User's Guide

LM7472EVM: Evaluation Module for LM74720-Q1 and LM74722-Q1 Ideal Diode Controllers

ABSTRACT

This user's guide describes the LM7472EVM evaluation module for evaluating the performance of the ideal diode controller with switched output, LM74720-Q1 and LM74722-Q1. The LM7472x-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

List of Figures

List of Tables

Trademarks

1 Introduction

TI's LM7472x-Q1 Evaluation module, LM7472EVM, is a two channel EVM which helps designers evaluate the operation and performance of the LM74720-Q1 in channel 1 and LM74722-Q1 in channel 2 respectively. This evaluation module demonstrates how LM7472x-Q1 with its dual gate drive controls two N-channel power MOSFETs with ideal diode MOSFET connected first followed by second MOSFET for switched output and power path cut-off. A strong boost regulator with fast turn ON/OFF comparators ensures robust and efficient MOSFET

switching performance during automotive testing such as ISO16750 or LV124 where an ECU is subjected to input short interruptions and AC superimpose input signals up to 200 kHz frequency. Low quiescent current (< 38 µA) in operation enables always ON system designs.

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
- Enable ON/OFF control
- 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
- Premium audio amplifier
- Camera ECU
- Head unit
- USB HUBs
- Power path protection, power mux and ORing

2 Description

The LM7472EVM 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/J5 and J2/J6, J8/J12 and J9/J13):

Input power is applied at the terminals J1 and J5 for channel 1 and J8 and J12 for channel 2. Terminals J2 and J6, J9 and J13 provide output connection to load for channel 1 and channel 2 respectively.

2.2 Enable Control (J4 and J11):

Enable control is usually used by external MCU or controller to turn off LM7472x-Q1 and cut off the power path. Setting 1-2 on J4 (channel 1) and J11 (channel 2) enables the controller and 2-3 disables the controller. TI recommends to connect EN to external MCU or to test point 1-2 for uninterrupted performance during negative transient tests.

2.3 Two Back-to-Back Connected MOSFETs (Q1/Q3-Q2/Q4 and M1/M3-M2/M4):

Each channel on the LM7472EVM is populated with one set of back-to-back connected N-channel MOSFETs (Q1 and Q2 in channel 1 and M1 and M2 in channel 2) capable to support 5-A automotive ECU applications. Placeholders for parallel FETs (Q3 and Q4 in channel 1 and M3 and M4 in channel 2) are provided for extending current to 10 A and can be used to validate other MOSFETs.

2.4 Output Slew Rate Control (R3 and C4, R10 and C13):

R3 and C4 on channel 1 and R10 and C13 on channel 2 provide output slew rate control of their respective channels and can be changed to achieve different output slew rate.

2.5 Output Schottky Diode (D3, D8) and LED Indication (D4, D10) :

Schottky diode D3 (channel 1) and D8 (channel 2) are populated on EVM by default and are recommended in conditions where output voltage can have negative transients that can exceed absolute maximum ratings of LM7472x-Q1. The Schottky diodes can be removed if negative transients are not possible at the output.

D4, D10 provides an indication on the status of the output voltage on channel 1 and channel 2.

2.6 TVS Selection for 12-V Battery Protection:

TVS D2 (channel 1) and D7 (channel 2), SMBJ36CA is a bidirectional 600-W TVS that protects the LM7472x-Q1 and MOSFETs from automotive ISO transients tests on a 12-V battery. For detailed information on TVS selection, refer to the data sheets for LM74720-Q1 and LM74722-Q1.

2.7 TVS Selection for 24-V Battery Protection:

For testing 24-V battery protection application on channel 2, D7 needs to be removed and appropriate TVS on D6 and D9 needs 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 data sheets for LM74720-Q1 and LM74722-Q1.

2.8 Test Points:

Table 2-1 lists the LM7472EVM board input and output connector functionality. Table 2-2 and Table 2-3 describe the test points description and the jumper functionality of the EVM respectively.

Table 2-1. Connectors: Input and Output

Channel	Connector	Description
1	J1	Power input connector to the positive rail of the input power supply
	J5	Ground connection for the power supply
	J2	Power output connector to the positive side of the load
	J6	Ground connection for the load
2	J8	Power input connector to the positive rail of the input power supply
	J12	Ground connection for the power supply
	J9	Power output connector to the positive side of the load
	J7	Power output connector to the positive side after the optional LC filter at output
	J13	Ground connection for the load

Table 2-2. Test Points Description

Test Point	Name	Description
TP1	VIN1	Input power supply to the EVM - channel 1
TP2	VOUT1	Output from the EVM - channel 1
TP3	VIN_MON1	Input monitoring for battery inputs - channel 1
TP6	GATE1	Output of Ideal Diode MOSFET Gate Control - channel 1
TP7	PD1	Output of Hot-Swap MOSFET Gate Control - channel 1
TP8	CAP1	Internal Boost Regulator output - channel 1
TP9	C1	Cathode pin - channel 1
TP10	VIN2	Input power supply to the EVM - channel 2
TP11	VOUT2	Output from the EVM - channel 2
TP12	VIN_MON2	Input monitoring for battery inputs - channel 2
TP15	GATE2	Output of Ideal Diode MOSFET Gate Control - channel 2
TP16	PD2	Output of Hot-Swap MOSFET Gate Control - channel 2
TP17	CAP2	Internal Boost Regulator output - channel 2
TP18	C2	Cathode pin - channel 2
TP4, TP5, TP13, TP14	PGND	Test Point for EVM Ground

Table 2-3. Jumpers and LED Description

Jumpers	Description
J4	EN/UVLO control channel 1 • 1-2 enables by connecting to common drain point • 2-3 disables by connecting to GND
J3	Enables LED indication for output - channel 1
J11	EN/UVLO control channel 2 • 1-2 enables by connecting to common drain point • 2-3 disables by connecting to GND
J10	Enables LED indication for output - channel 2

3 Schematic

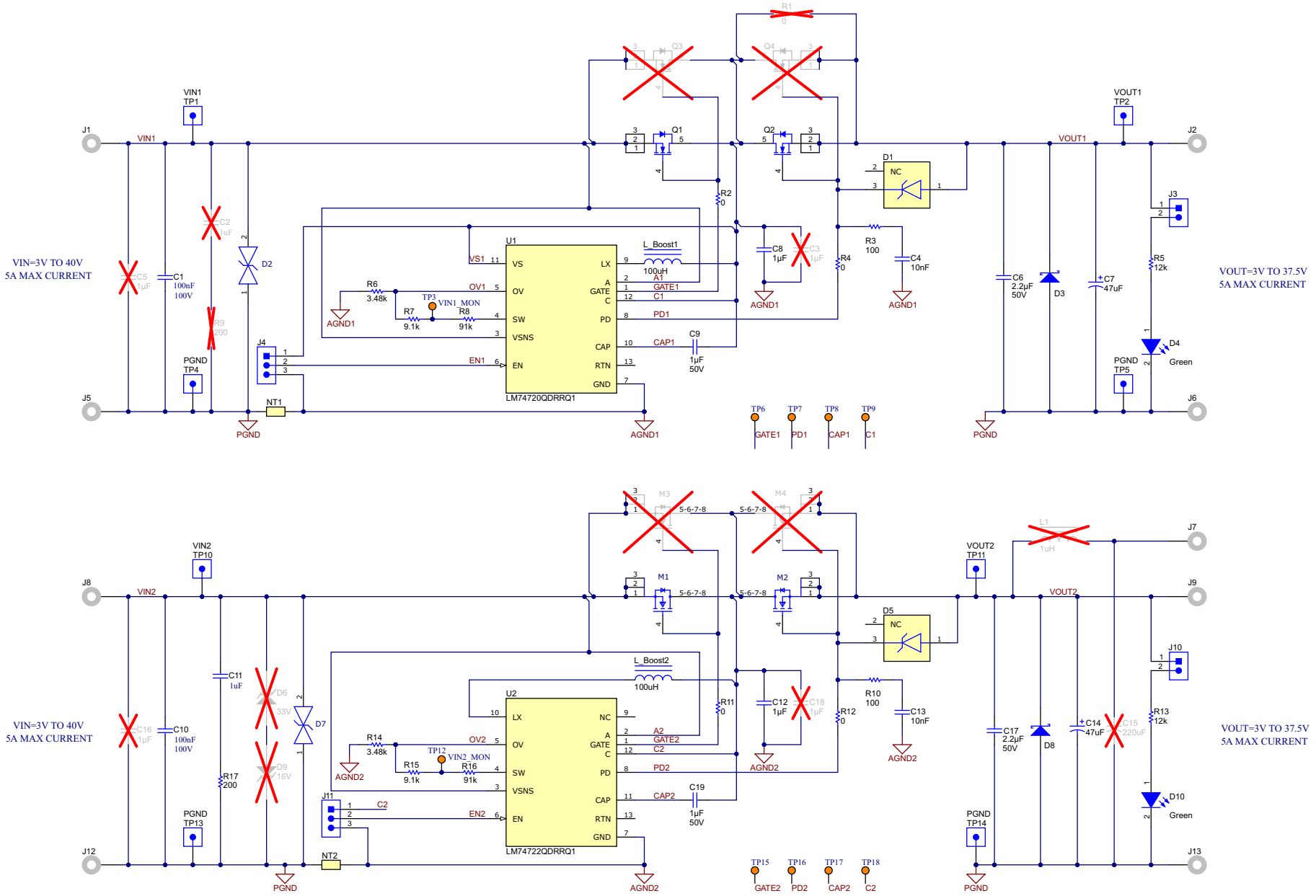


Figure 3-1. LM7472EVM Schematic

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 setup and results section describes the test procedure for LM74720-Q1 device. Similar procedure applies for LM74722-Q1 device also.

Default jumper setting for LM7472EVM board is shown in Figure 5-1.

Table 5-1. Default Jumper Setting for LM7472EVM

J4	J3	J11	J10
1-2 or connect 2 to external enable control	1-2, Output LED Indication	1-2 or connect 2 to external enable control	1-2, Output LED Indication

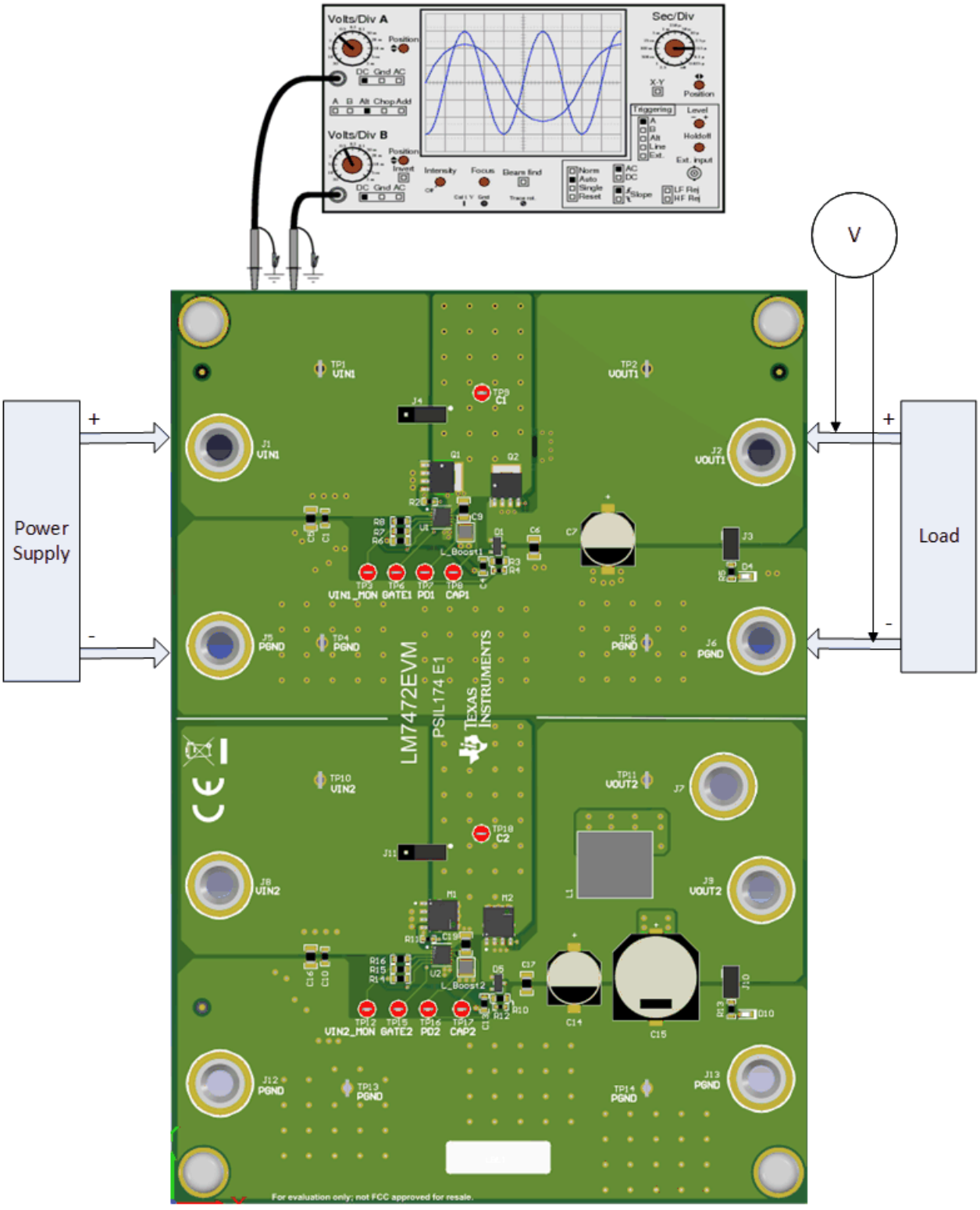


Figure 5-1. LM7472EVM Test Setup

5.1 Initial Setup

Test setup used for evaluating LM7472EVM is shown in Figure 5-1. Steps to be followed before testing the evaluation module are:

- Connect the power supply and load to LM7472EVM.
- 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 - GATE Voltage (Test Point Label GATE)
- Channel 4 - PD Voltage (Test Point Label PD)

Set the load to 200 mA, trigger to Channel 1 rising and turn ON the power supply. Startup behavior of LM7472EVM is captured in Figure 5-2.

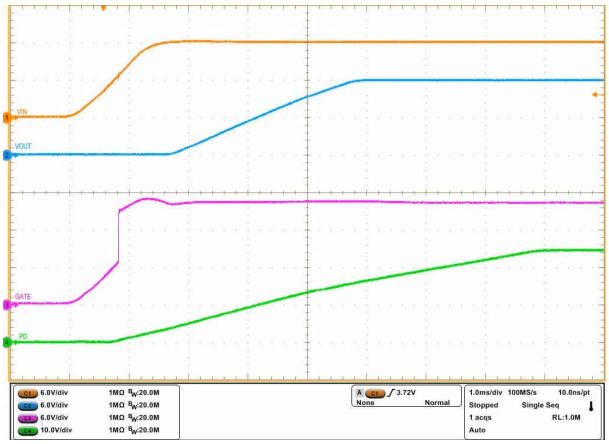


Figure 5-2. Power Up: GATE and PD

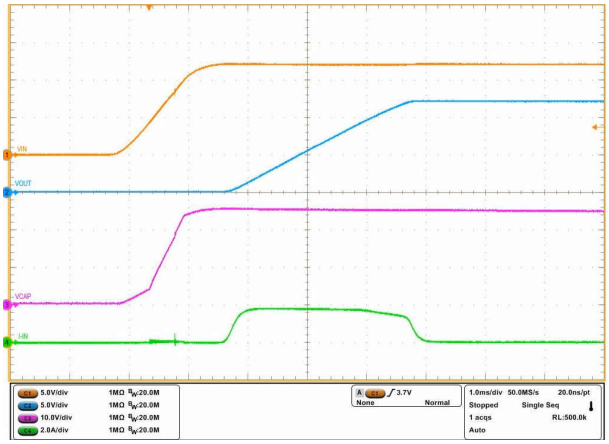


Figure 5-3. Power Up: Charge Pump and Inrush Current

Additional startup information is captured in Figure 5-3. Channel 3 captures the internal boost converter output voltage VCAP pin during startup.

5.3 Enable Control

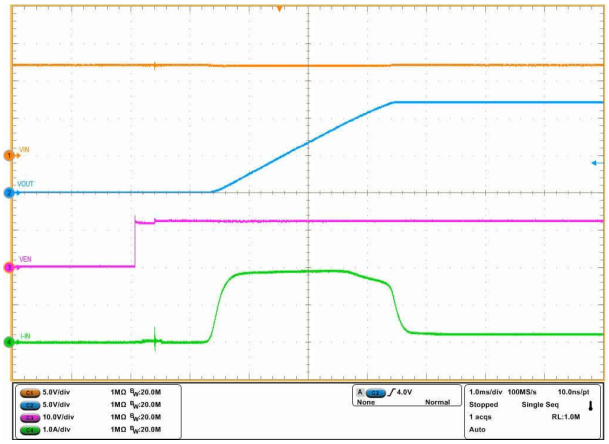


Figure 5-4. Turn ON Using EN - Inrush Current

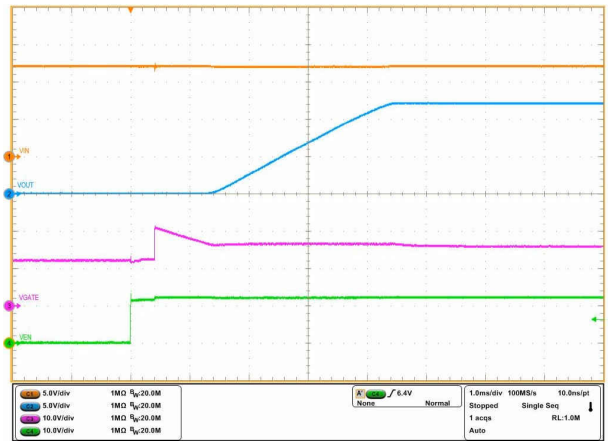


Figure 5-5. Turn ON Using EN - GATE

5.4 Hot-Plug and Disable using EN

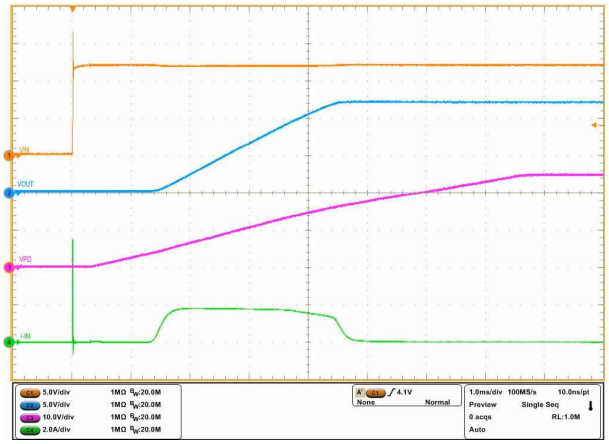


Figure 5-6. Hot-Plug 12 V

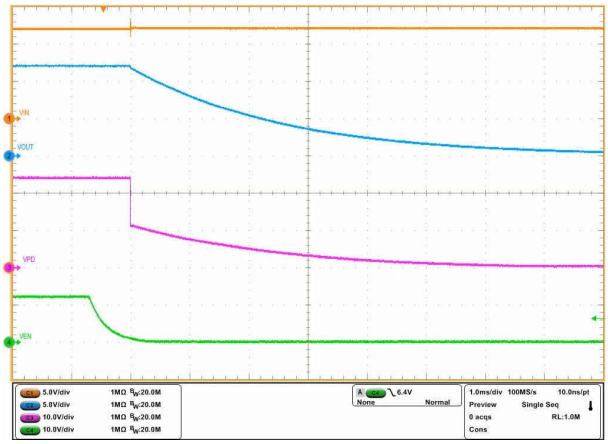


Figure 5-7. Disable Using EN

5.5 Inrush Current Control

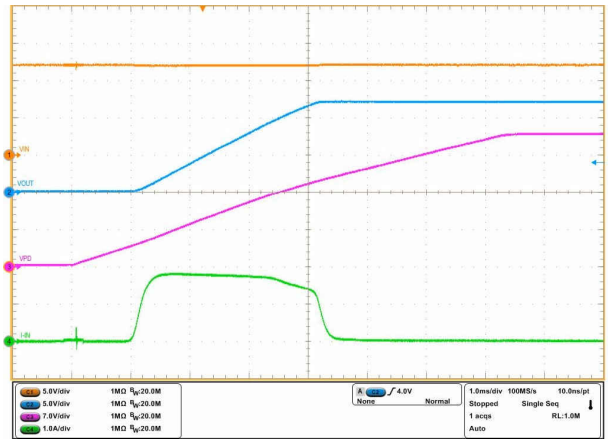


Figure 5-8. Inrush Current With No Load

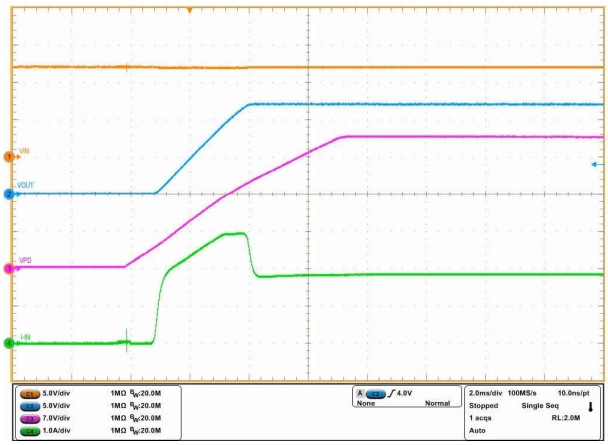


Figure 5-9. Inrush Current With 6-Ω Load

5.6 Load Response

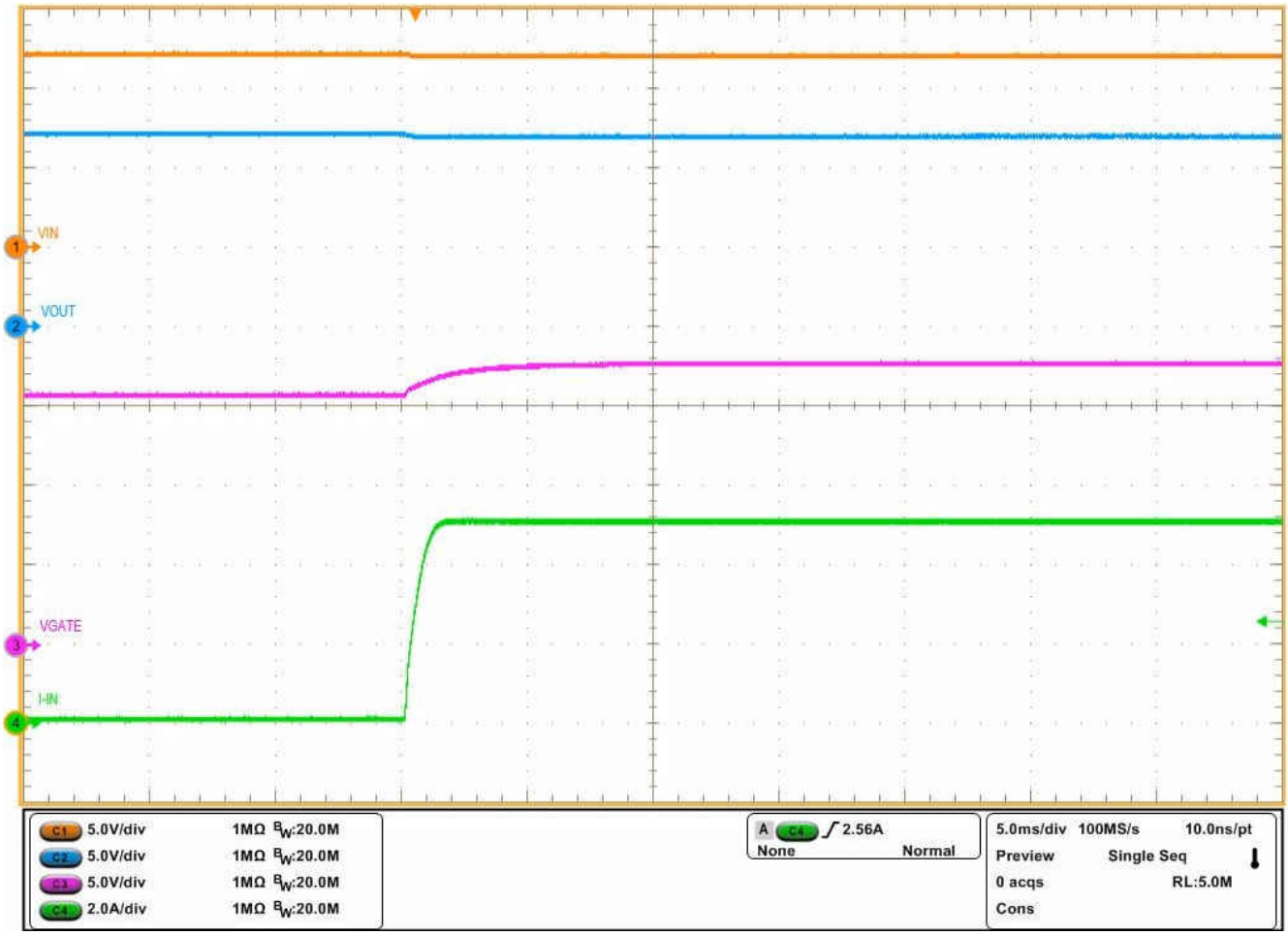
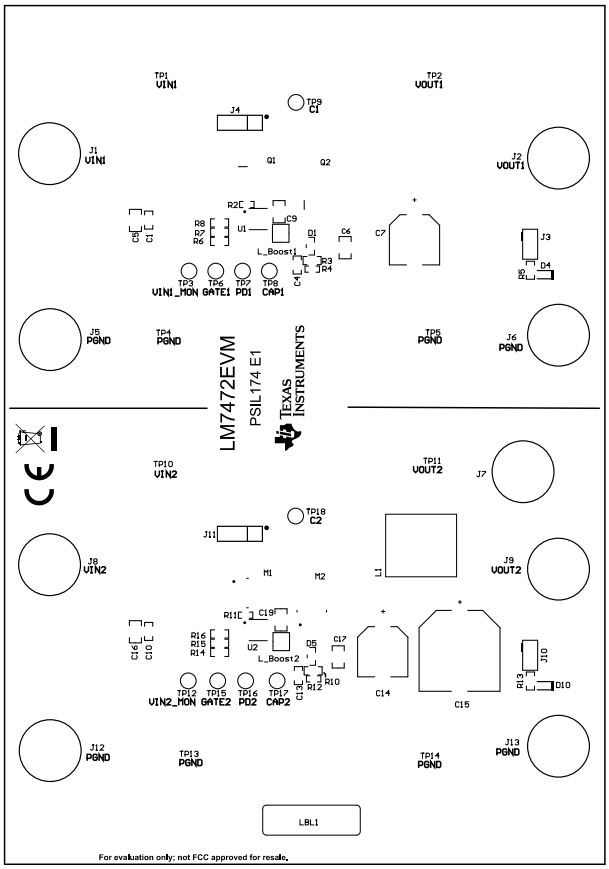


Figure 5-10. Load Transient Response 100 mA to 5 A

6 Board Layout and Bill of Materials

6.1 Board Layout



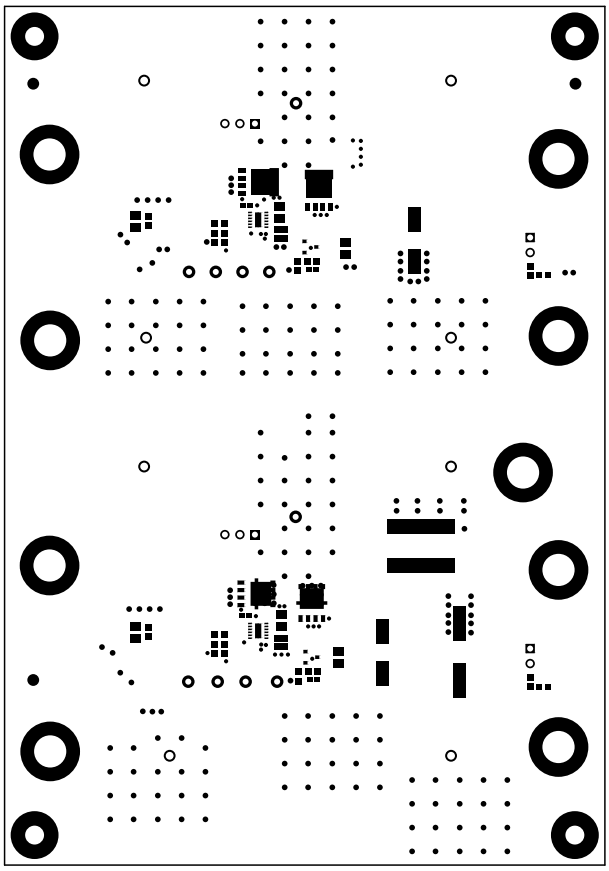
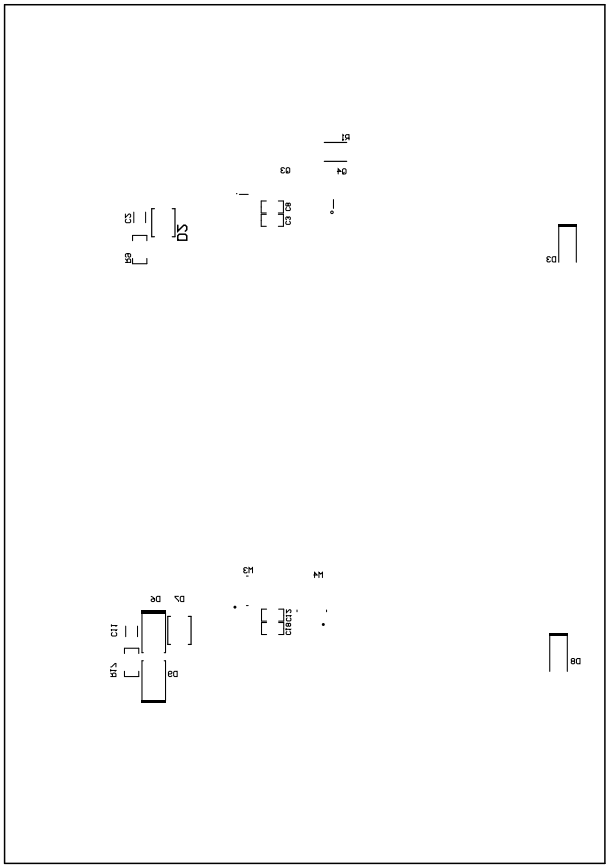


Figure 6-1. Component Placement and Solder Pad TOP



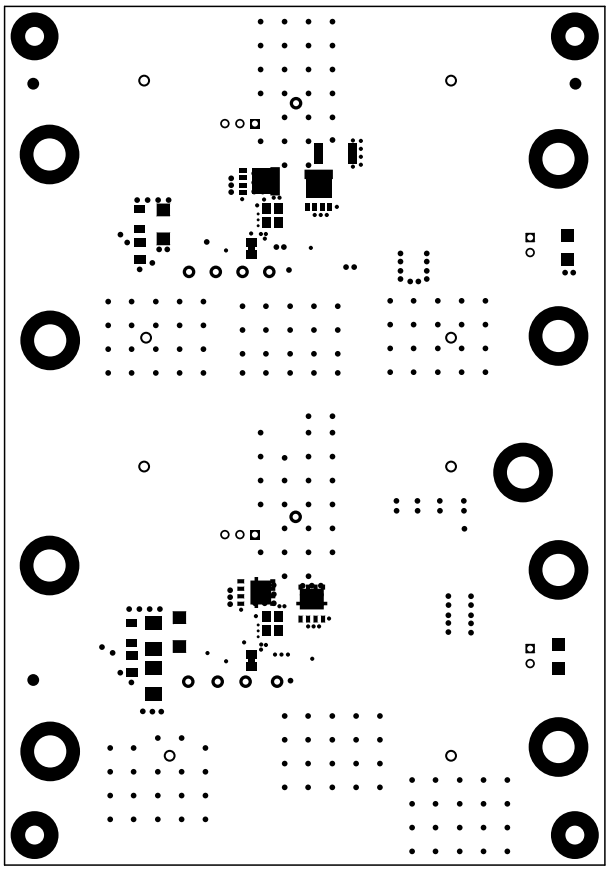


Figure 6-2. Component Placement and Solder Pad BOTTOM

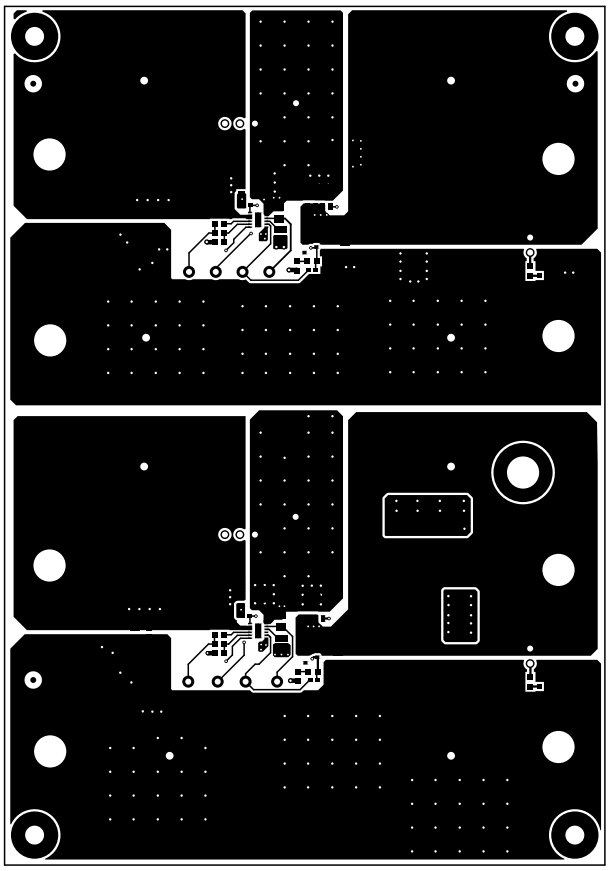


Figure 6-3. TOP Layer Routing

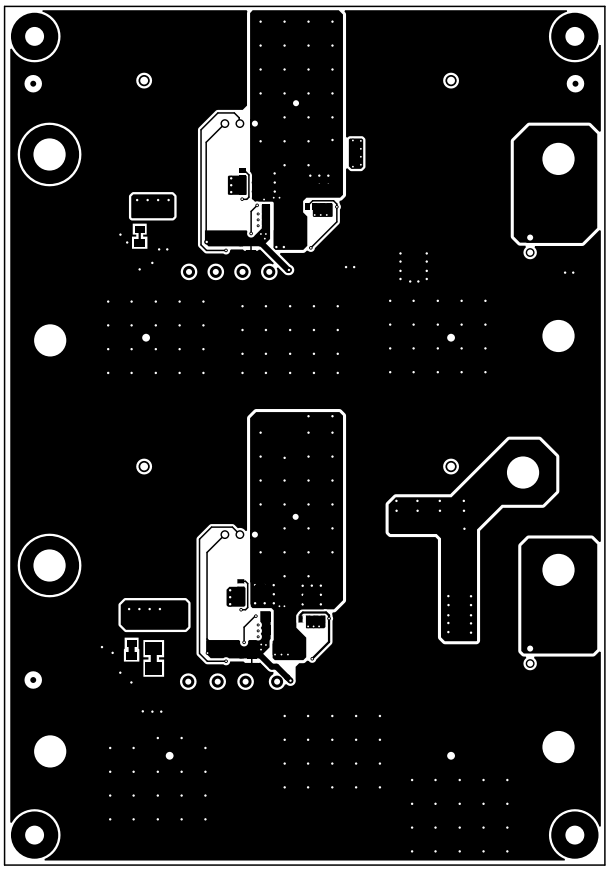


Figure 6-4. BOTTOM Layer Routing

6.2 Bill of Materials

Table 6-1. Bill or Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1, C10	2	0.1 uF	CAP, CERM, 0.1 µF, 100 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	603	HMK107B7104KAHT	Taiyo Yuden
C4, C13	2	0.01 uF	CAP, CERM, 0.01 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	603	CGA3E2X7R2A103K080AA	TDK
C6, C17	2	2.2 uF	CAP, CERM, 2.2 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	805	CGA4J3X7R1H225K125AB	TDK
C7, C14	2	47 uF	CAP, AL, 47 uF, 63 V, +/- 20%, 0.65 ohm, AEC-Q200 Grade 2, SMD	SMT Radial F	EEE-FK1J470P	Panasonic
C8, C9, C12, C19	4	1 uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	805	CGA4J3X7R1H105K125AB	TDK
C11	1	1 uF	CAP, CERM, 1 uF, 100 V, +/- 10%, X7S, AEC-Q200 Grade 1, 0805	805	CGA4J3X7S2A105K125AB	TDK
D1, D5	2		Zener Diode 18V 250mW ±2% Surface Mount TO-236AB	SOT23	BZX84-B18,215	Nexperia
D2, D7	2		Diode TVS Single Bi-Dir 36V 600W 2-Pin SMB	DO-214AA	SMBJ36CA	Littelfuse
D3, D8	2	70V	Diode, Schottky, 70 V, 1 A, SMA	SMA	B170-13-F	Diodes Inc.
D4, D10	2	Green	LED, Green, SMD	1.6x0.8x0.8mm	LTST-C190GKT	Lite-On

Table 6-1. Bill or Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
J1, J2, J5, J6, J7, J8, J9, J12, J13	9		Standard Banana Jack, Uninsulated, 8.9mm	Keystone575-8	575-8	Keystone
J3, J10	2		Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100mil, Tin	PEC02SAAN	Sullins Connector Solutions
J4, J11	2		Header, 100mil, 3x1, Tin, TH	Header, 3 PIN, 100mil, Tin	PEC03SAAN	Sullins Connector Solutions
L_Boost1, L_Boost2	2	100 uH	Inductor, Shielded, Composite, 100 uH, 0.17 A, 8.48 ohm, SMD	XPL2010	XPL2010-104MLB	Coilcraft
M1, M2	2		Power MOSFET 60 V, 2.4 mΩ, 155 A, Single N-Channel	LFPAK8	NVMJS2D5N06CLTWG	ON Semiconductor
Q1, Q2	2	60 V	MOSFET, N-CH, 60 V, 100 A, AEC-Q101, SOT669	SOT669	BUK7Y4R8-60EX	Nexperia
R2, R4, R11, R12	4	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	402	ERJ-2GE0R00X	Panasonic
R3, R10	2	100	RES, 100, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW0603100RJNEA	Vishay-Dale
R5, R13	2	12 k	RES, 12 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW060312K0JNEA	Vishay-Dale
R6, R14	2	3.48 k	RES, 3.48 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW06033K48FKEA	Vishay-Dale
R7, R15	2	9.1 k	RES, 9.1 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW06039K10JNEA	Vishay-Dale
R8, R16	2	91 k	RES, 91 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW060391K0JNEA	Vishay-Dale

Table 6-1. Bill or Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R17	1	200	RES, 200, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW1206200RJNEA	Vishay-Dale
SH-J3, SH-J4, SH-J10, SH-J11	4	1x2	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt	SPC02SYAN	Sullins Connector Solutions
TP1, TP2, TP4, TP5, TP10, TP11, TP13, TP14	8		TEST POINT SLOTTED .118", TH	Test point, TH Slot Test point	1040	Keystone
TP3, TP6, TP7, TP8, TP9, TP12, TP15, TP16, TP17, TP18	10		Test Point, Miniature, Orange, TH	Orange Miniature Testpoint	5003	Keystone
U1	1		Low IQ Ideal Diode Controller With Active Rectification	WSON12	LM74720QDRRQ1	Texas Instruments
U2	1		Low IQ Ideal Diode Controller With Active Rectification	WSON12	LM74722QDRRQ1	Texas Instruments
C2	0	1 uF	CAP, CERM, 1 uF, 100 V, +/- 10%, X7S, AEC-Q200 Grade 1, 0805	805	CGA4J3X7S2A105K125AB	TDK
C3, C5, C16, C18	0	1 uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	805	CGA4J3X7R1H105K125AB	TDK
C15	0	220 uF	CAP, AL, 220 uF, 63 V, +/- 20%, 0.16 ohm, AEC-Q200 Grade 2, SMD	SMT Radial H13	EEV-FK1J221Q	Panasonic
D6	0	33 V	Diode, TVS, Uni, 33 V, 53.3 Vc, SMB	SMB	SMBJ33A-13-F	Diodes Inc.
D9	0	16 V	Diode, TVS, Uni, 16 V, 26 Vc, SMB	SMB	SMBJ16A-13-F	Diodes Inc.
L1	0	1 uH	Inductor, Shielded, Composite, 1 uH, 43.5 A, 0.001 ohm, SMD	Inductor, 11.3x10x10mm	XAL1010-102MEB	Coilcraft

Table 6-1. Bill or Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
M3, M4	0		Power MOSFET 60 V, 2.4 mΩ, 155 A, Single N-Channel	LFPAK8	NVMJS2D5N06CLTWG	ON Semiconductor
Q3, Q4	0	60 V	MOSFET, N-CH, 60 V, 100 A, AEC-Q101, SOT669	SOT669	BUK7Y4R8-60EX	Nexperia
R1	0	0	RES, 0, 5%, 1 W, AEC-Q200 Grade 0, 2512	2512	CRCW25120000Z0EG	Vishay-Dale
R9	0	200	RES, 200, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW1206200RJNEA	Vishay-Dale

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