User's Guide

LM74800 Evaluation Module: LM74800EVM-CD

ABSTRACT

This user's guide describes the LM74800EVM-CD Evaluation Module for evaluating the performance of Ideal Diode Controller with Switched Output LM74800-Q1 and LM74801-Q1. The LM7480x-Q1 ideal diode controller drives and controls external back to back N-Channel MOSFETs to emulate an ideal diode rectifier with power path ON/OFF control and over voltage protection.

Table of Contents

Trademarks

1 Introduction

TI's LM74800 Evaluation Module LM74800EVM-CD helps designers evaluate the operation and performance of the LM74800-Q1 ideal diode controller with switched output. This evaluation module demonstrates how LM74800-Q1 controls two N-channel power MOSFETs with ideal diode MOSFET connected first followed by second MOSFET for switched output and power path cut-off. LM74800-Q1 is a dual gate drive Ideal diode controller where the first gate drive DGATE controls an external N-channel MOSFET to emulate an ideal diode and the second gate drive HGATE controls another external N-Channel MOSFET to cutoff the power path when disabled or during an over voltage condition. Second MOSFET is can also be used to clamp the output during over voltage or load dump conditions.

Note

For Class A performance during input micro-short test LV124 E-10, it is recommended to connect EN/UVLO, J5 pin 2 to J10 pin 1 or an external control using J5 pin 2.

1.1 Features

Key features of the EVM include

- 12-V and 24-V automotive reverse battery protection
- Input operating range 3 V to 40 V, extendable to 65 V
- 12-V battery protection 3 V to 40 V
- 24-V battery protection 3 V to 65 V
- 5-A maximum load current with option for 10-A operation
- Switched output for power path cutoff or clamp
- Enable ON/OFF control
- Programmable over voltage cutoff and output clamp operation
- Output voltage slew rate control

- LED Indication for Output ON/OFF detection
- On board TVS protection for automotive transient immunity

1.2 Applications

- Automotive reverse battery protection
- ADAS Domain Controller
- Camera ECU
- Head Unit
- USB HUBs
- Power path protection, Power Mux and ORing

2 Description

The LM74800EVM-CD is configured by default for evaluating 12-V automotive reverse battery protection with switched output to disconnect power path or clamp the output. On board options are provided for evaluating 24-V battery protection.

2.1 Input Power and Load (J1/J3 and J2/J4):

Input power is applied at the terminals J1 and J3. Terminals J2 and J4 provide output connection to load.

2.2 Enable Control (J5):

Enable control is usually used by external MCU or controller to turn off LM7480x-Q1 and cut off the power path. External input is recommended to be connected to jumper J5 pin 2. Otherwise setting 1-2 on J5 enables the controller and 2-3 disables the controller. It is recommended to connect EN to external MCU or to test point labeled "VOUT_ALWAYS_ON" for uninterrupted performance during negative transient tests.

2.3 Over Voltage Protection (J6):

Over voltage protection is configured through jumper J6. Setting 2-3 on J6 configures OVP protection to the input side. OVP rising threshold is set to 37.5 V with 2-3 setting on J6 and falling is set to 34.5 V. Setting 1-2 on J6 configures OV clamp operation. This provides output voltage to clamp (hysteretic ON/OFF output).

2.4 Input Voltage Monitor (J8 and VIN_MON):

Input Voltage monitor setting is done through test point labeled VIN_MON and J8 allows monitoring input voltage under different conditions. Setting J8 to 1-2 provides option to monitor battery voltage; this allows monitoring input voltage during normal and reversed battery conditions as well. Setting J8 to 2-3 allows monitoring only during the normal positive battery conditions only.

2.5 Two back-back connected MOSFETs (Q1/Q3 and Q2/Q4):

Q1 is a 60-V rated Dual N-Channel MOSFETs capable to support 5-A automotive ECU applications. Since is a Dual Channel back to back connected N-Channel MOSFET, it can support reverse battery protection, reverse-current blocking and can provides power path cut-off when disabled or during over voltage conditions. Options Q3 and Q4 are provided for extending current to 10 A and can be used to validate other MOSFETs.

2.6 Output slew rate control (R2 and C2):

R2 and C2 provide output slew rate control and can be changed to achieve different output slew rate.

2.7 Output Schottky Diode (D2) and LED indication:

Schottky Diode D2 is not populated on EVM by default and it is recommended where output voltage can have negative transients that can exceed absolute maximum ratings of LM7480x-Q1.

D5 provides an indication on the status of the output voltage.

2.8 TVS selection for 12-V battery protection:

TVS D1 SMBJ33CA is a bidirectional 600W TVS that protects the LM74800-Q1 and MOSFETs from automotive ISO transients tests on a 12-V battery. For detailed information on TVS selection, refer to the datasheet of LM74800-Q1.

2.9 TVS selection for 24-V battery protection:

For 24-V battery protection application, D1 needs to be removed and D3 along with D4 need to be mounted. Further 80-V rated MOSFETs are recommended for 24-V battery protection applications. For detailed information on TVS selection, refer to the datasheet of LM74800-Q1.

2.10 Test Points:

Test point labeled DGATE is used for monitoring gate voltage of Q1A and HGATE is used for gate voltage of Q1B. Test Point labelled VIN measures input voltage, VOUT measure output voltage. Test Point labelled VOUT_ALWAYS_ON measures the drain voltage of Q1 MOSFET. Test Points GND1, GND3 and GND4 provides access to the input GND voltage and GND2 provides access to the LM74800-Q1 GND pin.

Table 2-1. Connectors: Input and Output

Connector	Description
J1	Power input connector to the positive rail of the input power supply
J3	Ground connection for the power supply
J2	Power output connector to the positive side of the load
J4	Ground connection for the load

Table 2-2. Test Points Description

Test Points	Description
VIN	Input power supply to the EVM
VOUT	Output from the EVM
VOUT_ALWAYS_ON	Output voltage after the Ideal Diode MOSFET for connecting always ON loads
VIN_MON	Input monitoring for battery inputs
DGATE	Output of Ideal Diode MOSFET Gate Control
HGATE	Output of Hot-Swap MOSFET Gate Control
GND1, GND 2, GND3 and GND4	Test Point for EVM Ground

Table 2-3. Jumpers and LED Description

Jumpers	Description
J5	EN/UVLO Control • 1-2 Enables by connecting to VIN • 2-3 Disables by connecting to GND
J6	OVP Setting • 1-2 OVP set to Output Clamp (hysteretic) at 37.5 V • 2-3 OVP set to Input OVP Cutoff at 37.5 V
J7	Enables LED indication for output
J8	Input Voltage Sense • 1-2 Input Voltage Sense after Ideal Diode MOSFET • 2-3 Input Voltage Sense directly on input supply

3 Schematic

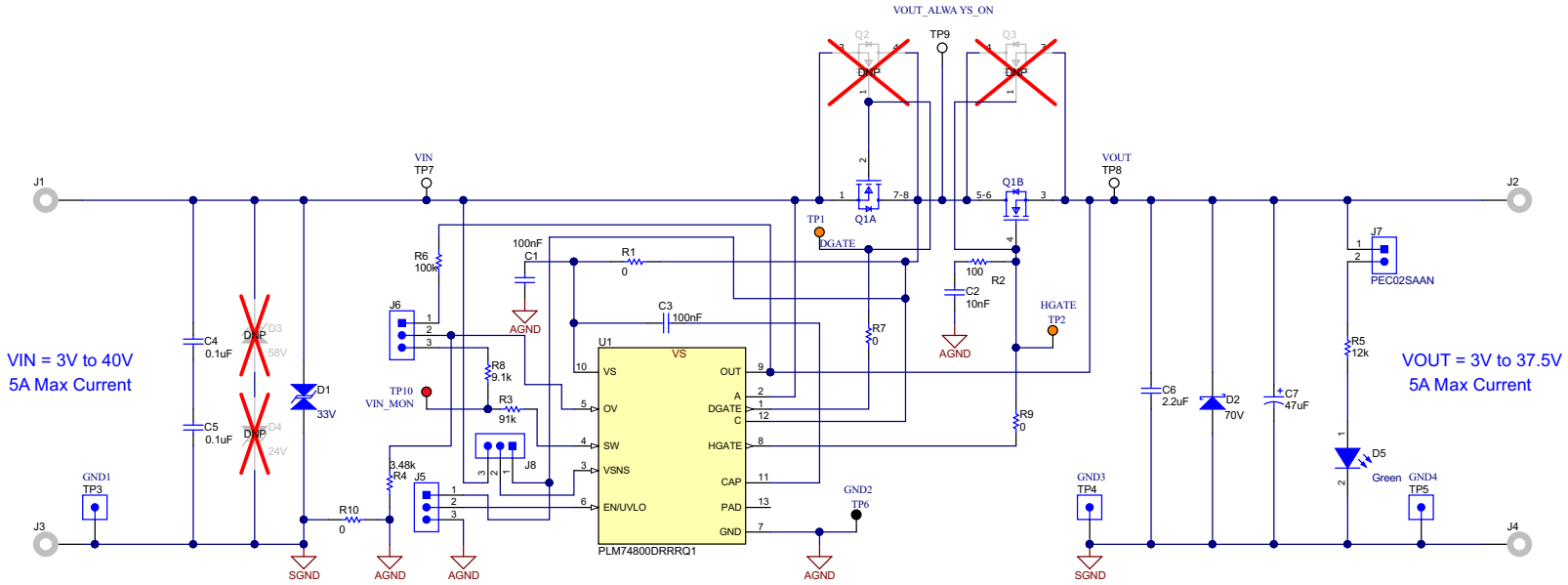

Figure 3-1. LM74800EVM-CD Schematic

4 Test Equipment Requirements

4.1 Power Supplies

One adjustable power supply 0-V to 40-V output, 0-A to 10-A output current limit.

4.2 Meters

One Digital Multi Meter minimum needed.

4.3 Oscilloscope

A DPO2024 or equivalent, three 10x voltage probes, and a DC current probe capable of measuring 10 A.

4.4 Loads

One resistive load or equivalent which can tolerate up to 10-A DC load at 12 V.

5 Test Setup and Results

This sections describes the test procedure for LM74800-Q1 device. Similar procedure applies for LM74801-Q1 device also.

Default jumper setting for LM74800EVM-CD board is shown in Figure 5-1.

Table 5-1. Default Jumper Setting for LM74800EVM-CD

J5	J6	J7	J8
1-2 or connect 2 to external enable control	2-3, OVP to Input	1-2, Output LED Indication	2-3, Input Voltage Sense

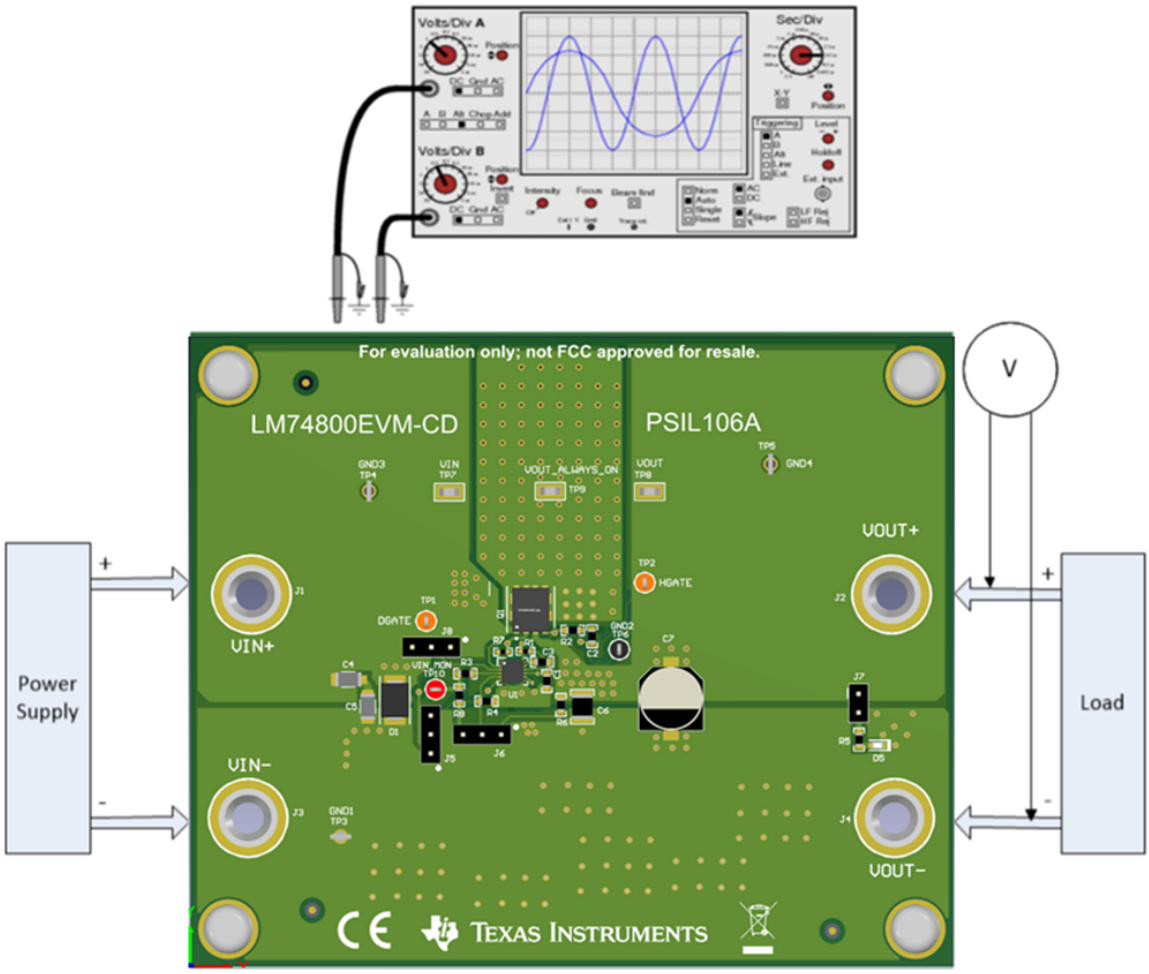

Figure 5-1. LM74800EVM-CD Test Setup

5.1 Initial Setup

Test setup used for evaluating LM74800EVM-CD is shown in Figure 5-1. Steps to be followed before testing the evaluation module are:

- Connect the power supply and load to LM74800EVM-CD.
- Set the power supply output to 12 V and current limit to 5 A.
- Set load to 200 mA or a load value less than 5 A.
- Set the jumpers to default jumper setting as shown in Table 5-1.

5.2 Power up

To verify the startup behavior, connect the oscilloscope to the evaluation module:

- Channel 1 - Input Voltage (Test Point Label VIN)
- Channel 2 - Output Voltage (Test Point Label VOUT)
- Channel 3 - DGATE Voltage (Test Point Label DGATE)
- Channel 4 - HGATE Voltage (Test Point Label HGATE)

Set the load to 200 mA, trigger to Channel 1 rising and turn ON the power supply. Startup behavior of LM74800EVM-CD is captured in Figure 5-2.

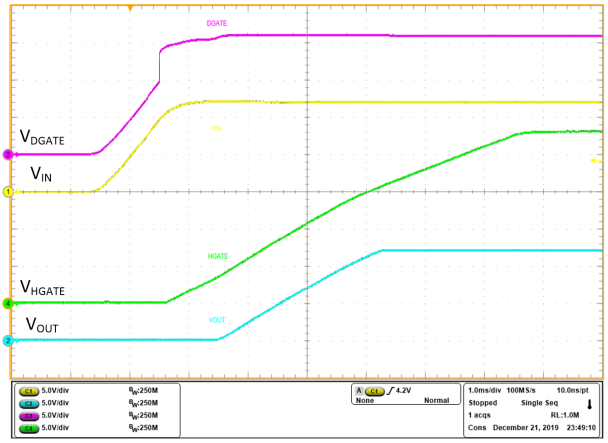

Figure 5-2. Power Up: DGATE and HGATE

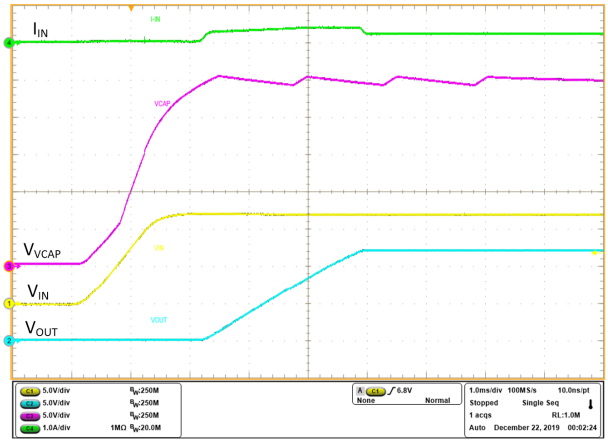

Figure 5-3. Power Up: Charge Pump and Inrush Current

Additional startup information is captured in Figure 5-3. Channel 3 captures the charge pump voltage on VCAP pin during startup. Charge pump turns on when POR threshold on VIN is reached and builds up to 13.5 V above VIN.

5.3 Over Voltage Protection

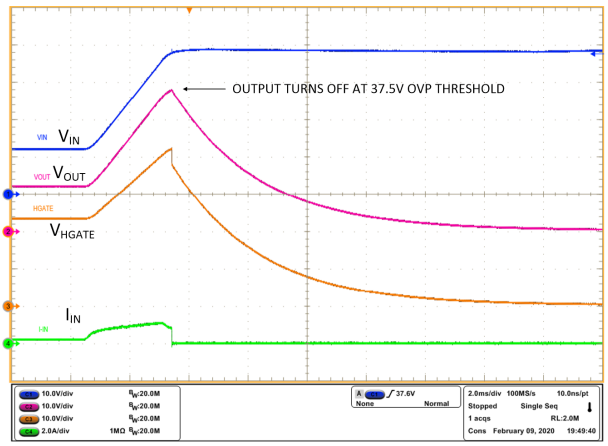

Figure 5-4. Over Voltage Protection

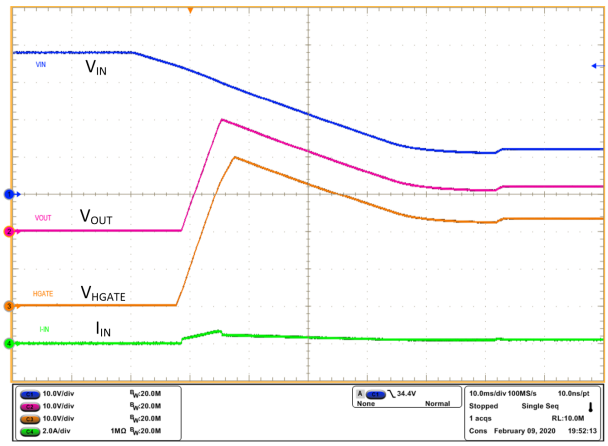

Figure 5-5. Over Voltage Recovery

5.4 Enable Control

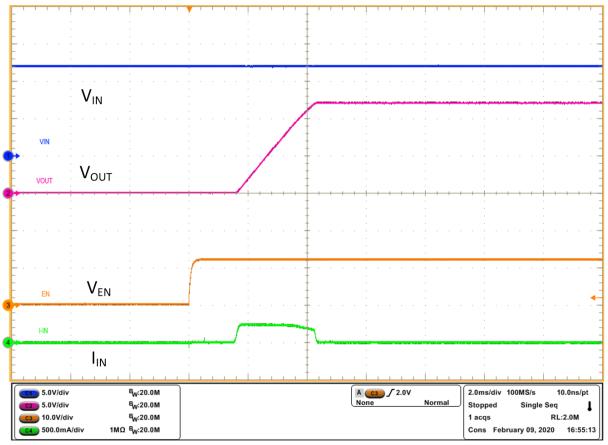

Figure 5-6. Turn ON using EN - Inrush Current

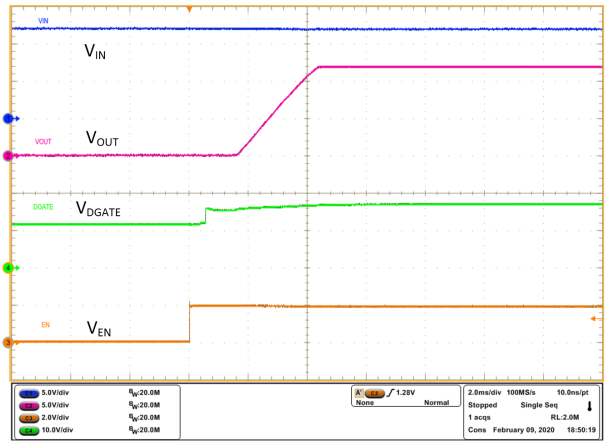

Figure 5-7. Turn ON using EN - DGATE

5.5 Hot-plug and Disable using EN

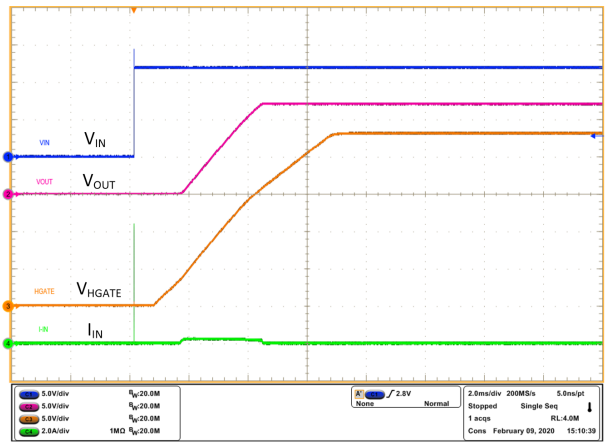

Figure 5-8. Hot-plug 12 V

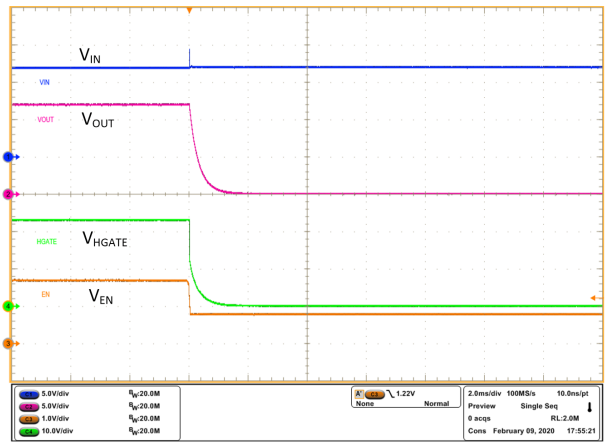

Figure 5-9. Disable using EN

5.6 Inrush Current Control

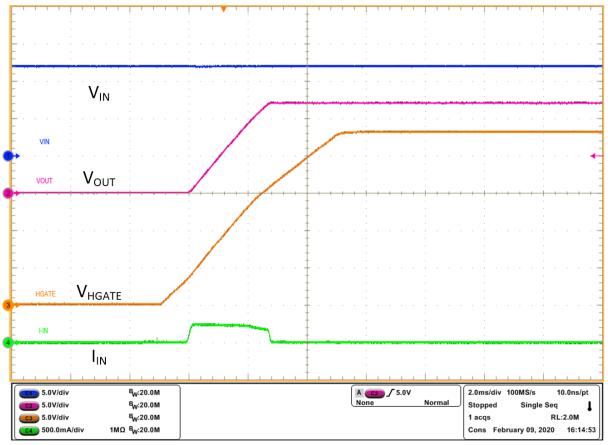

Figure 5-10. Inrush current with No Load

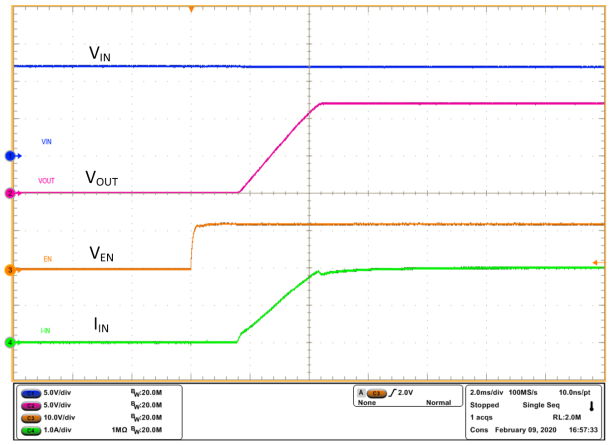

Figure 5-11. Inrush current with 6-Ω Load

5.7 Load Response

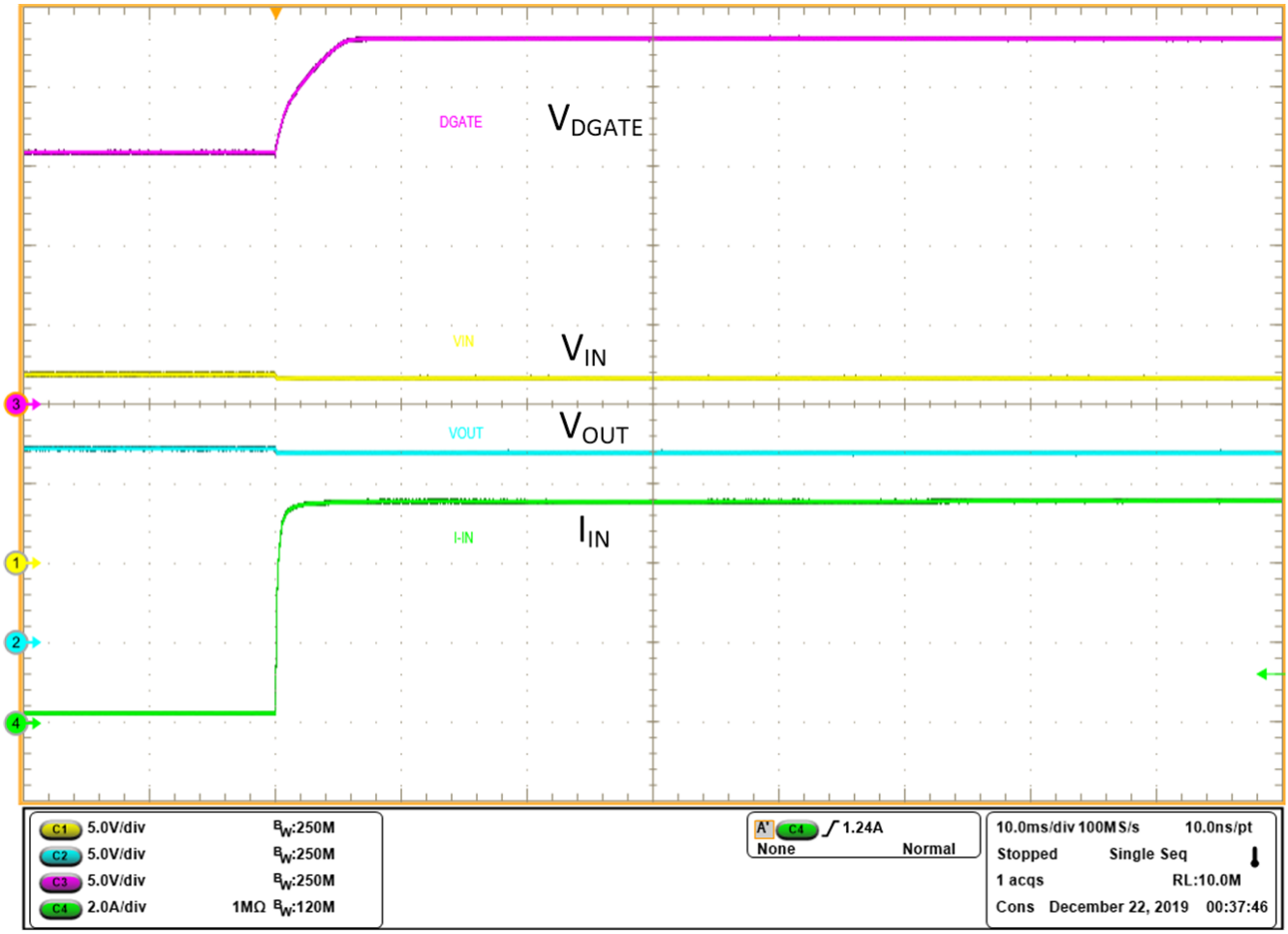

Figure 5-12. Load Transient Response 100 mA to 5 A

6 Board Layout and Bill of Materials

6.1 Board Layout

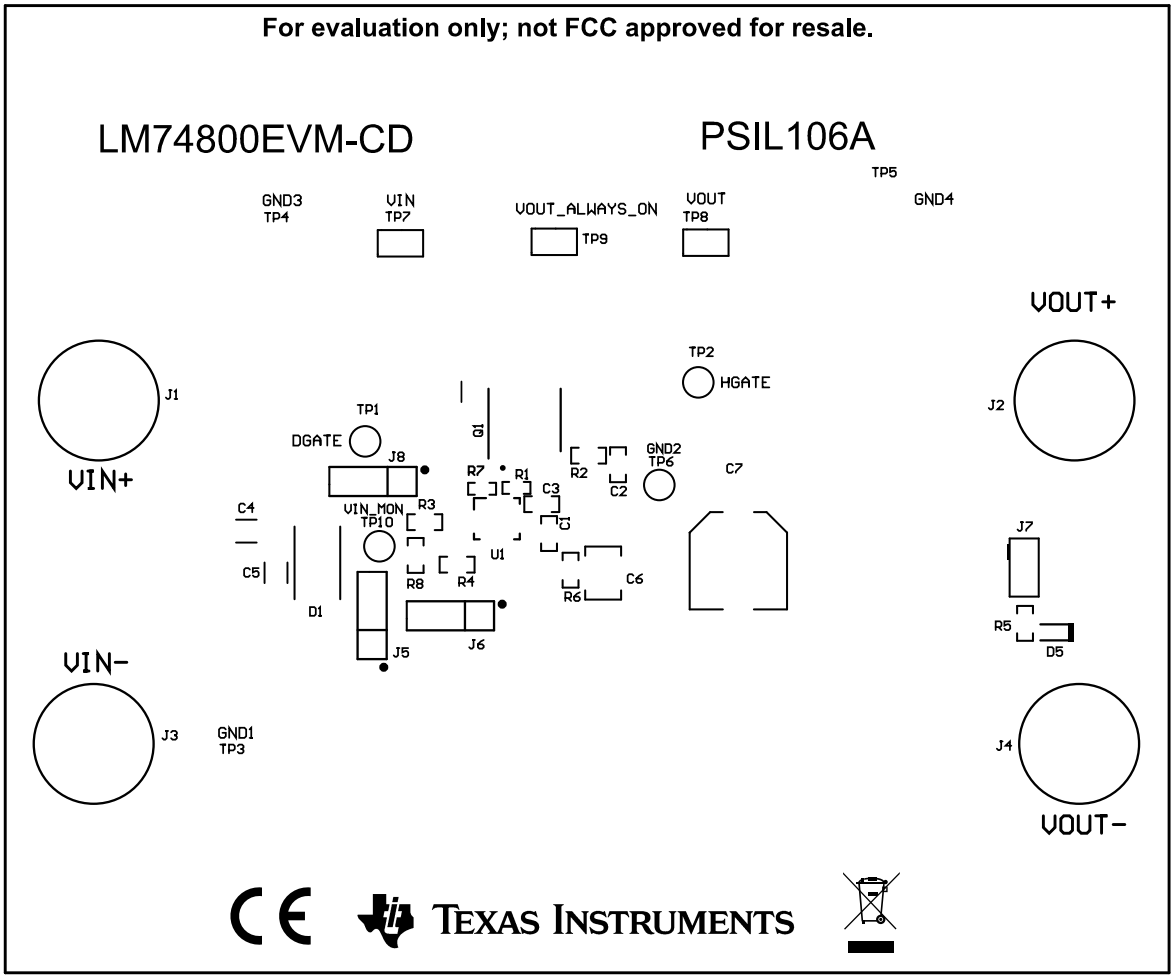

Figure 6-1. Component Placement TOP

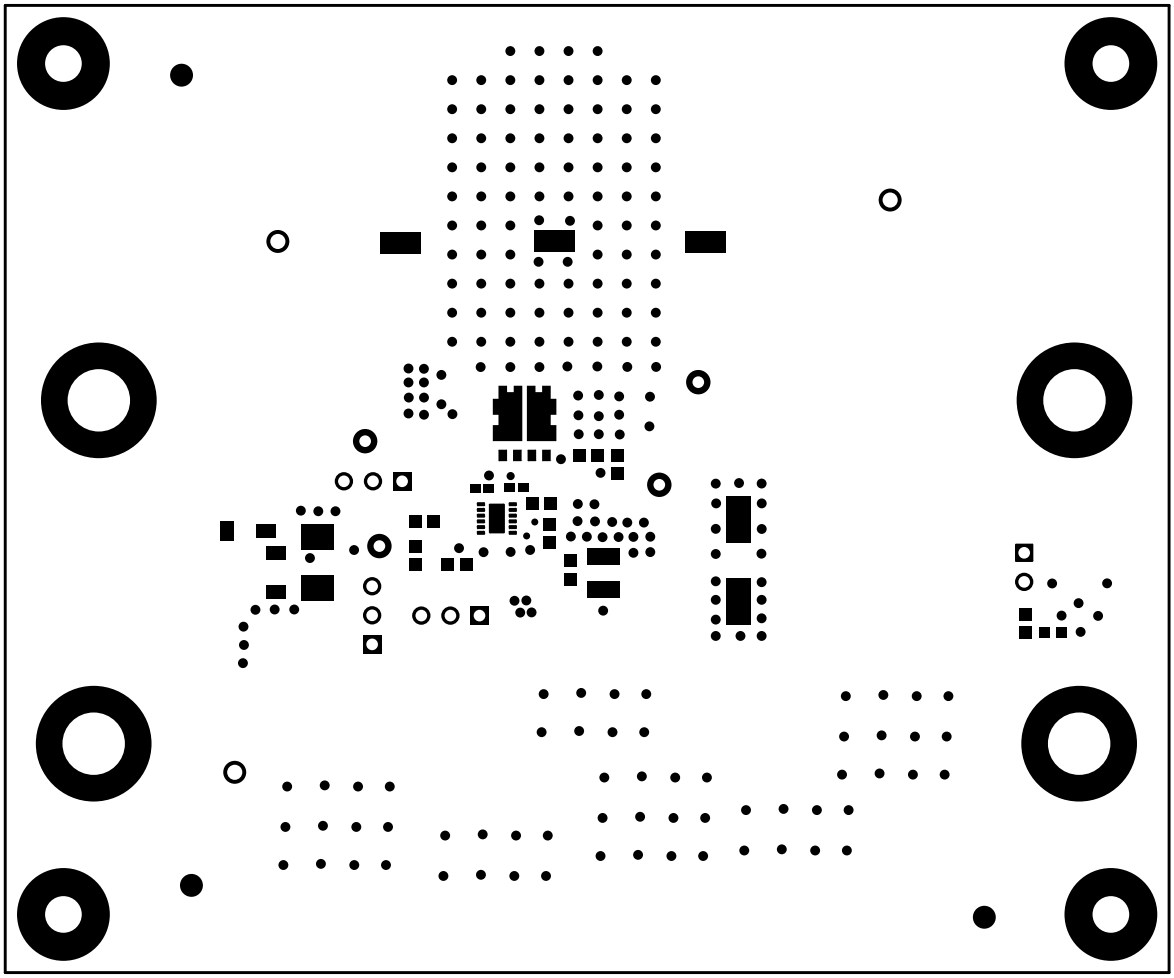

Figure 6-2. Component Placement BOTTOM

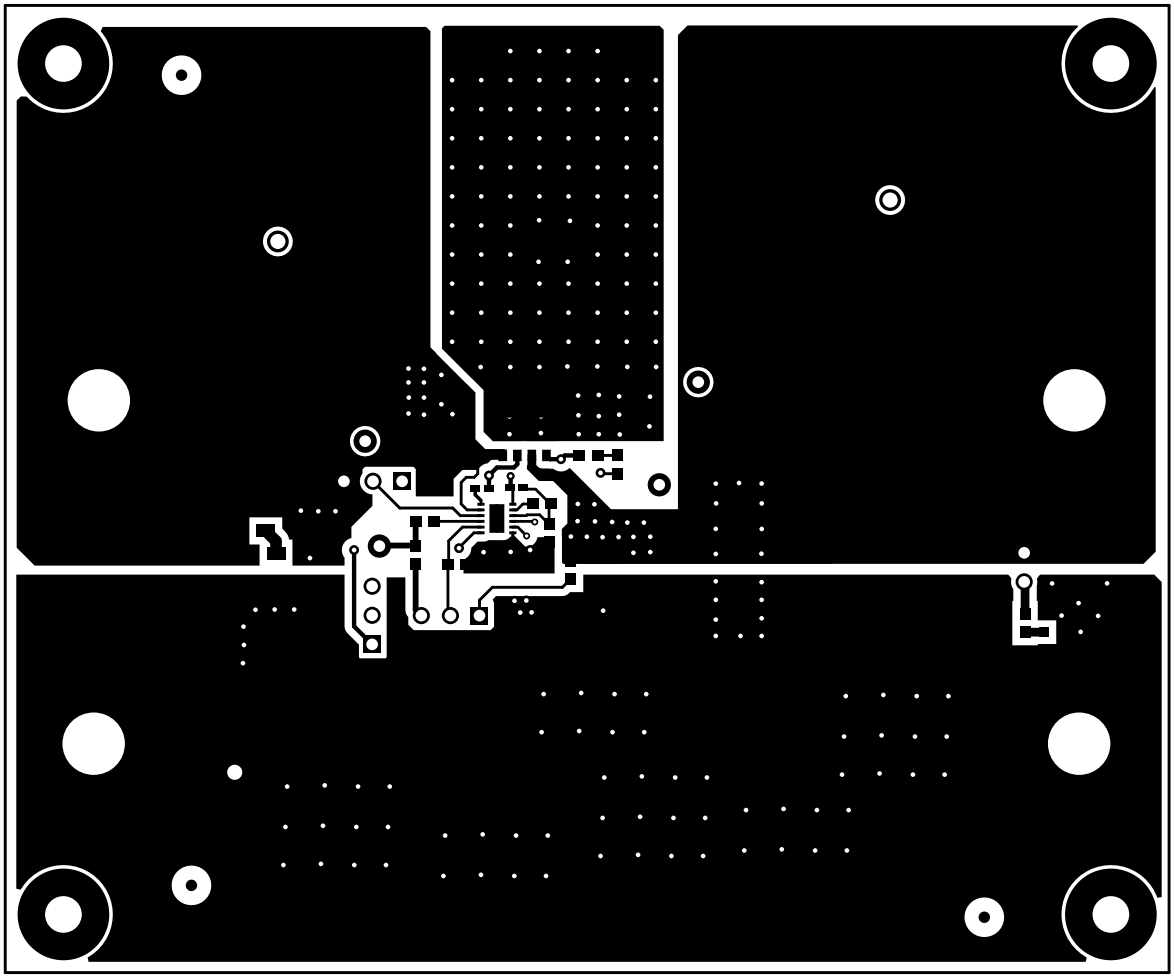

Figure 6-3. TOP Layer Routing

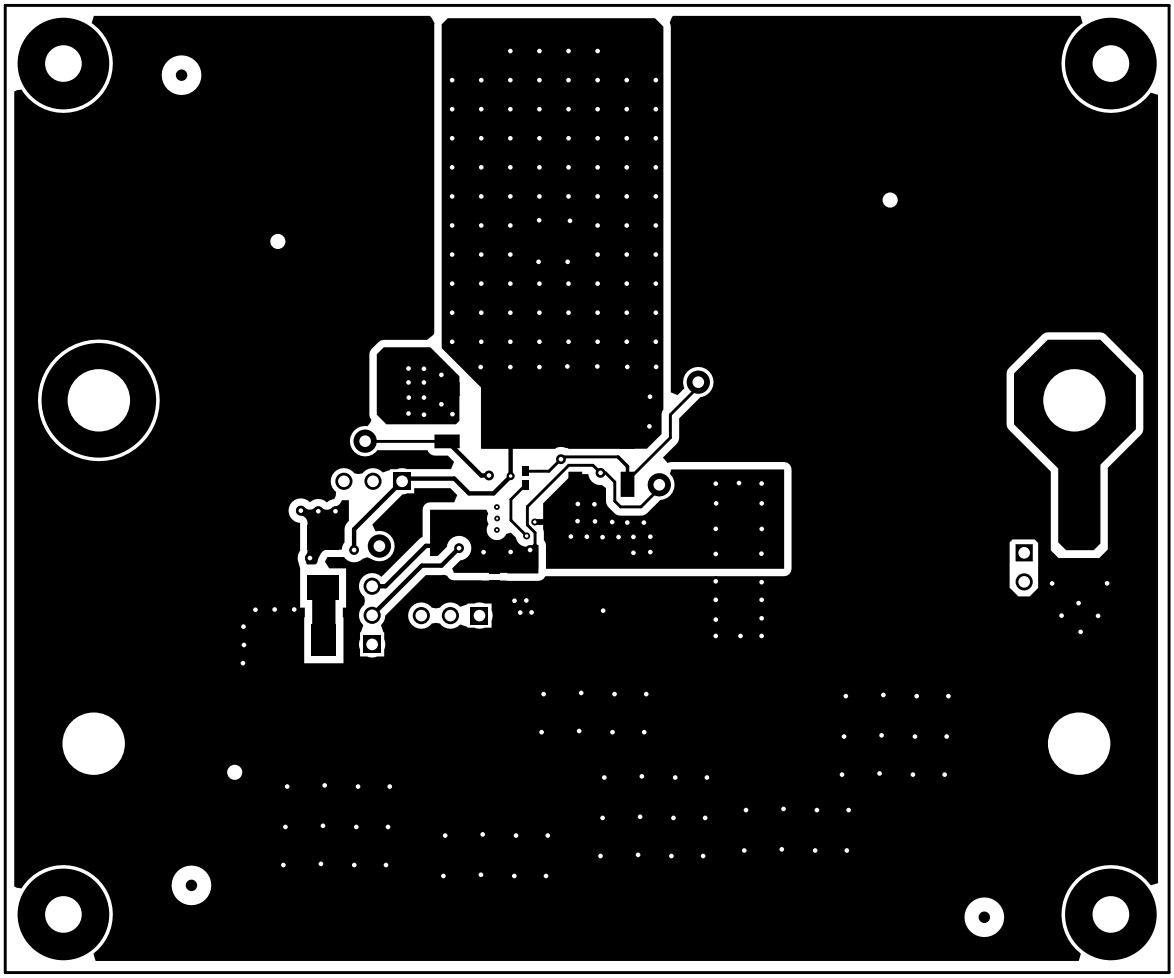

Figure 6-4. BOTTOM Layer Routing

6.2 Bill of Materials

Table 6-1. Bill of Materials

Fitted	Description	Designator	PartNumber	Quantity	Manufacturer	Package Reference	Value	Alternate Manufacturer
Fitted	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, 0603	C1	GRM188R72A104KA35J	1	MuRata	603	0.1 uF	
Fitted	CAP, CERM, 0.01 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	C2	CGA3E2X7R2A103K080AA	1	TDK	603	0.01 uF	
Fitted	CAP, CERM, 0.1 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	C3	CGA3E2X7R1E104K080AA	1	TDK	603	0.1 uF	
Fitted	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	C4, C5	CGA5L2X7R2A104K160AA	2	TDK	1206	0.1 uF	
Fitted	CAP, CERM, 2.2 uF, 100 V, +/- 10%, X7R, 1210	C6	C1210C225K1RACTU	1	Kemet	1210	2.2 uF	
Fitted	CAP, AL, 47 uF, 63 V, +/- 20%, 0.65 ohm, AEC-Q200 Grade 2, SMD	C7	EEE-FK1J470P	1	Panasonic	SMT Radial F	47 uF	
Fitted	Diode, TVS, Bi, 33 V, SMB	D1	SMBJ33CA-13-F	1	Diodes Inc.	SMB	33 V	
Fitted	Diode, Schottky, 70 V, 1 A, SMA	D2	B170-13-F	1	Diodes Inc.	SMA	70 V	
Fitted	LED, Green, SMD	D5	LTST-C190GKT	1	Lite-On	1.6x0.8x0.8mm	Green	
Fitted	Standard Banana Jack, Uninsulated, 8.9mm	J1, J2, J3, J4	575-8	4	Keystone	Keystone575-8		
Fitted	Header, 100mil, 3x1, Tin, TH	J5, J6, J8	PEC03SAAN	3	Sullins Connector Solutions	Header, 3 PIN, 100mil, Tin		
Fitted	Header, 100mil, 2x1, Tin, TH	J7	PEC02SAAN	1	Sullins Connector Solutions	Header, 2 PIN, 100mil, Tin		

Table 6-1. Bill of Materials (continued)

Fitted	Description	Designator	PartNumber	Quantity	Manufacturer	Package Reference	Value	Alternate Manufacturer
Fitted	Dual N-Channel MOSFET, 49 A, 60 V, 8-Pin DFN	Q1	NVMFD5C650NL	1	ON Semiconductor	DFN8_5X6		
Fitted	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	R1	RK73Z1ETTP	1	KOA Speer	402	0	
Fitted	RES, 100, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	R2	CRCW0603100RJNEA	1	Vishay-Dale	603	100	
Fitted	RES, 91 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	R3	CRCW060391K0JNEA	1	Vishay-Dale	603	91 k	
Fitted	RES, 3.48 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	R4	CRCW06033K48FKEA	1	Vishay-Dale	603	3.48 k	
Fitted	RES, 12 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	R5	CRCW060312K0JNEA	1	Vishay-Dale	603	12 k	
Fitted	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	R6	CRCW0603100KFKEA	1	Vishay-Dale	603	100 k	
Fitted	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	R7, R9	ERJ-2GE0R00X	2	Panasonic	402	0	
Fitted	RES, 9.1 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	R8	CRCW06039K10JNEA	1	Vishay-Dale	603	9.1 k	
Fitted	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	R10	ERJ-3GEY0R00V	1	Panasonic	603	0	
Fitted	Test Point, Miniature, Orange, TH	TP1, TP2	5003	2	Keystone	Orange Miniature Testpoint		
Fitted	TEST POINT SLOTTED .118", TH	TP3, TP4, TP5	1040	3	Keystone	Test point, TH Slot Test point		
Fitted	Test Point, Miniature, Black, TH	TP6	5001	1	Keystone	Black Miniature Testpoint		
Fitted	Test Point, Miniature, SMT	TP7, TP8, TP9	5015	3	Keystone	Testpoint_Keystone_Miniature		
Fitted	Test Point, Miniature, Red, TH	TP10	5000	1	Keystone	Red Miniature Testpoint		

Table 6-1. Bill of Materials (continued)

Fitted	Description	Designator	PartNumber	Quantity	Manufacturer	Package Reference	Value	Alternate Manufacturer
Fitted	Ideal Diode Controller with Load Dump Protection, DRR0012E (WSON-12)	U1	LM74800DRRRQ1	1	Texas Instruments	DRR0012E		Texas Instruments
Not Fitted	Diode, TVS, Uni, 58 V, 93.6 Vc, SMB	D3	SMBJ58A-13-F	0	Diodes Inc.	SMB	58 V	
Not Fitted	Diode, TVS, Uni, 24 V, 38.9 Vc, SMB	D4	SMBJ24A-13-F	0	Diodes Inc.	SMB	24 V	
Not Fitted	Fiducial mark. There is nothing to buy or mount.	FID1, FID2, FID3, FID4, FID5, FID6	N/A	0	N/A	N/A		
Not Fitted	INF-MOSFET-N-3	Q2, Q3	IPD100N06S4-03	0	Infineon	PG-TO252-3		

7 Revision History

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

Changes from Revision * (April 2020) to Revision A (October 2020)	Page
• Updated the numbering format for tables, figures and cross-references throughout the document	1
• Updated Figure 3-1	4
• Updated Figure 5-1	5
• Updated Board Layout images	10
• Updated the Bill of Materials	14

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), 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, regulatory 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 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.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265