User's Guide
SNOU132–November 2014

LM9061EVM User's Guide

Topic **Page**

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1 Introduction

The Texas Instruments LM9061EVM evaluation module (EVM) helps designers evaluate the operation and performance of the LM9061 High-Side Protection Controller. The EVM demonstrates protection to a connected load from over-voltage and over-current. One high side N-channel power MOSFET is used. For more information about LM9061 functional and electrical characteristics, see the LM9061 High-Side Protection Controller data sheet (SNOS738).

The EVM contains one LM9061 High-Side Protection Controller (See Table 1).

Table 1. Device Package Configurations

REF DES	IC	PACKAGE
U1	LM9061M/NOPB	SOIC-8

1.1 Features

- INPUT Voltage Range: 0 V to 36 V, limited by transient suppressor diode (D1)
- Over-Voltage Protection: 30 V
- Load Current Range: 0 A to 15 A
- Over-Current Protection: 10 A
- ON/OFF Voltage Range: 0 V to INPUT Voltage
- Board Size: 1.65 in x 3.11 in

The over-current protection may be adjusted by changing the value of resistor R1. The LM9061EVM has not been tested for currents above 15 A. Therefore, changing the value of resistor R1 should be done with some degree of caution.

2 Setup

This section describes the connectors on the EVM as well as how to properly connect, set up and use the LM9061EVM. Ensure the external power supply is turned off while making connections on the board. Before applying power to the LM9061EVM, all external connectors should be verified.

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2.1 Input/Output Connector Description

- **J1 – INPUT** is the power input connector to the positive rail of the input power supply.
- **J2 – OUTPUT** is the power output connector to the positive side of the load.
- **J3 – GND** is the ground connector to the ground side of the load.
- **J4 – GND** is the ground connector to the negative, or ground, rail of the input power supply.
- **TP1 – ON/OFF** is a digital input test point which controls the gate drive to the high-side N-channel MOSFET.

2.2 Board Setup

Before applying power to the LM9061EVM, all external connections should be verified. An external power supply should be turned off and connected with proper polarity to the INPUT (J1) and GND (J4) connectors. A load resistor should be connected between the OUTPUT (J2) and GND (J3). Electronic load equipment tends to be very low impedance during voltage rise so that the transistor Q1 might see very high currents during turn-on when using such loads. Electronic loads can be used with caution. Resistive loads are suggested for use with the LM9061EVM. Make sure that the external power supply source for the input voltage is capable of providing enough current to the output load so that the output voltage can be obtained.

The ON/OFF connector may be connected to the same external power supply as the INPUT. A separate power supply may also be used. If using a separate supply, ensure the voltage at the ON/OFF connector does not exceed the voltage at the INPUT. This also means that, during start up, power should be applied to the INPUT connector BEFORE the ON/OFF connector.

Once all the connections to the LM9061EVM are verified, power can be applied to the INPUT. For the EVM to begin operation, the ON/OFF test point needs to be pulled high. The ON/OFF threshold voltage is about 3.3 V.

The setup shown in Figure 1 is an example setup that is used throughout this user guide.

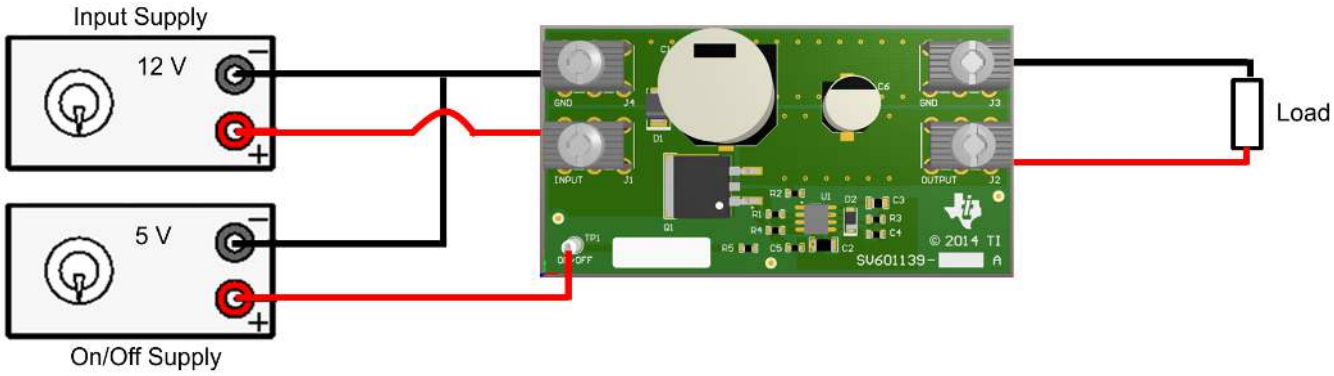

Figure 1. Test Setup Example

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3 Operation

3.1 Start Up Using ON/OFF

The ON/OFF test point is used to start up the operation of the LM9061EVM. To begin operation and drive the high side MOSFET, a voltage greater than 3.3 V should be applied to the ON/OFF test point. As an alternative start up method the ON/OFF test point can be connected to the INPUT connector. When the ON/OFF test point is pulled high, the output voltage, output current, and gate voltage ramp up as shown in Figure 2 and Figure 3. The INPUT voltage is 12 V and the load resistor is 3 Ω.

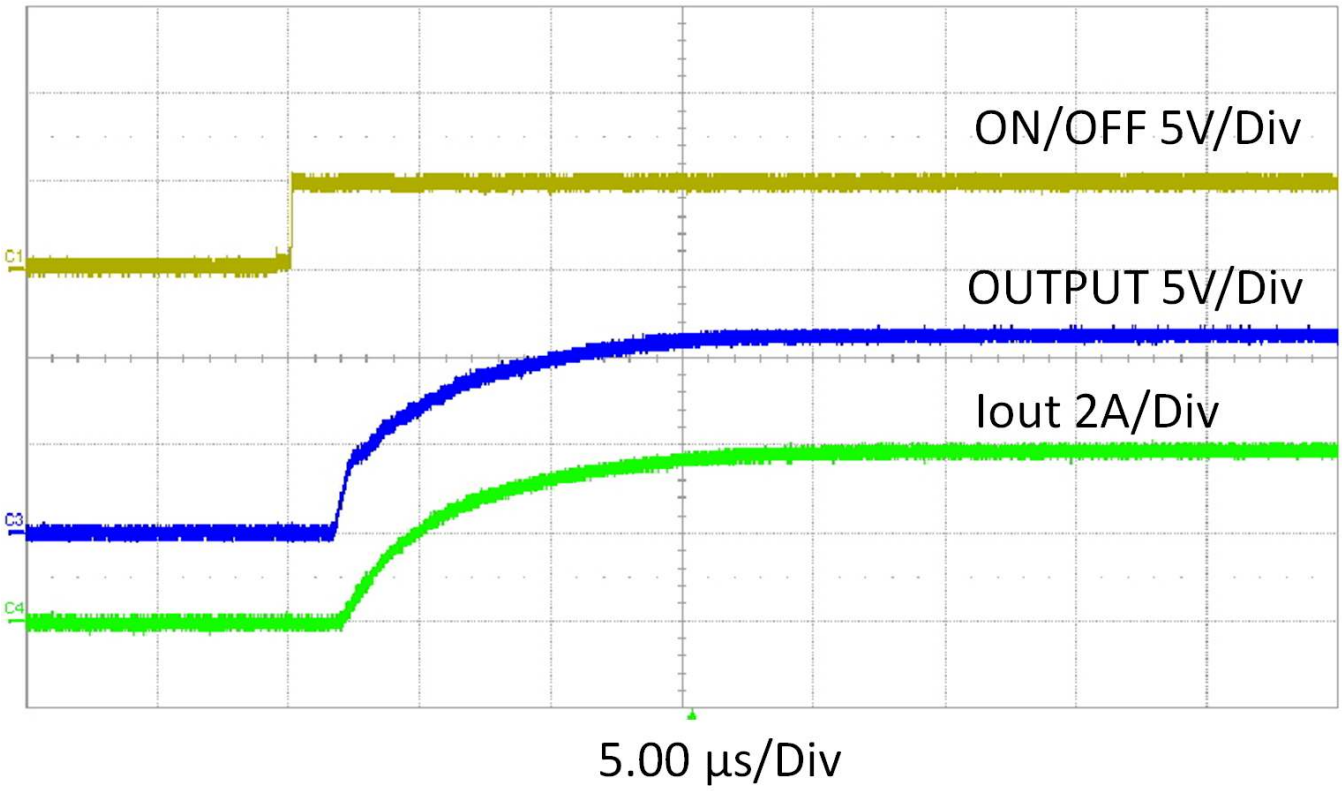

Figure 2. Output During Start Up

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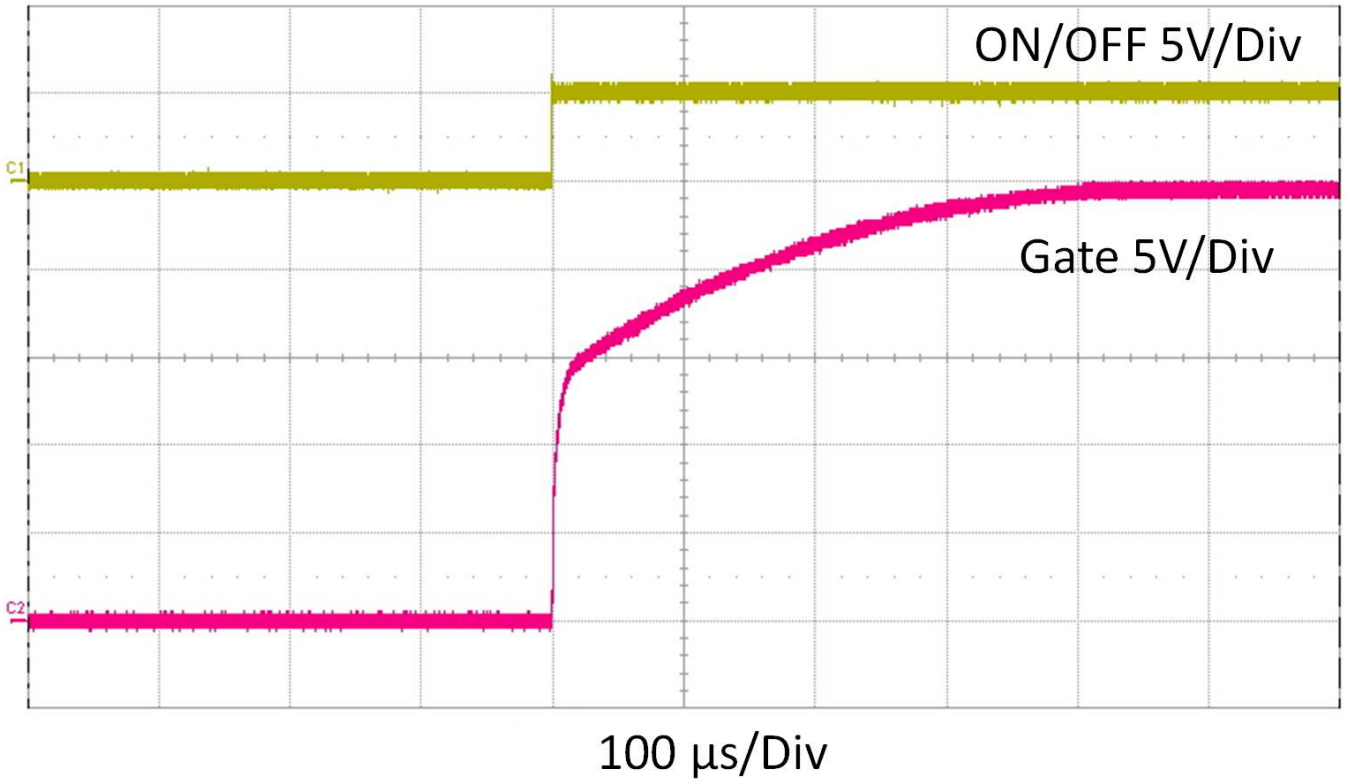

Figure 3. MOSFET Gate During Start Up

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3.2 Shut Down Using ON/OFF

The ON/OFF test point is also used to shut down the operation of the LM9061EVM. A voltage less than 3.3 V should be applied to the ON/OFF test point to shut down the operation and sink the gate capacitance charge from the high side MOSFET. As an alternative shut down method, the ON/OFF test point can be left open, allowing the internal pull-down of the ON/OFF pin to bring the voltage down to ground level. When the ON/OFF test point is pulled low, the output voltage, output current, and gate voltage ramp down as shown in Figure 4 and Figure 5. The INPUT voltage is 12 V and the load resistor is 3 Ω.

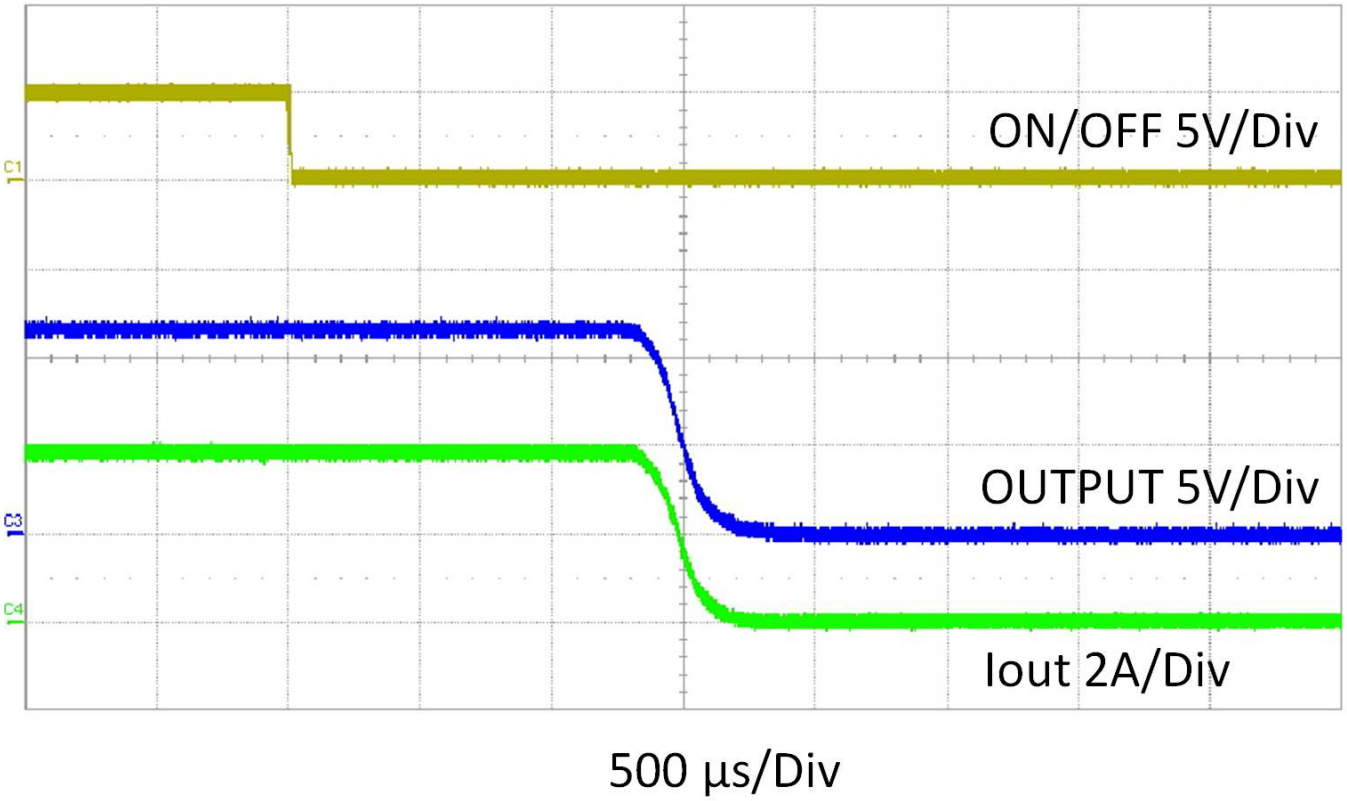

Figure 4. Output During Shut Down

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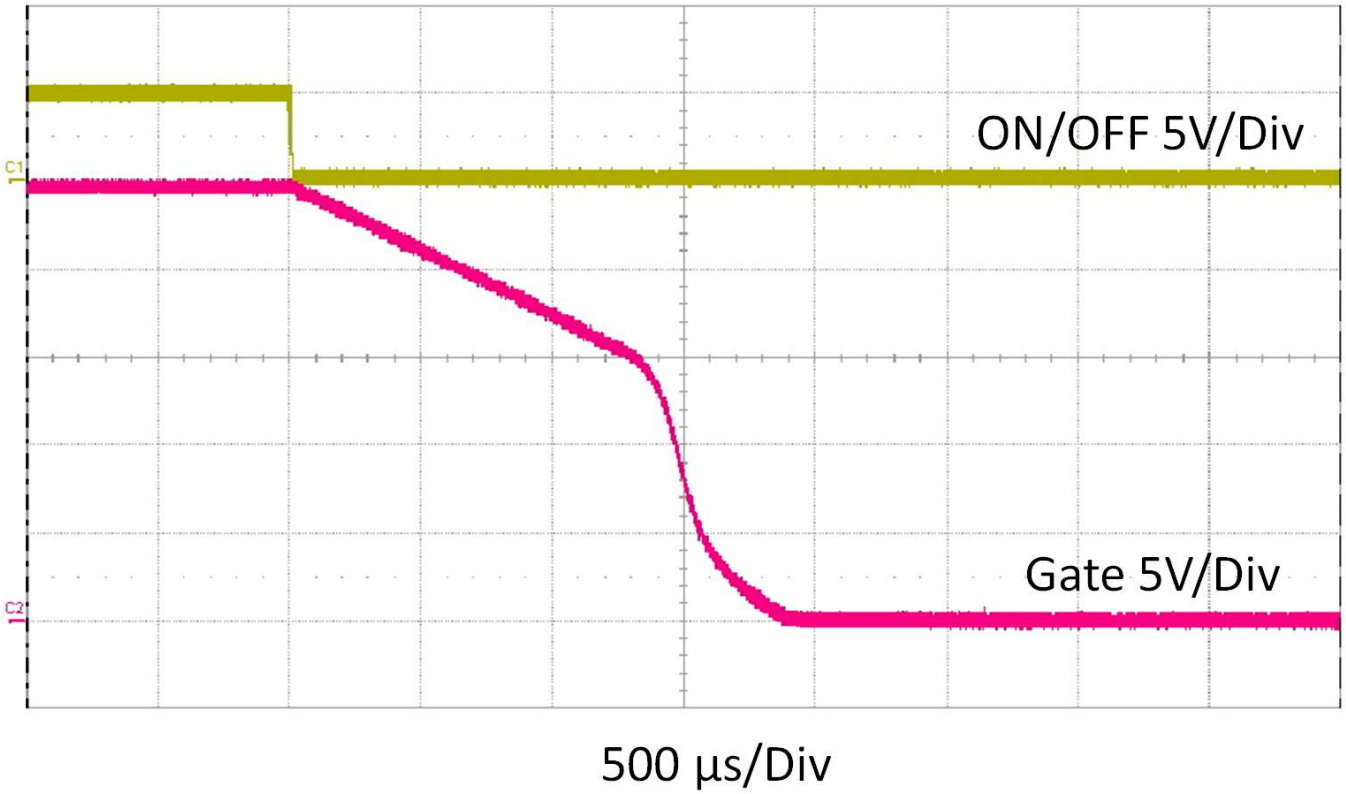

Figure 5. MOSFET Gate During Shut Down

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3.3 Over-Voltage Protection

The LM9061 internal over-voltage protection is activated when the voltage at the INPUT becomes greater than 30 V. When this occurs, the LM9061 will turn off the MOSFET by sinking current from its gate. Once the INPUT has returned to the normal operating range, the device will return to normal operation without requiring toggling the ON/OFF test point. Figure 6 shows the behavior during an over-voltage condition. The ON/OFF test point is 5 V and the load resistor is 20 Ω.

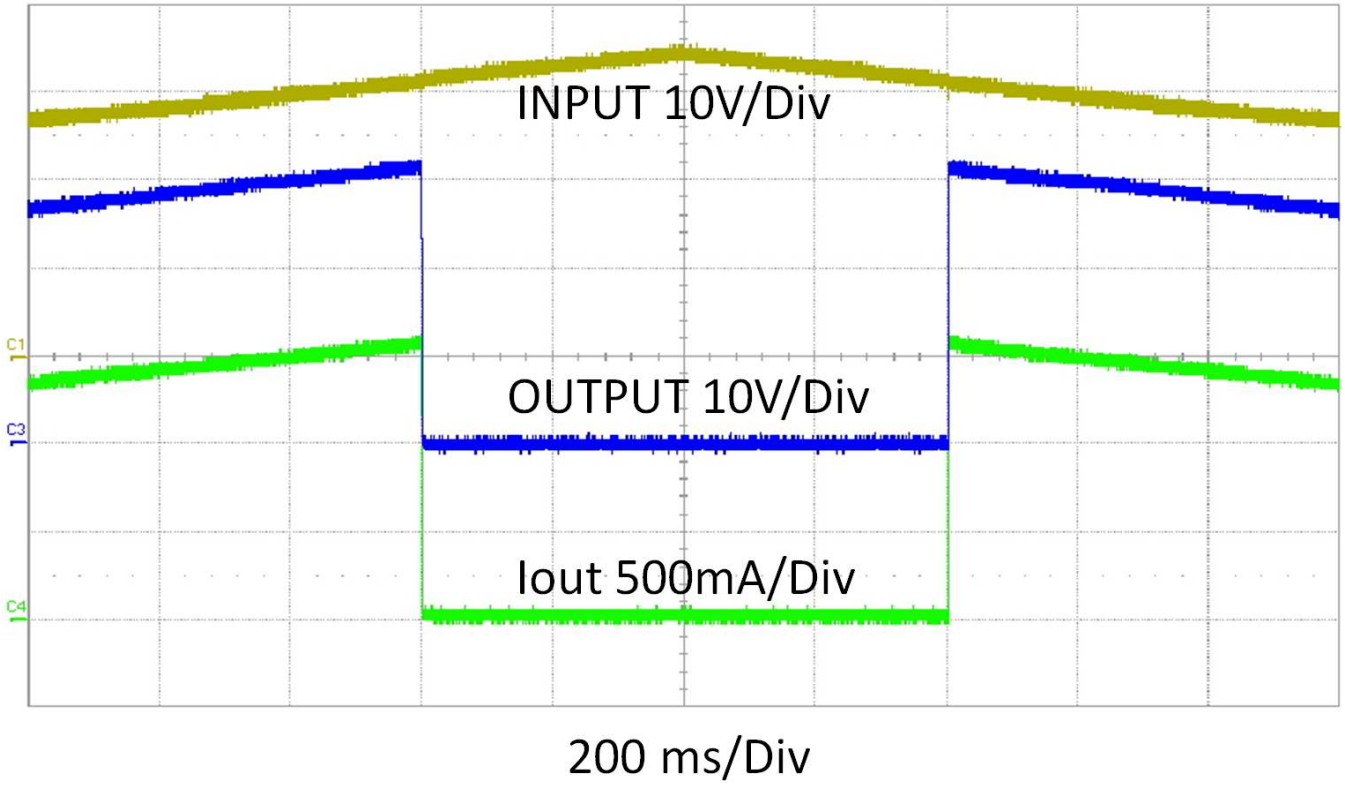

Figure 6. OUTPUT During Over-Voltage Protection

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3.4 Over-Current Protection with Delay Timer

The LM9061 senses excessive current by monitoring the V_{DS} drop across the MOSFET. This allows all of the energy available from the supply to be conducted to the load as required. A sense resistor in series with the load is not required, which allows power loss to be minimized especially with high current loads. The 261 Ω resistor (R1) and the 2.3 mΩ $R_{DS(ON)}$ of the MOSFET (Q1) sets the over-current protection threshold to about 10 A on the LM9061EVM.

The LM9061 also features a delay timer function to allow the MOSFET to conduct currents beyond the protection threshold for a brief period of time. This feature is important to drive loads which require a surge of current in excess of the normal operating current upon start up, such as lamps and motors. The 0.022 µF capacitor (C3) sets this protection delay time to about 12 ms, after which the LM9061 will begin sinking current from the MOSFET gate and latch the output off.

Figure 7 shows the behavior of the output and delay during an over-current condition. For equations to calculate component values for the over-current and delay thresholds, see the LM9061 High-Side Protection Controller data sheet (SNOS738).

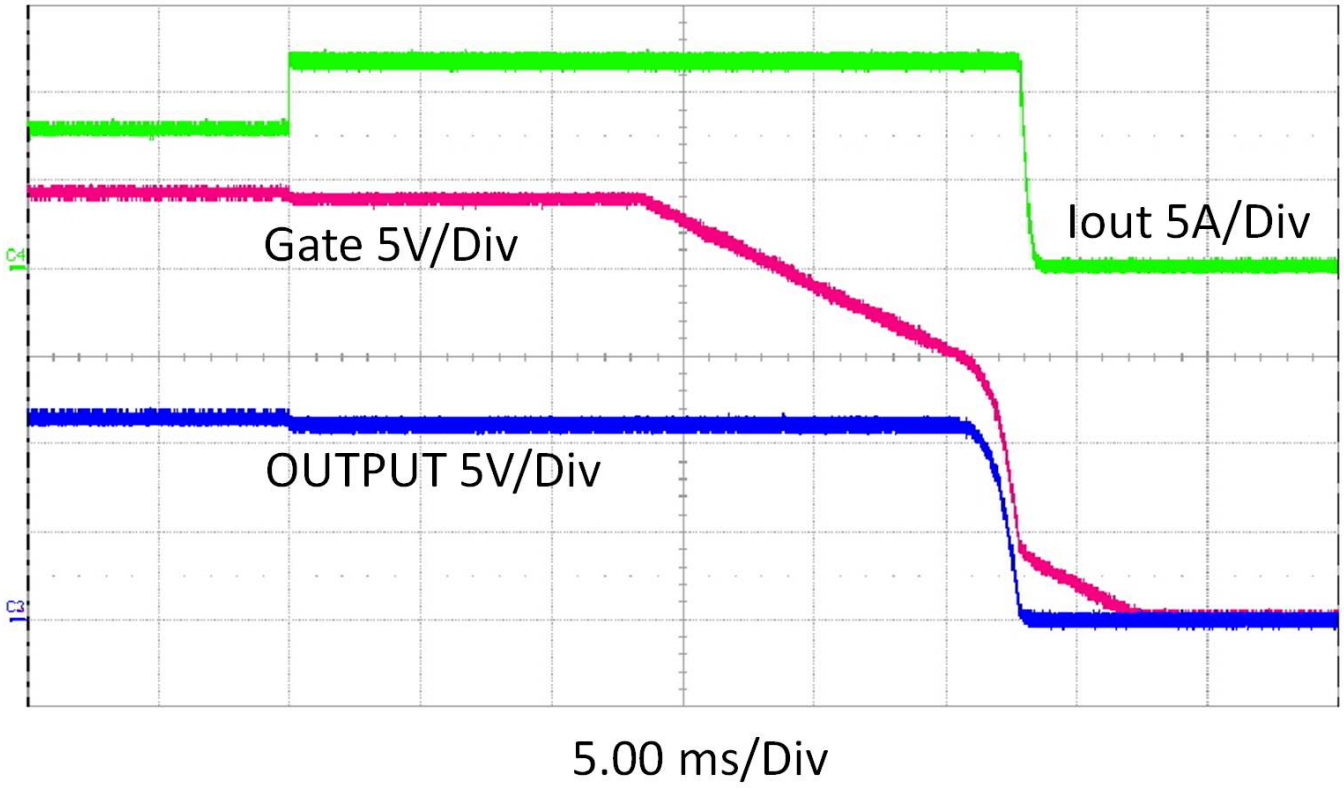

Figure 7. OUTPUT During Over-Current Protection

When the output is latched off due to over-current protection, the LM9061 will not re-start the MOSFET until the ON/OFF test point is toggled low then high.

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3.5 Increasing MOSFET Turn On Time

The resistor R4 and capacitor C5 can be populated to form an RC circuit to slow down the MOSFET's gate voltage transition during turn on and turn off. This can be useful to evaluate driving a larger gate capacitance or to reduce potential inrush currents.

3.6 Voltage Transient Suppression at INPUT

The diode D1 and capacitor C1 provide protection from possible voltage spikes at the INPUT connector. The diode D1 limits the operating voltage range of the EVM to a maximum of 36 V.

3.7 ON/OFF Pin Protection

In accidental cases where the ON/OFF test point is pulled high without a voltage at the INPUT, the diode D2 and resistor R5 may protect the LM9061 from being damaged. Regardless of the protection provided on the EVM, the user must still ensure that the ON/OFF test point voltage be in the range of 0 V to INPUT voltage.

3.8 Component Modifications

Before changing the default components and for information regarding component selection, see the LM9061 High-Side Protection Controller data sheet (SNOS738).

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4 Board Layout

Figure 8 and Figure 9 show the board layout for the LM9061EVM. The PCB provides 2 oz copper planes on the top and bottom as well as vias to help dissipate heat.

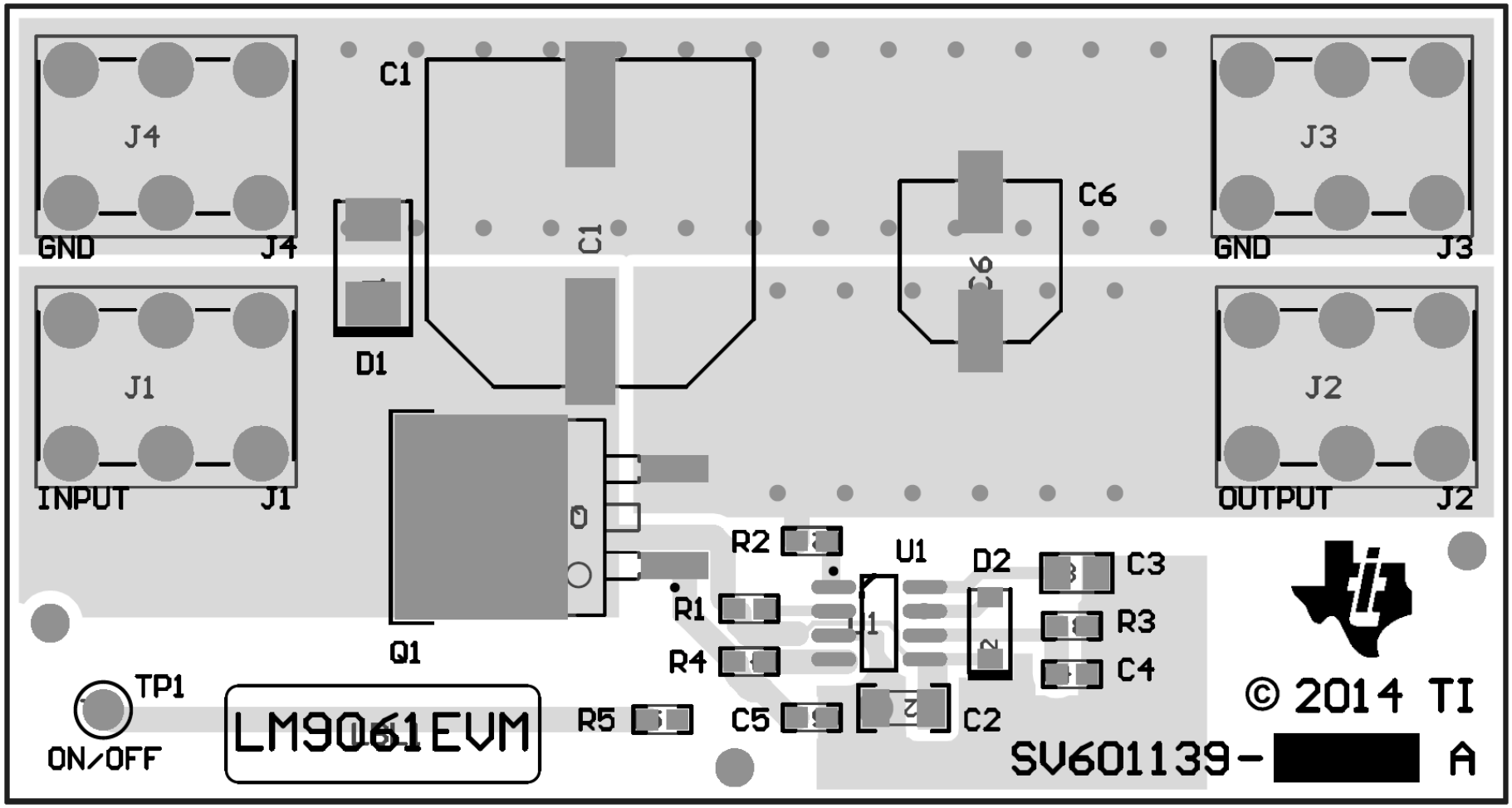

Figure 8. Layout, Top Layer

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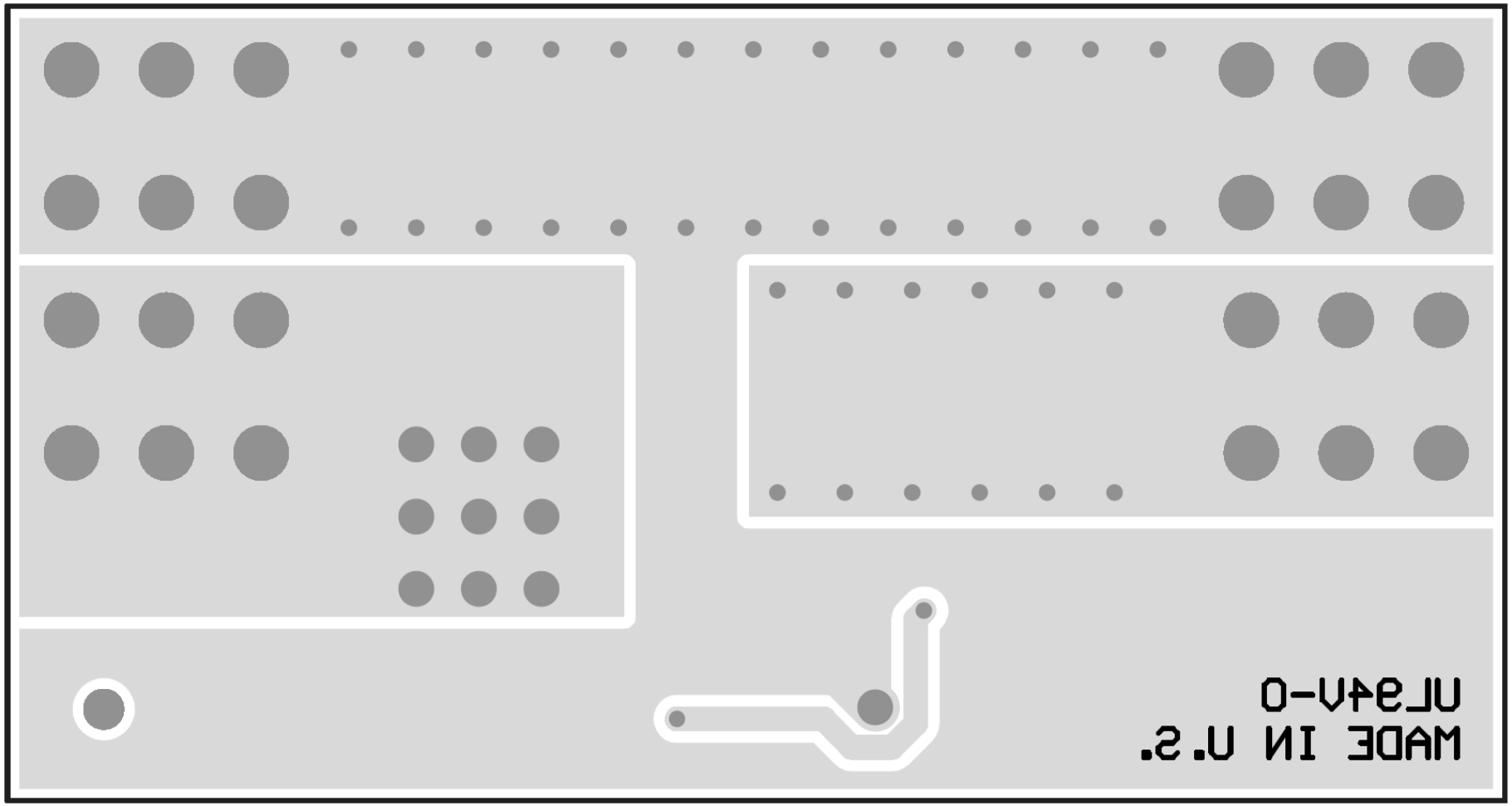

Figure 9. Layout, Bottom Layer

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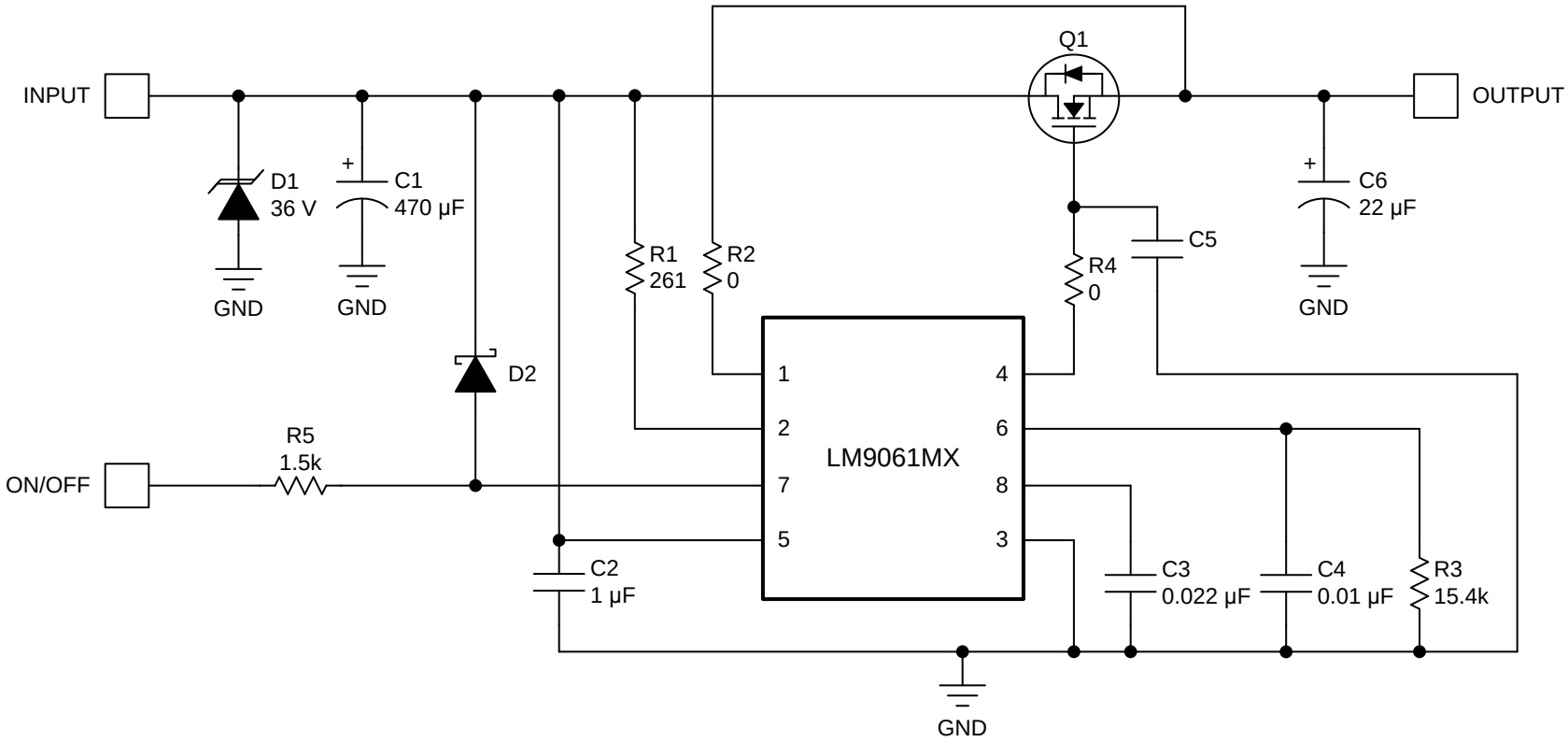

Figure 10. Schematic

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5 Bill of Materials

Table 2. LM9061EVM Bill of Materials

REF DES	COUNT	DESCRIPTION	SIZE	PART NUMBER	MANUFACTURER
!PCB	1	Printed Circuit Board		SV601139	Any
C1	1	CAP, AL, 470 µF, 63 V, +/- 20%, 0.082 Ω, SMD	SMT Radial J16	EEV-FK1J471M	Panasonic
C2	1	CAP, CERM, 1 µF, 100 V, +/- 20%, X7R, 1206	1206	C3216X7R2A105M160AA	TDK
C3	1	CAP, CERM, 0.022 µF, 100 V, +/- 5%, X7R, 0805	805	08051C223JAT2A	AVX
C4	1	CAP, CERM, 0.01 µF, 100 V, +/- 10%, X7R, 0603	603	C1608X7R2A103K	TDK
C6	1	CAP, AL, 22 µF, 63 V, +/- 20%, 0.7 Ω, SMD	HA0	EMVH630ADA220MHA0G	Nippon Chemi-Con
D1	1	Diode, TVS, Uni, 36V, 600W, SMB	SMB	SMBJ36A-13-F	Diodes Inc.
D2	1	Diode, Schottky, 60V, 3A, SOD-123	SOD-123	MBR0560-TP	Micro Commercial Components
J1, J2, J3, J4	4	TERMINAL SCREW PC 30AMP, TH	12.9x6.3x7.9 mm	8199	Keystone
LBL1	1	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650"H x 0.200"W	THT-14-423-10	Brady
Q1	1	MOSFET, N-CH, 100V, 120A, DDPAK	DDPAK	IPB027N10N3 G	Infineon Technologies
R1	1	RES, 261, 1%, 0.1 W, 0603	603	CRCW0603261RFKEA	Vishay-Dale
R2, R4	2	RES, 0, 5%, 0.1 W, 0603	603	CRCW06030000Z0EA	Vishay-Dale
R3	1	RES, 15.4 k, 1%, 0.1 W, 0603	603	CRCW060315K4FKEA	Vishay-Dale
R5	1	RES, 1.5 k, 5%, 0.1 W, 0603	603	CRCW06031K50JNEA	Vishay-Dale
TP1	1	Test Point, Miniature, White, TH	White Miniature Testpoint	5002	Keystone
U1	1	Power MOSFET Driver with Lossless Protection, 8-pin Narrow SOIC	M08A	LM9061MX	Texas Instruments
C5	0	CAP, CERM, 2200 pF, 100 V, +/- 10%, X7R, 0603	603	C1608X7R2A222K	TDK
FID1, FID2, FID3	0	Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A

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6 Related Documentation

- LM9061 High-Side Protection Controller data sheet (SNOS738).

7 Revision History

DATE	REVISION	NOTES
November 2014	*	Initial release.

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

      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*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). 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

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http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

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If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

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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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.

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