User's Guide

LM74810 Evaluation Module: LM74810EVM

ABSTRACT

This user's guide describes the LM74810EVM Evaluation Module for evaluating the performance of Ideal Diode Controller with Switched Output LM74810-Q1. The LM74810-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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1 Introduction

TI's Evaluation Module LM74810EVM helps designers evaluate the operation and performance of the LM74810-Q1 ideal diode controller with switched output. This evaluation module demonstrates how LM74810-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. LM74810-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

High Current Warning: LM74810EVM is capable to handle 10 A of current and necessary safety precautions are required when using the EVM. EVM does not produce > 5-A current on its own, but passes the current from input power to the load.

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
- 10-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
- Sensor HUB

- Head Unit
- USB HUBs
- Power path protection, Power MUX, Power ORing

2 Description

The LM74810EVM 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 LM7481x-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 on the output side. This provides output voltage to clamp (hysteretic ON/OFF output).

2.4 Input Voltage Monitor (J10 and VIN_MON):

Input Voltage monitor setting is done through test point labelled VIN_MON and J10 allows monitoring input voltage under different conditions. Setting J10 to 1-2 provides option to monitor battery voltage; this allows monitoring input voltage during normal and reversed battery conditions as well. Setting J10 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 and Q2 are 60-V rated N-Channel MOSFETs capable to support 10-A automotive ECU applications. LM74810-Q1 uses Q1 (or Q3) for reverse battery protection and reverse-current blocking. Q2 (or Q4) 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 C4):

R2 and C4 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 populated on EVM by default and it is recommended where output voltage can have negative transients that can exceed absolute maximum ratings of LM7481x-Q1.

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

2.8 TVS Selection for 12-V Battery Protection:

A single TVS such as 600-W SMBJ33CA can be used along with a 60-V rated MOSFET for automotive transient protection requirements on a 12-V battery, but in this EVM, Q1 and Q2 are 40-V rated. To protect the 40-V rated MOSFET, D3 and D4 are used and D1 is not populated on board. For detailed information on TVS selection, refer to the data sheet of LM74810-Q1.

2.9 TVS Selection for 24-V Battery Protection:

For 24-V battery protection application, D1, D2 and D3 needs to be removed from the board and use SMBJ58A for D3 along with SMBJ24A for D4. Further 80-V rated MOSFETs are recommended for 24-V battery protection applications. For detailed information on TVS selection, refer to the data sheet of LM74810-Q1.

2.10 RC Input Snubber Option (R7 and C15):

Resistor R7 and capacitor C15 provide an option for input snubber which may be required during the AC super imposed test to avoid excessive input voltage ringing when diode MOSFET (Q1) turns off every cycle of AC voltage ripple. Ringing can occur due to input cable inductance.

2.11 Optional LC Filter at the Output (L2 and C11):

An option for LC filter at the output is provided by L2 and C11.

2.12 Test Points:

Test point labeled DGATE is used for monitoring gate voltage of Q1 and HGATE is used for gate voltage of Q2. 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 LM74810-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
J9	Optional Output Connection with LC filter
J8	Optional Input LC Filter connection

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
J10	Input Voltage Sense • 1-2 Input Voltage Sense after Ideal Diode MOSFET • 2-3 Input Voltage Sense directly on input supply

3 Schematic

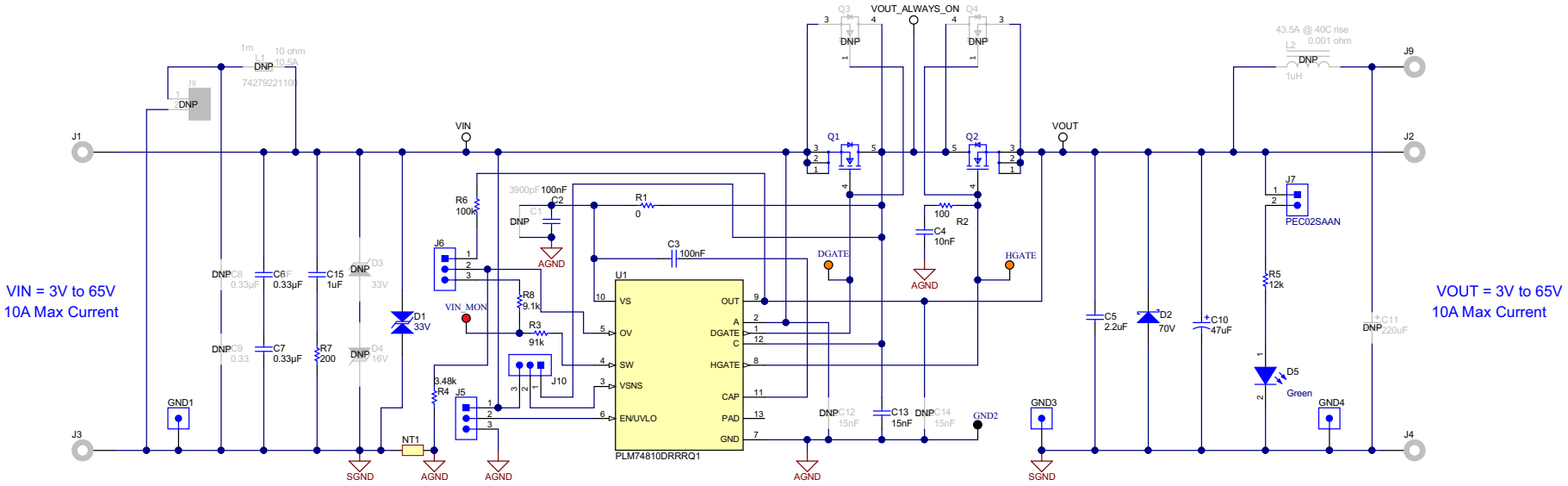

Figure 3-1. LM74810EVM Schematic

4 Test Equipment Requirements

4.1 Power Supplies

One adjustable power supply 0-V to 40-V output, 0-A to 15-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 15 A.

4.4 Loads

One resistive load or equivalent which can tolerate up to 15-A DC load at 12 V.

5 Test Setup and Results

This sections describes the test procedure for LM74810QDRRRQ1 device.

Default jumper setting for LM74810EVM board is shown in Table 5-1.

Table 5-1. Default Jumper Setting for LM74810EVM

J5	J6	J7	J10
1-2 or connect 2 to external enable control	2-3, OVP to Input	1-2, Output LED Indication	2-3, Input Voltage Sense

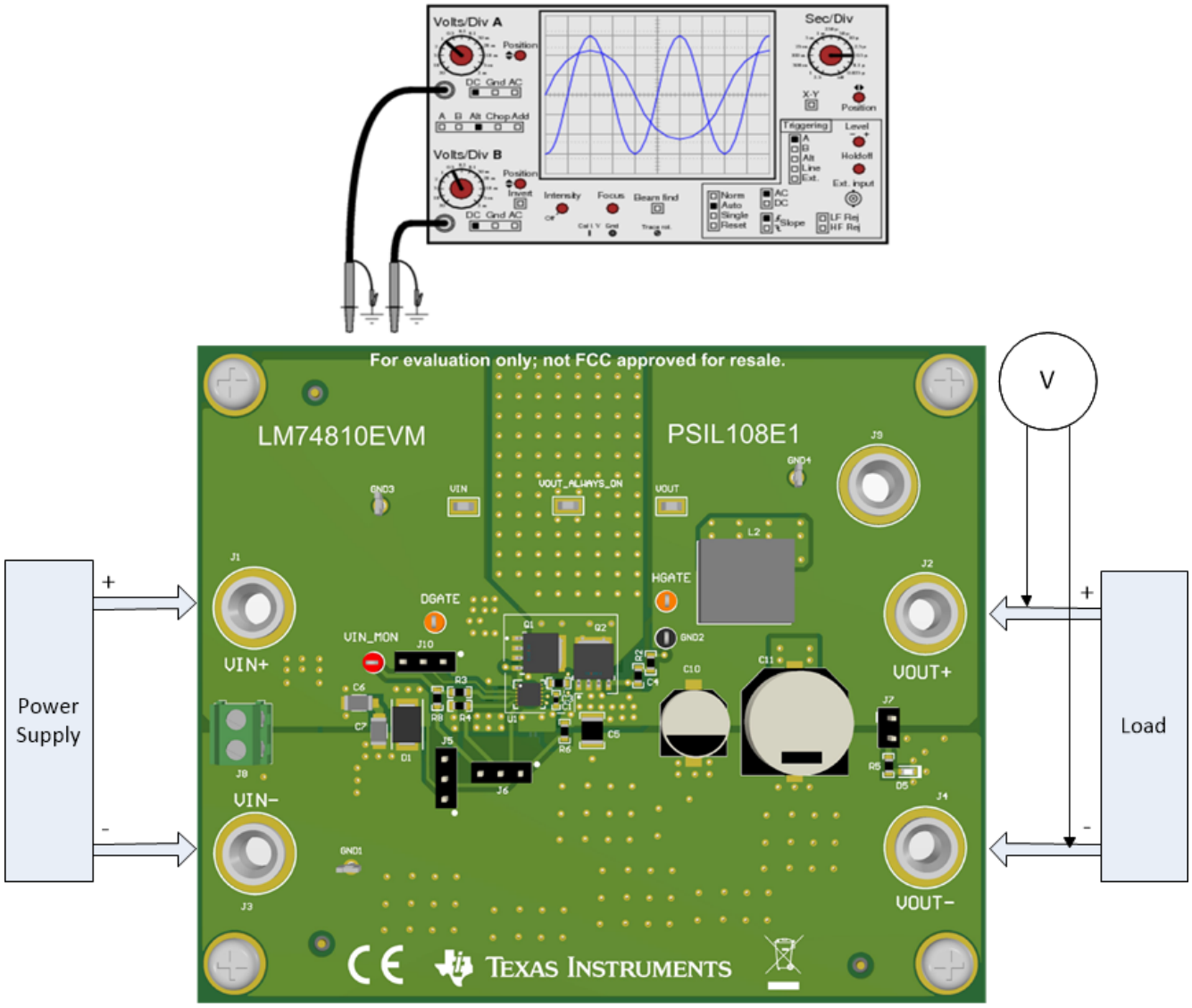

Figure 5-1. LM74810EVM Test Setup

5.1 Initial Setup

Test setup used for evaluating LM74810EVM is shown in Figure 5-1. Steps to be followed before testing the evaluation module are:

- Connect the power supply and load to LM74810EVM.
- Set the power supply output to 12 V and current limit to 10 A.
- Set load to 200 mA or a load value less than 10 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 LM74810EVM-CD is captured in Figure 5-2.

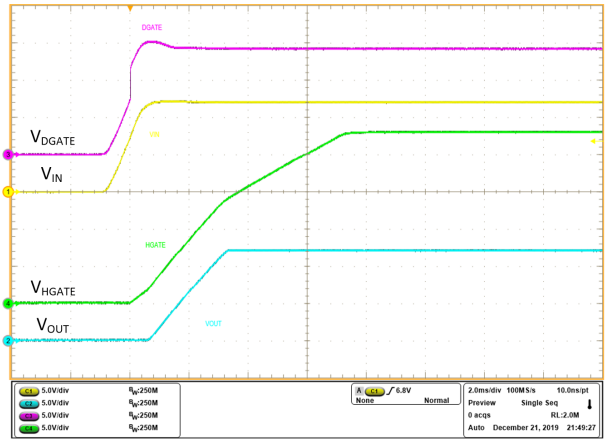

Figure 5-2. Power up: DGATE and HGATE

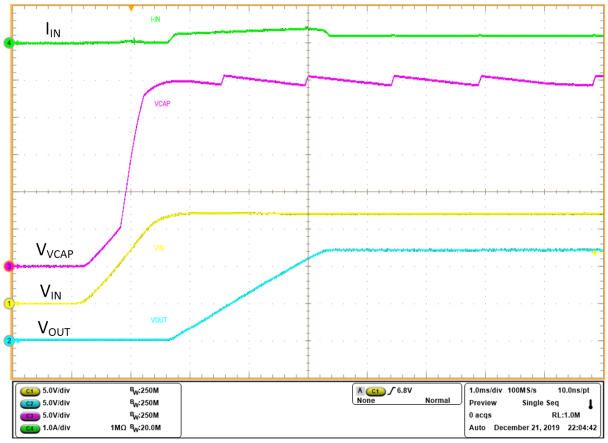

Figure 5-3. Power Up: Charge Pump and Inrush Current

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

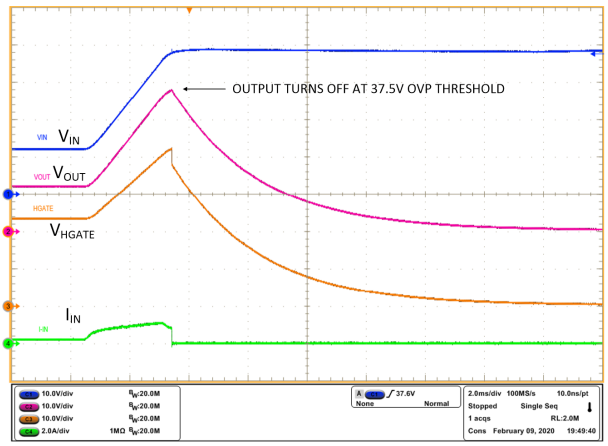

Figure 5-4. Over Voltage Protection

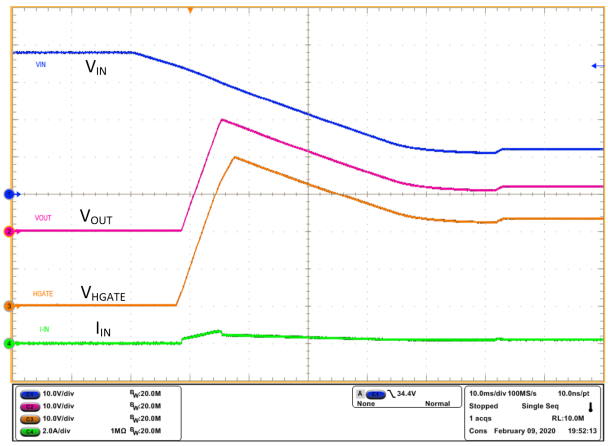

Figure 5-5. Over Voltage Recovery

5.4 Enable Control

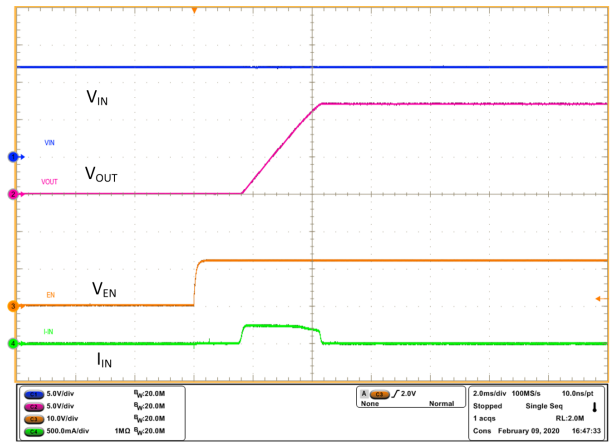

Figure 5-6. Turn ON using EN/UVLO

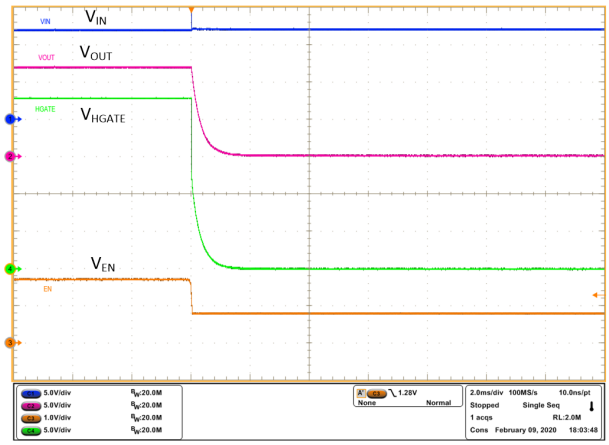

Figure 5-7. Turn OFF using EN/UVLO

5.5 Input Reverse Polarity

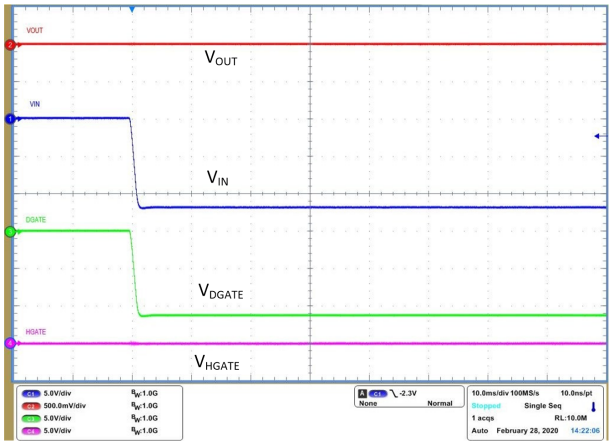

Figure 5-8. Input Reverse Polarity

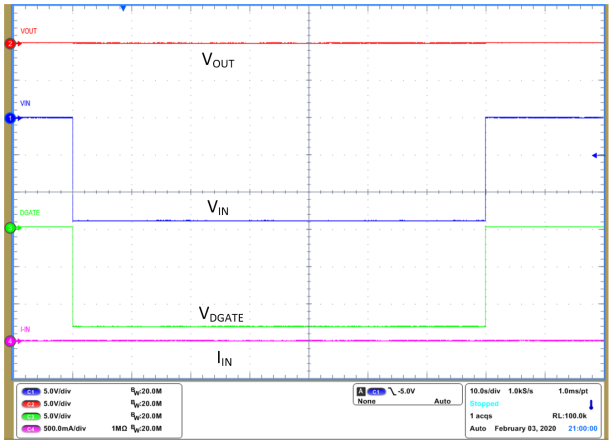

Figure 5-9. Input Reverse Polarity - 12-V 60s

5.6 Load Transient Response

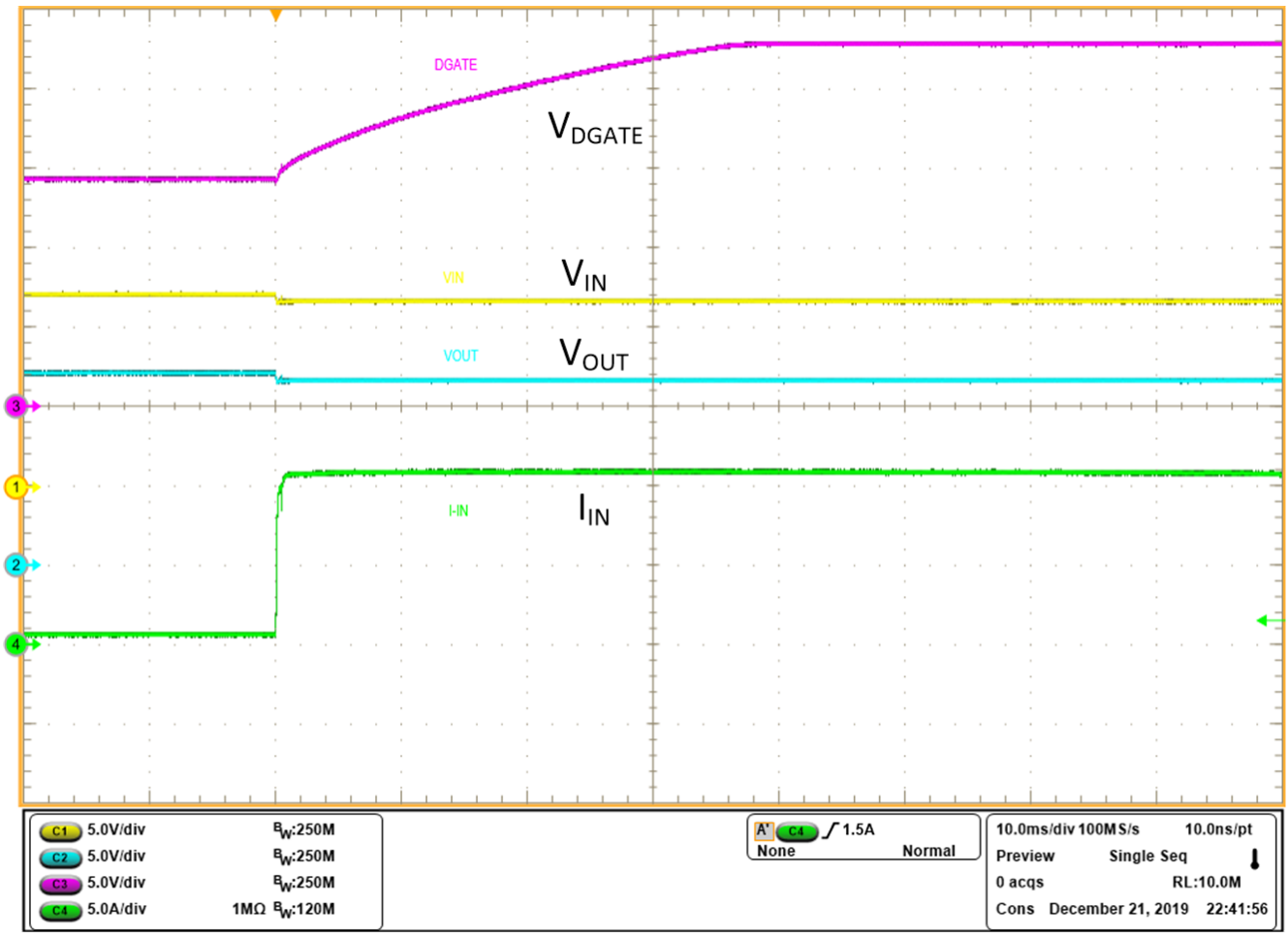

Figure 5-10. Load Transient Response DGATE

6 EVM Board Layout and Bill of Materials

6.1 EVM Board Layout

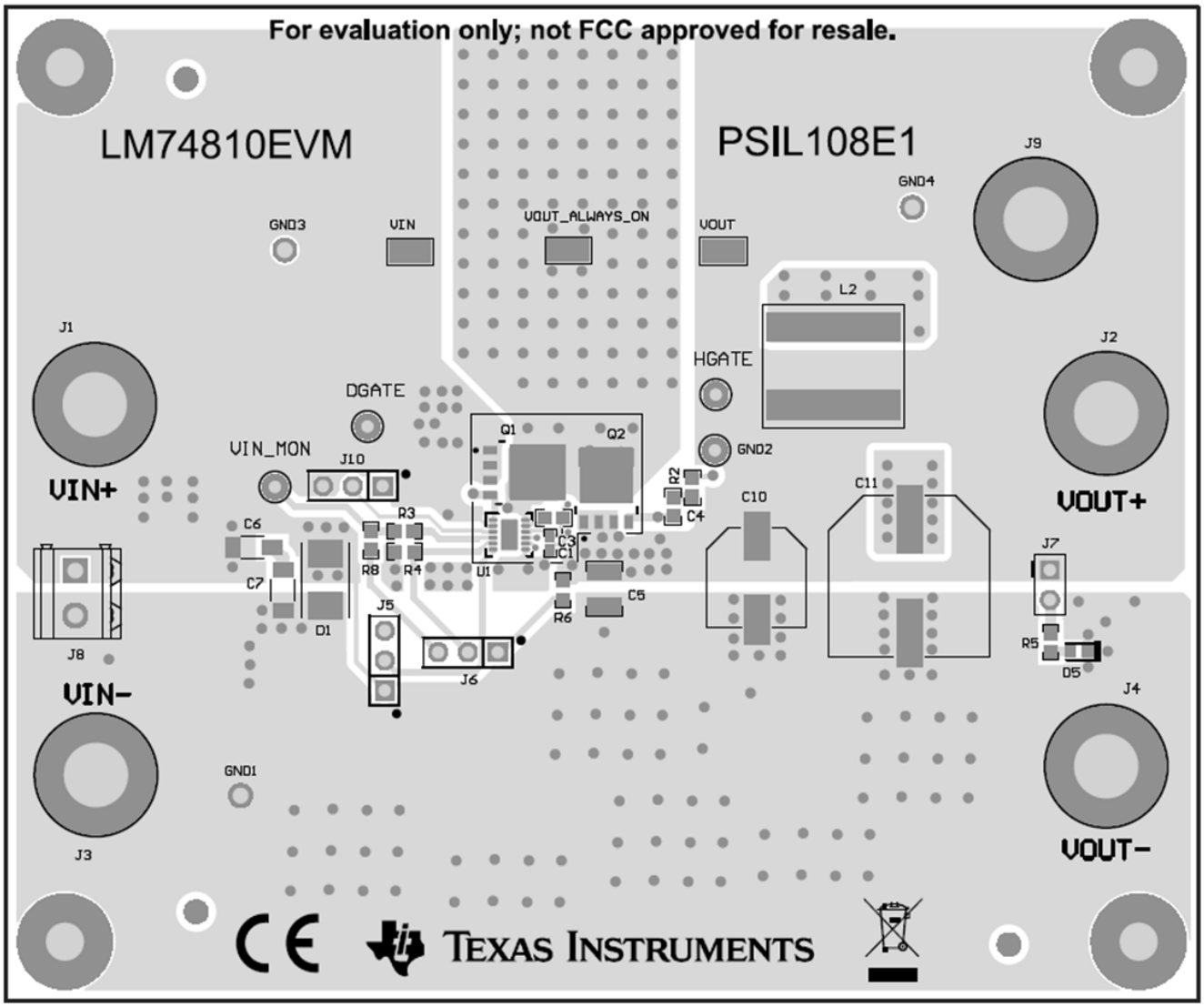

Figure 6-1. Component Placement TOP

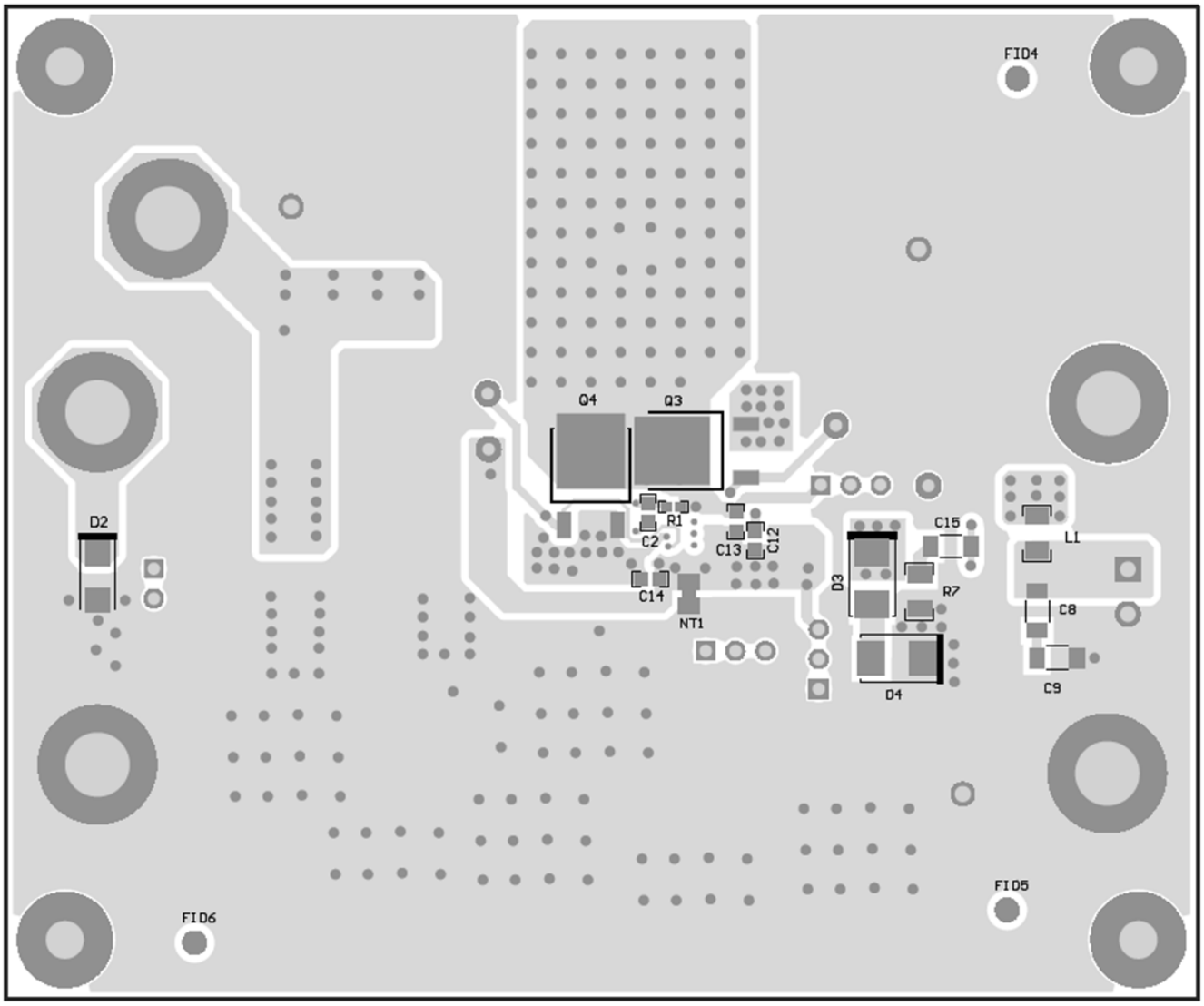

Figure 6-2. Component Placement BOTTOM

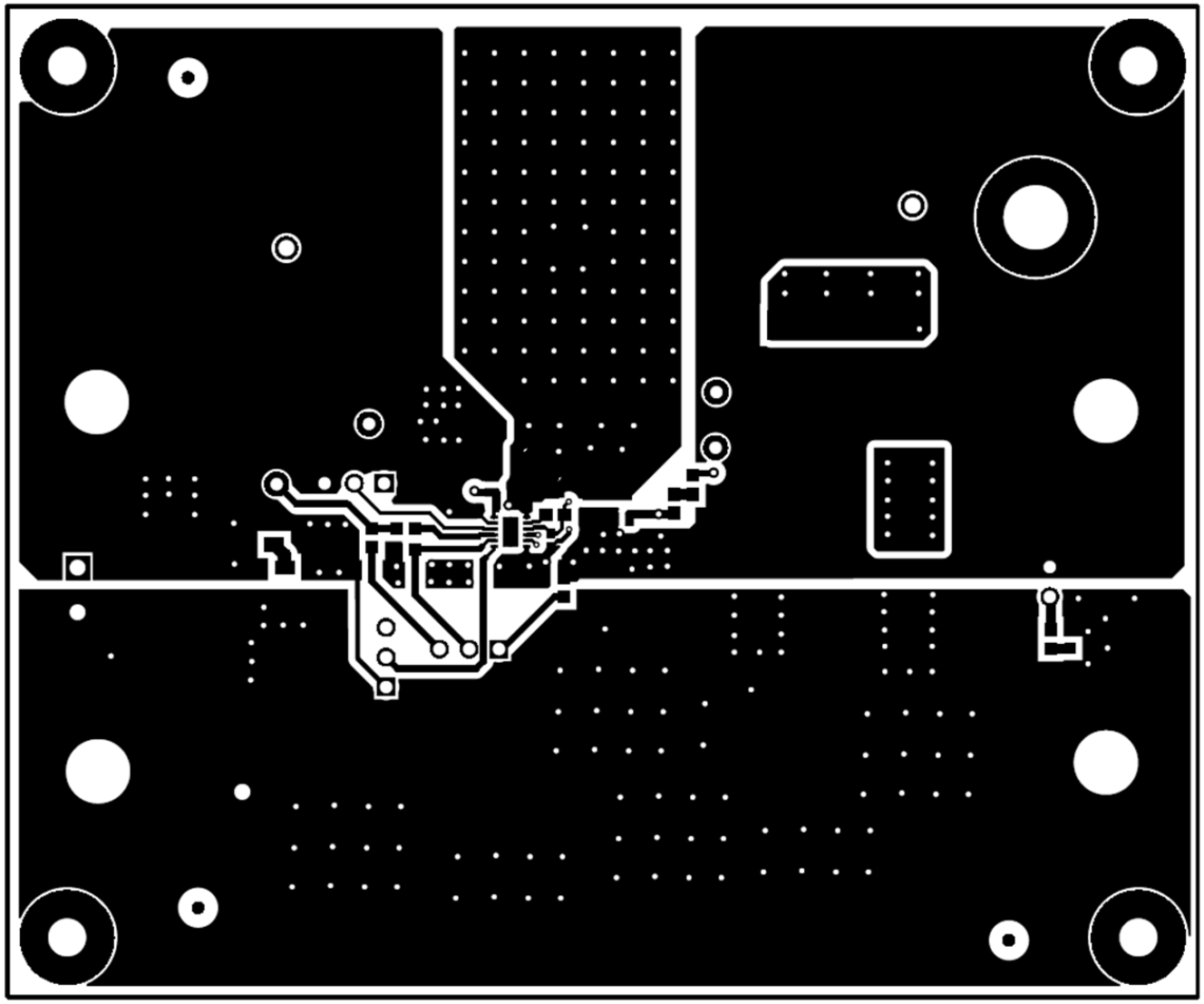

Figure 6-3. TOP Layer Routing

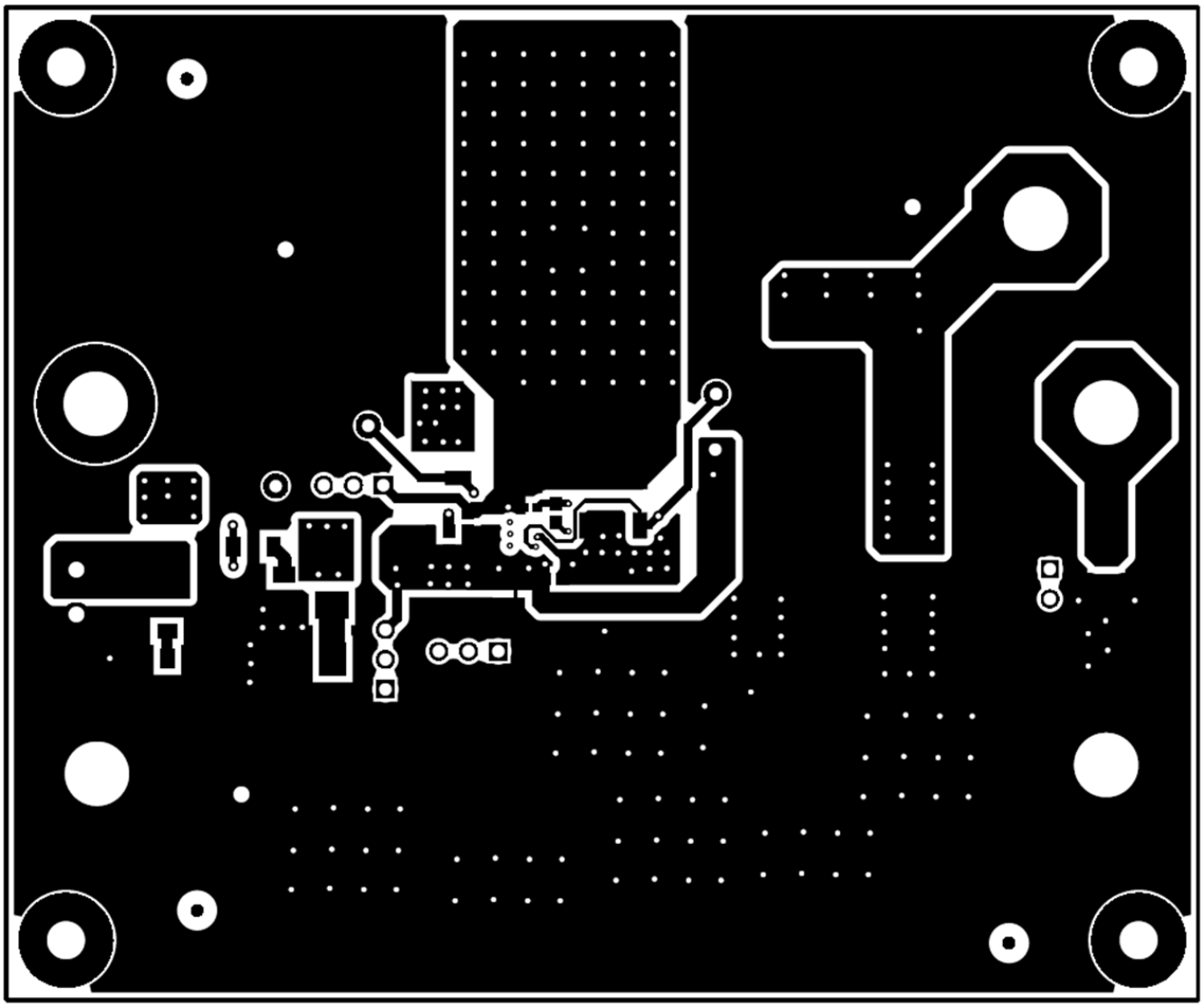

Figure 6-4. BOTTOM Layer Routing

6.2 Bill of Materials

Table 6-1. Bill of Materials

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
!PCB1	1		Printed Circuit Board		PSIL108	Any
C2	1	0.1 uF	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, 0603	0603	GRM188R72A104KA35J	MuRata
C3	1	0.1 uF	CAP, CERM, 0.1 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R1E104K080AA	TDK
C4	1	0.01 uF	CAP, CERM, 0.01 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R2A103K080AA	TDK

Table 6-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
C5	1	2.2 uF	CAP, CERM, 2.2 uF, 100 V, +/- 10%, X7R, 1210	1210	C1210C225K1RACTU	Kemet
C6, C7	2	0.33 uF	CAP, CERM, 0.33 µF, 50 V,+/- 10%, X8R, AEC-Q200 Grade 0, 1206	1206	CGA5L2X8R1H334K160AA	TDK
C10	1	47 uF	CAP, AL, 47 uF, 63 V, +/- 20%, 0.65 ohm, AEC-Q200 Grade 2, SMD	SMT Radial F	EEE-FK1J470P	Panasonic
C13	1	0.015 uF	CAP, CERM, 0.015 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R2A153K080AA	TDK
C15	1	1 uF	CAP, CERM, 1 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	GCM31CR72A105KA03	MuRata
D1	1	33 V	Diode, TVS, Bi, 33 V, SMB	SMB	SMBJ33CA-13-F	Diodes Inc.
D2	1	70 V	Diode, Schottky, 70 V, 1 A, SMA	SMA	B170-13-F	Diodes Inc.
D5	1	Green	LED, Green, SMD	1.6x0.8x0.8mm	LTST-C190GKT	Lite-On
DGATE, HGATE	2		Test Point, Miniature, Orange, TH	Orange Miniature Testpoint	5003	Keystone
GND1, GND3, GND4	3		TEST POINT SLOTTED .118", TH	Test point, TH Slot Test point	1040	Keystone
GND2	1		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone
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, J9	5		Standard Banana Jack, Uninsulated, 8.9mm	Keystone575-8	575-8	Keystone
J5, J6, J10	3		Header, 100mil, 3x1, Tin, TH	Header, 3 PIN, 100 mil, Tin	PEC03SAAN	Sullins Connector Solutions

Table 6-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
J7	1		Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100 mil, Tin	PEC02SAAN	Sullins Connector Solutions
Q1, Q2	2		N-channel 40 V, 0.9 mΩ logic level MOSFET in LFPAK56E	SOT1023	BUK9J0R9-40H	Nexperia
R1	1	0	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	RK73Z1ETTP	KOA Speer
R2	1	100	RES, 100, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100RJNEA	Vishay-Dale
R3	1	91 k	RES, 91 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060391K0JNEA	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
R7	1	200	RES, 200, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW1206200RJNEA	Vishay-Dale
R8	1	9.1 k	RES, 9.1 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06039K10JNEA	Vishay-Dale
U1	1		Ideal Diode Controller with Load Dump Protection, DRR0012E (WSON-12)	DRR0012E	PLM74810DRRRQ1	Texas Instruments
VIN, VOUT, VOUT_ALWAYS_ON	3		Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone
VIN_MON	1		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
C1	0	3900 pF	CAP, CERM, 3900 pF, 100 V, +/- 10%, X7R, 0402	0402	GRM155R72A392KA01D	MuRata

Table 6-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
C8, C9	0	0.33 uF	CAP, CERM, 0.33 µF, 50 V,+/- 10%, X8R, AEC-Q200 Grade 0, 1206	1206	CGA5L2X8R1H334K160AA	TDK
C11	0	220 uF	CAP, AL, 220 uF, 63 V, +/- 20%, 0.16 ohm, AEC-Q200 Grade 2, SMD	SMT Radial H13	EEV-FK1J221Q	Panasonic
C12, C14	0	0.015 uF	CAP, CERM, 0.015 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R2A153K080AA	TDK
D3	0	33 V	Diode, TVS, Uni, 33 V, 53.3 Vc, SMB	SMB	SMBJ33A-13-F	Diodes Inc.
D4	0	16 V	Diode, TVS, Uni, 16 V, 26 Vc, SMB	SMB	SMBJ16A-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
J8	0		Terminal Block, 2x1, 3.81mm, 24-16 AWG, 10A, 300VAC, TH	2x1 Terminal Block	691214310002	Wurth Elektronik
L1	0	10 ohm	Ferrite Bead, 10 ohm @ 100 MHz, 10.5 A, 1206	1206	74279221100	Wurth Elektronik
L2	0	1 uH	Inductor, Shielded, Composite, 1 uH, 43.5 A, 0.001 ohm, SMD	Inductor, 11.3x10x10mm	XAL1010-102MEB	Coilcraft
Q3, Q4	0		INF-MOSFET-N-3	PG-TO252-3	IPD100N06S4-03	Infineon

7 Revision History

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

Changes from Revision * (May 2020) to Revision A (December 2020) **Page**

- Updated the numbering format for tables, figures and cross-references throughout the document.....1
- Updated Figure 3-1 5
- Updated the Bill of Materials 14

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