EVM User's Guide: LM74912Q1EVM

Evaluation Module for LM74912-Q1 Ideal Diode Controller

Description

The LM74912Q1EVM assists designers to evaluate the operation and performance of the LM74912-Q1 ideal diode controller (24-pin VQFN package). This evaluation module demonstrates how LM74912-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 over current and overvoltage protection.

Features

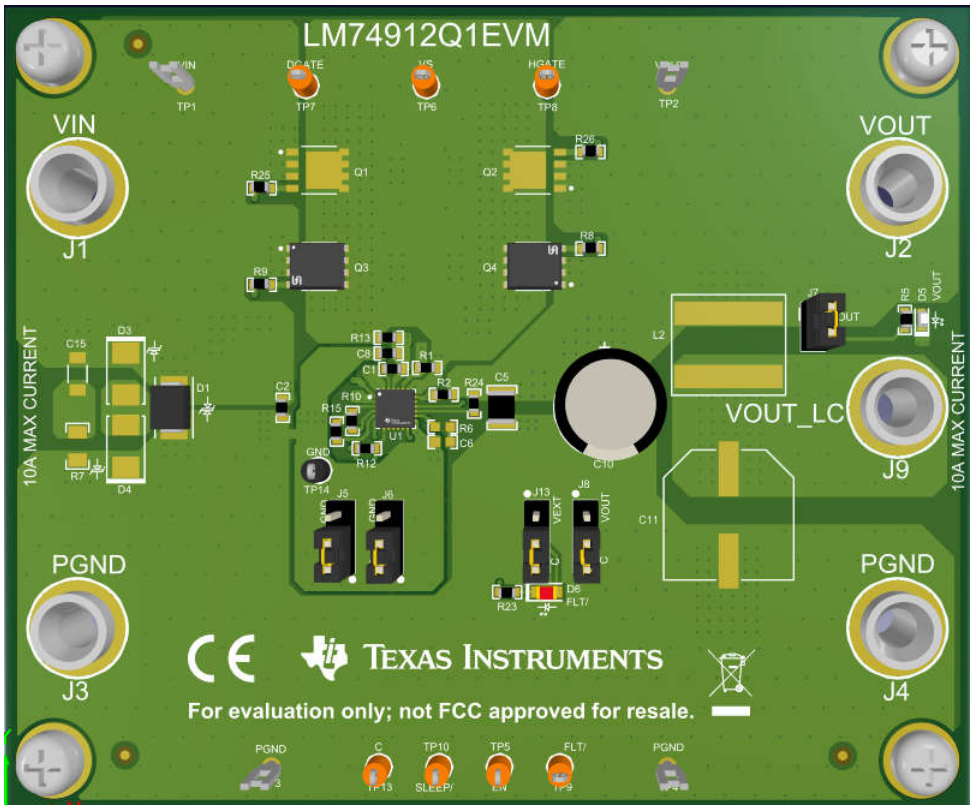
- 3-V to 65-V input range
- Output short circuit protection with current limit set at 14A
- Adjustable current limit using R_{SET} and R_{ISCP}
- LED for fault indication
- LED indication for output ON/OFF detection

Applications

Automotive reverse battery protection

- ADAS domain controller
- Camera, radar ECUs
- Head unit
- USB HUBs

Active ORing for redundant power



1 Evaluation Module Overview

1.1 Introduction

This user's guide describes the LM74912-Q1 evaluation module (EVM). This guide provides configuration information, test setup details and contains the EVM schematics, bill of materials, assembly drawings, and top and bottom board layouts.

1.2 Kit Contents

Table 1-1. LM74912Q1EVM Kit Contents

Item	Description	Quantity
LM74912Q1EVM	PCB	1

1.3 Specification

The LM74912Q1EVM has the following features:

- 3-V to 60-V input range
  - While testing for input voltage greater than 35 V, remove input 33 V TVS or use an appropriate TVS
- 5 A max current
  - Populate Q1 and Q2 for 10 A operation
- Meets 12-V battery automotive ISO7637 and ISO16750-2 transient requirements

1.4 Device Information

The LM74912-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 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. An integrated ideal diode controller (DGATE) drives the first MOSFET to replace a Schottky diode for reverse input protection and output voltage holdup.

With a second MOSFET in the power path, the device allows load disconnect (ON/OFF control) in case of overcurrent and overvoltage events using HGATE control. The device has an integrated current sense amplifier, which provides external MOSFET VDS sense-based short circuit protection with an adjustable current limit. When short circuit condition is detected on the output, the device latches off the load disconnect MOSFET. The device features an adjustable overvoltage cut-off protection feature. The device features a SLEEP mode, which enables ultra-low quiescent current consumption (6-µA) and provides refresh current to the always ON loads when the vehicle is in the parking state. The LM74912-Q1 has a maximum voltage rating of 65 V.

2 Hardware

2.1 Setup

The LM74912Q1EVM is configured by default for evaluating 12-V automotive reverse battery protection with switched output to disconnect power path or clamp the output. For evaluation of input voltages greater than 35V, the input TVS (D1) has to be removed and an appropriate TVS has to be installed to clamp the input transients to less than 70V.

Table 2-1. LM74912Q1EVM Evaluation Board Options and Setting

Part Number	EVM Function	Vin Range	Vin UVLO	Vin OVP	ENABLE (EN)	Overcurrent Protection	Features
LM74912Q1EVM	Ideal diode with overcurrent , under and overvoltage protection with fault output	3 V to 65 V	5.8 V	36.96 V	Active high	10 A (Adjustable using R_{SET}, R_{ISCP} and FET Rds(on))	Adjustable overcurrent protection and cconfigurable SLEEP mode

2.2 Physical Access

Table 2-2 lists the LM74912Q1EVM evaluation board input and output connector functionality. Table 2-3 and Table 2-4 describe the test point availability and the jumper functionality.

Table 2-2. 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 2-3. 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	SLEEP/	Active low SLEEP mode input.
TP13	C	Cathode of the ideal diode.

Table 2-4. Jumper and LED Descriptions

Jumper	Connection	Description
J5	1-2	EN connected to C. EN pulled High
	2-3	EN connected to GND. EN pulled Low
J6	1-2	SLEEP/ connected to C. SLEEP mode disabled
	2-3	SLEEP/ connected to GND. SLEEP mode active
J7	1-2	Output high D5 LED indication
J8	1-2	SLEEP_OV connected to VOUT. Overvoltage clamp functionality in SLEEP mode
	2-3	SLEEP_OV connected to C. Overvoltage cut-off functionality in SLEEP mode
J13	1-2	FLT/ external voltage pullup
	3-4	FLT/ pullup to C

2.2.1 Test Equipment and Setup

2.2.1.1 Power Supplies

One adjustable power supply with 0-V to 60-V output and 0-A to 50-A output current limit.

2.2.1.2 Meters

One DMM minimum needed.

2.2.1.3 Oscilloscope

A DPO2024 or equivalent, three 10X voltage probes, and a DC current probe.

2.2.1.4 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 General Configurations

3 Implementation Results

3.1 Test Setup and Procedures

Make sure the evaluation board has default jumper settings as shown in Table 3-1.

Table 3-1. Default Jumper Setting for LM74912Q1EVM Evaluation Board

Jumper	Default Setting	Functionality
J5	1-2	EN connected to C. EN pulled High.
J6	1-2	SLEEP/ connected to C. SLEEP mode disabled.
J7	1-2	D5 LED indication when output High.
J8	2-3	SLEEP_OV connected to C. Overvoltage cut-off functionality in SLEEP mode.
J13	2-3	FLT/ pulled up to C.

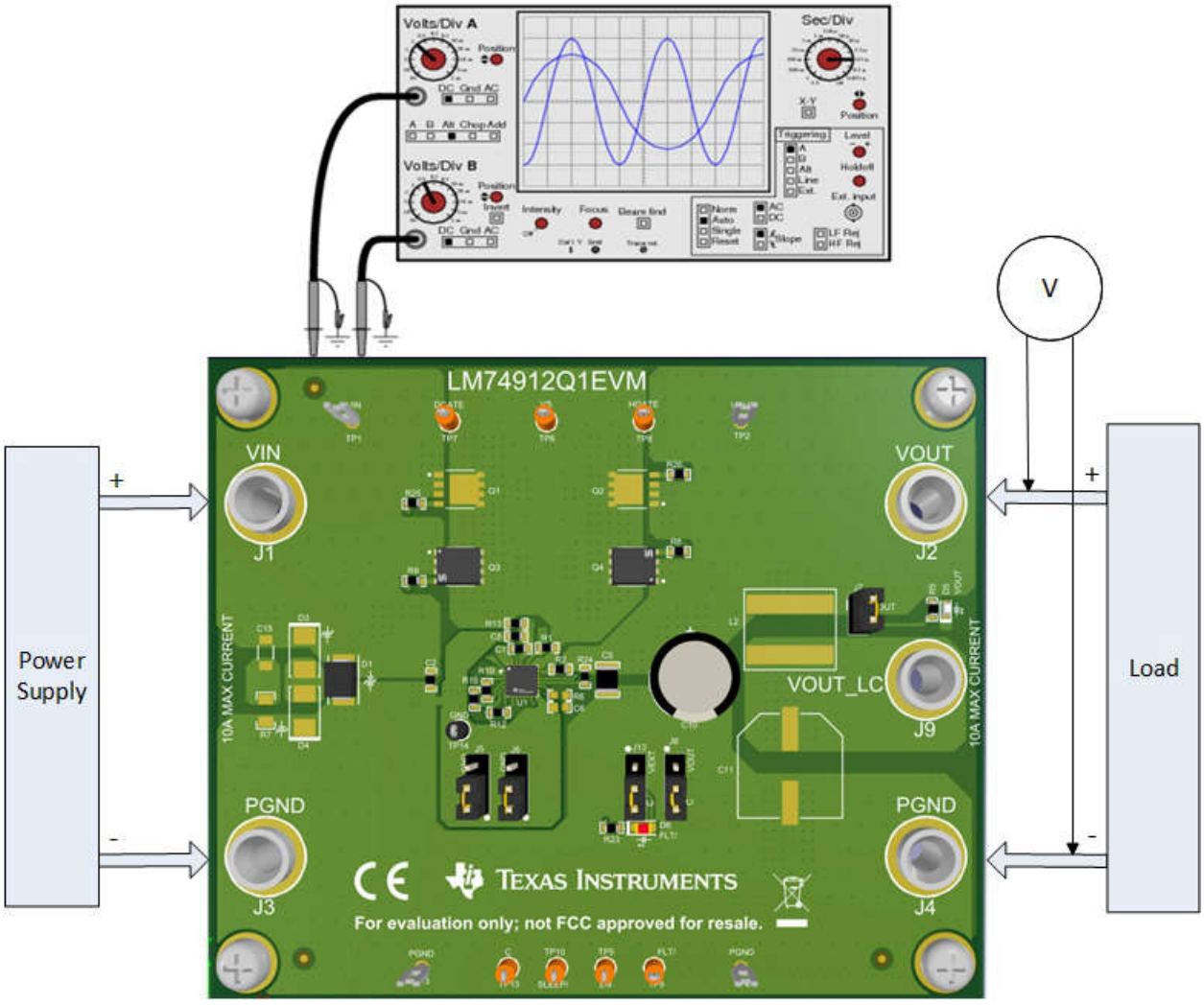


Figure 3-1. LM74912Q1EVM Setup With Test Equipment

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

1. Set the power supply output VIN to 0 V.
2. Turn ON the power supply and set the power supply output VIN 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 3-1.

3.1.1 Power-Up and Power-Down With EN Control

Use the following instructions to capture the precharging current profile.

1. Initially connect the EN pin to GND by setting J5 jumper at 2-3 position.
2. Set the input supply voltage VIN to 12 V and current limit of 10 A.
3. Turn ON the power supply.
4. Enable the LM74912-Q1 device by connecting EN pin to C. Change the J5 jumper setting to 1-2.
5. Observe the start-up profile of charge pump voltage (V_{CAP} – V_{VS}), output voltage, HGATE, and DGATE.
6. Disable the LM74912-Q1 device by connecting EN pin to GND. Change the J5 jumper setting to 2-3.
7. Observe the shutdown profile of charge pump voltage (V_{CAP} – V_{VS}), output voltage, HGATE, and DGATE.

Figure 3-2 shows an example of power-up with EN profile captured on the LM74912Q1EVM evaluation board.

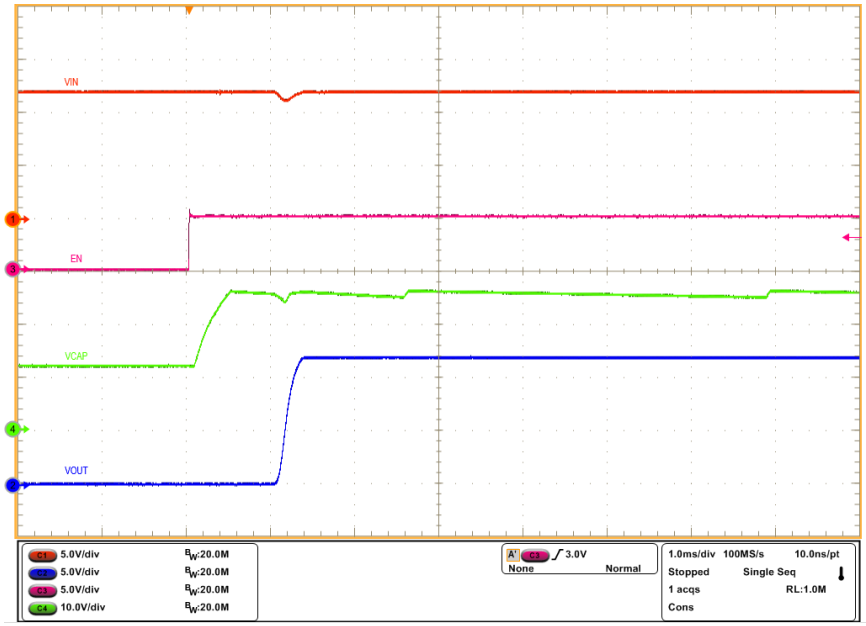


Figure 3-2. LM74912-Q1 Start-Up With EN - Charge Pump and Output Voltage Profile

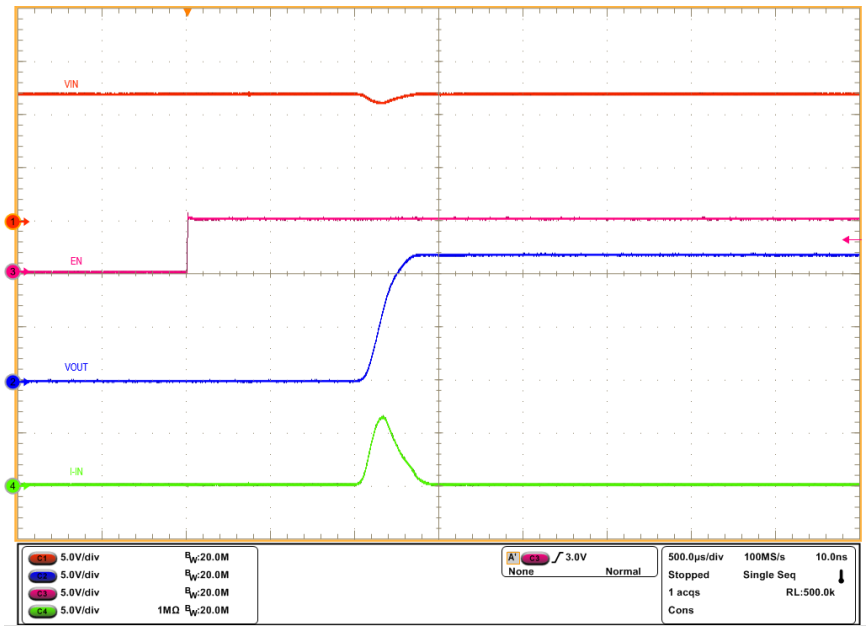


Figure 3-3. LM74912-Q1 Start-Up With EN - Output Voltage and Input Current Profile

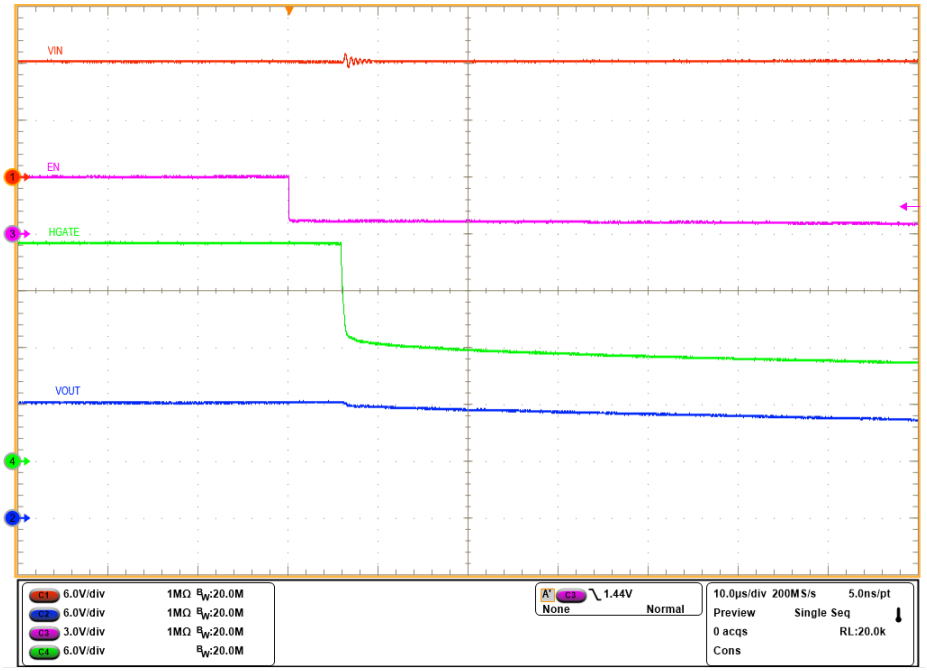


Figure 3-4. LM74912-Q1 Shutdown With EN - HGATE and Output Voltage Profile

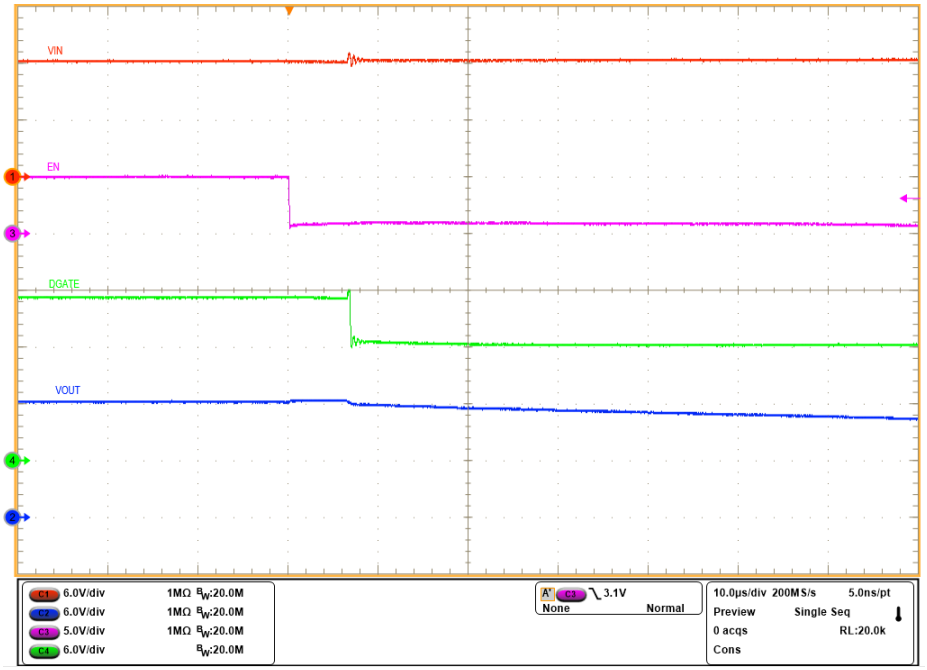


Figure 3-5. LM74912-Q1 Shutdown With EN - DGATE and Output Voltage Profile

3.1.2 Input Overvoltage Test

Use the following instructions to verify the overvoltage protection feature of LM74912-Q1.

1. Remove the input 33-V TVS (D1) incase you want to set and test the input overvoltage threshold, which is greater than the breakdown voltage (40V)of the TVS.
2. Set the input supply voltage VIN to 12 V and current limit of 10 A.
3. Turn ON the power supply and observe start-up of output voltage, HGATE, and DGATE.
4. Slowly increase the input voltage to 40 V. Observe the HGATE going low and turn OFF the load switch FETs (Q2 and Q4) when the input voltage reaches overvoltage protection threshold of 37 V.

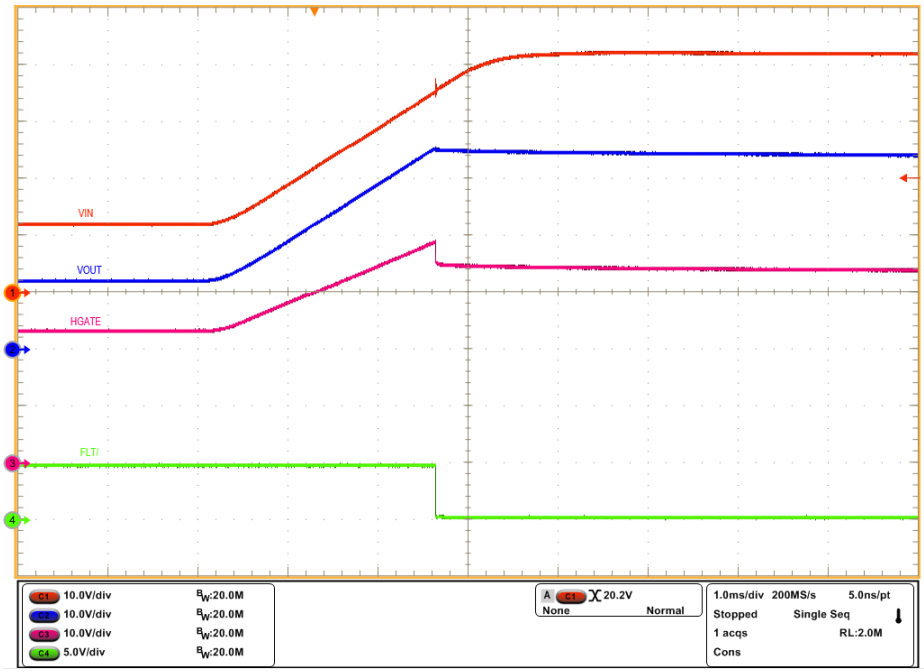


Figure 3-6. Overvoltage Protection

3.1.3 Output Hot-Short Test

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

1. To avoid drop in input voltage due to the input impedance, additional capacitance can be added across VIN to GND.
2. During output short circuit event, when the HGATE turns OFF there can be oscillations on the input voltage due to sudden interruption of current. R13 can be increased to 10 Ω. This 10 Ω resistor along with C8 helps the device from resetting (due to $V_{(VS\_PORF)}$) after HGATE turns OFF.
3. Set the input supply voltage VIN to 12 V and current limit of 10 A.
4. Turn ON the power supply and observe start-up of output voltage, HGATE, and DGATE.
5. Short the output to GND. That is, VOUT to GND with a cable and observe the short-circuit response of LM74912-Q1 using an oscilloscope.

Figure 3-7 shows hot-short response of LM74912-Q1 on LM74912Q1EVM evaluation board.

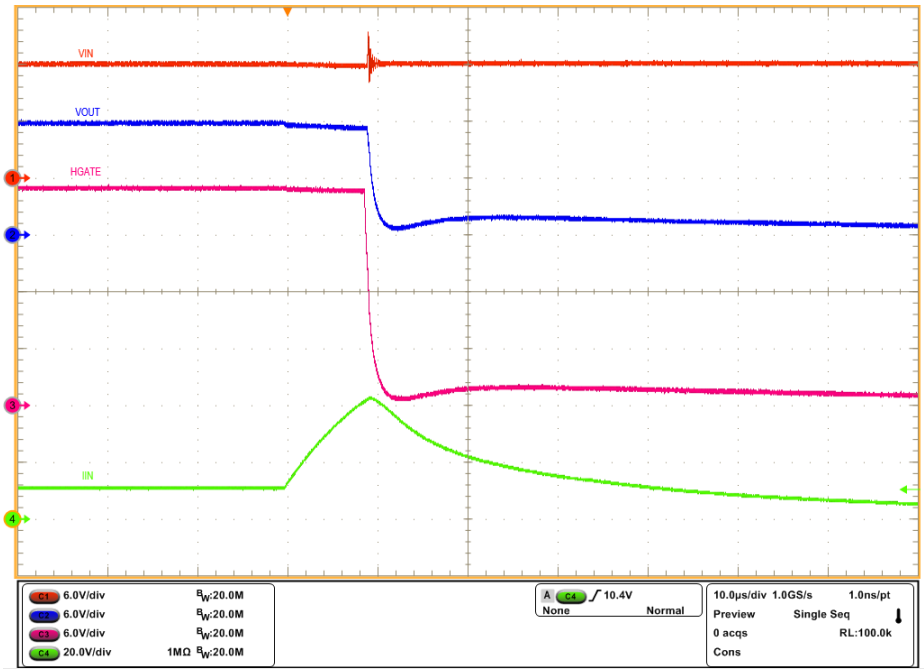


Figure 3-7. Output Hot-Short Response of LM74912-Q1 Device

4 Hardware Design Files

4.1 Schematic

Figure 4-1 illustrates the EVM schematic.

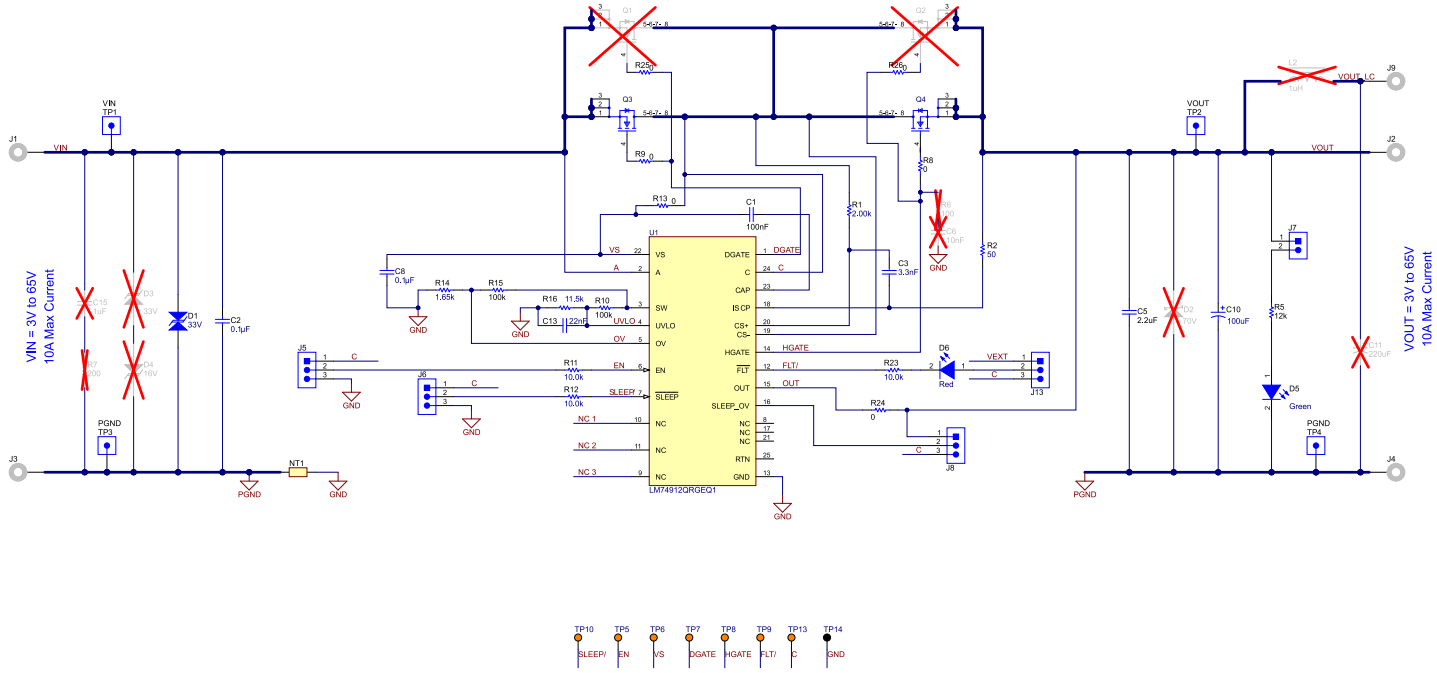


Figure 4-1. LM74912Q1EVM: Evaluation Module Schematic

4.2 PCB Layout

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

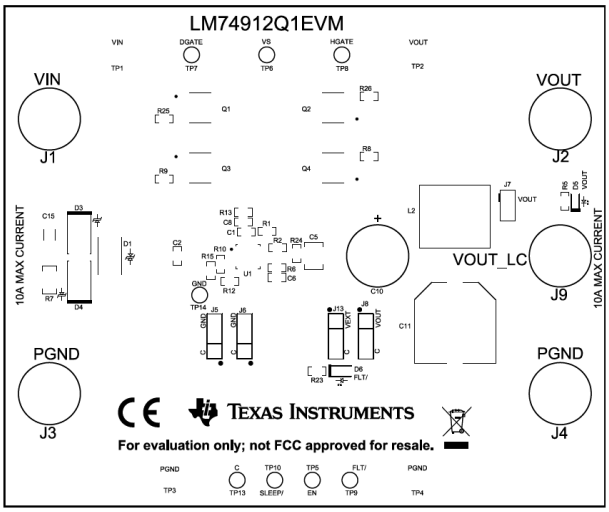


Figure 4-2. LM74912Q1EVM Board Top Overlay

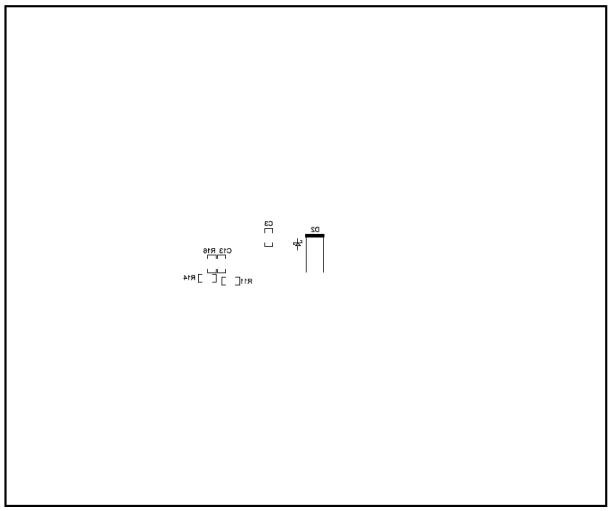


Figure 4-3. LM74912Q1EVM Board Bottom Overlay

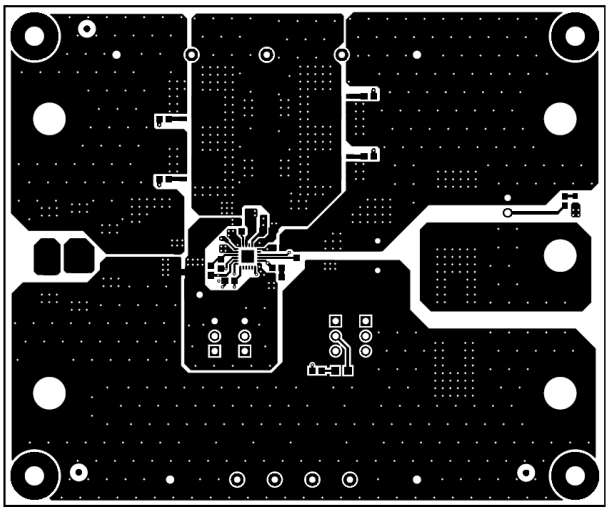


Figure 4-4. LM74912Q1EVM Board Top Layer

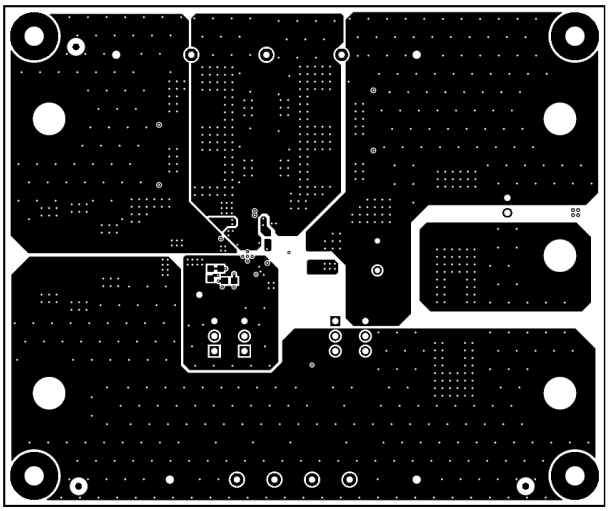


Figure 4-5. LM74912Q1EVM Board Bottom Layer

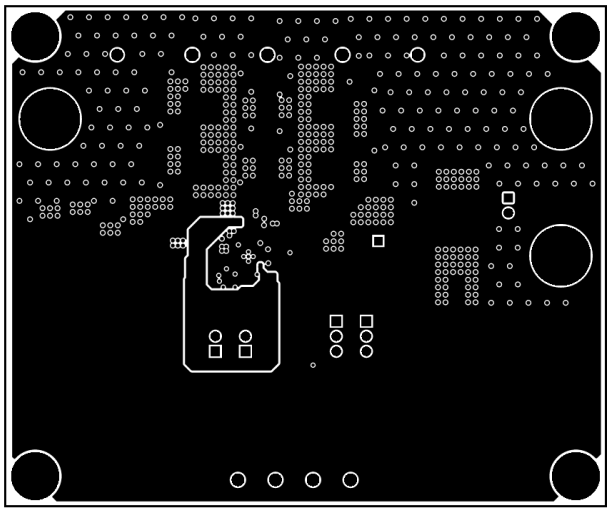


Figure 4-6. LM74912Q1EVM Board Inner Layer 1

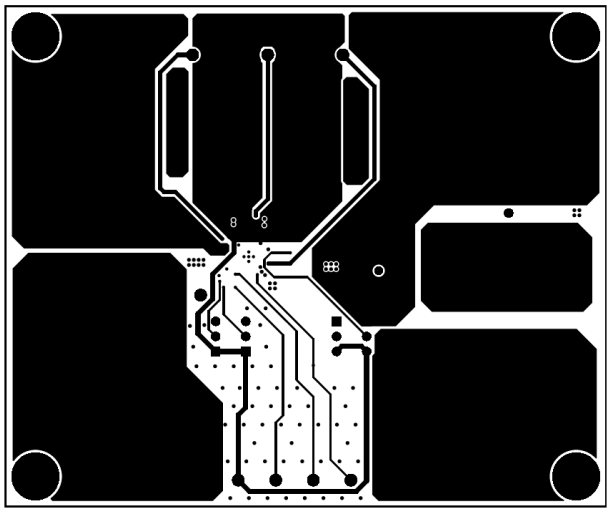


Figure 4-7. LM74912Q1EVM Board Inner Layer 2

4.3 Bill of Materials (BOM)

Table 4-1 lists the EVM BOM.

Table 4-1. LM74912Q1EVM Bill of Materials

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
C1	1	0.1uF	CAP, CERM, 0.1 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R1E104K080AA	TDK		
C2, C8	2	0.1uF	CAP, CERM, 0.1 µF, 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	GRM188R71E332KA01D	MuRata		
C5	1	2.2uF	CAP, CERM, 2.2 uF, 100 V, +/- 10%, X7R, 1210	1210	C1210C225K1RACTU	Kemet		
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		
C13	1	0.022uF	CAP, CERM, 0.022 uF, 25 V, +/- 10%, X7R, 0603	0603	C0603C223K3RACTU	Kemet		
D1	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		
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	4		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		
Q3, Q4	2		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	TQM050NB06CRRLG	Taiwan Semiconductor		
R1	1	2.00k	RES, 2.00 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ3EKF2001V	Panasonic		
R2	1	50	RES, 50, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060350R0FKEA	Vishay-Dale		

Table 4-1. LM74912Q1EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
R5	1	12k	RES, 12 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060312K0JNEA	Vishay-Dale		
R8, R9, R13, R24, R25, R26	6	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3GEY0R00V	Panasonic		
R10, R15	2	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		
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		
SH1, SH2, SH3, SH4, SH5	5	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec	969102-0000-DA	3M
TP1, TP2, TP3, TP4	4		TEST POINT SLOTTED .118", TH	Test point, TH Slot Test point	1040	Keystone		
TP5, TP6, TP7, TP8, TP9, TP10, TP13	7		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 Controller with Integrated Short Circuit Protection with Fault Output	VQFN24	LM74912QRGEQ1	Texas Instruments		
C6	0	0.01uF	CAP, CERM, 0.01 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R2A103K080AA	TDK		
C11	0	220uF	CAP, AL, 220 uF, 63 V, +/- 20%, 0.16 ohm, AEC-Q200 Grade 2, SMD	SMT Radial H13	EEV-FK1J221Q	Panasonic		
C15	0	1uF	CAP, CERM, 1 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	GCM31CR72A105KA03	MuRata		
D2	0	70 V	Diode, Schottky, 70 V, 1 A, SMA	SMA	B170-13-F	Diodes Inc.		
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.		
L2	0	1uH	Inductor, Shielded, Composite, 1 uH, 43.5 A, 0.001 ohm, SMD	Inductor, 11.3x10x10mm	XAL1010-102MEB	Coilcraft		

Table 4-1. LM74912Q1EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
Q1, 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		
R6	0	100	RES, 100, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100RJNE A	Vishay-Dale		
R7	0	200	RES, 200, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW1206200RJNE A	Vishay-Dale		

5 Additional Information

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All trademarks are the property of their respective owners.

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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 semiconductors 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.

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   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 DEGREDATION 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/lsds/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.

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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。

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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/lsds/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, INDEMITY 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.

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