

# LM74930-Q1 Evaluation Module for Ideal Diode Controller



## Description

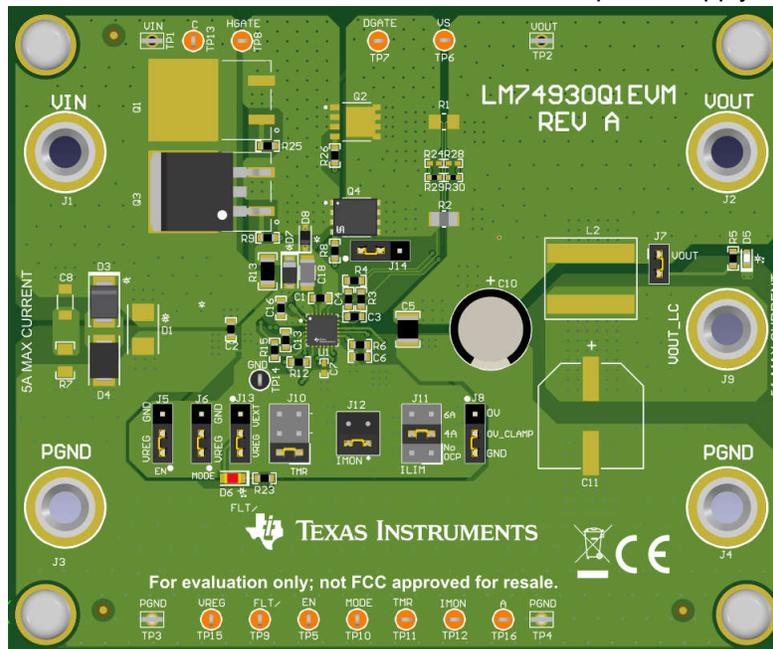
The LM74930-Q1 Evaluation Module (LM74930Q1EVM) helps designers evaluate the operation and performance of the LM74930-Q1 ideal diode controller with power path ON/OFF control, overcurrent, short-circuit and overvoltage protection. The wide input supply of LM74930-Q1, 4V to 65V, allows protection and control of 12-V and 24-V automotive battery powered ECUs. The LM74930-Q1 can drive back-to-back external N-Channel MOSFETs connected in common source topology to realize surge stopper functionality. With first MOSFET in the power path, the device allows load disconnect (ON/OFF control) in case of overcurrent and surge/overvoltage events using HGATE control. An integrated ideal diode controller (DGATE) drives the second MOSFET to replace a Schottky diode for reverse input protection and output voltage holdup.

## Features

- Reverse current blocking feature required for ORing application
- Input reverse battery protection
- Drives external back-to-back N-Channel MOSFETs in common source configuration
- Surge protection against transients like 200 V unsuppressed load dump
- Adjustable overcurrent and short circuit protection
- Analog current monitor output with 10% accuracy (IMON)
- Adjustable overvoltage and undervoltage
- MODE pin to allow bi-directional current flow (MODE = Low)

## Applications

- 12 V/24 V automotive reverse battery protection
- [Industrial transport](#)
- Redundant power supply ORing



LM74930Q1EVM

# 1 Evaluation Module Overview

## 1.1 Introduction

This user's guide describes the LM74930Q1EVM evaluation module for evaluating the performance of the LM74930-Q1 ideal diode controller devices. The LM74930-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, as well as overcurrent, short-circuit, and overvoltage protection. This document provides EVM configuration information and test setup details for evaluating the LM74930-Q1 device. The EVM schematic, board layout, and bill of materials (BOM) are also included.

**Table 1-1. LM74930Q1EVM Evaluation Board Options and Setting**

Part Number	EVM Function	Vin Range	Vin UVLO	Vin OVP	ENABLE (EN)	Overcurrent Protection		Features
						Low Setting	Hi Setting	
LM74930Q1EVM	Ideal diode with surge stopper functionality, circuit breaker, under and overvoltage protection with fault output	4 V to 65 V	5.3 V	36.96 V	Active high	4 A	6 A	Selectable overcurrent threshold and timer setting

## 1.2 Kit Contents

**Table 1-2. LM74930Q1EVM Kit Contents**

Item	Description	Quantity
LM74930Q1EVM	PCB	1

## 1.3 Specification

- 4-V to 65-V input range
- 4-A and 6-A adjustable overcurrent protection using on-board jumpers
- Programmable circuit breaker timer
- Load current monitoring output
- Programmable auto-retry and latch options
- LED for fault indication
- LED indication for output ON/OFF detection

## 1.4 Device Information

LM74930-Q1 is an ideal diode with surge stopper, circuit breaker, overvoltage protection and fault output. The LM74930-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 with overcurrent and overvoltage protection. The wide input supply of 3 V to 65 V allows protection and control of 12-V and 24-V automotive battery powered ECUs. The device can withstand and protect the loads from negative supply voltages down to -65 V.

## 2 Hardware

### 2.1 Test Points and Connectors

Table 2-1 lists the LM74930Q1EVM evaluation board input and output connector functionality. Table 2-2 and Table 2-3 describe the test point availability and the jumper functionality.

**Table 2-1. Input and Output Connector Functionality**

Connector	Label	Description
J1	VIN	Power input connector to the positive rail of the input power supply.
J3	PGND	Ground connection for the power supply.
J2	VOUT	Power output connector to the positive side of the load.
J9	VOUT_LC	Power output connector after the output CLC Filter.
J4	PGND	Ground connection for the load.

**Table 2-2. Test Points Description**

Test Points	Label	Description
TP1	VIN	Input power supply to the EVM.
TP2	VOUT	Output from the EVM.
TP3, TP4, TP14	PGND	EVM ground.
TP5	EN	Enable input.
TP6	VS	Input power supply to the IC.
TP7	DGATE	Diode controller gate drive output.
TP8	HGATE	GATE driver output for the HSFET.
TP9	FLT/	Active low open drain fault output.
TP10	MODE	MODE input to disable reverse current blocking function of DGATE.
TP11	TMR	Fault timer input.
TP12	IMON	Analog current monitor output.
TP13	C	Cathode of the ideal diode.
TP15	VREG	Onboard regulated voltage supply

**Table 2-3. Jumper and LED Descriptions**

Jumper	Connection	Description
J5	1-2	EN connected to VREG. EN pulled High.
	2-3	EN connected to GND. EN pulled Low.
J6	1-2	MODE connected to VREG.
	2-3	MODE connected to GND. RCB disabled.
J7	1-2	Output high D5 LED indication.
J8	1-2	OVCLAMP connected to OV for overvoltage clamp with timer functionality.
	2-3	OVCLAMP connected to GND when OV clamp not needed.
J10	1-2	TIMER duration set to 0.14ms.
	3-4	TIMER duration set to 0.68ms,
	5-6	Controller set in latch-off mode,
J11	1-2	Overcurrent protection disabled.
	3-4	Overcurrent protection threshold set to 4A.
	5-6	Overcurrent protection threshold set to 6A.
J12	1-2	IMON voltage set to 0.65V/A.
	3-4	IMON voltage set to 0.43V/A.
J13	1-2	Pulls FLT/ pin to external supply
	2-3	Pulls FLT/ pin to onboard VREG supply.

**Table 2-3. Jumper and LED Descriptions (continued)**

Jumper	Connection	Description
J14	1-2	Pulls OV resistor divider to VIN
	2-3	Pulls OV resistor divider to VOUT

## 2.2 Test Equipment and Setup

### 2.2.1 Power Supplies

One adjustable power supply with 0-V to 60-V output and 0-A to 10-A output current limit.

### 2.2.2 Meters

One DMM minimum needed.

### 2.2.3 Oscilloscope

A DPO2024 or equivalent, 3 × 10 voltage probes, and a DC current probe.

### 2.2.4 Loads

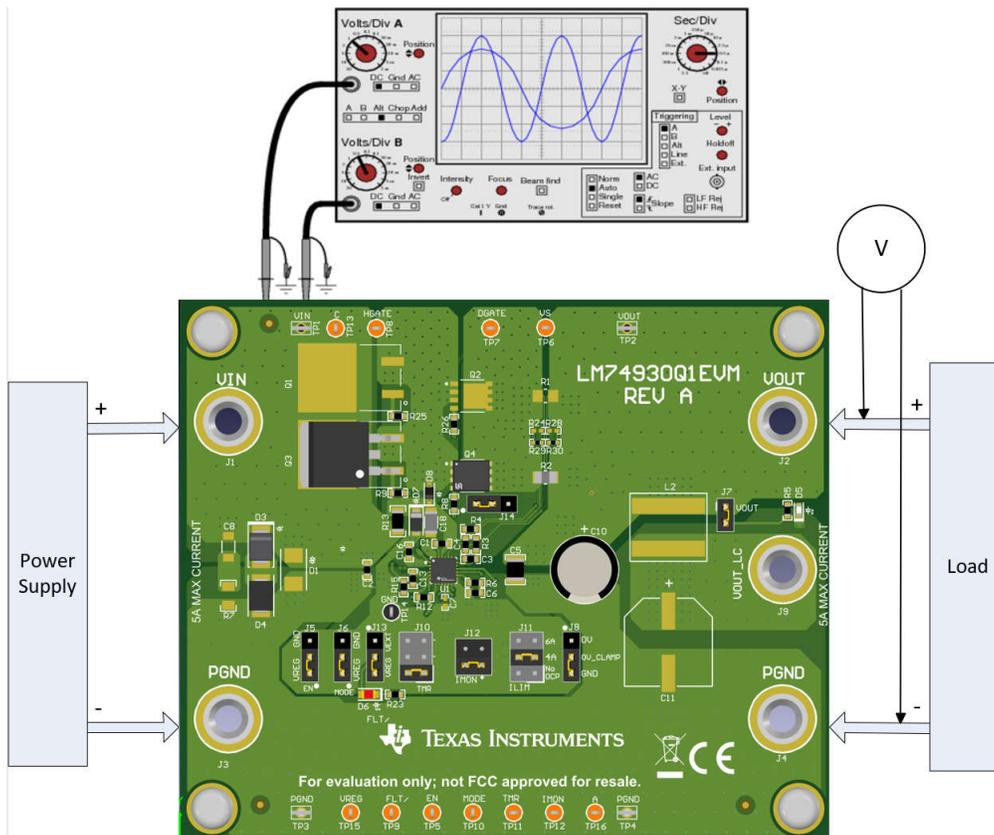
One resistive load or equivalent that can tolerate up to 50-A DC load at 60 V and capable of the output short.

## 2.3 Test Setup and Procedures

Make sure the evaluation board has default jumper settings as shown in [Table 2-4](#).

**Table 2-4. Default Jumper Setting for LM74930Q1EVM Evaluation Board**

Jumper	Default Setting	Functionality
J5	1-2	EN connected to VREG. EN pulled High.
J6	1-2	MODE connected to VREG. Reverse current blocking enabled.
J7	1-2	D5 LED indication when output High.
J8	2-3	OVCLAMP connected to GND. OVCLAMP functionality disabled.
J10	1-2	TIMER set to 0.14 ms.
J11	3-4	Overcurrent protection threshold set to 4 A.
J12	1-2	IMON voltage set to 0.65 V/A.
J13	2-3	FLT/ pulled up to VREG.
J14	1-2	OV resistor ladder pulled to VIN.



**Figure 2-1. LM74930Q1EVM Setup With Test Equipment**

Use the following instructions before starting any test and repeat again before moving to next test.

1. Set the power supply output  $V_{IN}$  to 0 V.
2. Turn ON the power supply and set the power supply output  $V_{IN}$  to 12 V and current limit of 10 A.
3. Turn OFF the power supply.
4. Set the jumper setting on EVM to default position as shown in [Table 2-4](#).

### 2.3.1 Power-up and Power-down with Input Voltage

Use the following instructions to capture the precharging current profile.

1. Set the input supply voltage  $V_{IN}$  to 12 V and current limit of 10 A.
2. Verify that the J5 jumper setting is set to 1-2.
3. Turn ON the input power supply.
4. Observe the start-up profile of charge pump voltage  $V_{CAP}$ , HGATE, DGATE and output voltage.
5. Turn OFF the input power supply.
6. Observe the shutdown profile of charge pump voltage ( $V_{CAP} - V_{VS}$ ), output voltage, HGATE, and DGATE.

[Figure 2-2](#) shows an example of power-up with EN profile captured on the LM74930Q1EVM evaluation board.

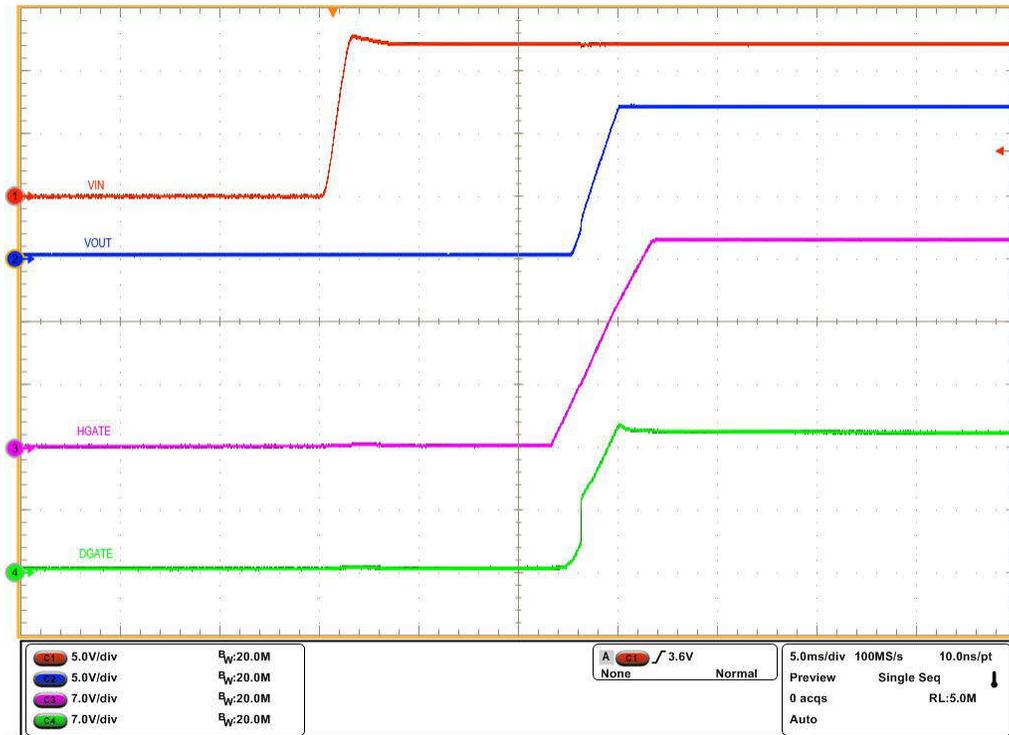


Figure 2-2. LM74930-Q1 Start-Up With VIN - HGATE, DGATE and VOUT

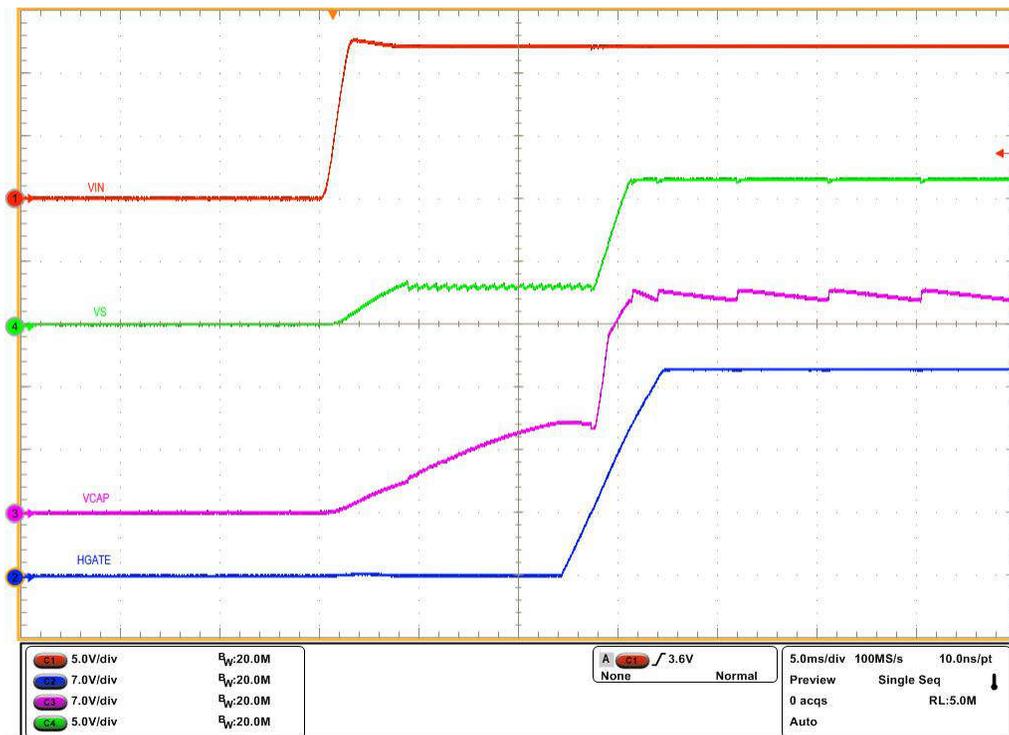
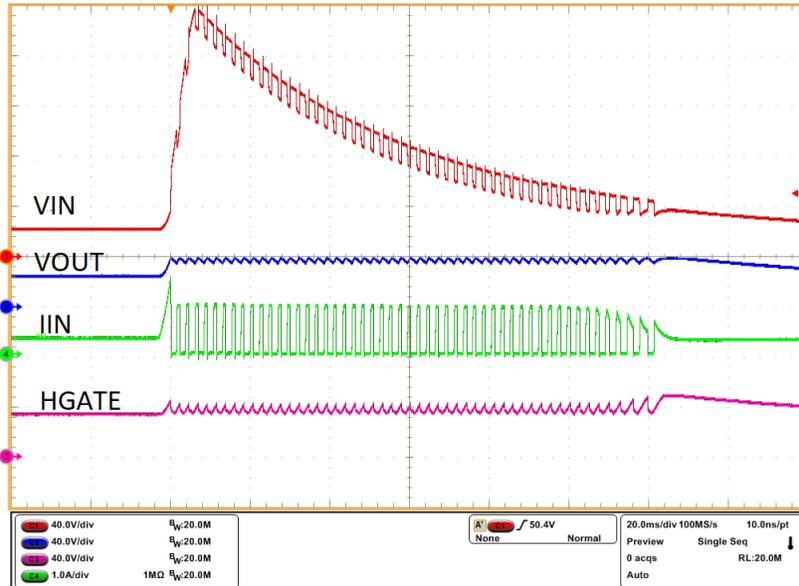


Figure 2-3. LM74930-Q1 Start-Up With VIN - VS, CAP and HGATE

### 2.3.2 Unsuppressed Load Dump 200 V - Output Clamp

Use the following instructions to verify the overvoltage protection feature of LM74930-Q1.

1. To test 200 V Unsuppressed Load Dump, the LD200N or similar equipment is needed as the input power supply.
2. Make sure the J8 jumper setting is set to 2-3.
3. Set the input supply voltage  $V_{IN}$  to 24 V and current limit of 5 A.
4. Turn ON the power supply and observe start-up of output voltage.
5. Now apply 200 V Unsuppressed Load Dump using LD200N equipment.
6. Observe OVCLAMP operation of LM74930-Q1 when input voltage is above OV threshold.



**Figure 2-4. Unsuppressed Load Dump 200 V - Output Clamp (OVCLAMP = GND)**

### 2.3.3 Overcurrent Protection Test

Use the following instructions to perform the overcurrent test on the LM74930Q1EVM.

1. Set the input supply voltage  $V_{IN}$  to 12 V and current limit of 10 A.
2. Turn ON the power supply and observe start-up of output voltage, HGATE, and DGATE.
3. By default the EVM is configured for 4-A overcurrent protection.
4. Apply 4-A load at the output with rheostat or electronic load and gradually increase the load current to 6 A.
5. Observe the overload behavior of LM74930-Q1.

Figure 2-5 and Figure 2-6 show test waveforms for an overcurrent fault.

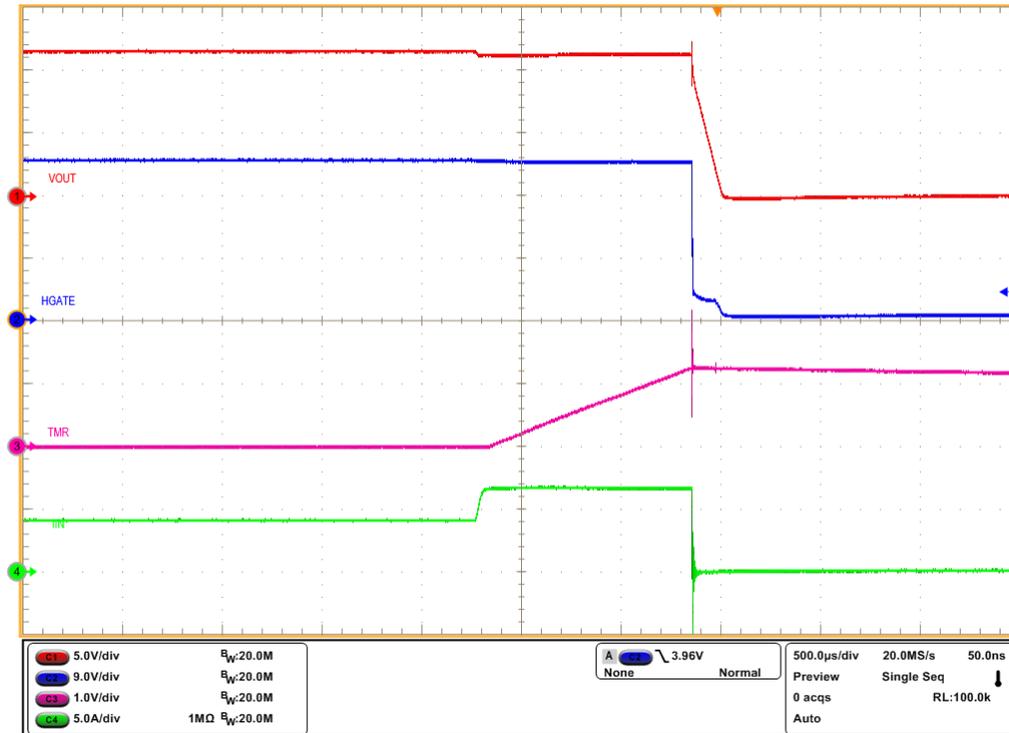
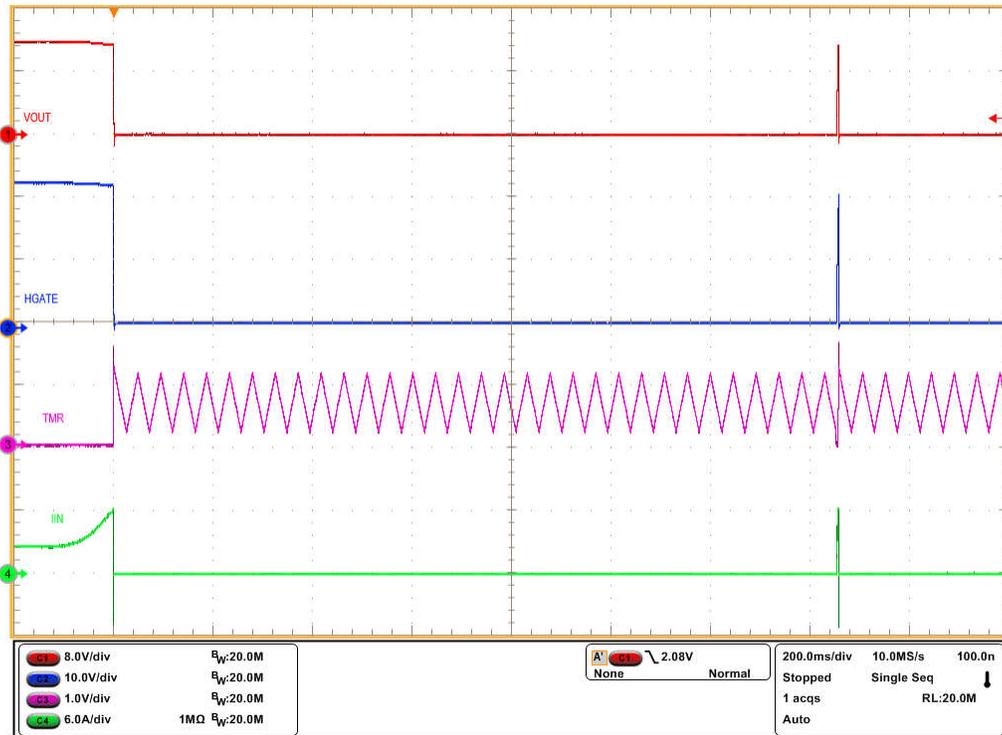


Figure 2-5. Overcurrent Response of LM74930-Q1 for a Load Step From 3.8 A to 6 A With 4-A Overcurrent Protection Setting



**Figure 2-6. Auto-Retry Response of LM74930-Q1 for an Overcurrent Fault**

### 2.3.4 Output Hot-Short Test

Use the following instructions to perform output the hot-short test.

1. Set the input supply voltage  $V_{IN}$  to 12 V and current limit of 10 A.
2. Turn ON the power supply and observe start-up of output voltage, HGATE, and DGATE.
3. Short the output to GND. That is,  $V_{OUT}$  to GND with a cable and observe the short-circuit response of LM74930-Q1 using an oscilloscope.

Figure 2-7 shows hot-short response of LM74930-Q1 on LM74930Q1EVM evaluation board.

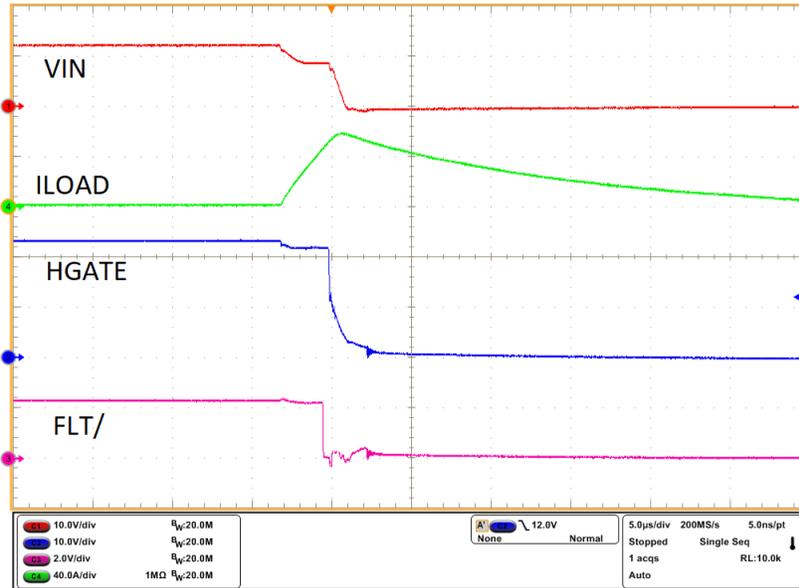


Figure 2-7. Output Hot-Short Response of LM74930-Q1 Device

### 3 Hardware Design Files

#### 3.1 Schematic

Figure 3-1 illustrates the EVM schematic.

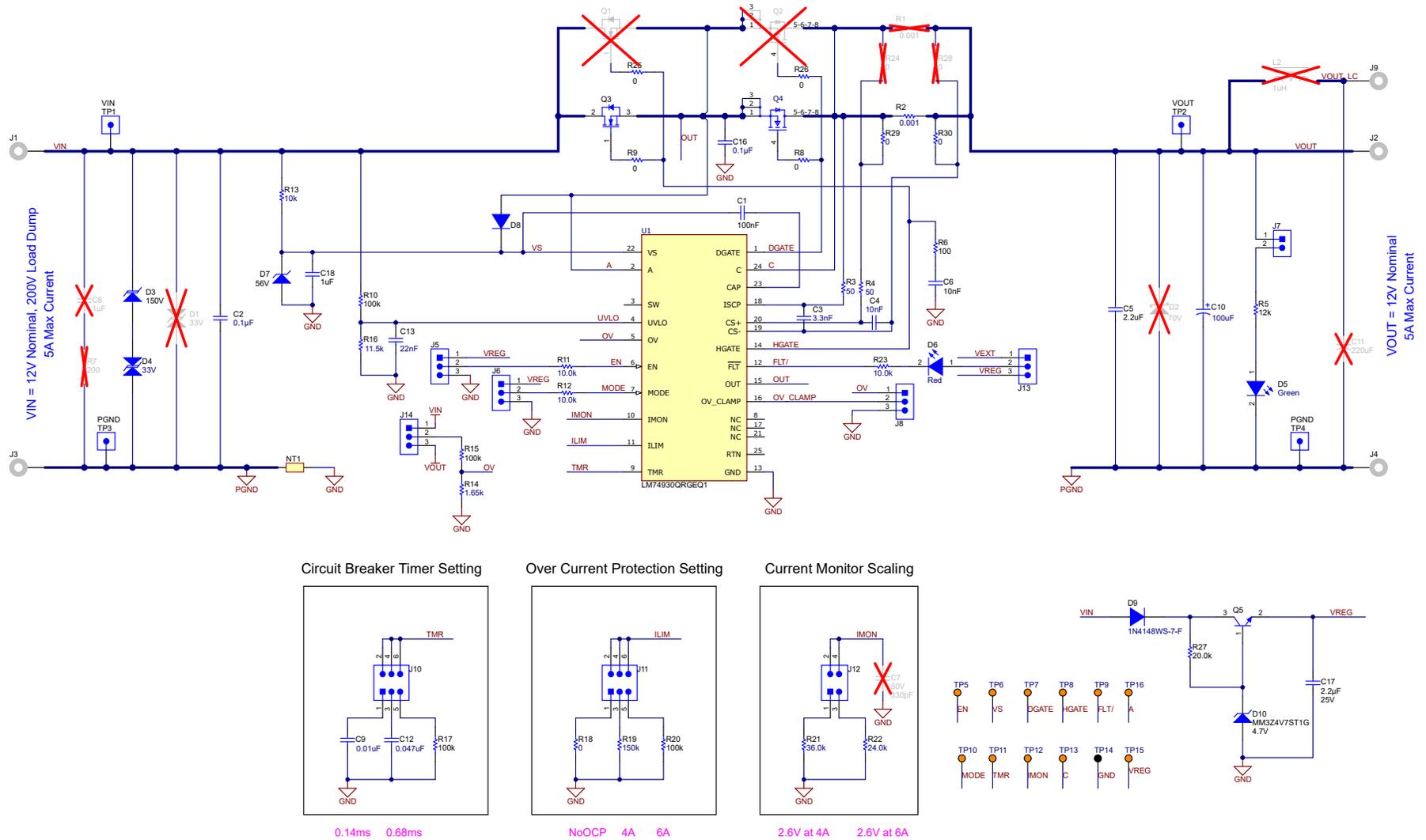


Figure 3-1. LM74930Q1EVM: Evaluation Module Schematic

### 3.2 PCB Layouts

Figure 3-2 and Figure 3-3 show component placement of the EVAL board. Figure 3-4 through Figure 3-7 show PCB layout images.

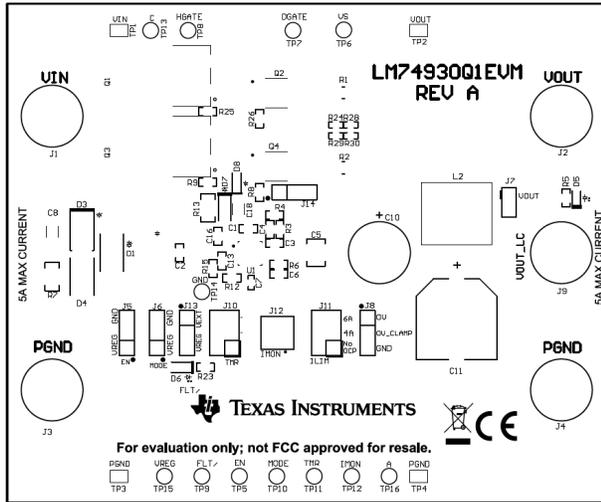


Figure 3-2. LM74930Q1EVM Board Top Overlay

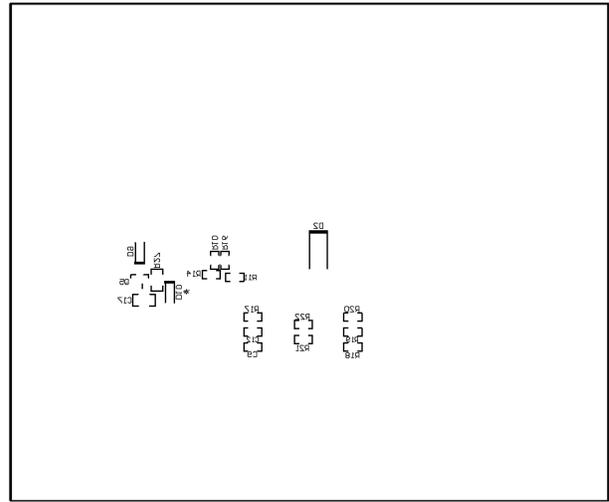


Figure 3-3. LM74930Q1EVM Board Bottom Overlay

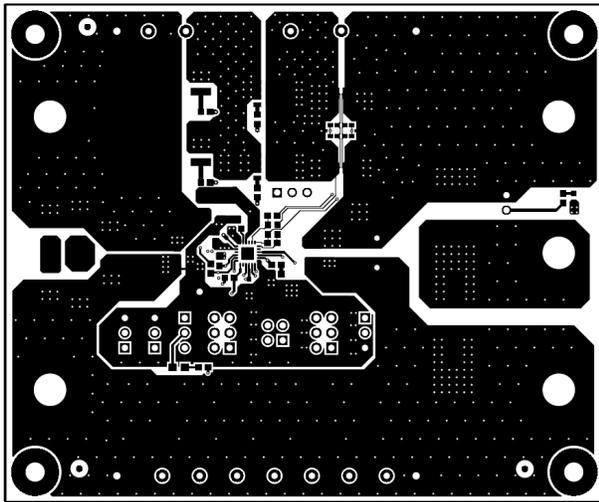


Figure 3-4. LM74930Q1EVM Board Top Layer

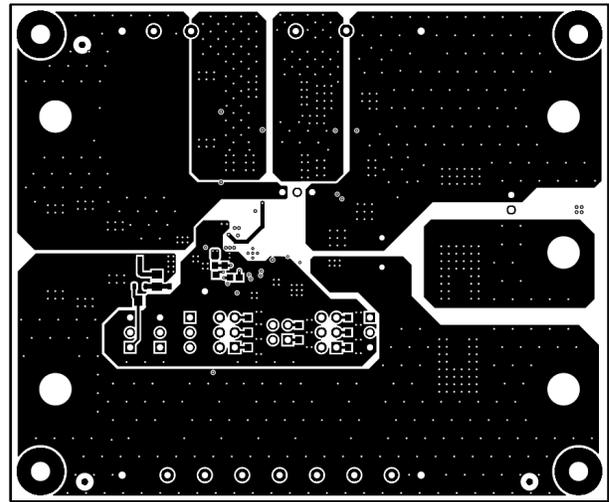


Figure 3-5. LM74930Q1EVM Board Bottom Layer

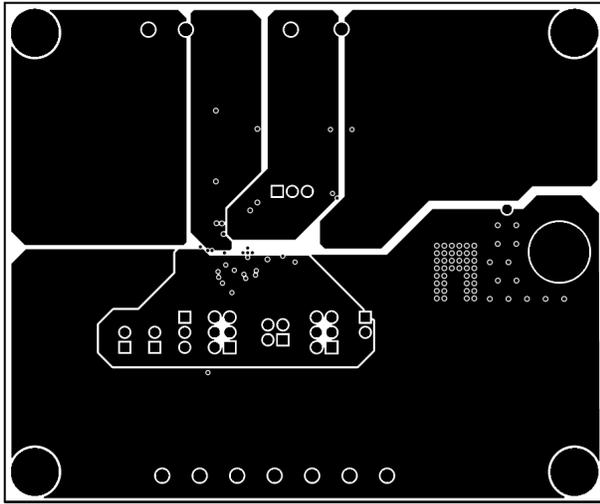


Figure 3-6. LM74930Q1EVM Board Inner Layer 1

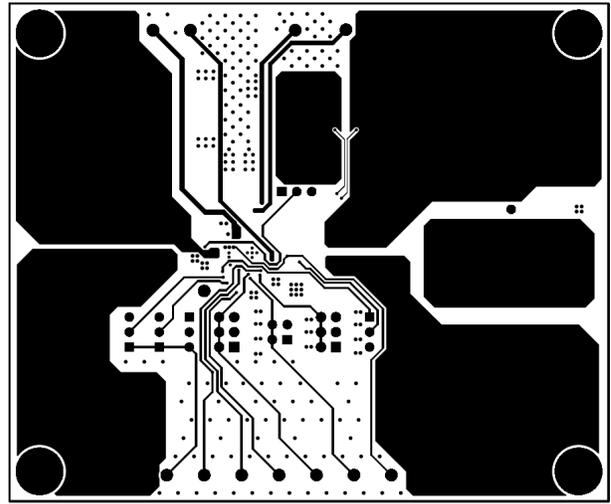


Figure 3-7. LM74930Q1EVM Board Inner Layer 2

### 3.3 Bill of Materials (BOM)

Section 3.3 lists the EVM BOM.

**Table 3-1. LM74930Q1EVM**

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
PCB1	1		Printed Circuit Board		LM74930Q1EVM	Any
C1	1	0.1uF	CAP, CERM, 0.1 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R1E104K080AA	TDK
C2, C16	2	0.1uF	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X8L, AEC-Q200 Grade 0, 0603	0603	GCJ188L8EL104KA07D	MuRata
C3	1	3300 pF	CAP, CERM, 3300 pF, 25 V, +/- 10%, X7R, 0603	0603	GCJ188R71E332KA01D	MuRata
C4	1	0.01uF	CAP, CERM, 0.01 uF, 50 V, +/- 10%, X7R, 0603	0603	GCM188R71H103KA37D	MuRata
C5	1	2.2uF	CAP, CERM, 2.2 uF, 100 V, +/- 10%, X7R, 1210	1210	C1210C225K1RACTU	Kemet
C6	1	0.01uF	CAP, CERM, 0.01 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R2A103K080AA	TDK
C9	1	0.01uF	CAP, CERM, 0.01 uF, 50 V, +/- 5%, C0G/NPO, 0603	0603	GRM1885C1H103JA01D	MuRata
C10	1	100uF	CAP, AL, 100 uF, 63 V, +/- 20%, AEC-Q200 Grade 2, TH	TH, 2-Leads, Body 10x12.5mm, Pin Spacing 5 mm	ELXZ630ELL101MJC5S	Chemi-Con
C12	1	0.047uF	CAP, CERM, 0.047 uF, 100 V, +/- 10%, X7S, AEC-Q200 Grade 1, 0603	0603	CGA3E3X7S2A473K080AB	TDK
C13	1	0.022uF	CAP, CERM, 0.022 uF, 25 V, +/- 10%, X7R, 0603	0603	C0603C223K3RACTU	Kemet
C17	1	2.2uF	CAP, CERM, 2.2 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	GCM21BR71E225KA73L	MuRata
C18	1	1uF	CAP, CERM, 1 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	GCM31CR72A105KA03	MuRata
D3	1	150 V	Diode, TVS, Uni, 150 V, 243 Vc, SMB	SMB	SMBJ150A-13-F	Diodes Inc.
D4	1	33 V	Diode, TVS, Bi, 33 V, SMB	SMB	SMBJ33CA-13-F	Diodes Inc.
D5	1	Green	LED, Green, SMD	1.6x0.8x0.8mm	LTST-C190GKT	Lite-On
D6	1	Red	LED, Red, SMD	Red 0805 LED	LTST-C170KRKT	Lite-On
D7	1	56 V	Diode, Zener, 56 V, 500 mW, AEC-Q101, SOD-123	SOD-123	MMSZ5263BT1G	ON Semiconductor
D8, D9	2	75 V	Diode, Switching, 75 V, 0.15 A, AEC-Q101, SOD-323	SOD-323	1N4148WS-7-F	Diodes Inc.
D10	1	4.7V	Diode, Zener, 4.7 V, 300 mW, SOD-323	SOD-323	MM3Z4V7ST1G	ON Semiconductor

**Table 3-1. LM74930Q1EVM (continued)**

Designator	Quantity	Value	Description	PackageReference	PartNumber	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, J9	5		Standard Banana Jack, Uninsulated, 8.9mm	Keystone575-8	575-8	Keystone
J5, J6, J8, J13, J14	5		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
J10, J11	2		Header, 100mil, 3x2, Tin, TH	3x2 Header	PEC03DAAN	Sullins Connector Solutions
J12	1		Header, 100mil, 2x2, Tin, TH	Header, 2x2, 2.54mm, TH	PEC02DAAN	Sullins Connector Solutions
Q3	1	200V	MOSFET, N-CH, 200 V, 34 A, DDPAK	DDPAK	IPB320N20N3 G	Infineon Technologies
Q4	1		MOSFET N-Channel 60 V 16A (Ta), 104A (Tc) 3.1W (Ta), 136W (Tc) Surface Mount, Wettable Flank 8-PDFNU (5x6)	PDFN56U	TQM050NB06CR RLG	Taiwan Semiconductor
Q5	1	160 V	Transistor, NPN, 160 V, 0.3 A, SOT-23	SOT-23	PMBT5551,215	Nexperia
R2	1	0.001	RES, 0.001, 1%, 1 W, 1206	1206	WSLP12061L000FEA	Vishay-Dale
R3, R4	2	50	RES, 50, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060350R0FKEA	Vishay-Dale
R5	1	12k	RES, 12 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060312K0JNEA	Vishay-Dale
R6	1	100	RES, 100, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100RJNEA	Vishay-Dale
R8, R9, R25, R26	4	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3GEY0R00V	Panasonic
R10, R15, R17, R20	4	100k	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
R11, R12, R23	3	10.0k	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603FT10K0	Stackpole Electronics Inc
R13	1	10k	RES, 10 k, 5%, 0.25 W, 1206	1206	CRCW120610K0JNEA	Vishay-Dale
R14	1	1.65k	RES, 1.65 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031K65FKEA	Vishay-Dale
R16	1	11.5k	RES, 11.5 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060311K5FKEA	Vishay-Dale
R18	1	0	RES, 0, 5%, 0.1 W, 0603	0603	ERJ-3GEY0R00V	Panasonic
R19	1	150k	RES, 150 k, 1%, 0.1 W, 0603	0603	CRCW0603150KFKEA	Vishay-Dale
R21	1	36.0k	RES, 36.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0736KL	Yageo
R22	1	24.0k	RES, 24.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0724KL	Yageo
R27	1	20.0k	RES, 20.0 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	ERJ-6ENF2002V	Panasonic

**Table 3-1. LM74930Q1EVM (continued)**

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
R29, R30	2	0	RES, 0, 5%, 0.063 W, 0402	0402	MCR01MZPJ000	Rohm
SH1, SH2, SH3, SH4, SH5, SH6, SH7, SH8, SH9	9	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
TP1, TP2, TP3, TP4	4		TEST POINT SLOTTED .118", TH	Test point, TH Slot Test point	1040	Keystone
TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP15, TP16	11		Test Point, Miniature, Orange, TH	Orange Miniature Testpoint	5003	Keystone
TP14	1		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone
U1	1		Ideal Diode Surge Stopper with Circuit breaker, overvoltage protection and fault output	VQFN24	LM74930QRGEQ1	Texas Instruments
C7	0	330 pF	CAP, CERM, 330 pF, 50 V, +/- 10%, X7R, 0402	0402	GRM155R71H331KA01D	MuRata
C8	0	1uF	CAP, CERM, 1 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	GCM31CR72A105KA03	MuRata
C11	0	220uF	CAP, AL, 220 uF, 63 V, +/- 20%, 0.16 ohm, AEC-Q200 Grade 2, SMD	SMT Radial H13	EEV-FK1J221Q	Panasonic
D1	0	33 V	Diode, TVS, Bi, 33 V, SMB	SMB	SMBJ33CA-13-F	Diodes Inc.
D2	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
L2	0	1uH	Inductor, Shielded, Composite, 1 uH, 43.5 A, 0.001 ohm, SMD	Inductor, 11.3x10x10mm	XAL1010-102MEB	Coilcraft
Q1	0	200 V	MOSFET, N-CH, 200 V, 34 A, DDPK	DDPAK	IPB320N20N3 G	Infineon Technologies
Q2	0		MOSFET N-Channel 60 V 16 A (Ta), 104 A (Tc) 3.1W (Ta), 136 W (Tc) Surface Mount, Wettable Flank 8-PDFNU (5x6)	PDFN56U	TQM050NB06CR RLG	Taiwan Semiconductor
R1	0	0.001	RES, 0.001, 1%, 1 W, 1206	1206	WSLP12061L000FEA	Vishay-Dale
R7	0	200	RES, 200, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW1206200RJNEA	Vishay-Dale
R24, R28	0	0	RES, 0, 5%, 0.063 W, 0402	0402	MCR01MZPJ000	Rohm

## **4 Additional Information**

### **Trademarks**

All trademarks are the property of their respective owners.

## STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.
  - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductor products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software
  - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
2. *Limited Warranty and Related Remedies/Disclaimers:*
  - 2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
  - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.
  - 2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

### **WARNING**

**Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.**

**User shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.**

**NOTE:**

**EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGRADATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.**

### 3 Regulatory Notices:

#### 3.1 United States

##### 3.1.1 Notice applicable to EVMs not FCC-Approved:

**FCC NOTICE:** This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

##### 3.1.2 For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:

#### **CAUTION**

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

#### **FCC Interference Statement for Class A EVM devices**

*NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.*

#### **FCC Interference Statement for Class B EVM devices**

*NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:*

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

#### 3.2 Canada

##### 3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247

#### **Concerning EVMs Including Radio Transmitters:**

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

#### **Concernant les EVMs avec appareils radio:**

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

#### **Concerning EVMs Including Detachable Antennas:**

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

### Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

#### 3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see [http://www.tij.co.jp/lstds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page) 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないものご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。日本テキサス・イ

ンスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see [http://www.tij.co.jp/lstds/ti\\_ja/general/eStore/notice\\_02.page](http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page)

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。 <https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

#### 3.4 European Union

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive):*

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

- 
- 4 *EVM Use Restrictions and Warnings:*
    - 4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.
    - 4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.
    - 4.3 *Safety-Related Warnings and Restrictions:*
      - 4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.
      - 4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.
    - 4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.
  5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.
  6. *Disclaimers:*
    - 6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.
    - 6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.
  7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2023, Texas Instruments Incorporated

## 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](https://www.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  
Copyright © 2023, Texas Instruments Incorporated