

## ABSTRACT

This user's guide describes the characteristics, operation, and use of the INA231EVM evaluation board (Rev A) hardware. This document discusses how to set up and configure the software and hardware, and reviews the program operation. Throughout this document, the terms *evaluation board*, *evaluation module*, and *EVM* are synonymous with the INA231EVM. This user's guide also includes information regarding operating procedures, the input and output connections, an electrical schematic, printed circuit board (PCB) layout drawings, and a parts list for the EVM.

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## 1 Overview

The [INA231](#) is a high-side current sensor and power monitor with an I<sup>2</sup>C interface. The INA231 monitors both current and supply voltage, with programmable conversion times and averaging modes. The INA231EVM is a platform used to evaluate the performance of the INA231 under various signal, shunt, and supply conditions.

This document gives a general overview of the INA231EVM and provides a general description of the features and functions to consider when using this evaluation module.

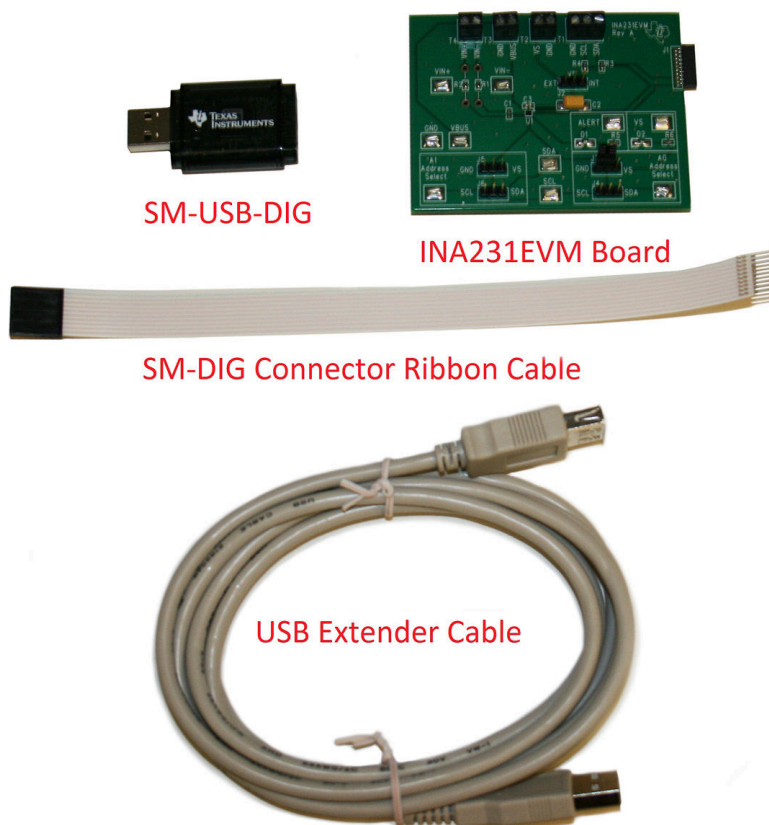
### 1.1 INA231EVM Kit Contents

[Table 1-1](#) summarizes the contents of the INA231EVM kit. [Figure 1-1](#) shows all of the included hardware. Contact the [Texas Instruments customer support center](#) if any component is missing.

TI recommends users check the [INA231 product folder](#) on the TI website at [www.ti.com](http://www.ti.com) to verify that they have the latest versions of the related software.

**Table 1-1. INA231EVM Kit Contents**

ITEM	QUANTITY
INA231EVM PCB Test Board	1
SM-USB-DIG Platform PCB	1
USB Extender Cable	1
SM-USB-DIG Connector Ribbon Cable	1
User's Guide CD-ROM	1



**Figure 1-1. Hardware Included with INA231EVM Kit**

## 1.2 Related Documentation from Texas Instruments

The following documents provide information regarding Texas Instruments' integrated circuits used in the assembly of the INA231EVM. This user's guide is available from the TI web site under literature number *SBOU128*. 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 [www.ti.com](http://www.ti.com), 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 1-2. Related Documentation**

DOCUMENT	LITERATURE NUMBER
<a href="#">INA231</a> Product Data Sheet	<a href="#">SBOS644</a>
SM-USB-DIG Platform User Guide	<a href="#">SBOU098</a>

## 2 INA231EVM Hardware

Figure 2-1 shows the overall system setup for the INA231EVM. The PC runs software that communicates with the SM-USB-DIG Platform. The SM-USB-DIG Platform generates the analog and digital signals used to communicate with the INA231 test board. Users can connect the INA231EVM test board to the system and monitor the power, current, and voltage of the system under test conditions.

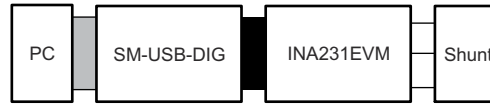


Figure 2-1. INA231EVM Hardware Setup

### 2.1 Theory of Operation for INA231 Hardware

Figure 2-2 shows a block diagram of the INA231 test board hardware setup. The PCB provides connections to the I<sup>2</sup>C interface and general-purpose inputs and outputs (GPIOs) on the SM-USB-DIG Platform board. The PCB also provides connection points for external connections of the shunt voltage, bus voltage, and ground.

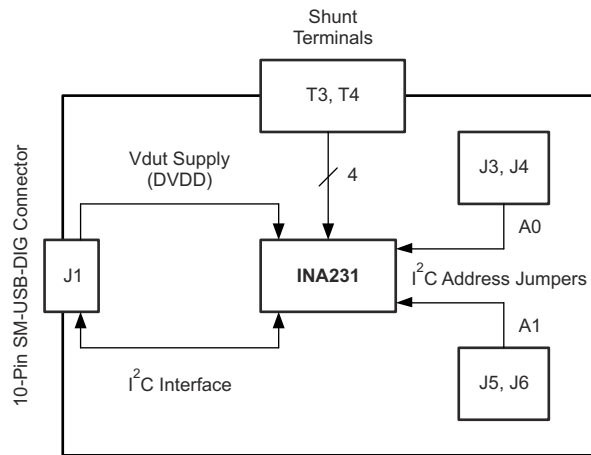


Figure 2-2. INA231EVM Test Board Block Diagram

## 2.2 Signal Definitions of H1 (10-Pin Connector Socket)

Table 2-1 lists the pinout for the 10-pin connector socket used to communicate between the INA231EVM and the SM-USB-DIG. Note that the INA231EVM only uses the necessary I<sup>2</sup>C communication lines (pins 1 and 3) and the V<sub>DUT</sub> and GND pins (pin 6 and pin 8) to issue commands to the INA231 chip.

**Table 2-1. Signal Definition of J1 on INA231EVM Board**

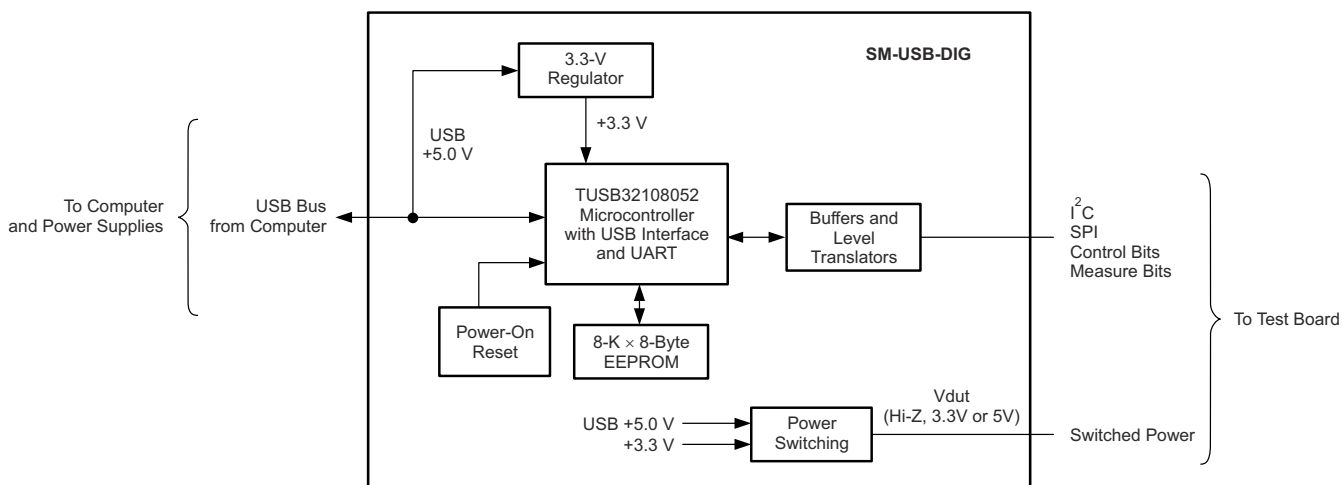
PIN ON J1	SIGNAL	DESCRIPTION
1	I2C_SCL	I <sup>2</sup> C Clock Signal (SCL)
2	CTRL/MEAS4	GPIO: Control Output or Measure Input
3	I2C_SDA1	I <sup>2</sup> C Data Signal (SDA)
4	CTRL/MEAS5	GPIO: Control Output or Measure Input
5	SPI_DOUT1	SPI Data Output (MOSI)
6	V <sub>DUT</sub>	Switchable DUT Power Supply: +3.3 V, +5 V, Hi-Z (Disconnected) <sup>(1)</sup>
7	SPI_CLK	SPI Clock Signal (SCLK)
8	GND	Power Return (GND)
9	SPI_CS1	SPI Chip Select Signal (CS)
10	SPI_DIN1	SPI Data Input (MISO)

(1) When V<sub>DUT</sub> is Hi-Z, all digital I/O are Hi-Z as well.

### 2.2.1 Theory of Operation for SM-USB-DIG Platform

Figure 2-3 shows the block diagram for the SM-USB-DIG Platform. This platform is a general-purpose data acquisition system that is used on other Texas Instruments evaluation modules. The details of its operation are included in a separate document, SBOU098 (available for download at [www.ti.com](http://www.ti.com)). The block diagram shown in Figure 2-3 gives a brief overview of the platform. The TUSB3210 is the primary control device for the SM-USB-DIG Platform.

The TUSB3210 is an 8052 microcontroller that has an onboard USB interface. The microcontroller receives information from the host computer and interprets the information into power, I<sup>2</sup>C, SPI, and other digital I/O patterns. During the digital I/O transaction, the microcontroller reads the response of any device connected to the I/O interface. The response from the device is sent back to the PC where the information is interpreted by the host computer.



**Figure 2-3. SM-USB-DIG Platform Block Diagram**

### 3 INA231EVM (Rev A) Hardware Setup

The INA231EVM (Rev A) hardware setup involves connecting the two PCBs of the EVM together, applying power, connecting the USB cable, and setting the jumpers. This section details this procedure.

#### 3.1 Electrostatic Discharge Warning

##### CAUTION

Many of the components on the INA231EVM 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.

#### 3.2 Connecting the Hardware

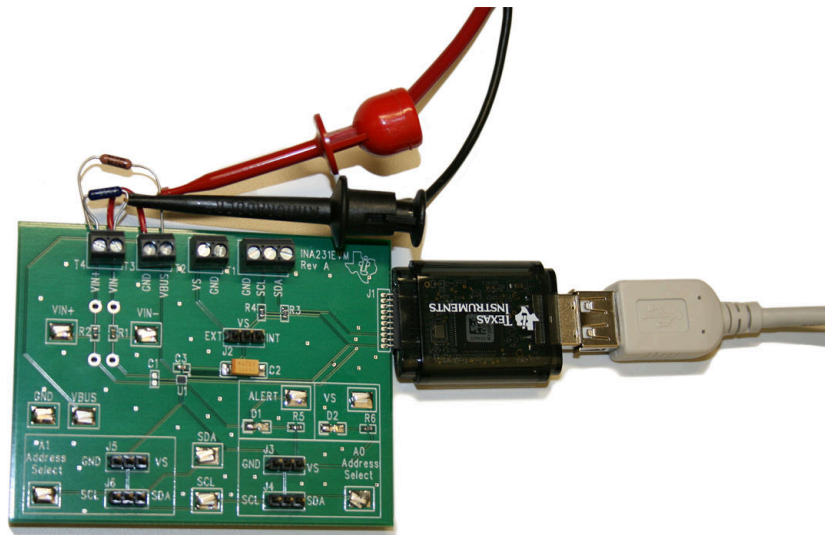
To set up the INA231EVM and connect the two PCBs of the EVM together (that is, the INA231 Test Board and SM-USB-DIG Platform board), gently slide the plug and socket ends of the 10-pin connectors together. Make sure that the two connectors are completely pushed together; loose connections may cause intermittent operation.

#### 3.3 Connecting Power

After the EVM and SM-USB-DIG are connected, make the desired  $V_{BUS}$  and shunt connections. Typically, setup involves a high- or low-side load and a shunt resistor across  $VIN+$  and  $VIN-$ . The setup in [Figure 3-1](#) represents a test scenario with a low-side shunt attached. This source for  $V_{BUS}$  is not included with the kit, and the voltage may differ depending on your testing needs. The external power source is connected to the terminal strip T3.

##### Note

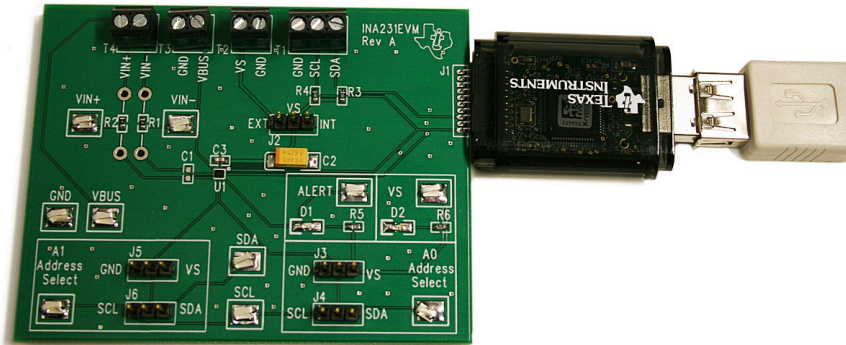
It is always necessary to connect the power to the SM-USB-DIG Platform board before connecting the USB cable.



**Figure 3-1. Typical Hardware Test Connections for the INA231EVM**

### 3.4 Connecting the USB Cable to the SM-USB-DIG Platform

After power is connected, the computer typically responds with a *Found New Hardware, USB Device* pop-up dialog. The pop-up window typically changes to *Found New Hardware, USB Human Interface Device*. This pop-up indicates that the device is ready for use. The SM-USB-DIG Platform uses the human interface device drivers that are part of the Microsoft® Windows® operating system.



**Figure 3-2. Connecting the USB Cable to the SM-USB-DIG Platform**

In some cases, the Windows *Add Hardware Wizard* may pop up. If this prompt appears, click *Yes* to let the system device manager install the human interface drivers. Windows then confirms installation of the drivers with the message shown in [Figure 3-3](#).



**Figure 3-3. Confirmation of SM-USB-DIG Platform Driver Installation**

### 3.5 INA231EVM Default Jumper Settings

Figure 3-4 shows the default jumper configuration for the INA231EVM. In general, the jumper settings of the SM-USB-DIG Platform do not need to be changed. Users may want to change some of the jumpers on the INA231EVM board to match their specific configurations. For example, user can set a specific I<sup>2</sup>C address by configuring J3-J6.

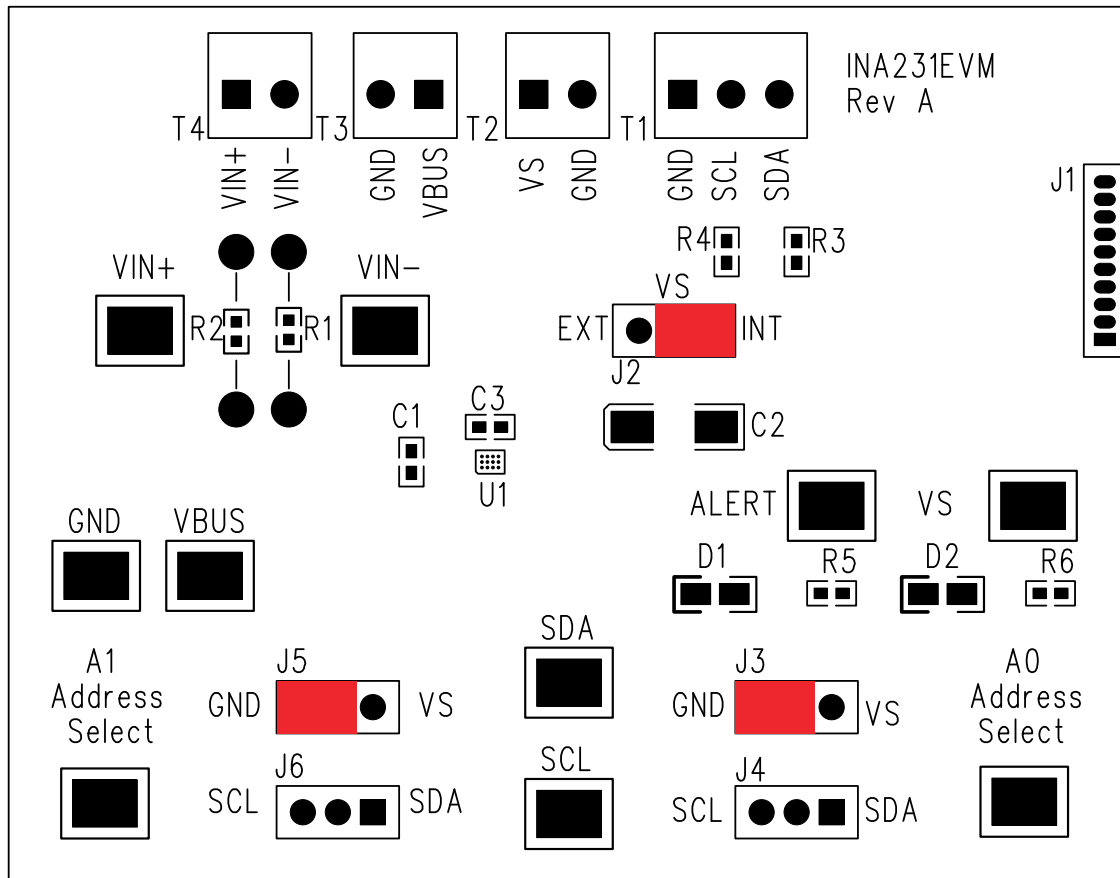


Figure 3-4. INA231EVM Default Jumper Settings

Typically, jumper 2 on the INA231EVM is always set to the INT position. When set to the INT position, the SM-USB-DIG Platform provides the supply for the INA231. When this jumper is set to the EXT position, an external supply voltage can be connected to terminal strip T2 to provide the supply for the INA231.

Jumpers 3 through 6 control the I<sup>2</sup>C address pins for the INA231. These jumpers can set the address for A0 and A1 to either supply, ground, SCL, or SDA. Make sure to only connect one jumper at a time for each address control. Failure to properly connect jumpers can cause shorts or interruptions in the communication lines. See also the [INA231 data sheet](#).

Table 3-1 summarizes the function of the INA231 Test Board jumpers. For most applications, all jumpers should be left in the respective default configurations.

Table 3-1. INA231EVM Test Board Jumper Functions

JUMPER	DEFAULT	PURPOSE
J2	INT	This jumper selects whether the V <sub>S</sub> pin on the INA231 is connected to the V <sub>DUT</sub> signal generated from the SM-USB-DIG Platform or whether the digital supply pin is connected to terminal T2, allowing for an external supply to power the device. The default INT position connects the V <sub>S</sub> pin to the V <sub>DUT</sub> control signal.
J3/J4	GND	This jumper selects the I <sup>2</sup> C A0 address selection for A0.
J5/J6	GND	This jumper selects the I <sup>2</sup> C A1 address selection for A1.



## 3.6 INA231EVM Features

This section describes some of the hardware features present on the INA231EVM test board.

### 3.6.1 J2: I<sup>2</sup>C V<sub>S</sub> Control Setting

Users can connect voltage signals to the INA231 supply pin through Jumper J2. If J2 is set to the INT position, the V<sub>S</sub> pin is connected to the switchable V<sub>DUT</sub> signal generated from the SM-USB-DIG Platform. This voltage can be set to either 3.3 V or 5 V, depending on how it is configured in the software. While J4 is set in the INT position, the V<sub>S</sub> Power button in the INA231EVM software is able to control whether the V<sub>DUT</sub> supply voltage is turned on or off.

When J2 is set in the EXT position, an external supply connected to terminal T2 can be used to provide the supply voltage for the INA231.

### 3.6.2 J3 and J4: I<sup>2</sup>C Address Hardware Setting (A0)

Jumpers J3 and J4 are used to set the hardware setting for the A0 I<sup>2</sup>C address pin on the INA231. Through J3, the user can set the A0 address to either a logic '1' or a logic '0'. Through J4, the user can set the A0 to either the SCL or SDA communication line. Make sure to only have either J3 or J4 connected individually; failure to keep these lines separate can lead to board shorts and problems with the I<sup>2</sup>C communication lines. See [Section 5.2.1](#) on how to configure the INA231EVM software to match the J3/J4 hardware setting.

### 3.6.3 J5 and J6: I<sup>2</sup>C Address Hardware Setting (A1)

Jumpers J5 and J6 are used to set the hardware setting for the A1 I<sup>2</sup>C address pin on the INA231. Through J3, the user can set the A1 address to either a logic '1' or a logic '0'. Through J4, the user can set the A1 address to either the SCL or SDA communication line. Make sure to only have either J5 or J6 connected individually; failure to keep these lines separate can lead to board shorts and problems with the I<sup>2</sup>C communication lines. See [Section 5.2.1](#) on how to configure the INA231EVM software to match the J5/J6 hardware setting.

### 3.6.4 External I<sup>2</sup>C Lines and Terminal Block T1

The I<sup>2</sup>C communication lines on the INA231EVM are tied to two sources: the internal I<sup>2</sup>C communication lines from the SM-USB-DIG and the terminal block T1. If the user wants to add external signals separate from the SM-USB-DIG, simply disconnect the SM-USB-DIG from the INA231EVM board and hook up the necessary SDA, SCL, and GND lines. Also, remember to apply an external supply to the lines that is compatible with the I<sup>2</sup>C communication device being used.

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#### Note

Failure to disconnect the SM-USB-DIG while using external I<sup>2</sup>C communication can cause damage to the SM-USB-DIG or any external communication devices that are connected.

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### 3.6.5 VIN+ and VIN- Input filter (R1, R2, and C1)

The INA231EVM has an optional input filter to remove high-frequency noise from the inputs VIN+ and VIN-. The default values for R1 and R2 are 0  $\Omega$ . Figure 3-5 shows the typical setup that TI recommends for basic INA231 evaluation.

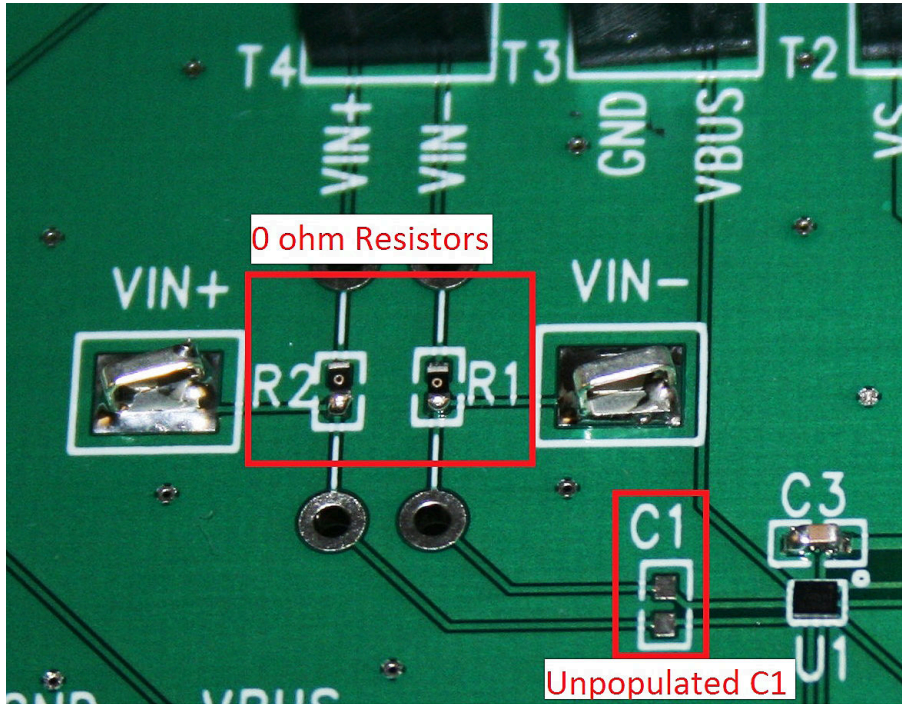


Figure 3-5. Typical Filter Setup

### 3.6.6 Shunt Monitor Configuration and Terminal Blocks T3 and T4

The INA231 is generally used in either a high-side or low-side shunt configuration, as shown in Figure 3-6. Terminal block T3 represents V<sub>BUS</sub> and ground, while terminal block T4 represents VIN+ and VIN-. Depending on the user's needs, either of these configurations may be used without making any changes to the INA231EVM board or software.

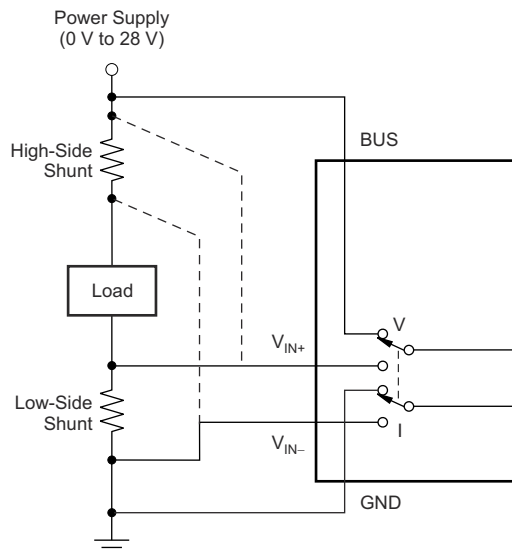


Figure 3-6. INA231 Shunt Configurations

## 4 INA231EVM Software Setup

This section discusses how to install the INA231EVM software.

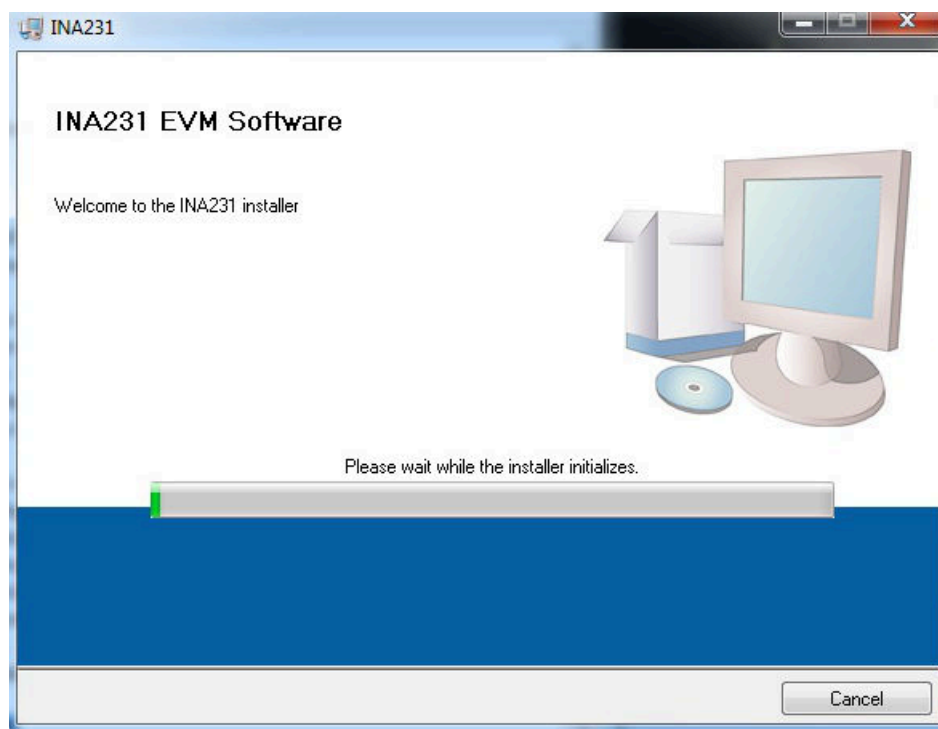
### 4.1 Operating Systems for the INA231EVM Software

The INA231EVM software has been tested on Microsoft® Windows® XP operating systems (OS) with United States and European regional settings. The software should also function on other Windows OS platforms.

### 4.2 Software Installation

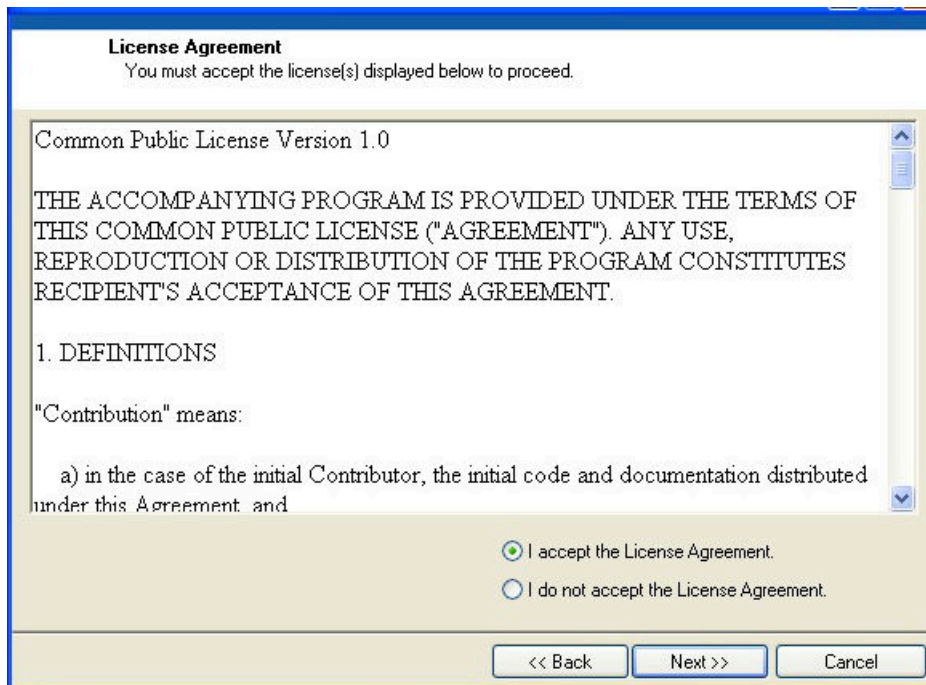
The INA231EVM software is included on the CD that is shipped with the EVM kit. The software is also available through the [INA231EVM product folder](#) on [www.ti.com](http://www.ti.com). To install the software to a computer, insert the disc into an available CD-ROM drive. Navigate to the drive contents and open the INA231EVM software folder. Locate the compressed file (*INA231EVM.zip*) and open it using WinZIP® or a similar file compression program; extract the INA231EVM files into a specific INA231EVM folder (for example, *C:\INA231EVM*) on your hard drive.

After the files are extracted, navigate to the INA231EVM folder created on the hard drive. Locate the *setup.exe* file and execute it to start the installation. The INA231 software installer file then begins the installation process as shown in [Figure 4-1](#).

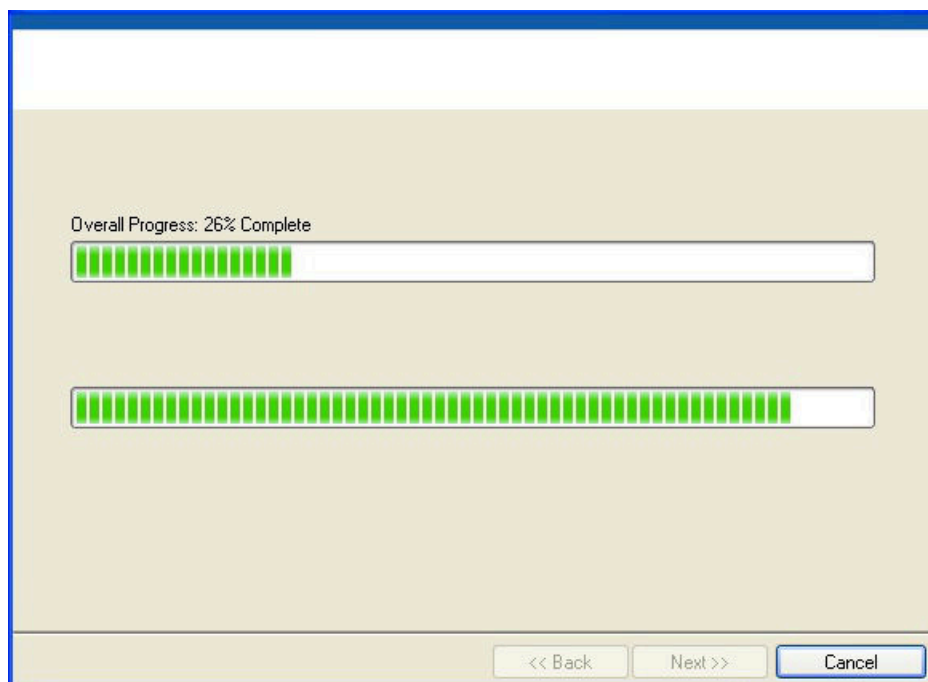


**Figure 4-1. INA231EVM Software Installation**

After the installation process initializes, the user is given the choice of selecting the directory in which to install the program; the default location is *C:\Program Files\INA231\* and *C:\Program Files\National Instruments\*. Following this option, two license agreements are presented that must be accepted, as shown in [Figure 4-2](#). After accepting the Texas Instruments and National Instruments license agreements, the progress bar opens and shows the installation of the software (see [Figure 4-3](#)). When the installation process is complete, click *Finish*.



**Figure 4-2. INA231EVM License Agreements**



**Figure 4-3. INA231EVM Software Installation Progress**

## 5 INA231EVM Software Overview

This section discusses how to use the INA231EVM software. Software operation involves a two-step process: configuration of the INA231 settings and operation of the tool.

### 5.1 Starting the INA231EVM Software

Users can operate the INA231 software through the Windows *Start* menu. From *Start*, select *All Programs*; then select the *INA231EVM* program.

Figure 5-1 shows how the software will appear if the INA231EVM is functioning properly.

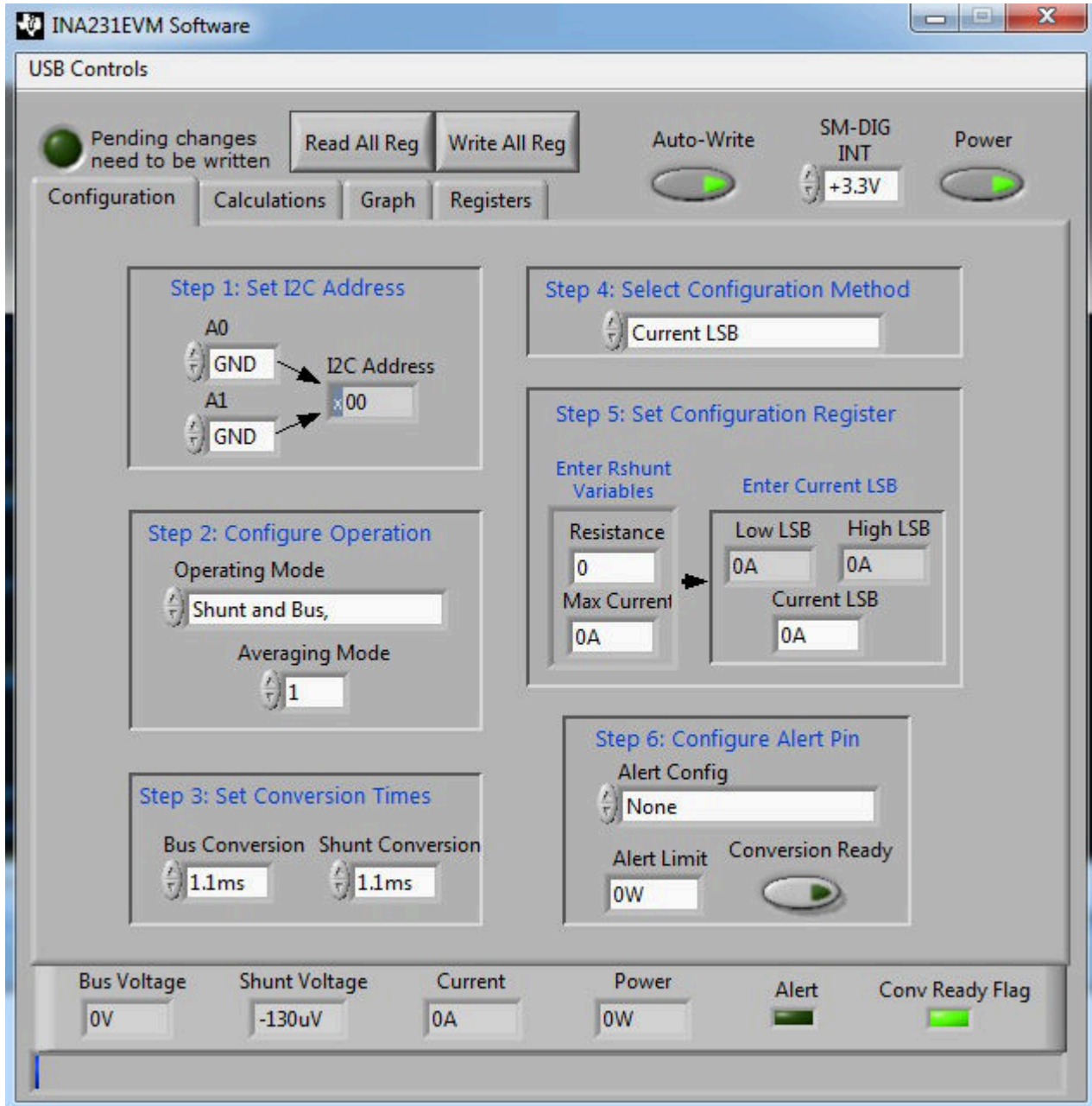
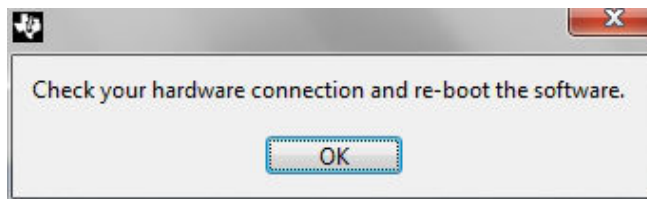


Figure 5-1. INA231EVM Software Interface

Figure 5-2 shows an error that pops up if the computer cannot communicate with the EVM. If you receive this error, first check to see that the USB cable is properly connected on both ends. This error can also occur if you connect the USB cable before the SM-USB-DIG Platform power source. Another reason for this error is that there may be an issue with the computer USB Human Interface Device Driver. Make sure that the device is recognized when the USB cable is plugged in; recognition is indicated by a Windows-generated confirmation sound.



**Figure 5-2. INA231EVM Software: Communication Error with the SM-USB-DIG Platform**

## 5.2 Configuring the INA231EVM Software

The INA231EVM software first requires a series of setup processes to configure the device and ensure that the device works properly. On the Configuration tab (see Figure 5-1), there are six steps noted:

1. Set I<sup>2</sup>C Address
2. Configure Operation
3. Set Conversion Times
4. Select Configuration Method
5. Set Configuration Register
6. Configure Alert Pin

This section explains how to configure the software and reviews some of the different setups that can be done.

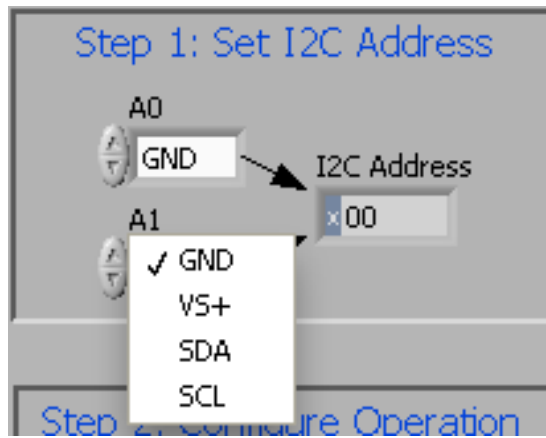
### 5.2.1 I<sup>2</sup>C Address Selection

The INA231 device has a flexible I<sup>2</sup>C address configuration that allows multiple devices on the same I<sup>2</sup>C lines. By moving the A0 and A1 addresses on jumpers J3-J6 to either GND, V<sub>S</sub>, SDA or SCL, the user can change the INA231 to a total of 16 I<sup>2</sup>C addresses (see Table 5-1).

**Table 5-1. INA231 I<sup>2</sup>C Address Configuration**

A1	A0	TARGET ADDRESS
GND	GND	1000000
GND	V <sub>S</sub>	1000001
GND	SDA	1000010
GND	SCL	1000011
V <sub>S</sub>	GND	1000100
V <sub>S</sub>	V <sub>S</sub>	1000101
V <sub>S</sub>	SDA	1000110
V <sub>S</sub>	SCL	1000111
SDA	GND	1001000
SDA	V <sub>S</sub>	1001001
SDA	SDA	1001010
SDA	SCL	1001011
SCL	GND	1001100
SCL	V <sub>S</sub>	1001101
SCL	SDA	1001110
SCL	SCL	1001111

Figure 5-3 shows how to configure the I<sup>2</sup>C addresses. Click the A0 or A1 box and select how to configure the hardware on the EVM. Failure to select the correct address prevents the INA231 device from communicating with the software.



**Figure 5-3. Setting the A1 Address**

### 5.2.2 Configure Operating Mode

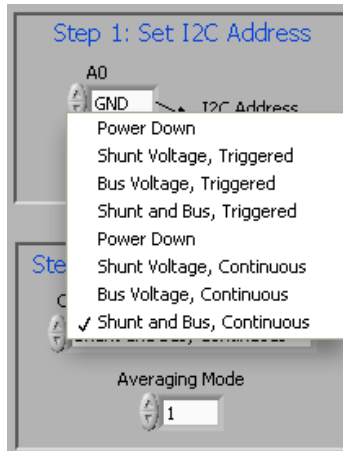
The second step of the INA231EVM configuration process allows the user to set the operating mode and the averaging mode.

The operating mode allows the user to restrict the amount of calculations done within the INA231 by changing the conversion to be triggered or continuous, or by shutting down the part altogether. When the device is operating in triggered mode, the device only performs conversions when the operating mode is set and the *Write All Reg* button at the top of the screen is selected. After the mode changes and *Write All Reg* is selected, the user must select the *Read All Reg* button to see the changes on the device reflected in the software.

When the INA231 is operating in continuous mode, conversions are performed directly after the previous conversion is complete. When the INA231EVM software is in continuous mode, the user can click the *Read All Reg* button to update the software at any time.

Power-down mode stops all conversions from taking place until the operating mode changes again. The device remains attached to power but draws minimal current and does not perform any conversions.

All three operating modes can also be limited to only measuring certain components of the device, as shown in [Figure 5-4](#). It is important to note that for complete functionality of the INA231, the user must choose a configuration with Shunt and Bus configuration. Failure to choose Shunt and Bus configuration disables a considerable portion of the unit functionality as discussed in the [INA231 data sheet](#).

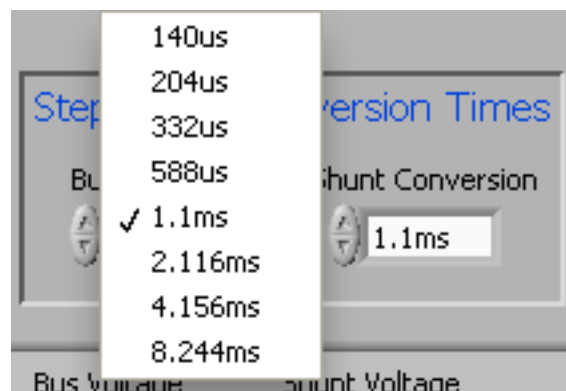


**Figure 5-4. Configuring Operating Mode**

The Configure Operation step also contains a drop-down box to select Averaging Mode. The user can set up the INA231 to take the average of several measurements before storing the value of the measurements in the register table.

### 5.2.3 Set Conversion Times

Setting the conversion times allows the user to customize the amount of measurement time for conversions. Typically, for the INA231EVM software, the user is not able to notice a visual difference between the conversion times unless a high averaging mode and conversion time are chosen. [Figure 5-5](#) shows the Shunt and Bus conversion times.



**Figure 5-5. Configuring Conversion Times**



### 5.2.4 Set Configuration Register

The user must set the Configuration Register correctly for the software to operate properly. There are two methods used to set the Configuration Register: first, the user can manually calculate the desired value and then input that value into the register table, as shown in Equation 1. Alternatively, the user can allow the software to create a recommended window and choose an LSB for the current as shown in Figure 5-7. Both methods accomplish the same goal by using Equation 1, but the method is selected by changing the value in Step 4: *Select Configuration Method* (as Figure 5-6 and Figure 5-7 show).

$$\text{Calibration Register} = \frac{0.00512}{\text{Current}_{\text{LSB}} \times R_{\text{SHUNT}}} \tag{1}$$

The current LSB is calculated by a recommended range in the INA231 data sheet as shown in Equation 2. It is important to note that with either of the methods used, the Current LSB and the Calibration Register values are calculated based on the other variable and the  $R_{\text{SHUNT}}$  value. See the section *Programming the INA231* in the [product data sheet](#) for more information on setting the Calibration Register value.

$$\frac{\text{Max Expected Current}}{2^{15}} \leq \text{Current}_{\text{LSB}} \leq \frac{\text{Max Expected Current}}{2^{12}} \tag{2}$$

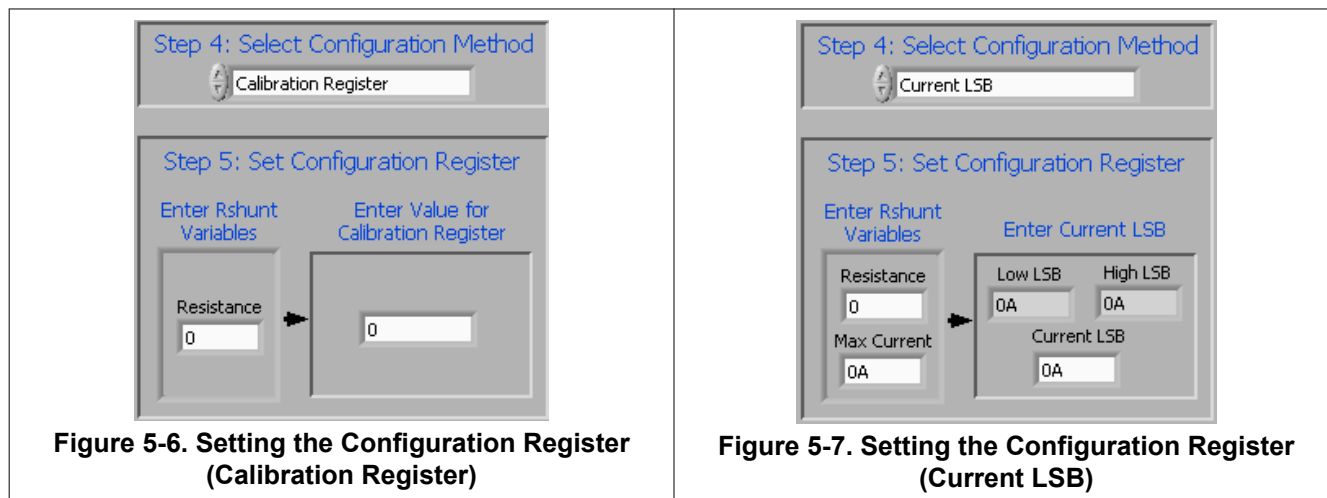


Figure 5-6. Setting the Configuration Register (Calibration Register)

Figure 5-7. Setting the Configuration Register (Current LSB)

### 5.2.5 Configuring the Alert Pin

The Alert Pin from the INA231 allows the user to set limits that monitor the registers and trigger a flag when they are exceeded. The user can change the register that is monitored by selecting the desired alert configuration as shown in Figure 5-8. The value considered is compared to the *Alert Limit* box. This Alert Limit box modifies the functionality based on the selected configuration. It is important to note that the INA231 Alert pin is set to active low by default.

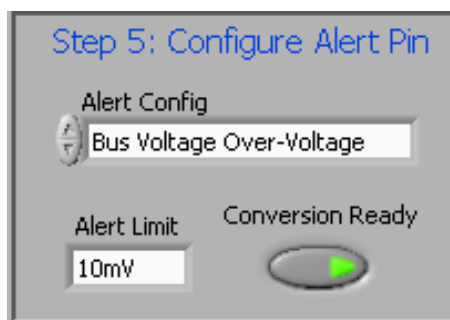


Figure 5-8. Configuring the Alert Pin

In addition to the INA231EVM software alert configuration, the Alert Configuration box includes the *Conversion Ready* button that allows for a special functionality on the Alert pin. When the INA231 completes the conversions for its current operation, the device triggers the Alert pin and notifies the user that another conversion can be performed. In most cases, the INA231 conversion ready flag is not visible because of the speed of the INA231 conversion process.

### 5.3 Using the INA231EVM Software

After configuring the INA231EVM software, the rest of the tabs can be evaluated. This section describes the basic operation of the device, and offers guidelines for interpreting the graphic user interface (GUI).

#### 5.3.1 INA231 Bus Voltage, Shunt Voltage, Current, and Power Reading Bar

The bottom bar of the INA231 software, as shown in [Figure 5-9](#), allows the user to constantly check the status of the INA231 unit itself. These values are updated each time the user clicks the *Read All Reg* button at the top of the software. In addition to the register values stored in the part, the software also includes flags for when the part is ready to trigger another conversion and when the Alert pin is triggered.

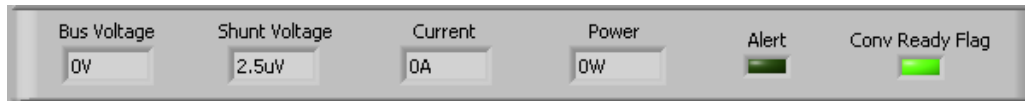


Figure 5-9. INA231 Results Bar

#### 5.3.2 Calculation and Theory of Operation

The Calculation tab, as shown in [Figure 5-10](#), allows the user to follow the software flow with basic calculations performed from within the device. It is important to note that the calculations are performed with the decimal values of the corresponding registers.

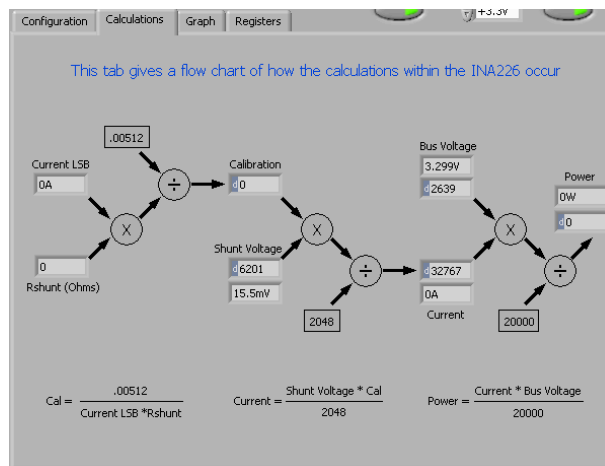


Figure 5-10. Theory of Operation Flowchart on the Calculation Tab

### 5.3.3 Register Tab

The Register tab contains information on the individual operation of the INA231 registers. Each register can be changed on a bit-by-bit basis to allow the user to have total control of the device beyond the general functionality of the GUI alone. Most of this functionality is displayed in the Configuration register tab, but by selecting the appropriate register and clicking the *Help With Reg* button on the Register tab, as shown in [Figure 5-11](#), the user can diagnose the individual uses of each bit in each register.

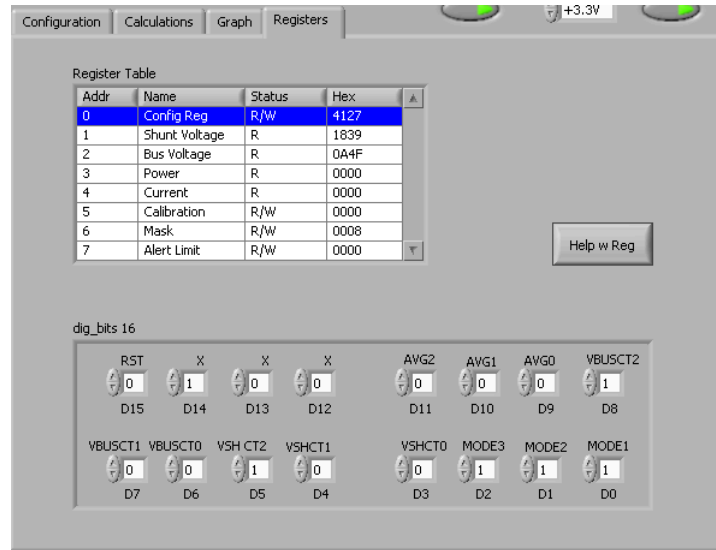


Figure 5-11. Registers Tab

### 5.3.4 Graph Tab

The Graph tab contains a plot window that shows the progression of data over time on the INA231. All four variables at the bottom of the EVM software ( $V_{BUS}$ ,  $V_{SHUNT}$ , Current, and Power) can be plotted using the drop-down box directly above the graph. After the desired plot has been selected, toggle the *Continuously Poll Data* button above the plot to begin polling for data. If the user desires to save the data from the plot, simply select the *USB Controls* drop-down at the top of the page, then select the *Start Graph Log* option. When the Start Graph Log is selected, the user is prompted to select a location for the data and to name the file.

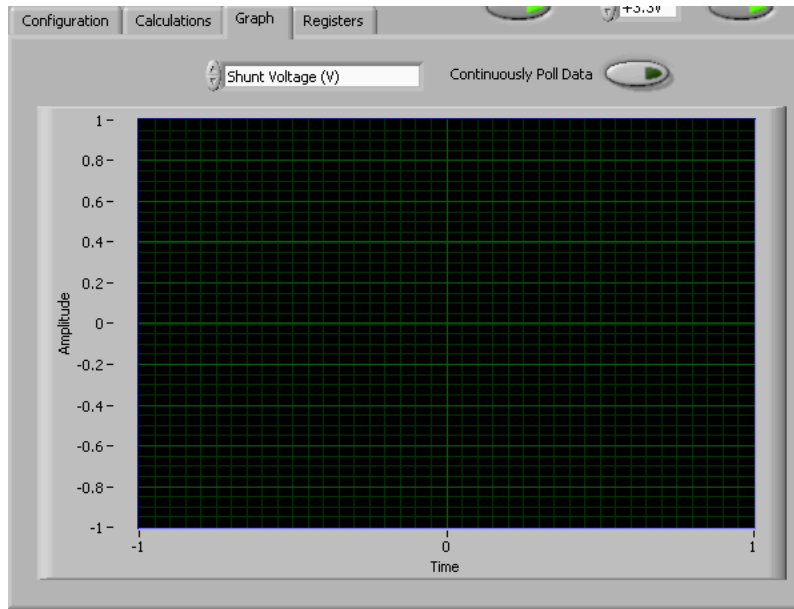


Figure 5-12. Graphing the INA231 Data

### 5.3.5 Auto-Write and the Supply Voltage

The INA231EVM software allows users to customize the board level voltage, regulated by the SM-USB-DIG. By selecting either 3.3 V or 5 V, the user can designate the operating voltage of the device.

The software also includes an Auto-Write feature shown in Figure 5-13, which is enabled by default. This feature automatically updates the register table whenever a change is made. When this feature is enabled, the *Write All Registers* button serves little purpose and is only used as an alternative to when Auto-Write is disabled.

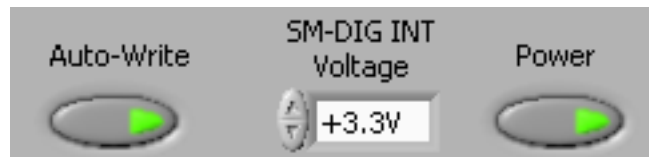


Figure 5-13. Auto-Write, Power Button, and Voltage Control

## 6 INA231EVM Documentation

This section contains the complete bill of materials, schematic diagram, and PCB layout for the INA231EVM.

---

### Note

The board layout is not to scale. This image is intended to show how the board is laid out; it is not intended to be used for manufacturing INA231EVM PCBs.

---

## 6.1 Schematic

Figure 6-1 shows the schematic for the INA231EVM.

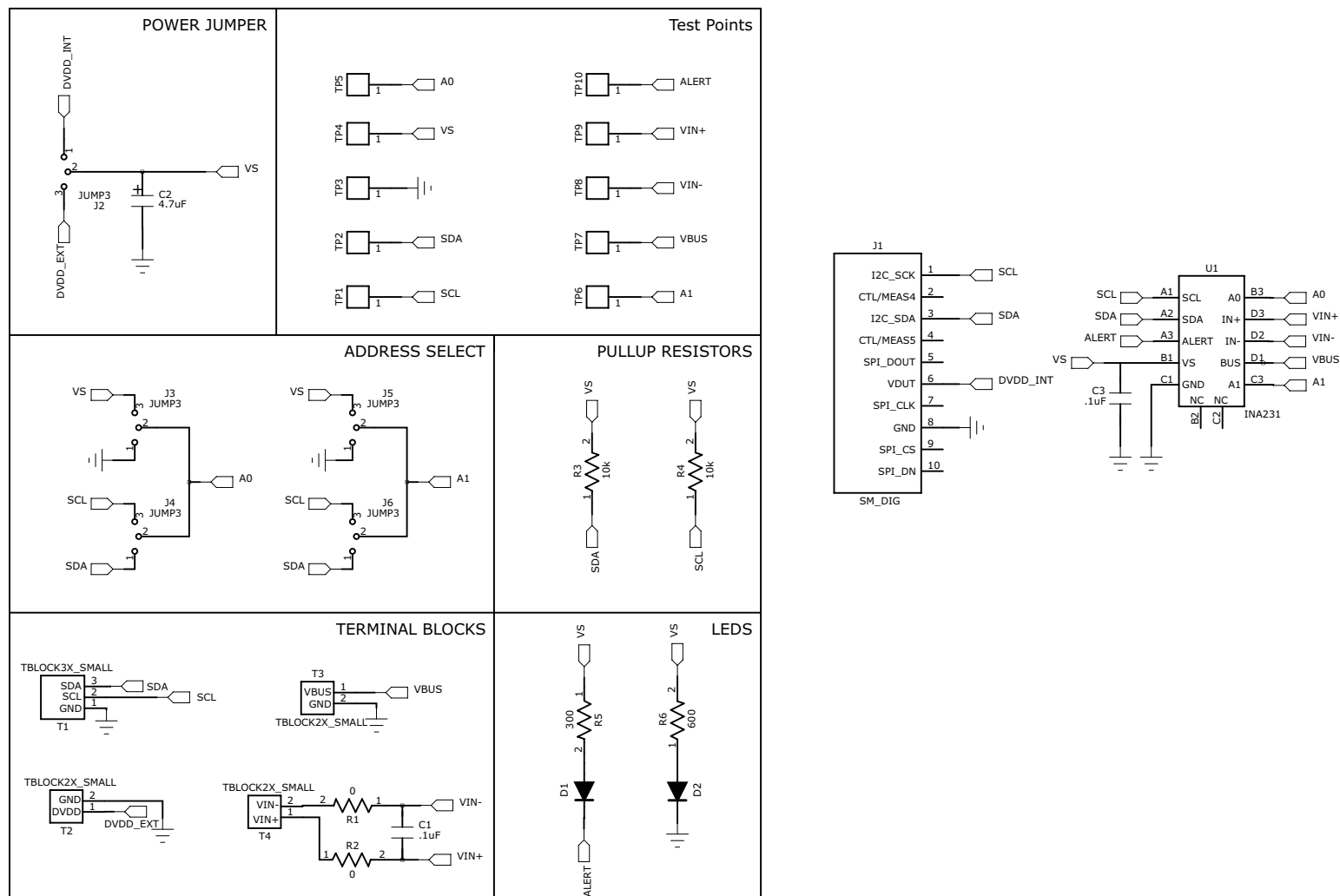


Figure 6-1. INA231EVM Schematic

## 6.2 PCB Layout

Figure 6-2 shows the component layout for the INA231EVM PCB.

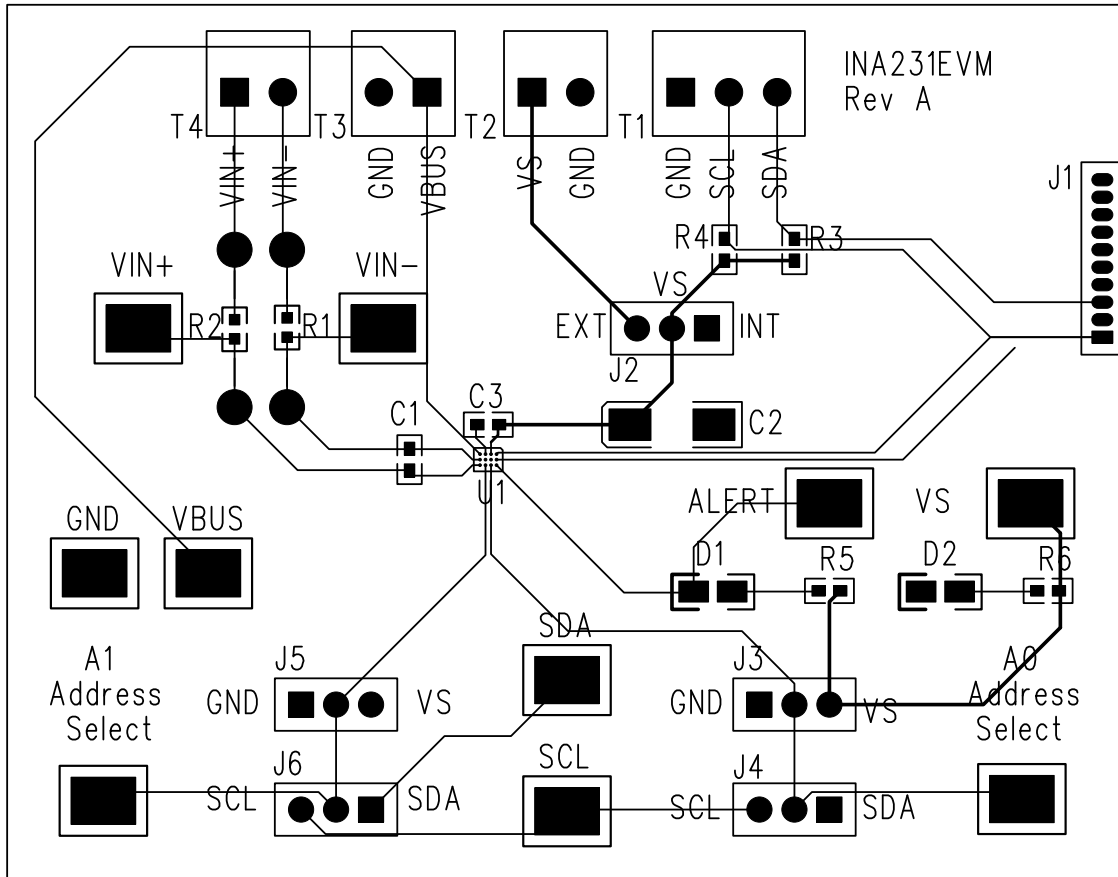


Figure 6-2. INA231EVM PCB Top Layer (Component Side)

## 6.3 Bill of Materials

Table 6-1 lists the bill of materials for the INA231EVM.

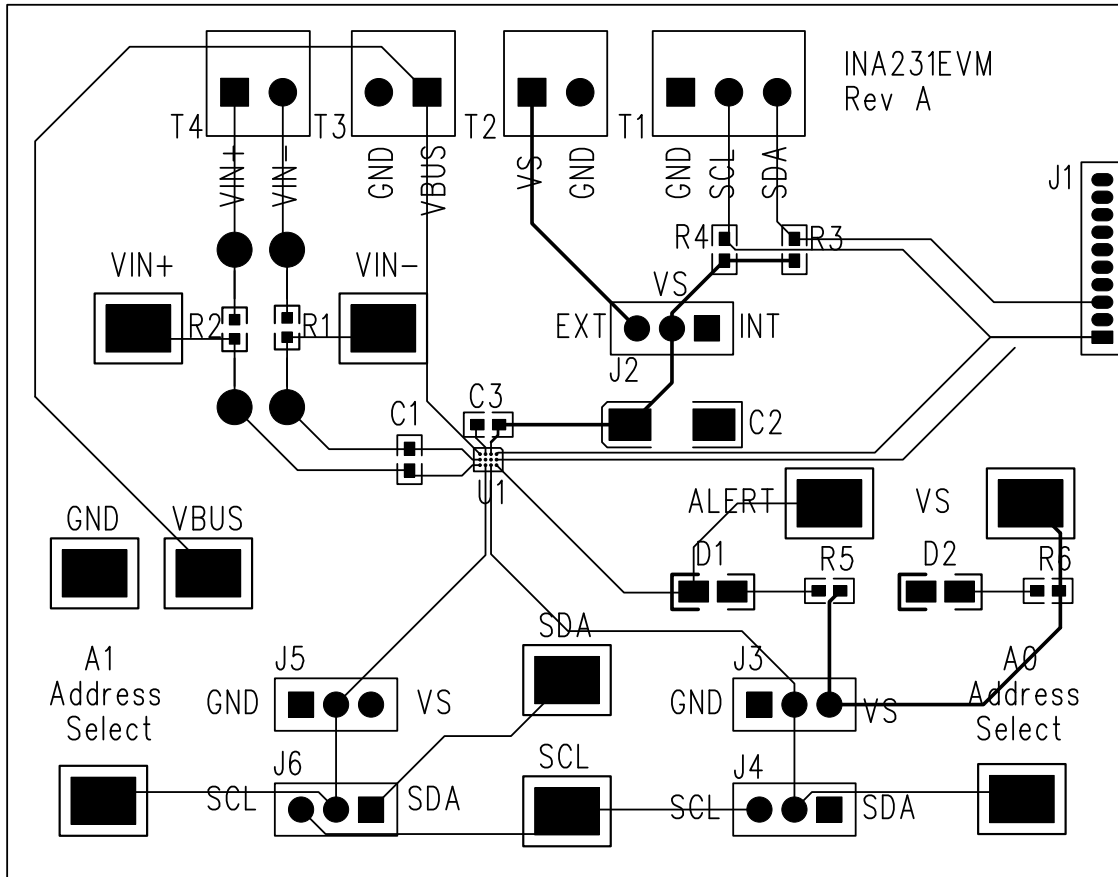
**Table 6-1. Bill of Materials: INA231EVM**

NO.	REF DES	DESCRIPTION	VENDOR OR MANUFACTURER	PART NUMBER
1	R5, R6	Resistor, 10 k $\Omega$ 1/10 W 5% 0603 SMD	Stackpole Electronics	RMCF0603JT10K0
2	R3, R4	Resistor, 300 $\Omega$ 1/10 W 5% 0603 SMD	Panasonic	ERJ-3GEYJ301V
3	R1, R2	Resistor, 0.0 $\Omega$ 1/10 W 0603 SMD	Stackpole Electronics	RMCF0603ZT0R00
4	C2	Capacitor, Tantalum 4.7 $\mu$ F 35 V 10% SM	AVX Corp.	TAJC475K035RNJ
5	C3, C4	Capacitor, Ceramic 0.10 $\mu$ F 25 V X7R 10% 0603	TDK Corp.	C1608X7R1E104K
6	D1, D2	LED Green Wide Angle 0603 SMD	Panasonic	LNJ3W0C83RA
7	U1	INA231 Current Shunt Monitor	Texas Instruments	INA231AIYFF
8	Jumpers All	Connector, Header 50-Position .100" SGL Gold	Samtec	TSW-150-07-G-S
9	Jumpers All	Shunt LP w/Handle 2-Pos 30AU	Tyco Electronics	881545-2
10	Test Points All	PC Test Point Compact SMT	Keystone Electronics	5016
11	T1	3-Block Terminal 3.5 mm	On Shore Technology Inc	ED555/3DS
12	T2, T3, T4	2-Block Terminal 3.5 mm	On Shore Technology Inc	ED555/2DS
13	Bumpons	Bumpon Hemisphere 0.50 x 0.14 Clear	3M	SJ-5312 (CLEAR)
14	J1	Connector, Socket RT Angle 1-Position 0.050	Mill-Max Manufacturing	851-93-10-20-001000



## 6.2 PCB Layout

Figure 6-2 shows the component layout for the INA231EVM PCB.



**Figure 6-2. INA231EVM PCB Top Layer (Component Side)**

## 6.3 Bill of Materials

Table 6-1 lists the bill of materials for the INA231EVM.

**Table 6-1. Bill of Materials: INA231EVM**

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3	R1, R2	Resistor, 0.0 $\Omega$ 1/10 W 0603 SMD	Stackpole Electronics	RMCF0603ZT0R00
4	C2	Capacitor, Tantalum 4.7 $\mu$ F 35 V 10% SM	AVX Corp.	TAJC475K035RNJ
5	C3, C4	Capacitor, Ceramic 0.10 $\mu$ F 25 V X7R 10% 0603	TDK Corp.	C1608X7R1E104K
6	D1, D2	LED Green Wide Angle 0603 SMD	Panasonic	LNJ3W0C83RA
7	U1	INA231 Current Shunt Monitor	Texas Instruments	INA231AIYFF
8	Jumpers All	Connector, Header 50-Position .100" SGL Gold	Samtec	TSW-150-07-G-S
9	Jumpers All	Shunt LP w/Handle 2-Pos 30AU	Tyco Electronics	881545-2
10	Test Points All	PC Test Point Compact SMT	Keystone Electronics	5016
11	T1	3-Block Terminal 3.5 mm	On Shore Technology Inc	ED555/3DS
12	T2, T3, T4	2-Block Terminal 3.5 mm	On Shore Technology Inc	ED555/2DS
13	Bumpons	Bumpon Hemisphere 0.50 x 0.14 Clear	3M	SJ-5312 (CLEAR)
14	J1	Connector, Socket RT Angle 1-Position 0.050	Mill-Max Manufacturing	851-93-10-20-001000

## 7 Revision History

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

<b>Changes from Revision * (February 2013) to Revision A (March 2023)</b>	<b>Page</b>
• Changed user guide title for INA231EVM (Rev A) hardware support.....	<a href="#">1</a>
• Changed all instances of legacy terminology to controller and target where I <sup>2</sup> C is mentioned.....	<a href="#">14</a>

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### 3 Regulatory Notices:

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

**FCC NOTICE:** 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 or RSS-247

#### **Concerning EVMs Including Radio Transmitters:**

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

#### **Concernant les EVMs avec appareils radio:**

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

#### **Concerning EVMs Including Detachable Antennas:**

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

### Concernant les EVMs avec antennes détachables

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

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<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

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If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

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

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- 
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    - 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:*
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      - 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.
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