User's Guide
SBOU124–March 2012

INA230EVM Evaluation Board and Software Tutorial

This user's guide describes the characteristics, operation, and use of the INA230EVM evaluation board. It discusses how to set up and configure the software and hardware, and reviews various aspects of the program operation. Throughout this document, the terms *evaluation board*, *evaluation module*, and *EVM* are synonymous with the INA230EVM. 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.

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1 Overview

The INA230 is a high-side current sensor and power monitor with an I²C™ interface. The INA230 monitors both current and supply voltage, with programmable conversion times and averaging modes. The INA230EVM is a platform for evaluating the performance of the INA230 under various signal, shunt, and supply conditions.

This document gives a general overview of the INA230EVM, and provides a general description of the features and functions to be considered while using this evaluation module.

1.1 INA230EVM Kit Contents

Table 1 summarizes the contents of the INA230EVM kit. Figure 1 shows all of the included hardware. Contact the Texas Instruments Product Information Center nearest you if any component is missing. It is highly recommended that you also check the INA230 product folder on the TI web site at www.ti.com to verify that you have the latest versions of the related software.

Table 1. INA230EVM Kit Contents

Item	Quantity
INA230EVM PCB Test Board	1
SM-USB-DIG Platform PCB	1
USB Extender Cable	1
SM-Dig Connector Ribbon Cable	1
User's Guide CD-ROM	1

Figure 1. Hardware Included with INA230EVM Kit

1.2 Related Documentation from Texas Instruments

The following documents provide information regarding Texas Instruments' integrated circuits used in the assembly of the INA230EVM. This user's guide is available from the TI web site under literature number ***SBOU124***. 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, 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
INA230 Product Data Sheet	SBOS601
SM-USB-DIG Platform User Guide	SBOU098

2 INA230EVM Hardware Setup

Figure 2 shows the overall system setup for the INA230EVM. 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 INA230 test board. Connectors on the INA230EVM test board allow the user to connect to the system under test conditions to monitor the power, current, and voltage.

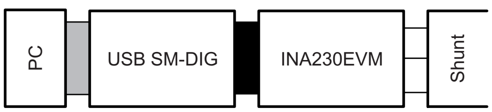

Figure 2. INA230EVM Hardware Setup

2.1 Theory of Operation for INA230 Hardware

A block diagram of the INA230 test board hardware setup is shown in Figure 3. The PCB provides connections to the I²C interface and general-purpose inputs/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.

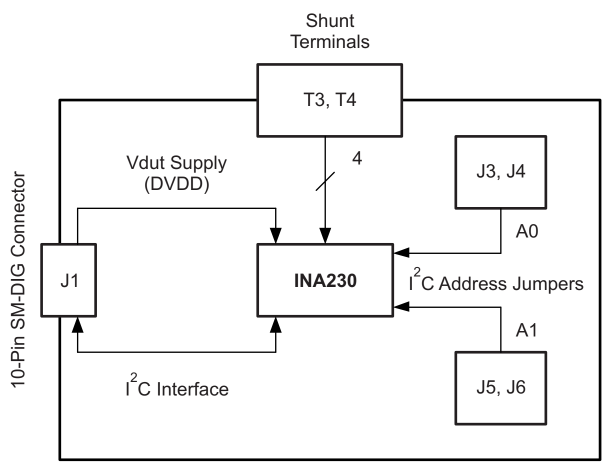

Figure 3. INA230EVM Test Board Block Diagram

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

Table 3 lists the pinout for the 10-pin connector socket used to communicate between the INA230EVM and the SM-USB-DIG. It should be noted that the INA230EVM only uses the necessary I^2C communication lines (pins 1 and 3) and the V_{DUT} and GND pins (pin 6 and pin 8) to issue commands to the INA230 chip.

Table 3. Signal Definition of J1 on INA230EVM Board

Pin on J1	Signal	Description
1	I2C_SCL	I^2C Clock Signal (SCL)
2	CTRL/MEAS4	GPIO: Control Output or Measure Input
3	I2C_SDA1	I^2C Data Signal (SDA)
4	CTRL/MEAS5	GPIO: Control Output or Measure Input
5	SPI_DOUT1	SPI Data Output (MOSI)
6	V_{DUT}	Switchable DUT Power Supply: +3.3 V, +5 V, Hi-Z (Disconnected)[(1)]
7	SPI_CLK	SPI Clock Signal (SCLK)
8	GND	Power Return (GND)
9	SPI_CS1	SPI Chip Select Signal ($\overline{CS}$)
10	SPI_DIN1	SPI Data Input (MISO)

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

2.2.1 Theory of Operation for SM-USB-DIG Platform

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 its operation are included in a separate document, SBOU098 (available for download at www.ti.com). The block diagram shown in Figure 4 gives a brief overview of the platform. The primary control device on the SM-USB-DIG Platform is the TUSB3210. The TUSB3210 is an 8052 microcontroller that has an onboard USB interface. The microcontroller receives information from the host computer that it interprets into power, I^2C, 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 it is interpreted by the host computer.

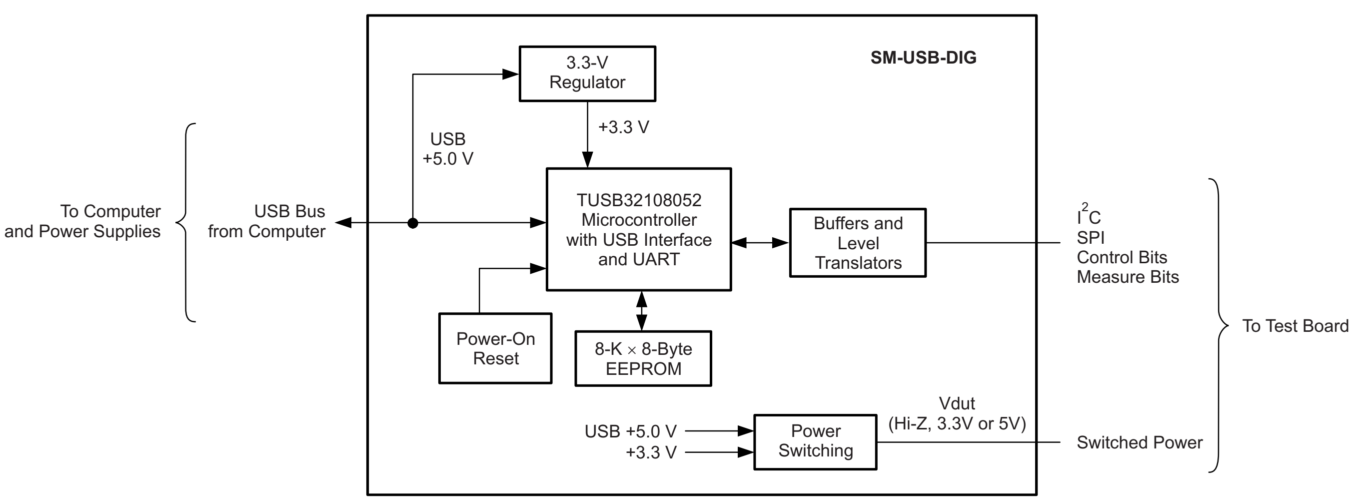

Figure 4. SM-USB-DIG Platform Block Diagram

3 INA230EVM Hardware

Setting up the INA230EVM hardware involves connecting the two PCBs of the EVM together, applying power, connecting the USB cable, and setting the jumpers. This section presents the details of this procedure.

3.1 Electrostatic Discharge Warning

CAUTION

Many of the components on the INA230EVM 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 INA230EVM and connect the two PCBs of the EVM together (that is, the INA230 Test Board and SM-USB-DIG Platform board), gently slide the male and female 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 conjoined, as Figure 5 illustrates, connect the desired V_{BUS} and shunt configuration intended to be measured. Typically, setup involves a high- or low-side load and a shunt resistor across VIN+ and VIN–. The setup in Figure 5 represents a test scenario with a low-side shunt attached. This source for V_{BUS} is not included with the kit, and its 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.

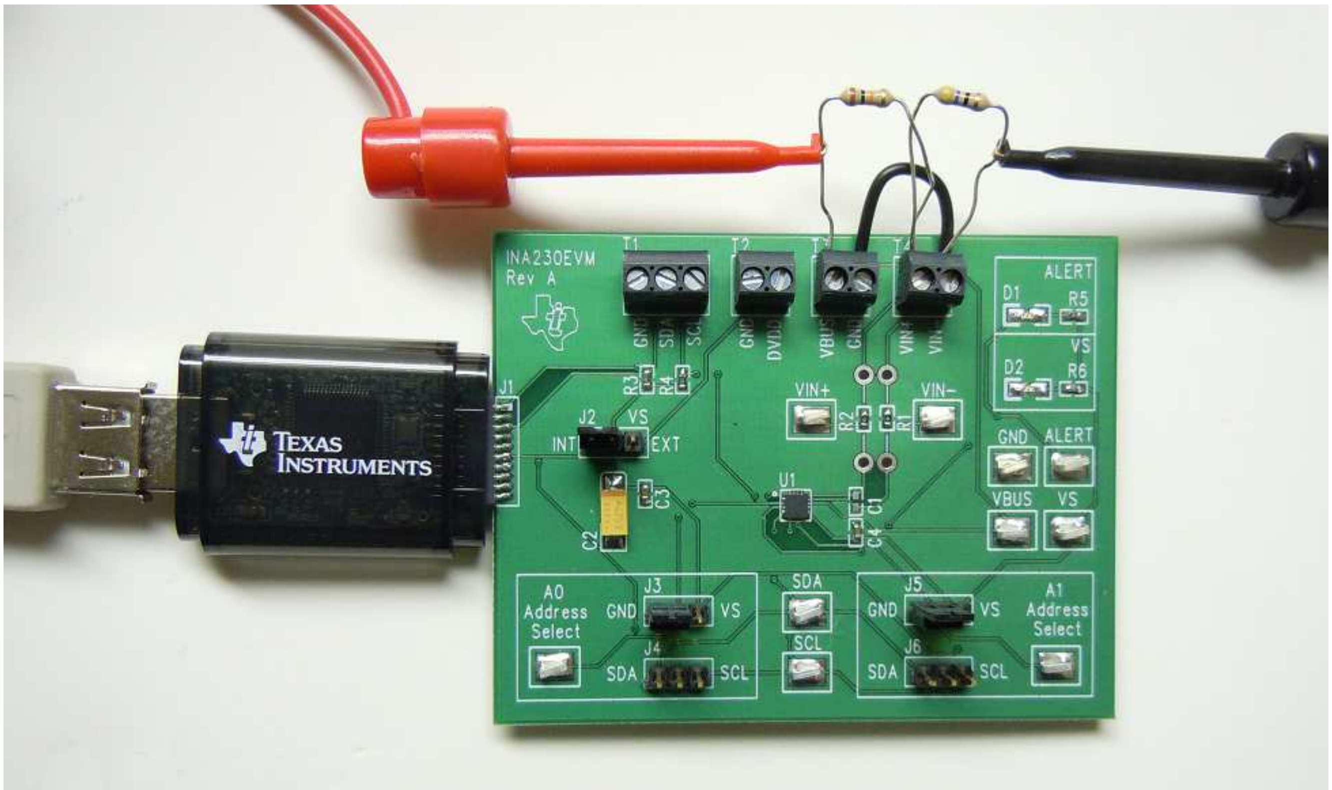

Figure 5. Typical Hardware Test Connections for the INA230EVM

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

Once power is connected, as shown in Figure 6, 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 to be used. The SM-USB-DIG Platform uses the human interface device drivers that are part of the Microsoft® Windows® operating system.

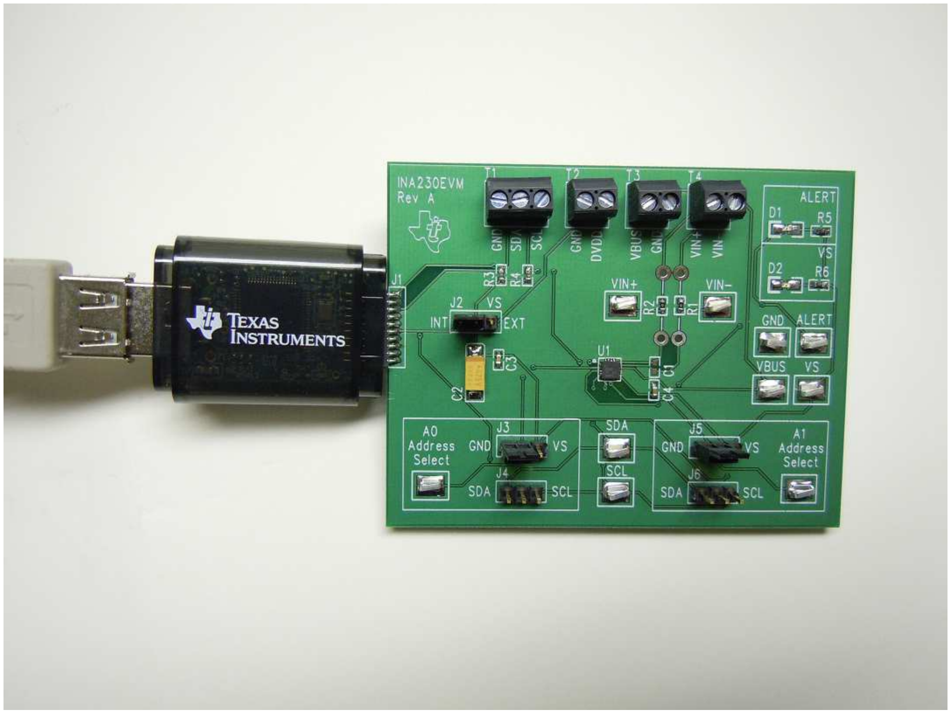

Figure 6. Connecting the USB Cable to the SM-USB-DIG Platform

In some cases, the Windows *Add Hardware Wizard* may pop up. If this prompt appears, allow the system device manager to install the human interface drivers by clicking **Yes** when requested to install drivers. Windows then confirms installation of the drivers with the message shown in Figure 7.

Figure 7. Confirmation of SM-USB-DIG Platform Driver Installation

3.5 INA230EVM Default Jumper Settings

Figure 8 shows the default jumper configuration for the INA230EVM. In general, the jumper settings of the SM-USB-DIG Platform do not need to be changed. You may want to change some of the jumpers on the INA230EVM board to match your specific configuration. For example, you may wish to set a specific I^2C address by configuring J3-J6.

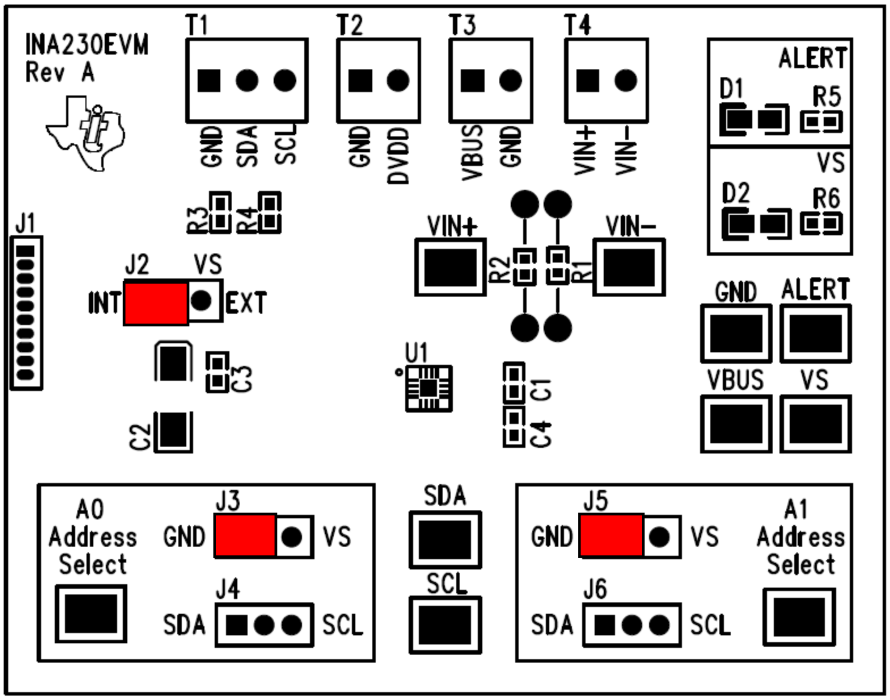

Figure 8. INA230EVM Default Jumper Settings

Typically, jumper 2 on the INA230EVM is always set to the INT position. When set to the INT position, the SM-USB-DIG Platform provides the supply for the INA230. 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 INA230.

Jumpers 3 through 6 control the I^2C address pins for the INA230. 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. For more information on the INA230 addressing, refer to the INA230 product data sheet.

Table 4 summarizes the function of the INA230 Test Board jumpers. For most applications, all jumpers should be left in the respective default configurations.

Table 4. INA230EVM Test Board Jumper Functions

Jumper	Default	Purpose
J2	INT	This jumper selects whether the V_S pin on the INA230 is connected to the V_{DUT} 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_S pin to the V_{DUT} control signal.
J3/J4	GND	This jumper selects the I^2C A0 address selection for A0.
J5/J6	GND	This jumper selects the I^2C A1 address selection for A1.

3.6 INA230EVM Features

This section describes some of the hardware features present on the INA230EVM test board.

3.6.1 J2: I²C V_S Control Setting

Jumper J2 selects what the INA230 supply pin is connected to. If J2 is set to the INT position, the V_S pin is connected to the switchable V_{DUT} 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_S Power button in the INA230EVM software is able to control whether the V_{DUT} 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 INA230.

3.6.2 J3 and J4: I²C Address Hardware Setting (A0)

Jumpers J3 and J4 are used to set the hardware setting for the A0 I²C address pin on the INA230. Using J3, the A0 address can be set to either a logic '1' or a logic '0'. Using J4, the A0 address can be set 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 I²C communication lines. See Section 5.2.1 on how to configure the INA230EVM software to match the J3/J4 hardware setting.

3.6.3 J5 and J6: I²C Address Hardware Setting (A1)

Jumpers J5 and J6 are used to set the hardware setting for the A1 I²C address pin on the INA230. Using J3, the A1 address can be set to either a logic '1' or a logic '0'. Using J4, the A1 address can be set 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 I²C communication lines. See Section 5.2.1 on how to configure the INA230EVM software to match the J5/J6 hardware setting.

3.6.4 External I²C Lines and Terminal Block T1

The I²C communication lines on the INA230EVM are tied to two sources: the internal I²C 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 INA230EVM 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 I²C communication device being used.

NOTE: Failure to disconnect the SM-USB-DIG while using external I²C communication can cause damage to the SM-USB-DIG or any external communication devices that are connected.

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

The INA230EVM has an optional input filter to remove high-frequency noise from the inputs VIN+ and VIN–. This filter is typically unpopulated. The default values for R1 and R2 are 0-Ω resistors. Figure 9 shows the typical setup, which is recommended for basic INA230 evaluation.

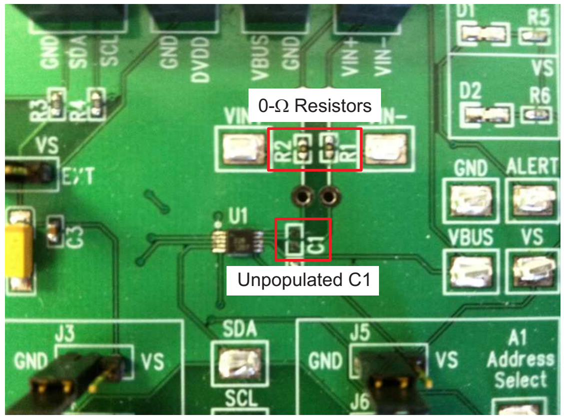

Figure 9. Typical Filter Setup

3.6.6 Shunt Monitor Configuration and Terminal Blocks T3 and T4

The INA230 is generally used in either a high-side or low-side shunt configuration, as shown in Figure 10. Terminal block T3 represents V_{BUS} 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 INA230EVM board or software.

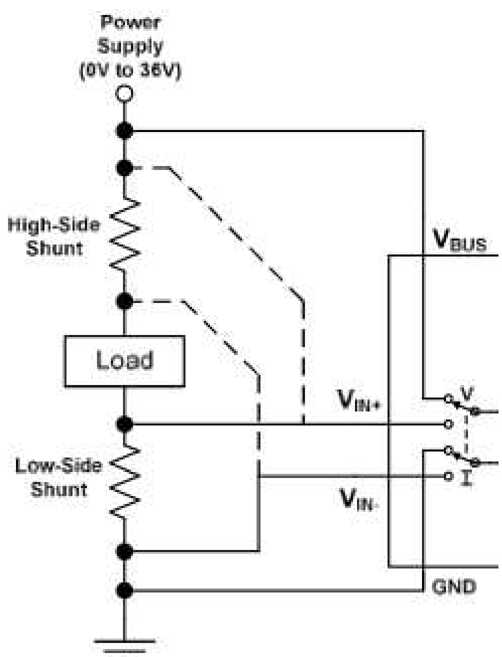

Figure 10. INA230 Shunt Configurations

4 INA230EVM Software Setup

This section discusses how to install the INA230EVM software.

4.1 Operating Systems for the INA230EVM Software

The INA230EVM 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 INA230EVM software is included on the CD that is shipped with the EVM kit. It is also available through the INA230EVM product folder on 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 theINA230EVM software folder. Locate the compressed file (*INA230EVM.zip*) and open it using WinZIP® or a similar file compression program; extract the INA230EVM files into a specific INA230EVM folder (for example, *C:\INA230EVM*) on your hard drive.

Once the files are extracted, navigate to the INA230EVM folder you created on the hard drive. Locate the *setup.exe* file and execute it to start the installation. The INA230 software installer file then begins the installation process as shown in Figure 11.

Figure 11. INA230EVM 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\INA230* and *C:\Program Files\National Instruments*. Following this option, two license agreements are presented that must be accepted, as shown in Figure 12. After accepting the Texas Instruments and National Instruments license agreements, the progress bar opens and shows the installation of the software, as Figure 13 illustrates. Once the installation process is completed, click **Finish**.

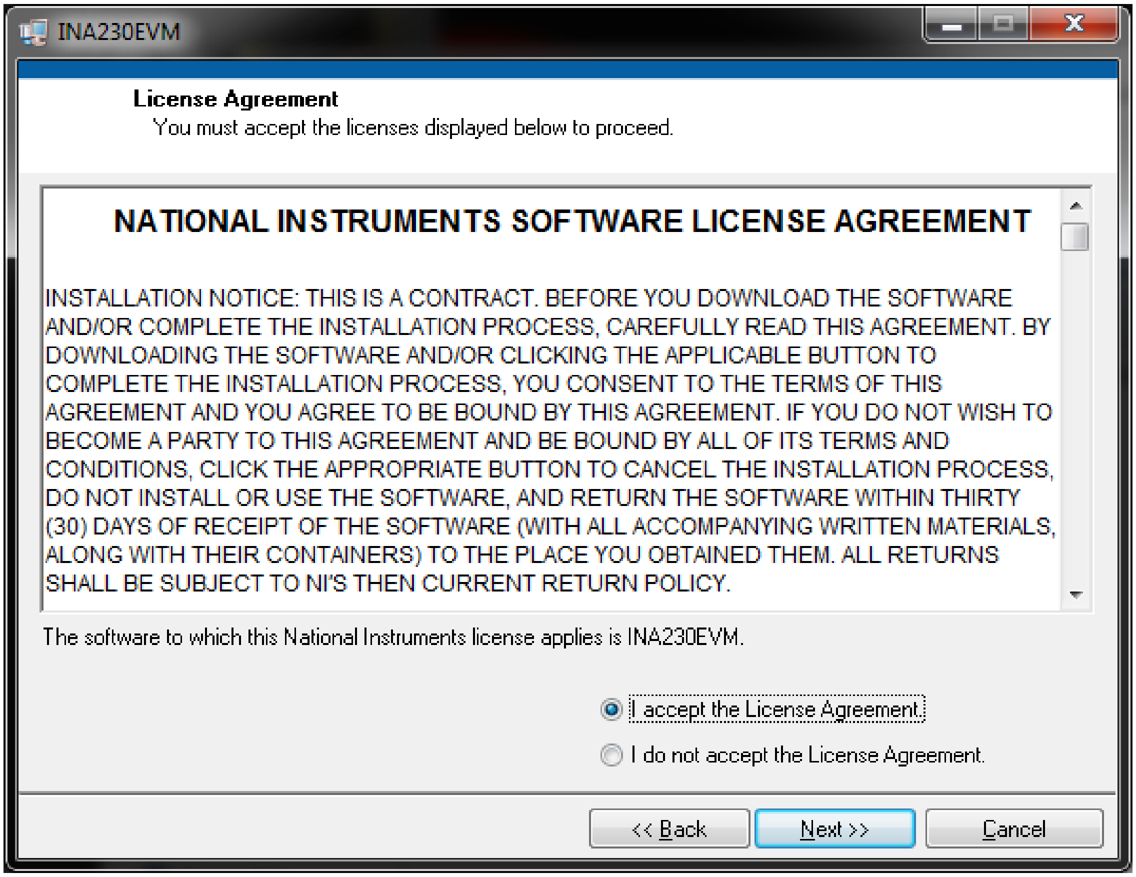

Figure 12. INA230EVM License Agreements

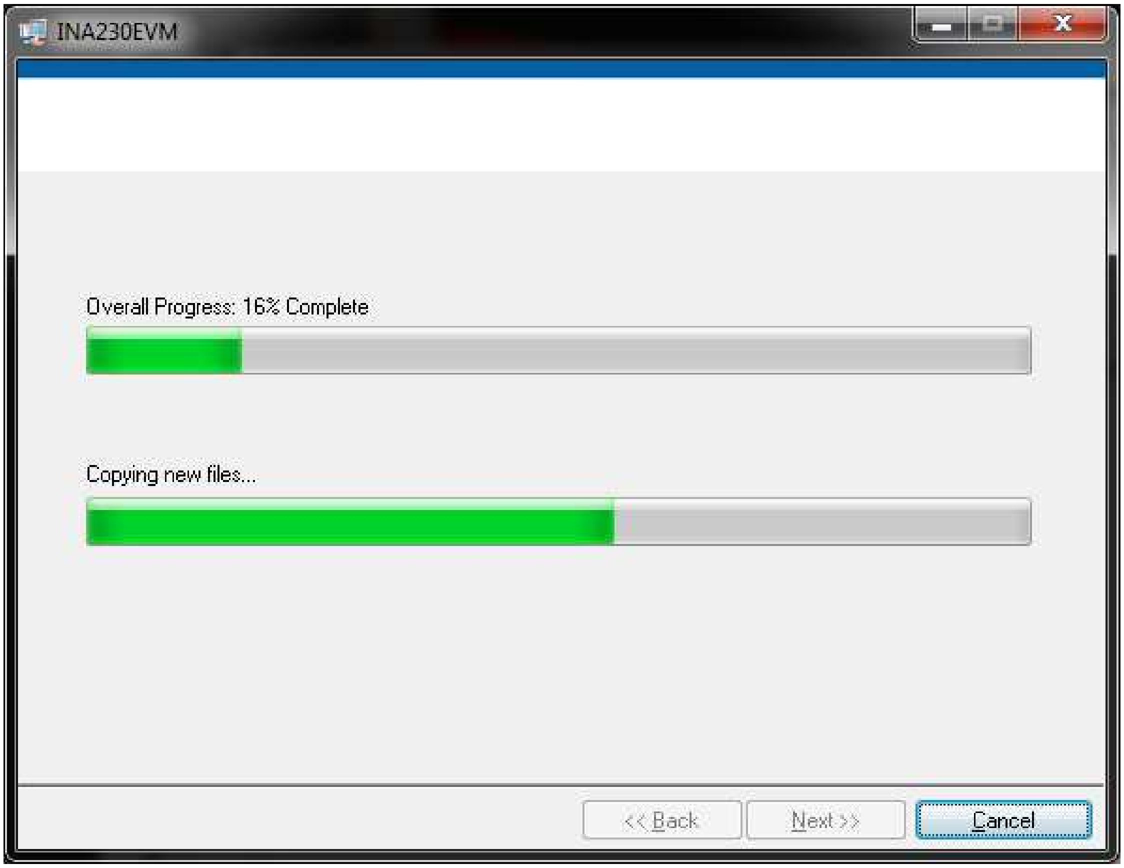

Figure 13. INA230EVM Software Installation Progress

5 INA230EVM Software Overview

This section discusses how to use the INA230EVM software. Software operation involves a two-step process: configuration of the INA230 settings, and operation of the tool.

5.1 Starting the INA230EVM Software

The INA230 software can be operated through the Windows *Start* menu. From Start, select *All Programs*; then select the *INA230EVM* program.

Figure 14 illustrates how the software should appear if the INA230EVM is functioning properly.

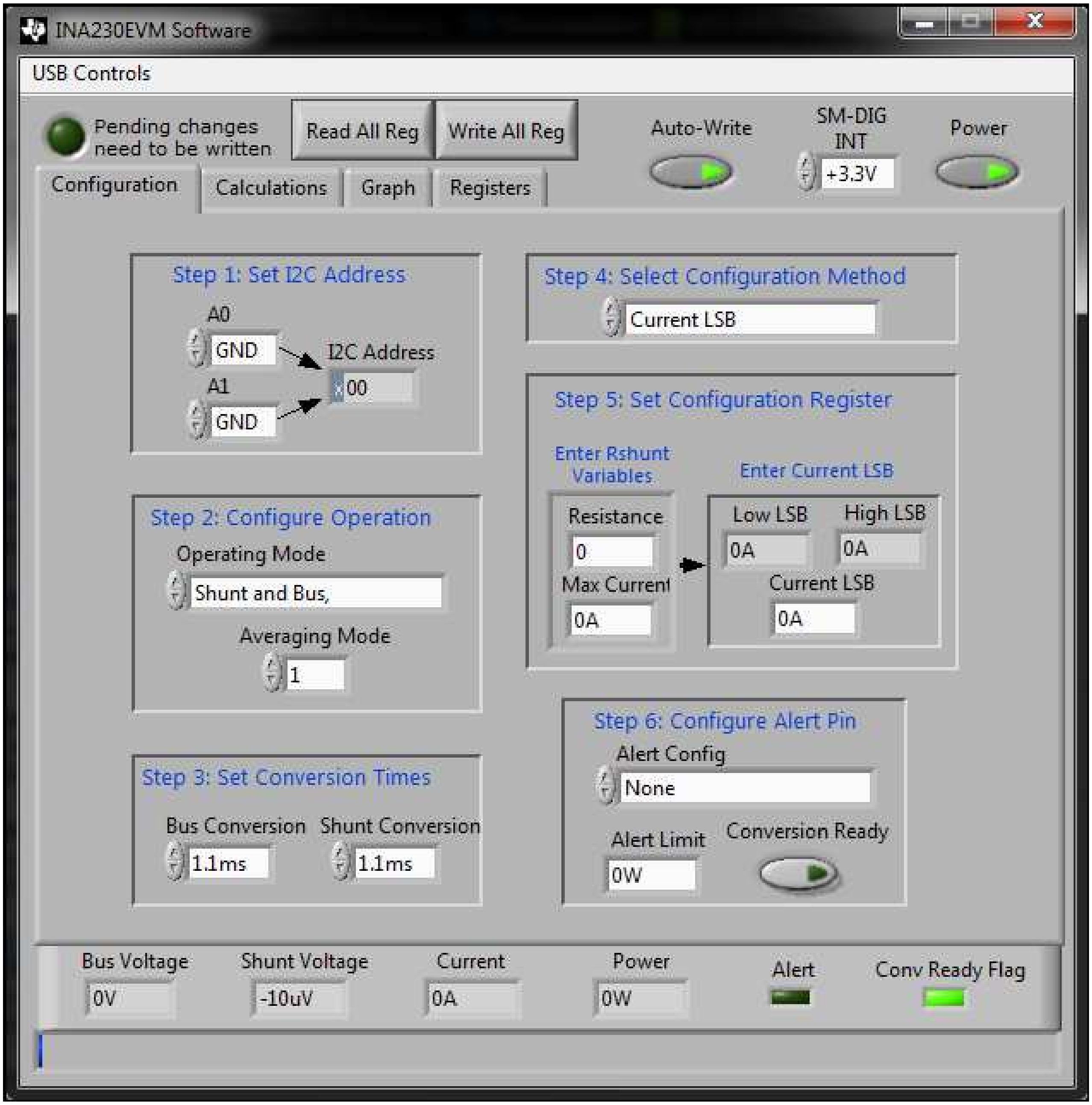

Figure 14. INA230EVM Software Interface

Figure 15 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 possible source for this error is a problem with your PC 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 15. INA230EVM Software: Communication Error with the SM-USB-DIG Platform

5.2 Configuring the INA230EVM Software

The INA230EVM software first requires a series of setup processes to configure the device and ensure that it works properly. On the Configuration tab (see Figure 14), there are six steps noted:

Step 1. Set I²C Address

Step 2. Configure Operation

Step 3. Set Conversion Times

Step 4. Select Configuration Method

Step 5. Set Configuration Register

Step 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 I²C Address Selection

The INA230 device has a flexible I²C address configuration that allows for multiple devices to be on the same I²C lines. By moving the A0 and A1 addresses on jumpers J3-J6 to either GND, V_S, SDA or SCL, the INA230 can be changed to a total of 16 I²C addresses as shown in Table 5.

Table 5. INA230 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

Figure 16 illustrates how to configure the I²C addresses. Click on either the A0 or A1 box and select how the hardware is configured on the EVM. Failure to select the correct address prevents the INA230 device from communicating with the software.

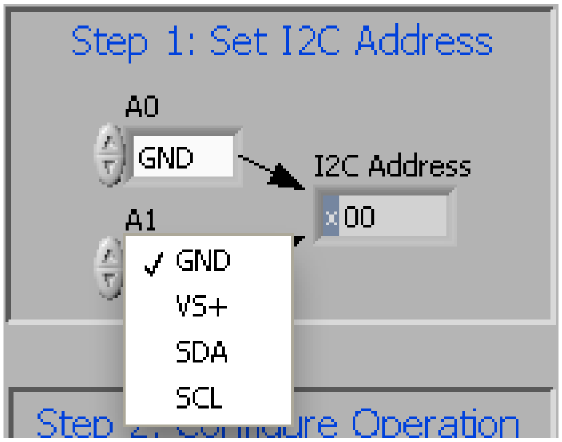

Figure 16. Setting the A1 Address

5.2.2 Configure Operating Mode

The second step of the INA230EVM 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 INA230 by changing the conversion to be triggered or continuous, or shutting down the part altogether. When the device is operating in triggered mode, it 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** has been selected, the **Read All Reg** button must also be selected in order for the changes on the device to be reflected in the software.

When the INA230 is operating in continuous mode, conversions are performed directly after the previous conversion is completed. When the INA230EVM software is in continuous mode, the software can be updated at any time by pressing the **Read All Reg** button.

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 17. It is important to note that for complete functionality of the INA230, a configuration must be chosen with Shunt and Bus configuration. Failure to choose Shunt and Bus configuration disables a considerable portion of the unit functionality as discussed in the INA230 data sheet.

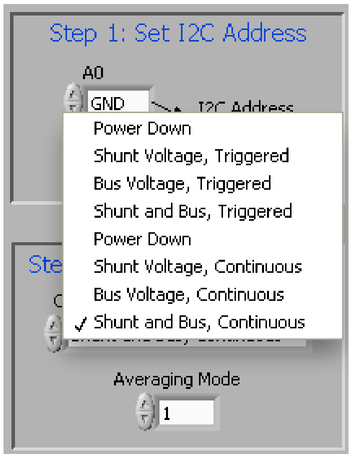

Figure 17. Configuring Operating Mode

The Configure Operation step also contains a drop down box for selecting the Averaging Mode. The INA230 can be setup 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 INA230EVM 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. The Shunt and Bus conversion times can be set as shown in Figure 18.

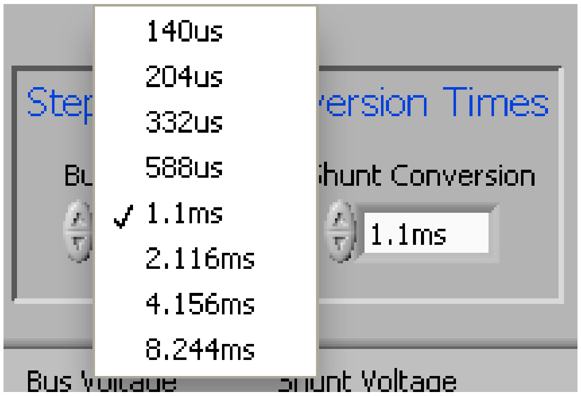

Figure 18. Configuring Conversion Times

5.2.4 Set Configuration Register

The Configuration Register must then be set 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 20. 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 19 and Figure 20 show).

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

The current LSB is calculated by a recommended range in the INA230 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_{SHUNT} value. See the section, *Programming the INA230* in the product data sheet for more information on setting the Calibration Register value.

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

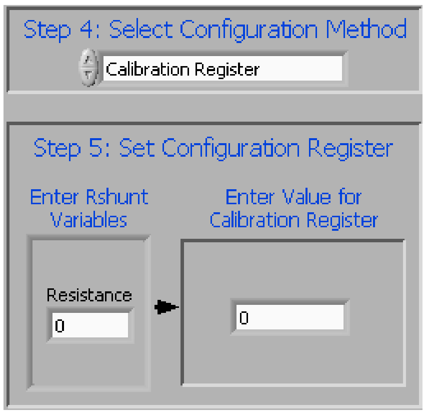

Figure 19. Setting the Configuration Register (Calibration Register)

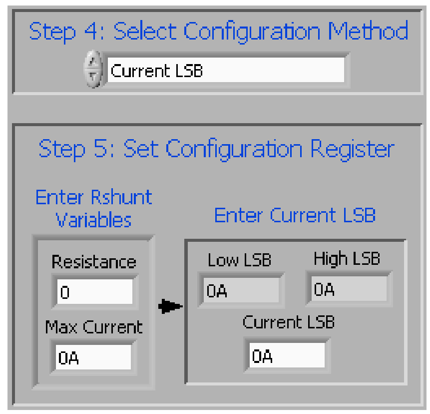

Figure 20. Setting the Configuration Register (Current LSB)

5.2.5 Configuring the Alert Pin

The Alert Pin from the INA230 allows the user to set limits that monitor the registers and trigger a flag when they are exceeded. The register that is being monitored can be changed by selecting the desired alert configuration as shown in Figure 21. The value that is being considered is compared to the *Alert Limit* box. This Alert Limit box modifies its functionality based on the selected configuration. It is important to note that by default, the INA230 Alert pin is set to active low.

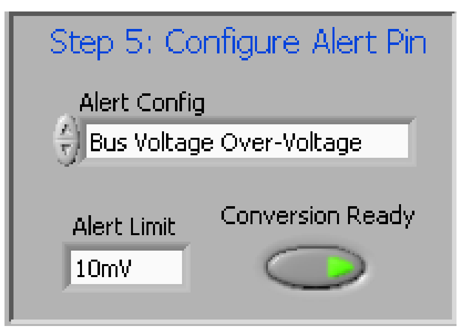

Figure 21. Configuring the Alert Pin

In addition to the INA230EVM software alert configuration, the Alert Configuration box includes the **Conversion Ready** button that allows for a special functionality on the Alert pin. When the INA230 completes the conversions for its current operation, it triggers the Alert pin and notifies the user that another conversion can be performed. In most cases, the INA230 conversion ready flag is not visible because of the speed of the INA230 conversion process.

5.3 Using the INA230EVM Software

After configuring the INA230EVM 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 INA230 Bus Voltage, Shunt Voltage, Current, and Power Reading Bar

The bottom bar of the INA230 software, as shown in Figure 22, allows the user to constantly check the status of the INA230 unit itself. These values are updated each time the **Read All Reg** button is pressed 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.

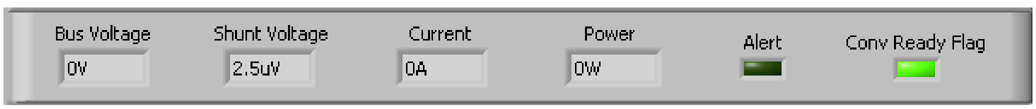

Figure 22. INA230 Results Bar

5.3.2 Calculation and Theory of Operation

The Calculation tab, as shown in Figure 23, 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.

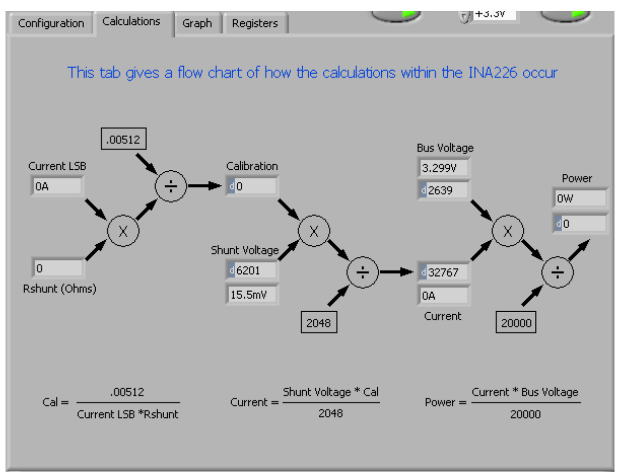

Figure 23. Theory of Operation Flowchart on the Calculation Tab

5.3.3 Register Tab

The Register tab contains information on the individual operation of the INA230 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 on the **Help With Reg** button on the Register tab, as shown in Figure 24, the user can diagnose the individual uses of each bit in each register.

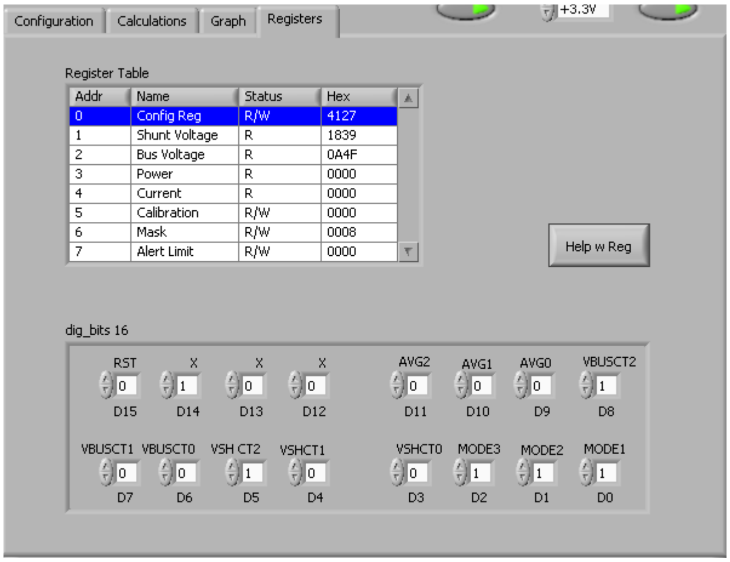

Figure 24. Registers Tab

5.3.4 Graph Tab

The Graph tab contains a plot window that shows the progression of data over time on the INA230. 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. Once the Start Graph Log has been selected, the user is prompted to select a location for the data and to name the file.

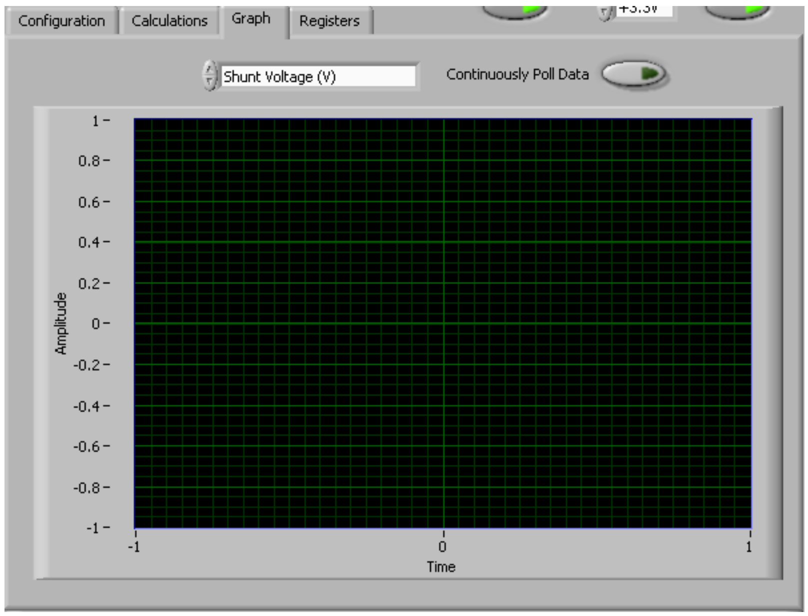

Figure 25. Graphing the INA230 Data

5.3.5 Auto-Write and the Supply Voltage

The INA230EVM 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 which voltage the device should operate at.

The software also includes an Auto-Write feature as shown in Figure 26, 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 AutWrite is disabled.

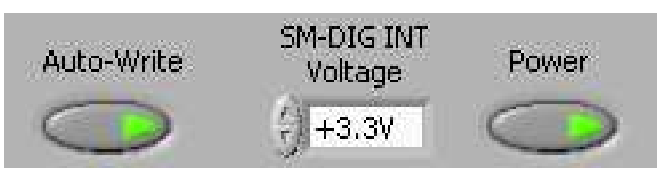

Figure 26. Auto-Write, Power Button, and Voltage Control

6 INA230EVM Documentation

This section contains the complete bill of materials, schematic diagram, and PCB layout for the INA230EVM.

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 INA230EVM PCBs.

6.1 Schematic

Figure 27 shows the schematic for the INA230EVM.

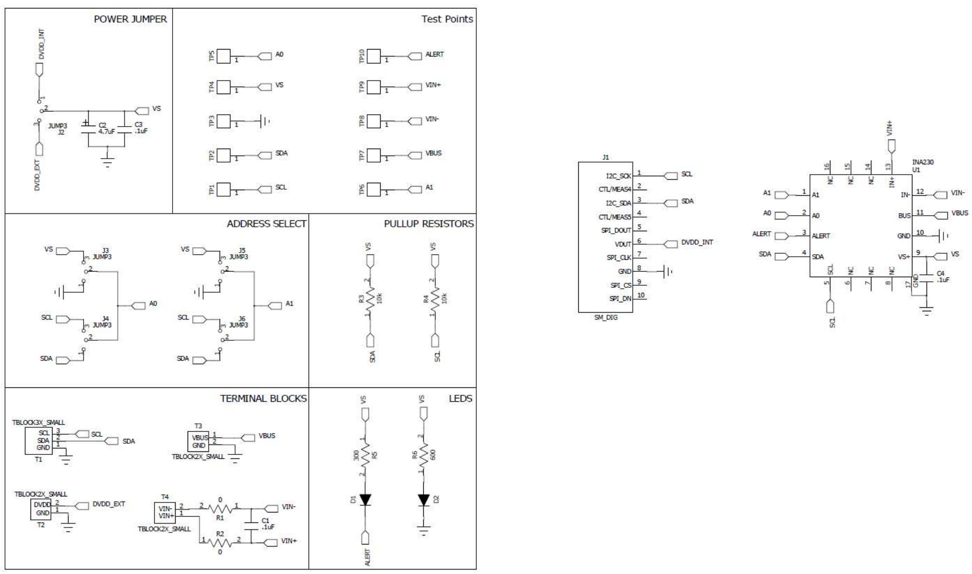

Figure 27. INA230EVM Schematic

6.2 PCB Layout

Figure 28 shows the component layout for the INA230EVM PCB.

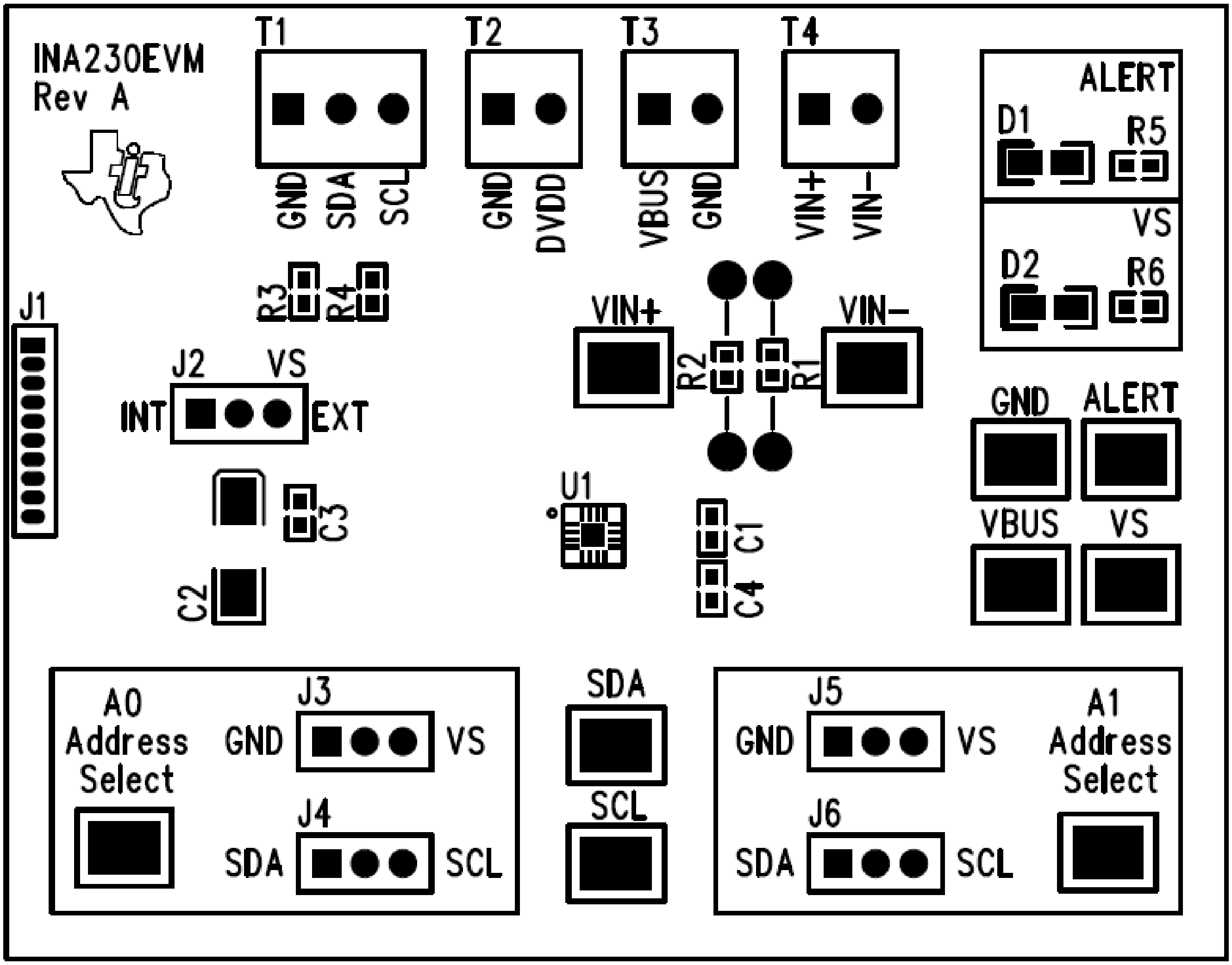

Figure 28. INA230EVM PCB Top Layer (Component Side)

6.3 Bill of Materials

Table 6 lists the bill of materials for the INA230EVM.

Table 6. Bill of Materials: INA230EVM

Item No.	Ref Des	Description	Vendor/Mfr	Part Number
1	R5, R6	Resistor, 10 kΩ 1/10 W 5% 0603 SMD	Stackpole Electronics	RMCF0603JT10K0
2	R3, R4	Resistor, 300 Ω 1/10 W 5% 0603 SMD	Panasonic	ERJ-3GEYJ301V
3	R1, R2	Resistor, 0.0 Ω 1/10 W 0603 SMD	Stackpole Electronics	RMCF0603ZT0R00
4	C2	Capacitor, Tantalum 4.7 µF 35 V 10% SM	AVX Corp.	TAJC475K035RNJ
5	C3, C4	Capacitor, Ceramic 0.10 µF 25 V X7R 10% 0603	TDK Corp.	C1608X7R1E104K
6	D1, D2	LED Green Wide Angle 0603 SMD	Panasonic	LNJ3W0C83RA
7	U1	INA230	Texas Instruments	
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

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It is important to operate this EVM within the input voltage range of 0V to 5V and the output voltage range of 0V to 36V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

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During normal operation, some circuit components may have case temperatures greater than +25°C. The EVM is designed to operate properly with certain components above +25°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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

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

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.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

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

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-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.

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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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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.

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2. Use this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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