Using the UCC24612-1EVM Secondary -Side Synchronous Rectifier Controller Diode-Replacement Board

User's Guide



Literature Number: SLUUBP3
July 2017

General Texas Instruments High Voltage Evaluation (TI HV EVM) User Safety Guidelines



Always follow TI's setup and application instructions, including use of all interface components within their recommended electrical rated voltage and power limits. Always use electrical safety precautions to help ensure your personal safety and those working around you. Contact TI's Product Information Center http://support/ti./com for further information.

Save all warnings and instructions for future reference.

Failure to follow warnings and instructions may result in personal injury, property damage, or death due to electrical shock and burn hazards.

The term TI HV EVM refers to an electronic device typically provided as an open framed, unenclosed printed circuit board assembly. It is **intended strictly for use in development laboratory environments, solely for qualified professional users having training, expertise and knowledge of electrical safety risks in development and application of high voltage electrical circuits. Any other use and/or application are strictly prohibited by Texas Instruments**. If you are not suitable qualified, you should immediately stop from further use of the HV EVM.

1. Work Area Safety
   (a) Keep work area clean and orderly.
   (b) Qualified observer(s) must be present anytime circuits are energized.
   (c) Effective barriers and signage must be present in the area where the TI HV EVM and its interface electronics are energized, indicating operation of accessible high voltages may be present, for the purpose of protecting inadvertent access.
   (d) All interface circuits, power supplies, evaluation modules, instruments, meters, scopes and other related apparatus used in a development environment exceeding 50Vrms/75VDC must be electrically located within a protected Emergency Power Off EPO protected power strip.
   (e) Use stable and nonconductive work surface.
   (f) Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.
2. Electrical Safety
   As a precautionary measure, it is always a good engineering practice to assume that the entire EVM may have fully accessible and active high voltages.
   (a) De-energize the TI HV EVM and all its inputs, outputs and electrical loads before performing any electrical or other diagnostic measurements. Revalidate that TI HV EVM power has been safely de-energized.
   (b) With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment connection, and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
   (c) After EVM readiness is complete, energize the EVM as intended.
   WARNING: WHILE THE EVM IS ENERGIZED, NEVER TOUCH THE EVM OR ITS ELECTRICAL CIRCUITS AS THEY COULD BE AT HIGH VOLTAGES CAPABLE OF CAUSING ELECTRICAL SHOCK HAZARD.
3. Personal Safety
   (a) Wear personal protective equipment (for example, latex gloves or safety glasses with side shields) or protect EVM in an adequate lucent plastic box with interlocks to protect from accidental touch.

Limitation for safe use:

EVMs are not to be used as all or part of a production unit.

Copyright © 2017, Texas Instruments Incorporated

Using the UCC24612-1EVM

1 Introduction

The UCC24612-1EVM evaluation module (EVM) is used to convert the output rectifier of a flyback converter from a diode to a synchronous rectifier (SR) FET to investigate and evaluate the efficiency benefits of using an SR over a rectifier diode.

The EVM comes with the UCC24612-1 SR controller installed. This controller was optimized to work with secondary side output regulated flyback converters (i.e. TL431 opto isolator feedback) in both Continuous Conduction Mode (CCM), Transition-Mode/Quasi-Resonant (TM/QR) and Discontinuous Conduction Mode (DCM). Please refer to the UCC24612 data sheet for operational and functional details.

The SR-MOSFET can achieve very low conduction loss compared to that of a diode rectifier, significantly improving efficiency of the converter. Use this EVM to substitute for the rectifier diode in an existing flyback, LLC, or Active Clamp Flyback converter to evaluate and optimize the SR performance. It is ideally suited for converters with output voltages ranging from 4 V to 28 V at current levels up to 5 A, but may be adaptable to other conditions with special considerations. Please note the design is only limited to 5 A due to the SR FET that was chosen for the design. More current could be achieved if a different FET was chosen for the design. Graphical representations of the EVM can be seen in Figure 1 and Figure 2. Test points on the EVM provide input nodes for VDD bias voltage (TP3), SR FET drain (VD, TP2), source (VS, TP1) and gate drive (VG, TP4) connections to the diode anode and cathode.

This user's guide provides the schematic, component list of materials, and installation instructions necessary to evaluate the UCC24612 in a flyback power converter.

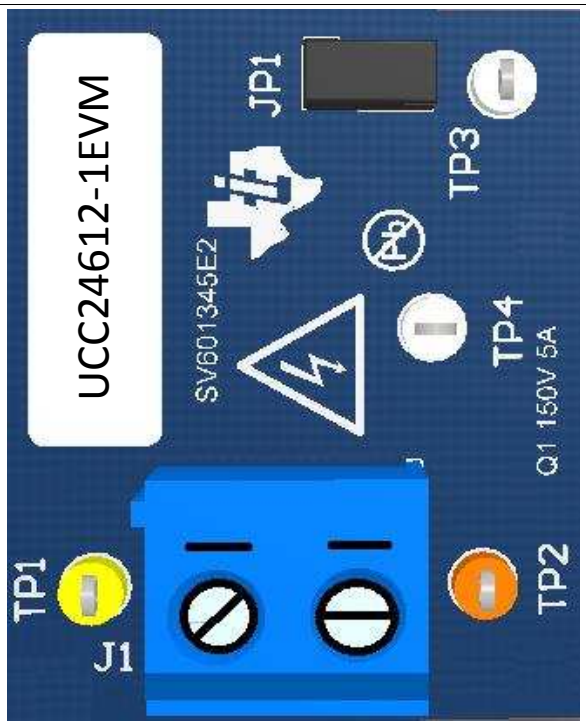


Figure 1. UCC24612-1EVM (Top View)

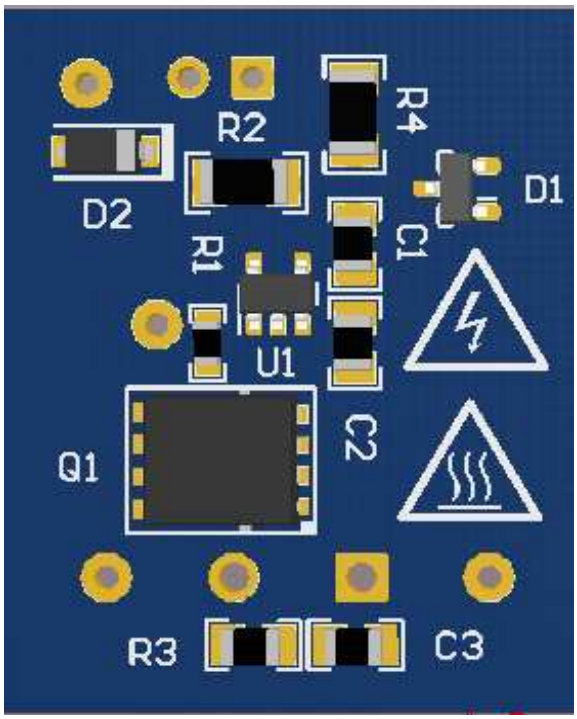


Figure 2. UCC24612-1EVM (Bottom View)

Copyright © 2017, Texas Instruments Incorporated

2 Description

This evaluation module uses the TI UCC24612-1 Synchronous Rectifier Controller together with a **150-V, 19-mΩ MOSFET**. The MOSFET can withstand up to 150 V during its off state, and can conduct up to 5 A RMS current without special cooling at room temperature of 25°C. Higher currents may be accommodated, but the additional dissipation by the MOSFET may raise its case temperature above the safe handling level unless extra cooling is provided.

Four test points and a terminal block provide access to several important nodes in the SR control circuit. Refer to the schematic diagram of the UCC24612-1EVM in Figure 3. In a low-side rectifier application, the EVM can connect directly to the converter's output, provided that the output voltage is in the range of 4 V to 28 V. Please refer to Figure 4 for circuit connections. For high-side rectifier applications please refer to Figure 5 for circuit connections.

The 2-position terminal block is used to connect the on-board MOSFET source and drain nodes to the application using wires. Short lengths of bare wire, 20 AWG – 18 AWG (0.75 – 1 mm diameter), are best but other sizes with or without insulation can be used. Please refer to Figure 4 and Figure 5 for circuit connections.

3 Schematic

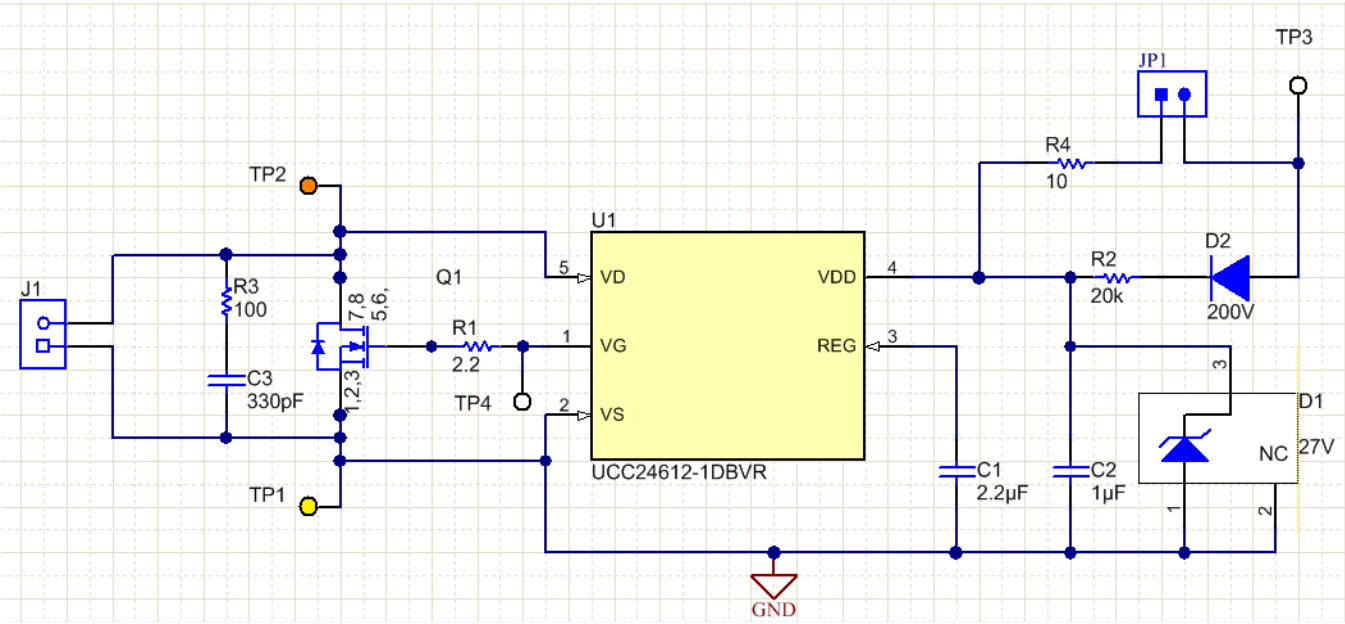


Figure 3. UCC24612-1EVM Schematic

NOTE:

(a) JP1 is populated for low side SR configuration Figure 4(Default).

(b) JP1 is not populated for high side SR configuration figure 5.

(c) Please note resistor R3 and capacitor C3 form an RC snubber and are not populated on the evaluation module. These are to be set by the user to reduce/dampen ringing on the secondary side of the transformer. **It is required that the user setup this snubber to ensure that the UCC24612 EVM functions properly.**

- Selection of components is covered in section 7, pages 5 and 6

Copyright © 2017, Texas Instruments Incorporated

4 Test Point and Terminal Block

(a) Terminal block (J1) is used to connect to the flyback power converter in place of a rectifier diode.
(b) Test Point 2 (TP2) is used for U1 and Q1 drain sensing/probing/connecting.
(c) Test Point 3 (TP3) is connected to the output of the flyback power to provide power to U1.
(d) Test Point 4 (TP4) is used to evaluate the gate drive (VG) of the UCC24612.

5 Specifications

Table 1. UCC24612-1EVM Test Points

CONNECTIONS	MAX
TP1(-) to TP2(+)	150 V
TP1(-) to TP3(+)	30 V
TP1 to TP3	5-A RMS

6 EVM Used in a Low-Side (LS) SR Application

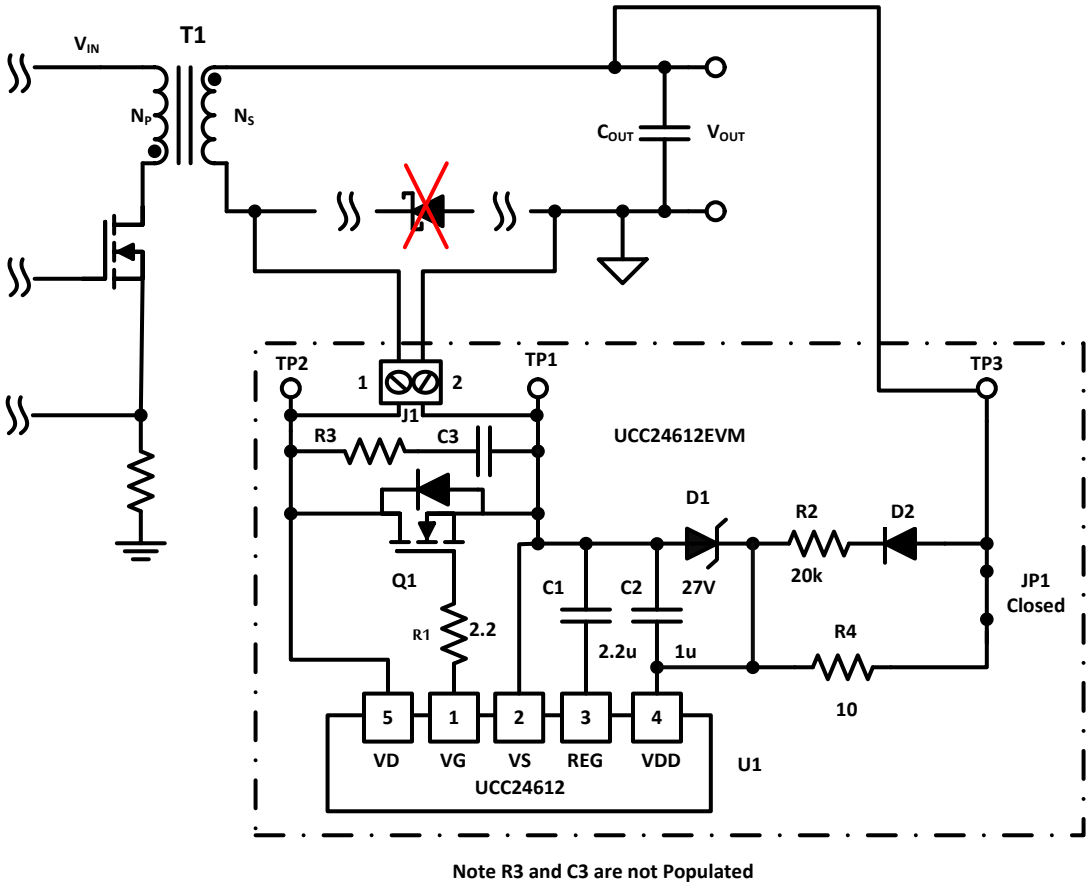


Figure 4. UCC24612-1EVM Used in Low-Side Rectifier Application

Copyright © 2017, Texas Instruments Incorporated

7 RC Snubber Setup for C3 and R3

It is required for the user to setup snubber components C3 and R3 to get the best performance when using the UCC24612-1EVM.

To setup these components will require knowing the flyback transformers secondary leakage inductance (Lslk) and measuring the secondary resonant ring frequency (fr) in circuit. It is recommended that the SR is not engaged while doing this. TP3 should be disconnected from the flyback converter to ensure FET Q1 is turned off while setting up the snubber.

The secondary winding capacitance (Cs) then needs to be calculated based on the following equation. Please note for a transformer with a secondary winding leakage inductance of 3.8 uH and a ring frequency of 2 MHz, the parasitic capacitance would be 1.7 nF.

$$Cs = \frac{1}{(2 \times \pi \times f_r)^2 \times Lslk} = \frac{1}{(2 \times \pi \times 2MHz)^2 \times 3.8uH} = 1.7nF \quad (1)$$

Based on the calculated Cs, Lslk and fr the snubber resistor R3 can be set to critically dampen the ringing on the secondary, which requires setting the Q of the circuit equal to 1.

$$R3 = \frac{1}{Q}\sqrt{\frac{Lslk}{Cs}} = \frac{1}{1}\sqrt{\frac{3.8uH}{1.7nF}} \approx 47\ ohm \quad (2)$$

Capacitor C3 is used to limit the time the snubber resistor is applied to the aux winding during the switching cycle. It is recommended to set the snubber capacitor C3 with the following equation based on the flyback converters switching frequency (f_{SW}). For a flyback converter switching at 85 kHz in the example would require a C3 of roughly 497 pF.

$$C3 = \frac{0.01}{5 \times fsw \times R3} = \frac{0.01}{5 \times 85kHz \times 47.3ohm} \approx 497pF \quad (3)$$

Please note that the calculations for R3 and C3 are just starting points and should be adjusted based on individual preference, performance and efficiency requirements.

8 High-Side Operation

To use the UCC24612-1EVM to replace a high-side rectifier requires removing jumper JP1 and connecting the EVM as shown in Figure 5. Please note that the EVM comes with a default filtering resistor (R2) of 20 kΩ. **However, resistor R2 needs to be adjusted based on your individual application.**

Copyright © 2017, Texas Instruments Incorporated

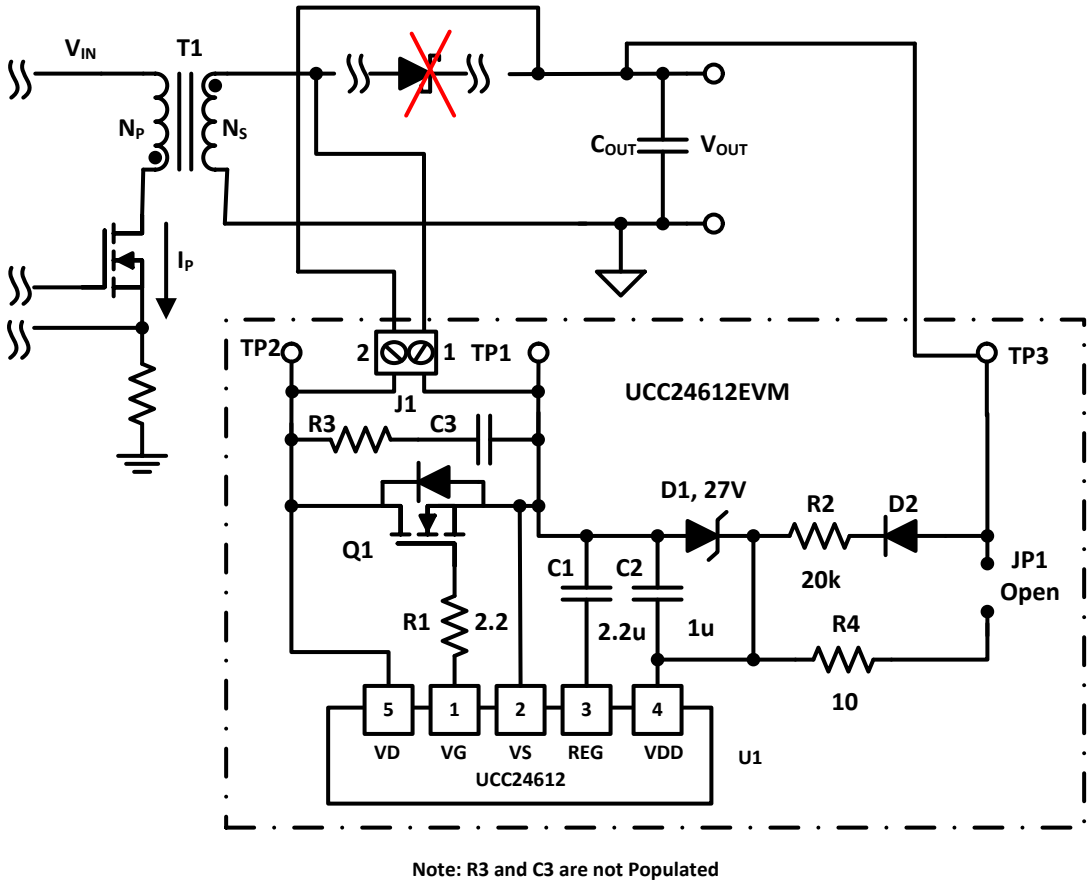


Figure 5. UCC24612-1EVM Used in High-Side Rectifier Application

If the magnitude of voltage across TP1 and TP2 is less than 28 V please remove R2 that is populated on the EVM (20 kΩ) and set R2 to 0 to 10 ohms and remove 27-V Zener diode D1 from the board.

If TP2 to TP1 is greater than 28 V use resistor R2 to setup an averaging filter to lower the DC voltage applied to VD.

The RC filter formed by C2 and R2 requires setting the filter pole frequency to a hundredth of the converter's maximum switching frequency. In this example the converter's maximum switching frequency (f_{SW}) was 85 kHz. Please note the switching frequency will vary based on design and preference.

$$R2 > \frac{1}{2\pi \times C1 \times \frac{f_{SW}}{100}} = \frac{1}{2\pi \times 1uF \times \frac{85kHz}{100}} \approx 187ohm \quad (4)$$

When the RC filter circuit is used, to engage the gate driver properly it is recommended that the VD voltage applied be between 4 V to 27 V to provide enough energy and voltage to the gate driver. This range can be determined in a fixed frequency flyback converter with the following equations. Variable D_{MAX} in the maximum duty cycle of the converter and D_{MIN} is the minimum duty cycle of the converter. Variable N_P is the flyback transformer's primary (T1) number of turns and N_S is the transformers secondary number of turns. Please refer to figure 5 for details.

Maximum VDD voltage ($V_{VD(MAX)}$):

$$V_{VD(MAX)} = \left(V_{OUT} + V_{IN(MAX)} \times \frac{N_S}{N_P}\right) \times D_{MAX} = \left(20V + 375V \times \frac{1}{13}\right) \times 0.5 = 24.4V \quad (5)$$

Minimum VDD voltage ($V_{VD(MIN)}$):

$$V_{VD(MIN)} = \left(V_{OUT} + V_{IN(MIN)} \times \frac{N_S}{N_P}\right) \times D_{MIN} = \left(20V + 72V \times \frac{1}{13}\right) \times 0.36 = 9.2V \quad (6)$$

Copyright © 2017, Texas Instruments Incorporated

9 Application Test Data

The UCC24612-1EVM was used in a synchronous rectifier in both a high side and low side application in an offline (V_{IN} = 85 V to 265 V RMS), 20-V (V_{OUT}), 60-W application. The controller used in this design was a UCC28740 secondary side regulated, variable-frequency flyback controller that had a maximum switching frequency of roughly 85 kHz. Please refer to the UCC28740 data sheet for further details.

9.1 Steady State Testing Low Side

- Snubber Components, R2 = 1.02 kΩ, R3 = 51.1Ω , C3 = 470 pF
- CH1 = VG, CH2 = Q1 drain (TP2), CH3 = V_{OUT} Voltage Ripple (TP3)

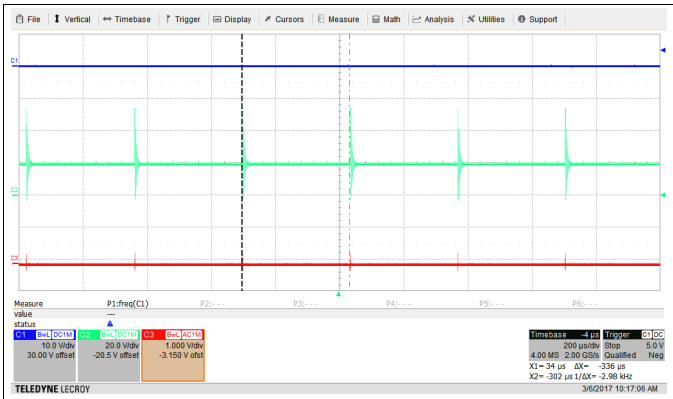


Figure 6. V_{IN} = 85 V RMS, I_{OUT} = 0 A

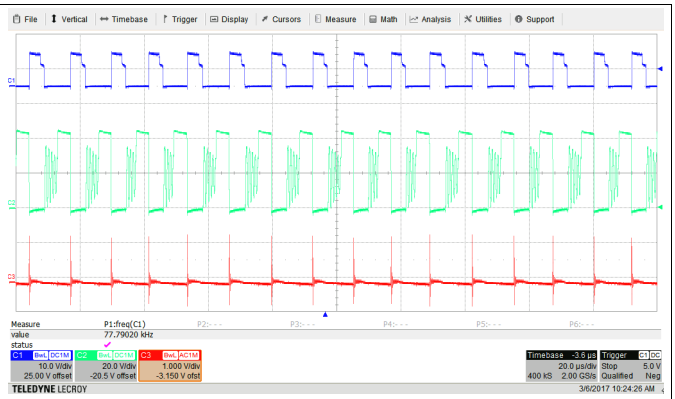


Figure 7. V_{IN} = 85 V RMS, I_{OUT} = 3 A

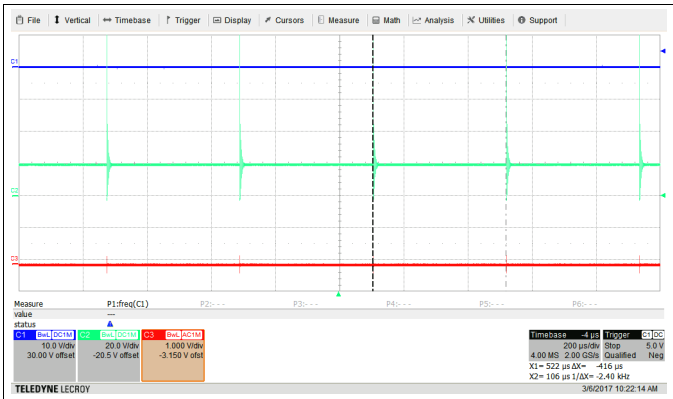


Figure 8. V_{IN} = 265 V RMS, I_{OUT} = 0 A

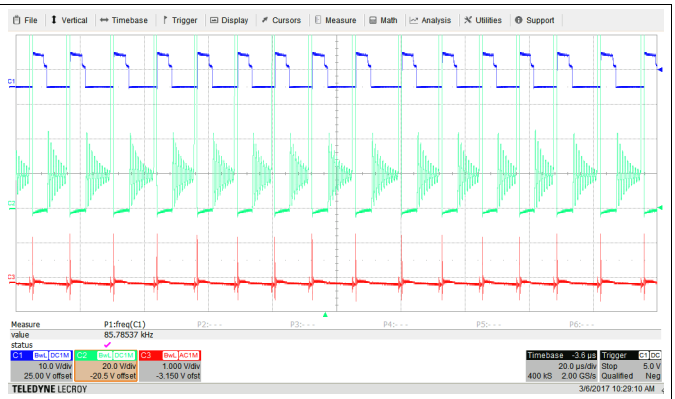


Figure 9. V_{IN} = 265 V RMS, I_{OUT} = 3 A

9.2 Steady State Testing High Side

- Snubber Components, R2 = 1.02 kΩ, R3 = 51.1Ω , C3 = 470 pF
- CH1 = VG, CH2 = Q1 drain (TP2), CH3 = V_{OUT} Voltage Ripple (TP3)

Copyright © 2017, Texas Instruments Incorporated

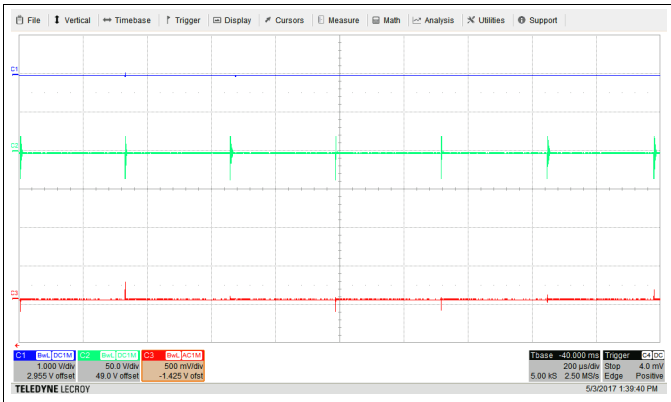


Figure 10. V_{IN} = 85 V RMS, I_{OUT} = 0 A

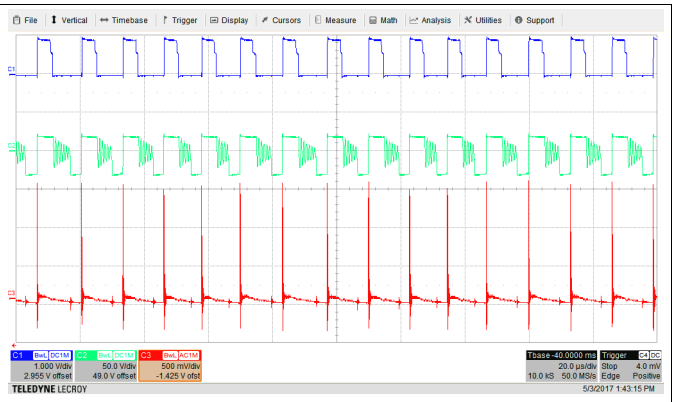


Figure 11. V_{IN} = 85 V RMS, I_{OUT} = 3 A

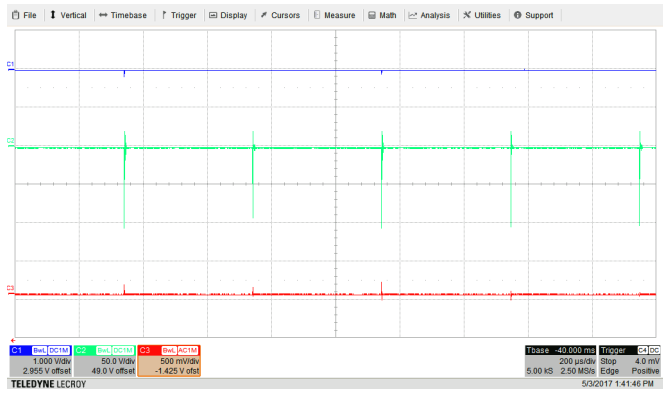


Figure 12. HS, V_{IN} = 265 V RMS, I_{OUT} = 0 A

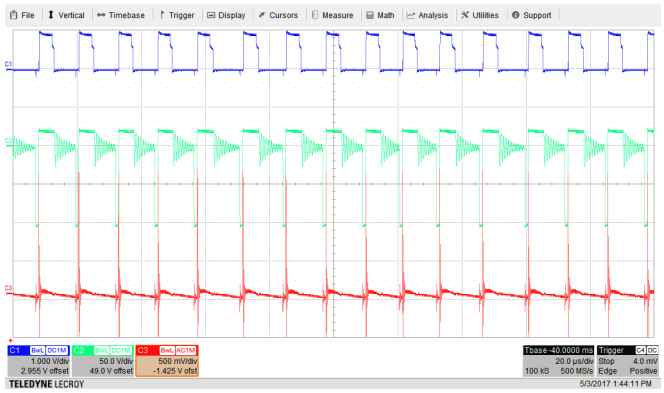


Figure 13. V_{IN} = 265 V RMS, I_{OUT} = 3 A

Copyright © 2017, Texas Instruments Incorporated

10 EVM Layout

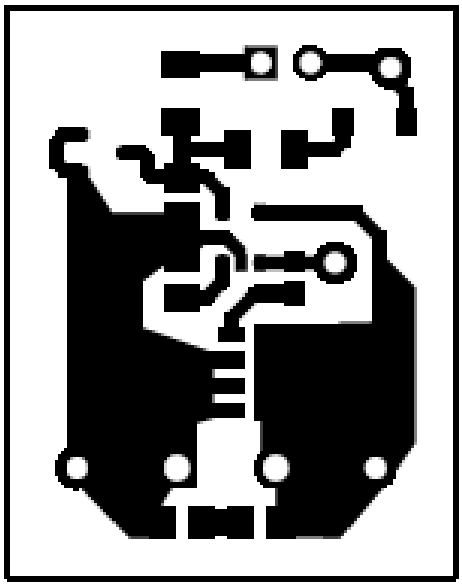


Figure 14. EVM Layout

Copyright © 2017, Texas Instruments Incorporated

11 List of Materials

UCC24612-1EVM list of materials as shown in Figure 1.

Table 2. UCC24612-1EVM List of Materials

QTY	DES	DESCRIPTION	PART NUMBER	MANUFACTURER
1	C1	Capacitor, ceramic, 2.2 µF, 50 V, ±20%, X7R, 0805	C2012X7R1H225M125AC	TDK
1	C2	Capacitor, ceramic, 1 µF, 50 V, ±10%, X7R, 0805	08055C105KAT2A	AVX
0	C3	Capacitor, ceramic, 330 pF, 50 V, ±10%, C0G/NP0, 0805	08055A331KAT2A	AVX
1	D1	Diode, Zener, 27 V, 225 mW, SOT-23	MMBZ5254BLT1G	ON Semiconductor
1	D2	Diode, fast rectifier, 200 V, 0.8 A, SOD-123	RF081M2STR	Rohm
1	J1	Terminal block, 5.08 mm, 2x1, Brass, TH	ED120/2DS	On-Shore Technology
1	JP1	Header, TH, 100 mil, 2 x 1, Gold plated, 230 mil above insulator	TSW-102-07-G-S	Samtec
1	Q1	MOSFET, N-channel, 150 V, 50 A, PG-TDSON-8	BSC190N15NS3 G	Infineon Technologies
1	R1	Resistor, 2.2 Ω, 5%, 0.1 W, 0603	CRCW06032R20JNEA	Vishay-Dale
1	R2	Resistor, 20 kΩ, 5%, 0.25 W, 1206	CRCW120620K0JNEA	Vishay-Dale
1	R4	Resistor, 10 Ω, 5%, 0.25 W, 1206	CRCW120610R0JNEA	Vishay-Dale
0	R3	Resistor, 100 Ω, 5%, 0.125 W, 0805	CRCW0805100RJNEA	Vishay-Dale
1	SH-JP1	Shunt, 100 mil, flash gold, black	SPC02SYAN	Sullins Connector Solutions
1	TP1	Test point, miniature, yellow, TH	5004	Keystone
1	TP2	Test point, miniature, orange, TH	5003	Keystone
2	TP3, TP4	Test point, miniature, white, TH	5002	Keystone
1	U1	UCC24612-1DBV, DBV0005A (SOT-5)	UCC24612-1DBVR	Texas Instruments

Copyright © 2017, Texas Instruments Incorporated

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 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.

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.

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

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２４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。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2017, Texas Instruments Incorporated

IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ('TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products http://www.ti.com/sc/docs/stdterms.htm), evaluation modules, and samples (http://www.ti.com/sc/docs/sampterms.htm).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2017, Texas Instruments Incorporated