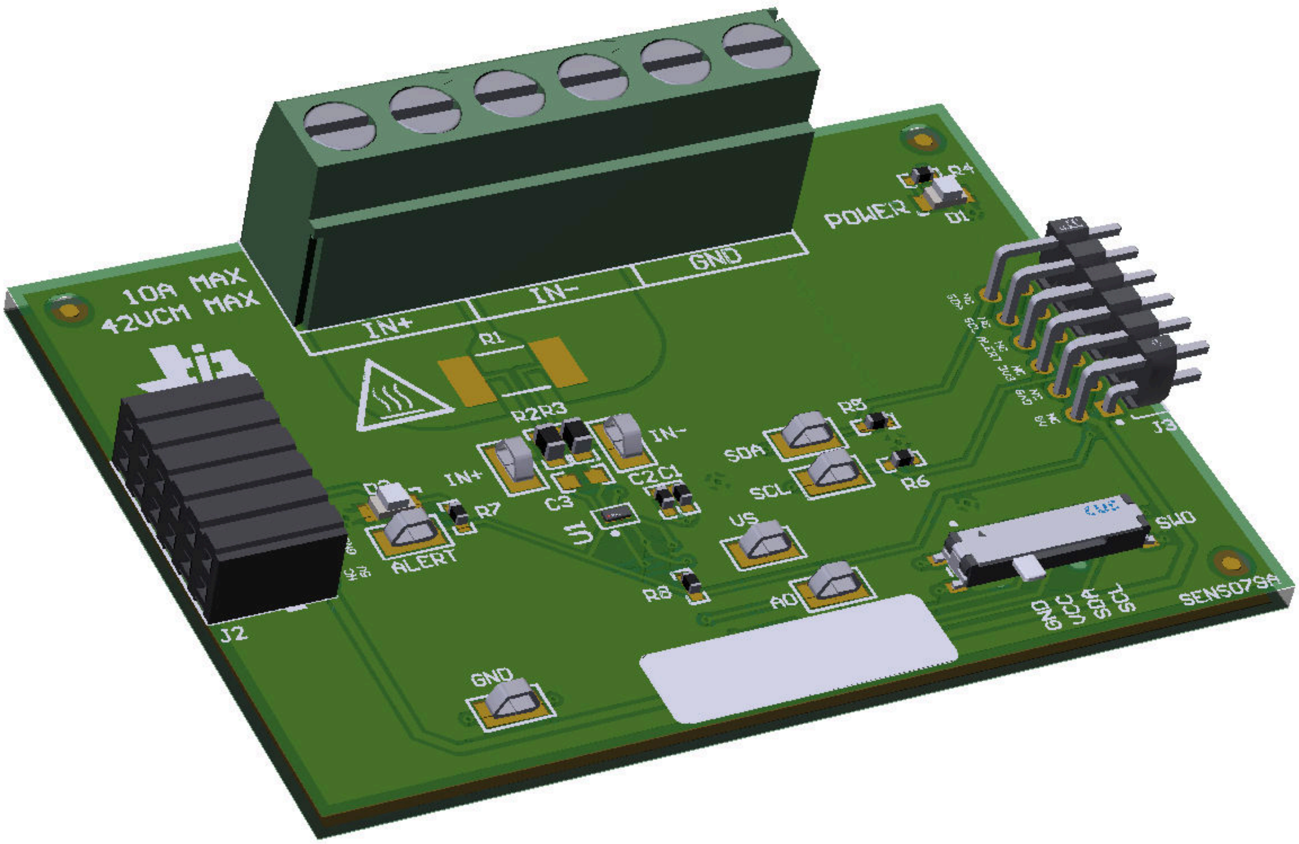
*User's Guide*

# *INA234EVM and INA236EVM*

### ABSTRACT

This user's guide describes the characteristics, operation, and use of the INA234 and INA236 evaluation modules (EVMs). These EVMs are designed to evaluate the performance of the INA234 and INA236. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the INA234EVM and INA236EVM. This document includes a schematic, reference printed circuit board (PCB) layouts, and a complete bill of materials (BOM).



# Table of Contents



## 1 Trademarks

All trademarks are the property of their respective owners.

## 2 Overview

The INA234 and INA236 devices are digital power monitors with integrated 16-bit (INA236) and 12-bit (INA234) delta-sigma ADCs specifically designed for current-sensing applications. The devices can measure a selectable full-scale differential input of ±81.92 mV or ±20.48 mV across the shunt with common-mode voltage support from –0.3 V to +42 V (–0.3 V to +28 V for INA234). The built-in digital accumulation calculates average power and current if calibration register is programmed. The INA234 and INA236 devices also have built-in diagnostics to indicate system health accessible through a digital output pin, ALERT. The output can be interfaced with a multitude of microcontrollers (MCUs) with a standard I2C interface.

**Table 2-1. Device Summary**

| PRODUCT | DIGITAL PROTOCOL | ADC RESOLUTION | MAX GAIN ERROR | MAX OFFSET VOLTAGE |
|---|---|---|---|---|
| INA234 | I2C | 16-bit | 1% | ±100 µV |
| INA236 | I2C | 12-bit | 0.2% | ±10 µV |

### 2.1 Kit Contents

Table 2-2 lists the contents of the EVM kit. Contact the nearest Texas Instruments Product Information Center if any component is missing.

**Table 2-2. Kit Contents**

| ITEM | QUANTITY |
|---|---|
| INA234EVM OR INA236EVM board | 1 |

Note that this EVM requires the TI Sensor Control Board (SCB), which is sold separately.

## 2.2 Related Documentation From Texas Instruments

This user's guide is available from the TI website under literature number SBOU241. 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 are available from www.ti.com or 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 2-3 lists documentation related to the EVM. Click the links in Table 2-3 for further information. The device name links to the product web folder on www.ti.com. The literature number links to the document PDF.

**Table 2-3. Related Documentation**

| DOCUMENT TITLE | DOCUMENT LITERATURE NUMBER |
|---|---|
| INA234 data sheet | SBOS844 |
| INA236 data sheet | SBOSA81 |

# 3 Hardware

The EVM is an easy-to-use platform for evaluating the main features and performance of the INA234 or INA236. The EVM supports current measurements up to 10 amps, and includes a graphical user interface (GUI) used to read and write device registers as well as view and save results data.

The EVM is intended to provide basic functional evaluation of the devices. The layout is not intended to be a model for the target circuit, nor is it laid out for electromagnetic compatibility (EMC) testing. The EVM consists of two printed circuit boards (PCBs). The larger PCB is referred to as the EVM, and has either the INA234 or INA236 installed. The smaller PCB is referred to as the SCB Controller, and is used to interface the EVM with the GUI.

## 3.1 Features

- GUI support to read and write device registers as well as view and save results data
- EVM detached from SCB for custom use cases
- Conveniently powered from a common micro-USB connector through the SCB

# 4 Operation

## 4.1 Quick Start Setup

The following instructions describe how to set up and use the EVM.

1. Purchase an SCB if you do not already have one.
2. Download this driver and install it as an administrator: https://www.ti.com/lit/zip/sbac253.
3. Attach the EVM to the SCB Controller as shown in Figure 4-1.
   a. Refer to Figure 4-2 when connecting multiple EVMs of the same type together.
4. Connect the EVM to a PC using the provided USB cable.
   a. Insert the micro USB cable into the SCB Controller onboard USB receptacle J2.
   b. Plug the other end of the USB cable into a PC.
5. Access the GUI from this link in either Chrome or Firefox: https://dev.ti.com/gallery/info/3907820/INA234_236EVM_GUI/ver/1.0.0/.
6. Connect the GND reference of the external system to the GND node of the EVM (pin 1 of J1).
7. Provide a differential input voltage signal to the IN+ and IN– nodes by connecting the signal leads to J1 pin 5 or 6 and J1 pin 3 or 4 on the EVM as explained in Section 4.2.2.

## 4.2 EVM Operation

To use the EVM with the SCB Controller (sold separately), connect the EVM as shown in Figure 4-1.

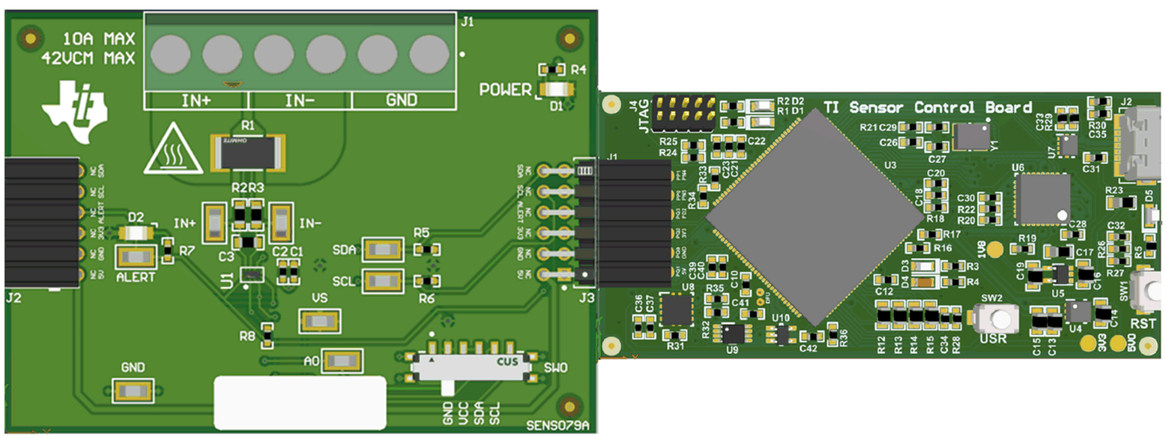



**Figure 4-1. EVM Connected to SCB Controller**

If using multiple EVMs, connect them as shown in Figure 4-2. Make sure to use a different chip address for each device. The GUI only supports one EVM/device type at a time.

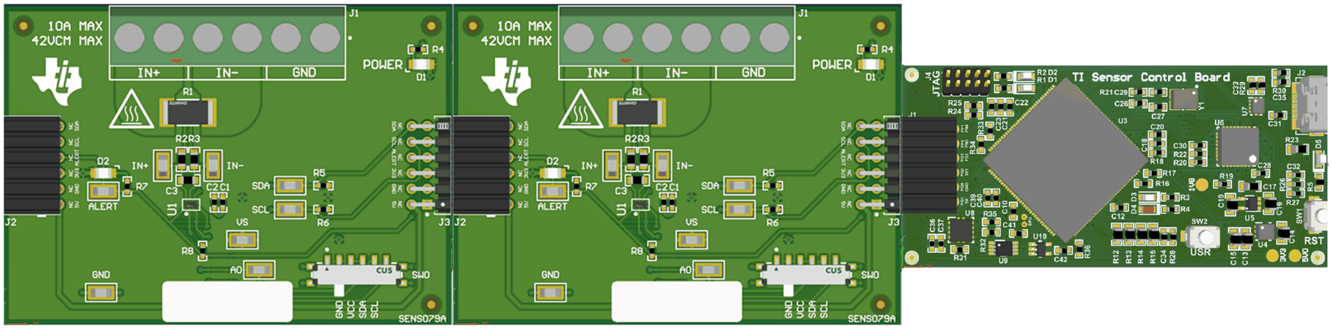


**Figure 4-2. Multiple EVMs Connected to SCB Controller**

### 4.2.1 Setup

#### *4.2.1.1 Driver Installation*

Download and install this driver: https://www.ti.com/lit/zip/sbac253. This is a one-time step per computer. Unzip the folder and **run the .exe file with administrator privileges**.

#### *4.2.1.2 Firmware*

Firmware updates will be pushed through the GUI (requires previous driver to be installed). Downloaded offline GUIs will only update the SCB Controller with the latest firmware available at the time of download. To check for the latest GUI or Firmware updates, launch the GUI from the web browser.

##### 4.2.1.2.1 Firmware Debug

If the firmware must be manually reinstalled for any reason, follow these steps to reinstall the firmware. Make sure the EVM is connected to the SCB.

1. First, see if the GUI can program the firmware manually.
    a. Plug in the SCB controller to the PC.
    b. Launch the GUI.
    c. It is possible that the MCU has already entered DFU mode. If so, the GUI may notify you and try to update the firmware to the latest version.
    d. If it does not update automatically, go to File > Program Device...
2. If that does not work (or if the **Program Device** button is grayed out), manually configure the MCU on the SCB Controller to be in Device Firmware Update (DFU) Mode. This can be done through either of the below methods with the SCB Controller powered on:
    a. Through software:
        - For safety, **turn off and disconnect all load sources and external voltages**.
        - Send the command 'bsl' on the SCB's USB Serial (COM) port.
    b. Though hardware:
        - While shorting the two test points labeled "DFU" (shown in Figure 4-3) with a pair of tweezers (or wire), press and release the RESET button.

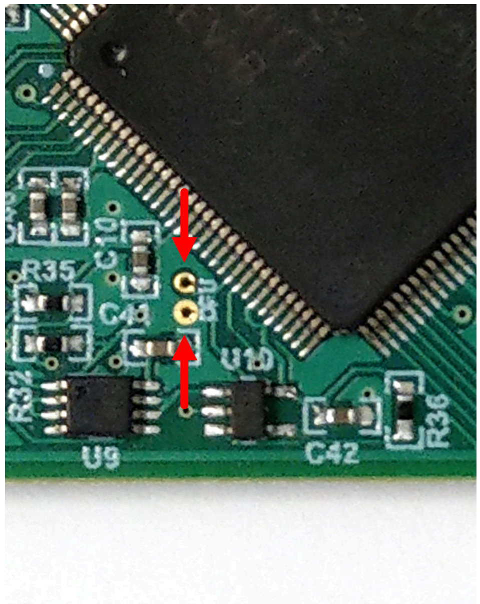



**Figure 4-3. Test Points Used to Enter DFU Mode Manually**

With the MCU in DFU mode, the firmware can now be uploaded through the method outlined in Step 1.

#### *4.2.1.3 GUI Setup and Usage*

The GUI can be accessed from this link in either Chrome or Firefox: https://dev.ti.com/gallery/info/3907820/INA234_236EVM_GUI/ver/1.0.0/.

##### 4.2.1.3.1 Initial Setup

To set up the GUI the first time:

1. Make sure that the previously mentioned driver was installed successfully to ensure that everything works properly and that the GUI can update the EVM firmware, if necessary.
2. Check to make sure the EVM/SCB Controller unit is plugged into the PC, then go to the previously-provided GUI link.
3. Click the **GUI Composer** application (Figure 4-4) to launch the GUI from the web browser.


**Figure 4-4. GUI Composer Application**

   a. Follow the prompts to download the **TI Cloud Agent** and browser extension shown in Figure 4-5 for the first-time GUI Composer setup These prompts will appear after you close the README.md dialog.

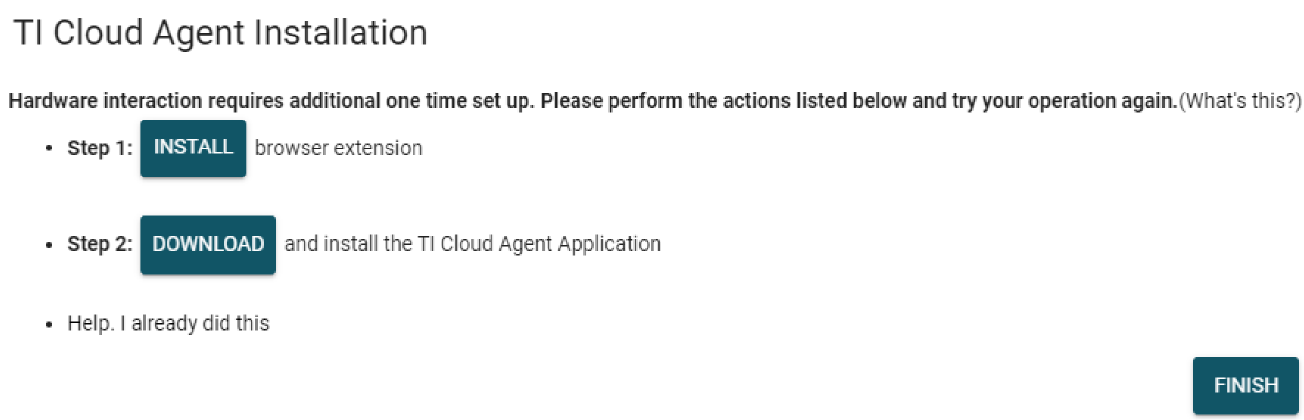



**Figure 4-5. TI Cloud Agent**

4. Optionally, click the icon in the *GUI Composer* application (Figure 4-4) and follow the prompts to download the GUI for offline use.

#### 4.2.1.3.2 GUI Operation

To operate the GUI, follow these steps:

1. Connect to and launch the GUI as described in Section 4.2.1.3.1.
2. Check to make sure that the EVM connected to the GUI, then close the README.md file page to initiate the connection. If successful, the **Hardware Connected** message should be visible near the bottom-left corner of the GUI as in Figure 4-6.

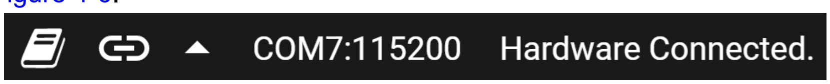



**Figure 4-6. Hardware Connected**

   a. A green indicator with the device type and the text **DEVICE CONNECTED** should also be visible near the top-left of the GUI window, as shown in Figure 4-7.

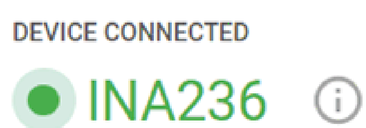



**Figure 4-7. Device Connected**

   b. If **Hardware Connected** and **DEVICE CONNECTED** do not show in the GUI, check the different hardware COM ports under **Options >> Serial Port**, as shown in Figure 4-8.

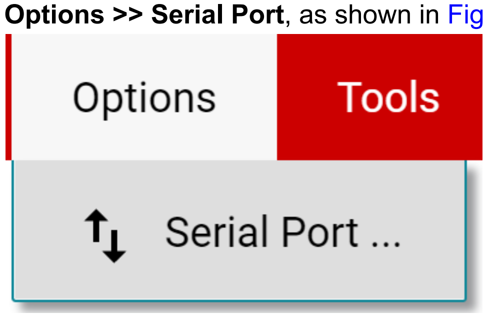



**Figure 4-8. Change Serial Port**

   c. If the hardware still does not connect, make sure you are using the correct GUI/EVM combination.

i. If you are using the correct GUI/EVM combination, you may need to reprogram the firmware of the SCB, as described in Firmware Debug.

3. Click the (registers) icon on the left menu to view and edit the device register map.
   a. From this page, you can read and write register settings on the EVM. For questions about a register or register bit field, select the icon. For more questions about registers, check the data sheet.
4. Click the (plots) icon on the left menu to go to the plots page. Under the plots page, you can view and collect results data over time. The plots page will look similar the one shown in Figure 4-9, depending on the connected device.

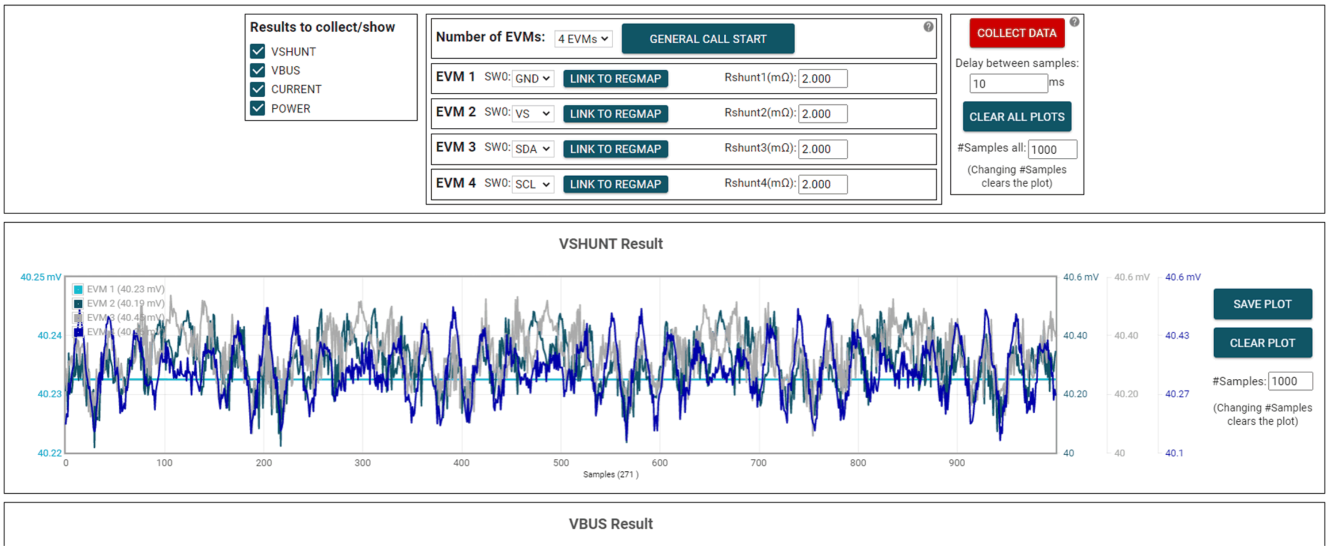



**Figure 4-9. GUI Plots Page**

   a. Below is a description of how to use the buttons and settings at the top of the plots page and next to each plot:
      i. Check the **Results to collect/show** box on the left to collect data from specific register values. If a results register is unselected, then the plot below will not show the data and the EVM will not try to read this value during the collect cycle. If you disable one of these settings while the EVM is collecting data, then the plot will not show, but data will still be collected and the plot will update in the background.
      ii. Set the **Number of EVMs** drop-down menu to the number of EVMs currently in use. See Figure 4-2 to see how to attach multiple EVMs together. Use the onboard switch(es) to select a different address for each EVM. The GUI only supports one EVM/device type at a time.
         1. Set the switch settings for each connected EVM. **EVM 1** will automatically populate with the lowest addressed device unless a setting has already been selected.
         2. Click the **LINK TO REGMAP** button to set the regmap of the desired EVM. Use this button to change settings for each connected device through the register map. Functionally, this button sets the default read/write address in the MCU and then reads all register values back to update the register map. Note that if data is being collected at a high frequency, then this may cause a minor delay in the collection data. For optimal performance, set device settings before you start collecting data.

iii. Click the **COLLECT DATA** button to start data collection.
    1. In this mode, the MCU reads and sends the selected result values for each device over a USB BULK channel. All results from one device are read before moving on to the next device. All result values from all EVMs together are considered one "sample set".
    2. The **Delay between samples** shows the delay between the start of each sample set. A delay of 0 corresponds to "as fast as possible". If the delay used is shorter than the amount of time it takes to read all results from all EVMs, the setting would be the same as a delay of 0. Note, the registers are read when the firmware is ready to read them, optionally based on the delay timer. It does not take into account conversion time or averaging. Although you can read and write to other registers through the register map page while collecting data, it is possible that this adds a delay to the data being collected.
    3. Click the **CLEAR ALL PLOTS** button to clear the data from all plots together. This can be done individually for each plot. Similarly, you can check the **#Samples all:** box to change the number of samples shown in each plot. This can also be done individually per plot.
    4. Click the **SAVE PLOT** button next to each plot to save the data in a spreadsheet.

### 4.2.2 Current Sensing Operation

The EVM allows the user to either emulate the voltage developed across a sense resistor based on a given set of system conditions by applying a differential voltage across the IN+ and IN– terminals directly, or to connect the device inputs to an external shunt. Optionally, a 2512 surface-mount technology (SMT) shunt resistor can be soldered across the pads of R1, and these inputs can be connected in series with the external system and load current. There are two terminals each for IN+ (J1 pins 5 and 6) and IN– (J1 pins 3 and 4) for convenience.

#### *4.2.2.1 Without Shunt Resistor*

To configure a measurement evaluation without a shunt resistor, follow these steps:

1. Connect a differential voltage across the IN+ and IN– terminals as shown in Figure 4-10.
   a. If the differential voltage supply is a floating supply, connect a –0.3-V to 48-V common-mode voltage (leave powered off until finished setting up) to the inputs by connecting the positive lead of the external voltage source to either the IN+ or IN– terminal. This action effectively raises the absolute common-mode voltage of the input pins. Make sure that the differential voltage plus or minus the common-mode voltage does not go out of the –0.3-V to 48-V range.

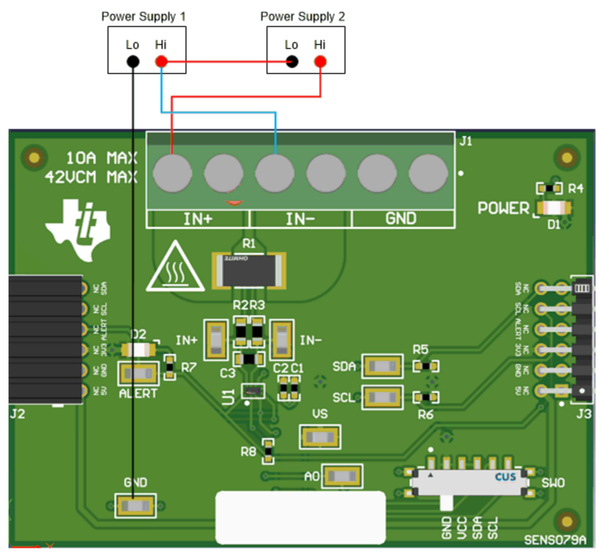



**Figure 4-10. IN+ and IN– Wiring Without a Shunt Resistor**

2. Connect the VBUS terminal (J1 pin 2) to the desired bus voltage (likely either IN+ or IN–).
3. Connect the source ground to the GND terminal (J1 pin 1).
4. Power on the system, and observe the device states and outputs through the GUI.

#### 4.2.2.2 With Shunt Resistor

To configure a measurement evaluation with a shunt resistor, follow these steps:

1. Connect a shunt resister by doing either of the following:
   a. Solder a 2512 resistor across the pads of R1 that connects the IN+ and IN– inputs.
   b. Connect an external shunt across the IN+ and IN– terminals of J1, preferably across pins 4 and 5, as shown in Figure 4-11.
      i. If an external shunt is being used, make the connections such that the sensing location is across the shunt and there will be no high current on the sensing path. See the *TI Precision Labs - Current Sense Amplifiers: Shunt Resistor Layout* video for more information.
2. Connect the IN+ and IN– terminals in series with the load while powered off.

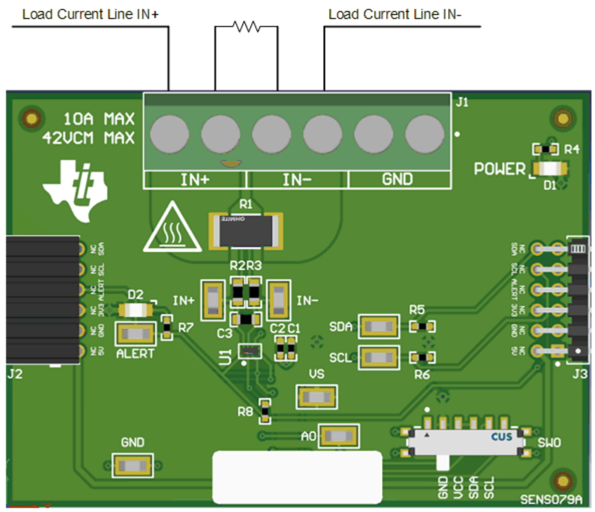



**Figure 4-11. IN+ and IN– Wiring With a Shunt Resistor**

> **WARNING**
>
> If measuring current, first make sure that the equipment (shunt resistor, wires, connectors, and so on) can support the amperage and power dissipation. Secondly, make sure that the current flowing through J1 does not exceed 10 A. Failure to do so can result in damage to the EVM, or personal injury.
>
> Do not touch high voltage terminals.
>
> The EVM may get hot.

3. Connect the VBUS terminal (J1 pin 2) to the desired bus voltage (likely either IN+ or IN–).
4. Connect the system ground to the GND terminal (J1 pin 1).
5. Power on the system, and observe the device states and outputs through the GUI.

### 4.2.3 Direct EVM USB Communication

If desired, the EVM can be communicated with directly without the use of the GUI through the USB port. This is done by sending the desired command string over the serial COM port and receiving the results either through the COM port or the USB BULK channel, based on the mode. This is useful for interfacing the EVM with custom setups, scripts, or GUIs.

#### *4.2.3.1 Standard USB CDC Read and Write Operations*

Use the serial COM port to read and write registers through USB CDC commands using the following format:

- Read register format: rreg ADR
  - Where ADR is the address in hex, and rreg is always lower case
  - Register addresses can be in upper or lower case, and do not need to be led by '0x'. 0 padding register addresses is also optional. For example, to read register address 0x1, some valid commands include:
    - rreg 1
    - rreg 01
    - rreg 0x01
      - When '0x' is used, the 'x' must be lower case.
  - For the previous example, the EVM would return the results in JSON format

    {"acknowledge":"rreg 0x01"}

    {"register":{"address":1,:"value":3}}

    {"evm_state":"idle"}
- Write register format: wreg ADR VAL
  - Where ADR and VAL are in hex, and wreg is always lower case
  - Register addresses and values can be in upper or lower case, and do not need to be led by '0x'. 0 padding register addresses and values is also optional. For example, to write register address 0x5 with the value 0x4121, some valid commands include:
    - wreg 5 4121
    - wreg 05 0x4121
    - wreg 0x05 0x4121
      - When '0x' is used, the 'x' must be lower case.
  - For the previous example, the EVM would return the results in JSON format:

    {"acknowledge":"wreg 0x01 0x4121"}

    {"console":"Writing 0x4121 to ADC_CONFIG register"}

    {"evm_state":"idle"}

#### 4.2.3.2 Collect Data Through the USB BULK Channel

The *Collect Data* function can also be started and stopped through the serial COM port, however the results will be sent over the USB BULK Channel. To do this, use the following format:

- Start collecting data format: collect timerPeriod collectFlags channelAddressIDs numDevices
  - Where each parameter is the decimal representation of the value in the following format:
    - timerPeriod: The delay used in the internal timer to allow data collection sample sets (in milliseconds, unsigned 32-bit value).
    - collectFlags: a byte of data that has a 1 to collect and a 0 to not collect each register value type, according to the following definitions (note to only use energy and charge flags when the device supports that, otherwise set to 0):
      - VSHUNT = 0b1000000
      - VBUS = 0b0100000
      - CURRENT = 0b0001000
      - POWER = 0b0000100
    - channelAddressIDs
      - This is the 4 LSBs of each address chained together, starting with the LSBs.
        - For example If EVM 1 is on channel 0x41 and EVM 2 is on 0x43, the value here would be 0b00110001
    - NumDevices is the number of EVMs chained together (1-4).
  - For example, to start data collection for VSHUNT, VBUS, and CURRENT and POWER every 10 ms, for four INA236s with EVM 1 SW0 = GND, EVM 2 SW0 = VS, EVM 3 SW0 = SDA and EVM 4 SW0 = SCL, you would send: collect 10 108 12816 4
    - For this example, the EVM would return the acknowledgment and status in JSON format:

      {"acknowledge":"collect 10 108 12816 4"}

      {"evm_state":"collecting"}
    - Note, for the rreg and wreg functions above, the EVM will return "collecting" instead of "idle" if collecting.
  - The USB BULK channel receives data in the format: frameID deviceNumID address registerSize data
    - Where each parameter is the decimal representation of the value in the following format:
      - frameID (1 byte): Always reads 0. Used to ensure data is aligned.
      - deviceNumID (1 byte): An ID number corresponding to the EVM number.
        - From the above example, this will be 1 if reading from EVM 1, 2 from EVM 2, 3 from EVM 3, and 4 from EVM 4.
      - address (1 byte): The register address that was read from the device.
      - registerSize (1 byte): The number of bytes that the following data will have.
      - data (1 byte at a time): The register data value, given in bytes with the most significant byte first.
- Stop collecting data format: stop
  - The EVM would return the acknowledgment and status in JSON format:

    {"acknowledge":"stop"}

    {"evm_state":"idle"}

# 5 Circuitry

This section summarizes the EVM subsystems and their components.

## 5.1 Current Sensing IC

This section describes the main INA device and supporting components.

U1 is the main INA current-sensing device (either the INA234 or INA236). C1 and C2 are bypass capacitors that are placed near the sensor to help mitigate power supply noise and provide current quickly to the device when needed. LED D1 with current limiting resistor R4 are used to indicate when the EVM is powered on.

The device pins can be monitored directly through the test points.

## 5.2 Input Signal Path

This section describes the circuitry of the input signal path.

J1 is the main connection terminal. Pin 1 of J1 is used to tie the system ground to the EVM ground. Pin 2 of J1 is used for the VBUS measurement within the sensor. Pins 3 and 4 are tied to IN–, and Pins 5 and 6 are tied to IN+. There are two pins each for IN– and IN+ for convenience.

R1 can be used for an optional onboard shunt resistor with a 2512 footprint. Alternatively, a shunt can be placed across the IN+ and IN– terminals of J1. If desired, a differential voltage can be applied directly for measurement tests.

C3, R2, and R3 combine to make an optional input filter. R2 and R3 are populated with 0-Ω resistors by default. When using input filtering, take into account the input bias current of the device.

## 5.3 Digital Circuitry

This section describes the digital circuitry around the device.

### 5.3.1 I2C

J2 and J3 are the main header pins that connect the digital and power pins to the SCB Controller or other EVMs. J3 connects to the EVM/SCB on the right, while J2 connects to more EVMs on the left. R5 and R6 are used as pullup resistors for the main digital IO pins.

SW0 sets the I2C address of the device. This can be useful when using the EVM with a custom controller (other than the SCB Controller), or when connecting multiple EVMs together. Currently the SCB Controller and GUI are set up to use four EVMs at a time.

R8 is used as a pullup resistor for the ALERT pin, which is routed to both J2 and J3. LED D2 and current limiting resistor R7 are used to indicate when the ALERT has triggered.

# 6 Schematics, PCB Layout, and Bill of Materials

**Note**

Board layouts are not to scale. These figures are intended to show how the board is laid out. The figures are not intended to be used for manufacturing EVM PCBs.

## 6.1 Schematics

This section shows the schematics for the INA234 and INA236 EVMs. The schematics are identical except for the IC itself.

### 6.1.1 SENS079 (INA234EVM, INA236EVM)

Figure 6-1 and Figure 6-2 show the schematic of the EVM. Figure 6-1 shows the circuitry for the EVM. Figure 6-2 shows the mechanical components included with the EVM.

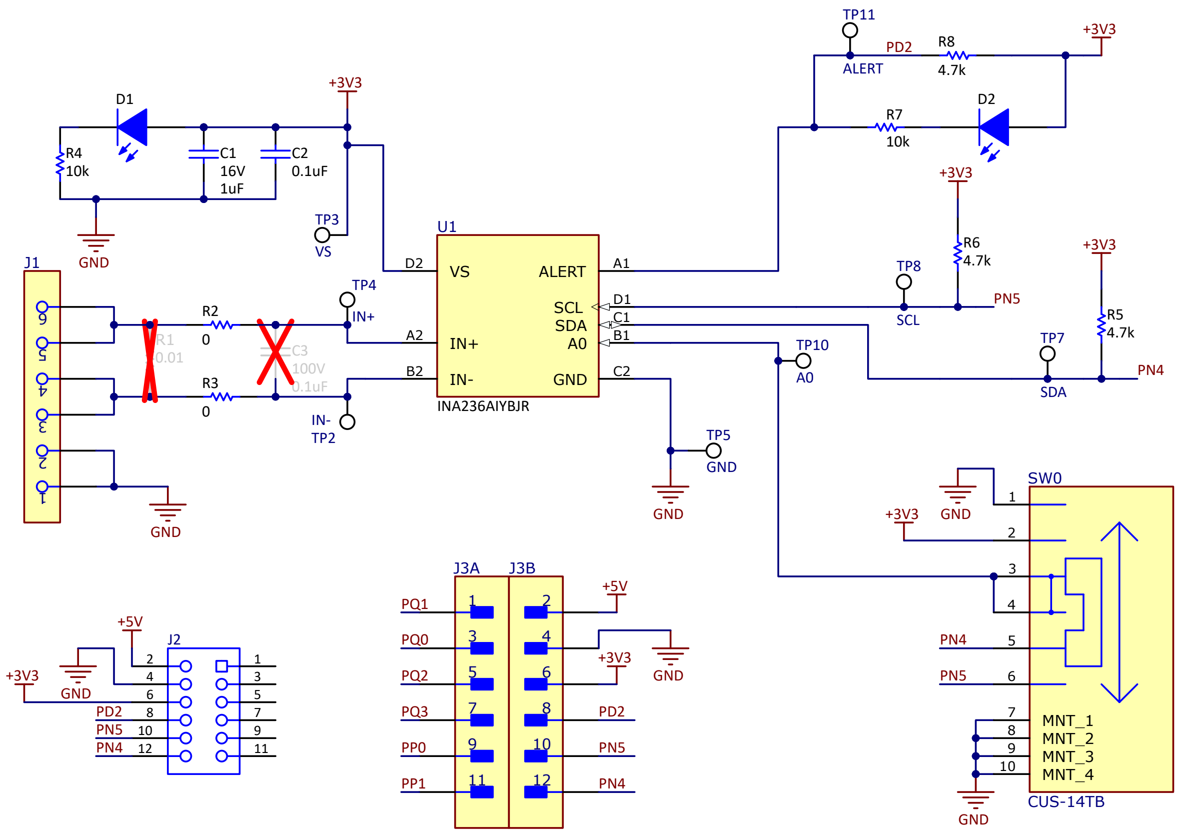



**Figure 6-1. SENS079 Schematic**

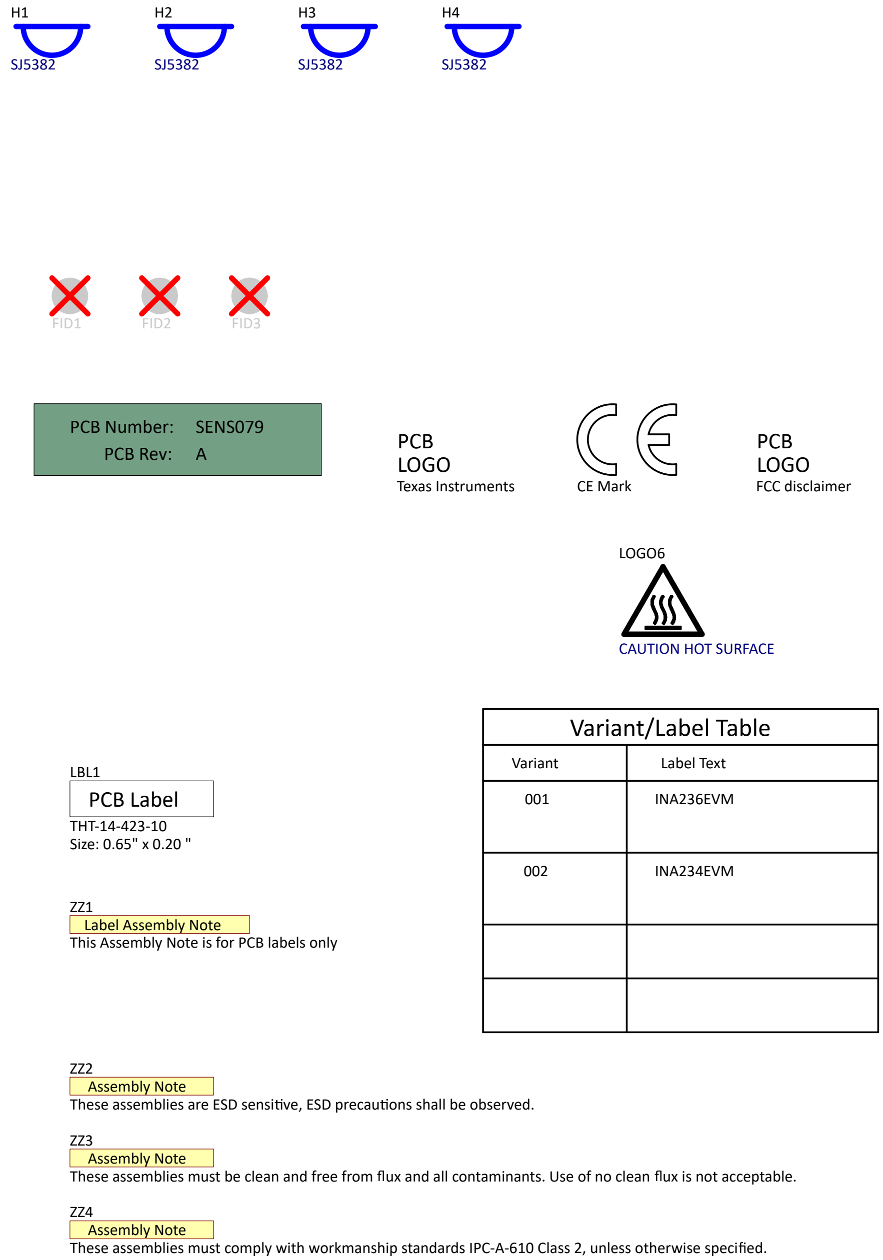



**Figure 6-2. SENS079 Hardware Schematic**

## 6.2 PCB Layout

### 6.2.1 SENS079 (INA234EVM, INA236EVM)

Figure 6-3 through Figure 6-6 illustrate the PCB layers of the EVM.

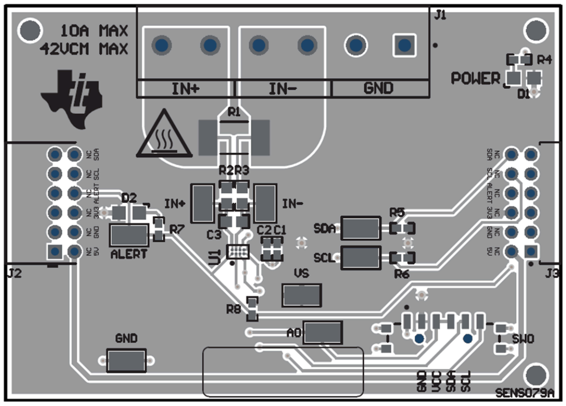



**Figure 6-3. SENS079 Top View**

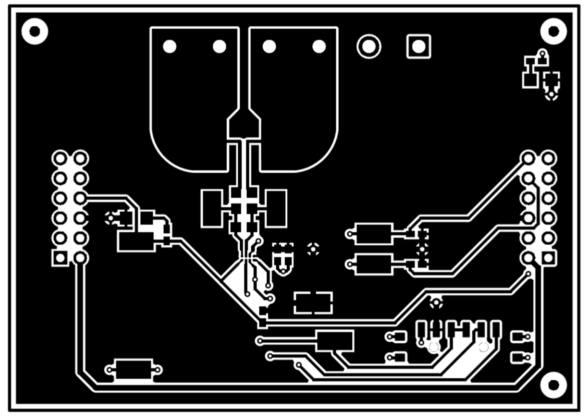


**Figure 6-4. SENS079 Top Layer**

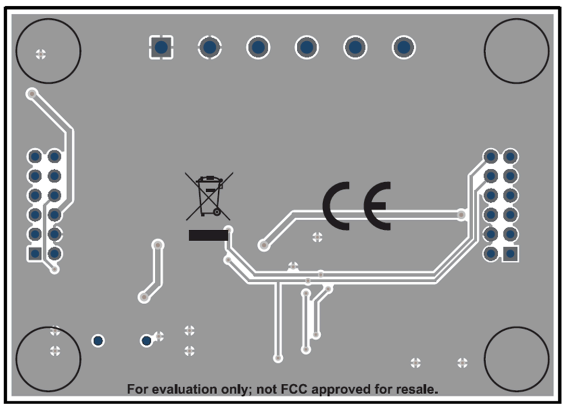



**Figure 6-5. SENS079 Bottom View**

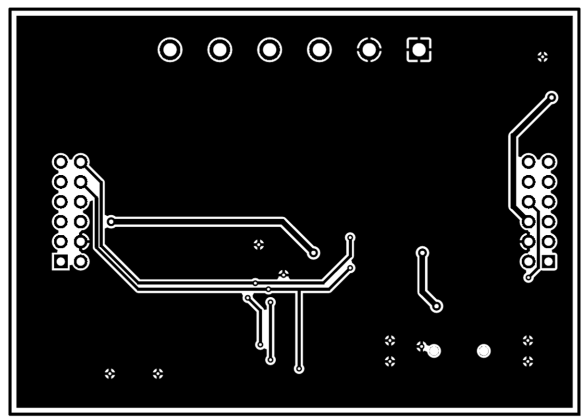


**Figure 6-6. SENS079 Bottom Layer**

## 6.3 Bill of Materials

This section shows the bill of materials for the SENS079.

### 6.3.1 SENS079 (INA234EVM, INA236EVM)

Table 6-1 through Table 6-3 provide the parts list for the EVM. Table 6-1 through Table 6-2 are variant specific, while Table 6-3 shows the parts common to both SENS079 variants.

**Table 6-1. INA234EVM Exclusive Bill of Materials**

| Designator | QTY | Value | Description | Package Reference | Part Number | Manufacturer |
|---|---|---|---|---|---|---|
| U1 | 1 | | 28-V, 12-Bit, I2C Output Current, Voltage, and Power Monitor | DSBGA8 | INA234AIYBJR | Texas Instruments |

**Table 6-2. INA236VM Exclusive Bill of Materials**

| Designator | QTY | Value | Description | Package Reference | Part Number | Manufacturer |
|---|---|---|---|---|---|---|
| U1 | 1 | | 42-V, 16-Bit, Precision I2C Output Current, Voltage, and Power Monitor | DSBGA8 | INA236AIYBJR | Texas Instruments |

**Table 6-3. SENS079 Variants Bill of Materials**

| Designator | QTY | Value | Description | Package Reference | Part Number | Manufacturer |
|---|---|---|---|---|---|---|
| !PCB1 | 1 | | Printed Circuit Board | | SENS079 | Any |
| C1 | 1 | 1uF | CAP, CERM, 1 µF, 16 V,+/- 20%, X5R, 0402 | 0402 | C1005X6S1C105K050BC | TDK |
| C2 | 1 | 0.1uF | CAP, CERM, 0.1 uF, 50 V, +/- 20%, X7R, 0402 | 0402 | GRM155R71H104ME14D | MuRata |
| D1, D2 | 2 | White | LED, White, SMD | 0805 | VAOL-S8WR4 | Visual Communications Company, LLC |
| H1, H2, H3, H4 | 4 | | Bumpon, Hemisphere, 0.25 X 0.075, Clear | 75x250 mil | SJ5382 | 3M |
| J1 | 1 | | TERM BLK 6POS SIDE ENTRY 5MM PCBASSEMBLY NOTE: Trim leads per ZZ5 | HDR6 | 691137710006 | Wurth Electronics |
| J2 | 1 | | Receptacle, 2mm, 6x2, Gold, R/A, TH | Receptacle, 2mm, 6x2, R/A, TH | NPPN062FJFN-RC | Sullins Connector Solutions |
| J3 | 1 | | 'Connector Header Through Hole, Right Angle 12 position 0.079" (2.00mm) | HDR12 | NRPN062PARN-RC | Sullins Connector Solutions |
| LBL1 | 1 | | Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll | PCB Label 0.650 x 0.200 inch | THT-14-423-10 | Brady |
| R2, R3 | 2 | 0 | RES, 0, 5%, 0.125 W, 0603 | 0603 | MCT06030Z0000ZP500 | Vishay/Beyschlag |
| R4, R7 | 2 | 10k | RES, 10 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402 | 0402 | CRCW040210K0JNED | Vishay-Dale |
| R5, R6, R8 | 3 | 4.7k | RES, 4.7 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402 | 0402 | CRCW04024K70JNED | Vishay-Dale |
| SW0 | 1 | | Slide Switch SP4T Surface Mount, Right Angle | SMT_SW_11MM3_4MM1 | CUS-14TB | Nidec Copal Electronics |
| TP2, TP3, TP4, TP5, TP7, TP8, TP10, TP11, | 8 | | Test Point, Miniature, SMT | Testpoint_Keystone_Miniature | 5015 | Keystone |
| C3 | 0 | 0.1uF | CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7S, AEC-Q200 Grade 1, 0603 | 0603 | CGA3E3X7S2A104K080AB | TDK |
| FID1, FID2, FID3 | 0 | | Fiducial mark. There is nothing to buy or mount. | N/A | N/A | N/A |
| R1 | 0 | | 10 mOhms ±0.5% 2W Chip Resistor 2512 (6432 Metric) Automotive AEC-Q200, Current Sense, Moisture Resistant Metal Film | 2512 | PCS2512DR0100ET | Ohmite |

## 7 Revision History

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

| Changes from Revision * (May 2021) to Revision A (February 2022) | Page |
|---|---|
| • Removed SCB as a kitted item | 3 |