User's Guide

LM74721EVM: Evaluation Module for LM74721-Q1 Ideal Diode Controller

ABSTRACT

This user's guide describes the LM74721EVM evaluation module for evaluating the performance of the ideal diode controller with switched output, LM74721-Q1. The LM74721-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 LM74721 Evaluation Module LM74721EVM helps designers evaluate the operation and performance of the LM74721-Q1 ideal diode controller with switched output. This evaluation module demonstrates how LM74721-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. The device can withstand and protect the loads from negative supply voltages down to –33-V DC. An integrated ideal diode controller (GATE) drives the first

MOSFET to replace a Schottky diode for reverse input protection and output voltage holdup. Integrated VDS clamp feature enables input TVS less system designs for automotive ISO7637 pulse suppression. 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.

1.1 Features

Key features of the EVM include:

- Integrated VDS clamp for Input TVS less operation for ISO7637 pulse 1 suppression
- 12-V automotive reverse battery protection down to –33 V
- Input operating range 3 V to 40 V, extendable to 65 V
- 5-A maximum load current
- Option for switched output for power path cutoff or clamp
- Enable ON/OFF control
- Programmable over voltage cutoff
- Option for output voltage slew rate control
- LED indication for output ON/OFF detection

1.2 Applications

- Automotive reverse battery protection
- ADAS domain controller
- Camera, radar ECUs
- Head unit
- Premium audio amplifier

2 Description

The LM74721EVM is configured by default for evaluating ideal diode only configuration. On-board options are provided for evaluating the back-to-back N-channel MOSFETs, which realize ideal diode rectifier with power path ON/OFF control and over voltage protection functionalities.

2.1 Input Power and Load (J2, J6 and J3, J7):

Input power is applied at the terminals, J2 and J6. Terminals J3 and J7 provide output connection to load.

2.2 Enable Control (J5):

Enable control is usually used by external MCU or controller to turn off LM74721-Q1 and cut off the power path. Setting 1-2 on J5 enables the controller and 2-3 disables the controller. TI recommends to connect the 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 and Q2):

Q1 is a 60-V rated N-channel MOSFET capable to support 5-A automotive ECU applications. Q1 helps support reverse battery protection up to –33 V, reverse-current blocking and also dissipate the automotive ISO7637 pulse 1 transient during VDS clamp operation. By default, the Q2 FET is not populated and is bypassed by R1 resistor. In order to evaluate power path cut-off ON/OFF and over voltage cut-off functionalities, Q2 needs to be populated and R1 removed.

2.4 Output Slew Rate Control (R5 and C5):

When Q2 is populated, R5 and C5 provide output slew rate control and can be changed to achieve different output slew rate.

2.5 Output Schottky Diode (D3) and LED Indication:

Schottky diode D3 is populated on EVM by default and is recommended where output voltage can have negative transients that can exceed absolute maximum ratings of LM74721-Q1. It can be removed if negative transients are not possible at the output.

D4 provides an indication on the status of the output voltage.

2.6 TVS Selection for 12-V Battery Protection:

By default, the TVS diode D2 at the input is not populated as the LM74721-Q1 enables input TVS less system designs for automotive ISO7637-2 pulse 1 suppression. A suitable TVS can be populated in case voltage transients beyond the absolute maximum rating of the device can occur on the positive side in the system.

2.7 Test Points:

Table 2-1 lists the LM74721EVM board input and output connector functionality. Table 2-2 and Table 2-3 provide the test points description and the jumper functionality of the EVM respectively.

Table 2-1. Connectors: Input and Output

Connector	Description
J2	Power input connector to the positive rail of the input power supply
J6	Ground connection for the power supply
J3	Power output connector to the positive side of the load
J1	Power output connector to the positive side after the optional LC filter
J7	Ground connection for the load

Table 2-2. Test Points Description

Test Point	Name	Description
TP1	VIN	Input power supply to the EVM
TP2	VOUT	Output from the EVM
TP3	VIN_MON	Input monitoring for battery inputs
TP6	GATE	Output of Ideal Diode MOSFET Gate Control
TP7	PD	Output of Hot-Swap MOSFET Gate Control
TP8	CAP1	Internal Boost Regulator output
TP9	C	Cathode pin
TP4, TP5	PGND	Test Point for EVM Ground

Table 2-3. Jumpers and LED Description

Jumpers	Description
J5	EN/UVLO control • 1-2 enables by connecting to common drain point • 2-3 disables by connecting to GND
J7	Enables LED indication for output

3 Schematic

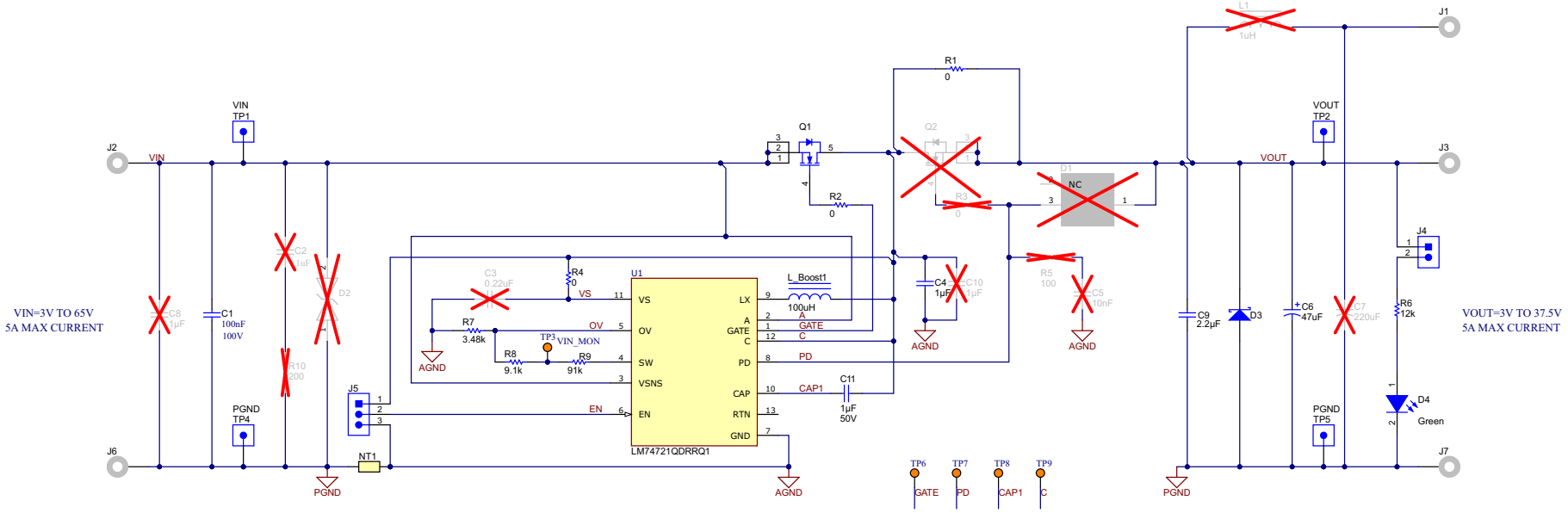


Figure 3-1. LM74721EVM Schematic

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 section describes the test procedure for LM74721-Q1 device.

Default jumper setting for LM74721EVM board is shown in Figure 5-1.

Table 5-1. Default Jumper Setting for LM74721EVM

J5	J4
1-2 or connect 2 to external enable control	1-2, Output LED Indication

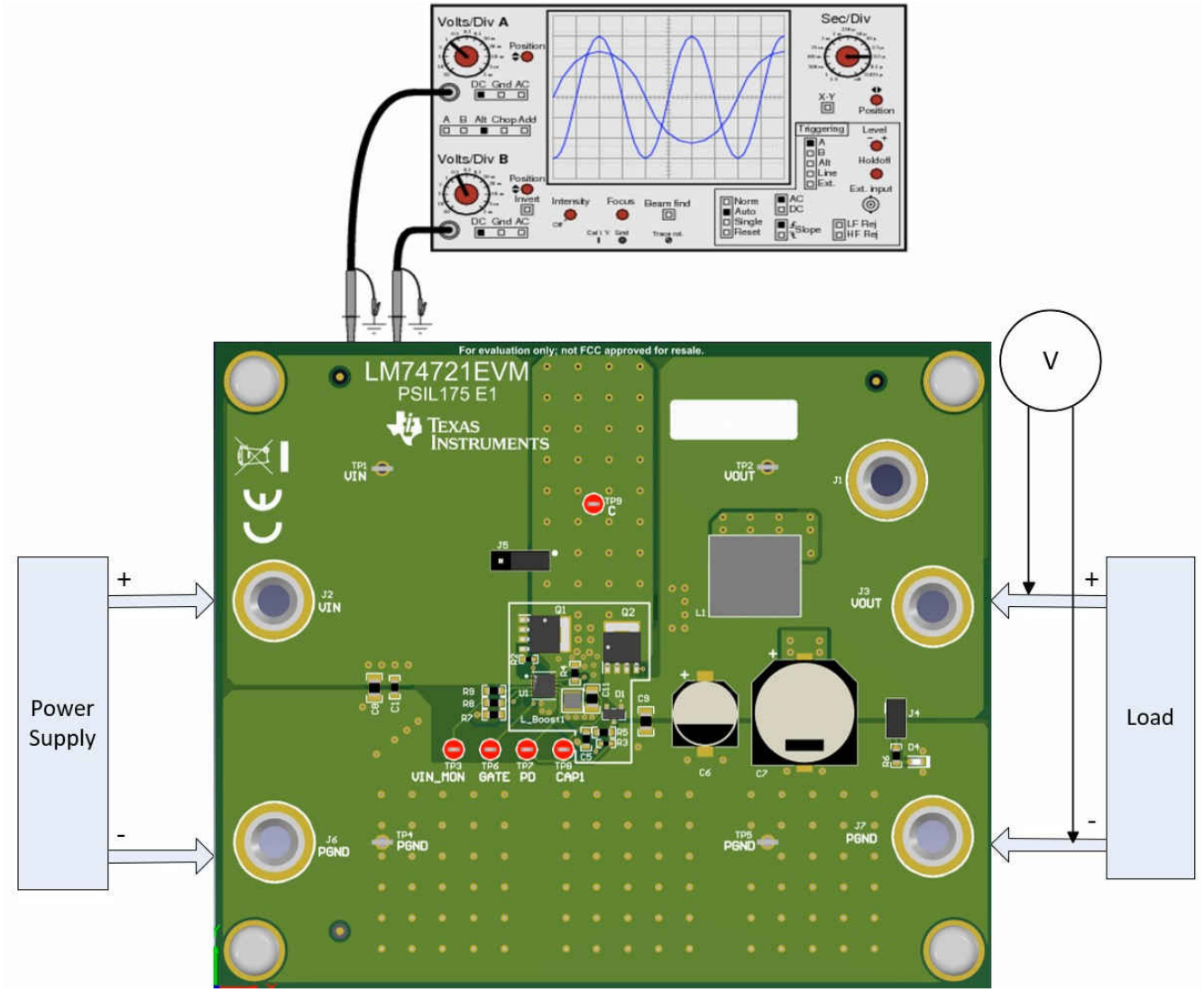


Figure 5-1. LM74721EVM Test Setup

5.1 Initial Setup

Test setup used for evaluating LM74721EVM is shown in Figure 5-1. Steps to be followed before testing the evaluation module are:

- Connect the power supply and load to LM74721EVM.
- 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 LM74721EVM is captured in Figure 5-2.

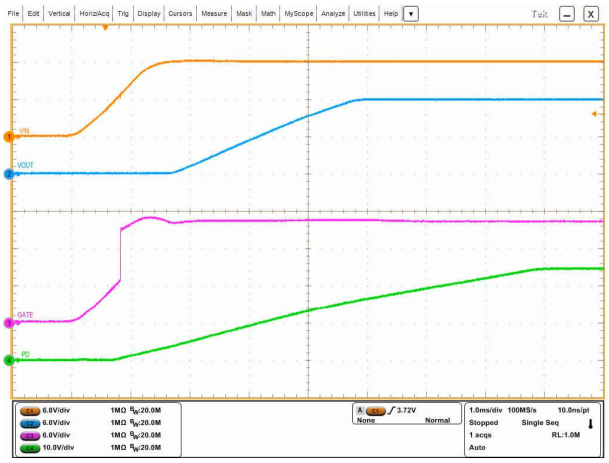


Figure 5-2. Power Up: GATE and PD

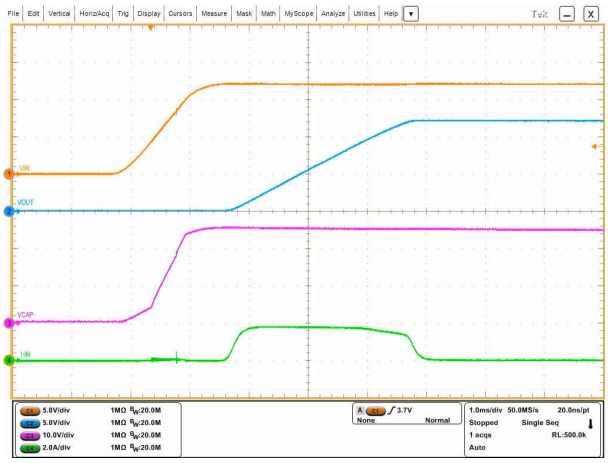


Figure 5-3. Power Up: Charge Pump and Inrush Current

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

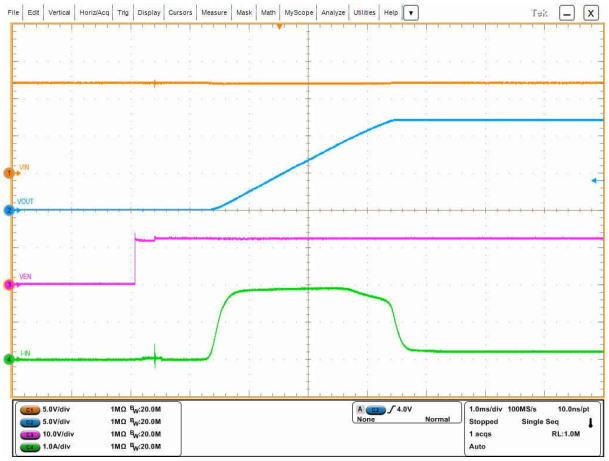


Figure 5-4. Turn ON Using EN - Inrush Current

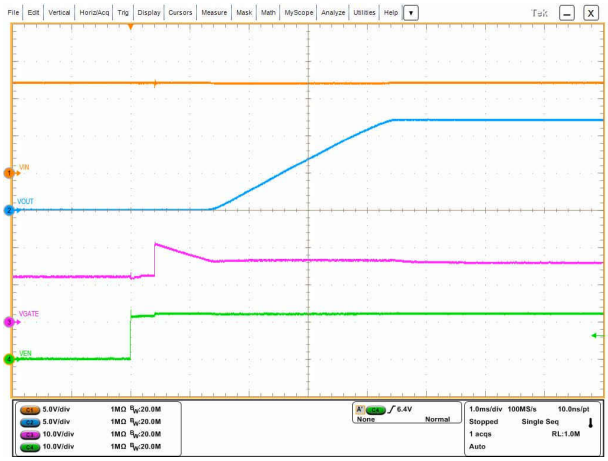


Figure 5-5. Turn ON Using EN - DGATE

5.4 Hot-Plug and Disable Using EN

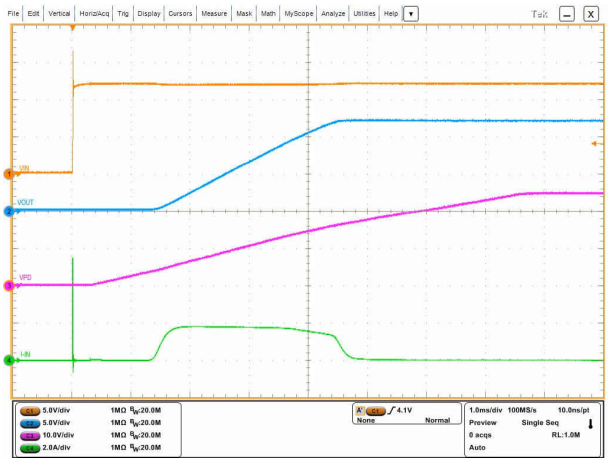


Figure 5-6. Hot-Plug 12 V

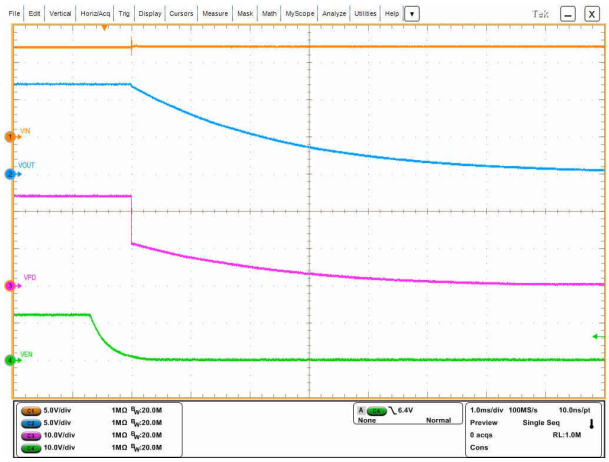


Figure 5-7. Disable Using EN

5.5 Inrush Current Control

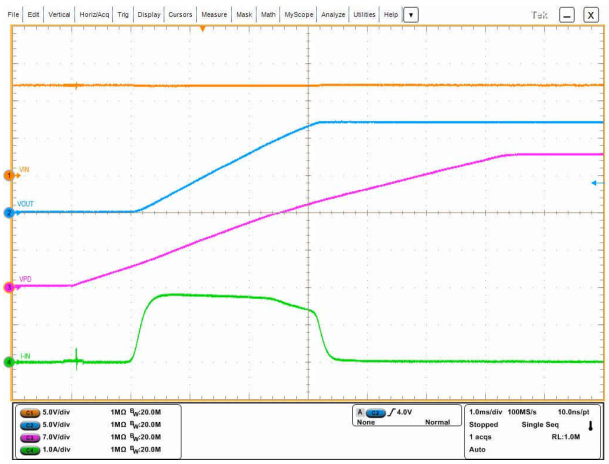


Figure 5-8. Inrush Current With No Load

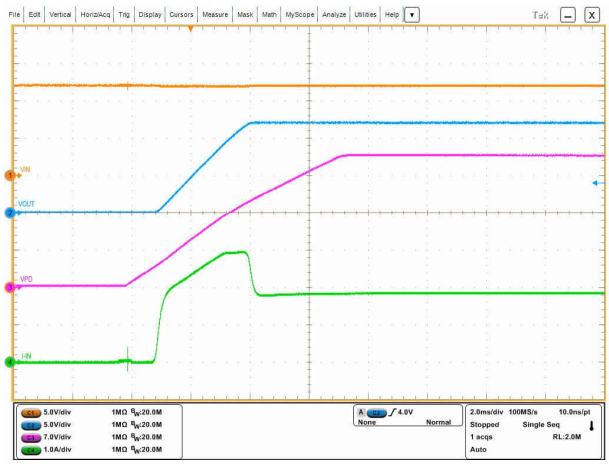


Figure 5-9. Inrush Current With 6-Ω Load

5.6 Load Response

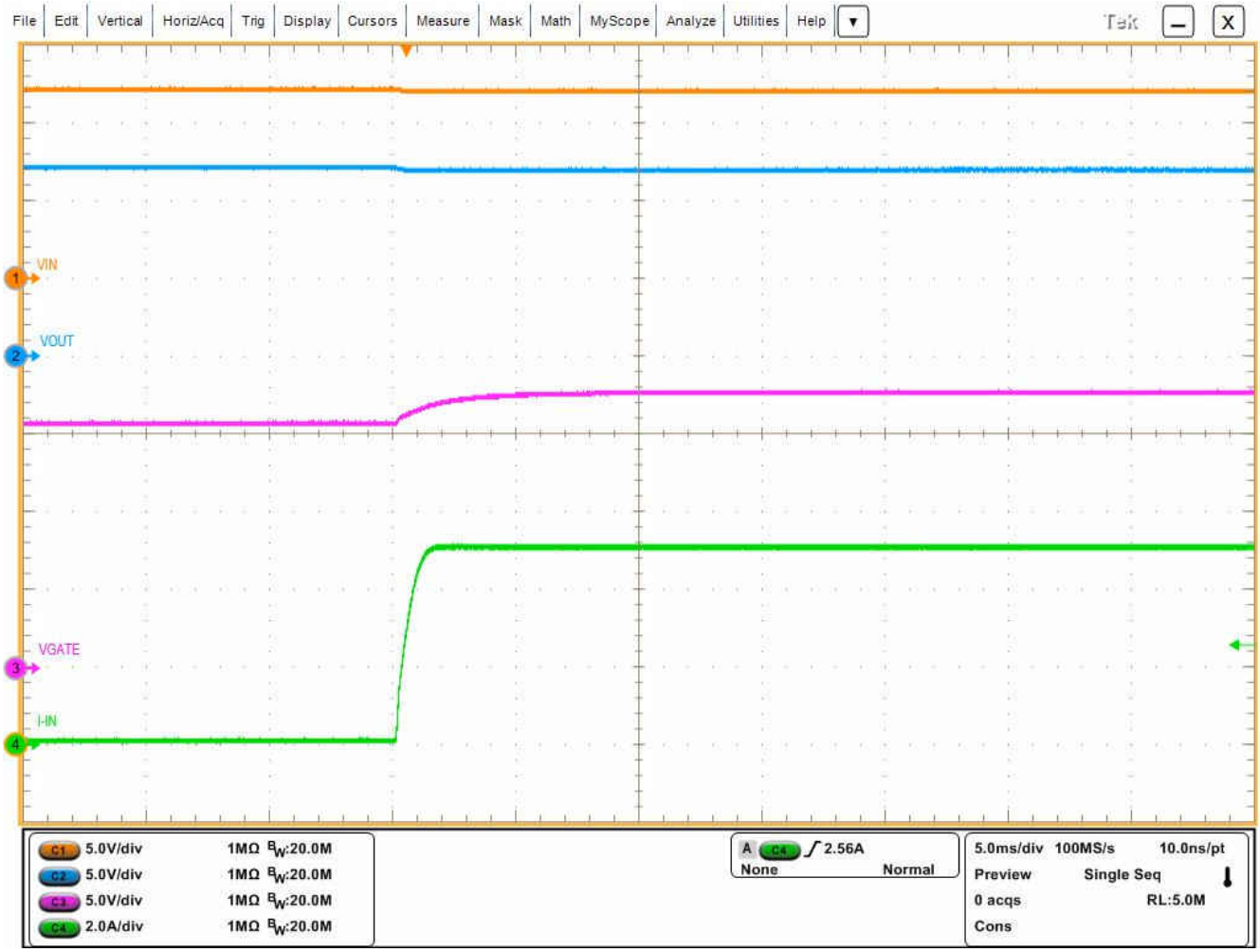


Figure 5-10. Load Transient Response 100 mA to 5 A

6 Board Layout and Bill of Materials

6.1 Board Layout

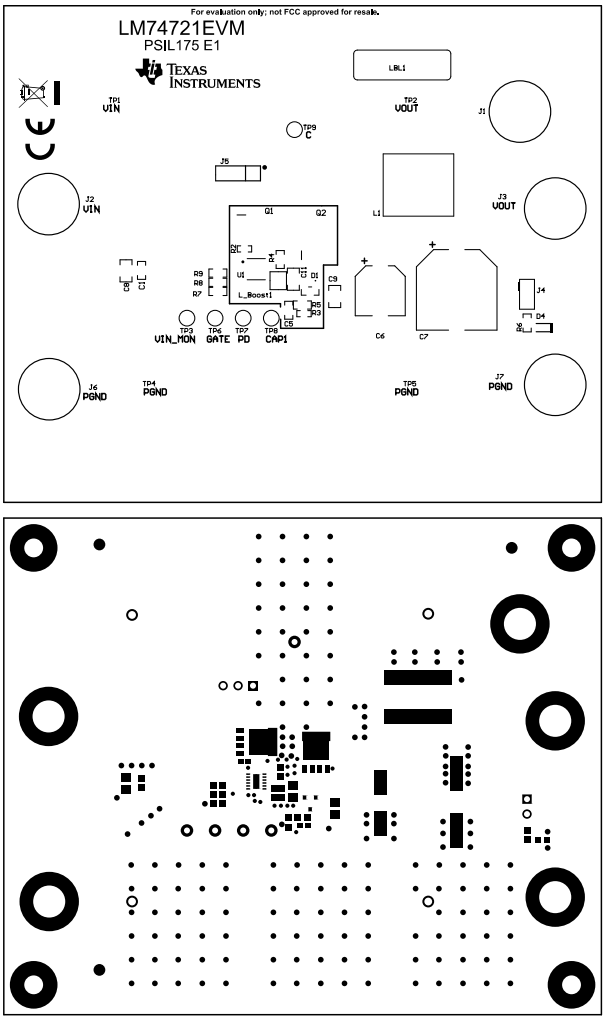
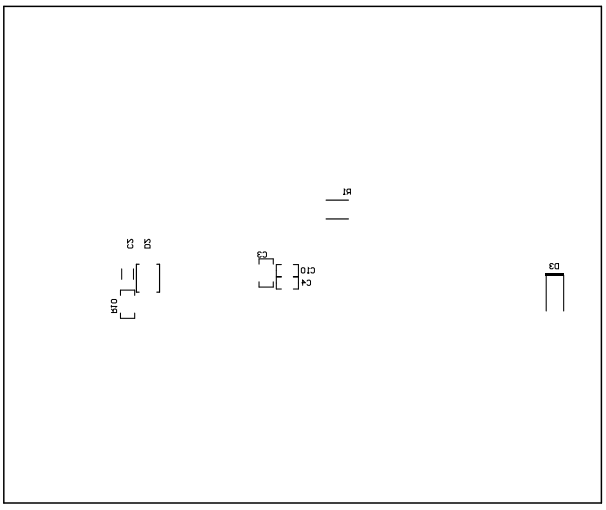


Figure 6-1. Component Placement and Solder Pad TOP



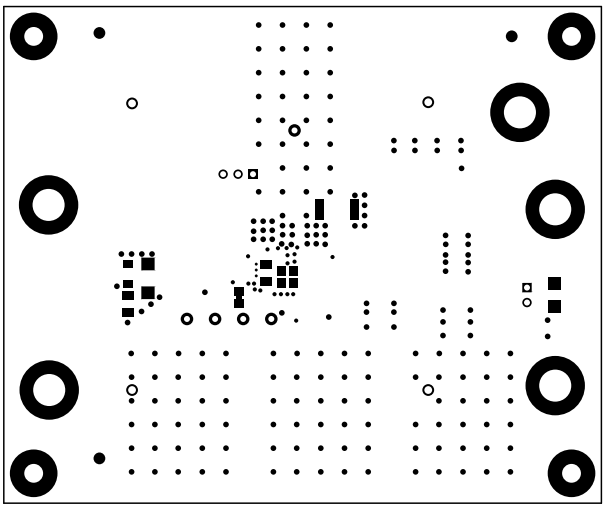


Figure 6-2. Component Placement and Solder Pad BOTTOM

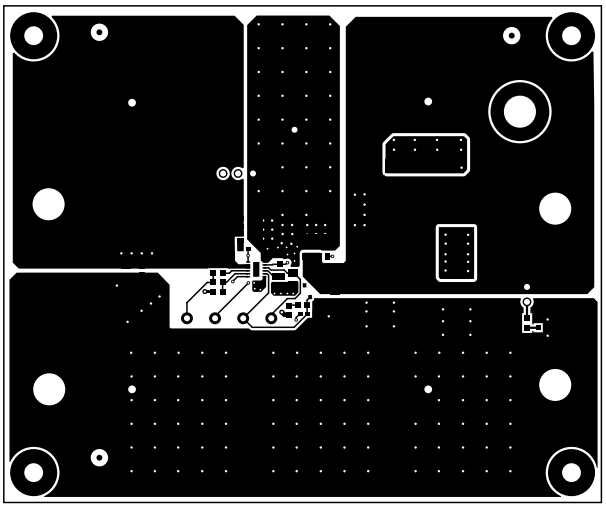


Figure 6-3. TOP Layer Routing

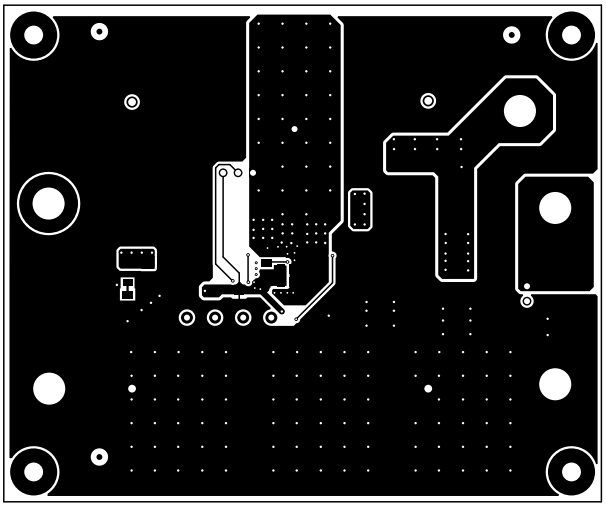


Figure 6-4. BOTTOM Layer Routing

6.2 Bill of Materials

Table 6-1. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1	1	0.1 uF	CAP, CERM, 0.1 µF, 100 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	603	HMK107B7104KAHT	Taiyo Yuden
C4, C11	2	1 uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	805	CGA4J3X7R1H105K125AB	TDK
C6	1	47 uF	CAP, AL, 47 uF, 63 V, +/- 20%, 0.65 ohm, AEC-Q200 Grade 2, SMD	SMT Radial F	EEE-FK1J470P	Panasonic
C9	1	2.2 uF	CAP, CERM, 2.2 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	805	CGA4J3X7R1H225K125AB	TDK
D3	1	70 V	Diode, Schottky, 70 V, 1 A, SMA	SMA	B170-13-F	Diodes Inc.
D4	1	Green	LED, Green, SMD	1.6x0.8x0.8mm	LTST-C190GKT	Lite-On
FID1, FID2, FID3, FID4, FID5, FID6	6		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
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, J6, J7	5		Standard Banana Jack, Uninsulated, 8.9mm	Keystone575-8	575-8	Keystone
J4	1		Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100mil, Tin	PEC02SAAN	Sullins Connector Solutions
J5	1		Header, 100mil, 3x1, Tin, TH	Header, 3 PIN, 100mil, Tin	PEC03SAAN	Sullins Connector Solutions

Table 6-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
L_Boost1	1	100 uH	Inductor, Shielded, Composite, 100 uH, 0.17 A, 8.48 ohm, SMD	XPL2010	XPL2010-104MLB	Coilcraft
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady
Q1	1	60 V	MOSFET, N-CH, 60 V, 100 A, AEC-Q101, SOT669	SOT669	BUK7Y4R8-60EX	Nexperia
R1	1	0	RES, 0, 5%, 1 W, AEC-Q200 Grade 0, 2512	2512	CRCW25120000Z0EG	Vishay-Dale
R2	1	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	402	ERJ-2GE0R00X	Panasonic
R4	1	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	ERJ-3GEY0R00V	Panasonic
R6	1	12 k	RES, 12 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW060312K0JNEA	Vishay-Dale
R7	1	3.48 k	RES, 3.48 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW06033K48FKEA	Vishay-Dale
R8	1	9.1 k	RES, 9.1 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW06039K10JNEA	Vishay-Dale
R9	1	91 k	RES, 91 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW060391K0JNEA	Vishay-Dale
SH-J4, SH-J5	2	1x2	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt	SPC02SYAN	Sullins Connector Solutions

Table 6-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
TP1, TP2, TP4, TP5	4		TEST POINT SLOTTED .118", TH	Test point, TH Slot Test point	1040	Keystone
TP3, TP6, TP7, TP8, TP9	5		Test Point, Miniature, Orange, TH	Orange Miniature Testpoint	5003	Keystone
U1	1		Low IQ Ideal Diode with VDS Clamp and Active Rectification	WSON12	LM74721QDRRQ1	Texas Instruments
C2	0	1 uF	CAP, CERM, 1 uF, 100 V, +/- 10%, X7S, AEC-Q200 Grade 1, 0805	805	CGA4J3X7S2A105K125AB	TDK
C3	0	0.22 uF	CAP, CERM, 0.22 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	CGA5H2X7R2A224K115AA	TDK
C5	0	0.01 uF	CAP, CERM, 0.01 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	603	CGA3E2X7R2A103K080AA	TDK
C7	0	220 uF	CAP, AL, 220 uF, 63 V, +/- 20%, 0.16 ohm, AEC-Q200 Grade 2, SMD	SMT Radial H13	EEV-FK1J221Q	Panasonic
C8, C10	0	1 uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	805	CGA4J3X7R1H105K125AB	TDK
D1	0		Zener Diode 18V 250mW ±2% Surface Mount TO-236AB	SOT23	BZX84-B18,215	Nexperia
D2	0		Diode TVS Single Bi-Dir 36V 600W 2-Pin SMB	DO-214AA	SMBJ36CA	Littelfuse
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 of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
Q2	0	60 V	MOSFET, N-CH, 60 V, 100 A, AEC-Q101, SOT669	SOT669	BUK7Y4R8-60EX	Nexperia
R3	0	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	402	ERJ-2GE0R00X	Panasonic
R5	0	100	RES, 100, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW0603100RJNEA	Vishay-Dale
R10	0	200	RES, 200, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW1206200RJNEA	Vishay-Dale

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