User's Guide

LM7480-Q1 Evaluation Module for Unsuppressed Load Dump Protection: LM74800EVM-CS

ABSTRACT

This user's guide describes the LM74800EVM-CS 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.

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Trademarks

1 Introduction

TI's LM74800 Evaluation Module LM74800EVM-CS helps designers evaluate the operation and performance of the LM74800-Q1 ideal diode controller with switched output.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 overvoltage protection. This evaluation module demonstrates how LM74800-Q1 along with two back-to-back N-Channel MOSFETs configured in common-source topology can provide 200-V unsuppressed load dump protection with reverse battery protection to the downstream circuit. The first gate drive HGATE controls an external N-channel MOSFET to turn off or clamp output voltage to acceptable safe level and the second gate drive DGATE controls another external N-Channel MOSFET to emulate an ideal diode.

1.1 Features

Key features of the EVM include:

- 12-V and 24-V automotive reverse battery protection
- Input operating range 3 V to 65 V
- 12-V battery protection 3 V to 40 V
- 24-V battery protection 3 V to 65 V
- 2-A Nominal, 2.5-A peak load current
- Supports 200-V unsuppressed load dump protection
- 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-CS is configured by default for evaluating 24-V battery, 6 V during cold crank 200-V unsuppressed load dump protection with reverse battery protection. Note that during 200-V unsuppressed load dump protection, only the VS pin will be exposed to 200 V through a 10-kΩ resistor. A 60-V rated zener diode is used to clamp and protect the VS pin. The rest of the circuit is not exposed to higher voltage as the MOSFET Q1 can either be turned off completely or output voltage clamped to safe level.

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 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 38.4 V with 2-3 setting on J6 and falling is set to 35.2 V. Setting 1-2 on J6 configures OV clamp operation. This provides output voltage to clamp (hysteretic ON/OFF output).

2.4 Two Back-Back Connected MOSFETs (Q1/Q3 and Q2):

Q1 and Q2 are 200-V and 60-V rated N-Channel MOSFETs respectively which are capable of supporting 2-A load current for automotive applications. Since the MOSFETs are connected back to back in common-source topology, they can support 200-V unsuppressed load dump protection, reverse battery protection, reverse-current blocking and can provide power path cut-off when disabled or during over voltage conditions. Option Q3 provids for extending current to 5 A and can be used to validate other MOSFETs.

2.5 Output Slew Rate Control (R2 and C4):

R2 and C4 provide output slew rate control and can be changed to achieve different output slew rate.

2.6 Output Schottky Diode (D3) and LED Indication:

Schottky Diode D3 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.

2.7 TVS Selection for 200-V Unsuppressed Load Dump Protection:

Two TVS diodes D1 and D2 are required at the input. The breakdown voltage of two TVS in the positive side is higher than the maximum system voltage, 200 V. On the negative side, diode D3 is used to clamp ISO 7637-2 pulse 1. SMBJ150A for D2 and SMBJ33CA for D1 are recommended.

2.8 Test Points:

Test point labeled DGATE (TP4) is used for monitoring gate voltage of Q2 and HGATE (TP3) is used for gate voltage of Q1. Test Point labelled VIN (TP1) measures input voltage, VOUT (TP2) measure output voltage. Test Point labelled VA (TP6) measures the source voltage of Q1 and Q2 MOSFETs which is also connected to the A

pin. 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
VA	Common-source point of Q1 and Q2 MOSFETs and A pin of LM7480x-Q1
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 38.4 V
J7	Enables LED indication for output

3 Schematic

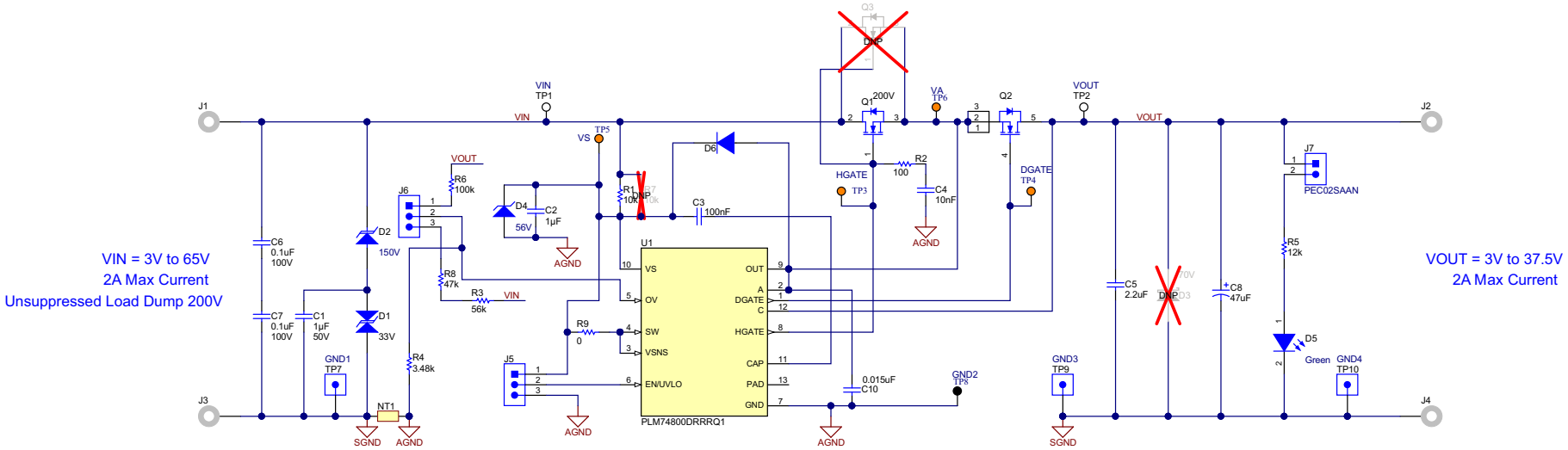

Figure 3-1. LM74800EVM-CS Schematic

4 Test Equipment Requirements

4.1 Power Supplies

One adjustable power supply 0-V to 600-V output, 0-A to 10-A output current limit. Automotive Test Equipment which can generate ISO 7637-2 and ISO 16750-2 including 200-V unsuppressed load dump Pulse 5 A.

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-CS board is shown in Figure 5-1.

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

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

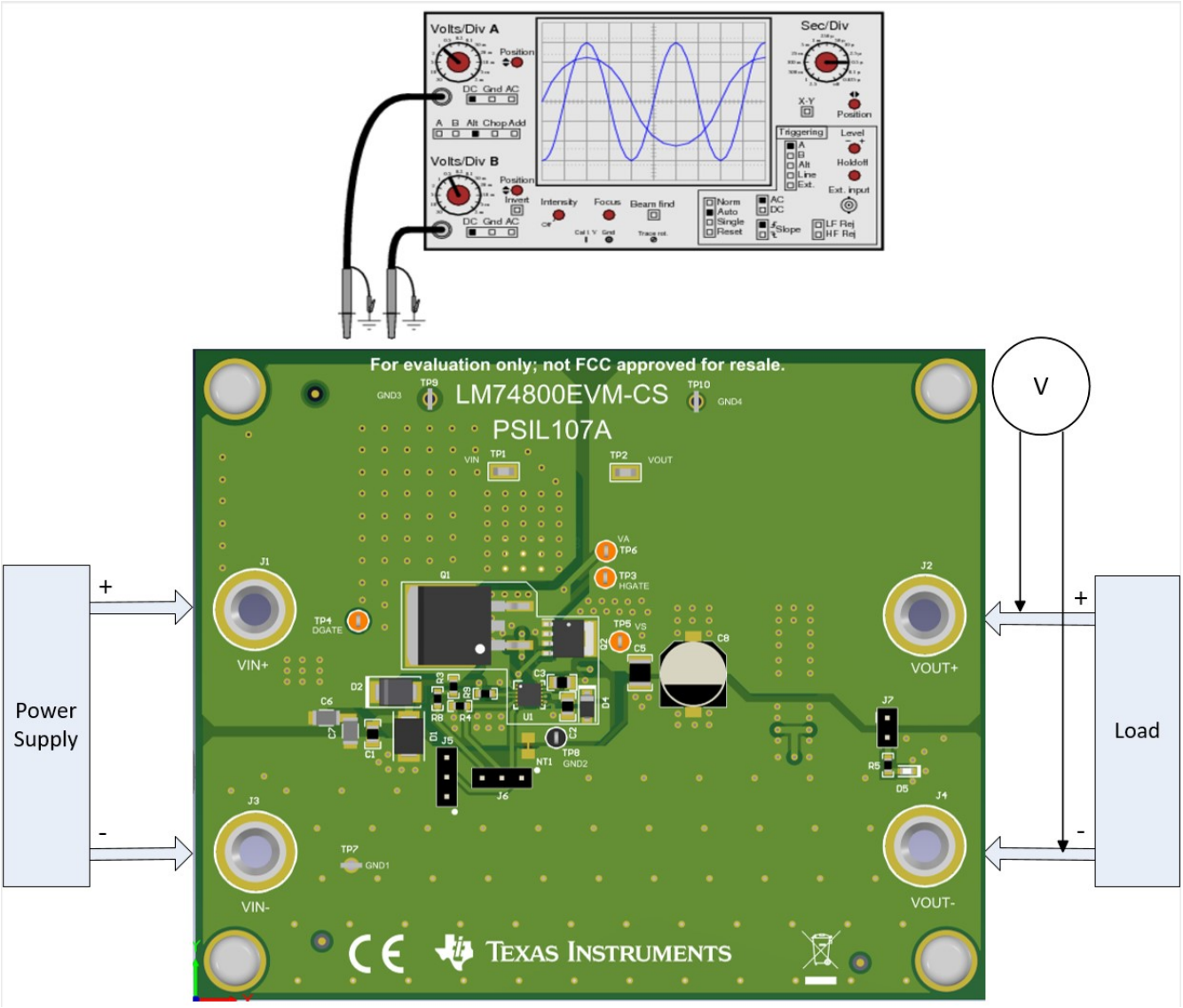

Figure 5-1. LM74800EVM-CS Test Setup

5.1 Initial Setup

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

- Connect the power supply and load to LM74800EVM-CS.
- 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 - A pin Voltage (Test Point Label VA)
- 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. Start-up behavior of LM74800EVM-CS is captured in Figure 5-2.

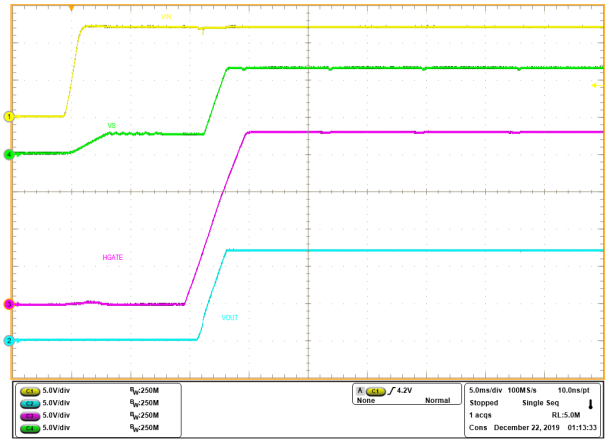

Figure 5-2. Power Up 12 V: HGATE and Output

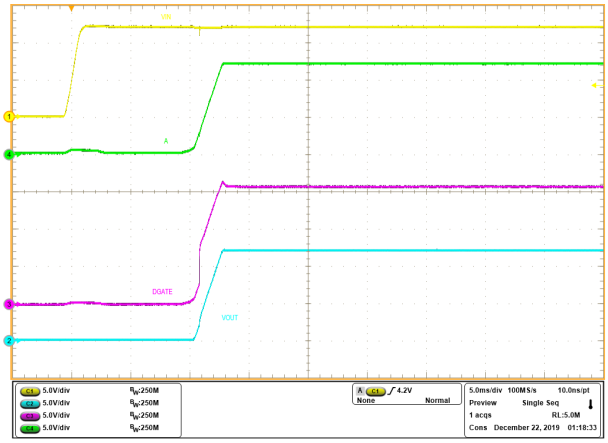

Figure 5-3. Power Up 12 V: DGATE and A

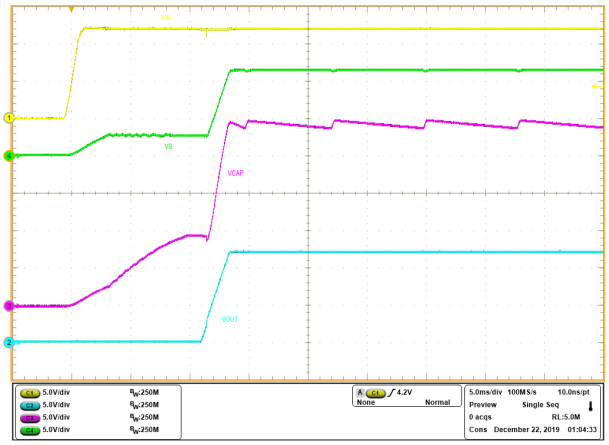

Figure 5-4. Power Up 12 V: Charge Pump VCAP

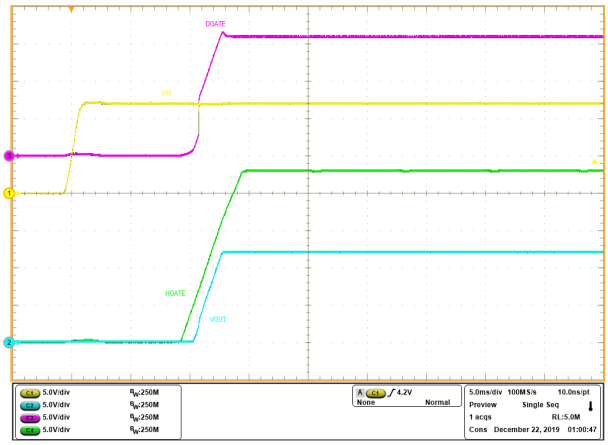

Figure 5-5. Power Up 12 V: DGATE and HGATE

5.3 200-V Unsuppressed Load Dump Protection

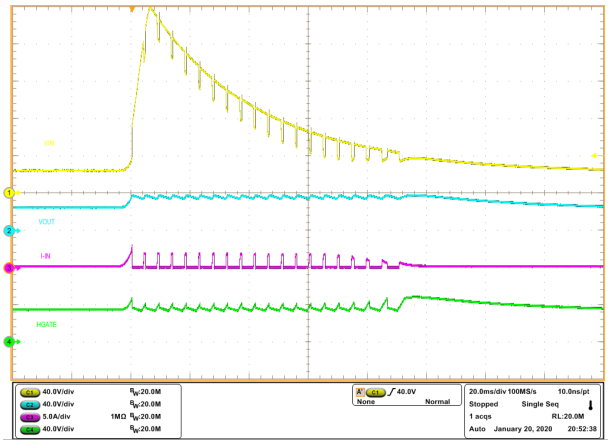

Figure 5-6. Unsuppressed Load Dump 200 V - Output Clamp

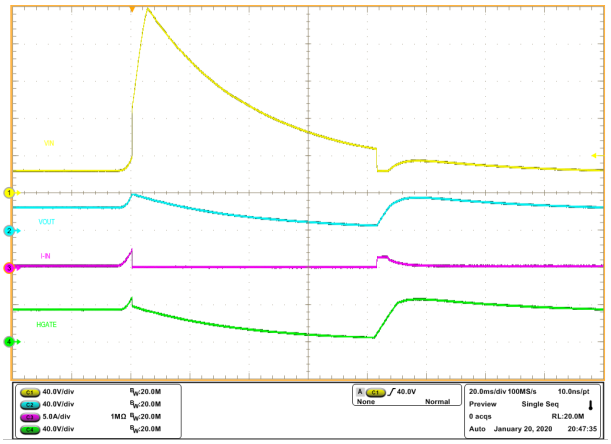

Figure 5-7. Unsuppressed Load Dump 200 V - Output Cut-off

5.4 ISO 7637-2 Pulse 1 –600 V 50 Ω

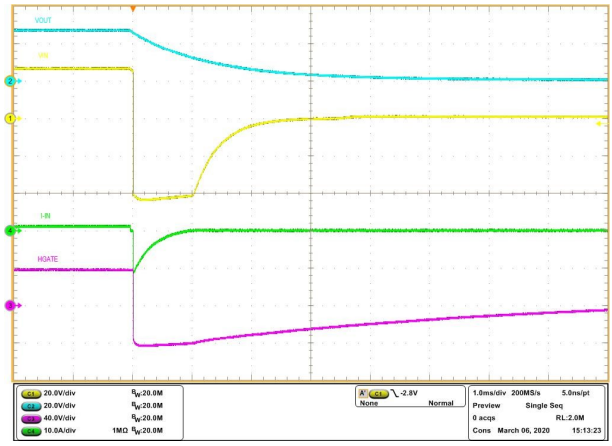

Figure 5-8. ISO 7637-2 Pulse 1 –600 V 50 Ω

6 Board Layout and Bill of Materials

6.1 Board Layout

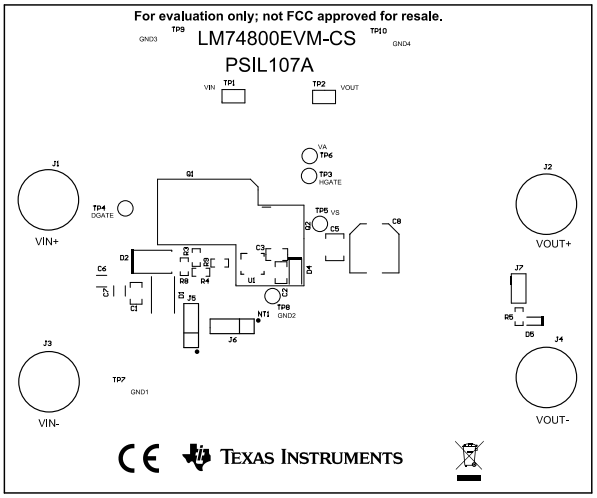

Figure 6-1. Component Placement TOP

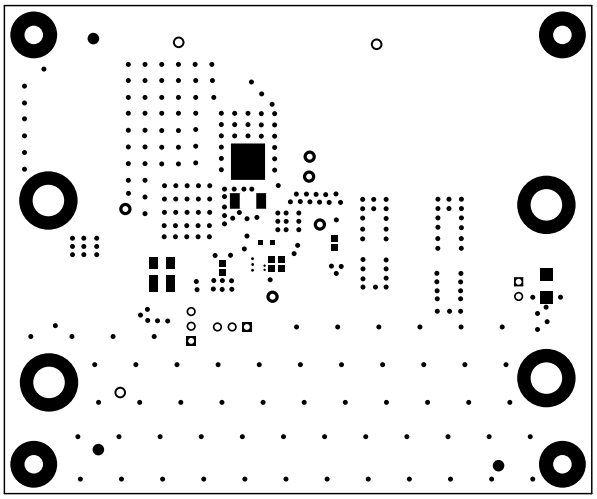

Figure 6-2. Component Placement BOTTOM

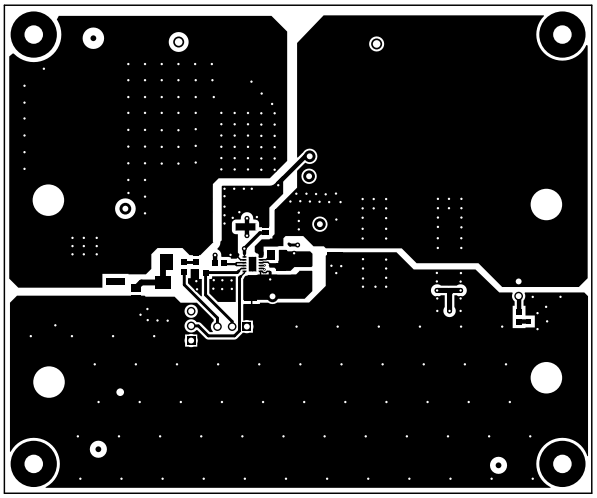

Figure 6-3. TOP Layer Routing

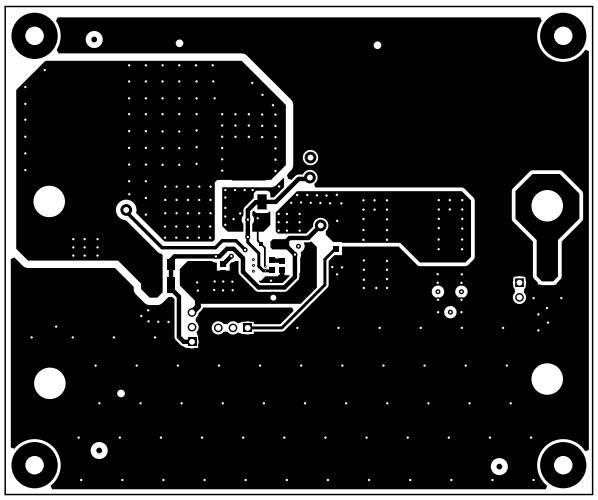

Figure 6-4. BOTTOM Layer Routing

6.2 Bill of Materials

Table 6-1. Bill of Materials

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate Manufacturer
C1, C2	2	1 uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	CGA4J3X7R1H105K125AB	TDK	
C3	1	0.1 uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 0, 0805	0805	C0805C104K5RACAUTO	Kemet	
C4	1	0.01 uF	CAP, CERM, 0.01 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R2A103K080AA	TDK	
C5	1	2.2 uF	CAP, CERM, 2.2 uF, 100 V, +/- 10%, X7R, 1210	1210	C1210C225K1RACTU	Kemet	
C6, C7	2	0.1 uF	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	CGA5L2X7R2A104K160AA	TDK	
C8	1	47 uF	CAP, AL, 47 uF, 63 V, +/- 20%, 0.65 ohm, AEC-Q200 Grade 2, SMD	SMT Radial F	EEE-FK1J470P	Panasonic	
C10	1	0.015 uF	CAP, CERM, 0.015 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R2A153K080AA	TDK	
D1	1	33 V	Diode, TVS, Bi, 33 V, SMB	SMB	SMBJ33CA-13-F	Diodes Inc.	
D2	1	150 V	Diode, TVS, Uni, 150 V, 243 Vc, SMB	SMB	SMBJ150A-13-F	Diodes Inc.	
D4	1	56 V	Diode, Zener, 56 V, 500 mW, AEC-Q101, SOD-123	SOD-123	MMSZ5263BT1G	ON Semiconductor	
D5	1	Green	LED, Green, SMD	1.6x0.8x0.8mm	LTST-C190GKT	Lite-On	
D6	1	75 V	Diode, Switching, 75 V, 0.15 A, AEC-Q101, SOD-323	SOD-323	1N4148WS-7-F	Diodes Inc.	

Table 6-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate Manufacturer
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply	
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone	
J1, J2, J3, J4	4		Standard Banana Jack, Uninsulated, 8.9mm	Keystone575-8	575-8	Keystone	
J5, J6	2		Header, 100mil, 3x1, Tin, TH	Header, 3 PIN, 100mil, Tin	PEC03SAAN	Sullins Connector Solutions	
J7	1		Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100mil, Tin	PEC02SAAN	Sullins Connector Solutions	
Q1	1	200 V	MOSFET, N-CH, 200 V, 34 A, DDPAK	DDPAK	IPB320N20N3 G	Infineon Technologies	None
Q2	1	60 V	MOSFET, N-CH, 60 V, 100 A, AEC-Q101, SOT669	SOT669	BUK7Y4R8-60EX	Nexperia	None
R1	1	10 k	RES, 10 k, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW120610K0JNEA	Vishay-Dale	
R2	1	100	RES, 100, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100RJNEA	Vishay-Dale	
R3	1	56 k	RES, 56 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060356K0JNEA	Vishay-Dale	
R4	1	3.48 k	RES, 3.48 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06033K48FKEA	Vishay-Dale	
R5	1	12 k	RES, 12 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060312K0JNEA	Vishay-Dale	
R6	1	100 k	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100KFKEA	Vishay-Dale	
R8	1	47 k	RES, 47 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060347K0JNEA	Vishay-Dale	
R9	1	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale	

Table 6-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate Manufacturer
TP1, TP2	2		Test Point, Miniature, SMT	Testpoint_Keystone_ Miniature	5015	Keystone	
TP3, TP4, TP5, TP6	4		Test Point, Miniature, Orange, TH	Orange Miniature Testpoint	5003	Keystone	
TP7, TP9, TP10	3		TEST POINT SLOTTED .118", TH	Test point, TH Slot Test point	1040	Keystone	
TP8	1		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone	
U1	1		Ideal Diode Controller with Load Dump Protection, DRR0012E (WSON-12)	DRR0012E	PLM74800DRRRQ1	Texas Instruments	Texas Instruments
D3	0	70 V	Diode, Schottky, 70 V, 1 A, SMA	SMA	B170-13-F	Diodes Inc.	
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A	
Q3	0	150 V	MOSFET, N-CH, 150 V, 33 A, AEC-Q101, DPAK	DPAK	AUIRFR4615TRL	International Rectifier	None
R7	0	10 k	RES, 10 k, 5%, 0.5 W, 1210	1210	RC1210JR-0710KL	Yageo	

Revision History

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

DATE	REVISION	NOTES
March 2021	*	Initial release

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