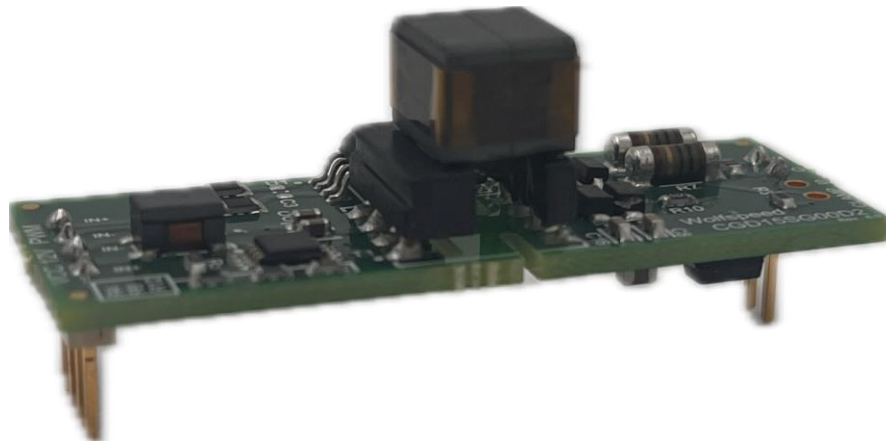


CGD15SG00D2 Gate Driver User Guide



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Contents

1. Introduction.....	8
2. Schematic and Functionality.....	10
3. Physical Dimensions.....	13
4. Electrical Connection Points.....	14
5. PCB Layout.....	15
6. Revision History.....	17
7. Appendix.....	17
8. Important Notes.....	18

This document is prepared as a user guide to install and operate Wolfspeed® evaluation hardware. All parts of this user guide are provided in English, and the cautions are provided in English, Mandarin, and Japanese. If the end user of this board is not fluent in any of these languages, it is your responsibility to ensure that they understand the terms and conditions described in this document, including without limitation the hazards of and safe operating conditions for this board.

本文件中的所有内容均以英文书写，“注意”部分的内容以英文、中文和日语书写。作为本板子的终端用户，即使您不熟悉上述任何一种语言，您也应当确保正确理解本文件中的条款与条件，包括且不限于本板子的危险隐患以及安全操作条款。

当書類のすべての内容は英語で書きます。「注意点」の内容は英語、中国語、また日本語で書きます。当ボードの端末使用者は上記の言語が一つでもわからないなら、当端末使用者は当書類の条約と条件が理解できるのを確保すべきです。そして、当ボードの危険や安全に使用する条件を含み、また限りません。

Note: This Wolfspeed-designed evaluation hardware for Wolfspeed® components is a fragile, high voltage, high-temperature power electronics system that is meant to be used as an evaluation tool in a lab setting and to be handled and operated by highly qualified technicians or engineers. When this hardware is not in use, it should be stored in an area that has a storage temperature ranging from -40° Celsius to 105° Celsius. If this hardware is transported, special care should be taken during transportation to avoid damaging the board or its fragile components and the board should be transported carefully in an electrostatic discharge (ESD) bag, or with ESD or shorting protection that is the same as, or similar to, the protection that is or would be used by Wolfspeed when shipping this hardware, to avoid any damage to electronic components. Please contact Wolfspeed at forum.wolfspeed.com if you have any questions about the protection of this hardware during transportation. The hardware does not contain any hazardous substances, is not designed to meet any industrial, technical, or safety standards or classifications, and is not a production-qualified assembly.

本样机（易碎、高压、高温电力电子系统）由科锐为评估其功率半导体产品而设计，用以作为在实验室环境下由专业的技术人员或工程师处理和使用的评估工具。本样机不使用时，应存储在-40°C~105°C温度范围的区域内；如需运输样机，运输过程中应该特别小心，避免损坏电路板等易碎组件。如果您对此硬件在运输之中的保护有任何疑问，请联系forum.wolfspeed.com。样机应放置在防静电包装袋内谨慎运输，避免损坏电子组件。本样机不含任何有害物质，但其设计不符合任何工业、技术或安全标准或分类，也不是可用于生产的组件。

このクリーのコンポーネント用評価ハードウェアは壊れやすい高電圧の高温パワーエレクトロニクスシステムであり、ラボ環境での評価ツールとして使用され、優秀な技術者やエンジニアによって処理され、操作されることを意図している。ハードウェアが使用されていない場合、保管温度が-40°Cから105°Cの範囲に保管してください。このハードウェアを輸送する場合は、輸送中にボードまたはその壊れやすいコンポーネントに損傷を与えないよう特別な注意を払う必要がある。また電子部品の損傷を避けるためにボードを静電気放電(ESD)袋に静置して慎重に輸送すべき。ハードウェアの輸送中の保護について質問があれば

<https://forum.wolfspeed.com/> に連絡してください。ハードウェアには危険物質が含まれていないが、工業的、技術的、安全性の基準または分類に適合するように設計されておらず、生産適格組立品でもない。



CAUTION

PLEASE CAREFULLY REVIEW THE FOLLOWING PAGE, AS IT CONTAINS IMPORTANT INFORMATION REGARDING THE HAZARDS AND SAFE OPERATING REQUIREMENTS RELATED TO THE HANDLING AND USE OF THIS BOARD.

警告

请认真阅读以下内容，因为其中包含了处理和使用本板子有关的危险和安全操作要求方面的重要信息。

警告

ボードの使用、危険の対応、そして安全に操作する要求などの大切な情報を含むので、以下の内容をよく読んでください。

**CAUTION**

DO NOT TOUCH THE BOARD WHEN IT IS ENERGIZED AND ALLOW THE BULK CAPACITORS TO COMPLETELY DISCHARGE PRIOR TO HANDLING THE BOARD. THERE CAN BE VERY HIGH VOLTAGES PRESENT ON THIS EVALUATION BOARD WHEN CONNECTED TO AN ELECTRICAL SOURCE, AND SOME COMPONENTS ON THIS BOARD CAN REACH TEMPERATURES ABOVE 50 ° CELSIUS. FURTHER, THESE CONDITIONS WILL CONTINUE FOR A SHORT TIME AFTER THE ELECTRICAL SOURCE IS DISCONNECTED UNTIL THE BULK CAPACITORS ARE FULLY DISCHARGED.

Please ensure that appropriate safety procedures are followed when operating this board, as any of the following can occur if you handle or use this board without following proper safety precautions:

- Death
- Serious injury
- Electrocution
- Electrical shock
- Electrical burns
- Severe heat burns

You must read this document in its entirety before operating this board. It is not necessary for you to touch the board while it is energized. All test and measurement probes or attachments must be attached before the board is energized. You must never leave this board unattended or handle it when energized, and you must always ensure that all bulk capacitors have completely discharged prior to handling the board. Do not change the devices to be tested until the board is disconnected from the electrical source and the bulk capacitors have fully discharged.

警告

请勿在通电情况下接触板子，在处理板子前应使大容量电容器完全释放电力。接通电源后，该评估板上可能存在非常高的电压，板子上一些组件的温度可能超过50 摄氏度。此外，移除电源后，上述情况可能会短暂持续，直至大容量电容器完全释放电量。

操作板子时应确保遵守正确的安全规程，否则可能会出现下列危险：

- 死亡
- 严重伤害
- 触电
- 电击
- 电灼伤
- 严重的热烧伤

请在操作本板子前完整阅读本文件。通电时不必接触板子。在为板子通电前必须连接所有测试与测量探针或附件。通电时，禁止使板子处于无人看护状态，或操作板子。必须确保在操作板子前，大容量电容器释放了所有电量。只有在切断板子电源，且大容量电容器完全放电后，才可更换待测试器件

警告

通電している時、ボードに接触するのは禁止です。ボードを処分する前に、大容量のコンデンサーで電力を完全に釈放すべきです。通電してから、ボードにひどく高い電圧が存在している可能性があります。ボードのモジュールの温度は50 度以上になるかもしれません。また、電源を切った後、上記の状況がしばらく持続する可能性がありますので、大容量のコンデンサーで電力を完全に釈放するまで待ってください。

ボードを操作するとき、正確な安全ルールを守るのを確保すべきです。さもないと、以下の危険がある可能性があります：

- 死亡
- 重症
- 感電
- 電撃
- 電気の火傷
- 厳しい火傷

当ボードを操作する前に、完全に当書類をよく読んでください。通電している時にボードに接触する必要がありません。通電する前に必ずすべての試験用のプローブあるいはアクセサリーをつないでください。通電している時に無人監視やボードを操作するのは禁止です。ボードを操作する前に、大容量のコンデンサーで電力を完全に釈放するのを必ず確保してください。ボードの電源を切った後、また大容量のコンデンサーで電力を完全に釈放した後、試験設備を取り換えることができます。

1. Introduction

The purpose of this user guide is to demonstrate the design and use of Wolfspeed’s CGD15SG00D2 isolated single-channel gate driver tailored for Wolfspeed’s Silicon Carbide (SiC) MOSFETs utilizing +15V / -3V gate drive levels. Rev 7.0 of this gate driver differs from the previously released Rev 4.0, which demonstrated the use of a 5Kvac optocoupler and a non-isolated gate driver that functioned in conjunction to perform isolation. SiC gate driver technology has since undergone vast improvements, and this revision seeks to demonstrate a design that is more compatible with current technologies. In direct functional comparison, U1(Optocoupler) and U2 (Gate Driver IC) have been combined. The bias supply framework also reflects an LLC-based discrete solution as opposed to the module-level solution of the previous revision. Central features of the PCB have been retained to ensure that the Rev 7.0 serves as a plug-in replacement. This design includes the following features:

- Creepage-enhancing grooves between the logic side and the power side of the printed circuit board (PCB)
- 2W isolated power supply that enables the operation of larger MOSFETs at higher frequencies
- 5kVRMS single-channel isolated gate driver with opto-compatible input
- Separate gate turn-on and gate turn-off resistors with a dedicated diode, which allows user-friendly optimization of both turn-on and turn-off signals
- Common mode inductor on logic power input for enhanced electromagnetic interference (EMI) immunity
- 5V and 3.3V logic compatibility on PWM pins

The top and bottom views of Wolfspeed’s CGD15SG00D2 gate driver board are shown in Figure 1 and Figure 2. The creepage-enhancing grooves can be seen on the bottom view. The turn-on and turn-off resistors and the accompanying diode are all on the top side of the board to facilitate changes on the laboratory bench.



Figure 1: Top view of the board



Figure 2: Bottom view of the board

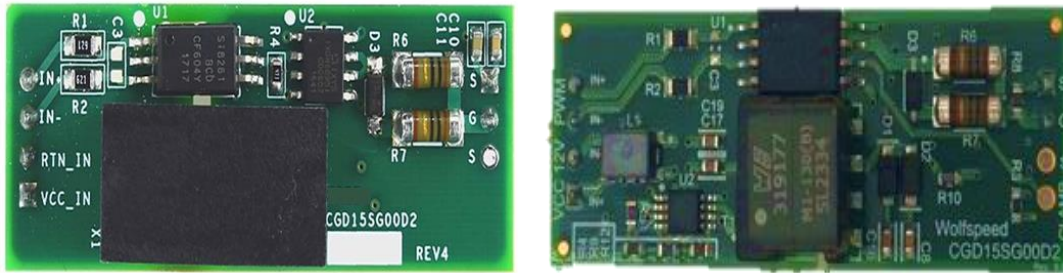


Figure 3: Difference between Rev 4(left) and Rev 7 (right)

2. Schematic and Functionality

The schematic diagram of the CGD15SG00D2 gate driver board is illustrated in Figure 4. The four electrical connection points from J1 consist of the following: VCC IN+ and IN-, and PWM IN- and IN+, in that order from the top. Signals 1 and 2 (VCC IN+ and IN-) connect to the bias supply circuit through a 22uH wirewound common-mode choke. Signals 3 and 4 (PWM IN- and IN+) provide an input to Texas Instruments' opto-compatible isolated gate driver IC UCC23514, which provides a common-mode transient immunity of 150kV/us. The biasing voltage for the secondary side of the gate driver IC is supplied by an ultra-low-EMI, open-loop LLC transformer driver (U2) UCC25800 by Texas Instruments and isolation transformer 750319177 from Wurth Elektronik with a 1:1.67 turns ratio.

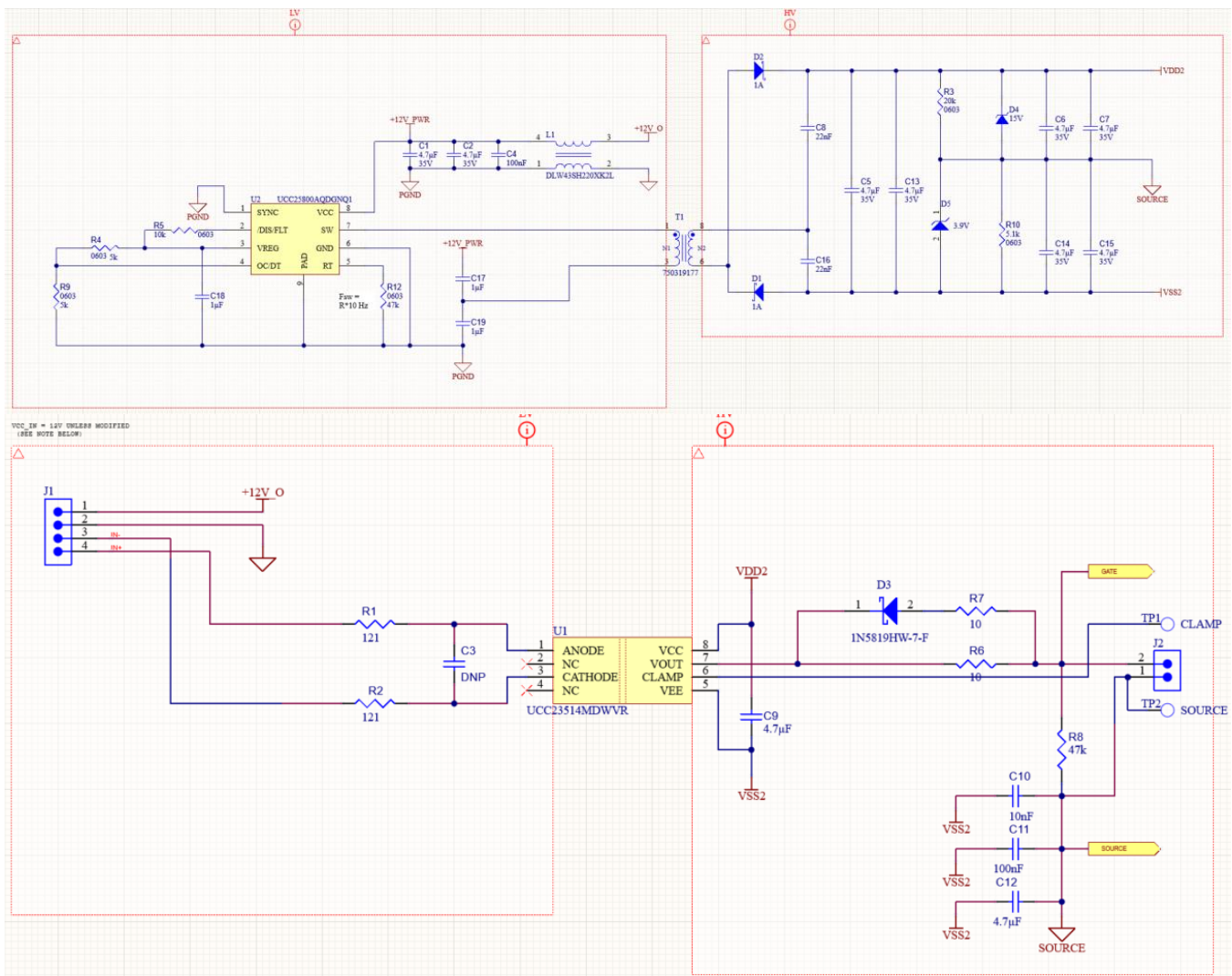


Figure 4: Schematics of CGD15SG00D2 gate driver board

The output of the gate driver IC feeds into gate resistors R6 and R7 and diode D3 (as shown in Figure 4) that supply the gate turn-on and gate turn-off signals. These gate resistors R6 and R7 are metal electrode leadless face (MELF) 207 packages with a power rating of 0.4W. To minimize stray inductance and achieve tight coupling,

capacitors C10-C12 (as shown in Figure 7) have been placed very close to the source output pin. A new feature in this revision of the board is the addition of a miller clamp pin. This is implemented as a provisional pin on the J2 header and can be used to improve immunity to high dv/dt by holding the MOSFET gate to VSS2 with low impedance. Specified operating conditions for CGD15SG00D2 gate driver board are shown in Table 2.

The LLC driver, U2, generates a dual output of +15 V (turn-on signal) and -3.3 V (turn-off signal) on the secondary side of the transformer, which provides an isolation voltage rating of 4000VAC. In the bias supply circuit, a 5k resistor is populated at the OC/DT pin to provide Thevenin resistance readings to set dead time and OCP levels. A 47k resistor is populated at the RT pin to set the switching frequency to approximately 500kHz. The 12V supply from the header powers the driver through a choke for minimized EMI. The secondary side of the transformer functions in a voltage doubler configuration, consisting of two resonant capacitors that together provide a total resonant capacitance of 44nF. Both resonant capacitors carry a DC offset equal to half the output voltage. Two 4.7uF capacitors provide energy storage and high-frequency decoupling at the output of the rectifier. Between the primary and secondary side of the transformer, notches are added to increase the creepage distance to 8mm.

The negative gate bias voltage helps prevent partial turn-on or shoot-through events by pulling the gate well below the threshold, increasing its immunity to stray signals. Although Wolfspeed SiC MOSFETs are fully off with 0V gate bias, transient spikes may be caused by high dv/dt and the capacitance between the gate and drain node. Providing a negative gate bias in the off state enables faster switching conditions and lower switching loss without the risk of partial turn-on. In this design, both positive and negative rails are regulated with Zener diodes to maintain the gate voltage within 5% across different loading conditions. The positive rail uses a 15V Zener in parallel with a 20k resistor and the negative rail shows a 3.9V Zener with 5.1k resistor to ensure proportional charging and discharging of the capacitors on both rails.

Table 1: Specified Operating Conditions of CGD15SG00D2 Gate Driver Board

Symbol	Parameter	Min	Typical	Max	Unit
V_s	Power Supply Voltage	11	12	12.5	V
V_{IH}	PWM Input Low to High		2.8		V
V_{IL}	PWM Input High to Low	0.9			V
V_{OH}	Output high voltage		15.4		V
V_{OL}	Output low voltage		-3.3		V
I_{o_pk}	Output peak current			+4.5 / -5.3 ¹	A
P_{O_AVG}	Output power			2 ²	W
V_{isol}	Isolation Voltage		800 ³		Vpk
dv/dt	Output to input	150			V/ns
W	Weight		9		g
Top	Operating temperature		0 to 50		°C
Tstor	Storage temperature		-40 to 85		°C

1. Actual output current will depend on the values of turn on and turn off gate resistors (R6 and R7). Currently populated with 10 Ohm parts.
2. Output power rated at 25C
3. Isolation rating based on the transformer rating for basic insulation of 800Vpk per IEC61558-2-16 overvoltage category II, pollution degree 2.

NOTE: The gate drive board assembly has not been assessed to a third-party standard. It is the user's responsibility to ensure it meets the requirements of the system to which it is applied.

Figure 5 shows the output voltage regulation of the bias supply up to the rated load power. A load was applied directly to the bias supply between VDD2 and VSS2, and the resulting voltages relative to “SOURCE” were measured.

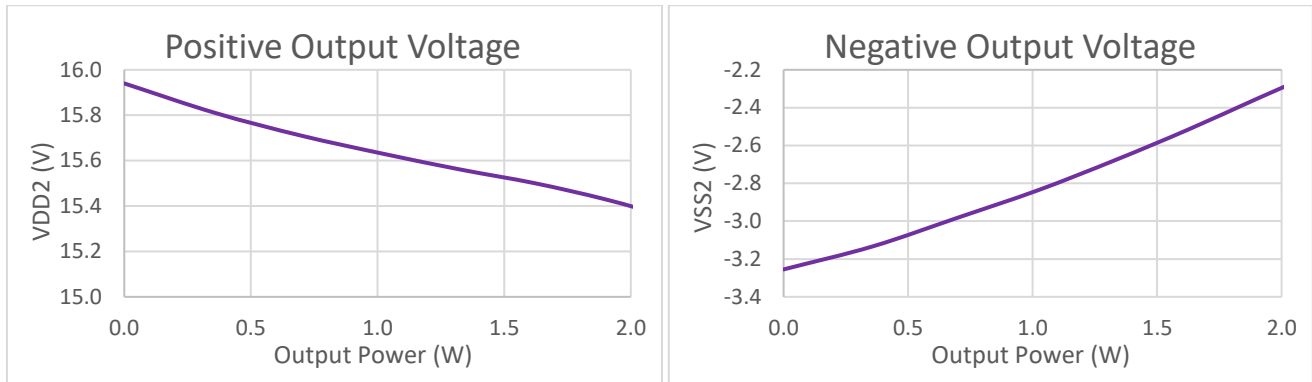


Figure 5: Typical bias supply output voltage at various loads

3. Physical Dimensions

Physical dimensions of Wolfspeed's CGD15SG00D2 gate driver board when fully assembled are 47.6 X 17.8 X 22.8 mm (as shown in Figure 6).

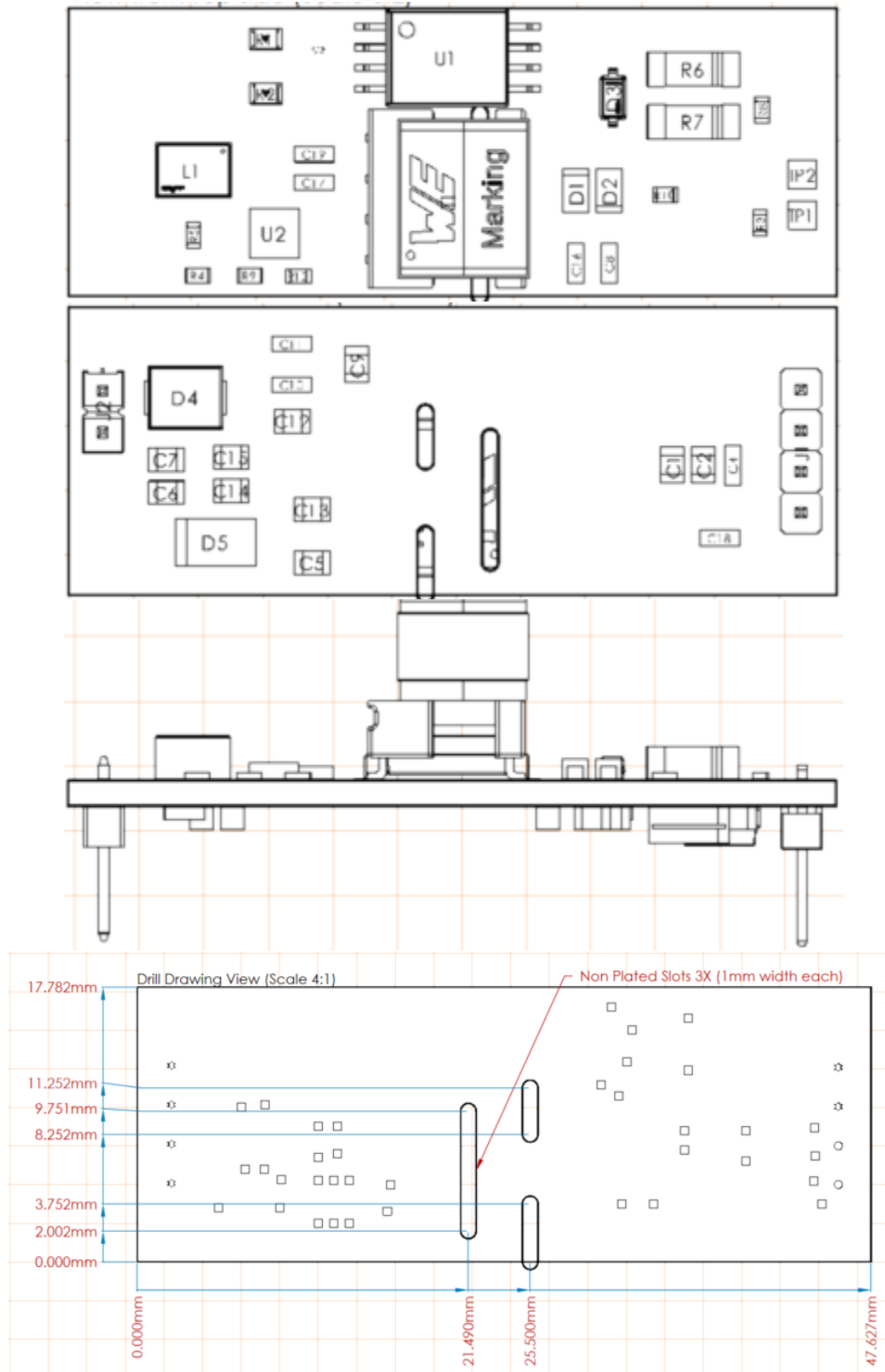


Figure 6: Physical dimensions of CGD15SG00D2

4. Electrical Connection Points

Connection points of CGD15SG00D2 are in the form of two headers, J1 and J2 (as shown in Figure 7). Header J1 has connection points VCC_IN+, VCC_IN-, PWM_IN+ and PWM_IN-. PWM_IN+ and PWM_IN- are the input PWM signals that provide an input to Texas Instruments' opto-compatible isolated gate driver IC UCC23514. VCC_IN+ and VCC_IN- are the input power for the isolated bias supply DC/DC converter. Header J2 has connection points to the gate and source of the MOSFET as well as a clamp pin. J2 is populated with a 2-pin header (TSW-102-07-G-S). A 4-pin header (TSW-104-07-G-S-LL) can be populated to utilize the clamp feature.

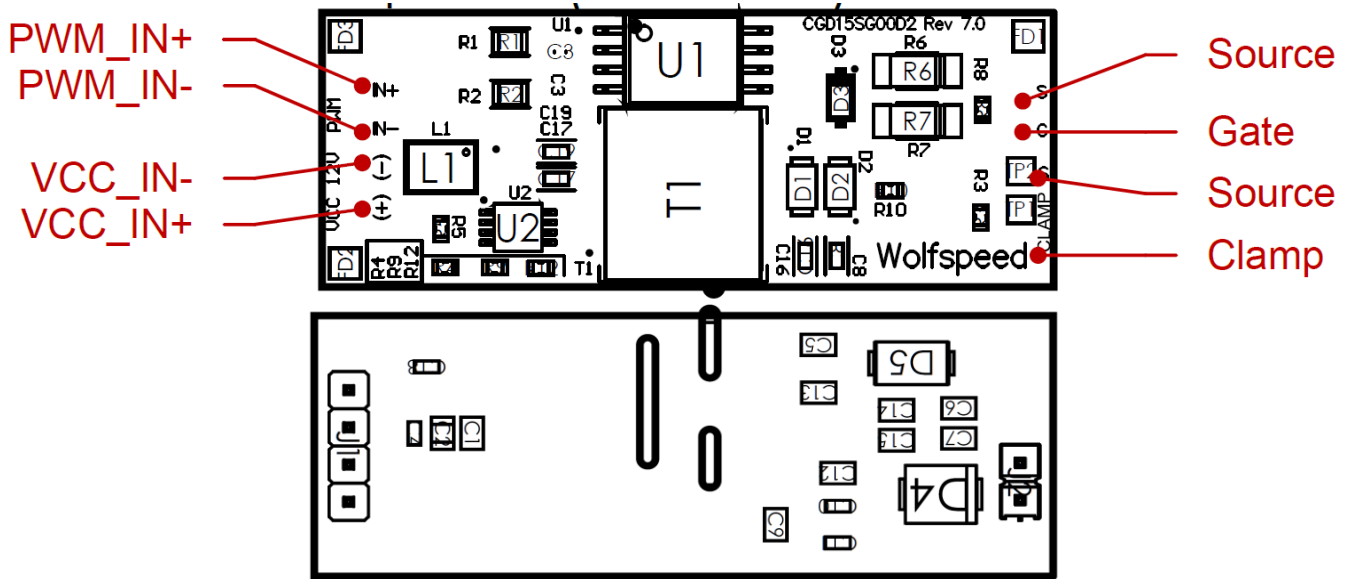


Figure 7: Connection points of CGD15SG00D2 gate driver board

5. PCB Layout

Good PCB layout practice is essential to drive SiC MOSFETs effectively. Minimizing stray inductance in the gate and source path helps reduce ringing and voltage drops that occur due to $L \cdot di/dt$. Figure 8 shows the top copper layer of the CGD15SG00D2 gate driver board with the gate driver IC (U1), gate drive resistors (R6 & R7), and diode (D3). Here, we can also see the transformer driver U2 and the transformer T1 with its creepage-enhancing slots. C8 and C16 are the resonant capacitors of the LLC and R3 and R10 are the resistors for the positive and negative rail. D1 and D2 are also part of the secondary side circuitry. R4, R5, R9 and R12 connect to various pins on U2 to help determine V_{ref} , overcurrent limits, dead time, fault detection, and switching frequency. Figure 9 shows the inner copper layer 1. Large PGND and source planes are placed on this layer under LV- and HV-side circuitry, respectively, keeping clearance constraints in mind. The addition of these large grounding planes helps with signal integrity and minimizes overall parasitic inductance.

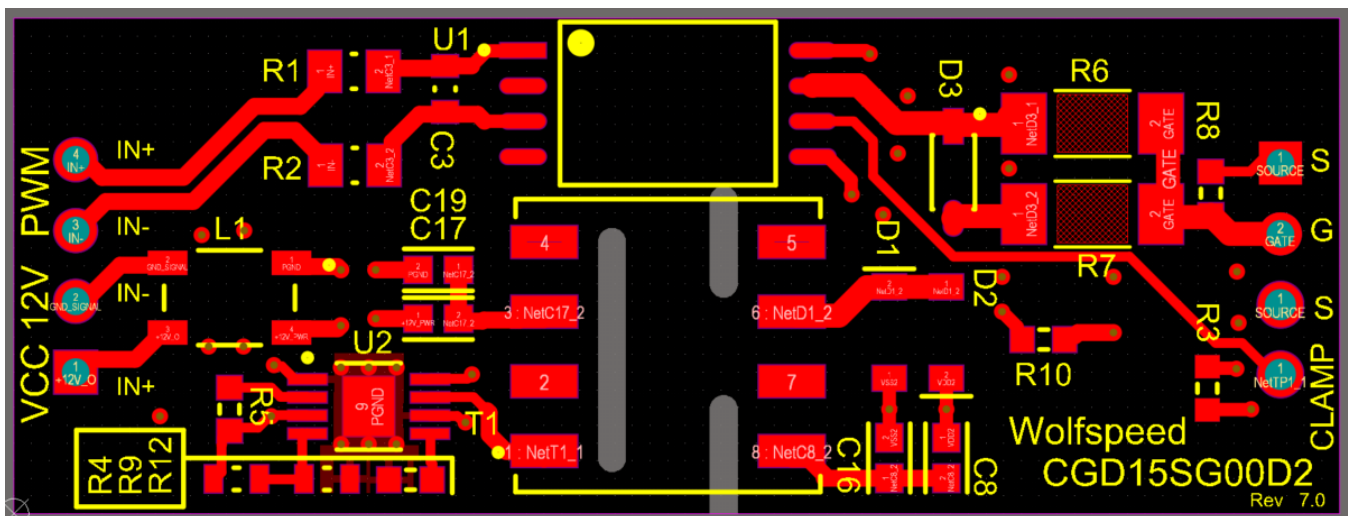


Figure 8: Top layer copper

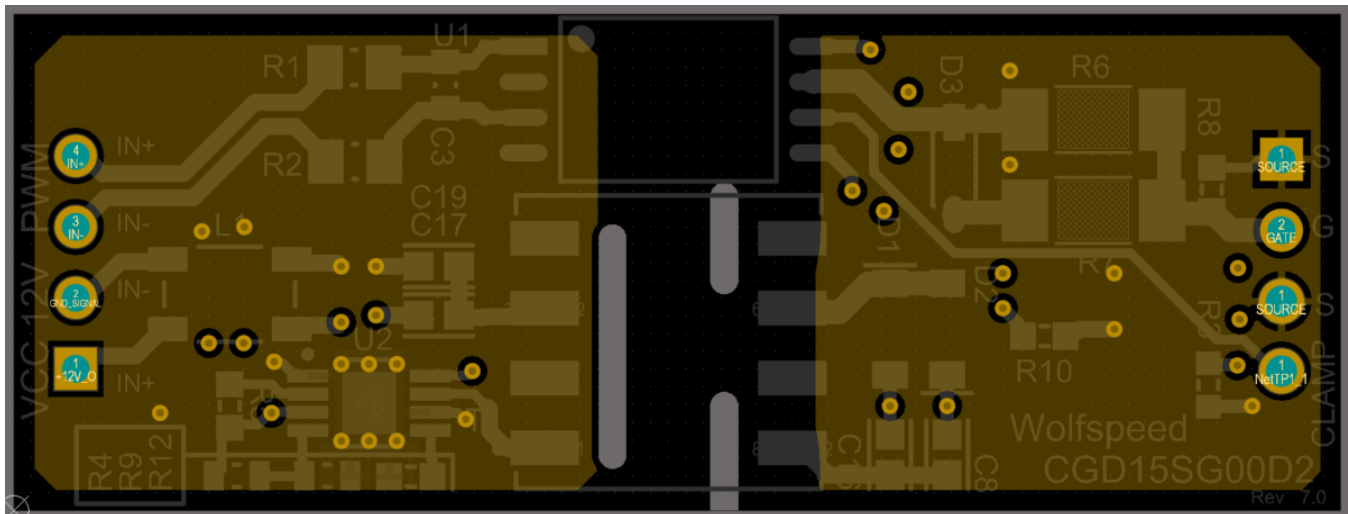


Figure 9: Inner layer 1 copper

Inner layer 2 in Figure 10 shows three planes. The plane on the primary side of the transformer/LV is assigned to the net VCC (+12V PWR from the schematic). The secondary side shows two planes, VDD(+15V) and VSS(-3.3V)

placed under components that share those nets to enable mutual inductance cancellation through via paths as well as noise immunity. The bottom layer of the PCB further illustrates more of the circuit components, including the filtering capacitors C10, C11, and C12 at the output of gate driver U1, and C1, C2, C4 and C18 filtering and decoupling capacitors for the pins of U2 (primary side). C6, C7, C14 and C15 are the output capacitors for U2’s voltage regulation circuit and C5 and C13 are the output capacitors for U2’s secondary side. D4 and D5 are the Zener diodes that help regulate the voltage rails and J2 is the 2-pin connector that supplies the gate and source signals to the SiC MOSFET.

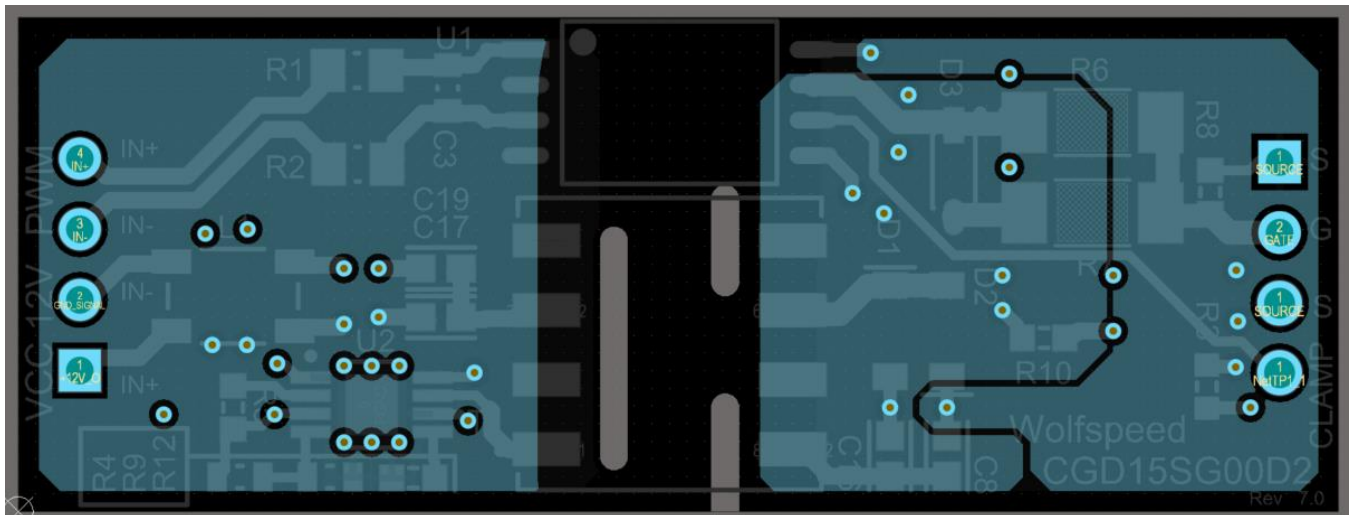


Figure 10: Inner layer 2 copper

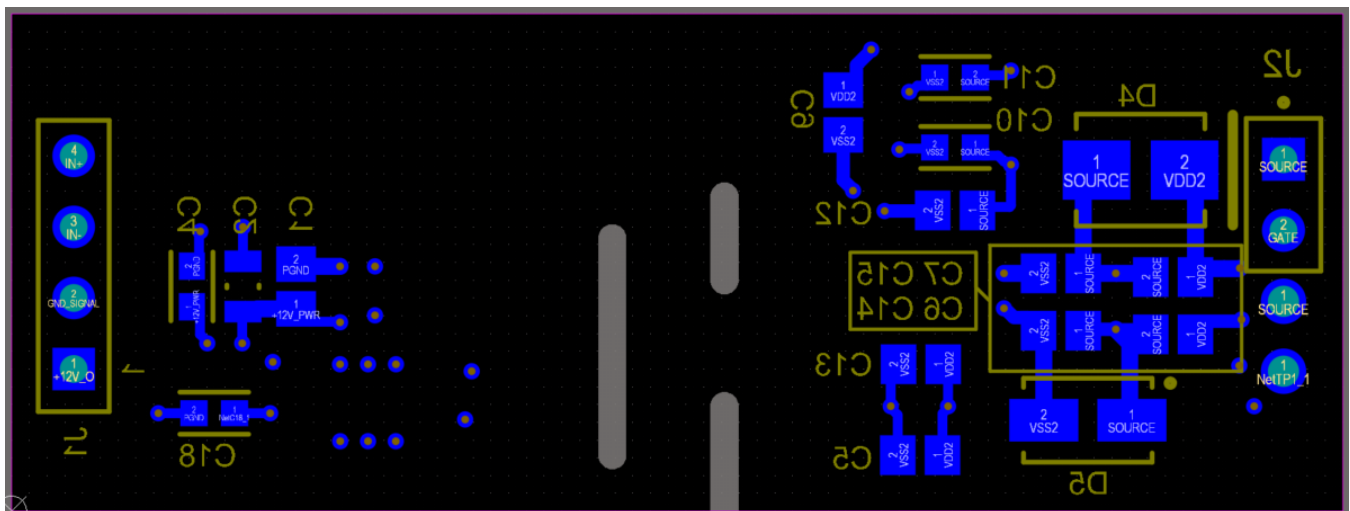


Figure 11: Bottom layer copper

6. Revision History

Date	Revision	Changes
April 2018	Rev B	
January 2024	3	Branding and Formatting updates
October 2024	4	Circuitry and Technology updates

7. Appendix

Rev 5 and Rev 6 of the CGD15SG00D2 gate driver board were unreleased variants used for internal testing.

8. Important Notes

Purposes and Use

Wolfspeed, Inc. (on behalf of itself and its affiliates, “Wolfspeed”) reserves the right in its sole discretion to make corrections, enhancements, improvements, or other changes to the board or to discontinue the board.

THE BOARD DESCRIBED IS AN ENGINEERING TOOL INTENDED SOLELY FOR LABORATORY USE BY HIGHLY QUALIFIED AND EXPERIENCED ELECTRICAL ENGINEERS TO EVALUATE THE PERFORMANCE OF WOLFSPEED POWER SWITCHING DEVICES. THE BOARD SHOULD NOT BE USED AS ALL OR PART OF A FINISHED PRODUCT. THIS BOARD IS NOT SUITABLE FOR SALE TO OR USE BY CONSUMERS AND CAN BE HIGHLY DANGEROUS IF NOT USED PROPERLY. THIS BOARD IS NOT DESIGNED OR INTENDED TO BE INCORPORATED INTO ANY OTHER PRODUCT FOR RESALE. THE USER SHOULD CAREFULLY REVIEW THE DOCUMENT TO WHICH THESE NOTIFICATIONS ARE ATTACHED AND OTHER WRITTEN USER DOCUMENTATION THAT MAY BE PROVIDED BY WOLFSPEED (TOGETHER, THE “DOCUMENTATION”) PRIOR TO USE. USE OF THIS BOARD IS AT THE USER’S SOLE RISK.

Operation of Board

It is important to operate the board within Wolfspeed’s recommended specifications and environmental considerations as described in the Documentation. Exceeding specified ratings (such as input and output voltage, current, power, or environmental ranges) may cause property damage. If you have questions about these ratings, please contact Wolfspeed at forum.wolfspeed.com prior to connecting interface electronics (including input power and intended loads). Any loads applied outside of a specified output range may result in adverse consequences, including unintended or inaccurate evaluations or possible permanent damage to the board or its interfaced electronics. Please consult the Documentation prior to connecting any load to the board. If you have any questions about load specifications for the board, please contact Wolfspeed at forum.wolfspeed.com for assistance.

Users should ensure that appropriate safety procedures are followed when working with the board as serious injury, including death by electrocution or serious injury by electrical shock or electrical burns can occur if you do not follow proper safety precautions. It is not necessary in proper operation for the user to touch the board while it is energized. When devices are being attached to the board for testing, the board must be disconnected from the electrical source and any bulk capacitors must be fully discharged. When the board is connected to an electrical source and for a short time thereafter until board components are fully discharged, some board components will be electrically charged and/or have temperatures greater than 50° Celsius. These components may include bulk capacitors, connectors, linear regulators, switching transistors, heatsinks, resistors and SiC diodes that can be identified using board schematics. Users should contact Wolfspeed at forum.wolfspeed.com for assistance if a board schematic is not included in the Documentation or if users have questions about a board’s components. When operating the board, users should be aware that these components will be hot and could electrocute or electrically shock the user. As with all electronic evaluation tools, only qualified personnel knowledgeable in handling electronic performance evaluation, measurement, and diagnostic tools should use the board.

User Responsibility for Safe Handling and Compliance with Laws

Users should read the Documentation and, specifically, the various hazard descriptions and warnings contained in the Documentation, prior to handling the board. The Documentation contains important safety information about voltages and temperatures.

Users assume all responsibility and liability for the proper and safe handling of the board. Users are responsible for complying with all safety laws, rules, and regulations related to the use of the board. Users are responsible for (1) establishing protections and safeguards to ensure that a user's use of the board will not result in any property damage, injury, or death, even if the board should fail to perform as described, intended, or expected, and (2) ensuring the safety of any activities to be conducted by the user or the user's employees, affiliates, contractors, representatives, agents, or designees in the use of the board. User questions regarding the safe usage of the board should be directed to Wolfspeed at forum.wolfspeed.com.

In addition, users are responsible for:

- Compliance with all international, national, state, and local laws, rules, and regulations that apply to the handling or use of the board by a user or the user's employees, affiliates, contractors, representatives, agents, or designees.
- Taking necessary measures, at the user's expense, to correct radio interference if operation of the board causes interference with radio communications. The board may generate, use, and/or radiate radio frequency energy, but it has not been tested for compliance within the limits of computing devices pursuant to Federal Communications Commission or Industry Canada rules, which are designed to provide protection against radio frequency interference.
- Compliance with applicable regulatory or safety compliance or certification standards that may normally be associated with other products, such as those established by EU Directive 2011/65/EU of the European Parliament and of the Council on 8 June 2011 about the Restriction of Use of Hazardous Substances (or the RoHS 2 Directive) and EU Directive 2002/96/EC on Waste Electrical and Electronic Equipment (or WEEE). The board is not a finished product and therefore may not meet such standards. Users are also responsible for properly disposing of a board's components and materials.

No Warranty

THE BOARD IS PROVIDED "AS IS" WITHOUT WARRANTY OF ANY KIND, INCLUDING BUT NOT LIMITED TO ANY WARRANTY OF NON-INFRINGEMENT, MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE, WHETHER EXPRESS OR IMPLIED. THERE IS NO REPRESENTATION THAT OPERATION OF THIS BOARD WILL BE UNINTERRUPTED OR ERROR FREE.

Limitation of Liability

IN NO EVENT SHALL WOLFSPEED BE LIABLE FOR ANY DAMAGES OF ANY KIND ARISING FROM USE OF THE BOARD. WOLFSPEED'S AGGREGATE LIABILITY IN DAMAGES OR OTHERWISE SHALL IN NO EVENT EXCEED THE AMOUNT, IF ANY, RECEIVED BY WOLFSPEED IN EXCHANGE FOR THE BOARD. IN NO EVENT SHALL WOLFSPEED BE LIABLE FOR INCIDENTAL, CONSEQUENTIAL, OR SPECIAL LOSS OR DAMAGES OF ANY KIND, HOWEVER CAUSED, OR ANY PUNITIVE, EXEMPLARY, OR OTHER DAMAGES. NO ACTION, REGARDLESS OF FORM, ARISING OUT OF OR IN ANY WAY CONNECTED WITH ANY BOARD FURNISHED BY WOLFSPEED MAY BE BROUGHT AGAINST WOLFSPEED MORE THAN ONE (1) YEAR AFTER THE CAUSE OF ACTION ACCRUED.

Indemnification

The board is not a standard consumer or commercial product. As a result, any indemnification obligations imposed upon Wolfspeed by contract with respect to product safety, product liability, or intellectual property infringement do not apply to the board.