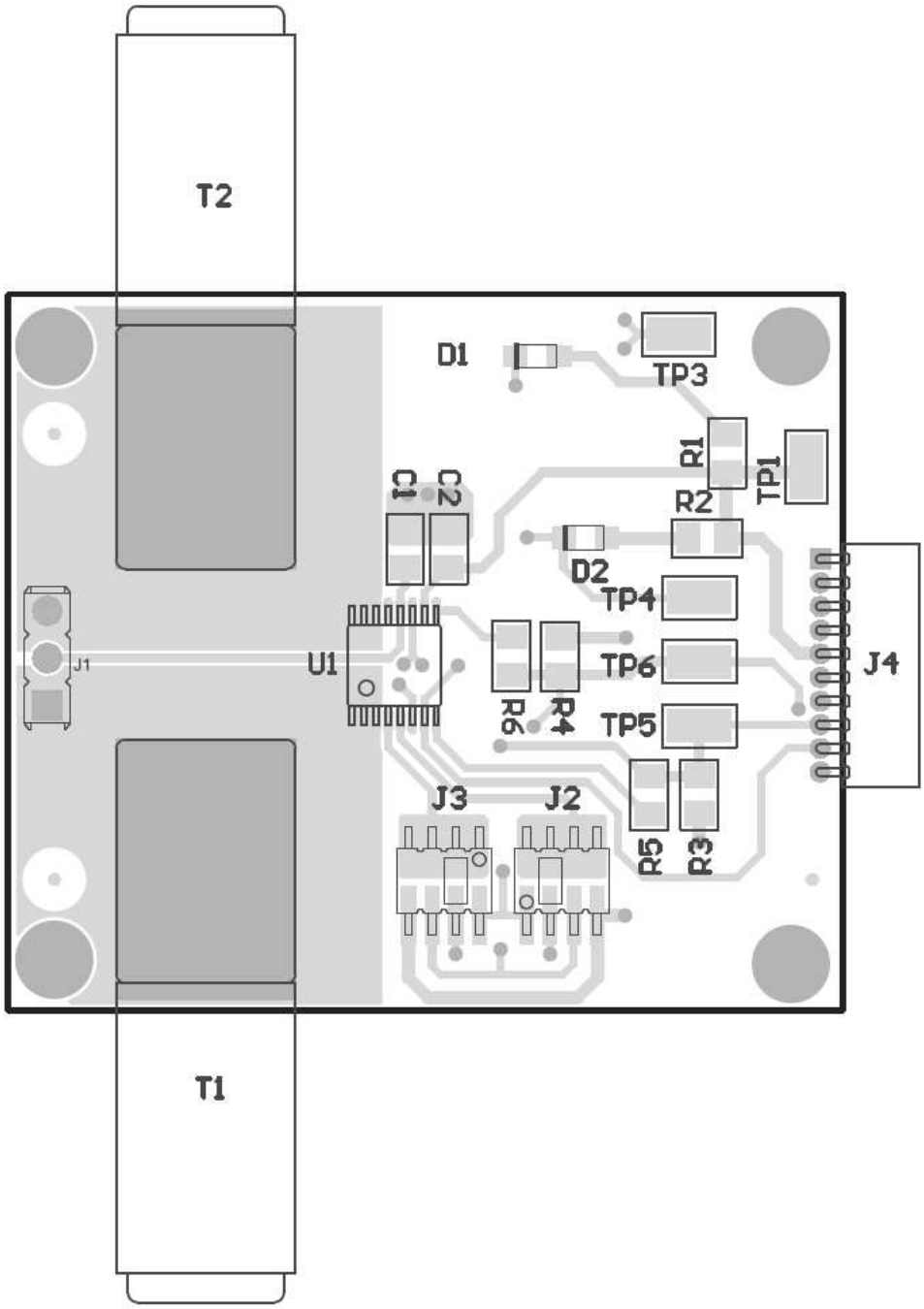


Figure 22. INA260EVM PCB Top Layer (Component Side)

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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 µF, 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

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

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FCC Interference Statement for Class B EVM devices

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- *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.*

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

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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.

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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.

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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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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
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