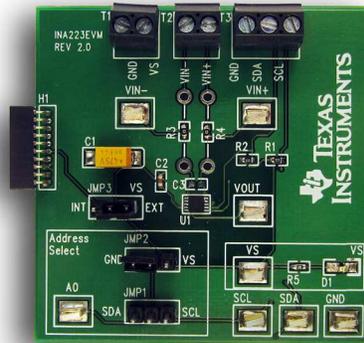


INA223EVM User's Guide and Software Tutorial



INA223EVM

This user's guide describes the characteristics, operation, and use of the INA223EVM evaluation board. It discusses how to set up and configure the software and hardware, and reviews various aspects of the program operation. 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.

Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the INA223EVM.

INA223EVM (continued)

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1 Overview

The INA223 is a voltage output device that monitors current, bus voltage, and power of a supply line by sensing a voltage drop across a shunt. The INA223EVM is a platform for evaluating the performance of the INA223 under various signal, shunt, and supply conditions. This document gives a general overview of the INA223EVM, and provides a general description of the features and functions to be considered while using this evaluation module.

1.1 INA223EVM Kit Contents

The INA223EVM kit includes the following items:

- (1) INA223 PCB evaluation board
- (1) SM-USB-DIG Platform PCB
- (1) USB extender cable
- (1) SM-USB-DIG connector ribbon cable
- (1) User's guide CD-ROM

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 check the TI web site at <http://www.ti.com> to verify that you have the latest versions of the related software.

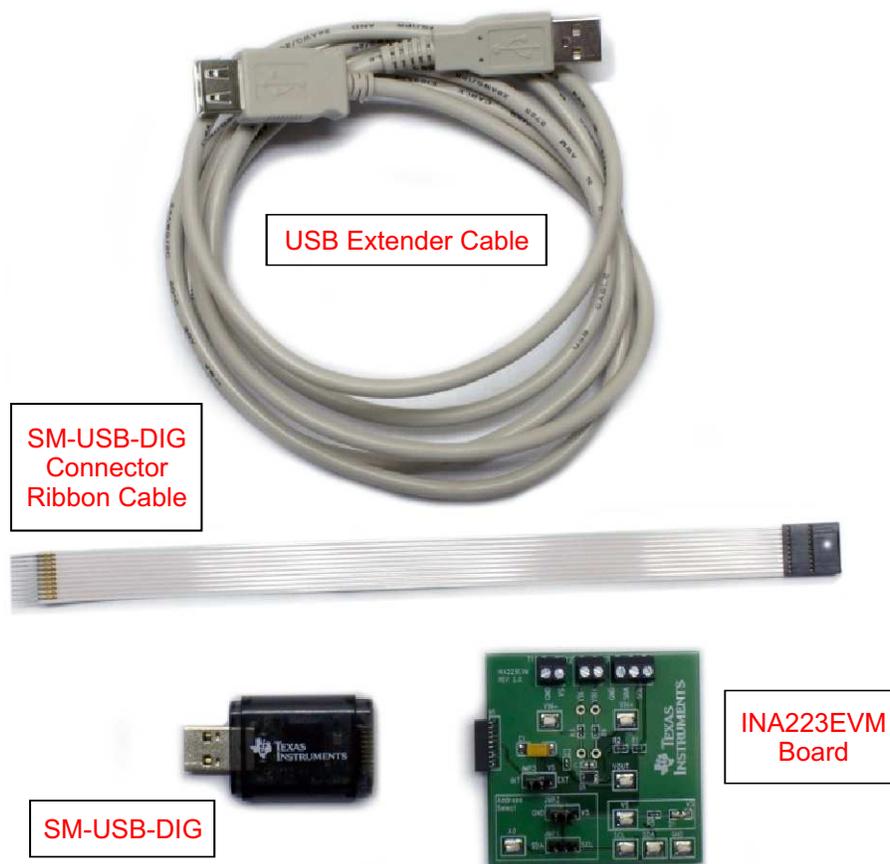


Figure 1. Hardware Included with INA223EVM Kit

1.2 Related Documentation

The following document provides information regarding Texas Instruments integrated circuits used in the assembly of the INA223EVM. This user's guide is available from the TI web site under literature number SBOU125 . 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 at <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. Related Documentation

Document	Literature Number
INA223 Product Data Sheet	SBOS528
SM-USB-DIG Platform User's Guide	SBOU098

2 INA223EVM Hardware Setup

This section discusses the overall system setup for the INA223EVM. A PC runs software that communicates with the SM-USB-DIG Platform. This platform generates the analog and digital signals used to communicate with the INA223 board. Connectors on the INA223 allow the user to connect to the system under test conditions where the power, current, and voltage are monitored.

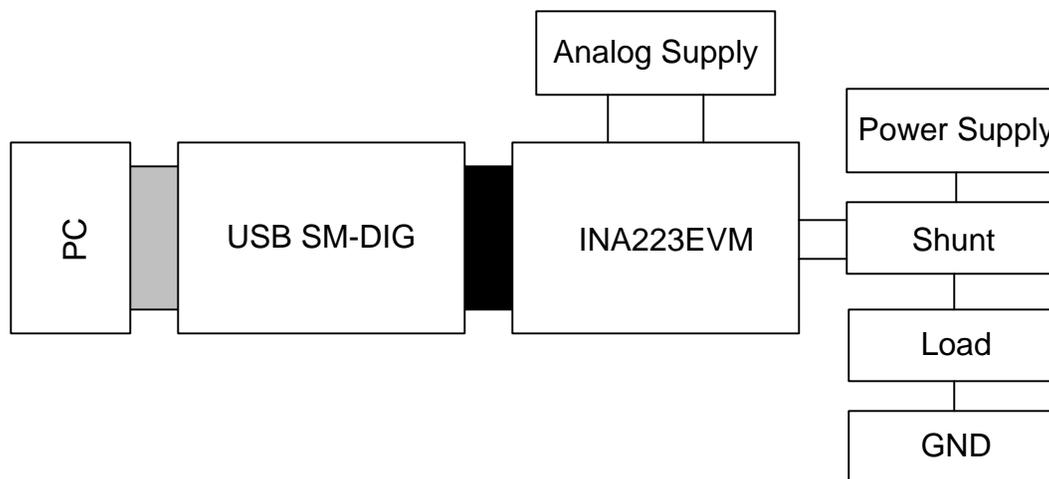


Figure 2. Hardware Setup

2.1 Theory of Operation for INA223 Hardware

A block diagram of the INA223 test-board hardware setup is shown in Figure 3. The PCB provides connections to the I²C™ and general-purpose inputs and outputs (GPIO) on the SM-USB-DIG Platform board. It also provides connection points for external connections to the shunt voltage.

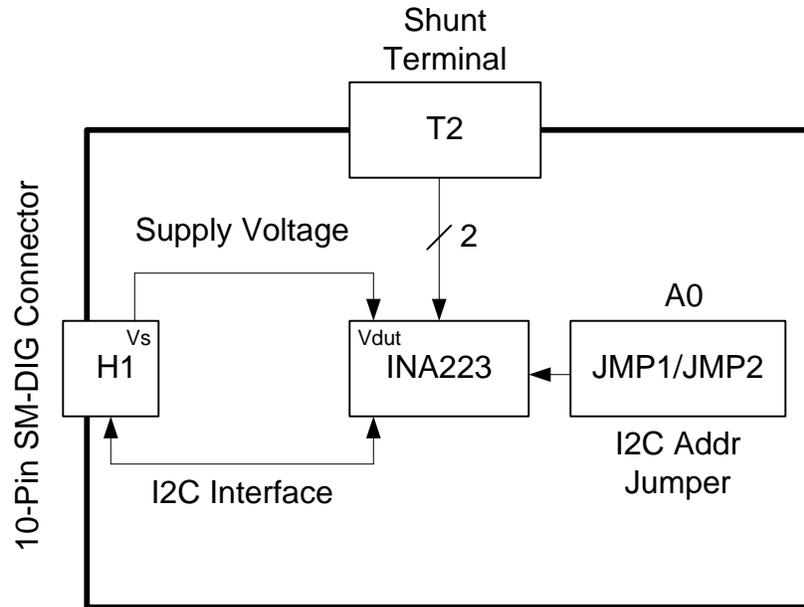


Figure 3. INA223 Test Board Block Diagram

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

Table 2 shows the pinout for the 10-pin connector socket used to communicate between the INA223EVM and the SM-USB-DIG. It should be noted that to issue commands to the INA223 chip, the INA223EVM only uses H1 connector pins 1 and 3 (I²C communication lines), pin 6 (VDUT), and pin 8 (GND).

Table 2. INA223EVM H1 Pin Connections

Pin on H1	Signal	Description
1	I2C_SCL	I ² C clock signal (SCL)
2	CTRL/MEAS4 ⁽¹⁾	GPIO—Control output or measure input
3	I2C_SDA1	I ² C data signal (SDA)
4	CTRL/MEAS5 ⁽¹⁾	GPIO—Control output or measure input
5	SPI_DOUT3 ⁽¹⁾	SPI™ data output (MOSI)
6	VDUT	Switchable DUT power supply: +3.3V, +5V, Hi-Z (disconnected). ⁽²⁾
7	SPI_CLK ⁽¹⁾	SPI clock signal (SCLK)
8	GND	Power return (GND)
9	SPI_CS1 ⁽¹⁾	SPI chip select signal (\overline{CS})
10	SPI_DIN1 ⁽¹⁾	SPI data input (MISO)

⁽¹⁾ This signal is not used on the INA223EVM.

⁽²⁾ When VDUT is Hi-Z, all digital inputs and outputs (I/O) are Hi-Z as well.

2.3 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](#)). The block diagram shown in Figure 4 is given as a brief overview of the SM-USB-DIG Platform.

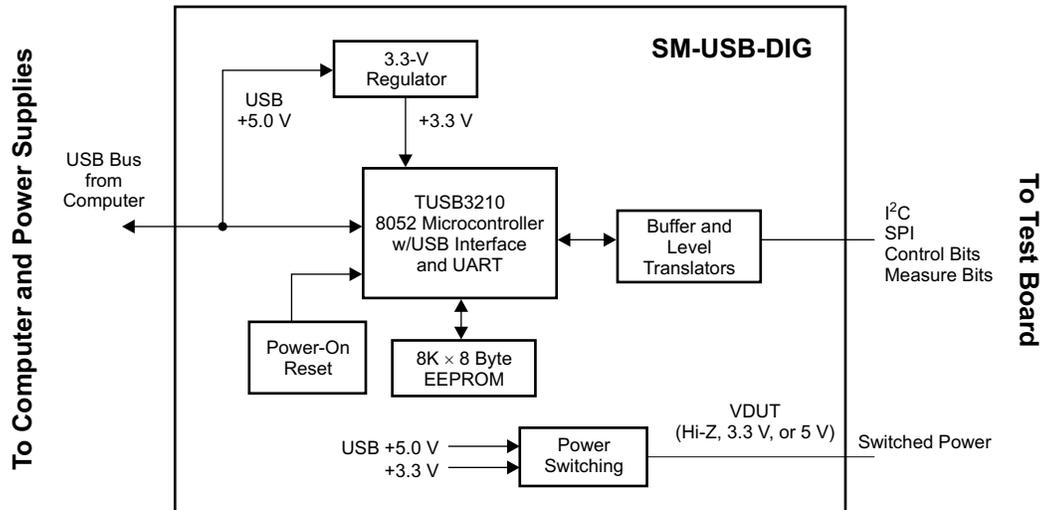


Figure 4. SM-USB-DIG Platform Block Diagram

The *brain* of the SM-USB-DIG Platform is the TUSB3210, an 8052 microcontroller that has a built-in USB interface. The microcontroller receives information from the host computer that is interpreted into power, I²C, 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.

3 INA223EVM Hardware Overview

The INA223EVM hardware setup involves connecting the two EVM PCBs together, applying power, connecting the USB cable, and setting the jumpers. This section describes the details of this procedure.

3.1 Electrostatic Discharge Warning

Many of the components on the INA223EVM 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 connect the INA223 test board and the SM-USB-DIG Platform together, 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 joined, as shown in [Figure 5](#), connect the desired V_{BUS} and shunt configuration to be measured. Typically, setup involves a high- or low-side load and a shunt resistor across V_{IN+} and V_{IN-} . The example in [Figure 5](#) represents a test scenario with a low-side shunt attached. The power supply for V_{BUS} is not included with the kit and is supplied by the customer; the specific voltage needed depends on your testing needs.

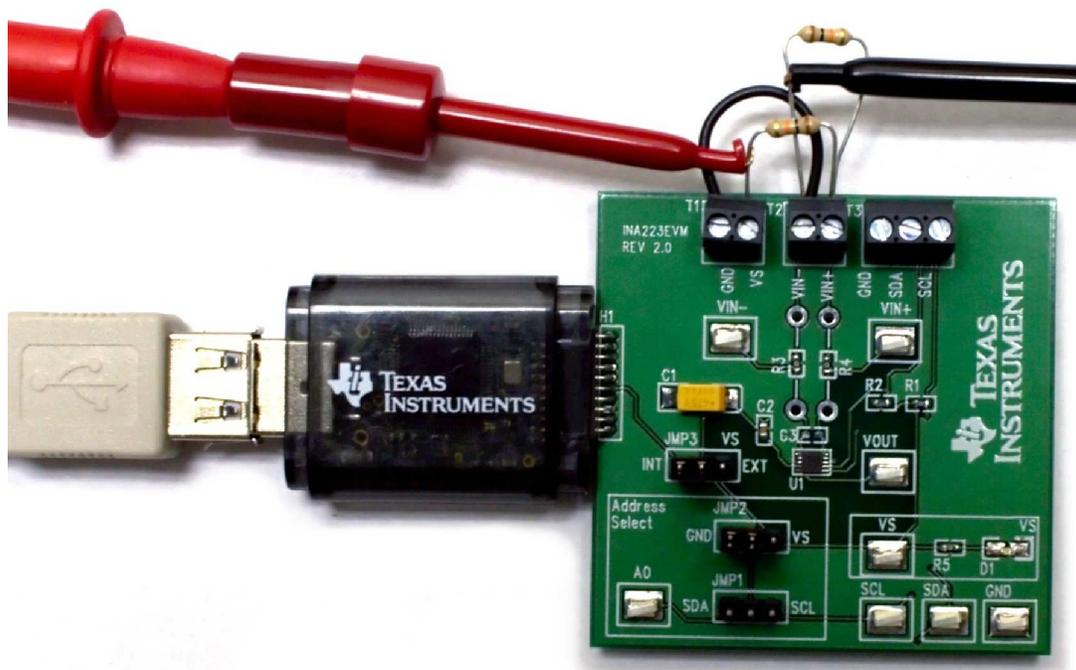


Figure 5. Typical Hardware Test Connections on the INA223EVM

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

Figure 6 shows the USB connection to the SM-USB-DIG Platform board. The first time you connect to the PC, the computer typically responds with a *Found New Hardware, USB Device* pop-up window. The pop-up window then likely changes to *Found New Hardware, USB Human Interface Device*. The SM-USB-DIG Platform uses the human interface device drivers that are part of with Microsoft® Windows® operating systems.

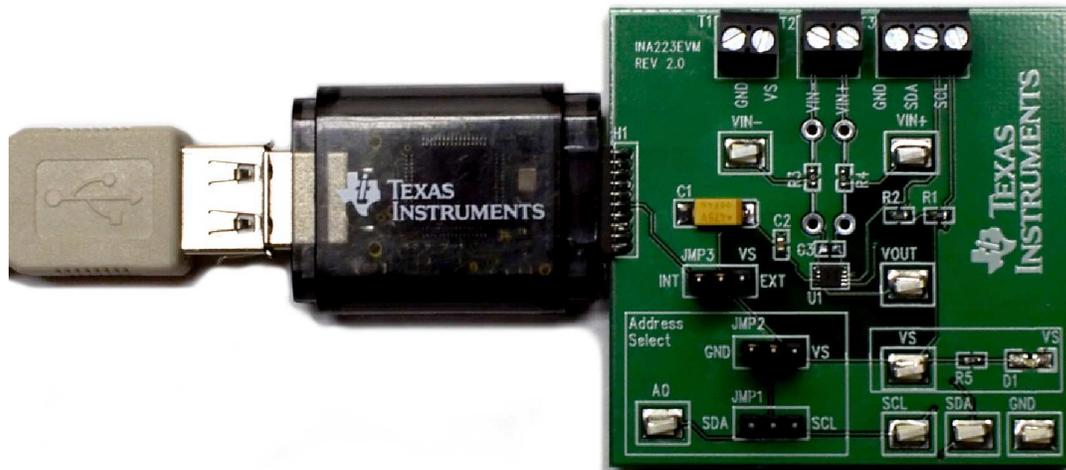


Figure 6. Connecting the USB Cable to the SM-USB-DIG Platform

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



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

3.5 INA223EVM Default Jumper Settings

Figure 8 shows the default jumper configuration for the INA223EVM. You may want to change some of the jumpers on the INA223EVM to match your specific configuration. For example, you may wish to set a specific I²C address by configuring jumper 1 (JMP1) and jumper 2 (JMP2).

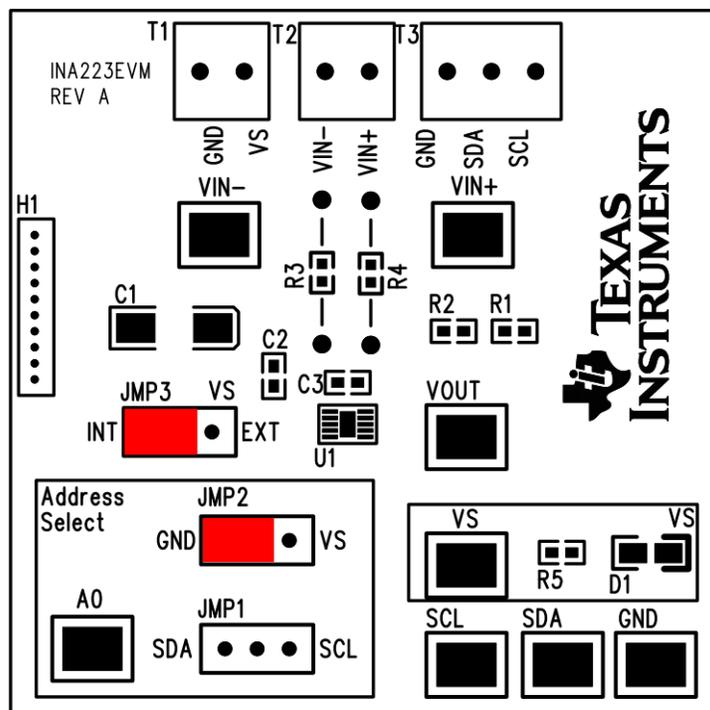


Figure 8. INA223EVM Default Jumpers

Jumper 3 (JMP3) on the INA223EVM is typically set to the internal (INT) position. When set to the INT position, the device supply voltage is generated and controlled from the SM-USB-DIG Platform. When this jumper is set to the external (EXT) position, INA223 pin 4 (V_s) connects to terminal strip T1 and can be powered from an external supply.

JMP1 and JMP2 control the I²C address pin for the INA223; these jumpers set the address for A0 to either high, low, SCL, or SDA. Make sure to connect only one jumper at a time for the address control (for example, if JMP1 is connected, do not connect JMP2, and vice versa). Failure to properly connect jumpers can cause shorts or interruptions in the communication lines. For more information on the INA223 addressing, consult the INA223 data sheet ([SBOS528](#)).

Table 3 summarizes the function of the INA223 test board jumpers. For most applications, all the jumpers should be left in their default configurations.

Table 3. INA223 Test Board Jumper Functions

Jumper	Default	Description
JMP1	Open	These jumpers select the I ² C A0 address selection for A0. Four separate I ² C addresses can be selected, depending on whether JMP2 is set to high or low, or JMP1 is set to SDA or SCL.
JMP2	GND	
JMP3	INT	This jumper selects whether the V_s pin on the INA223 is connected to the digital power-supply signal (VDUT) generated from the SM-USB-DIG Platform (INT position), or whether the VDUT pin is connected to terminal T1, thus allowing for an external supply to power the digital circuitry (EXT position).

3.6 INA223EVM Hardware

This section describes some of the hardware features present on the INA223EVM board.

3.6.1 JMP3: I²C versus Control Setting

The JMP3 setting determines if the INA223 is powered from the SM-USB-DIG platform or an external power supply. If JMP3 is set to the INT position, the V_S pin is connected to the switchable VDUT 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.

When JMP3 is set to the EXT position, an external supply connected to terminal T1 must be used to provide the digital supply voltage for the INA223.

3.6.2 JMP1 and JMP2: I²C Address Hardware Setting (A0)

JMP1 and JMP2 are used to set the hardware setting for the A0 I²C address pin on the INA223. Using JMP2, the A0 address can be set to either a logic '1' or a logic '0'. Using JMP1, the A0 address can be set to either the SCL or SDA communication line. Make sure to only have a jumper installed on JMP1 or JMP2. Failure to keep these lines separate can lead to board shorts and problems with the I²C communication lines. See the [I²C Address Selection](#) section for how to configure the INA223EVM software to match the JMP1 and JMP2 hardware settings.

3.6.3 External I²C lines and Terminal Block T3

The I²C communication lines on the INA223EVM are tied to two sources: The internal I²C communication lines from the SM-USB-DIG Platform and terminal block T3. If external signals separate from the SM-USB-DIG are to be used, simply disconnect the SM-USB-DIG from the INA223 board and connect to external SDA, SCL, and GND lines. Also, remember to apply an external V_S that is compatible with the I²C communication device being used.

CAUTION

Failure to disconnect the SM-USB-DIG Platform while using external I²C communication can cause damage to the SM-USB-DIG or external communication device.

3.6.4 V_{IN+} and V_{IN-} Input Filter (R4, R3, and C3)

The INA223EVM has an optional input filter located between the terminal block T2 and the INA223 input pins. This filter helps to remove high-frequency noise from the V_{IN+} and V_{IN-} inputs. The EVM ships with this filter not used. C3 is typically unpopulated and R3 and R4 have 0- Ω resistors installed. If filtering is desired, limit the value for R3 and R4 to 10- Ω or less. Figure 9 shows the typical setup that is recommended for basic INA223 evaluation. See the INA223 data sheet ([SBOS528](#)) for more details.

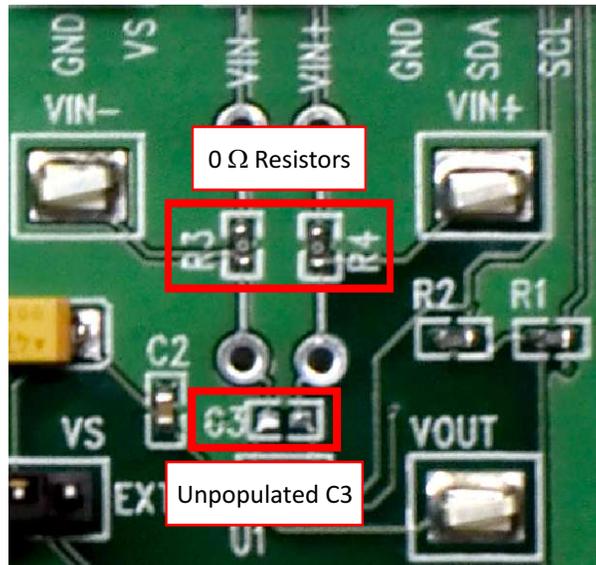


Figure 9. Typical Filter Setup

3.6.5 Shunt Monitor Configuration and Terminal Block T2

The INA223 is typically used in a high-side configuration, as shown in Figure 10. The T2 terminal block includes the connections for V_{IN+} and V_{IN-} , which should be connected directly across the shunt resistor. Depending on the user's needs, either of these configurations may be used without any changes needed to the INA223EVM board or software.

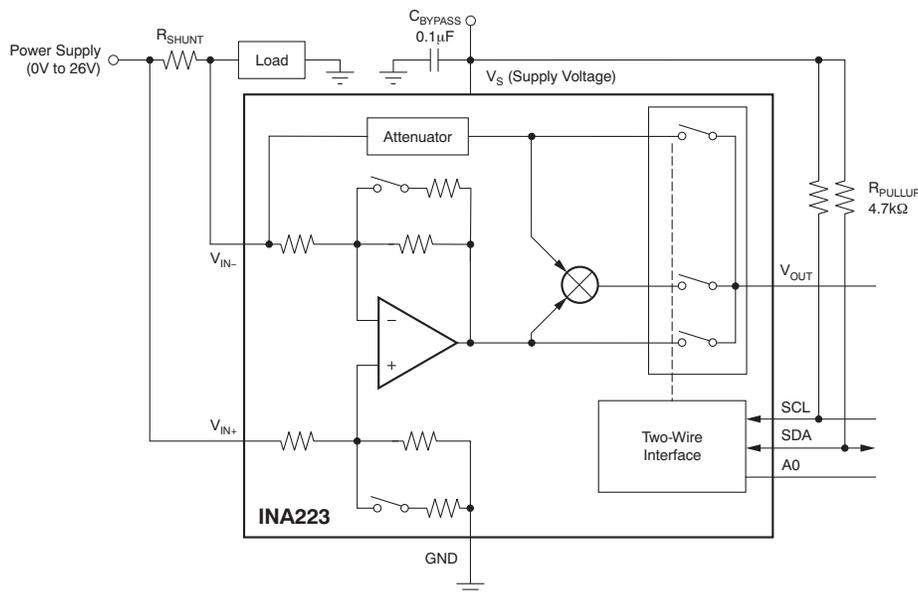


Figure 10. INA223 Shunt Configurations

4 INA223EVM Software Setup

This section discusses how to install the INA223 software.

4.1 Operating Systems for INA223EVM Software

The INA223 software has been tested on the Microsoft Windows XP operating system (OS) with United States and European regional settings. This software should also function on other Windows operating systems.

4.2 INA223 Software Installation

The INA223EVM software is included on the CD that is shipped with the EVM kit. It is also available through the INA223EVM product folder on the TI web site. To download the software to your system, insert the disc into an available CD-ROM drive. Navigate to the drive contents and open the INA223EVM software folder. Locate the compressed file (INA223EVM.zip) and open it. Extract the INA223EVM files into a folder labeled INA223EVM (for example, C:\INA223EVM) on your hard drive.

After the files are extracted, navigate to the INA223EVM folder you created on your hard drive. Locate the setup.exe file and run it to start the installation. The INA223 software installer file opens to begin the installation process, as shown in [Figure 11](#).

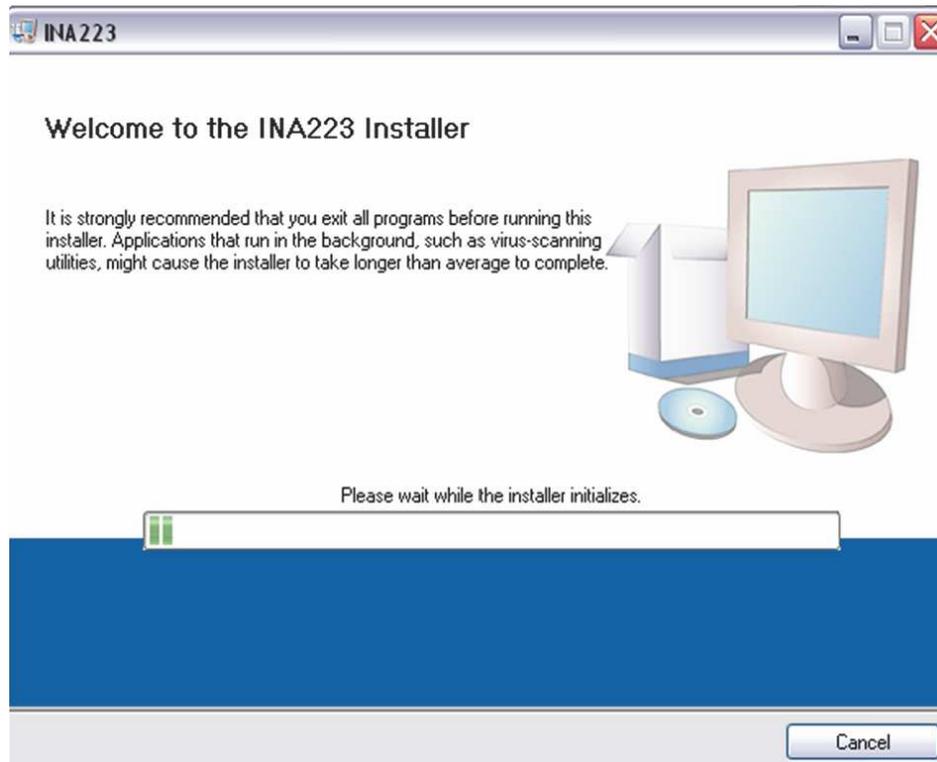


Figure 11. Software Install Window

After the install begins, the user is given the choice of selecting the directory to install the program, usually defaulting to *C:\Program Files\INA223* and *C:\Program Files\National Instruments*. Following this option, two license agreements are presented that must be accepted, as shown in [Figure 12](#).

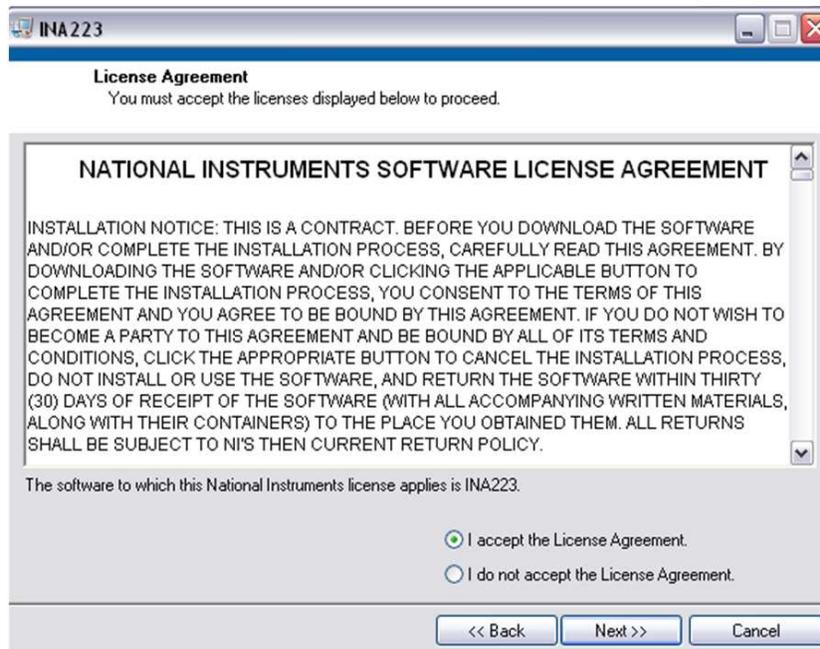


Figure 12. Software License Agreement

After accepting the Texas Instruments and National Instruments license agreements, the progress bar opens and shows the installation of the software, as shown in [Figure 13](#). After the installation process is complete, click *Finish*.

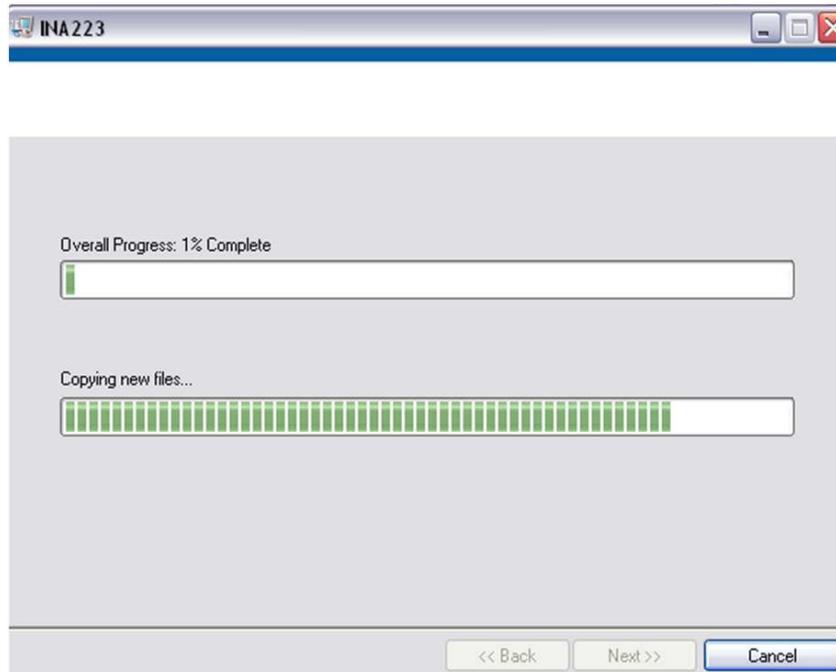


Figure 13. Software Install Progress

5 INA223EVM Software Overview

This section describes how to use the INA223EVM software. The software operation contains a two-step process: configuration and operation.

5.1 Starting the INA223EVM Software

To start the INA223 software, go to the Windows Start menu, select *All Programs*, and then select the INA223EVM program. [Figure 14](#) illustrates how the software should appear if the INA223EVM is functioning properly.

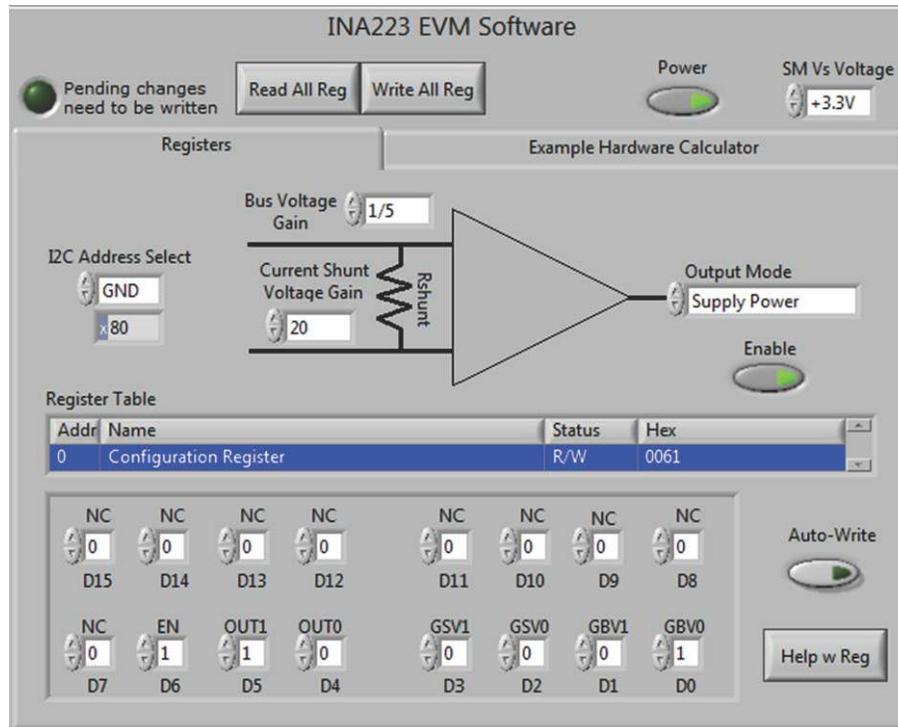


Figure 14. INA223EVM Software Interface

[Figure 15](#) shows the error that appears if the computer cannot communicate with the EVM. In the event you receive this error, first ensure that the USB cable is properly connected on both ends. This error can also occur if you connect the USB cable to your PC before the SM-USB-DIG Platform is connected to the EVM board. Another possible source for this error is a problem with the computer USB human interface device driver. Make sure that the device is recognized when the USB cable is plugged in, indicated by a Windows-generated confirmation sound.

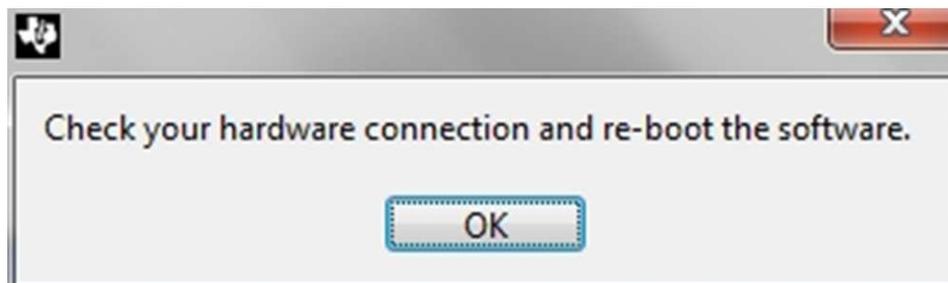


Figure 15. Communication Error with SM-USB-DIG Platform

5.2 Configuring the INA223 Software

The next steps of this user's guide describes how to configure the software and hardware for different configurations.

5.2.1 I²C Address Selection

The INA223 has a flexible I²C address configuration that allows for multiple devices to be on the same I²C lines. By moving the A0 address on jumpers JMP1 and JMP2 to either GND, VS, SDA or SCL, the INA223 can be changed to four different I²C addresses, as shown in Table 4.

Table 4. INA223 I²C Address Configuration

A0	Address
GND	1000000
VS	1000001
SDA	1000010
SCL	1000011

Figure 16 shows how to configure the I²C addresses. Click on the I²C Address Select button (shown in the red box) to select how the hardware is configured on the EVM. If the correct address is not selected, the INA223 cannot communicate with the software.

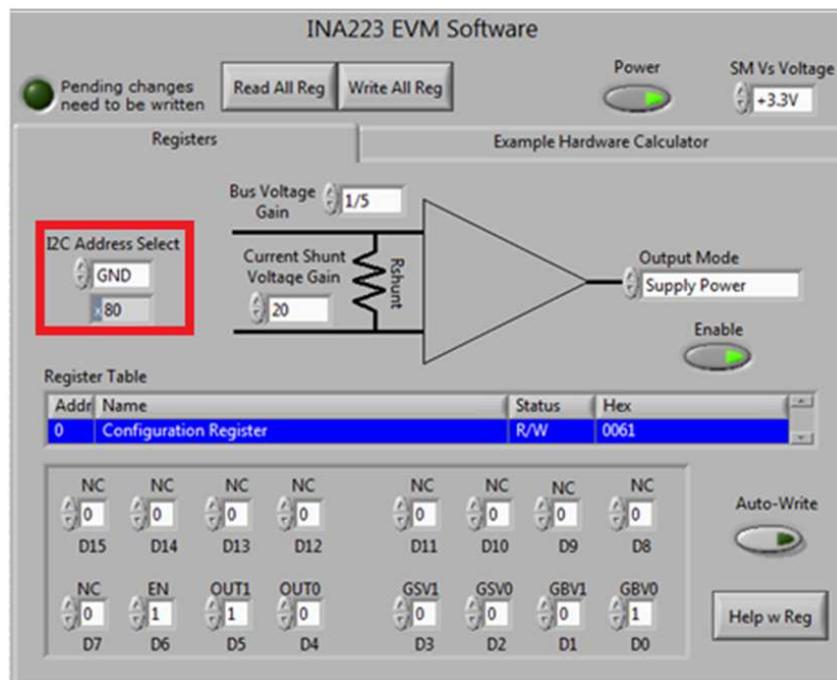


Figure 16. Setting the A0 Address

5.2.2 Output Mode

The output mode configuration allows the user to toggle between different output signals generated from the INA223, and is shown in the red box of [Figure 17](#). The four options available for output mode are: Shunt Voltage, Bus Voltage, Supply Power, and Load Power.

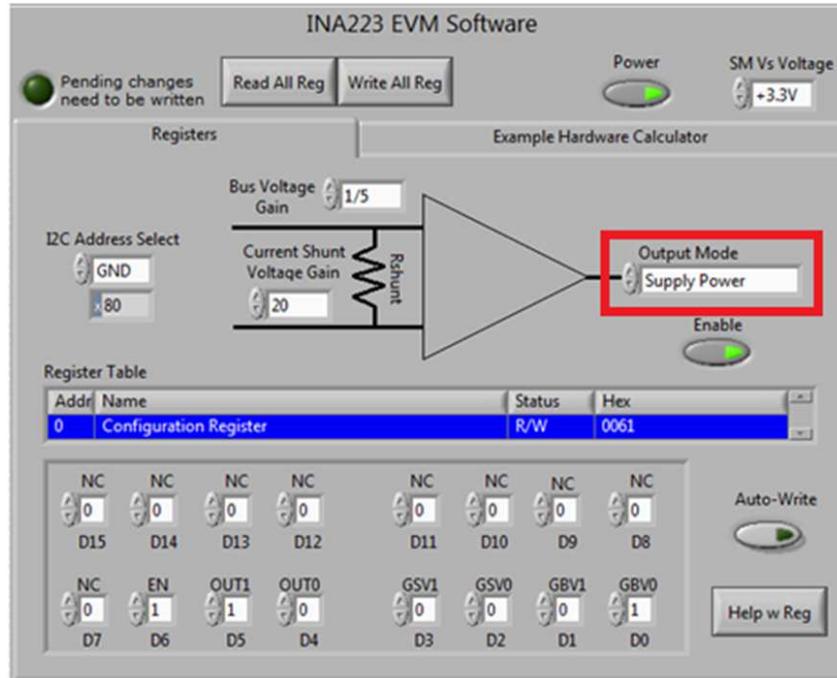


Figure 17. Configuring the Output Mode

The two power output modes of the INA223EVM is used to select whether the signal representing the power being supplied by the power supply or the power being consumed by the load is made available at the output pin. When the *Supply Power* option is selected, the V_{BUS} measurement is taken internally at the VIN+ pin of the INA223 and combined with the V_{SHUNT} measurement to calculate the power being supplied.

The *Load Power* option operates in a similar manner to the *Supply Power* option, except that the V_{BUS} measurement is taken internally at the VIN- pin of the INA223. The power being consumed by the load is found by taking the V_{BUS} measurement from the VIN- pin. The Supply Power and Load Power results are very similar with the exception being that the Load Power option removes the power being dissipated across the shunt resistor from the result. At high current shunt gains, the differences between Load Power and Supply Power are negligible. At low current shunt gains, the power dissipated across the sense resistor can result in a noticeable difference between these two results.

It is important to note that valid bus voltage and shunt voltage measurements must be within the linear range of the device in order for the INA223 to correctly calculate power using [Equation 1](#).

$$\text{POWER} = V_{\text{OUT}} / \text{Power}_{\text{GAIN}} \times R_{\text{SHUNT}} \quad (1)$$

Where V_{OUT} is calculated based on [Equation 2](#):

$$V_{\text{OUT}} = V_{\text{CM}} \times V_{\text{SENSE}} \times \text{Power}_{\text{GAIN}} \quad (2)$$

and $\text{Power}_{\text{GAIN}}$ values are shown in [Table 5](#).

Table 5. Power Gain Values

Bus Voltage Gain	Shunt Voltage Gain	Power _{GAIN}
1/10	20	0.667
1/10	128	4.267
1/10	300	10
1/5	20	1.333
1/5	128	8.533
1/5	300	20
2/5	20	2.667
2/5	128	17.067
2/5	300	40

The remaining two configurations, *Bus Voltage* and *Shunt Voltage*, measure the bus voltages at the VIN-pin and the shunt voltage developed directly across the shunt resistor, respectively. The actual output voltage of either measurement is based on the input voltage multiplied by the corresponding gain settings, as shown in sections [Section 5.2.3](#) and [Section 5.2.4](#).

NOTE: For maximum accuracy, select a gain that gives a full-scale voltage, just below the maximum output voltage.

5.2.3 Bus Voltage Gain

The *Bus Voltage Gain* field allows the user to select the gain that the bus voltage is multiplied by. It is important to choose a value that places the output voltage within the linear output range of the device. Failure to ensure that the outputs are within the linear range of the device can result in inaccurate results.

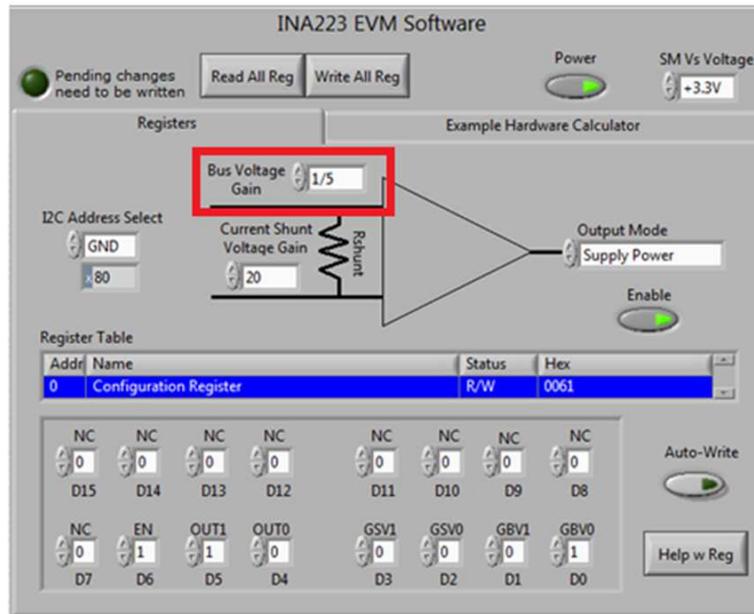


Figure 18. Configuring the Bus Voltage Gain

5.2.4 Current Shunt Voltage Gain

The *Current Shunt Voltage Gain* field is used to select the device shunt voltage gain setting. It is important to choose a value that places the output voltage within the linear output range of the device. Failure to ensure that the outputs are within the linear range of the device can result in inaccurate results.

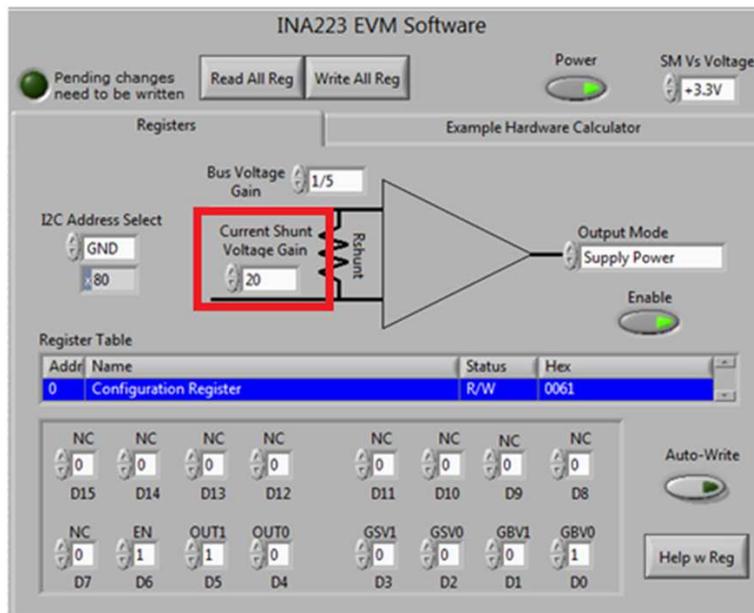


Figure 19. Configuring the Current Shunt Voltage Gain

5.3 Using the INA223 Software

5.3.1 Register Table

The register table (shown by the red box in Figure 20) contains information on the internal registers of the INA223 registers. Each register can be changed on a bit-by-bit basis to allow the user to have total control of the part, outside the general functionality of the graphical user interface (GUI). Most of this functionality is displayed in the Configuration Register; however, by selecting the appropriate register and clicking on the *Help w Reg* button (shown in Figure 20), the individual use of each bit in each register can be diagnosed.

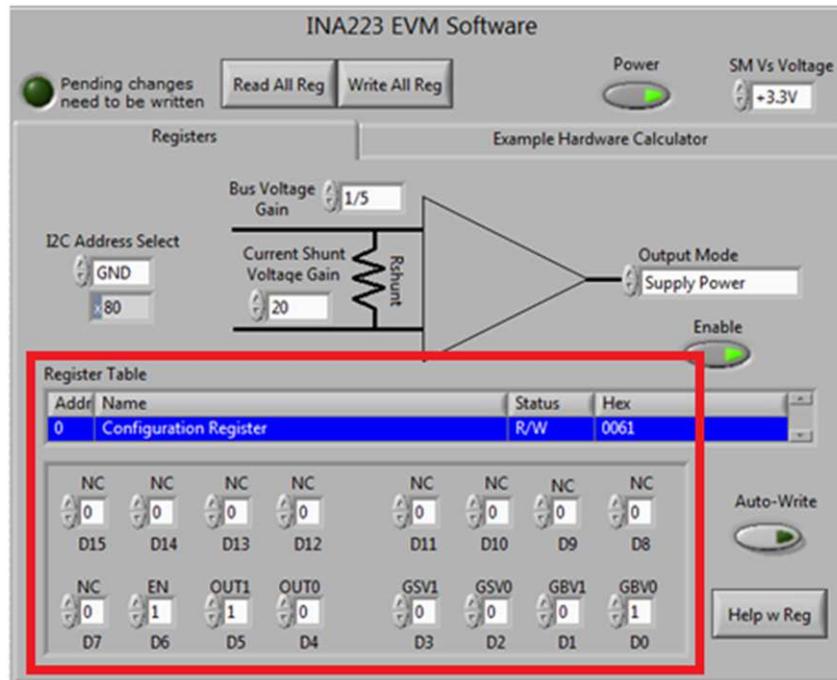


Figure 20. Register Table

5.3.2 Auto-Write and DVDD Voltage

The INA223EVM software allows for customization of the board level voltage, regulated by the SM-USB-DIG. Select either +3.3V or +5V for the operating voltage of the chip, as shown in the upper red box in [Figure 21](#).

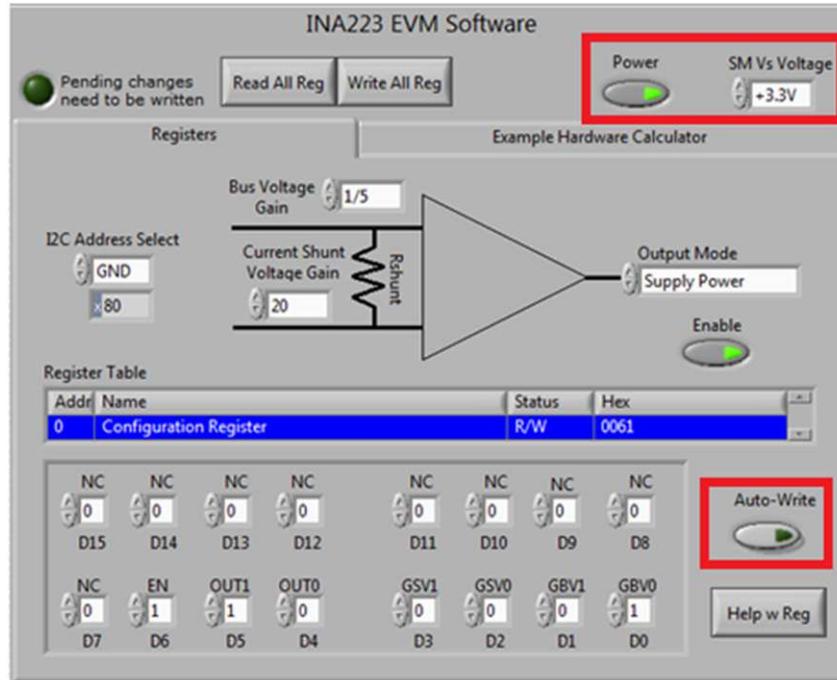


Figure 21. Auto-Write, Power, and Voltage Controls

The software also includes an *Auto-Write* feature (as shown in the lower red box in [Figure 21](#)). Auto-Write is enabled by default, and automatically updates the register table whenever a change is made. When this feature is enabled, the *Write all Reg* button serves little purpose, and is only used as an alternative for when this button is disabled.

5.3.3 Example Hardware Calculator

The *Example Hardware Calculator* tab allows the user to simulate the analog results of the INA223EVM. By adjusting the controls on this page, and entering inputs for V_{in+} (V), V_{in-} (V), and R_{shunt} , the approximate values for V_{out} (V) and $Power$ (W) can be estimated. Note that the appropriate output mode must be selected to ensure accurate results, and that no limitations of the device are violated in the *Error* field.

This calculator is used to help ensure that the physical output and settings are operating correctly. The EVM and device digital communication interface are only designed to configure the device settings. There is no analog readback available with this EVM. This means that the output voltages shown on this calculator tab in the software are calculated results based on the parameters entered and not representative of the measurements of the actual device.

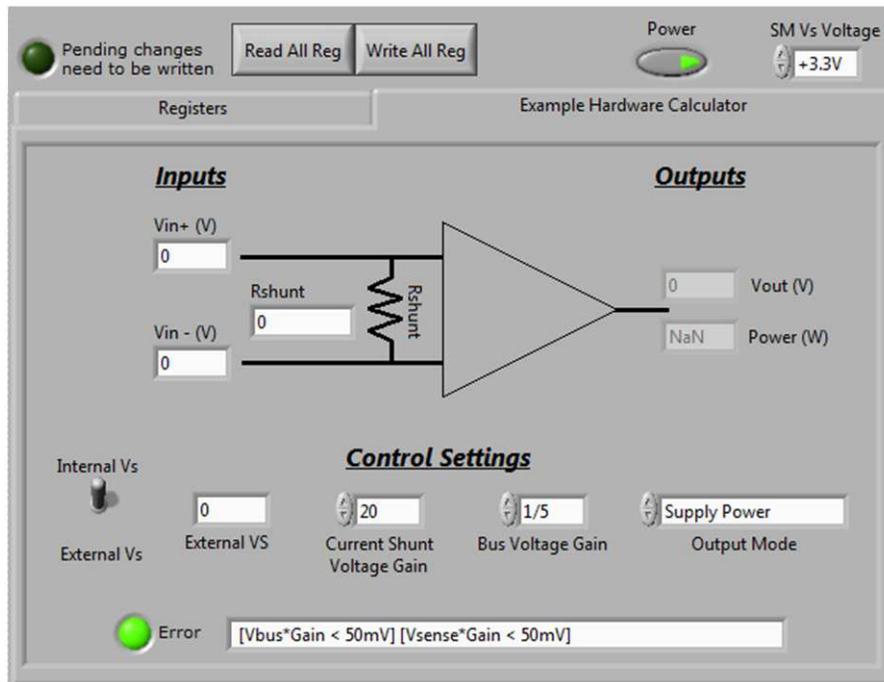


Figure 22. Example Hardware Calculator

6 INA223EVM Documentation

This section contains the complete bill of materials, schematic diagram, and PCB layout for the INA223EVM. Documentation information for the SM-USB-DIG Platform can be found in the SM-USB-DIG Platform User's Guide ([SBOU058](#)), available at the TI web site at <http://www.ti.com>.

6.1 Bill of Materials

Table 6 lists the bill of materials for the INA223 Test Board.

Table 6. Bill of Materials

Ref Des	Description	Manufacturer	Digikey Part Number	Manufacturer Part Number
R1, R2	RES 10K OHM 1/10W 5% 0603 SMD	Stackpole Electronics	RMCF0603JT10K0CT-ND	RMCF0603JT10K0
R5	RES 300 OHM 1/10W 5% 0603 SMD	Panasonic	P300GCT-ND	ERJ-3GEYJ301V
R3, R4	RES 0.0 OHM 1/10W 0603 SMD	Stackpole Electronics	RMCF0603ZT0R00CT-ND	RMCF0603ZT0R00
C2	CAP TANTALUM 4.7UF 35V 10% SM	AVX Corp	478-1717-1-ND	TAJCA475K035RNJ
C3, C4	CAP CER .10UF 25V X7R 10% 0603	TDK Corp	445-1316-1-ND	C1608X7R1E104K
D1	LED GREEN WIDE ANGLE 0603 SMD	Panasonic	P14140CT-ND	LNJ3W0C83RA
U1	INA223	Texas Instruments		
Jumpers All	CONN HEADER 50POS .100" SGL GOLD	Samtec	SAM1029-50-ND	TSW-150-07-G-S
Test Points All	PC TEST POINT COMPACT SMT	Keystone Electronics	5016KCT-ND	5016
T3	3Block Terminal 3.5mm	On Shore Technology Inc	ED2636-ND	OSTTE030161
T1, T2	2Block Terminal 3.5mm	On Shore Technology Inc	ED1514-ND	ED555/2DS
Bumpons	BUMPON .50X.14 BLACK	3M	SJ5012-0-ND	SJ-5012 (BLACK)
H1	CONN SOCKET RT ANG 1POS .050	Mill-Max Manufacturing	ED8850-ND	851-93-10-20-001000

6.2 Schematic

Figure 23 shows the schematic for the INA223EVM board.

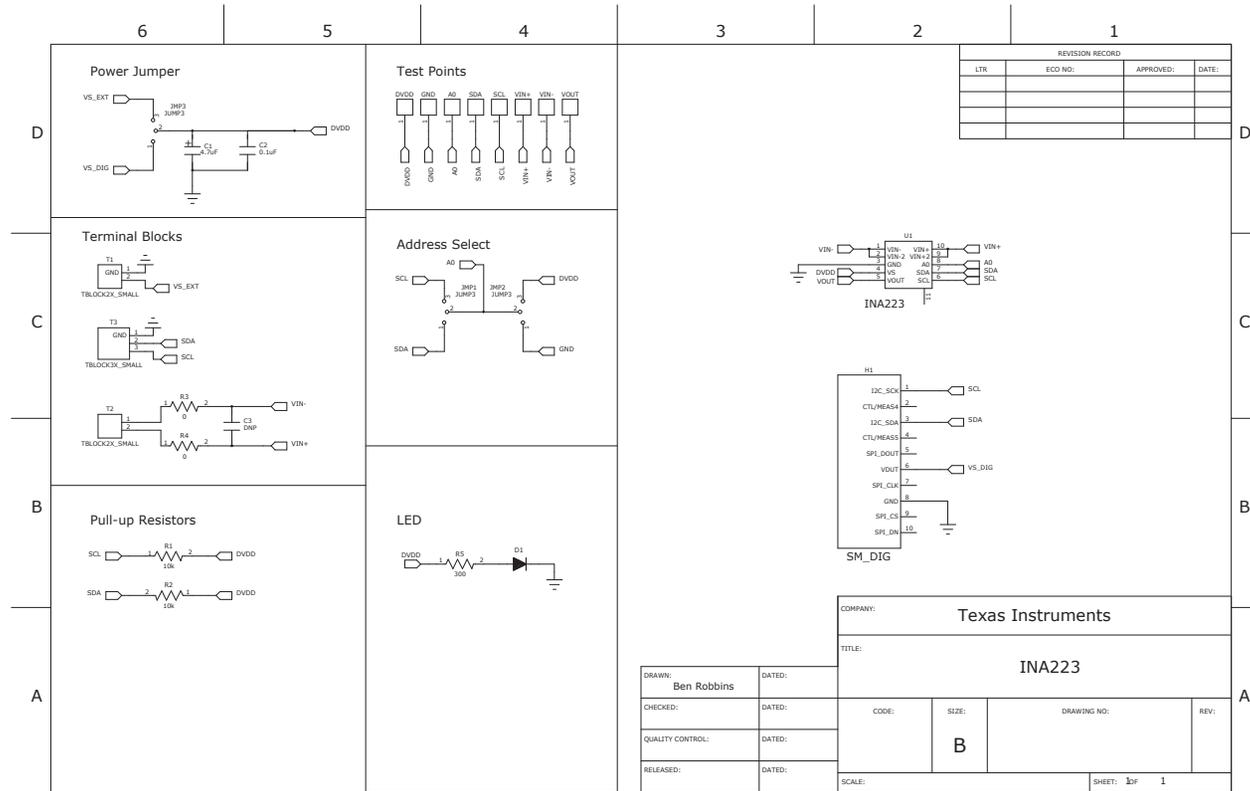


Figure 23. INA223EVM Board Schematic

6.3 PCB Component Layout

Figure 24 shows the layout of the components for the INA223EVM PCB.

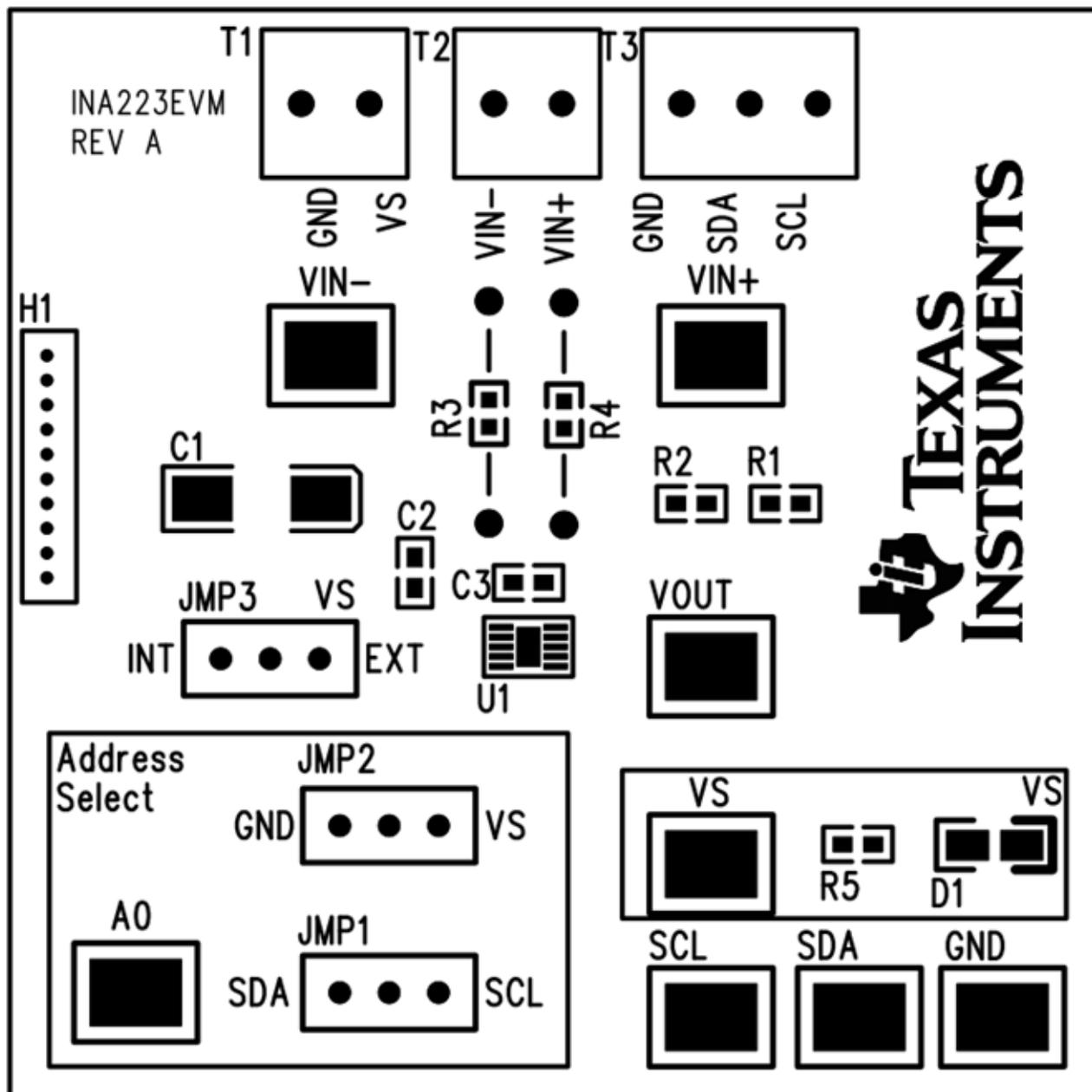


Figure 24. INA223EVM PCB Component Layout

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It is important to operate this EVM within the input voltage range of 0 V to 26 V and the output voltage range of 0 V to 5.5 V.

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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General Statement for EVMs including a radio

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.

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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If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

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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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