Evaluating the ADuM4177, 40 A Source/30 A Sink SiC Isolated Gate Driver with Slew-Rate Control and Built-In Self Tests

FEATURES

- 40 A (source), 30 A (sink) peak drive output capability
- Output power device resistance: 0.38 Ω per MOSFET
- Test infrastructure for
  - SPI communication
  - Slew-rate control
  - Desaturation detection
  - Miller drive
  - Active short-circuit
  - Temperature sensing
  - Fault reporting
  - Multiple dummy loads

EVALUATION KIT CONTENTS

- EVAL-ADuM4177EBZ evaluation board

EQUIPMENT NEEDED

- Three variable power supplies up to 25 V and 1 A
- USB-SDP-CABLEZ required for SPI communication
- Signal generator
- Oscilloscope

DOCUMENTS NEEDED

- ADuM4177 data sheet

SUPPORTED *I*COUPLER MODELS

- ADuM4177

SOFTWARE NEEDED

- ADuM4177 evaluation software

GENERAL DESCRIPTION

The EVAL-ADuM4177EBZ evaluation board shows the advanced features of the ADuM4177 while maintaining flexibility in a testing environment. The EVAL-ADuM4177EBZ evaluation board layout delivers a circuit that is easy to control through jumper pins and with access to all of the pins through headers and input and output connectors. A more optimized layout is possible that increases the performance of the system.

The EVAL-ADuM4177EBZ evaluation board works with the USB-SDP-CABLEZ programming cable to access the secondary side electronically erasable programmable read-only memory (EEPROM) and includes the option to drive the serial-peripheral interface (SPI) bus with any other SPI compatible system. The USB-SDP-CABLEZ operates with a 3.3 V logic supply, while the ADuM4177 is typically powered with 5 V. Resistor dividers are added on the SPI channels to allow interfacing.

This user guide shows how to use the ADuM4177 evaluation board to perform basic evaluations such as propagation delay testing, active short-circuit (ASC) function, and desaturation (DESAT). This user guide also shows how to use the evaluation software to access the user configurable bits and explains how to simulate EEPROM settings and program bits into nonvolatile memory.

Full specifications on the ADuM4177 are available in the ADuM4177 data sheet available from Analog Devices, Inc., and must be consulted with this user guide when using the EVAL-ADuM4177EBZ evaluation board.

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REVISION HISTORY

5/2023—Revision 0: Initial Version

EVAL-ADUM4177EBZ EVALUATION BOARD PHOTOGRAPH

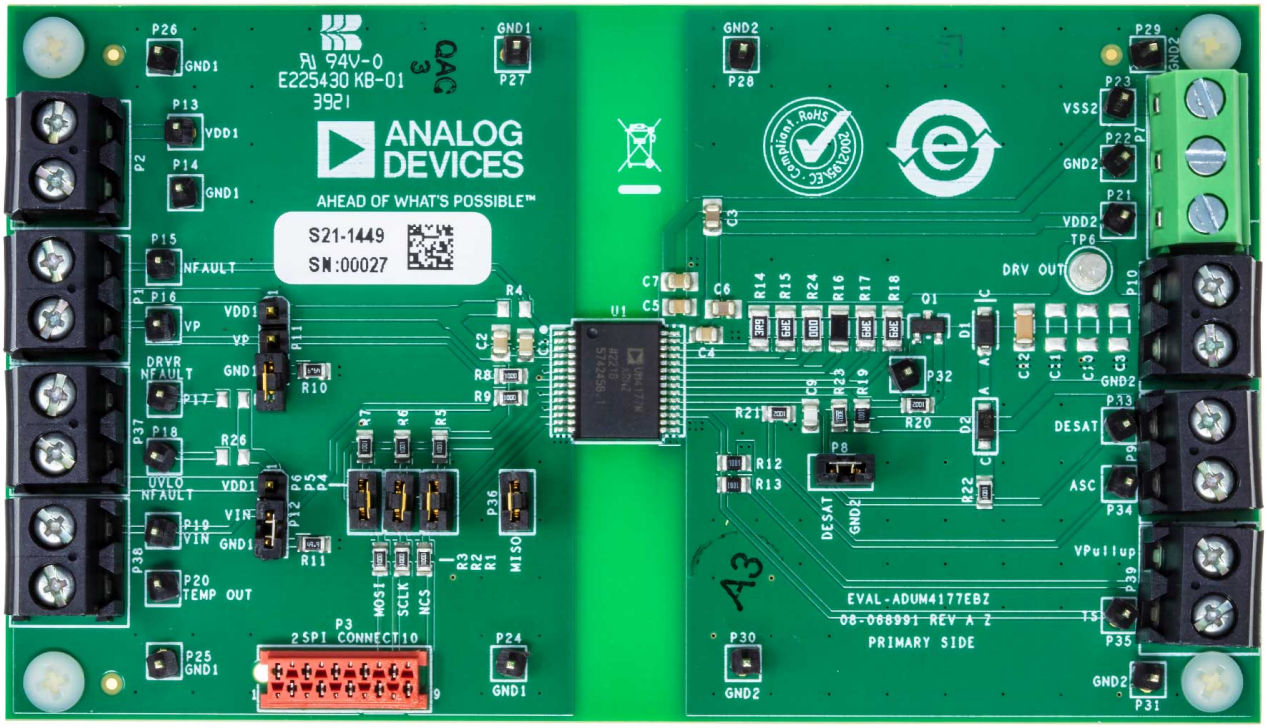

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Figure 1. EVAL-ADuM4177EBZ Evaluation Board Photograph

EVALUATION BOARD CONFIGURATIONS

The EVAL-ADuM4177EBZ evaluation board is preconfigured with the output resistors and a capacitive-load as follows:

- R14: V_{OUT_ON1} resistor, 3.9 Ω
- R15: V_{OUT_ON2} resistor, 3.9 Ω
- R16: V_{OFF_SOFT} resistor, 300 Ω
- R17: V_{OUT_OFF1} resistor, 3.9 Ω
- R18: V_{OUT_OFF2} resistor, 3.9 Ω
- C12: Load capacitor, 100 nF

Figure 2 provides the information about the ADuM4177 and its external components, which the user can use to modify the gate driver design. Figure 3 outlines the evaluation board features available for the user.

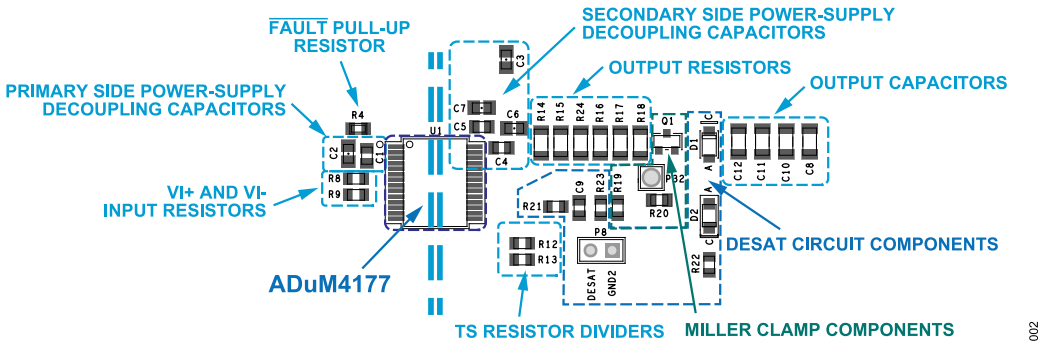

Figure 2. Outline of ADuM4177 Top Component Details

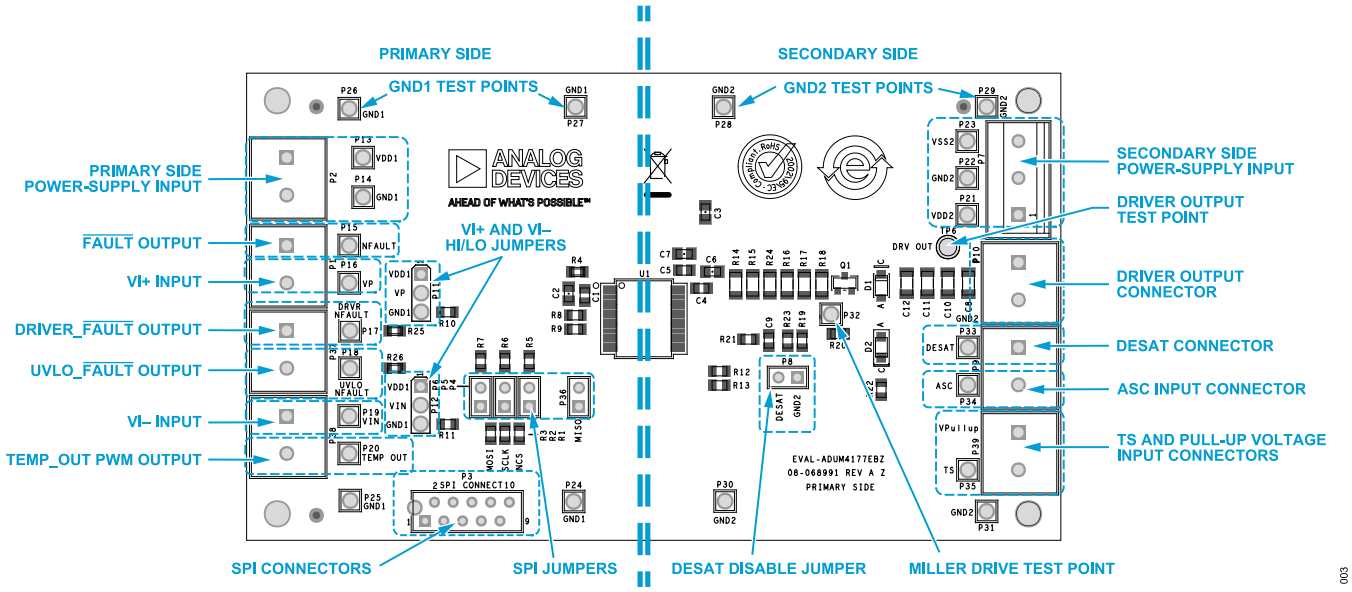

Figure 3. Outline of EVAL-ADuM4177EBZ Evaluation Board Features

EVALUATION BOARD CONFIGURATIONS

POWER CONNECTIONS

The ADuM4177 is an isolated gate driver, and there are two different isolation regions on the device. The left side of the IC (Pin 1 to Pin 14) is referred to as the primary side. The right side of the IC (Pin 15 to Pin 28) is referred to as the secondary side. The primary side is powered by the V_{DD1} pin and the GND_1 pin. The primary side controls the input logic, SPI communications, and fault reporting. Voltages between 4.4 V and 7 V are recommended for the V_{DD1} pin to the GND_1 pin. The secondary side voltage controls the output side of the ADuM4177. The voltage from the V_{DD2} pin to the V_{SS2} pin controls the voltage swing seen at the driven power device. The V_{DD2} pin to V_{SS2} pin voltages are recommended to be between 15 V and 23 V. By default, the secondary side voltage must be a bipolar voltage were V_{SS2} to GND_2 must be between −5 V to −3.25 V to support silicon carbide (SiC) power devices. Unipolar mode of operation is also possible where V_{SS2} is connected to GND_2 that requires disabling the V_{SS2} UVLO through SPI programming.

Caution: Do not supply bipolar voltage when operating in unipolar mode as it damages the ADuM4177.

INPUT AND OUTPUT CONNECTIONS

Drive the V_P pin in P1 screw terminal with any 5 V logic or 3.3 V logic, push-pull complementary metal-oxide semiconductor (CMOS) connection or with an adequate open-drain configuration if the correct pull-up resistor is used. When the V_P pin is driven with a 50 Ω load capable source, a jumper in P11 from Pin 2 (V_P) to Pin 3 (GND_1) is recommended to connect the 50 Ω load termination. Resistor R10 is a 0603 surface-mount device (SMD) resistor that allows 50 Ω termination.

Drive the V_{IN} pin in P38 screw terminal. When the V_{IN} pin is driven with a 50 Ω load capable source, a jumper in P12 from Pin 2 (V_{IN}) to Pin 3 (GND_1) is recommended to connect the 50 Ω load termination resistor R11.

When the inputs V_P and V_{IN} is not driven, jumper P11 and P12 can be used to toggle from V_{DD1} and GND_1 through the 50 Ω resistors.

Monitor the output in P10 screw terminal or use TP6 DRV OUT test point.

USING SPI

The EVAL-ADuM4177EBZ evaluation board interfaces easily with the USB-SDP-CABLEZ cable. When using the SPI bus, place jumpers on the MOSI, MISO, NCS, and SCLK jumper pins. Connect the USB-SDP-CABLEZ to Jumper P3. The EVAL-ADuM4177EBZ evaluation board has an indexing hole to ensure proper polarity.

Test any other SPI system on the EVAL-ADuM4177EBZ evaluation board by connecting cables to the bottom side of the MOSI, MISO, NCS, and SCLK jumpers. The pins of the EVAL-ADuM4177EBZ evaluation board are labeled on the silkscreen.

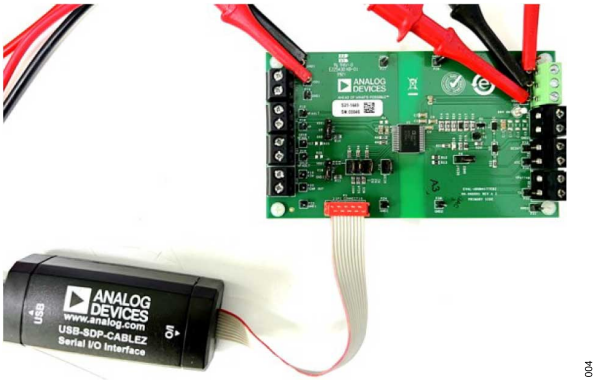

Figure 4. EVAL-ADuM4177EBZ Evaluation Board with USB-SDP-CABLEZ Connected

DESAT OVERRIDE

The P8 jumper provides a simple method for tying the DESAT pin to the GND_2 pin. This method removes the possibility of DESAT fault stopping the output drive. When testing DESAT capability of the ADuM4177, remove the default jumper on P8 then connect the collector/drain of the power switch to the DESAT pin through P9 screw terminal.

ASC INPUT

Access ASC pin through P9 screw terminal and P34. A 10 kΩ resistor R21 connects ASC to GND_2 to pull down ASC to GND_2 level when there is no input in P9 or P34.

TEMPERATURE SENSE INPUT

Without remote temperature sensing device in place, the temperature sense (TS) pin is pulled to V_{SS2} through 1 kΩ resistor R12, which produces about 210 mV of TS voltage with respect to V_{SS2} corresponding to high temperature operation mode. To create a middle range voltage on the TS pin, another 1 kΩ resistor is provided connected to $V_{PULL-UP}$ on P39 screw terminal and TS pin. Connecting $V_{PULL-UP}$ pin to GND_2 pin simulates a midrange temperature simulation on TS. To simulate a low temperature reading on the TS pin, supply $V_{PULL-UP}$ with a positive voltage resulting in a higher voltage in TS corresponding to a low temperature reading at the ADuM4177 remote temperature sensing pins. By default, the TS comparator of the ADuM4177 is disabled, thus, high or low temperature readings does not flag a fault.

EVALUATION BOARD CONFIGURATIONS

EXAMPLE PROPAGATION DELAY TESTING

Perform an example propagation delay testing from a stock configuration as shown in Figure 5. The V_P pin is driven by a pulse generator with 50 Ω termination. The V_{DD1} pin is fed with 5 V referenced to the GND_1 pin. The V_{DD2} pin is fed with 18 V referenced to the GND_2 pin. The V_{SS2} pin is fed with −5 V referenced to the GND_2 pin. For this configuration, the USB-SDP-CABLEZ is not used but it is possible to perform the test with the USB-SDP-CABLEZ connected to the ADuM4177.

Measuring P10 and/or TP6 DRV OUT test point simulates what an insulated-gate bipolar transistor (IGBT)/SiC with a 3.9 Ω series gate resistances sees at the gate.

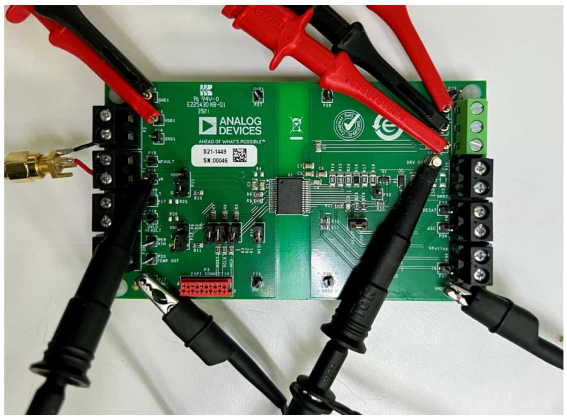

Figure 5. Example Propagation Delay Test Setup

EVALUATION BOARD SOFTWARE

SOFTWARE INSTALLATION PROCEDURE

To use the USB-SDP-CABLEZ for SPI communication, an ADuM4177 LabVIEW® executable GUI is available. The ADuM4177 GUI requires to install USB-SDP-CABLEZ drivers and a LabVIEW run-time engine 2015 or compatible.

To install the drivers and the LabVIEW software, do the following steps:

1. Install **SDPdrivers.exe**, available within the **ADuM4177 Customer Eval.zip**.
2. Install LabVIEW Run-Time Engine 2015 SPI (32-bit) or later (available from National Instruments).
3. Extract the ADuM4177 Customer Eval.zip to desired folder. Opening the **ADuM4177 Customer Evaluation Rev. XX.exe** runs the ADuM4177 GUI. It is recommended to have the USB-SDP-CABLEZ plugged in before opening the GUI.

PROGRAM BUTTON DESCRIPTIONS

Run

This button allows the LabVIEW program to run. When the ADuM4177 GUI is opened, the default setting is run as shown by the black arrow.

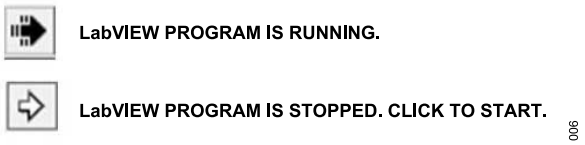

Figure 6. Run Button

Stop

This button stops the LabVIEW program. Alternate methods of stopping the program are to close the window or to force quit the program.

Figure 7. Stop Button

Read

Read buttons are available for each user accessible register. Click **Read** button to read the register inline with the **Read** button. Each time the **Read** button is clicked, the GUI actually performs two SPI transfers. The first transfer requests the read of the intended register, and the second transfer reads the result. If probing the SPI lines, each Read request results in two $\overline{CS}$ falling edges.

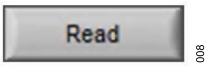

Figure 8. Read Button

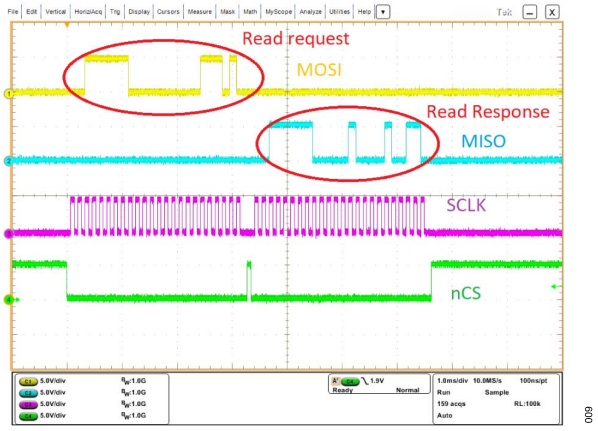

Figure 9. Example Single Read Button Press Waveforms

Write

Write buttons are available for registers that are user adjustable. Click **Write** button to write the data in the GUI inline with the **Write** button. All necessary cyclic redundancy check (CRC) codes are automatically calculated and transmitted by the ADuM4177 GUI.

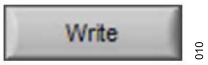

Figure 10. Write Button

EVALUATION SOFTWARE EXAMPLE OPERATION

These examples assume the setup described in the Software Installation Procedure is done.

TEST COMPUTER TO CABLE CONNECTION

The following example sequence shows how to make sure the ADuM4177 GUI is communicating with the programming cable.

1. Connect programming cable to computer.
2. Open **ADuM4177 Customer Evaluation Rev. XX.exe**.
3. Observe initial register status.
4. Perform Example Read Command.

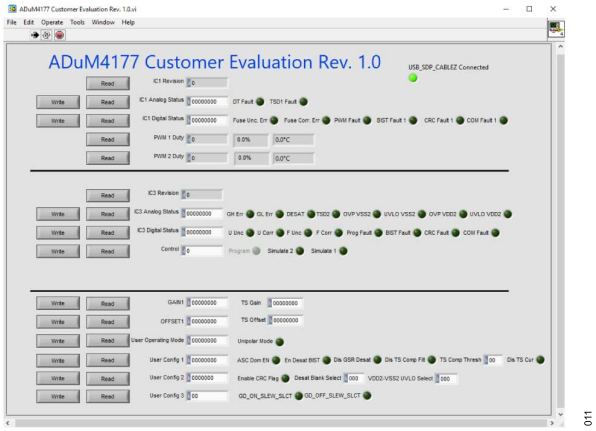

Figure 11. Initial Register Status

Example Read Command

To perform a read command, first power up the ADuM4177 V_{DD1}/GND_1, V_{DD2}/GND_2, and V_{SS2}/GND_2. For default UVLO values, recommended voltages are:

$V_{DD1}/GND_1 = 5$ V

$V_{DD2}/GND_2 = 18$ V

$V_{SS2}/GND_2 = -4$V

Click **Read** button to read the single register that is found on the same line in the GUI.

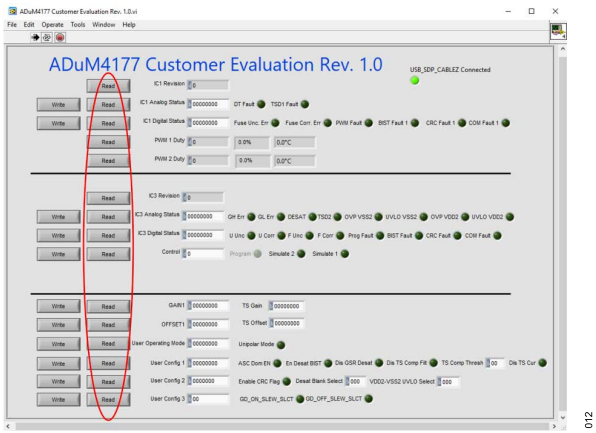

Figure 12. Read Register Targets

To establish that the ADuM4177 GUI is communicating correctly with the ADuM4177, reading **IC1 Revision** and **IC3 Revision** show that the ADuM4177 is properly connected and powered up. The GUI displays a nonzero number in IC1 Revision and IC3 Revision output windows if SPI communication with the ADuM4177 is successful.

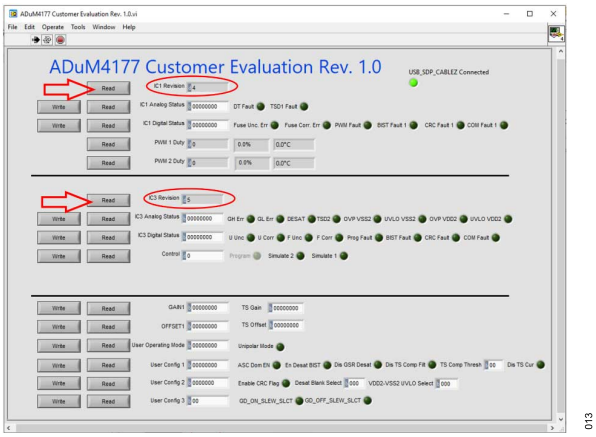

Figure 13. Read IC1 and IC3 Revision Numbers

EXAMPLE EEPROM WRITE

The sequence to write to nonvolatile memory is:

1. Write **1** to both simulate bits.
2. Write desired values to writable registers.
   - At this point, register effects show up on the ADuM4177 until a complete power cycle.
3. Write **1** to program bit, and both simulate bits at the same time.
   - At this point, register values and effects persist even after a power cycle.

To write data to the EEPROM, the **Sim_Trim** bits must first be set. As shown in Figure 14, clicking either **Simulate 1** or **Simulate 2** indicator lights activate both. The value is not written to the ADuM4177 until the **Write** button is clicked.

EVALUATION SOFTWARE EXAMPLE OPERATION

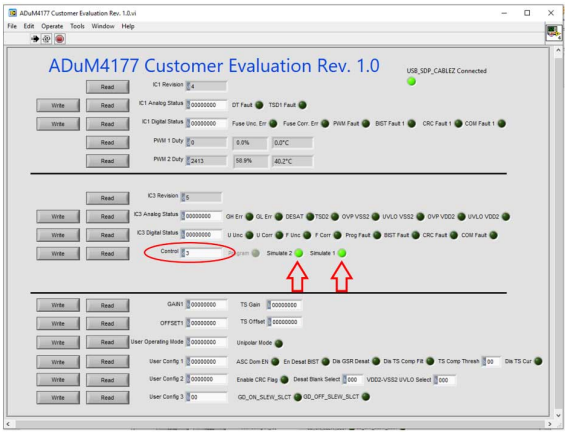

Figure 14. Simulate Bits

After **Write** is clicked, the **Program** indicator becomes dark as shown in Figure 15. This indicates that both Simulate 1 and Simulate 2 are **1**, and the ADuM4177 loads the registers given to it. If the registers are required to be written to nonvolatile memory, writing a **1** to **Program** saves the registers to EEPROM.

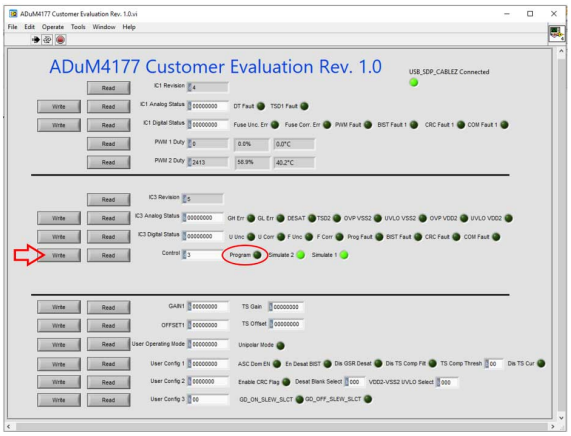

Figure 15. After Write is Clicked on Control Register

The following example loads a changed register into nonvolatile memory. In this example, TS Gain is set to **00000011**. As shown in Figure 16, enter the desired value into the **TS Gain** field (marker with red arrow), and click **Write** button (marked with another red arrow).

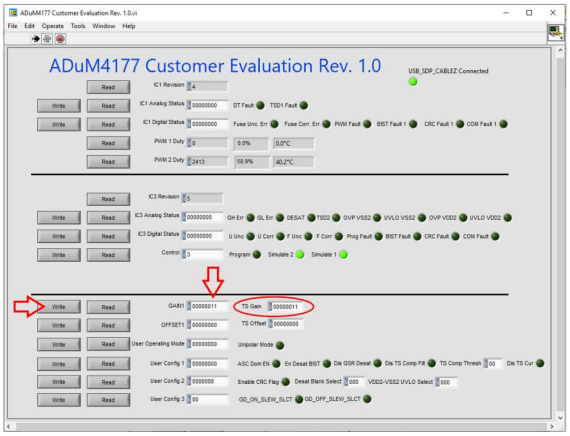

Figure 16. Setting TS Gain to 00000011

At this point, the effects of the TS Gain change can be shown on the ADuM4177 GUI. As shown in Figure 16, the value is reported in the field circled with red. If a power cycle occurs, the register resets to the previous value in the EEPROM.

Setting the Program bit to **1**, and keeping the simulate bits set to **1**, and then click **Write** to program the registers to EEPROM as shown in Figure 17.

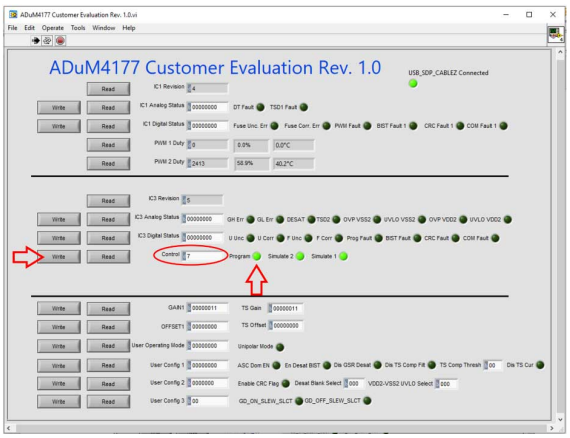

Figure 17. Programming Values to EEPROM

To verify that the programming is complete (as shown in Figure 18), click **Read** button and verify that the **Program** indicator light is off.

EVALUATION SOFTWARE EXAMPLE OPERATION

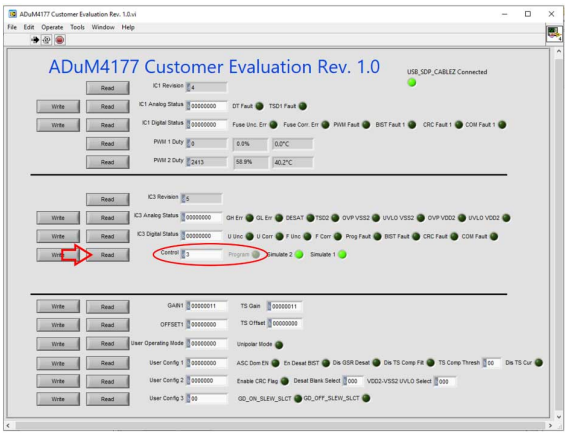

Figure 18. Verify Programming Complete

At this point, after a power cycle, the TS Gain value is set to **00000011**. For this exercise, power the ADuM4177 down. As shown in Figure 19, click all **Read** buttons and note the outputs. They should be all **0**. This is because the ADuM4177 is unpowered.

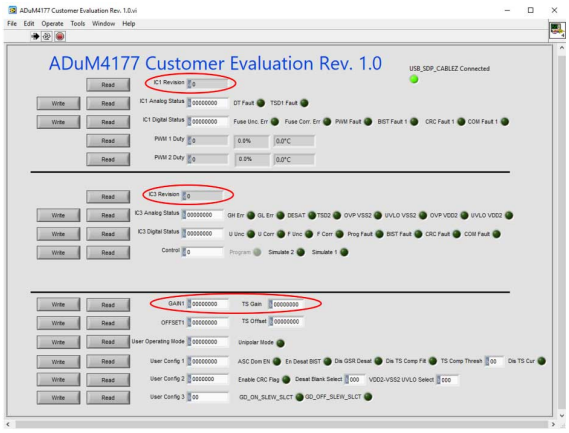

Figure 19. Clearing the Register Read in the GUI

Power up the ADuM4177 and as shown in Figure 20, click **Read** buttons to verify values are written to the EEPROM, and return to the registers on power up.

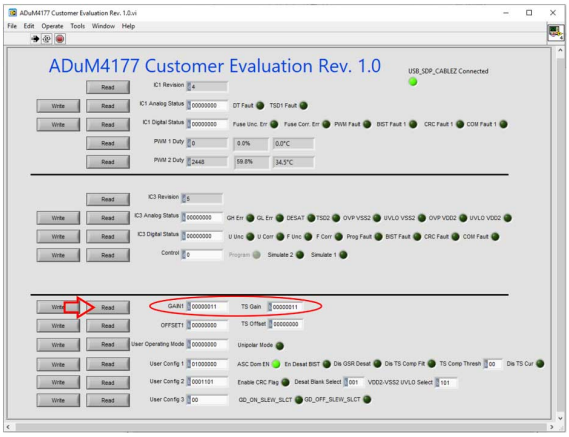

Figure 20. TS Gain Register Loaded on Startup

You have now successfully written to EEPROM and verified the write.

EXAMPLE VDD2_UVLO_SLCT EEPROM WRITE

The following steps show how to program the nonvolatile memory with a new UVLO setting on V_{DD2}. The same steps can be used to program other user selectable registers.

The sequence to write a new V_{DD2} UVLO to nonvolatile memory is:

1. Write **1** to both simulate bits.
2. Write desired V_{DD2} UVLO values to writable registers.
   - At this point, register effects show up on the ADuM4177 until a complete power cycle.
3. Write **1** to program bit, and both simulate bits at the same time.
   - At this point, register values and effects persist even after a power cycle.

To write data to the EEPROM, the **Sim_Trim** bits must first be set. As shown in Figure 21, clicking either **Simulate 1** or **Simulate 2** indicator lights activate both. The value is not written to the ADuM4177 until the Write button is clicked.

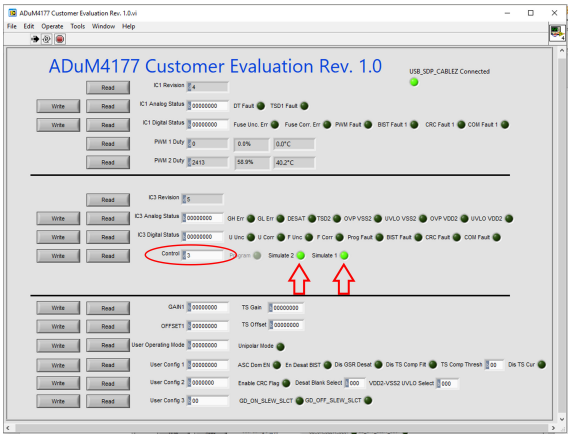

Figure 21. Simulate Bits

EVALUATION SOFTWARE EXAMPLE OPERATION

In this example, as shown in Figure 22, VDD2_UVLO_SLCT is set to **000**. Enter **000** value into the **VDD2-VSS2 UVLO Select** field, and click **Write** button.

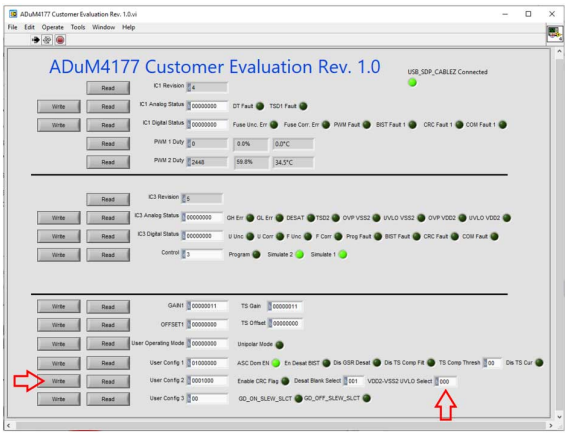

Figure 22. Setting VDD2_UVLO_SLCT to 000

At this point, if a power cycle occurs, the register is reset to the previous value in the EEPROM. For the purpose of this exercise, keep the ADuM4177 powered up.

Setting the Program bit to **1**, and keeping the simulate bits set to **1** show the result as shown in Figure 23. Click **Write** to program the registers to EEPROM, and see the result in the **Program** control being grayed out as shown in Figure 24. This is to signify the GUI does not expect the user to attempt to control the value of Program at this point.

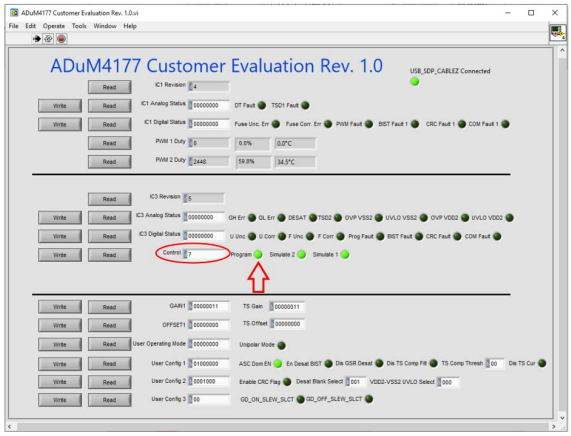

Figure 23. Preparing to Write to EEPROM, Write is Not Clicked Yet

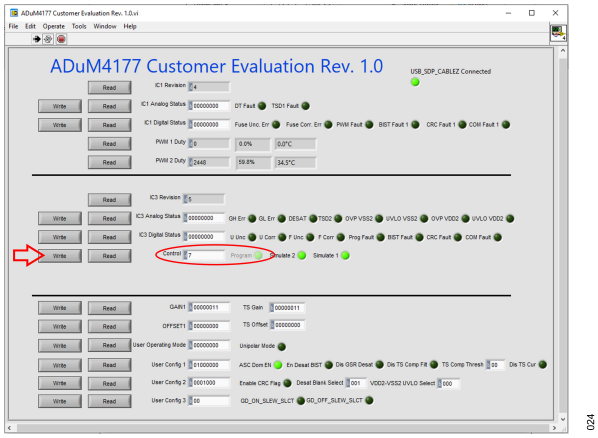

Figure 24. Clicking Write to Program EEPROM

To verify that the programming is complete, as shown in Figure 25, click **Read** button and verify that the **Program** indicator light is off.

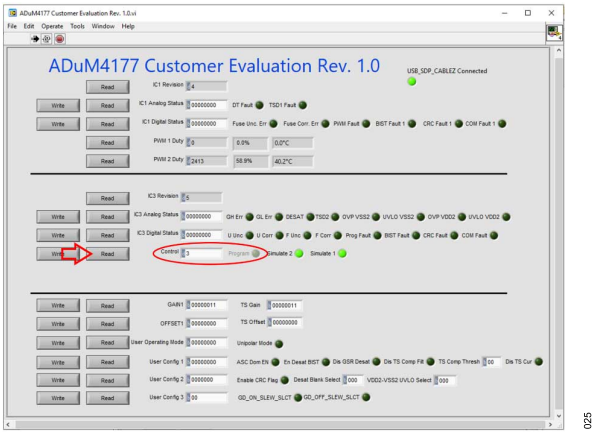

Figure 25. Verify Programming Complete

At this point, after a power cycle, the VDD2_UVLO_SLCT value is set to **000**. For this exercise, power the ADuM4177 down. Power the ADuM4177 up, and as shown in Figure 26, click **Read** button to verify that the values are written to the EEPROM, and return to the registers on power up.

EVALUATION SOFTWARE EXAMPLE OPERATION

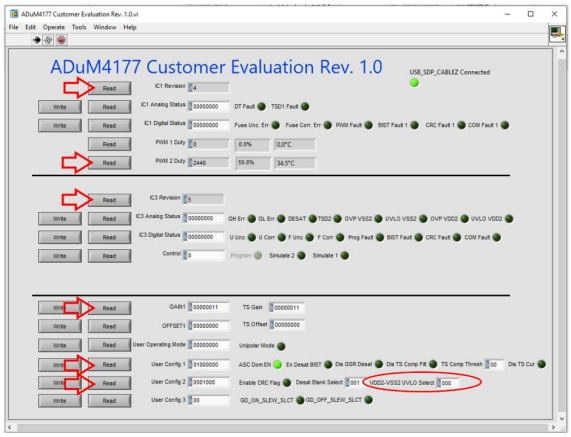

Figure 26. VDD2_UVLO_SLCT Register Loaded on Startup

You have now successfully written to EEPROM and verified the write. At this point, the UVLO value for V_{DD2} is lowered from the default value.

EVALUATION BOARD SCHEMATIC AND ARTWORK

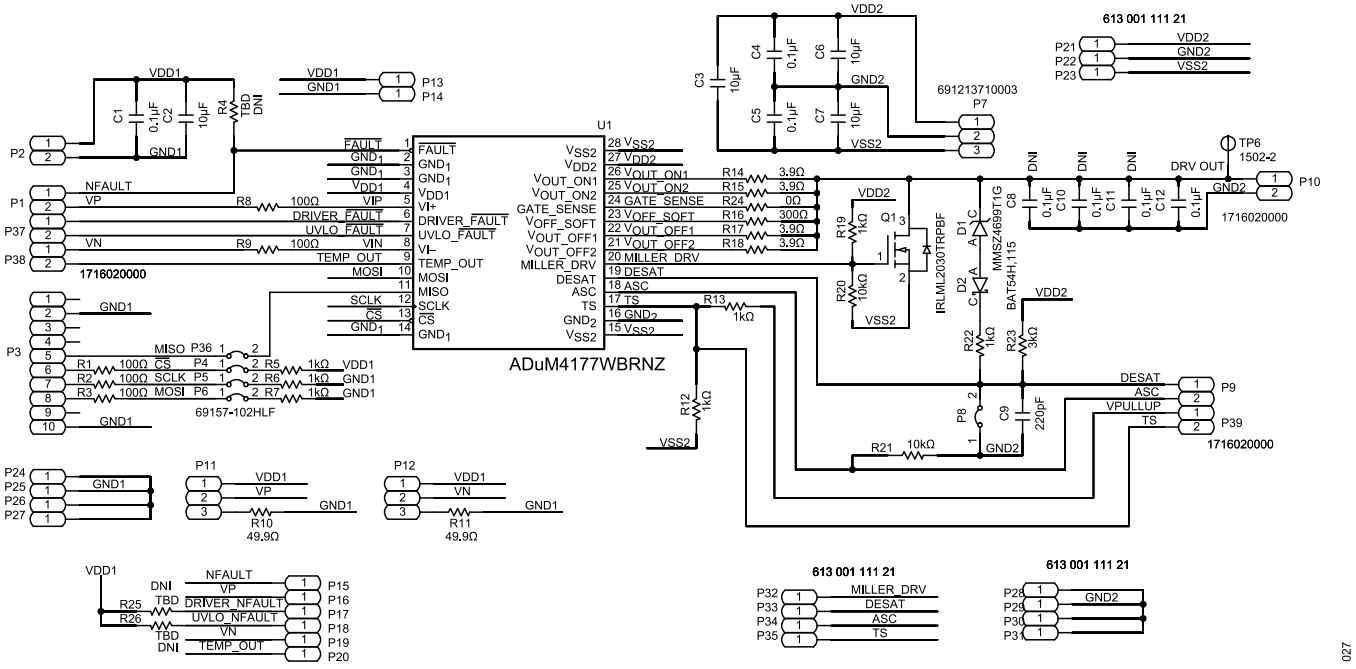

Figure 27. EVAL-ADuM4177EBZ Evaluation Board Schematic

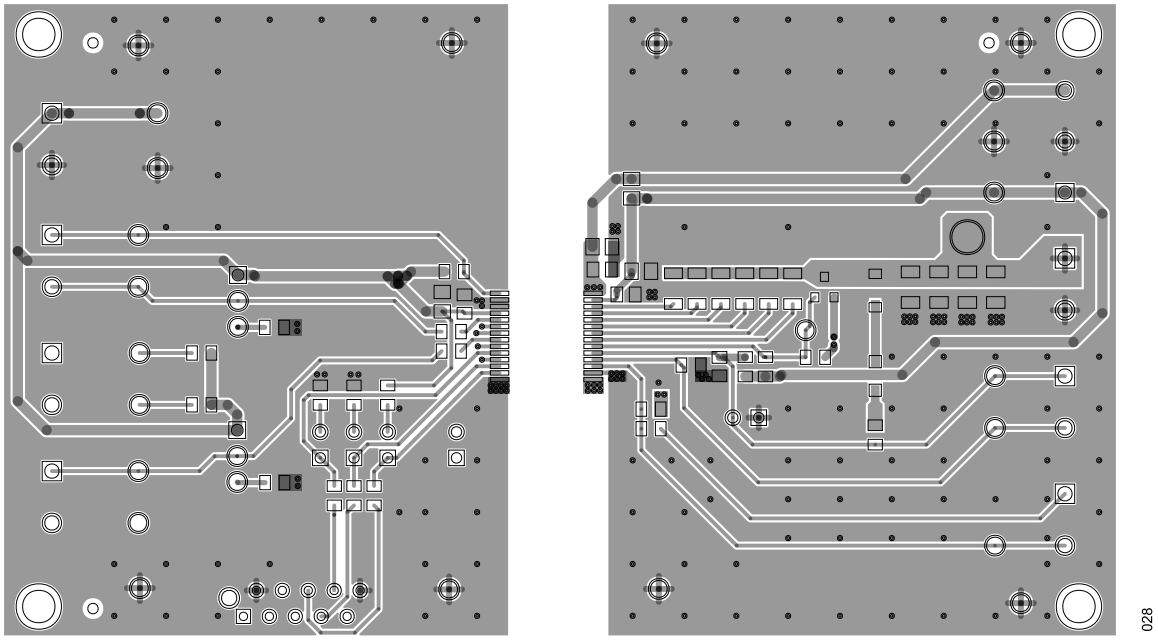

Figure 28. EVAL-ADuM4177EBZ Evaluation Board Top Layer Layout

EVALUATION BOARD SCHEMATIC AND ARTWORK

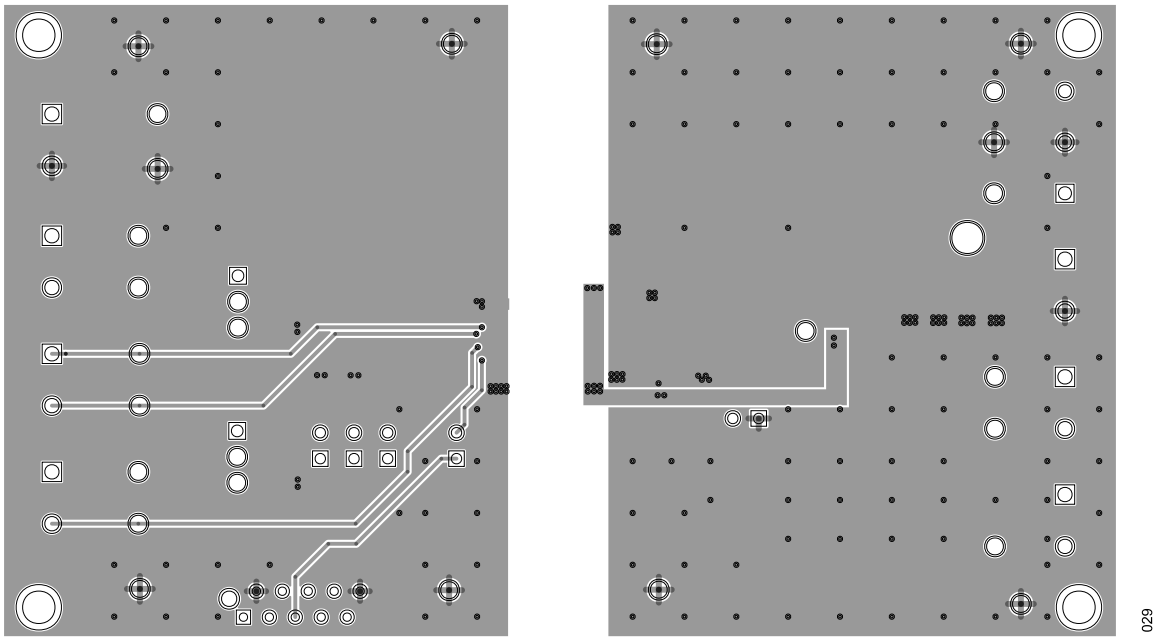

Figure 29. EVAL-ADuM4177EBZ Evaluation Board Bottom Layer Layout

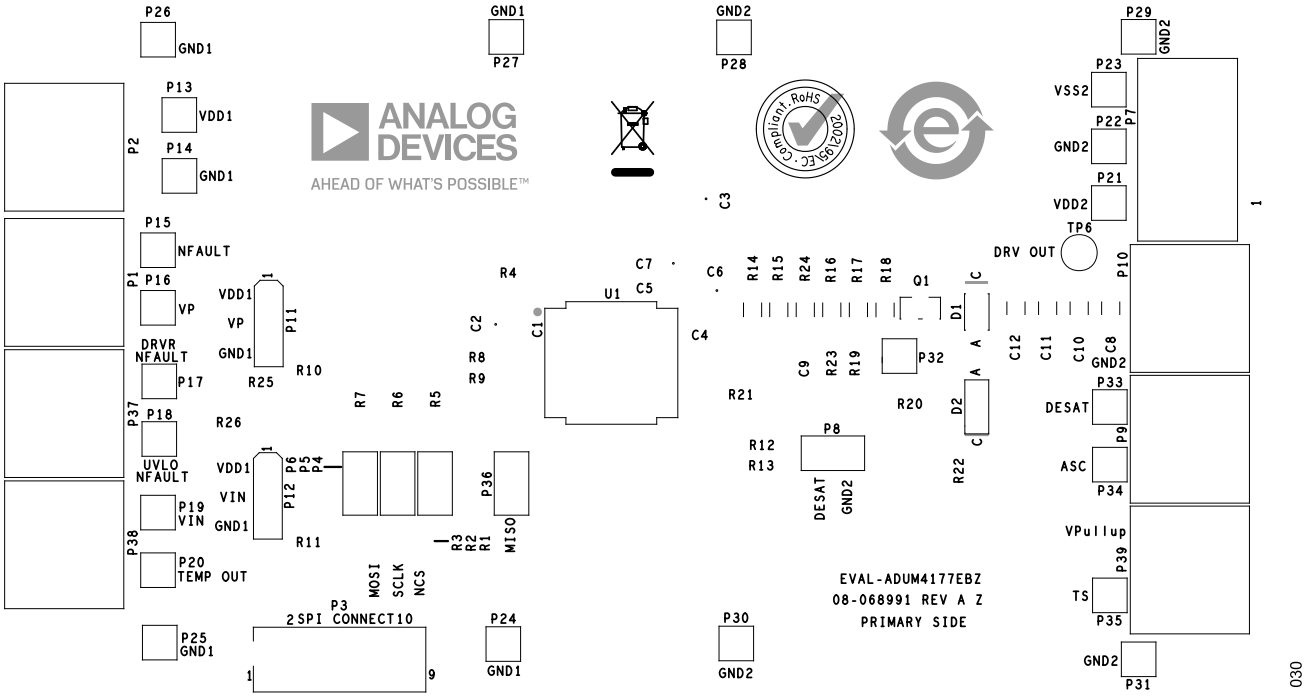

Figure 30. EVAL-ADuM4177EBZ Evaluation Board Top Layer Silkscreen

ORDERING INFORMATION

BILL OF MATERIALS

Table 1. EVAL-ADuM4177EBZ Bill of Materials

Item	Quantity	Reference Designator[1]	Part Description	Manufacturer, Part Number
Required Circuit Components				
1	1	N/A	PCB	Analog Devices Inc., 08_068991a
2	1	C1	Capacitor, ceramic, 0.1 µF, 50 V, 5%, X7R, 0805	AVX Corporation, 08055C104JAT2A
4	1	C12	Capacitor, ceramic, 0.1 µF, 50 V, 10%, X7R, 1206	Yageo, CC1206KRX7R9BB104
5	4	C2, C3, C6, C7	Capacitors, ceramic, 10 µF, 25 V, 10%, X5R, 0805	TDK, C2012X5R1E106K125AB
6	2	C4, C5	Capacitors, ceramic, 0.1 µF, 50 V, 5%, X7R, 0805	Kemet, C0805C104J5RACTU
7	1	C9	Capacitor, ceramic, 220 pF, 50 V, 5%, C0G, 0805	Yageo, CC0805JRNPO9BN221
8	1	D1	Zener diode, 12V, 5%, 0.5 W, SOD-123	Onsemi, MMSZ4699T1G
9	1	D2	Schottky diode barrier, 30 V	NXP Semiconductors, BAT54H,115
10	7	P1, P2, P9, P10, P37, P38, P39	Connectors, fixed terminal blocks, PCB mount, pitch 5.08 mm, 2 poles	Weidmuller, 1716020000
11	2	P11, P12	Connectors, PCB header strips, 2.54 mm pitch, male, straight mounting angle, 3 poles	Samtec, TSW-103-08-G-S
12	23	P13 to P35	Connectors, PCB pin headers, 2.54 mm pitch, male, straight mounting angle, 1 pole	Wurth Elektronik, 61300111121
13	1	P3	Connector, board-to-board application, mezzanine micro-match, 1.27 mm pitch, female, straight mounting angle, 10 poles	TE Connectivity, 8-215079-0
14	5	P4, P5, P6, P8, P36	Connectors, board-to-board application, BERGSTIK series, 2.54 mm pitch, male, straight mounting angle, 2 poles	Amphenol FCI, 69157-102HLF
15	1	P7	Connector, PCB fixed terminal block, 5 mm pitch, straight mounting angle, 3 poles, wire gauge 16 AWG (min) and 26 AWG (max)	Wurth Elektronik, 691213710003
16	1	Q1	Transistor, NMOSFET, HEXFET power MOSFET, 30 V	Infineon Technologies AG, IRLML2030TRPBF
17	5	R1, R2, R3, R8, R9	Resistors, SMD, 100 Ω, 1%, 1/8 W, 0805, AEC-Q200	Panasonic, ERJ-6ENF1000V
18	2	R10, R11	Resistors, SMD, 49.9 Ω, 1%, 1/8 W, 0805, AEC-Q200	Panasonic, ERJ-6ENF49R9V
19	3	R12, R13, R19	Resistors, SMD, 1 kΩ, 1%, 1/2 W, 0805, AEC-Q200	Vishay, CRCW08051K00FKEAHP
20	4	R14, R15, R17, R18	Resistors, SMD, 3.9 Ω, 1%, 1/4 W, 1206, AEC-Q200	Panasonic, ERJ-8RQF3R9V
21	1	R16	Resistor, SMD, 300 Ω, 1%, 1/4 W, 1206, AEC-Q200	Vishay, CRCW1206300RFKEA
22	2	R20, R21	Resistors, SMD, 10 kΩ, 1%, 1/8 W, 0805, AEC-Q200	Panasonic, ERJ-6ENF1002V
23	4	R5, R6, R7, R22	Resistors, SMD, 1 kΩ, 1%, 1/8 W, 0805, AEC-Q200	Panasonic, ERJ-6ENF1001V
24	1	R23	Resistor, SMD, 3 kΩ, 0.1%, 1/4 W, 0805, AEC-Q200	Panasonic, ERJ-PB6B3001V
25	1	R24	Resistor, SMD, 0 Ω, 5%, 1/4 W, 206, AEC-Q200	Vishay, CRCW12060000Z0EA

ORDERING INFORMATION

Table 1. EVAL-ADuM4177EBZ Bill of Materials (Continued)

Item	Quantity	Reference Designator[1]	Part Description	Manufacturer, Part Number
27	1	TP6	Terminal turret connector single end 0.219" (5.56 mm) Tin, board thickness 0.062" (1.57 mm), brass, through hole mounting type	Keystone Electronics, 1502-2
28	1	U1	IC, 40 A source/30 A sink SiC isolated gate driver with slew-rate control and built-in self tests	Analog Devices Inc., ADuM4177WBRNZ
Mechanical Parts				
2	4	N/A	Threaded hex standoff nylon, female, outside diameter 0.25" (6.35 mm), thread size 4 to 40, length 0.5" (12.7 mm)	Keystone, 1902C
3	4	N/A	Pan head machine screw phillips driven nylon, thread size 4 to 40, length 0.250" (6.35 mm)	B&F Fastener Supply, NY PMS 440 0025 PH
4	7	N/A	Shunt, 3 A, 2.54 mm pitch, open top grip, black, female, 2 poles	TE Connectivity, 881545-2

[1] N/A = Not applicable

ESD Caution
ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.