

# EVM User's Guide: LMI800PSEVM

## LMI800PS Evaluation Module



### Description

The LMI800PS evaluation module (EVM) contains evaluation and reference circuitry for the LMI800PS hot-swap controller. The LMI800PS device combines a high-performance hot-swap controller with a PMBus interface to accurately measure, protect, and control the electrical operating conditions of systems connected to an 800V backplane power bus or PSU.

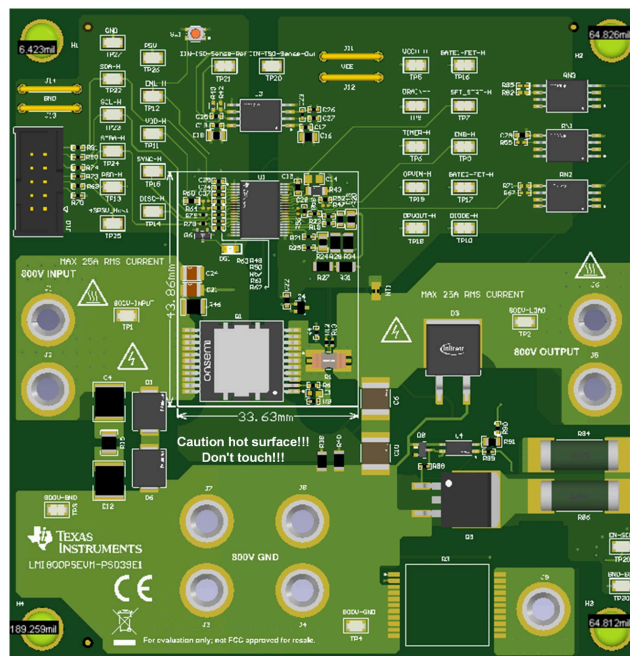
### Features

- 700V to 870V (typical) operation
- 5A to 25A programmable overcurrent threshold using PMBus

- Adjustable output voltage slew rate control
- Adjustable transient current blanking timer using PMBus
- Option to apply output hot-short using onboard a SiC Combo JFET and an isolated gate drive circuit
- Onboard output discharge circuit in the event of an input UVLO

### Applications

- Input hot-swap and hot-plug
- [Server](#) and [high performance computing](#)
- [Data center switches](#)



LMI800PSEVM

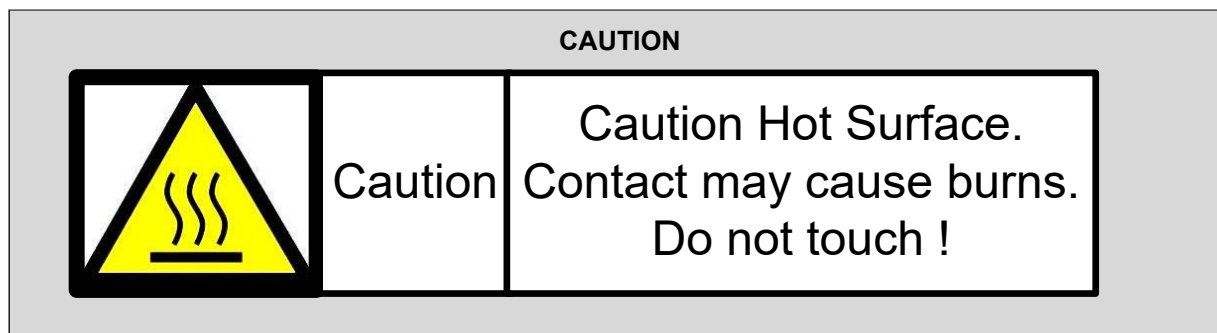
# 1 Evaluation Module Overview

## 1.1 Introduction

The LMI800PSEVM provides the design engineer with a fully functional intelligent monitoring and protection controller board designed for positive 800V systems. This EVM user's guide describes the various functions of the board, how to test and evaluate the board, and how to utilize the GUI design tool to modify components for a specific application. To use the advanced telemetry and monitoring capabilities of this device, the user needs to use the [LMI800PSEVM-GUI](#) through the [USB-TO-GPIO2 Evaluation Board](#) from Texas Instruments only. However, the LMI800PS can act as a hot-swap and protection circuit without any software installation. The SMBus & I2C & SAA Debug Tool in Texas Instruments' Fusion Digital Power software, which provides a general-purpose interface to communicate with any I2C, SMBus, or PMBus device can also be used to communicate with the LMI800PSEVM through the [USB-TO-GPIO2 Evaluation Board](#) from Texas Instruments only. This EVM demonstrates a 10kW, 800V high-side hot-swap design for AI-powered enterprise data centers.

This EVM user's guide describes the evaluation module (EVM) for the LMI800PS hot-swap controller with following features:

- 700V to 870V (typical) operation
- 5A to 25A programmable overcurrent threshold using PMBus
- Adjustable output voltage slew rate control
- Adjustable transient current blanking timer using PMBus
- Option to apply output hot-short using onboard a SiC Combo JFET and an isolated gate drive circuit
- Onboard output discharge circuit in the event of an input UVLO
- TVS diode for input and Schottky diode for output transient protections
- Programmable current limiting and power limiting for complete SOA protection
- Programmable fault timer to eliminate nuisance shutdowns
- Programmable undervoltage and overvoltage protection
- Programmable power good indicator
- Programmable auto-retry or latch options
- Integrated isolated DC/DC converter to power the hot-swap controller in different configurations
- Real-time monitoring of VIN, VOUT, IIN, PIN, TEMP, and EIN



## 1.2 Kit Contents

**Table 1-1. LMI800PSEVM: Kit Contents**

| Item        | Description                                        | Quantity |
|-------------|----------------------------------------------------|----------|
| LMI800PSEVM | Evaluation module for LMI800PS hot-swap controller | 1        |

The [USB-TO-GPIO2](#) adapter is not included in the kit and needs to be separately ordered at [USB-TO-GPIO2 Evaluation board | TI.com](#).

## 1.3 Specification

[Table 1-2](#) summarizes the LMI800PSEVM specifications.

**Table 1-2. LMI800PSEVM Design Specifications**

| PARAMETER                                            | VALUE                                     |
|------------------------------------------------------|-------------------------------------------|
| Input voltage range ( $V_{IN}$ )                     | 700V to 870V                              |
| Maximum RMS load current ( $I_{OUT(max)}$ )          | 12A                                       |
| Over-current protection threshold ( $I_{TRIP}$ )     | 12.5A                                     |
| Maximum output capacitance ( $C_{LOAD}$ )            | 300 $\mu$ F                               |
| Are all the loads off until the PG is asserted?      | Yes                                       |
| Maximum ambient temperature                          | 70°C                                      |
| Fault timer                                          | 170 $\mu$ s, 350 $\mu$ s, and 520 $\mu$ s |
| Output voltage slew rate                             | 0.45V/ms                                  |
| Need to survive a hot-short on the output condition? | Yes                                       |
| Need to survive a power-up into short condition?     | Yes                                       |
| Can a board be hot-plugged in or power cycled?       | Yes                                       |
| Load current monitoring needed?                      | Yes                                       |
| Fault response                                       | Latch-off                                 |

## 1.4 Device Information

The LMI800PSEVM enables the evaluation of the LMI800PS hot-swap controller, along with driving two SiC Combo JFETs in parallel. The input power is applied across the connectors J1/J2 and J3/J4, while J5/J6 and J7/J8 provide the output connection for the EVM. Refer to the schematic in [Figure 4-1](#) and EVM test setup in [Section 3.1](#). To power up the EVM, a 5V auxiliary power supply must be provided at TP26 (P5V) and TP27 (GND). TVS diodes D1, D2, D6, and D7 provide the input protection from transient overvoltages. Schottky diodes D3 and D4 protect the output by clamping the negative voltage excursion.

The connector J10 is used to interface the LMI800PSEVM with the [USB-to-GPIO2](#) adapter.

The [LMI800PSEVM-GUI](#) communicates to the LMI800PS evaluation module *only through the USB-to-GPIO2 adapter*.

**Table 1-3. LMI800PSEVM Evaluation Board Options and Settings**

| EVM Function                                           | Vin UVLO Threshold | Vin OVLO Threshold | Analog Fault TIMER                                     | Output Slew Rate (dv/dt) | PLIM                                                                                     | ILIM                                  |
|--------------------------------------------------------|--------------------|--------------------|--------------------------------------------------------|--------------------------|------------------------------------------------------------------------------------------|---------------------------------------|
| Performance evaluation of LMI800PS hot-swap controller | Disabled           | 870V               | Selectable - 170 $\mu$ s, 350 $\mu$ s, and 520 $\mu$ s | 0.45V/ms                 | Programmable in PMBus - Default value is approximately 72W with $R_{SNS}$ of 2m $\Omega$ | Default - 12.5A with $V_{CL}$ of 25mV |

### CAUTION

Do not leave the EVM powered on when unattended

### WARNING

Signal traces, components, and component leads are located on the bottom of the circuit module. There can be exposed voltages, hot surfaces, or sharp edges as a result. When operating the board, do not reach under.

### CAUTION

The communication interface is not isolated on the EVM. Make sure there is no ground potential between the computer and the EVM. Note that the computer is referenced to the ground potential of the EVM.

## 2 Hardware

### 2.1 General Configurations

#### 2.1.1 Physical Access

The LMI800PSEVM input and output connectors functionalities are listed in [Table 2-1](#). The availability of test points are described in [Table 2-2](#).

**Table 2-1. Input and Output Connector Functionality**

| Connector   | Label          | Description                                                      |
|-------------|----------------|------------------------------------------------------------------|
| J1/J2       | 800V-INPUT (+) | Positive terminal for the input power to the EVM                 |
| J3/J4/J7/J8 | 800V-LOAD (+)  | Positive terminal for the output power from the EVM              |
| J5/J6       | 800V-GND (–)   | Negative terminal for the EVM (Common for both input and output) |

**Table 2-2. Test Points Description**

| Test Points | Label             | Description                                                                   |
|-------------|-------------------|-------------------------------------------------------------------------------|
| TP1         | 800V-INPUT        | 800V input voltage to the EVM                                                 |
| TP2         | 800V-LOAD         | 800V output voltage from the EVM                                              |
| TP3         | 800V-GND          | 800V GND reference point of the EVM                                           |
| TP4         |                   |                                                                               |
| TP5         | VCCH-H            | Positive supply for high voltage domain with respect to VEEH                  |
| TP6         | TIMER-H           | Fault timer pin voltage with respect to VEEH                                  |
| TP7         | SFT_STRT-H        | SFT_STRT pin voltage with respect to VEEH                                     |
| TP8         | DRAIN-H           | DRAIN pin voltage with respect to VEEH                                        |
| TP9         | ENB-H             | ENB pin voltage with respect to VEEH                                          |
| TP10        | DIODE-H           | DIODE pin voltage with respect to VEEH                                        |
| TP11        | VDD-H             | VDD pin voltage with respect to GND                                           |
| TP12        | ENL-H             | ENL pin voltage with respect to GND                                           |
| TP13        | PGD-H             | PGD pin voltage with respect to GND                                           |
| TP14        | DISC-H            | DISC pin voltage with respect to GND                                          |
| TP15        | SYNC-H            | SYNC pin voltage with respect to GND                                          |
| TP16        | GATE1-FET-H       | GATE1 pin voltage with respect to VEEH                                        |
| TP17        | GATE2-FET-H       | GATE2 pin voltage with respect to VEEH                                        |
| TP18        | OPVOUT-H          | OPVOUT pin voltage with respect to VEEH                                       |
| TP19        | OPVIN-H           | OPVIN pin voltage with respect to VEEH                                        |
| TP20        | IIN-ISO-Sense-Out | IMON output voltage with respect to IIN-ISO-Sense-Ref                         |
| TP21        | IIN-ISO-Sense-Ref | Reference for IIN-ISO-Sense-Out                                               |
| TP22        | SDA-H             | SDA pin voltage with respect to GND                                           |
| TP23        | SCL-H             | SCL pin voltage with respect to GND                                           |
| TP24        | SMBA-H            | SMBA pin voltage with respect to GND                                          |
| TP25        | +3P3V_Host        | 3.3V power supply from USB-TO-GPIO2 USB interface adapter with respect to GND |
| TP26        | P5V               | 5V auxiliary power supply needs to be connected with respect to GND           |
| TP27        | GND               | Low voltage reference point                                                   |
| TP29        | EN-SCP            | Enable signal to U2 with respect to GND                                       |
| TP30        | GND-SCP           | Reference point for EN-SCP (Connected to GND)                                 |

#### 2.1.2 Test Equipment and Setup

##### 2.1.2.1 Power Supplies

Evaluation of this EVM needs following power supplies.

1. One adjustable power supply with 0V to 1000V output and 0A to 20A output current limit, for example EA-PSI 11000-40,

2. One 5V power supply with at least 500mA of current limit.

#### 2.1.2.2 Meters

Evaluation of this EVM needs two Digital Multi Meters (DMM).

#### 2.1.2.3 Oscilloscope

Evaluation of this EVM needs a MSO58B or equivalent oscilloscope, 10x passive voltage probes (for example, TPP1000), galvanically isolated high-voltage differential probe (for example, TIVP1, TIVP05), high-voltage differential oscilloscope probe (for example, THDP0200), isolated differential measurement system with a 500MHz bandwidth and a differential voltage range up to  $\pm 2.5\text{kV}$  (for example, TIVP05 used with the TIVPWS500X probe tip), and a DC current probe of 150A rated (for example, TCP0150).

#### 2.1.2.4 Loads

Evaluation of this EVM needs one eLoad, which can tolerate up to 20A DC load at 1000V (for example, PLZ12005WH2).

#### 2.1.2.5 USB-to-GPIO Interface Adapter

A communication adapter is required between the LMI800PSEVM and the host computer to use the [LMI800PSEVM-GUI](#) or the SMBus & I2C & SAA Debug Tool in Texas Instruments' Fusion Digital Power software. *These GUIs communicate with the Texas Instruments [USB-to-GPIO2](#) USB interface adapter evaluation module only.* This adapter can be purchased at [USB-TO-GPIO2 Evaluation board | TI.com](#).

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The LMI800PSEVM kit does not include this USB-TO-GPIO2 adapter.

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#### Note

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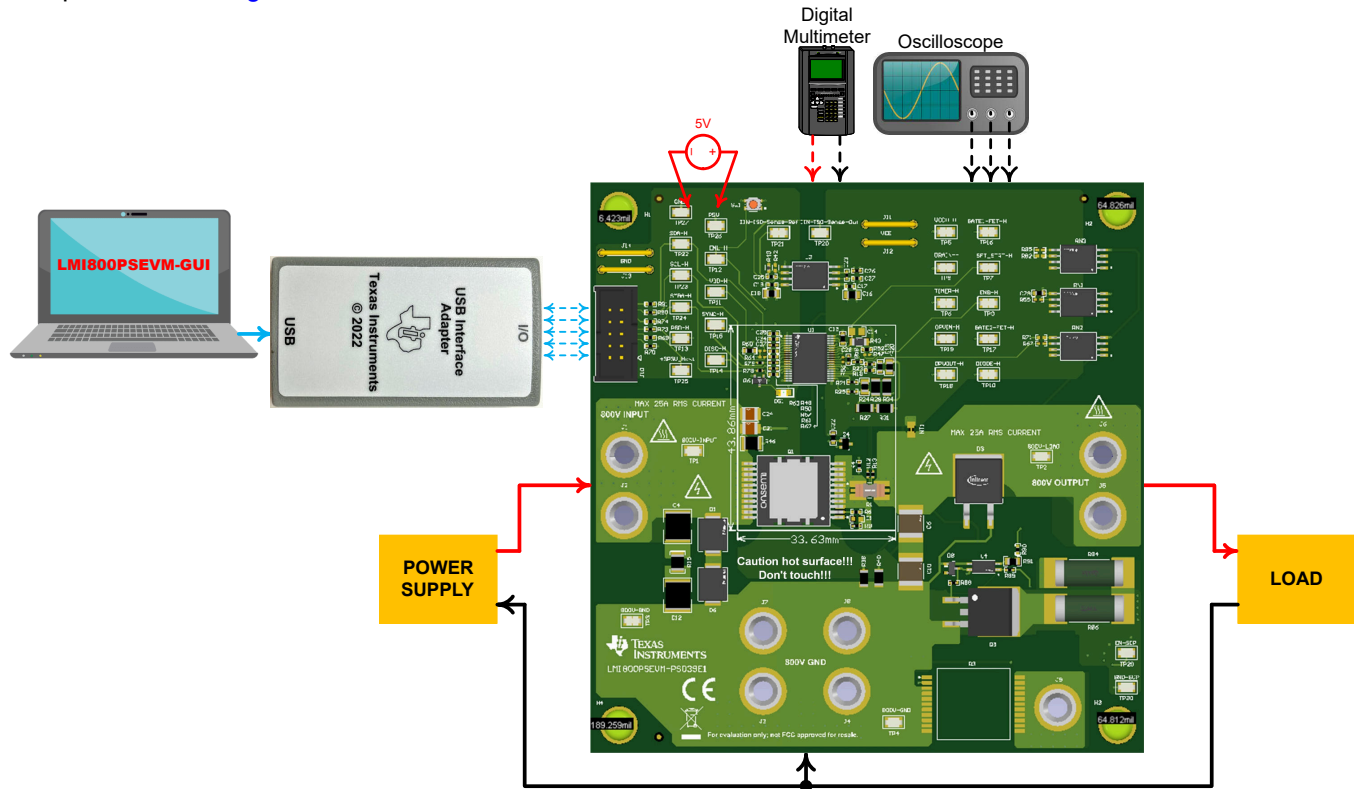
The [LMI800PSEVM-GUI](#) does not communicate with any other adapter.

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## 3 Implementation Results

### 3.1 Test Setup and Procedures

In this user's guide, the test procedure is described for the LMI800PS hot swap controller. The experimental setup is shown in [Figure 3-1](#).



**Figure 3-1. LMI800PSEVM Setup with Test Equipment**

#### Procedure for Initial EVM Power-Up:

As this EVM is designed for high-voltage systems (800V), it is advisable to perform the initial power-up using a lower input voltage (for example, 60V to 70V). Follow these steps to power the EVM for the first time:

- Pre-connection Impedance Check:** Before connecting any power supplies, use a digital multimeter to measure the following impedances. All measurements must indicate high impedance (high Z):
  - J1 (800V INPUT) to J3 (800V GND),
  - J5 (800V OUTPUT) to J3 (800V GND),
  - J1 (800V INPUT) to J5 (800V OUTPUT).
- Connect the Texas Instruments [USB-to-GPIO2](#) USB interface adapter at the J10 connector
- Connect a 5V power supply to TP26 (P5V) and TP27 (GND) setting a current limit of no more than 500mA, then turn the power supply on.
- Measure the voltage across TP11 (VDD-H) and J14 (GND); the voltage must be approximately 5V.
- Measure the voltage across TP5 (VCC-H) and J11 (VEE); the voltage must be approximately 5V.
- Verify PMBus Communication:**
  - Open the SMBus & I2C & SAA Debug Tool (a low-level communication utility within the TI Fusion Digital Power Designer software),
  - Enter the device address as 10h,
  - Send the CLEAR\_FAULTS command (03h, Send Byte) and verify that the status shows "ACK".
- Read the VIN\_UV\_FAULT\_LIMIT (59h, Read/Write Word) register. Make sure it displays 0x0000h (indicating UVLO is disabled). If it does not, write 0x0000h to the register, then read it again to confirm the value.

8. Apply 60V to 70V to the J1 (800V INPUT) and J3 (800V GND) connectors. Set a current limit of no more than 200mA. Measure the voltage across the J5 (800V OUTPUT) and J3 (800V GND) connectors; the voltage must be approximately equal to the input voltage (approximately 60V).
9. Measure the voltage across TP16 (GATE1-FET-H) and J11 (VEE); the voltage must be approximately 12V.
10. Measure the voltage across TP17 (GATE2-FET-H) and J11 (VEE); the voltage must be approximately 12V.
11. **Troubleshooting:** If steps 8 through 10 are unsuccessful, read the READ\_DIAGNOSTIC\_WORD (E1h, Read Word) in the Debug Tool to identify the reported faults using [Table 3-1](#).
12. **High-Voltage Testing:** If steps 8 through 10 are successful, gradually increase the voltage at J1 (800V INPUT) and J3 (800V GND) in 10V increments up to 800V. Continuously monitor the voltage across TP16 (GATE1-FET-H) and J11 (VEE); the voltage must remain at approximately 12V. If the GATE voltage becomes zero, read the READ\_DIAGNOSTIC\_WORD (E1h, Read Word) to diagnose the fault.

**Table 3-1. READ\_DIAGNOSTIC\_WORD (E1h, Read Word) Register Description**

| Bit | Description            | Default |
|-----|------------------------|---------|
| 15  | VOUT_UNDERVOLTAGE_WARN | 0       |
| 14  | IIN_OP_WARN            | 0       |
| 13  | VIN_UNDERVOLTAGE_WARN  | 0       |
| 12  | VIN_OVERVOLTAGE_WARN   | 0       |
| 11  | POWER_GOOD             | 1       |
| 10  | OVER_TEMPERATURE_WARN  | 0       |
| 9   | TIMER_LATCHED_OFF      | 0       |
| 8   | FET_FAIL               | 0       |
| 7   | CONFIG_PRESET          | 1       |
| 6   | DEVICE_OFF             | 0       |
| 5   | VIN_UNDERVOLTAGE_FAULT | 0       |
| 4   | VIN_OVERVOLTAGE_FAULT  | 0       |
| 3   | IIN_OC/PFET_OP_FAULT   | 0       |
| 2   | OVER_TEMPERATURE_FAULT | 0       |
| 1   | CML_FAULT              | 0       |
| 0   | CIRCUIT_BREAKER_FAULT  | 0       |

## 3.2 Test Results

This section provides typical performance waveforms for the LMI800PSEVM. Actual performance data is affected by measurement techniques and environmental variables; therefore, these curves are presented for reference and can differ from actual results obtained.

### 3.2.1 Input Hot-Plug

**Test Conditions:**  $V_{IN} = 800V$ ,  $C_{IN} = \text{NO CAPACITOR}$ ,  $C_{OUT} = \text{approximately } 100\mu F$

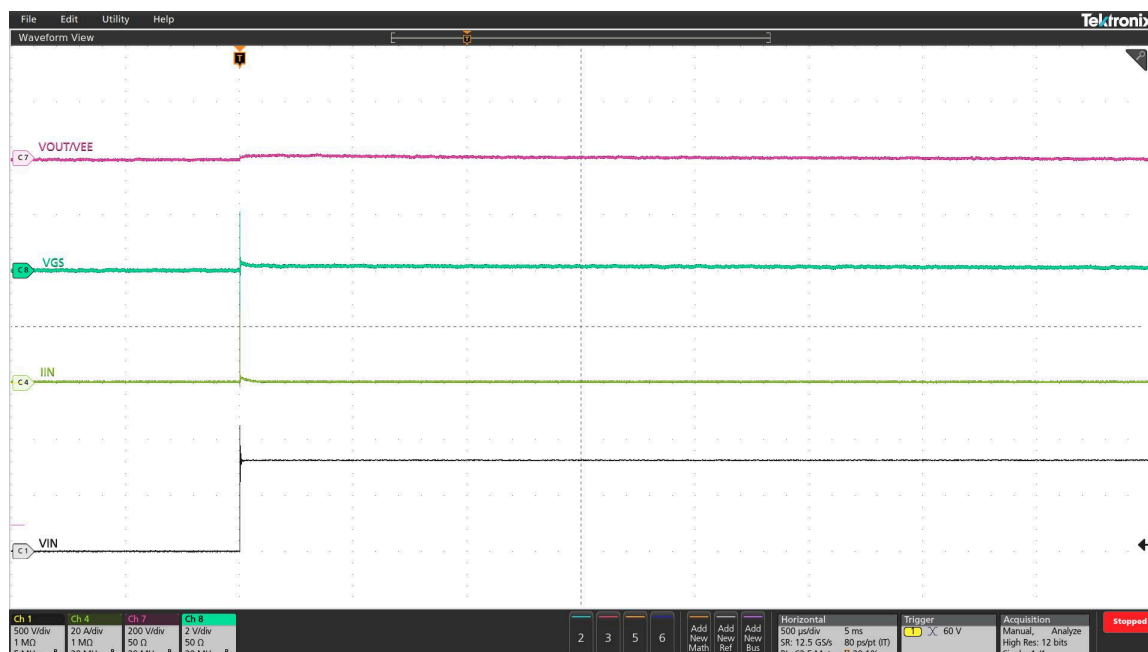


Figure 3-2. Input Hot Plug Profile (Zoomed out)

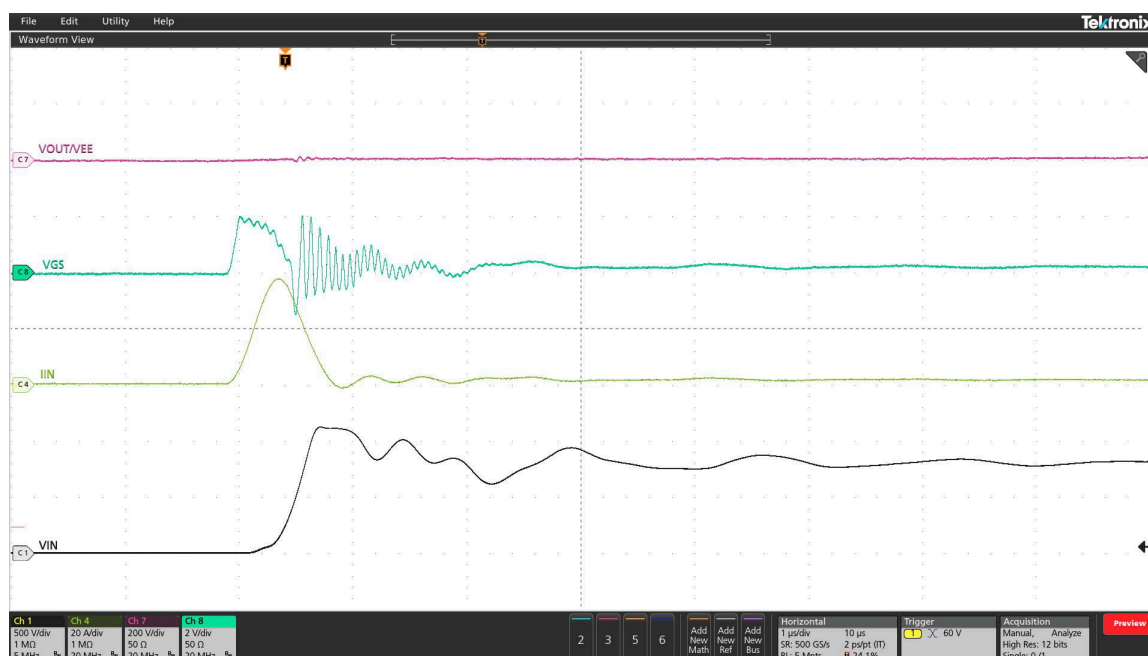


Figure 3-3. Input Hot Plug Profile (Zoomed in)

### 3.2.2 Start-Up with Enable

#### 3.2.2.1 Start-Up With Constant Output Voltage Slew-Rate

**Test Conditions:**  $V_{IN} = 840V$ ,  $C_{OUT} = \text{approximately } 300\mu F$ , and  $C_{DVRT} = 44nF$

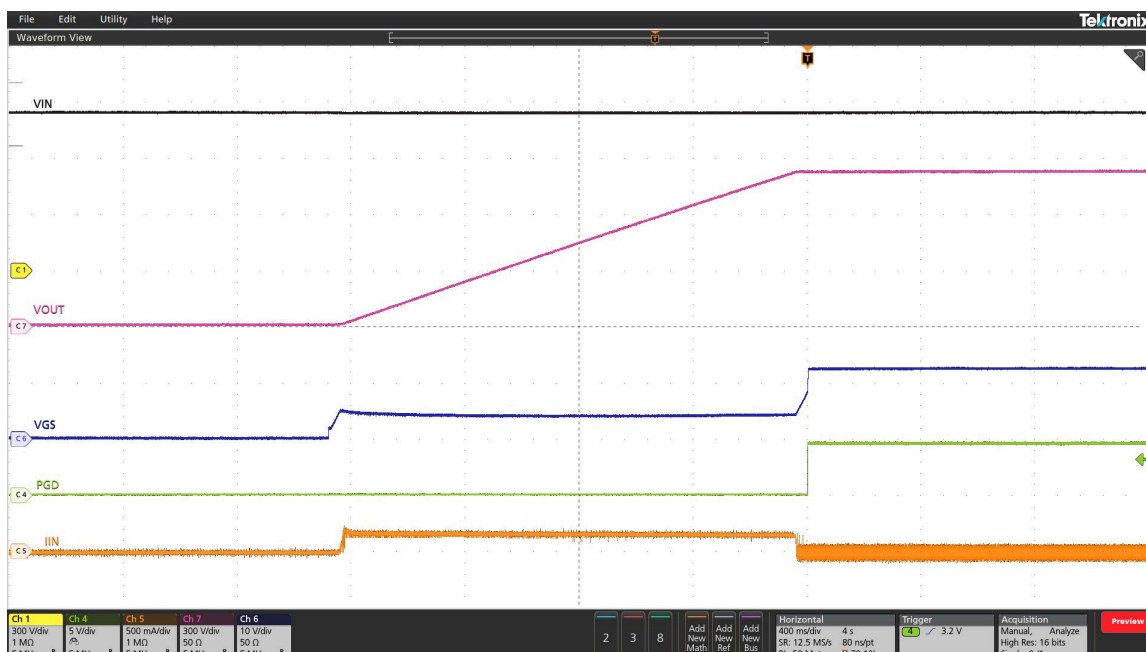


Figure 3-4. Start-Up Profile With Constant Output Voltage Slew-Rate

### 3.2.2.2 Start-Up With PLIM Hiccup Mode

**Test Conditions:**  $V_{IN} = 840V$ ,  $C_{OUT} =$  approximately  $300\mu F$ ,  $C_{TMR} = 20nF$  ( $T_{FLT} =$  approximately  $1ms$ ),  $R_{SNS} = 1m\Omega$ ,  $FAh = 0x0Fh$ ,  $CCh = 0x58h$ , and  $FDh = 0x0231h$ .

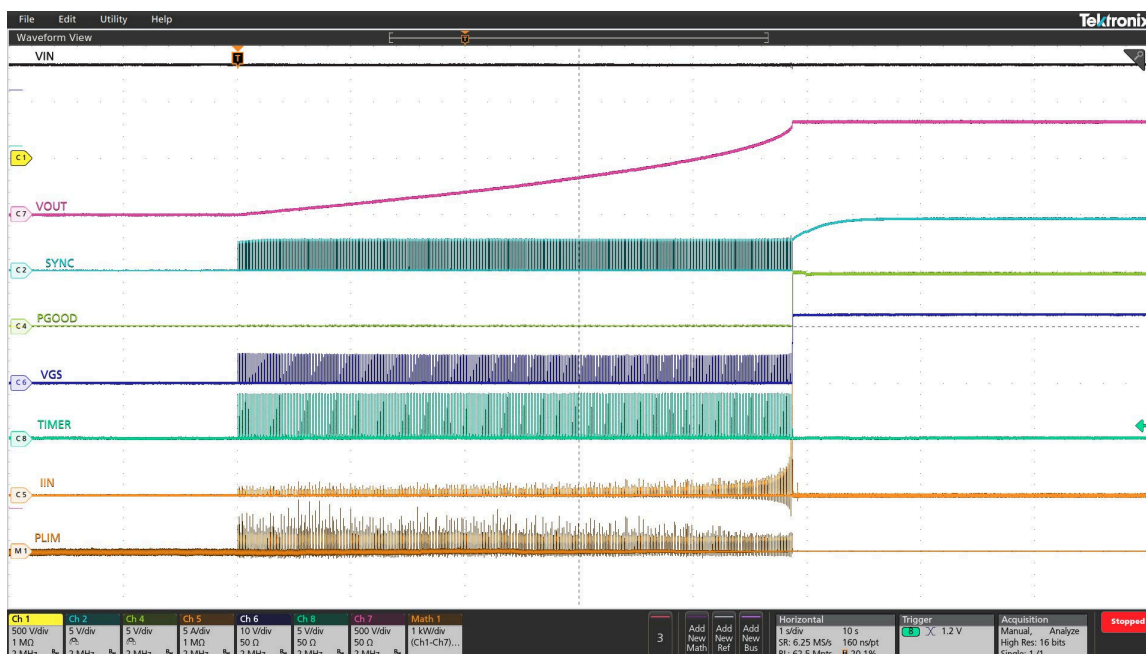
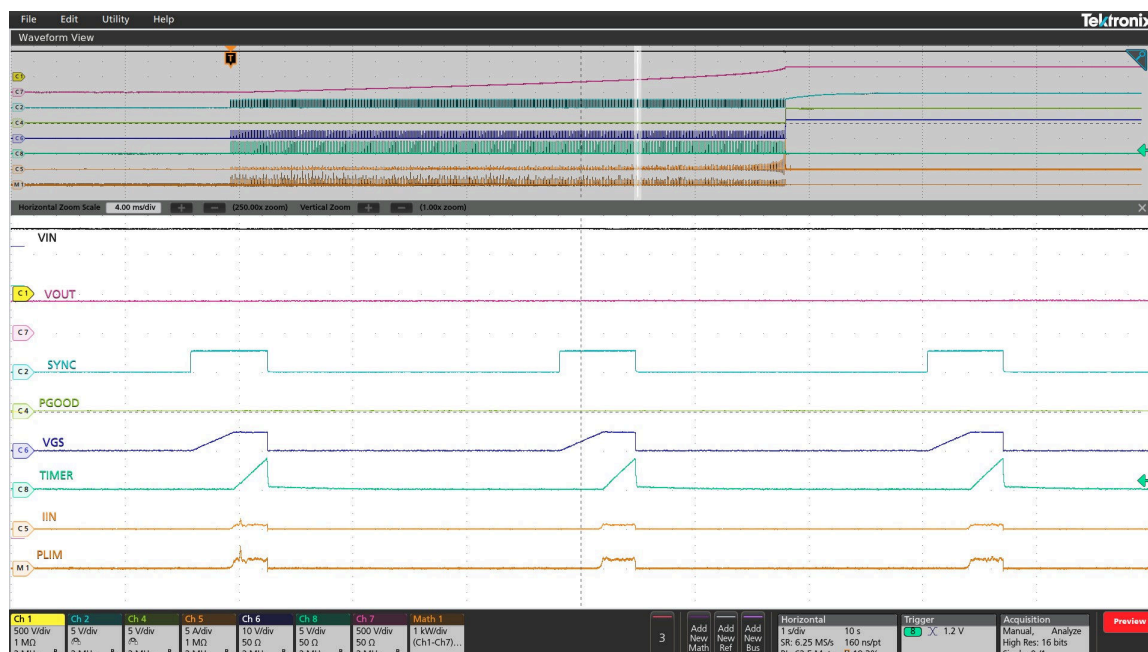


Figure 3-5. Start-Up Profile With PLIM Hiccup Mode

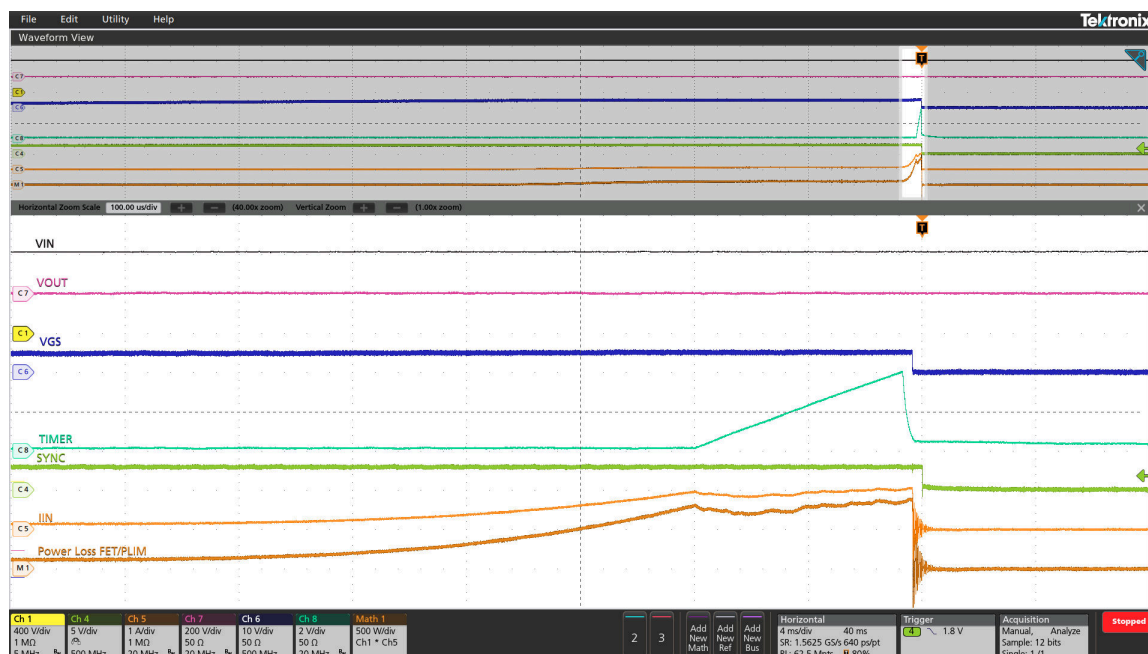


**Figure 3-6. Start-up Profile With PLIM Hiccup Mode (Zoomed In)**

### 3.2.3 Power-Up Into Short

#### 3.2.3.1 Power-Up Into Short in Constant Output Voltage Slew-Rate-Based Start-Up

**Test Conditions:**  $V_{IN} = 840V$ ,  $T_{FLT} = \text{approximately } 180\mu s$ , and  $P_{LIM} = 800W$



**Figure 3-7. Power-Up Into Short Response in Constant Output Voltage Slew-Rate Based Start-Up**

#### Note

Zoomed time scale is  $100\mu s/\text{div}$  for the waveform above.

### 3.2.3.2 Power-Up Into Short in PLIM Hiccup Mode

**Test Conditions:**  $V_{IN} = 840V$ ,  $C_{OUT} = \text{approximately } 300\mu F$ ,  $C_{TMR} = 20nF$  ( $T_{FLT} = \text{approximately } 1ms$ ),  $R_{SNS} = 1m\Omega$ ,  $FAh = 0x0Fh$ ,  $CCh = 0x58h$ , and  $FDh = 0x0231h$ .

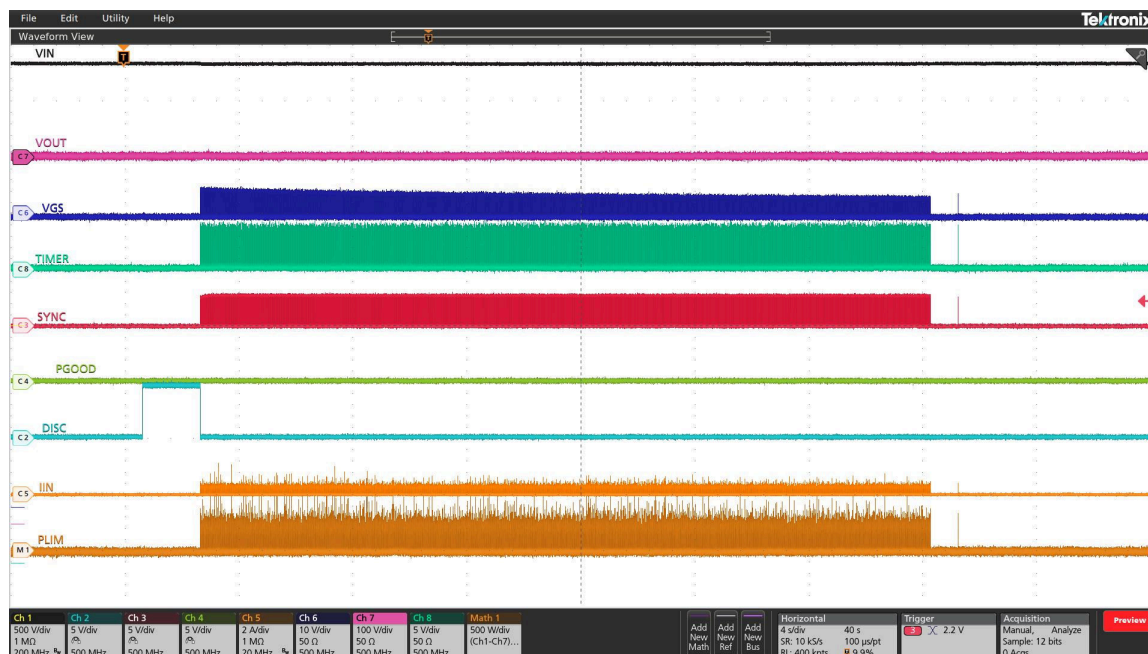


Figure 3-8. Power-Up Into Short Response in PLIM Hiccup Mode

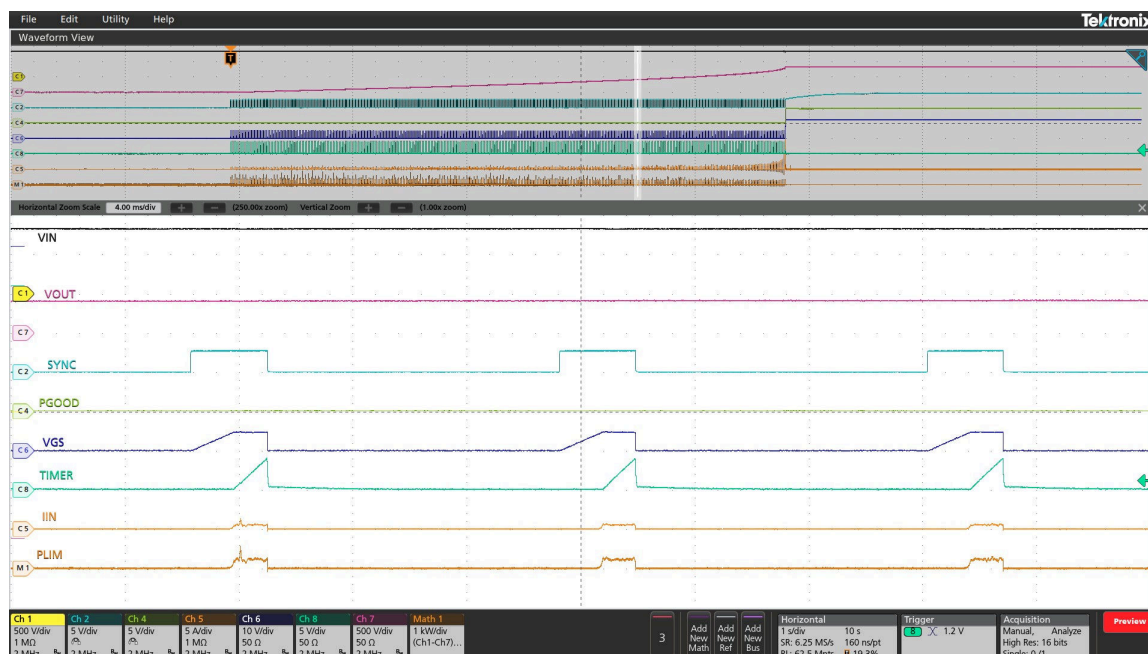


Figure 3-9. Power-Up Into Short Response in PLIM Hiccup Mode (Zoomed In)

### 3.2.4 Undervoltage and Overvoltage Lockout

**Test Conditions:**  $C_{LOAD} = 100\mu s$ ,  $R_{LAOD} = 24k\Omega$ ,  $C_{SS} = 44nF$ , UV rising threshold = 727V, UV falling threshold = 699V, OV rising threshold = 883V, OV falling threshold = 872V, and input voltage swept from 700V to 930V and then to 700V.

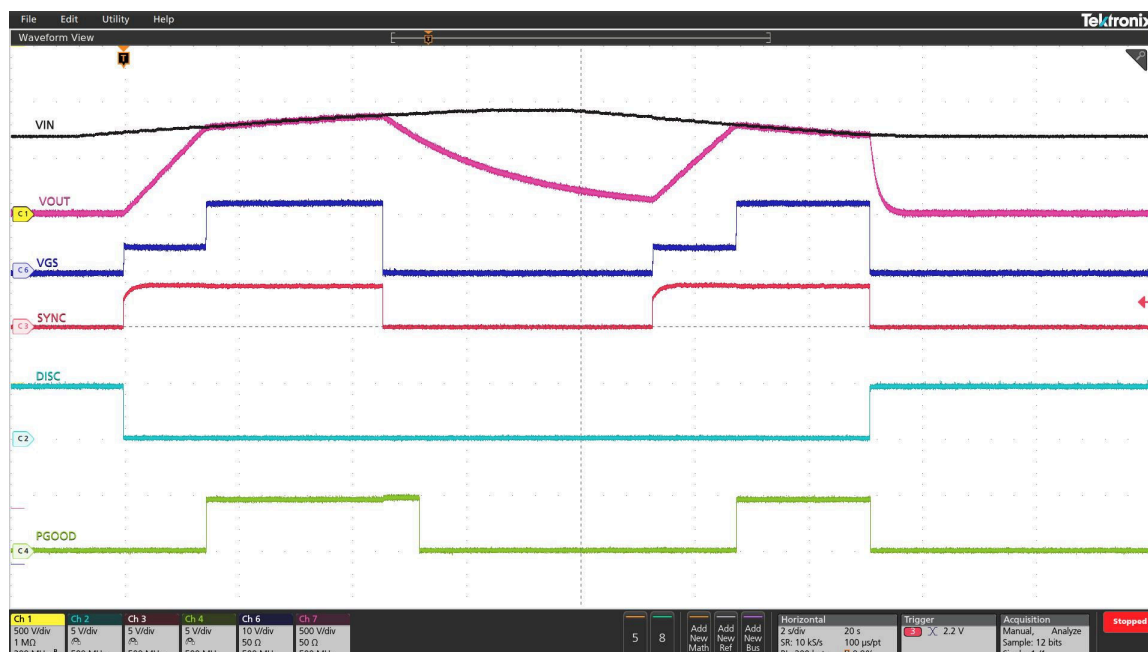


Figure 3-10. Undervoltage and Overvoltage Lockout and Recovery Responses

### 3.2.5 Overcurrent Performance

**Test Conditions:**  $V_{IN} = 300V$ ,  $I_{CL} = 15A$  (15mV/1mΩ),  $I_{CBL1} = 18.75A$  ( $1.25 \times I_{CL}$ ),  $I_{CBL2} = 33.75A$  ( $2.25 \times I_{CL}$ ),  $I_{CB} = 45A$  ( $3.0 \times I_{CL}$ ),  $t_{FLT} = \text{approximately } 300\mu s$ ,  $t_{CBL1} = 57ms$ , and  $t_{CBL2} = 570\mu s$

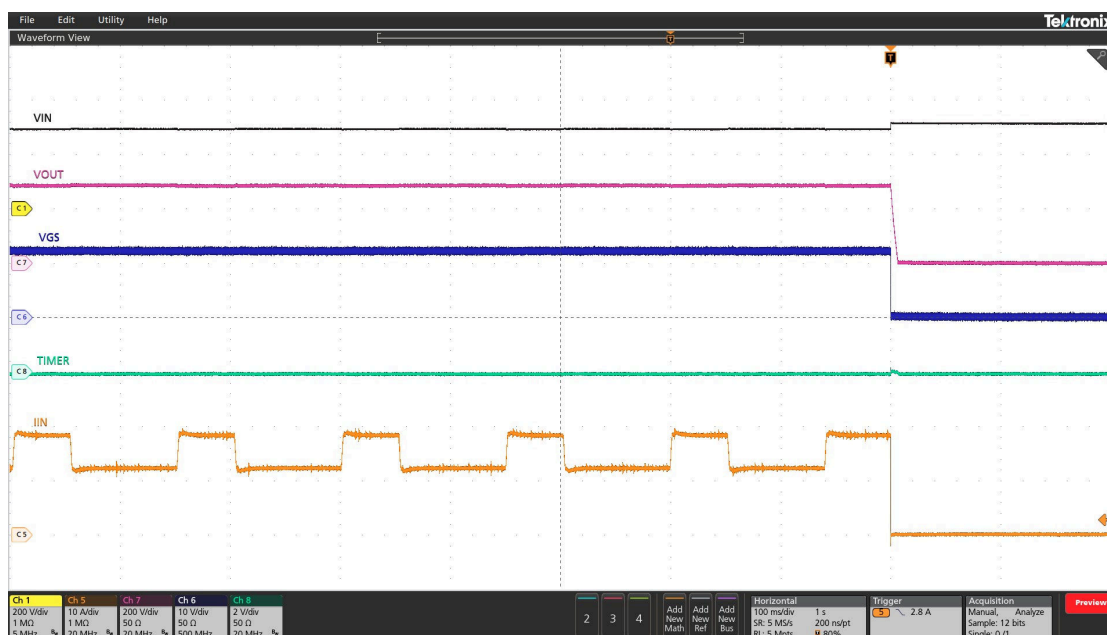
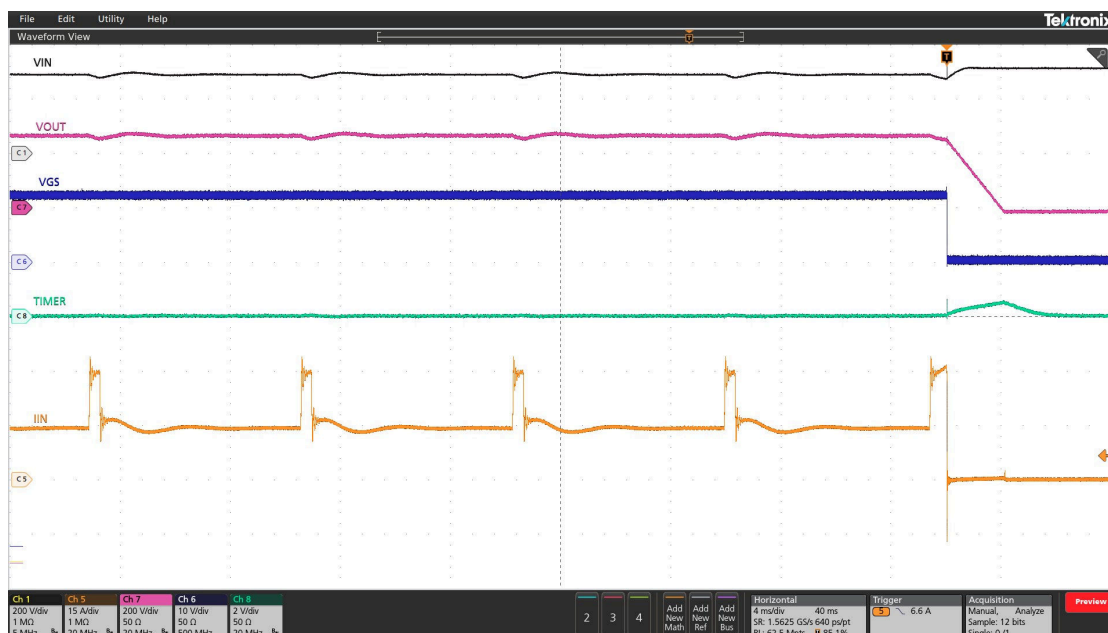


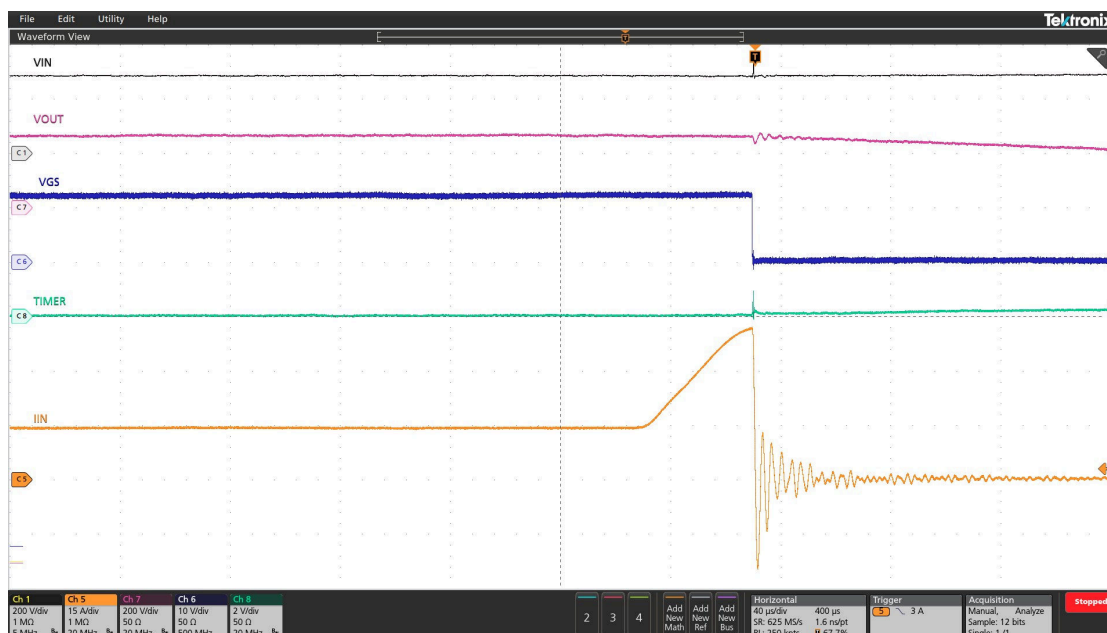
Figure 3-11. Transient Overload Response - 1

Description for Figure 3-11: The current load is increased from 12A for 97ms to 18A for 53ms (Frequency = 10Hz and duty cycle = 35%), preventing  $t_{CBL2}$  from triggering. However,  $t_{CBL1}$  is triggered. A current pulse of less than 57ms at 18A can pass through, but a pulse longer than 57ms activates an overcurrent fault, which is created by increasing the duty cycle of 18A current pulse from 35% to 41%.



**Figure 3-12. Transient Overload Response - 2**

Description for [Figure 3-12](#): The current load is increased from 12A for 7.3ms to 32A for 385μs (Frequency = 130Hz and duty cycle = 5%), at which point both  $t_{CBL1}$  and  $t_{CBL2}$  trigger for 57ms and 570μs, respectively. A current pulse of less than 570μs at 32A can pass through, but a pulse longer than 570μs activates an overcurrent fault, which is created by increasing the duty cycle of 32A current pulse from 5% to 8%.



**Figure 3-13. Transient Overload Response - 3**

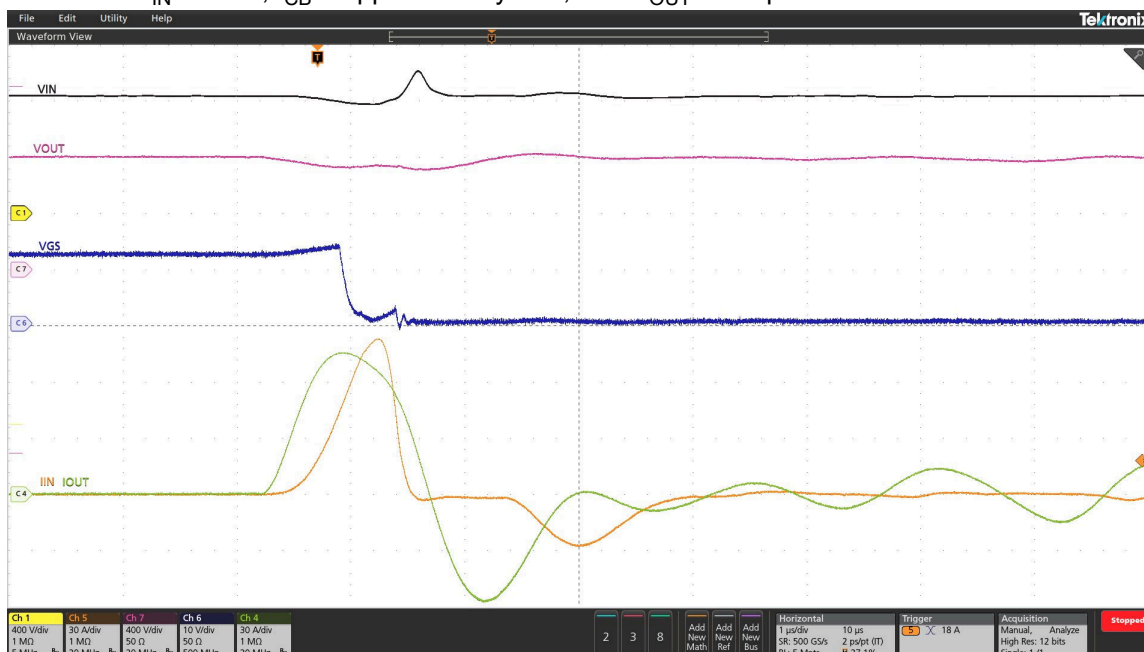
Description for [Figure 3-13](#): The current load is increased from 14A to 40A. A 40A current pulse falls between  $I_{CBL2}$  and  $I_{CB}$ . Therefore, no current blanking occurs, and the overcurrent event is activated directly.

#### Note

The current limit in steady-state is disabled by default, according to bit[7] in the `DEVICE_SETUP3` register (F0h, Read/Write Byte). Consequently, the analog fault timer ( $C_{TMR}$ ) does not run during an overcurrent event. This is expected behavior.

### 3.2.6 Output Hot Short

**Test Conditions:**  $V_{IN} = 840V$ ,  $I_{CB} =$  approximately 60A, and  $C_{OUT} = 100\mu F$



**Figure 3-14. Output Hot-Short Response in LM1800PSEVM**

Description for [Figure 3-14](#): Output hot-short event is created using TPSI3052-Q1 (an automotive reinforced isolated switch driver), a SiC combo JFET, and a 3.2Ω resistance (HSC3003R2J).

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**Note**

Make sure there is a sufficient input capacitor to eliminate voltage dips at the input. A combination of electrolytic and ceramic capacitors is preferred. With these capacitors, a large current can be provided for a short period of time during a short circuit.

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To obtain repeatable and similar short-circuit testing results is very difficult. The following contributes to the variation in results:

- Source bypassing
- Input leads
- Board layout
- Component selection
- Output shortening method
- Relative location of the short
- Instrumentation

The actual short exhibits a certain degree of randomness because the short microscopically bounces and arcs. Make sure that the configuration and methods are used to obtain realistic results. Hence, do not expect to see waveforms exactly like the waveforms in this user's guide because every setup is different.

## 4 Hardware Design Files

### 4.1 Schematic

The EVM schematic is shown in Figure 4-1.

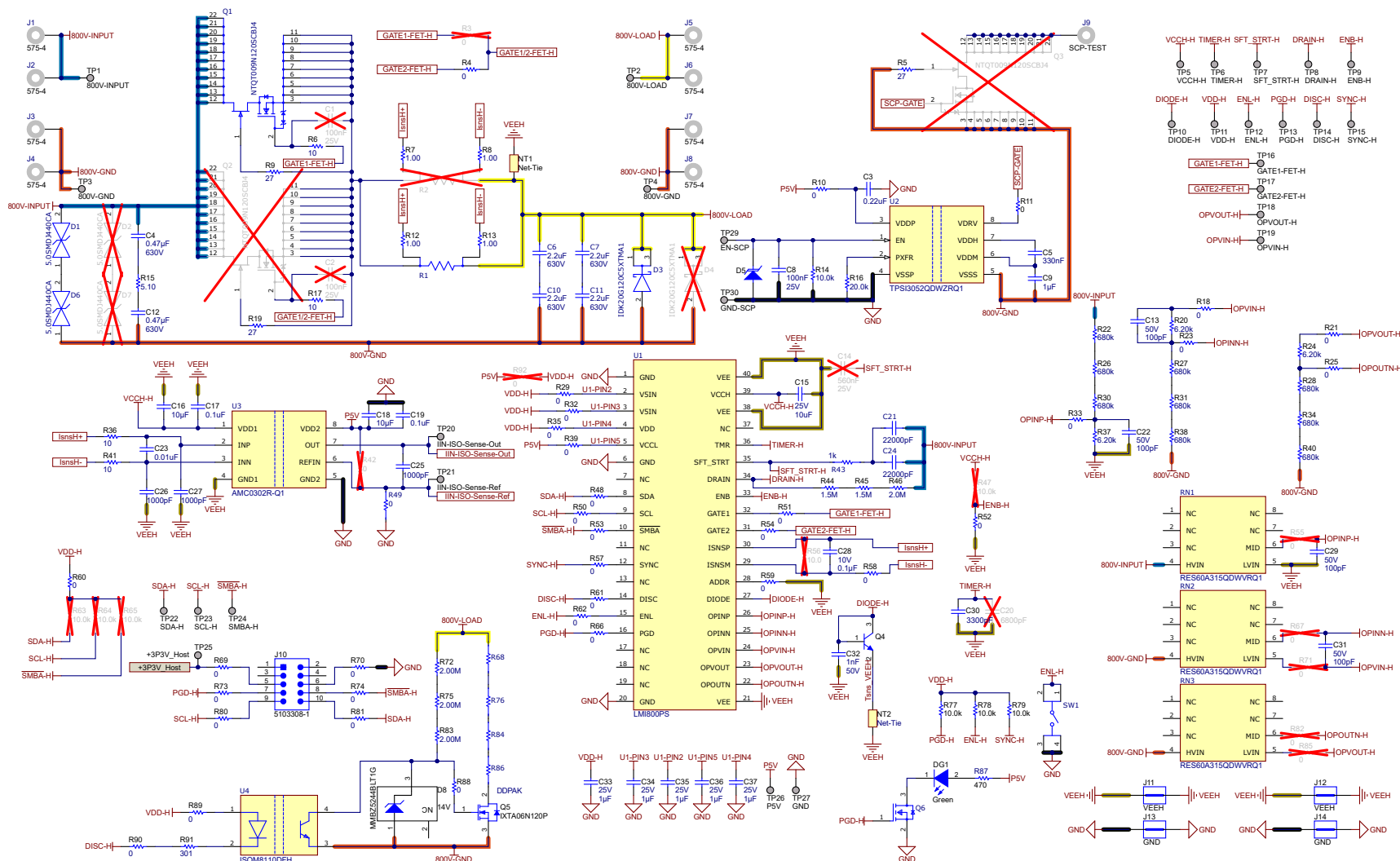
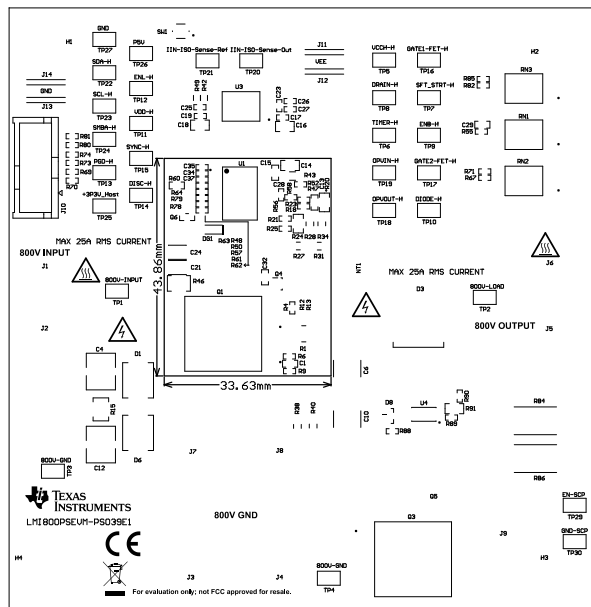


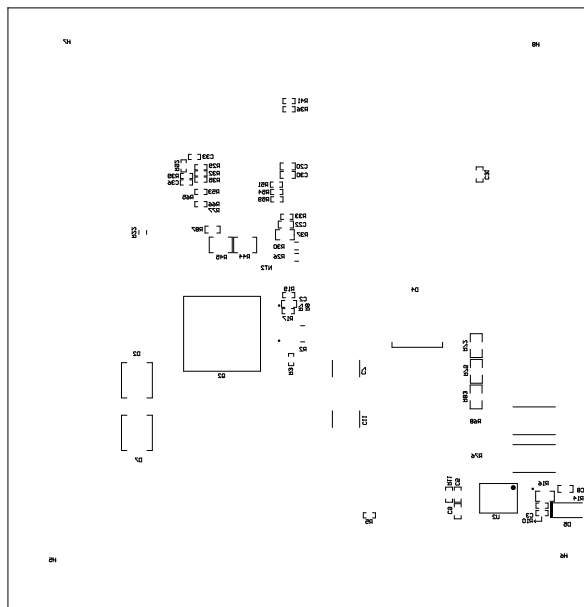
Figure 4-1. LMI800PSEVM Board Schematic

## 4.2 PCB Layouts

The component placements of the EVM are shown in [Figure 4-2](#) and [Figure 4-3](#). EVM layers are shown in [Figure 4-4](#) to [Figure 4-11](#).



**Figure 4-2. LMI800PSEVM Board: Top Overlay**



**Figure 4-3. LMI800PSEVM Board: Bottom Overlay**

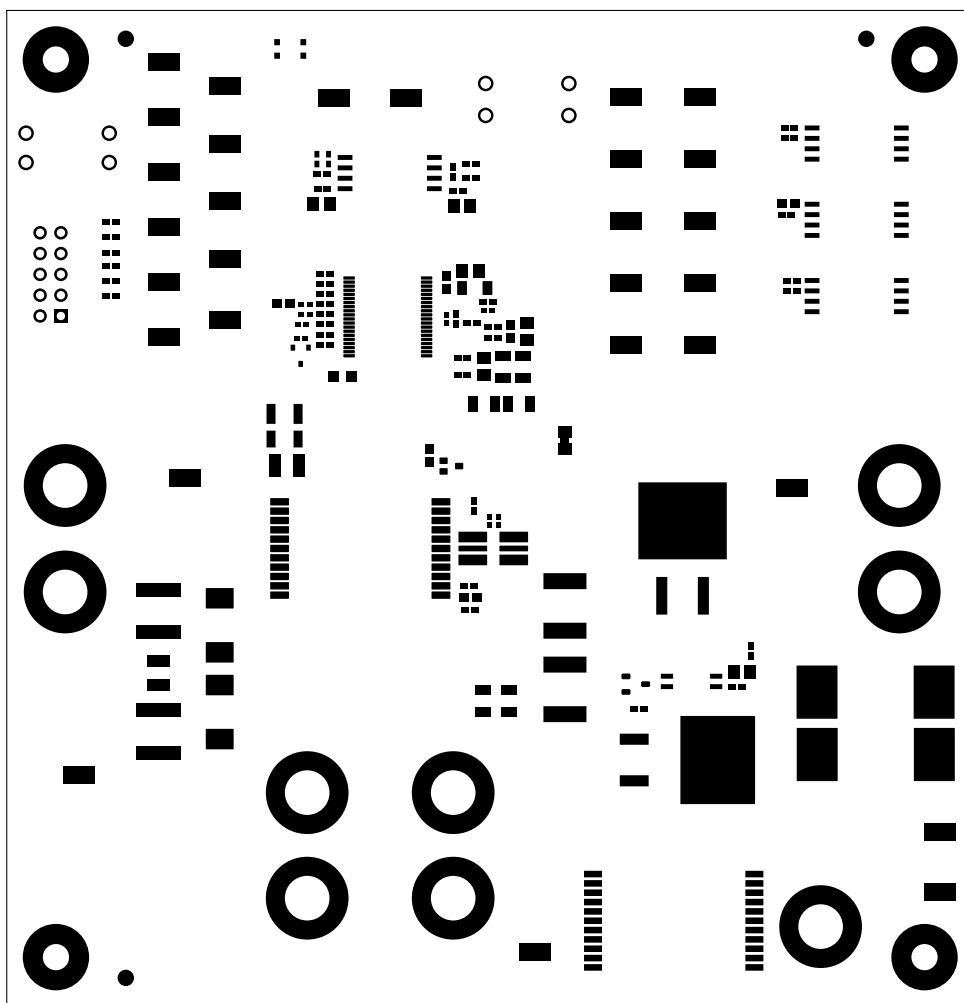


Figure 4-4. LMI800PSEVM Board: Top Solder

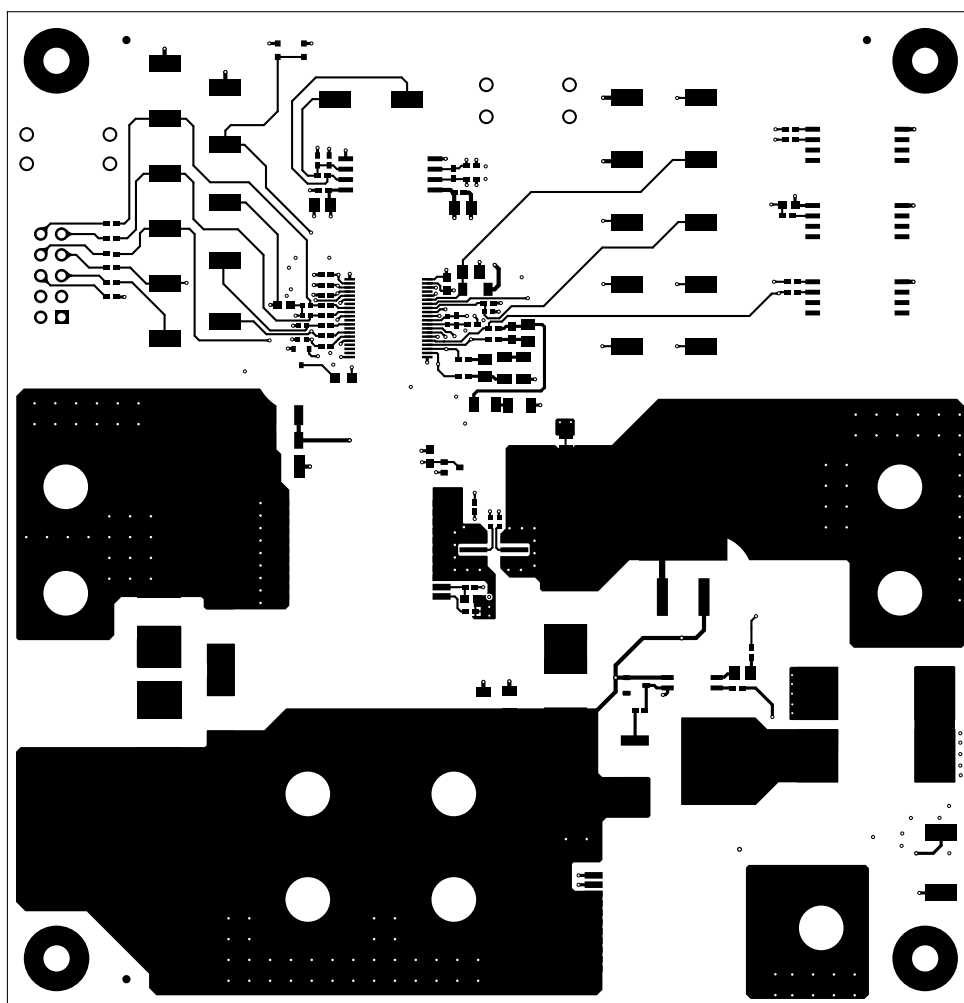
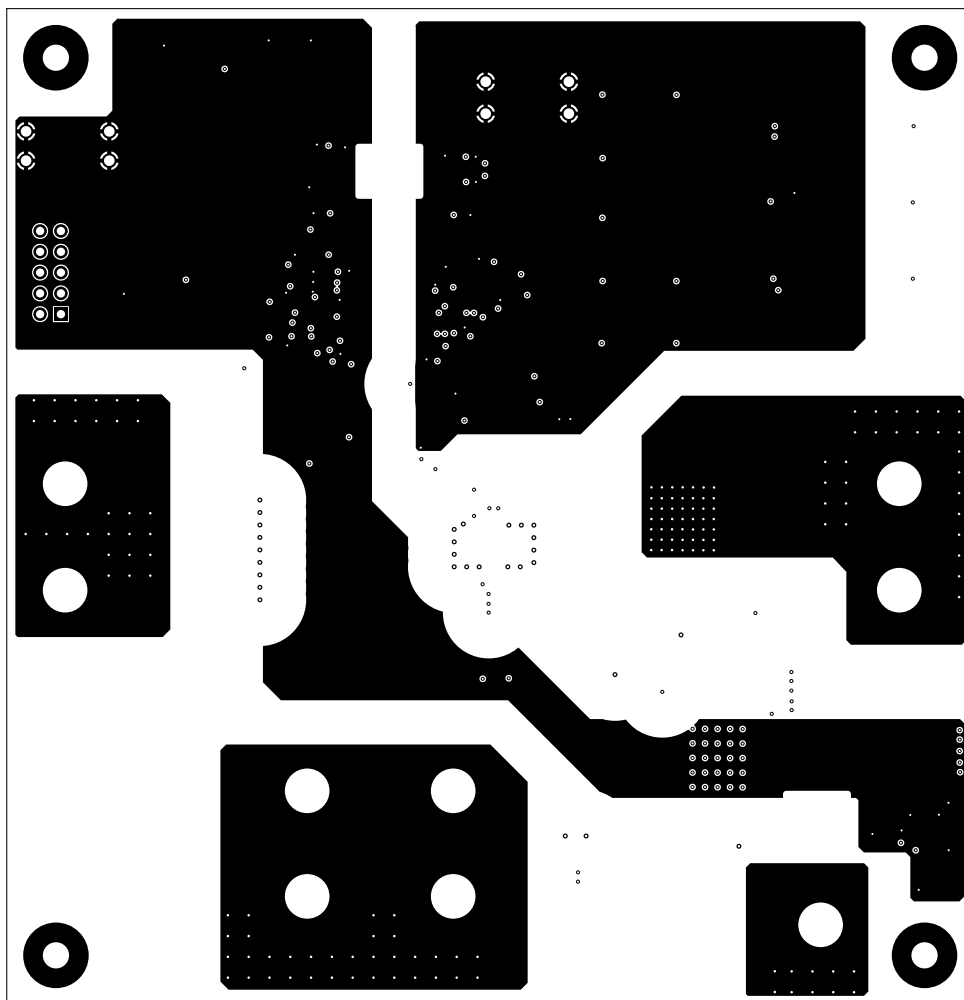
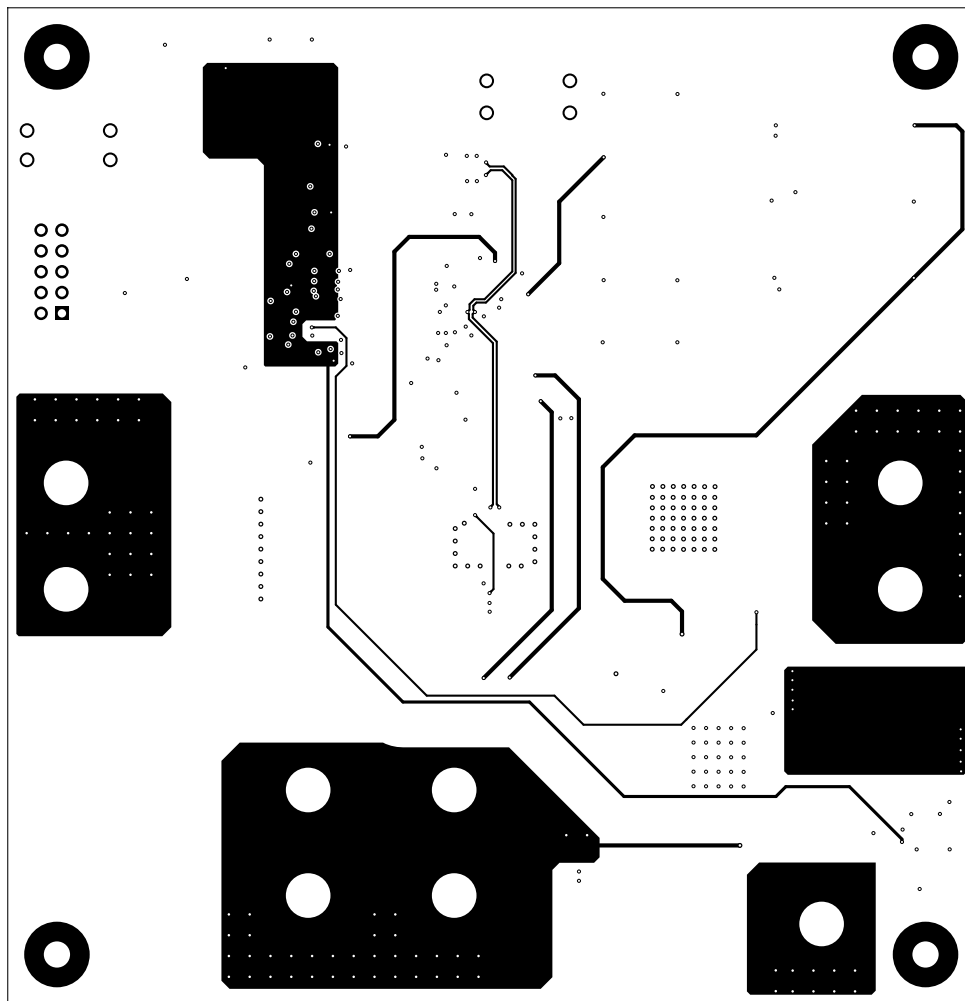


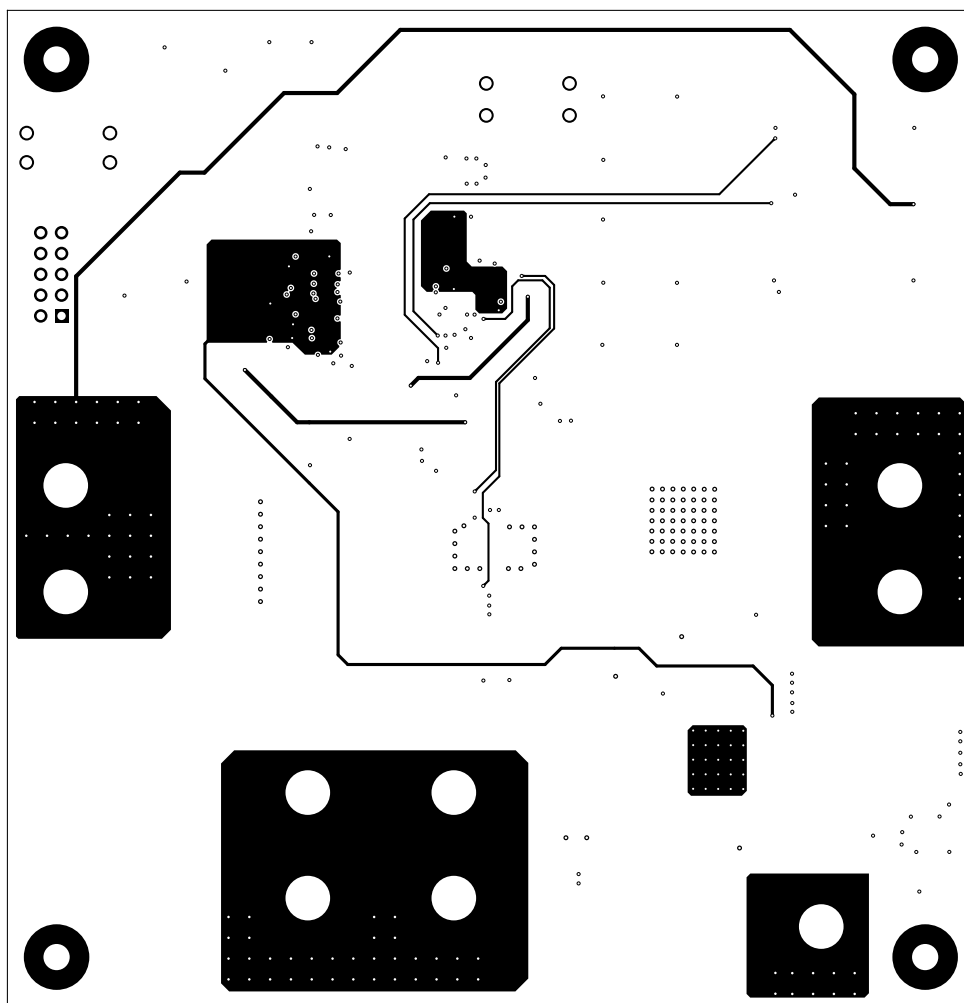
Figure 4-5. LMI800PSEVM Board: Top Layer



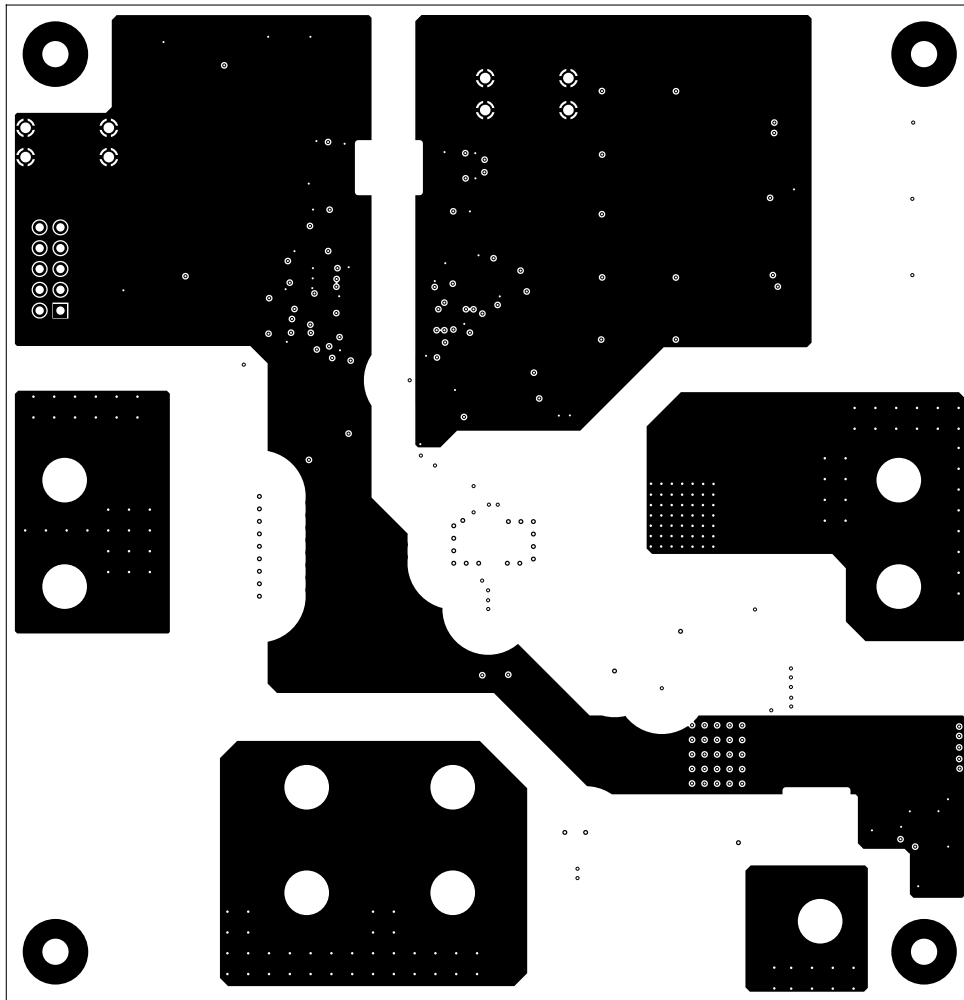
**Figure 4-6. LMI800PSEVM Board: Inner Layer - 1**



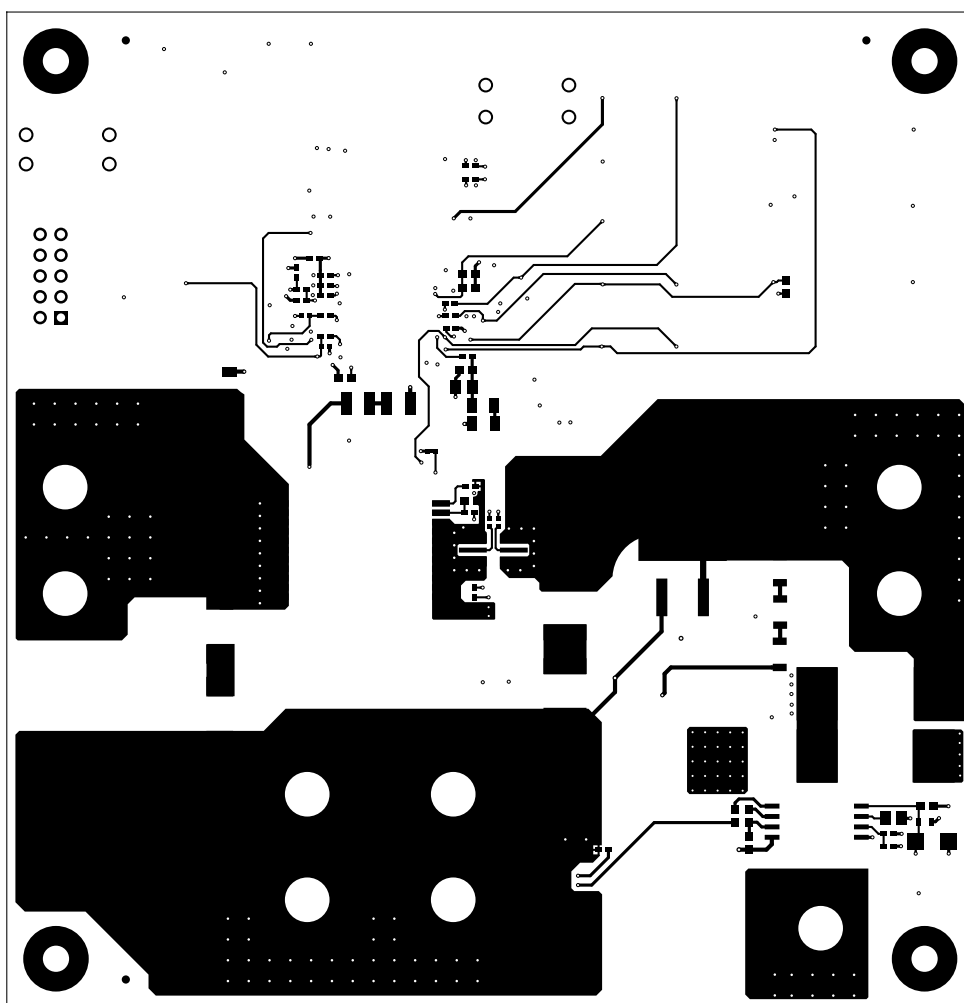
**Figure 4-7. LMI800PSEVM Board: Inner Layer - 2**



**Figure 4-8. LMI800PSEVM Board: Inner Layer - 3**



**Figure 4-9. LMI800PSEVM Board: Inner Layer - 4**



**Figure 4-10. LMI800PSEVM Board: Bottom Layer**

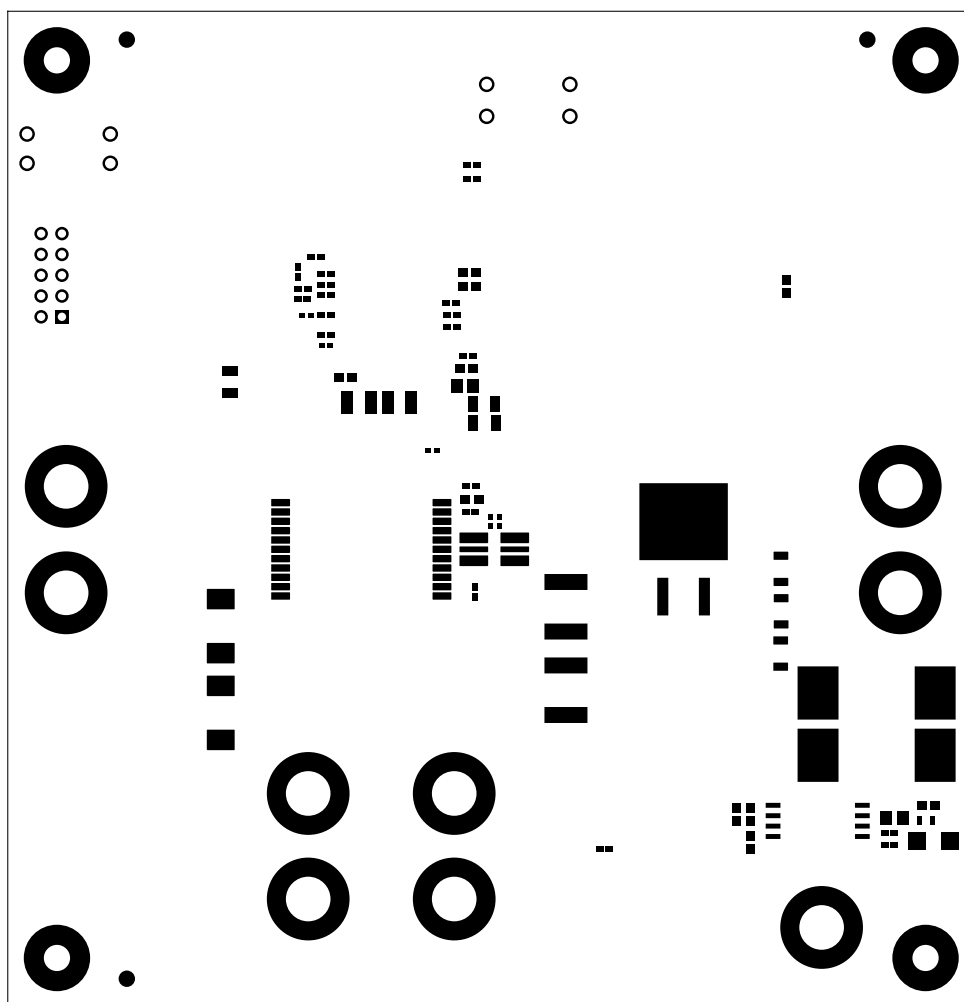


Figure 4-11. LMI800PSEVM Board: Bottom Solder

### 4.3 Bill of Materials (BOM)

Table 4-1 shows the EVM BOM.

**Table 4-1. LMI800PSEVM Bill of Materials**

| Designator         | Quantity | Value   | Description                                                                      | Footprint                   | Part Number         | Manufacturer                |
|--------------------|----------|---------|----------------------------------------------------------------------------------|-----------------------------|---------------------|-----------------------------|
| !PCB1              | 1        |         | Printed Circuit Board                                                            |                             | PS005               | Any                         |
| C1, C2, C3, C4, C9 | 5        | 1uF     | CAP, CERM, 1 uF, 100 V, +/- 10%, X7S, 0805                                       | 0805_HV                     | C2012X7S2A105K125AB | TDK                         |
| C10                | 1        | 0.1uF   | CAP, CERM, 0.1 uF, 16 V, +/- 10%, X7R, 0402                                      | 0402                        | GRM155R71C104KA88D  | MuRata                      |
| C11, C12           | 2        | 1000pF  | CAP, CERM, 1000 pF, 50 V, +/- 10%, X7R, 0402                                     | 0402L                       | C0402C102K5RACTU    | Kemet                       |
| C13                | 1        | 0.1uF   | CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, 0603                                     | 0603_HV                     | GRM188R72A104KA35J  | MuRata                      |
| C14, C19           | 2        |         | CAP, 1uF, 25V, 10%, X7R, 0603                                                    | 0603L                       | CL10B105KA8NNNC     | Samsung                     |
| C20                | 1        | 1000pF  | CAP, CERM, 1000 pF, 50 V, +/- 10%, X7R, 0603                                     | 0603                        | GRM188R71H102KA01D  | MuRata                      |
| C25                | 1        | 0.033uF | CAP, CERM, 0.033 uF, 100 V, +/- 10%, X7R, 0805                                   | 0805_HV                     | GRM21BR72A333KA01L  | MuRata                      |
| C26                | 1        | 0.068uF | CAP, CERM, 0.068 uF, 100 V, +/- 10%, X7R, 0805                                   | 0805_HV                     | C2012X7R2A683K085AA | TDK                         |
| C27                | 1        | 0.1uF   | CAP, CERM, 0.1 uF, 100 V, +/- 10%, X5R, 0805                                     | 0805_HV                     | C2012X5R2A104K125AA | TDK                         |
| C28                | 1        | 6800pF  | CAP, CERM, 6800 pF, 50 V, +/- 5%, C0G/NP0, 0603                                  | 0603                        | GRM1885C1H682JA01D  | MuRata                      |
| C29                | 1        | 0.01uF  | CAP, CERM, 0.01 F, 50 V, +/- 10%, X7R, 0603                                      | 0603                        | 885012206089        | Wurth Elektronik            |
| C30                | 1        | 0.02uF  | CAP, CERM, 0.02 F, 50 V, +/- 10%, X7R, 0603                                      | 0603                        | CC0603KRX7R9BB203   | Yageo                       |
| D1, D2             | 2        |         | TVS Diode, 8.0SMDJ Series, Unidirectional, 60 V, 125.1 V, DO-214AB (SMC), 2 Pins | FP-8.0SMDJ60A_DO-214 AB-MFG | 8.0SMDJ60A          | Littelfuse                  |
| D3, D4             | 2        | 100V    | Diode, Schottky, 100 V, 20 A, AEC-Q101, TO-277A                                  | TO-277A                     | FSV20100V           | Fairchild Semiconductor     |
| H1, H2, H5, H6     | 4        |         | Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead                        | NY PMS 440 0025 PH          | NY PMS 440 0025 PH  | B&F Fastener Supply         |
| H3, H4, H7, H8     | 4        |         | Standoff, Hex, 0.5"L #4-40 Nylon                                                 | Keystone_1902C              | 1902E               | Keystone                    |
| J1,J2, J3          | 3        |         | Terminal Connector Rectangular Lug, Grounding 4-14 AWG 1/4 Stud                  | FP-ML4-CY_TERMINAL_LUG-MFG  | ML4-CY              | Panduit                     |
| J7                 | 1        |         | Header (shrouded), 100mil, 5x2, Gold, TH                                         | CONN_5103308-1              | 5103308-1           | TE Connectivity             |
| J8, J9, J10        | 3        |         | Header, 100mil, 3x2, Tin, TH                                                     | SULLINS_PEC03DAAN           | PEC03DAAN           | Sullins Connector Solutions |

**Table 4-1. LMI800PSEVM Bill of Materials (continued)**

| Designator                               | Quantity | Value   | Description                                                                                                | Footprint                       | Part Number                      | Manufacturer               |
|------------------------------------------|----------|---------|------------------------------------------------------------------------------------------------------------|---------------------------------|----------------------------------|----------------------------|
| Q1, Q2, Q3, Q4                           | 4        |         | MOSFET N-Channel 100 V 255A (Ta) 341W (Ta) Surface-mount LPAK88 (SOT1235)                                  | FP-PSMN2R3-100SSEJ_LFP AK88-MFG | PSMN2R3-100SSEJ                  | Nexperia                   |
| Q5                                       | 1        | 40 V    | Transistor, NPN, 40 V, 0.2 A, SOT-323                                                                      | SOT-323                         | MMBT3904WT1G                     | ON Semiconductor           |
| R1, R2                                   | 2        | 500     | Res Metal Strip 3920 0.0005 Ohm 1% 9W 100ppm/C Pad SMD Automotive T/R                                      | FP-CSS2H-3920R-L500F_3920-MFG   | CSS2H-3920R-L500F                | Bourns                     |
| R3, R4, R6, R10, R36, R37, R47, R48, R49 | 9        | 1.00    | RES, 1.00, 1%, 0.063 W, AEC-Q200 Grade 0, 0402                                                             | 0402L                           | CRCW04021R00FKED                 | Vishay-Dale                |
| R5                                       | 1        | 150k    | RES, 150 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603                                                              | 0603_HV                         | CRCW0603150KFKEA                 | Vishay-Dale                |
| R7                                       | 1        | 0       | RES SMD 0 OHM JUMPER 1/8W 0805                                                                             | 0805_HV                         | CRCW08050000Z0EA                 | Vishay Dale                |
| R8, R19, R20, R21                        | 4        | 10.0k   | RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402                                                           | 0402L                           | CRCW040210K0FKED                 | Vishay-Dale                |
| R9, R13                                  | 2        | 10.0, 0 | RES, 10.0, 1%, 0.063 W, AEC-Q200 Grade 0, 0402, RES, 0, 5%, 0.063 W, 0402                                  | 0402L                           | CRCW040210R0FKED, RC0402JR-070RL | Vishay-Dale, Yageo America |
| R11                                      | 1        | 95.3k   | RES, 95.3 k, 1%, 0.1 W, 0603                                                                               | 0603_HV                         | RC0603FR-0795K3L                 | Yageo                      |
| R12                                      | 1        | 178k    | RES, 178 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603                                                              | 0603_HV                         | CRCW0603178KFKEA                 | Vishay-Dale                |
| R14                                      | 1        | 3.74k   | RES, 3.74 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402                                                           | 0402L                           | CRCW04023K74FKED                 | Vishay-Dale                |
| R15                                      | 1        | 12.7k   | RES, 12.7 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402                                                           | 0402L                           | CRCW040212K7FKED                 | Vishay-Dale                |
| R16                                      | 1        | 100k    | RES, 100 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402                                                            | 0402L                           | CRCW0402100KFKEA                 | Vishay-Dale                |
| R17                                      | 1        | 0       | RES, 0, 0%, 0.25 W, AEC-Q200 Grade 0, 0603                                                                 | 0603                            | RCS06030000Z0EA                  | Vishay-Dale                |
| R22, R24, R31, R38, R40, R42             | 6        | 0       | RES, 0, 5%, 0.063 W, 0402                                                                                  | 0402L                           | RC0402JR-070RL                   | Yageo America              |
| R25, R26, R28, R29, R30, R32, R33, R34   | 8        | 0       | RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402                                                                | 0402                            | CRCW04020000Z0ED                 | Vishay-Dale                |
| R35                                      | 1        | 10      | 10 Ohms 1% 0.25W, 1/4W Chip Resistor 0603 (1608 Metric) Automotive AEC-Q200, Pulse Withstanding Thick-film | FP-RCS060310R0FKEA_0603-MFG     | RCS060310R0FKEA                  | Vishay                     |
| R44                                      | 1        |         | 0 Ohms Jumper 0.125W, 1/8W Chip Resistor 0805 (2012 Metric) Automotive AEC-Q200 Thick-film                 | FP-RMCF0805ZT0R00_0805-MFG      | RMCF0805ZT0R00                   | Stackpole Electronics      |
| R50                                      | 1        | 6.81k   | RES, 6.81 k, 0.1%, 0.1 W, 0603                                                                             | 0603                            | RT0603BRD076K81L                 | Yageo America              |
| R51                                      | 1        | 9.09k   | RES, 9.09 k, 0.1%, 0.1 W, 0603                                                                             | 0603                            | RT0603BRD079K09L                 | Yageo America              |
| R52                                      | 1        | 11.4k   | RES, 11.4 k, 0.1%, 0.1 W, 0603                                                                             | 0603                            | RT0603BRD0711K4L                 | Yageo America              |

**Table 4-1. LMI800PSEVM Bill of Materials (continued)**

| Designator    | Quantity | Value | Description                                        | Footprint         | Part Number      | Manufacturer      |
|---------------|----------|-------|----------------------------------------------------|-------------------|------------------|-------------------|
| R53           | 1        | 3.36k | RES, 3.36 k, 0.1%, 0.1 W, 0603                     | 0603              | RT0603BRD073K36L | Yageo America     |
| R54           | 1        | 6.65k | RES, 6.65 k, 0.1%, 0.1 W, 0603                     | 0603              | RT0603BRD076K65L | Yageo America     |
| R55           | 1        | 16.7k | RES, 16.7 k, 0.1%, 0.1 W, 0603                     | 0603              | RT0603BRD0716K7L | Yageo America     |
| SH1, SH2, SH3 | 3        |       | Shunt, 2.54mm, Gold, Blue                          | Wurth_60900213621 | 60900213621      | Wurth Elektronik  |
| TP1           | 1        |       | Test Point, Multipurpose, Green, TH                | Keystone5126      | 5126             | Keystone          |
| TP2           | 1        |       | Test Point, Multipurpose, Green, TH                | Keystone5126      | 5126             | Keystone          |
| TP3           | 1        |       | Test Point, Multipurpose, Green, TH                | Keystone5126      | 5126             | Keystone          |
| TP4           | 1        |       | Test Point, Multipurpose, Green, TH                | Keystone5126      | 5126             | Keystone          |
| TP5           | 1        |       | Test Point, Multipurpose, Green, TH                | Keystone5126      | 5126             | Keystone          |
| TP8           | 1        |       | Test Point, Multipurpose, Green, TH                | Keystone5126      | 5126             | Keystone          |
| TP11          | 1        |       | 1mm Uninsulated Shorting Plug, 10.16mm spacing, TH | Harwin_D3082-05   | D3082-05         | Harwin            |
| TP14          | 1        |       | Test Point, Multipurpose, Green, TH                | Keystone5126      | 5126             | Keystone          |
| TP17, TP18    | 2        |       | Test Point, Multipurpose, Black, TH                | Keystone5011      | 5011             | Keystone          |
| U1            | 1        |       | LMI800PSPWPR                                       | PWP0028V-MFG      | LMI800PSPWPR     | Texas Instruments |

## **5 Additional Information**

### **5.1 Trademarks**

All trademarks are the property of their respective owners.

## 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 with 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 DEGRADATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

### 3 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 instructions, 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 détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

#### 3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see [http://www.tij.co.jp/sds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/sds/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。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

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 (which for 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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

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3. 技術基準適合証明を取得後ご使用いただく。

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上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社  
東京都新宿区西新宿 6 丁目 2 4 番 1 号  
西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see [http://www.tij.co.jp/sds/ti\\_ja/general/eStore/notice\\_02.page](http://www.tij.co.jp/sds/ti_ja/general/eStore/notice_02.page)

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#### 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.

#### 4 *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:*

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