## Table of Contents

1 Trademarks .......................................................................................................................... 8  
2 Description .......................................................................................................................... 8  
  2.1 Typical Applications ........................................................................................................ 8  
  2.2 Warnings ......................................................................................................................... 8  
  2.3 Connector Description .................................................................................................... 8  
3 REACH Compliance ........................................................................................................... 10  
4 Performance Specifications ............................................................................................... 10  
  4.1 Boost Current Regulator ............................................................................................... 10  
  4.2 Boost-to-Battery Current Regulator ............................................................................... 11  
5 Performance Data and Typical Characteristic Curves ....................................................... 11  
  5.1 Startup Waveforms ......................................................................................................... 12  
  5.2 PWM Dimming ............................................................................................................... 13  
  5.3 Faults .............................................................................................................................. 13  
  5.4 EMI Scan ......................................................................................................................... 14  
6 Schematic, PCB Layout, and Bill of Materials ................................................................. 15  
  6.1 Schematic ......................................................................................................................... 15  
  6.2 Layout .............................................................................................................................. 16  
  6.3 Bill of Materials ............................................................................................................... 19  
7 Software ................................................................................................................................ 22  
  7.1 Demonstration Kit Software Installation for MSP-EXP432E401Y LaunchPad Board .... 22  
  7.2 Installation Error Recovery ............................................................................................. 30  
  7.3 Programming the MSP-EXP432E401Y LaunchPad Board ......................................... 31  
8 TPS92682EVM-70 Power UP and Operation ................................................................. 36  
  8.1 SPI Command .................................................................................................................. 38  
  8.2 GUI Devices Window ...................................................................................................... 39  
Revision History ...................................................................................................................... 43
List of Figures

1 Component Connections ........................................................................................................9
2 CC Boost Efficiency for $V_{in} = 12\text{ V}$ ...........................................................................11
3 CC Buck-Boost Efficiency for $V_{in} = 12\text{ V}$ ....................................................................11
4 Softstart waveforms for $CHxSS3:0 = 7$ ...............................................................................12
5 Softstart waveforms for $CHxSS3:0 = 31$ ............................................................................12
6 CC Boost and Boost-to-Battery PWM Dimming ..................................................................13
7 CC Boost Switch Current Sense .............................................................................................13
8 CC Boost LED Short Over-Current Protection .....................................................................14
9 CC Boost-to-Battery LED Open Over-Voltage Protection ....................................................14
10 CC Boost Conducted EMI Scan ............................................................................................14
11 CC Boost-to-Battery Conducted EMI Scan ..........................................................................14
12 TPS92682EVM-70 Schematic ..............................................................................................15
13 TPS92682EVM-70 Assembly ................................................................................................16
14 TPS92682EVM-70 Top Layer and Top Overlay (Top View) ....................................................16
15 TPS92682EVM-70 Inner-layer 1 ..........................................................................................17
16 TPS92682EVM-70 Inner-layer 2 ..........................................................................................17
17 TPS92682EVM-70 Bottom Layer (Bottom View) ................................................................18
18 Setup Screen 1 .....................................................................................................................22
19 Setup Screen 2 .....................................................................................................................23
20 Setup Screen 3 .....................................................................................................................23
21 Setup Screen 4 .....................................................................................................................24
22 Setup Screen 5 .....................................................................................................................24
23 Setup Screen 6 .....................................................................................................................25
24 Setup Screen 7 .....................................................................................................................25
25 Setup Screen 8 .....................................................................................................................26
26 Setup Screen 9 .....................................................................................................................26
27 Setup Screen 10 ....................................................................................................................27
28 Setup Screen 11 ....................................................................................................................27
29 Setup Screen 12 ....................................................................................................................28
30 Setup Screen 13 ....................................................................................................................28
31 Setup Screen 14 ....................................................................................................................29
32 Setup Screen 15 ....................................................................................................................29
33 Setup Screen 16 ....................................................................................................................29
34 Setup Screen 17 ....................................................................................................................30
35 Setup Screen 18 ....................................................................................................................30
36 Driver Installation Error .......................................................................................................31
37 LaunchPad Connection for Programming ..........................................................................32
38 UniFlash Programming, Step 1 ..........................................................................................32
39 UniFlash Programming, Step 2 ..........................................................................................33
40 UniFlash Programming, Step 3 ..........................................................................................33
41 UniFlash Programming, Step 4 ..........................................................................................34
42 UniFlash Programming, Step 5 ..........................................................................................34
43 LaunchPad Connection for GUI Operation ..........................................................................35
44 LaunchPad Connection to TPS92682EVM-70 .....................................................................36
45 GUI Setup Screen 1 ..............................................................................................................37
46 GUI Setup Screen 2 ..............................................................................................................37
47 GUI Setup Screen 3 ..............................................................................................................37
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>48</td>
<td>GUI, Main Window</td>
<td>38</td>
</tr>
<tr>
<td>49</td>
<td>SPI Command Window</td>
<td>39</td>
</tr>
<tr>
<td>50</td>
<td>Devices Window</td>
<td>40</td>
</tr>
<tr>
<td>51</td>
<td>Devices Window Setting</td>
<td>41</td>
</tr>
<tr>
<td>52</td>
<td>Fault Status after Pushing the Read Faults Once</td>
<td>41</td>
</tr>
<tr>
<td>53</td>
<td>Fault Status after Pushing the Read Faults Twice</td>
<td>41</td>
</tr>
<tr>
<td>54</td>
<td>Enabling the EVM</td>
<td>42</td>
</tr>
<tr>
<td>55</td>
<td>Fault Status</td>
<td>42</td>
</tr>
</tbody>
</table>
## List of Tables

1. Connector Descriptions ........................................................................................................... 9
2. Test Points .................................................................................................................................. 10
3. TPS92682EVM-070 Boost Channel Performance Specifications ........................................... 10
4. TPS92682EVM-070 Boost-to-Battery Channel Performance Specifications ........................... 11
5. TPS92682EVM-70 Bill of Materials .......................................................................................... 19
General Texas Instruments High Voltage Evaluation (TI HV EMV) User Safety Guidelines

WARNING

Always follow TI's set-up and application instructions, including use of all interface components within their recommended electrical rated voltage and power limits. Always use electrical safety precautions to help ensure your personal safety and those working around you. Contact TI's Product Information Center http://ti.com/customer support for further information.

Save all warnings and instructions for future reference.

WARNING

Failure to follow warnings and instructions may result in personal injury, property damage or death due to electrical shock and burn hazards.

The term TI HV EVM refers to an electronic device typically provided as an open framed, unenclosed printed circuit board assembly. It is intended strictly for use in development laboratory environments, solely for qualified professional users having training, expertise and knowledge of electrical safety risks in development and application of high voltage electrical circuits. Any other use and/or application are strictly prohibited by Texas Instruments. If you are not suitable qualified, you should immediately stop from further use of the HV EVM.

1. Work Area Safety:
   a. Keep work area clean and orderly.
   b. Qualified observer(s) must be present anytime circuits are energized.
   c. Effective barriers and signage must be present in the area where the TI HV EVM and its interface electronics are energized, indicating operation of accessible high voltages may be present, for the purpose of protecting inadvertent access.
   d. All interface circuits, power supplies, evaluation modules, instruments, meters, scopes, and other related apparatus used in a development environment exceeding 50Vrms/75VDC must be electrically located within a protected Emergency Power Off EPO protected power strip.
   e. Use stable and non-conductive work surface.
   f. Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.

2. Electrical Safety:

   As a precautionary measure, it is always good engineering practice to assume that the entire EVM may have fully accessible and active high voltages.
   a. De-energize the TI HV EVM and all its inputs, outputs and electrical loads before performing any electrical or other diagnostic measurements. Revalidate that TI HV EVM power has been safely de-energized.
   b. With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment hook-ups and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
   c. Once EVM readiness is complete, energize the EVM as intended.
3. Personal Safety
   a. Wear personal protective equipment e.g. latex gloves or safety glasses with side shields or protect EVM in an adequatelucent plastic box with interlocks from accidental touch.

   **Limitation for safe use:**
   EVMs are not to be used as all or part of a production unit.
This user's guide describes the specifications, board connection description, characteristics, operation, and use of the TPS92682-Q1 constant current (CC) mode in boost and boost-to-battery configurations. The TPS92682-Q1 device implements a fixed-frequency peak current mode control technique with programmable switching frequency, slope compensation, and soft-start. Additional features include wide input voltage range (4.5 V to 65 V), programmable spread spectrum frequency modulation, programmable fault handling, and adjustable output current setting. A complete schematic diagram, printed circuit board layouts, and bill of materials are included in this document.

1 Trademarks

SimpleLink, LaunchPad are trademarks of Texas Instruments.

2 Description

The TPS92682EVM-70 solution provides a two channel, constant current boost and boost-to-battery LED current regulator which is configurable via serial peripheral interface (SPI). The EVM is designed to operate with an input voltage in the range of 6.5 V to 20 V. The EVM provides maximum output power of 25 W for boost channel and 15 W for the boost-to-battery channel. The TPS92682EVM-70 provides high efficiency, SPI programmable fault handling, \( I_{\text{LED}} \) setting, and spread-spectrum. The channel-1 of the EVM is configured as CC boost and channel-2 as CC boost-to-battery.

2.1 Typical Applications

This document outlines the operation and implementation of the TPS92682-Q1 as a two-channel boost and boost-to-battery LED current regulator with the specifications listed in Table 3. For applications with a different input voltage range or different \( I_{\text{LED}} \) range, refer to the TPS92682-Q1 data sheet. The MSP-EXP432E401Y SimpleLink™ Ethernet MSP432E401Y MCU LaunchPad™ Development Kit controls the TPS92682EVM-70 evaluation board. The MSP-EXP432E401Y is available on TI website. However, any SPI controller can be used to program the TPS92682EVM board. Ensure that the LaunchPad board from TI has been programmed before running the GUI. The programming instructions are provided in Section 7.

2.2 Warnings

Observe the following precaution when using the TPS92682EVM-70 evaluation module.

Caution hot surface. Contact may cause burns. Do not touch.

2.3 Connector Description

Table 1 describes the connectors and Table 2 lists the test points on the EVM and how to properly connect, set up, and use the TPS92682EVM-70.

Figure 1 shows the connection diagram and the default jumper locations of the TPS92682EVM-70.
Figure 1. Component Connections

Table 1. Connector Descriptions

<table>
<thead>
<tr>
<th>Connector</th>
<th>Label</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>J10</td>
<td>SPI control from the MSP-EXP432E401Y LaunchPad</td>
<td>J10 and J11 allow attachment of a header cable for SPI control of the TPS92682-Q1 to the TI SimpleLink™ Ethernet MSP-EXP432E401Y MCU LaunchPad™ Development Kit, part number MSP-EXP432E401Y</td>
</tr>
<tr>
<td>J11</td>
<td>SPI control signals to other SPI controlled EVM</td>
<td>J8 and J9 allow star connection of TPS92682EVM-70 boards to each other with one MSP-EXP432E401Y control board.</td>
</tr>
<tr>
<td>J8</td>
<td>J9</td>
<td>VIN, GND</td>
</tr>
<tr>
<td>J1</td>
<td>J2</td>
<td>Channel-1 and Channel-2 and GND</td>
</tr>
<tr>
<td>J5</td>
<td>J6</td>
<td>VDD jumper</td>
</tr>
<tr>
<td>J3</td>
<td>J4</td>
<td>PWM1 and PWM2 jumpers</td>
</tr>
<tr>
<td>J7</td>
<td>SSN configuration jumper</td>
<td>J7 allows configuration of the SSN chip select line, when multiple chips on the same SPI bus are used. By default, evaluation module is configured to be connected to the SSN0 of the MSP-EXP432E401Y controller board.</td>
</tr>
</tbody>
</table>
Table 2. Test Points

<table>
<thead>
<tr>
<th>Test Point</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal turrets</td>
<td>All metal turrets are grounds.</td>
</tr>
<tr>
<td>VBAT</td>
<td>The VBAT test point allows for voltage measurement of the external power supply applied to the evaluation board.</td>
</tr>
<tr>
<td>VIN</td>
<td>The VIN test point allows for voltage measurement of the power applied to the boost and boost-to-battery channels after the EMI filter.</td>
</tr>
<tr>
<td>VDD</td>
<td>The VDD test point allows for voltage measurement of the VDD output of the TPS92682-Q1.</td>
</tr>
<tr>
<td>LH</td>
<td>The LH test point allows for applying a voltage to the LH pin and placing the TPS92682-Q1 in Limp Home mode.</td>
</tr>
<tr>
<td>FLT1</td>
<td>The FLT1 test point can be used to monitor the fault occurrence of the channel-1. When a fault occurs, FLT1 voltage level goes low. Note that during power up, FLT1 is low (due to POR). The Fault pins can be reset by setting bit-7 of the EN register 0x00.</td>
</tr>
<tr>
<td>FLT2</td>
<td>The FLT2 test point can be used to monitor the fault occurrence of the channel-2. When a fault occurs, FLT2 voltage level goes low. Note that during power up, FLT2 is low (due to POR). The Fault pins can be reset by setting bit-7 of the EN register 0x00. The FLT2 test point can also be used for synchronizing of the TPS92682-Q1 with an external clock.</td>
</tr>
<tr>
<td>EN</td>
<td>EN test point is connected to the EN-pin of the TPS92682-Q1 device.</td>
</tr>
<tr>
<td>PWM1</td>
<td>PWM1 test point is connected to the PWM1-pin of the TPS92682-Q1 device.</td>
</tr>
<tr>
<td>PWM2</td>
<td>PWM2 test point is connected to the PWM2-pin of the TPS92682-Q1 device.</td>
</tr>
<tr>
<td>LED1+</td>
<td>The LED1+ test point allows for voltage measurement of the channel-1 (boost) LED positive output.</td>
</tr>
<tr>
<td>LED1-</td>
<td>The LED1- test point is connected to the channel-1 (boost) LED negative output. This test point is connected to the EVM ground via a zero-Ω resistor.</td>
</tr>
<tr>
<td>LED2+</td>
<td>The LED2+ test point is connected to the channel-2 (boost-to-battery) LED positive output.</td>
</tr>
<tr>
<td>LED2-</td>
<td>The LED2- test point is connected to the channel-2 (boost-to-battery) LED negative output.</td>
</tr>
</tbody>
</table>

3 REACH Compliance

In compliance with the Article 33 provision of the EU REACH regulation we are notifying you that this EVM includes component(s) containing at least one substance of very high concern (SVHC) above 0.1%. These uses from Texas Instruments do not exceed 1 ton per year. The SVHC specifications are:

<table>
<thead>
<tr>
<th>Component Manufacturer</th>
<th>Component part number</th>
<th>SVHC Substance</th>
<th>SVHC CAS (when available)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHOENIX CONTACT GmbH &amp; Co. KG</td>
<td>1715721 and 1715747</td>
<td>Lead (Pb)</td>
<td>7439-92-1</td>
</tr>
</tbody>
</table>

4 Performance Specifications

This section provides the performance specifications and requirements for the boost and boost-to-battery LED current regulators.

4.1 Boost Current Regulator

The Table 3 provides the EVM electrical performance specifications for the boost current regulator, channel-1.

Table 3. TPS92682EVM-070 Boost Channel Performance Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Characteristics</td>
<td>Voltage, $V_{IN}$</td>
<td>6.5</td>
<td>12</td>
<td>20</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Maximum Input Current, $I_{IN}$</td>
<td></td>
<td></td>
<td>4</td>
<td>A</td>
</tr>
<tr>
<td>Output Characteristics</td>
<td>LED forward voltage, $V_{F,LED}$</td>
<td>2.8</td>
<td>3.0</td>
<td>3.2</td>
<td>V</td>
</tr>
</tbody>
</table>
Table 3. TPS92682EVM-070 Boost Channel Performance Specifications (continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of LEDs $N_{\text{LED}}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output voltage $V_{\text{OUT}}$</td>
<td>LED+ to LED–</td>
<td>12</td>
<td></td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Maximum output current, $I_{\text{LED}}$</td>
<td></td>
<td>0.55</td>
<td></td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Maximum Output Power, $P_{\text{OUT}}$</td>
<td></td>
<td>25</td>
<td></td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>PWM dimming frequency $f_{\text{PWM}}$</td>
<td></td>
<td></td>
<td>400</td>
<td></td>
<td>Hz</td>
</tr>
</tbody>
</table>

**Systems Characteristics**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switching frequency $F_{\text{SW}}$</td>
<td></td>
<td></td>
<td>400</td>
<td></td>
<td>kHz</td>
</tr>
<tr>
<td>Dither modulation $f_{\text{DM}}$</td>
<td></td>
<td>400</td>
<td>600</td>
<td></td>
<td>Hz</td>
</tr>
<tr>
<td>Output over-voltage threshold $V_{\text{O(OV)}}$</td>
<td></td>
<td></td>
<td>60</td>
<td></td>
<td>V</td>
</tr>
</tbody>
</table>

4.2 *Boost-to-Battery Current Regulator*

The Table 4 provides the EVM electrical performance specifications for the boost-to-battery current regulator, channel-2.

Table 4. TPS92682EVM-070 Boost-to-Battery Channel Performance Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage, $V_{\text{IN}}$</td>
<td></td>
<td>6.5</td>
<td>12</td>
<td>20</td>
<td>V</td>
</tr>
<tr>
<td>Maximum Input Current, $I_{\text{IN}}$</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>A</td>
</tr>
<tr>
<td><strong>Output Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED forward voltage, $V_{\text{F(LED)}}$</td>
<td></td>
<td>2.8</td>
<td>3.0</td>
<td>3.2</td>
<td>V</td>
</tr>
<tr>
<td>Number of LEDs $N_{\text{LED}}$</td>
<td></td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output voltage $V_{\text{OUT}}$</td>
<td>LED+ to LED–</td>
<td></td>
<td>40</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Maximum output current, $I_{\text{LED}}$</td>
<td></td>
<td></td>
<td>0.55</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Maximum Output Power, $P_{\text{OUT}}$</td>
<td></td>
<td></td>
<td>15</td>
<td></td>
<td>W</td>
</tr>
<tr>
<td>PWM dimming frequency $f_{\text{PWM}}$</td>
<td></td>
<td></td>
<td>400</td>
<td></td>
<td>Hz</td>
</tr>
<tr>
<td><strong>Systems Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switching frequency $F_{\text{SW}}$</td>
<td></td>
<td>400</td>
<td></td>
<td></td>
<td>kHz</td>
</tr>
<tr>
<td>Dither modulation $f_{\text{DM}}$</td>
<td></td>
<td>400</td>
<td>600</td>
<td></td>
<td>Hz</td>
</tr>
<tr>
<td>Output over-voltage threshold $V_{\text{O(OV)}}$</td>
<td></td>
<td></td>
<td>40</td>
<td></td>
<td>V</td>
</tr>
</tbody>
</table>

5 **Performance Data and Typical Characteristic Curves**

Figure 2 and Figure 3 show the efficiency results for the boost and boost-to-battery vs. LED current, $I_{\text{LED}}$. The results show different number of series connected LEDs in the output. It is important to note that the efficiency results include the power loss in the input EMI filter.
5.1 **Startup Waveforms**

Figure 4 and Figure 5 show the startup waveforms, $I_{\text{LED}}$ and Compensator voltage of the boost and boost-to-battery channels. In this setup, a string of 12×LEDs are connected to the output of the boost and 6×LEDs to the output of the boost-to-battery channel.

Figure 4. Softstart waveforms for CHxSS3:0 = 7

Figure 5. Softstart waveforms for CHxSS3:0 = 31
5.2 PWM Dimming

Figure 6 shows PWM dimming of the two boost and boost-to-battery channels of the TPS92682EVM-070. The $I_{LED}$ is programmed to its maximum value. A string of 12×LEDs connected to the output of the boost and 6×LEDs to the output of the boost-to-battery channels. When internal PWM dimming counter is used, the two channels, by default, have 180° phase-shift.

![PWM Dimming Chart](image)

$V_{IN} = 12 \text{ V}$

Figure 6. CC Boost and Boost-to-Battery PWM Dimming

Figure 7 shows the switch current across the sense resistor at the rising edge of the PWM dimming for the boost channel.

![Switch Current Sense Chart](image)

$V_{IN} = 12 \text{ V}, \text{ and } V_{OUT} = 40 \text{ V}$

Figure 7. CC Boost Switch Current Sense

5.3 Faults

TPS92682-Q1 include various fault handling and diagnostic features. Figure 8 and Figure 9 show the LED short protection for CC boost channel and LED open protection for the boost-to-battery channel.

As shown in Figure 8, when a short across the LED load occurs, the overcurrent (OC) protection is triggered (if OC Fault is enabled), the COMP-pin is pulled low, and the associated channel is turned off. The channel remains off for the programmed main fault timer (MFT), when the channel performs a soft-start sequence.

As shown in Figure 9, when open LED load occurs, the load voltage increases above the programmed overvoltage (OV) threshold, and the associated channel turns off. The channel remains off until the load voltage drops below a OV hysteresis value, when the channel performs a soft-start sequence. Set the OV threshold by programming the OV register and the OV detection resistor dividers.
5.4 EMI Scan

Figure 10 shows the conducted EMI for the boost channel with 12 series connected LED load and $I_{\text{LED}} = 570$ mA. Figure 11 shows the conducted EMI for the boost-to-battery channel with 6 series connected LED load and $I_{\text{LED}} = 570$ mA.
6 Schematic, PCB Layout, and Bill of Materials

This section contains TPS92682EVM-70 schematics, PCB layouts, and bill of materials (BOM).

6.1 Schematic

Figure 12 illustrates the TPS92682EVM-70 schematic.

Figure 12. TPS92682EVM-70 Schematic
6.2 Layout

The TPS92682EVM-70 is a four-layer board. Figure 13, Figure 14, Figure 15, Figure 16 and Figure 17 illustrate the assembly, the top, the inner-layer1, the inner-layer2 and the bottom side of the TPS92682EVM-70 PCB layout. The Inner-layer 1 is a ground plane and there is no routing on this layer.

Figure 13. TPS92682EVM-70 Assembly

Figure 14. TPS92682EVM-70 Top Layer and Top Overlay (Top View)
Figure 15. TPS92682EVM-70 Inner-layer 1

Figure 16. TPS92682EVM-70 Inner-layer 2
Figure 17. TPS92682EVM-70 Bottom Layer (Bottom View)
### 6.3 Bill of Materials

Table 5 lists the TPS92682EVM-70 bill of materials.

#### Table 5. TPS92682EVM-70 Bill of Materials

<table>
<thead>
<tr>
<th>Designator</th>
<th>Quantity</th>
<th>Value</th>
<th>Description</th>
<th>Package</th>
<th>Part Number</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1, C6, C37, C38, C39, C41, C42</td>
<td>7</td>
<td>10 µF</td>
<td>CAP, CERM, 10 uF, 50 V, ±20%, X7R</td>
<td>1210</td>
<td>C3225X7R1H106M250AC</td>
<td>TDK</td>
</tr>
<tr>
<td>C2, C3, C10, C11, C12, C17, C18, C19, C20, C47</td>
<td>10</td>
<td>4.7 µF</td>
<td>CAP, CERM, 4.7 µF, 100 V, ±10%, X7S</td>
<td>1210</td>
<td>C3225X7S2A475K200AB</td>
<td>TDK</td>
</tr>
<tr>
<td>C4, C9, C15, C21, C26, C36, C43, C46, C50</td>
<td>9</td>
<td>0.1 µF</td>
<td>CAP, CERM, 0.1 µF, 100 V, ±10%, X7R</td>
<td>0603</td>
<td>GRM188R72A104KA35D</td>
<td>MuRata</td>
</tr>
<tr>
<td>C5, C13, C14, C22, C23, C24, C28, C31, C32, C35, C40, C44, C45, C48, C49, C52, C53</td>
<td>17</td>
<td>0.01 µF</td>
<td>CAP, CERM, 0.01 µF, 100 V, ±10%, X7R, AEC-Q200 Grade 1</td>
<td>0603</td>
<td>CGA3E2X7R2A103K080AA</td>
<td>TDK</td>
</tr>
<tr>
<td>C6</td>
<td>1</td>
<td>33 µF</td>
<td>CAP, AL, 33 µF, 100 V, ±20%, AEC-Q200 Grade 2, SMD</td>
<td>D10xL10mm</td>
<td>MAL215097904E3</td>
<td>Vishay</td>
</tr>
<tr>
<td>C7</td>
<td>1</td>
<td>470 pF</td>
<td>CAP, CERM, 470 pF, 100 V, ±5%, C0G/NP0</td>
<td>0603</td>
<td>GRM188S2CA471J010D</td>
<td>MuRata</td>
</tr>
<tr>
<td>C8</td>
<td>1</td>
<td>4700 pF</td>
<td>CAP, CERM, 4700 pF, 100 V, ±10%, X7R, AEC-Q200 Grade 1</td>
<td>0603</td>
<td>CGA3E2X7R2A472K080AA</td>
<td>TDK</td>
</tr>
<tr>
<td>C25, C27, C51, C54</td>
<td>4</td>
<td>1000 pF</td>
<td>CAP, CERM, 1000 pF, 50 V, ±10%, X7R</td>
<td>0603</td>
<td>GRM188R71H102KA01D</td>
<td>MuRata</td>
</tr>
<tr>
<td>C29</td>
<td>1</td>
<td>0.047 µF</td>
<td>CAP, CERM, 0.047 µF, 25 V, ±10%, X7R</td>
<td>0603</td>
<td>GRM188S71E473KA01D</td>
<td>MuRata</td>
</tr>
<tr>
<td>C30, C57</td>
<td>2</td>
<td>100 pF</td>
<td>CAP, CERM, 100 pF, 50 V, ±5%, C0G/NP0, 0603</td>
<td>0603</td>
<td>885012006057</td>
<td>Wurth Elektronik</td>
</tr>
<tr>
<td>C33</td>
<td>1</td>
<td>1 µF</td>
<td>CAP, CERM, 1 µF, 100 V, ±10%, X7R</td>
<td>1206</td>
<td>CL31B105KCHNNNE</td>
<td>Samsung</td>
</tr>
<tr>
<td>C55, C56</td>
<td>2</td>
<td>2.2 µF</td>
<td>CAP, CERM, 2.2 µF, 16 V, ±10%, X7R</td>
<td>0603</td>
<td>GRM188S71C225KE43</td>
<td>MuRata</td>
</tr>
<tr>
<td>C58</td>
<td>1</td>
<td>0.1 µF</td>
<td>CAP, CERM, 0.1 µF, 100 V, ±10%, X7S, AEC-Q200 Grade 1</td>
<td>0603</td>
<td>CGA3E3X7S2A104K080AB</td>
<td>TDK</td>
</tr>
<tr>
<td>C59, C60, C61, C62</td>
<td>4</td>
<td>0.1 µF</td>
<td>CAP, CERM, 0.1 µF, 50 V, ±10%, X7R</td>
<td>0805</td>
<td>C0805C104K5RACTU</td>
<td>Kemet</td>
</tr>
<tr>
<td>D1, D2</td>
<td>2</td>
<td>100 V</td>
<td>Diode, Schottky, 100 V, 3 A, AEC-Q101</td>
<td>POWERDI5</td>
<td>PDS3100Q-13</td>
<td>Diodes Inc</td>
</tr>
<tr>
<td>H10, H12, H13, H14, H15, H16, H17, H18</td>
<td>8</td>
<td></td>
<td>RFI SHIELD CLIP TIN SMD</td>
<td>S2711-46R</td>
<td></td>
<td>Harwin</td>
</tr>
<tr>
<td>J1</td>
<td>1</td>
<td></td>
<td>Terminal Block, 5.08 mm, 4x1, TH</td>
<td>4POS Terminal Block</td>
<td>1715747</td>
<td>Phoenix Contact</td>
</tr>
<tr>
<td>J2, J5</td>
<td>2</td>
<td></td>
<td>Terminal Block, 5.08 mm, 2x1, TH</td>
<td>2POS Terminal Block</td>
<td>1715721</td>
<td>Phoenix Contact</td>
</tr>
<tr>
<td>J3, J4, J6</td>
<td>3</td>
<td></td>
<td>Header, 100 mil, Gold, TH</td>
<td>2x1</td>
<td>TSW-102-07-G-S</td>
<td>Samtec</td>
</tr>
<tr>
<td>J7</td>
<td>1</td>
<td></td>
<td>Header, 100 mil, Gold, TH</td>
<td>3x1</td>
<td>TSW-103-07-G-D</td>
<td>Samtec</td>
</tr>
<tr>
<td>J8</td>
<td>1</td>
<td></td>
<td>Header, 2.54 mm, Tin, R/A, TH</td>
<td>10x2</td>
<td>TSW-110-08-T-D-RA</td>
<td>Samtec</td>
</tr>
<tr>
<td>J9</td>
<td>1</td>
<td></td>
<td>Receptacle, 2.5 mm, Gold, R/A, TH</td>
<td>10x2</td>
<td>SSW-110-02-G-D-RA</td>
<td>Samtec</td>
</tr>
<tr>
<td>J10, J11</td>
<td>2</td>
<td></td>
<td>Header (shrouded), 100 mil, Gold, TH</td>
<td>10x2</td>
<td>S103309-5</td>
<td>TE Connectivity</td>
</tr>
<tr>
<td>Designator</td>
<td>Quantity</td>
<td>Value</td>
<td>Description</td>
<td>Package</td>
<td>Part Number</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>------------</td>
<td>----------</td>
<td>-------</td>
<td>-------------</td>
<td>---------</td>
<td>-------------</td>
<td>--------------</td>
</tr>
<tr>
<td>L1</td>
<td>1</td>
<td>3.3 µH</td>
<td>Inductor, Shielded, Composite, 3.3 µH, 8 A, 0.02081 Ω, AEC-Q200 Grade 1, SMD</td>
<td>6.4x3.1x6.6</td>
<td>XAL6030-332MEB</td>
<td>Coilcraft</td>
</tr>
<tr>
<td>L2, L3</td>
<td>2</td>
<td>22 µH</td>
<td>Inductor, Shielded Drum Core, Powdered Iron, 22 µH, 4.1 A, 0.0705 Ω, AEC-Q200 Grade 0, SMD</td>
<td>10.2x4.0x10.2</td>
<td>IHLP4040DZER220M8A</td>
<td>Vishay</td>
</tr>
<tr>
<td>Q1, Q3</td>
<td>2</td>
<td>- 60 V</td>
<td>MOSFET, P-CH, -60 V, -3.6 A</td>
<td>PowerPAK 1212</td>
<td>SI7415DN-T1-GE3</td>
<td>Vishay</td>
</tr>
<tr>
<td>Q2, Q5</td>
<td>2</td>
<td>100 V</td>
<td>MOSFET, N-CH, 100 V, 20 A, AEC-Q101</td>
<td>8-PowerVDFN</td>
<td>STL8N10LF3</td>
<td>STMicroelectronics</td>
</tr>
<tr>
<td>Q4</td>
<td>1</td>
<td>60 V</td>
<td>Transistor, PNP, 60 V, 2.7 A, AEC-Q101</td>
<td>SOT-23</td>
<td>PBSS4041PT,215</td>
<td>NXP</td>
</tr>
<tr>
<td>R1</td>
<td>1</td>
<td>7.5 Ω</td>
<td>RES, 7.5, 5%, 0.75 W, AEC-Q200 Grade 0</td>
<td></td>
<td>CRCW20107R50JNEF</td>
<td>Vishay</td>
</tr>
<tr>
<td>R2</td>
<td>1</td>
<td>0.3 Ω</td>
<td>RES, 0.3, 1%, 0.5 W, AEC-Q200 Grade 1</td>
<td>1</td>
<td>ERJ8BQFR30V</td>
<td>Panasonic</td>
</tr>
<tr>
<td>R3, R20</td>
<td>2</td>
<td>100 Ω</td>
<td>RES, 100, 1%, 0.1 W, AEC-Q200 Grade 0</td>
<td>1206</td>
<td>RC1206JR-070RL</td>
<td>Yageo America</td>
</tr>
<tr>
<td>R4, R11, R17, R21</td>
<td>4</td>
<td>0</td>
<td>RES, 0, 5%, 0.25 W</td>
<td>1206</td>
<td>CRCW06030000J0EA</td>
<td>Vishay</td>
</tr>
<tr>
<td>R5, R9, R16, R23, R29</td>
<td>5</td>
<td>0</td>
<td>RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0</td>
<td>1</td>
<td>CRCW06031000J0EA</td>
<td>Vishay</td>
</tr>
<tr>
<td>R6</td>
<td>1</td>
<td>120 kΩ</td>
<td>RES, 120 k, 0.1%, 0.1 W</td>
<td>0603</td>
<td>RT0603BRD07120KL</td>
<td>Yageo America</td>
</tr>
<tr>
<td>R7, R8, R26, R27</td>
<td>4</td>
<td>10 Ω</td>
<td>RES, 10.0, 1%, 0.1 W, AEC-Q200 Grade 0</td>
<td>0603</td>
<td>CRCW060310R0FKEA</td>
<td>Vishay</td>
</tr>
<tr>
<td>R10, R30</td>
<td>2</td>
<td>100 Ω</td>
<td>RES, 100, 1%, 0.1 W, AEC-Q200 Grade 0</td>
<td>0603</td>
<td>CRCW0603100RFKEA</td>
<td>Vishay</td>
</tr>
<tr>
<td>R12, R33</td>
<td>2</td>
<td>0.04 Ω</td>
<td>RES, 0.04, 1%, 1 W</td>
<td>2010</td>
<td>CSRN2010FK40L0</td>
<td>Stackpole</td>
</tr>
<tr>
<td>R13</td>
<td>1</td>
<td>2.55 kΩ</td>
<td>RES, 2.55 k, 1%, 0.1 W, AEC-Q200 Grade 0</td>
<td>0603</td>
<td>CRCW06032K55FKEA</td>
<td>Vishay</td>
</tr>
<tr>
<td>R14</td>
<td>1</td>
<td>1.0 Ω</td>
<td>RES, 1.0, 1%, 0.125 W, AEC-Q200 Grade 0</td>
<td>0805</td>
<td>CRCW08051R00FKEA</td>
<td>Vishay</td>
</tr>
<tr>
<td>R15</td>
<td>1</td>
<td>715 Ω</td>
<td>RES, 715, 1%, 0.1 W, AEC-Q200 Grade 0</td>
<td>0603</td>
<td>CRCW0603715RFKEA</td>
<td>Vishay</td>
</tr>
<tr>
<td>R22, R32</td>
<td>2</td>
<td>100 kΩ</td>
<td>RES, 100, 1%, 0.1 W, AEC-Q200 Grade 0</td>
<td>0603</td>
<td>CRCW0603100KFKEA</td>
<td>Vishay</td>
</tr>
<tr>
<td>R24, R28</td>
<td>2</td>
<td>10 kΩ</td>
<td>RES, 10, 1%, 0.1 W, AEC-Q200 Grade 0</td>
<td>0603</td>
<td>CRCW060310KFKEA</td>
<td>Vishay</td>
</tr>
<tr>
<td>R25</td>
<td>1</td>
<td>150 kΩ</td>
<td>RES, 150, 1%, 0.1 W, AEC-Q200 Grade 0</td>
<td>0603</td>
<td>CRCW0603150KFKEA</td>
<td>Vishay</td>
</tr>
<tr>
<td>R31</td>
<td>1</td>
<td>4.53 kΩ</td>
<td>RES, 4.53 k, 1%, 0.1 W, AEC-Q200 Grade 0</td>
<td>0603</td>
<td>ERJ-3EKF4531V</td>
<td>Panasonic</td>
</tr>
<tr>
<td>R36</td>
<td>1</td>
<td>47.5 Ω</td>
<td>RES, 47.5, 1%, 0.1 W, AEC-Q200 Grade 0</td>
<td>0603</td>
<td>CRCW060347R5FKEA</td>
<td>Vishay</td>
</tr>
<tr>
<td>R37</td>
<td>1</td>
<td>4.7 kΩ</td>
<td>RES, 4.7, 5%, 0.1 W, AEC-Q200 Grade 0</td>
<td>0603</td>
<td>CRCW06034K70JNEA</td>
<td>Vishay</td>
</tr>
<tr>
<td>SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7</td>
<td>7</td>
<td>Shunt, 2.54mm, Gold, Black</td>
<td>2x1, 2.54mm</td>
<td>60900213421</td>
<td>Wurth Elektronik</td>
<td></td>
</tr>
<tr>
<td>TP1, TP2, TP3</td>
<td>3</td>
<td>Test Point, Miniature, Red, TH</td>
<td>TH</td>
<td>5000</td>
<td>keystone</td>
<td></td>
</tr>
<tr>
<td>TP4, TP5, TP16</td>
<td>3</td>
<td>Terminal, Turret, TH, Double</td>
<td>Turret</td>
<td>1502-2</td>
<td>keystone</td>
<td></td>
</tr>
<tr>
<td>TP6, TP7, TP11, TP13</td>
<td>4</td>
<td>Test Point, Miniature, White, TH</td>
<td>TH</td>
<td>5002</td>
<td>keystone</td>
<td></td>
</tr>
<tr>
<td>TP8, TP9, TP10, TP12, TP14, TP15</td>
<td>6</td>
<td>Test Point, Miniature, Black, TH</td>
<td>TH</td>
<td>5001</td>
<td>keystone</td>
<td></td>
</tr>
<tr>
<td>U1</td>
<td>1</td>
<td></td>
<td>Dual Channel Constant Voltage and Constant Current Controller with SPI Interface, RHM0032C (VQFN-32)</td>
<td>RHM0032C</td>
<td>TPS92682QRHMQ1</td>
<td>Texas Instruments</td>
</tr>
</tbody>
</table>
Table 5. TPS92682EVM-70 Bill of Materials (continued)

<table>
<thead>
<tr>
<th>Designator</th>
<th>Quantity</th>
<th>Value</th>
<th>Description</th>
<th>Package</th>
<th>Part Number</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>U2</td>
<td>1</td>
<td></td>
<td>High-Speed, Low-Power, Robust EMC Quad-Channel Digital Isolator, DBQ0016A</td>
<td>DBQ0016A</td>
<td>ISO7740DBQ</td>
<td>Texas Instruments</td>
</tr>
<tr>
<td>U3</td>
<td>1</td>
<td></td>
<td>High Speed, Robust EMC Quad-Channel Digital Isolators, DBQ0016A (SSOP-16)</td>
<td>DBQ0016A</td>
<td>ISO7741DBQR</td>
<td>Texas Instruments</td>
</tr>
</tbody>
</table>
7 Software

This section describes the installation of the GUI software and the drivers needed to operate the TPS92682EVM-70.

7.1 Demonstration Kit Software Installation for MSP-EXP432E401Y LaunchPad Board

1. Right-click on TPS92682 LaunchPad Evaluation Software Installer.exe and select Run As Administrator.
2. Windows Account Control asks to allow the program to make changes to the computer. Click Yes.
3. Select Agree to the installation license terms and install in the recommended location.
4. Installation may take a while, as it may need to install Microsoft .NET Framework.
5. If the installer asks to reboot after installing Microsoft .NET, click restart later to complete the driver installation.
6. After running the TPS92682 LaunchPad Evaluation Software Installer.exe, the evaluation software window appears as shown in Figure 18.

![Figure 18. Setup Screen 1](image)

Click Next > to install.
Click **Next >** to accept the License Agreement.

Select **Full Install** and click **Next >** to install the evaluation software, the UniFlash, and the required XDS drivers. Full installation for both Windows 10 and 7 are provided.
If .NET Framework 4.5 or higher does not exist on the computer, the .NET Framework installation begins. Installation of .NET Framework will take several minutes. If .NET Framework 4.5 or higher exists on the computer, the installation jumps to the XDS driver installation.

A window appears indicating the completion of the .NET Framework installation.
Click **Next >** to continue the installation.

Click **Next >** to install the XDS driver.
The completion of the XDS driver installation is shown in Figure 25.

The TI-Emulators installation starts at this point. This will install the necessary drivers for running the application. In the next few steps as shown in Figure 26, Figure 27 and Figure 28 click Next > to perform the installation.
Accept the license agreement in Figure 27.

In the next few windows click **Next >**, and if prompted by Windows Security about software installation as shown in Figure 29, select **Install**.
The screen showing the completion of the TI Emulators installation is shown in Figure 30. Click on Finish to move to the next step.

The UniFlash installation starts at this point. UniFlash is required to program the LaunchPad. In the next few steps as shown in Figure 31, Figure 32 and Figure 33 click Next > to start the installation.
Figure 31. Setup Screen 14

Figure 32. Setup Screen 15

Figure 33. Setup Screen 16
When UniFlash installation completes, click **Finish** to launch the UniFlash and program the LaunchPad.

![Setup Screen 17](image)

**Figure 34. Setup Screen 17**

When UniFlash installation completes, click **Finish** to launch the UniFlash and program the LaunchPad.

![Setup Screen 18](image)

**Figure 35. Setup Screen 18**

**Figure 35** shows the completion notification of the TPS92682-Q1 Evaluation Software. Un-check the Launch Application and click **Finish**.

### 7.2 Installation Error Recovery

If the screen shown in **Figure 36** appears, follow the steps below to install an unsigned driver one time.

- Click **Start** and select **Settings**.
- Select **Update and Security**.
- Select **Recovery**.
- Click **Restart Now** under **Advanced Startup**.
- Click **Troubleshoot**.
- Select **Advanced Options**.
Select **Startup Settings**.

Click **Restart**.

On the **Startup Settings** screen, press **F7** during reboot to disable driver signature enforcement. The host computer restarts.

Repeat the entire reinstallation process.

A message appears informing that installing .NET failed. Close that window and continue.

Click **Install unsigned drivers** twice.

After restarting a second time, the host computer resets, which requires all drivers to be digitally signed the next time a default installation executes, unless these steps are repeated.

---

**Figure 36. Driver Installation Error**

### 7.3 Programming the MSP-EXP432E401Y LaunchPad Board

The LaunchPad Board must be programmed using the UniFlash before running the GUI. Connect the included Micro-USB cable to the USB port of the PC and the LaunchPad as shown in **Figure 37**. Connect a jumper between PINs 3 and 4 of the JP1 as shown in **Figure 37**.
Typically, the installed UniFlash program opens at the end of the software setup shown in Figure 34. If the UniFlash program is not open, launch the program. The window shown in Figure 38 opens.

Click Session shown in Figure 38 and select Load Session.
As shown in Figure 39, navigate to the "\Texas Instruments\TPS92682 LaunchPad Evaluation Software\uniflash" location and select the msp432e401y.uniflash file.

Figure 40. UniFlash Programming, Step 3

Click on the flash image file shown in the red box of Figure 40. Navigate to the "\Texas Instruments\TPS92682 LaunchPad Evaluation Software\uniflash" location and select the AlgCSM_DRV.out file as shown in Figure 41.
Figure 41. UniFlash Programming, Step 4

Click **Load Image**. After the program is loaded into the LaunchPad, a message appears in the console that the *Program Load completed successfully*, as shown in Figure 42.

Figure 42. UniFlash Programming, Step 5

Close the UniFlash program, disconnect the Micro-USB from the LaunchPad and connect it to the USB port U7 on the other side of the LaunchPad, as shown in Figure 43.
Figure 43. LaunchPad Connection for GUI Operation
8  **TPS92682EVM-70 Power UP and Operation**

To start the EVM operation, connect the header J10 on TPS92682EVM-70 to the header J2/J4 on the LaunchPad, and the header J11 to the header J1/J3, using two included ribbon cables as shown in Figure 44.

![Figure 44. LaunchPad Connection to TPS92682EVM-70](image)

Apply power (12 V) to the TPS92682EVM-70 board (terminal J1). Connect LED loads to the outputs of the EVM (terminal J2 and J5). Ensure that the loads are such that the maximum input and output current, maximum output power and maximum output voltage indicated on the EVM are not exceeded.

Run the program `LED_Controller_GUI_LP.exe`, located at the "\Texas Instruments\TPS92682 LaunchPad Evaluation Software”, to start the GUI. The window shown in Figure 45 opens.
Click the EVM selection dropdown box. Select **TPS92682 CC - PSIL070**.

On the screen shown in Figure 46, select 1 as the number of devices. A new tab appears as shown in Figure 47. Select **682** for Device Type. Select **0** for Desired Address. Click **Add Device**.
The main GUI window appears as shown in Figure 48. This window includes three sub-windows:

- **MCU Control Box (1):** includes controls for external PWM
- **SPI Command Box (2):** is used to manually read from and write to the registers on the SPI BUS
- **Devices Box (3):** is the main GUI control window to configure the TPS92682-Q1 device

![Figure 48. GUI, Main Window](image)

### 8.1 SPI Command

The SPI command box, allow access to the read from and write to registers. In order to ensure connection to the TPS92682-Q1, perform the following steps as shown in Figure 49:

1. Write the register address zero in the **Register Address** box: 0x00.
2. Click **Send** twice.

   The default value (0x3C) for the register 0 shows in the SPI Status window.

To write to a register, select the **Write** check-box. Write the desired data in the **Write Data** box shown in Figure 49. Click **Send** to write the data to the associated register address.
8.2 GUI Devices Window

In TPS92682EVM-70, channel-1 is configured as a CC mode boost converter and channel-2 as a CC mode boost-to-battery. The settings shown in red in Figure 50 can be used to configure and turn on and regulate the LED current of the two channels.
Apply the settings shown in Figure 51.

1. Select the Internal PWM box to set the PWM dimming to internal.

2. To set the switching frequency, $f_{SW}$ to 400kHz, do not change the Channel Clock Div from the default value of 2.

3. Enter the Channel 1 and Channel 2 Soft Start value to 100.

4. Enter the desired value for the CH1 and CH2 V/I Adjust DAC. This DAC controls the $I_{LED}$ current. For TPS92682EVM-070, the DAC maximum value of 255 corresponds with an $I_{LED}$ of approximately 570 mA. The relation between $I_{LED}$ and the DAC value is shown in Equation 1.

   \[
   I_{LED} = \frac{\text{VIADJ} \times 0.171}{255 \times R_{CS}}
   \]  

   where
   - $R_{CS}$ is the current sense resistor (R3 for channel-1 and R20 for channel-2)  

5. The EVM generates the internal PWM using a 10-bit DAC counter. Set the PWM duty cycle to a value between zero and 1023 for PWM dimming. In order to turn on the LEDs with 100% duty cycle, set the PWM DAC value to 1023.

6. By default CHx-Slope is set to code "5", which corresponds to 250 mV of peak slope. For the TPS92682EVM-70, it is recommended to set the slopes for both channels to a code "1" or "2" as shown in Figure 51.
After applying these settings, the fault status registers FLT1 (0x11) and FLT2 (0x12) must be checked. Before enabling and turning on the outputs, the fault registers must be read (cleared). The Power Cycle (PC) bit must be cleared in order for the TPS92682-Q1 is enabled. The fault status can be obtained by pushing the Read Faults button in Figure 52.

The first time the Read Fault button is pushed, the previous status of the fault registers are shown and the faults are cleared. The second time the Read Faults button is pushed, the cleared faults will change to green as shown in Figure 53.
Some of the faults or diagnostic bits, as undercurrent (UC) and undervoltage (UV) may remain red as the channels are not turned on. For example for channel-2 (boost-to-battery), the output undervoltage (UV) remains red as the load voltage is initially zero. Therefore, this fault is disabled by default until the soft-start sequence is complete. The output overvoltage (OV), cycle-by-cycle current limit (ILIM), IS Open (ISO), RT Open (RTO), Power Cycle (PC) and Thermal Warning (TW) should be cleared (change status to green) before enabling the channels.

Before enabling the channels, make sure to connect LED loads to the outputs of the TPS92682EVM-070. By setting the Channel 1 and Channel 2 Enable check boxes, the two channels are turned on. At this point after clicking **Read Faults**, for 100% PWM duty cycle, all faults as shown in Figure 54 are cleared.

![Figure 54. Enabling the EVM](image)

In some cases, for PWM duty cycles of less than 100%, the UC diagnostic bit may continue to display as red.

![Figure 55. Fault Status](image)

To turn off the channels, de-select the Channel 1 and Channel 2 Enable.

*If a power cycle occurs, all the registers reset to default values. In this case, it is necessary to repeat all the steps described in Section 8 before re-enabling the converter.*
Revision History

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

Changes from Original (May 2019) to A Revision

<table>
<thead>
<tr>
<th>Changes from Original (May 2019) to A Revision</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Updated Figures 18 to 20.</td>
<td>22</td>
</tr>
<tr>
<td>• Updated Figure 23.</td>
<td>25</td>
</tr>
<tr>
<td>• Updated Figures 26 to 30.</td>
<td>26</td>
</tr>
<tr>
<td>• Updated Figure 35.</td>
<td>30</td>
</tr>
<tr>
<td>• Updated Figure 39 and Figure 41.</td>
<td>33</td>
</tr>
<tr>
<td>• Updated Figure 48 and Figure 49.</td>
<td>38</td>
</tr>
</tbody>
</table>
STANDARD TERMS FOR EVALUATION MODULES

1. Delivery: TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User’s acceptance of the EVM is expressly subject to the following terms.

1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software.

1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 Limited Warranty and Related Remedies/Disclaimers:

2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects within ten (10) business days after the defect has been detected.

2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:
EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.
2

Regulatory Notices:

3.1 United States

3.1.1 Notice applicable to EVMs not FCC-Approved:

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:

CAUTION
This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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

FCC Interference Statement for Class A EVM devices
NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices
NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

• Reorient or relocate the receiving antenna.
• Increase the separation between the equipment and receiver.
• Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
• Consult the dealer or an experienced radio/TV technician for help.

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247
Concerning EVMs Including Radio Transmitters:
This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

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

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

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.

3.3 Japan

3.3.1 Notice for EVMs delivered in Japan: Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。http://www.tij.co.jp/lsds/ti_ia/general/eStore/notice_01.page

3.3.2 Notice for Users of EVMs Considered “Radio Frequency Products” in Japan: EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

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

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

3.4 European Union

3.4.1 For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive):

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.
EVM Use Restrictions and Warnings:

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 Safety-Related Warnings and Restrictions:

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designers. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designers.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. Accuracy of Information: To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. Disclaimers:

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSES OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS. USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSEES AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.
8. **Limitations on Damages and Liability:**

8.1 **General Limitations.** IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMs, REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

8.2 **Specific Limitations.** IN NO EVENT SHALL TI’S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. **Return Policy.** Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. **Governing Law:** These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2019, Texas Instruments Incorporated
IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI's Terms of Sale (www.ti.com/legal/termsofsale.html) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2019, Texas Instruments Incorporated