

## KIT-CRD-3DD12P Buck-Boost Evaluation Kit

## KIT-CRD-3DD12P 降压升压评估套件

## KIT-CRD-3DD12P 昇降压評価キット



## Application Note CPWR-AN27, Rev. A Cree Power Applications

Cree, Inc.  
4600 Silicon Drive  
Durham, NC 27703 USA

科税有限责任公司  
4600 硅驱动器  
Durham, NC 27703 USA

クリー株式会社  
4600 シリコンドライブ  
Durham, NC 27703 USA

*This document is prepared as an application note to install and operate Cree evaluation hardware.*



All parts of this application note 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。若本板子的终端用户不熟悉上述任何一种语言，则您应当确保该终端客户能够理解本文件中的条款与条件，包括且不限于本板子的危险以及安全操作条件。

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 Cree-designed evaluation hardware for Cree 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 150° Celsius and 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 to avoid any damage to electronic components. 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.

本工具（一种易碎、高压、高温电力电子系统）是由科锐为其组件设计的评估硬件，旨在用作实验室环境下的评估工具，并由够格的技术人员或工程师处理和操作。本硬件不使用时，应存储在-40oC到150oC温度范围的区域内；如需运输本硬件，运输过程中应该特别小心，避免损坏电路板或其易碎组件。电路板应放置在静电放电（ESD）袋中谨慎运输，避免损坏电子组件。本硬件不含任何有害物质，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℃から150℃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るべき。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  
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。

## Table of Contents

1. Introduction.....	7
2. Package Contents .....	8
3. Board Overview .....	8
4. Electrical Performance .....	9
5. Example Topologies .....	11
6. Mechanical Assembly .....	12
7. Terminals and Connections .....	14
8. Test Point Locations .....	17
9. Configuring the Evaluation Kit for TO-247-3L Devices .....	19
10. Current Sensing.....	19
11. Example Application 1 (Boost Converter).....	20
12. Example Application 2 (Buck Converter) .....	21
13. Appendix.....	23
I. Inductor Specification .....	23
II. PCB Layout.....	24
III. Schematic .....	27
IV. Bill of Materials (BOM).....	28
14. Revision History .....	29
15. Important Notes .....	30

## 1. Introduction

The purpose of Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit (as shown in Figure 1) is to demonstrate the high-speed switching performance of Cree's 3rd Generation (C3M™) Silicon Carbide (SiC) Metal Oxide Semiconductor Field-Effect Transistor (MOSFET). This evaluation kit supports the new TO-247-4L package. The TO-247-4L package comes with an added Kelvin source pin that reduces the effects of  $L \cdot di/dt$  in the gate circuit. The reduced  $L \cdot di/dt$  in the gate circuit allows more voltage to be applied at the gate and source which results in faster dynamic switching.

Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit also accepts the traditional TO-247-3L package without the need of any additional adapters. This provides the end user with the ability to test and compare the performance of Cree's 3<sup>rd</sup> Generation (C3M™) MOSFETs in various packages.

The evaluation kit comes in a half bridge configuration with the provision of adding a MOSFET or diode in the upper and lower positions. This allows the evaluation board to be configured in common power conversion topologies such as synchronous buck or synchronous boost converter topologies. There is also a provision of adding diodes in either the top or the bottom positions. This provision allows users to run the evaluation kit in an asynchronous buck converter topology or in an asynchronous boost converter topology. To reduce power loss, Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit comes with a low loss inductor made up of "Sendust" material.



Figure 1. Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit

CPWR-AN27, Rev A, 04-2019

Copyright © 2019 Cree, Inc. All rights reserved.

The information in this document is subject to change without notice.

Cree, the Cree logo, and Zero Recovery are registered trademarks of Cree, Inc.



## 2. Package Contents

The package contents of Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit are listed in Table 1.

ITEM NO.	QTY.	DESCRIPTION	Mfg.	P/N
1	1	CRD-3DD12P rev22 Buck Boost Eval Board Assy.	Make	CRD-3DD12P
2	4	High force clip	Aavid Thermalloy	MAX03-HNG
3	1	Heat sink extrusion, custom length 4 in.	Aavid Thermalloy	780603U04000G
4	2	MOSFET, 1200V, 75 mohm	Cree	C3M0075120K
5	4	Kapton Thermal Interface (Cut to 22mm x 29mm rectangle)	Fischer Elektronik	KAP 1 P
6	1	Foam insert top	Make	See drawing
7	1	Conductive foam strip	Make	See drawing
8	1	S/N Label	Make	n/a
9	1	Cover graphic Label	Make	n/a
10	1	Foam insert	Make	See drawing
11	6	Male-Female Threaded Hex Standoff Nylon 6/6, 1/4" Hex Size, 1-1/2" Long, 6-32 to 6-32	McMaster-Carr	92745A348
12	2	Spacer, 1/4" OD, 5/32" Length, un-threaded Al, #6 screw	McMaster-Carr	92510A031
13	6	Nylon Hex Nut, 6-32 Thread Size	McMaster-Carr	94812A300
14	2	Phillips Round Head Screw, M3 x 0.5 mm Thread, 10 mm Long	McMaster-Carr	92005A120
15	2	Steel Split Lock Washer for M3 Screw Size, 3.4 mm ID, 6.2 mm OD	McMaster-Carr	91202A222
16	1	Package Box	Uline	S-16677
17	3	2"x3" 4mil re-closeable poly bag	Uline	S-12269
18	1	ESD Label on box	Uline	S-2245
19	2	CONN ADAPT SMA PLUG TO BNC JACK	Amphenol	242102

*Table 1: Package Contents of Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit*

## 3. Board Overview

The physical dimensions of Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit are 222 mm X 97 mm X 49 mm (as shown in Figure 2). The evaluation kit comes with a Printed Circuit Board (PCB), Cree's (C3M™) 1200 V 75 mΩ MOSFETs (P/N: C3M0075120K), heatsink (including mounting clips), thermal pad and hardware accessories.

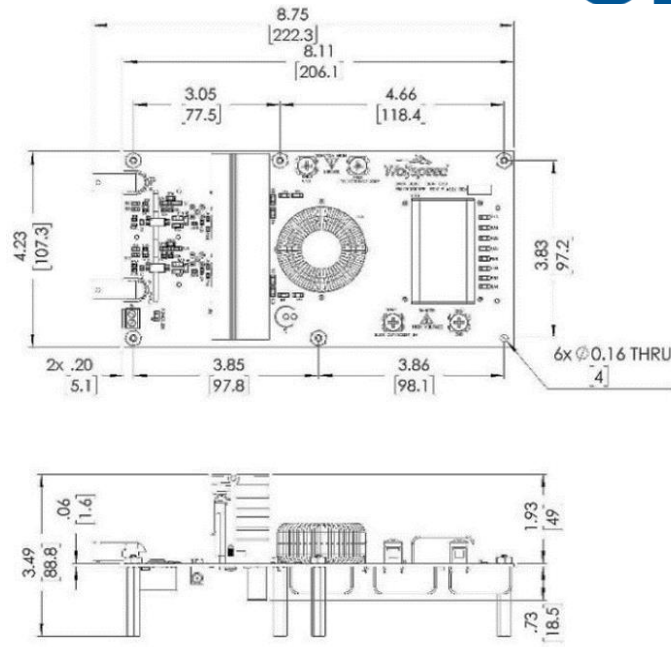


Figure 2. Physical Dimensions of Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit

## 4. Electrical Performance



### CAUTION

IT IS NOT NECESSARY FOR YOU TO TOUCH THE BOARD WHILE IT IS ENERGIZED. WHEN DEVICES ARE BEING ATTACHED FOR TESTING, THE BOARD MUST BE DISCONNECTED FROM THE ELECTRICAL SOURCE AND ALL BULK CAPACITORS MUST BE FULLY DISCHARGED.

SOME COMPONENTS ON THE BOARD REACH TEMPERATURES ABOVE 50° CELSIUS. THESE CONDITIONS WILL CONTINUE AFTER THE ELECTRICAL SOURCE IS DISCONNECTED UNTIL THE BULK CAPACITORS ARE FULLY DISCHARGED. DO NOT TOUCH THE BOARD WHEN IT IS ENERGIZED AND ALLOW THE BULK CAPACITORS TO COMPLETELY DISCHARGE PRIOR TO HANDLING THE BOARD.

PLEASE ENSURE THAT APPROPRIATE SAFETY PROCEDURES ARE FOLLOWED WHEN OPERATING THIS 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.

#### 警告

通电时不必接触板子。连接器件进行测试时，必须切断板子电源，且大容量电容器必须释放完所有电量。

板子上一些组件的温度可能超过 50 摄氏度。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。通电时禁止触摸板子，应在大容量电容器完全释放电量后，再操作板子。请确保在操作板子时已经遵守了正确的安全规程，否则可能会造成严重伤害，包括触电死亡、电击伤害、或电灼伤。

#### 警告

通电している時にボードに接触する必要がありません。設備をつないで試験する時、必ずボードの電源を切ってください。また、大容量のコンデンサーで電力を完全に釈放してください。

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。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。通电している時にボードに接触するのは禁止です。大容量のコンデンサーで電力をまだ完全に釈放していない時、ボードを操作しないでください。

ボードを操作している時、正確な安全ルールを守っているのを確保してください。さもないければ、感電、電撃、厳しい火傷などの死傷が出る可能性があります。

The electrical specifications of Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit are shown in Table 2. A maximum of 800 V can be applied to the input and the output of the evaluation kit. The maximum power capability of the evaluation kit is 2500 W. A single 15 VDC power source (VCC (Logic Power)) is added on the evaluation kit to provide power to the logic circuit. The amount of current that the VCC (Logic Power) source will require depends on the switching frequency and the type of devices that are populated on the PCB Board of the evaluation kit. The VCC Input Current is the standby current that the evaluation kit will draw, when nothing is being switched.

CPWR-AN27, Rev A, 04-2019

Copyright © 2019 Cree, Inc. All rights reserved.

The information in this document is subject to change without notice.

Cree, the Cree logo, and Zero Recovery are registered trademarks of Cree, Inc.

Items	Values
Max Input Voltage	800V
Max Output Voltage	800V
Max Output Power	2500W*
VCC (Logic Power)	15VDC
VCC Input Current (standby)	40mA* (typical)
Frequency	100kHz*

**Table 2: Electrical Specifications of Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit**

(\* Power and frequency limits are based on the inductor. Different output power and switching frequency can be achieved with a different inductor.)

## 5. Example Topologies

### a. Synchronous Buck Converter

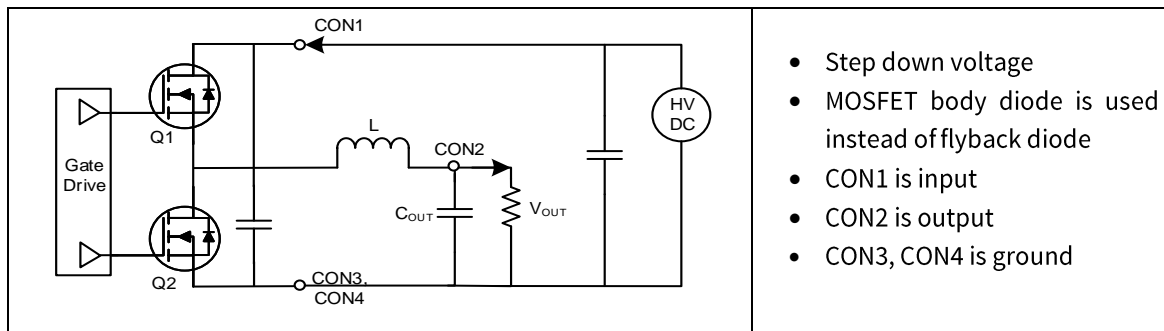


Figure 3. Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit configured as Synchronous Buck Converter

### b. Synchronous Boost Converter

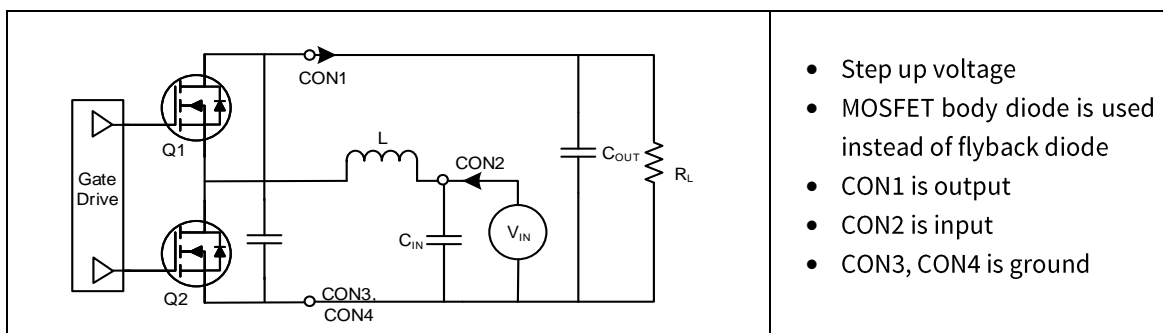


Figure 4 Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit configured as Synchronous Boost Converter

### c. Asynchronous Buck Converter

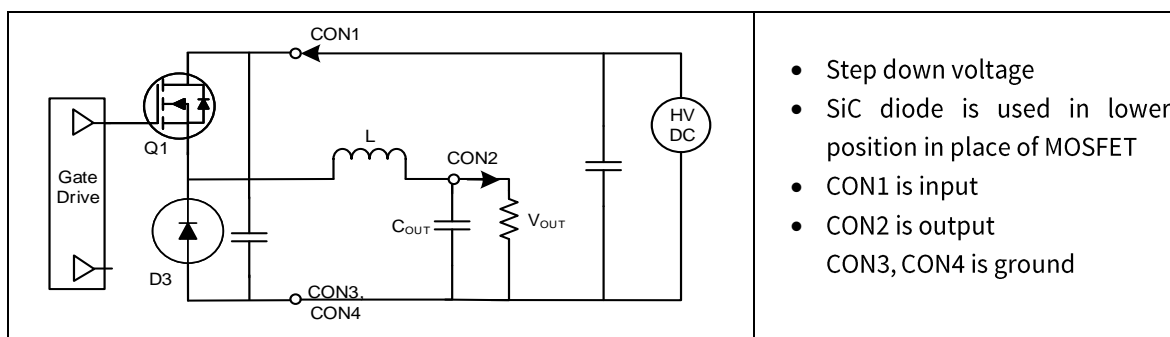


Figure 5. Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit configured as Asynchronous Buck Converter

### d. Asynchronous Boost Converter

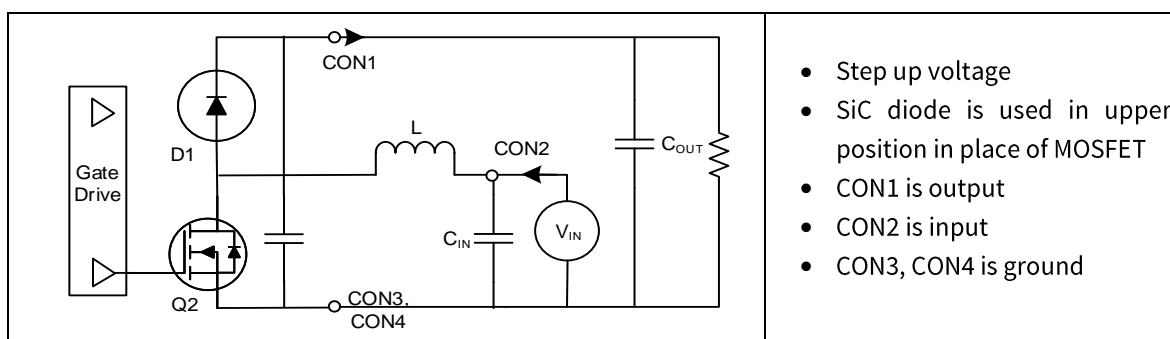


Figure 6. Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit configured as Asynchronous Boost Converter

## 6. Mechanical Assembly

Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit must be assembled prior to testing. The heatsink, standoffs, thermal insulator, and semiconductor devices must be installed according to the arrangement mentioned in Figure 7. The two screws and washers must be installed from the bottom side of the PCB. Please note that the spacers should be placed between the heatsink and the PCB and the two heatsink mounting screws should not be overtightened.

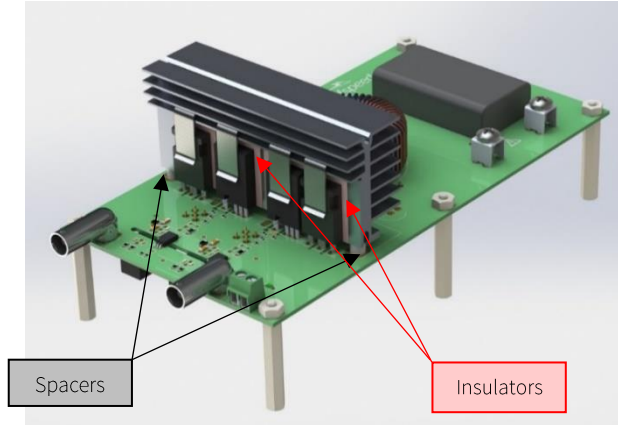


Figure 7. Mechanical Assembly of Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation kit

## Cooling:

The heatsink of Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit must have a cooling fan to dissipate the heat generated from the losses of MOSFETs or diodes. The amount of appropriate airflow is dependent on the losses, which can vary widely depending on voltage, current, frequency, and other factors. Cree suggests that an end user use a 12 V, 80 mm fan rated for 133 CFM (@2.03 inches H<sub>2</sub>O), such as P/N: PFB0812DHE from Delta Inc., which when functioning correctly should provide sufficient airflow to cool down the heatsink and the inductor at full load.

## Inductor:

The inductor of Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit is a toroidal design, based on a high temperature rated powdered core (as shown in Figure 8). The maximum rated DC current of the inductor is 8A. The inductor is designed to support Pulse Width Modulation (PWM) frequencies up to 100kHz (Test Conditions: P<sub>OUT</sub>=2500 W, V<sub>IN</sub>=400 V/ V<sub>OUT</sub>=800V (OR) P<sub>OUT</sub>=2500 W, V<sub>IN</sub>=800 V/V<sub>OUT</sub> =400 V). The inductor requires airflow to keep the temperatures within the 180 °C (max.). The evaluation kit can operate at higher frequencies (>100 kHz); however, the current may need to be reduced. The complete inductor specification can be found in the Appendix.



Figure 8. Inductor of Cree's KITCRD-3DD12P Buck-Boost, Evaluation Kit

## 7. Terminals and Connections



### CAUTION

\*\*\*HIGH VOLTAGE RISK\*\*\*

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

The connectors on the board have very high voltage levels present when the board is connected to an electrical source, and thereafter until the bulk capacitors are fully discharged. Please ensure that appropriate safety procedures are followed when working with these connectors 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. When devices are being attached for testing, the board must be disconnected from the electrical source and all bulk capacitors must be fully discharged. After use the board should immediately be disconnected from the electrical source. After disconnection any stored up charge in the bulk capacitors will continue to charge the connectors. Therefore, you must always ensure that all bulk capacitors have completely discharged prior to handling the board.

### 警告

\*\*\*高压危险\*\*\*

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。通电时禁止触摸板子，应在大容量电容器完全释放电量后，再触摸板子。

板子上的连接器在充电时以及充电后都具有非常高的电压，直至大容量电容器完全释放电量。请确保在操作板子时已经遵守了正确的安全流程，否则可能会造成严重伤害，包括触电死亡、电击伤害或电灼伤。连接器件进行测试时，必须切断板子电源，且大容量电容器必须释放了所有电量。使用后应立即切断板子电源。切断电源后，大容量电容器中存储的电量会继续输入至连接器中。因此，必须始终在操作板子前，确保大容量电容器已完全释放电量。

### 警告

\*\*\*高压危险\*\*\*

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。通電している時にボードに接触するのは禁止です。大容量のコンデンサーで電力をまだ完全に釈放していない時、ボードに接触しな

いでください。ボードのコネクターは充電中また充電した後、ひどく高い電圧が存在しているので、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。ボードを操作している時、正確な安全ルールを守っているのを確保してください。さもないと、感電、電撃、厳しい火傷などの死傷が出る可能性があります。設備をつないで試験する時、必ずボードの電源を切ってください。また、大容量のコンデンサーで電力を完全に釈放してください。使用後、すぐにボードの電源を切ってください。電源を切

った後、大容量のコンデンサーに貯蓄している電量はコネクターに持続的に入るので、ボードを操作する前に、必ず大容量のコンデンサーの電力を完全に釈放するのを確保してください。



An illustration of the terminals and the connections of Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit has been provided in Figure 9.

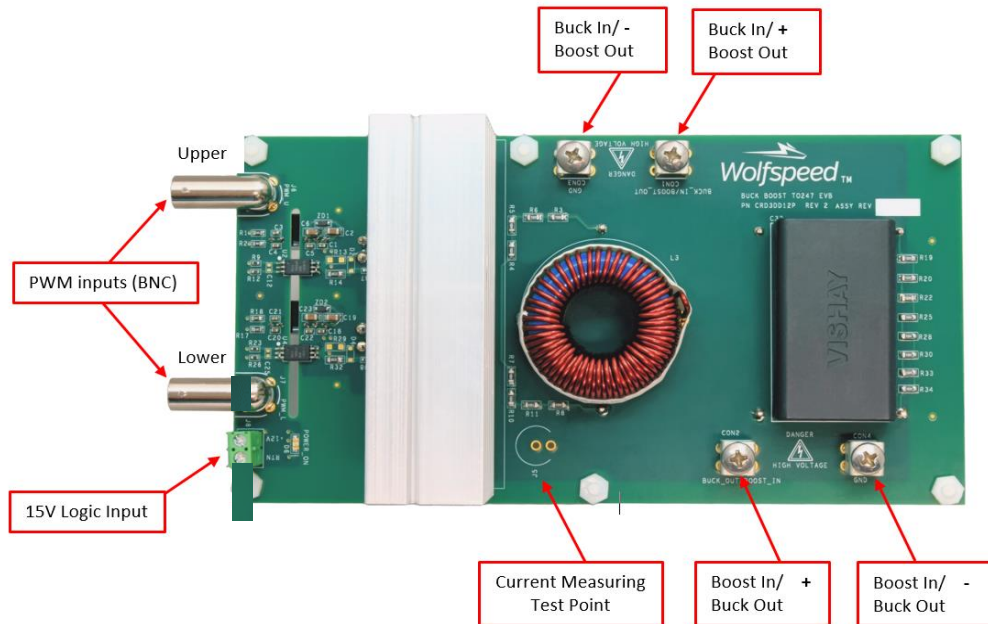


Figure 9. Top View Cree's of Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit

## Power Terminals:

Terminals CON1, CON2, CON3 and CON4 are the power terminals (as shown in Figure 10), and their definitions vary based on the topology.

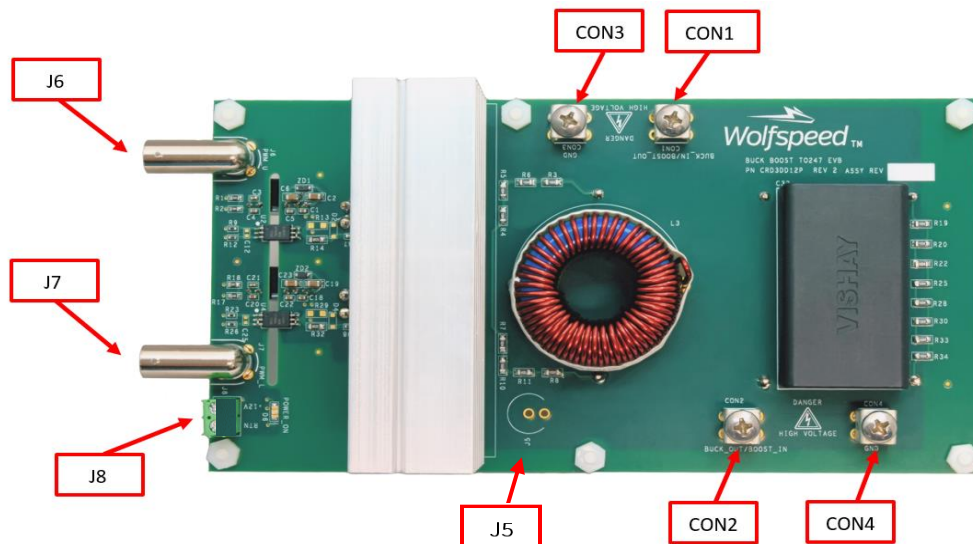


Figure 10. Terminals and Connections of Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation kit

## Logic Power and PWM Input Signals:

The 15 VDC logic power supply is connected to J8 (as shown in Figure 10). The pin definition of J8 is shown in table 3. The total amount of current drawn from the 15 VDC supply depends on the circuit topology, devices installed and the PWM frequency. The standby current drawn from the 15 VDC supply without any switching condition is listed in Table 4. The 15 VDC supply mainly powers the gate drivers designed for the lower and the upper PWM Input channels (J7 & J6) (as shown in Figure 10). The pin definition of each PWM channel is shown in Table 5.

J8	
1	15V+ (VCC)
2	COMMON

Table 3. Pin definitions of connector J8

Parameter	Typical
Input current (standby)	40mA
PWM Input Signal	5V

Table 4. Input Requirements

Terminal	Signal	Reference
J6	PWM Input Upper Channel	PWM_U
J7	PWM Input Lower Channel	PWM_L

Table 5. Pin definitions of connectors J6 and J7

## 8. Test Point Locations

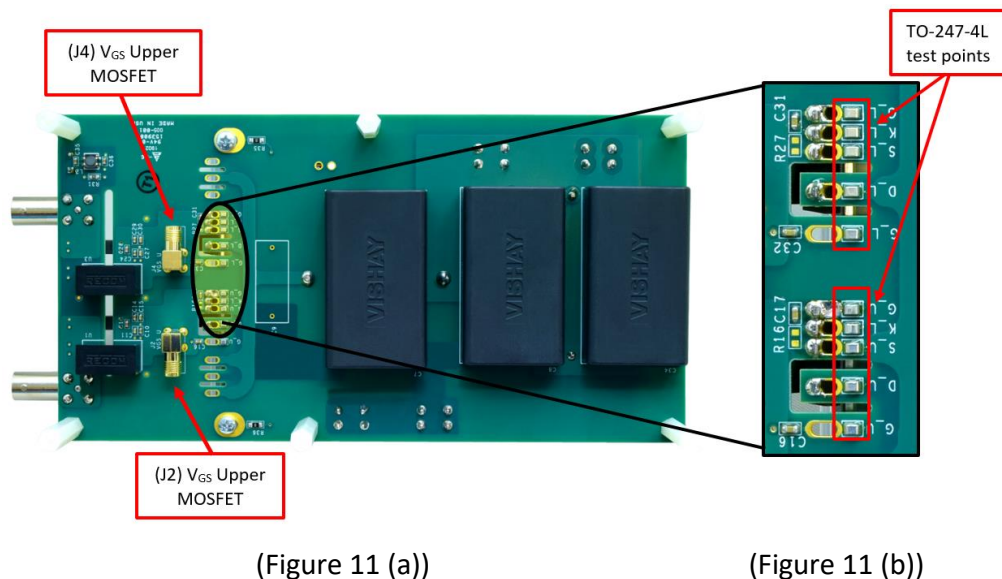


Figure 11 (a). Bottom View of Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation kit

Figure 11 (b). TO-247-4L Test Loops

Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit comes with many test points (as shown in Figure 11 (a) and Figure 11(b)) to make it convenient for users to capture critical waveforms such as drain to source voltage (VDS), gate to source voltage (VGS), and drain current (ID). It is critical to take these measurements as close as possible to the device pins. On the bottom side of the evaluation kit's PCB board, there is a test loop placed right next to the device pins for both TO-247-3 or TO-247-4 footprints (as shown in Figure 12). The test loop makes it convenient for the users to attach the clip-on probes to the PCB board.

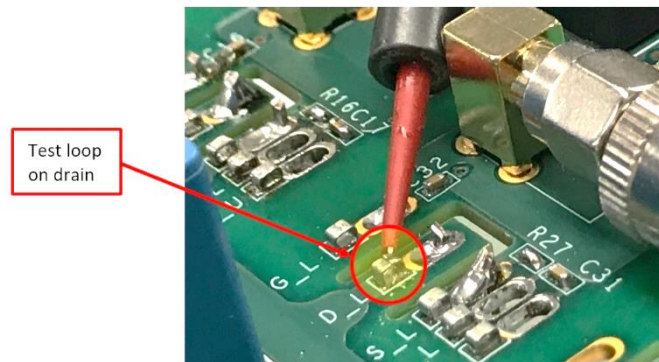


Figure 12. Test Point on the drain (TO-247-4 footprint)

There is also a Sub Miniature A (SMA) connector located on the bottom side of the board for monitoring the VGS on both the upper and the lower devices. Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit comes with two SMA to Bayonet Neill–Concelman (BNC) adapters (as shown in Figure 13 (a)). A standard 10X passive (compensated) probe can be connected to the BNC adapter (as shown in Figure 13 (b)), but first it must be fitted with a BNC male adapter. Cree recommends using a compensated probe with an SMA connector while taking gate signal measurements. By using a simple 50  $\Omega$  SMA to BNC cable between the PCB board and the oscilloscope, users can experience impedance mismatch. Users can also obtain gate waveforms by using the SMA connectors with a compensated passive probe plugged into the oscilloscope in the high impedance setting.



Figure 13 (a)

Figure 13 (b)

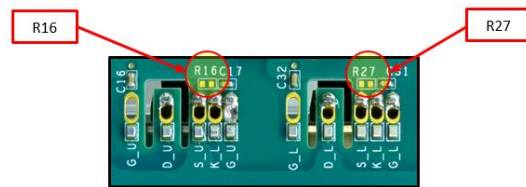
Figure 13(a). Lower MOSFET (J4) SMA connector shown with BNC adapter (included)

Figure 13 (b). 10X Passive probe fitted with BNC adapter

## 9. Configuring the Evaluation Kit for TO-247-3L Devices

While a standard KIT-CRD-3DD12P, Buck-Boost Evaluation kit is configured to evaluate C3M™ MOSFETs in a TO-247-4L package, the evaluation kit also supports C3M™ MOSFETs in a traditional TO-247-3L package. To convert either the upper or the lower MOSFET (Table 6) position into a TO-247-3L configuration, a 0Ω 0603 type resistor must be populated in each position (R16, R27) on the bottom side of the PCB (as shown in Figure 14). The main purpose of 0Ω resistor is to tie the Kelvin source and the power source together, which makes it convenient for a user to accommodate the TO-247-3L package on the PCB.

**If a user converts the board to evaluate a TO-247-3L device and thereafter wants to test a TO-247-4L device, then the 0Ω resistor must be removed from each position before testing.**



Device	Resistor
Upper MOSFET (Q1)	R16
Lower MOSFET (Q2)	R27

Figure 14. Location of Resistors on the bottom side of PCB

Table 6. Definition of Resistors

## 10. Current Sensing

**Please note that Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit will not work without a current sensing device or without populating a jumper at J5.**

Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit comes with a placeholder (J5) (as shown in Figure 10) for adding a current viewing device, such as the current viewing resistor from T&M Research (P/N: SDN-414-01) (as shown in Figure 15), among many others. The current viewing resistor from T & M Research has a resistance of 10mΩ; therefore, it is compatible with most oscilloscopes that have a probe attenuation set to 100X (50Ω input). If a different resistor is chosen then it should have as low inductance as possible.



Figure 15. Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit with Current Viewing Resistor Installed

If the user does not use a current viewing resistor to sense current, then a short jumper must be populated at J5. This jumper should be soldered into J5 with a minimal length, to minimize the insertion inductance.



Figure 16. Current Measuring Test Point on Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit

## 11. Example Application 1 (Boost Converter)

To run Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit in an Asynchronous Boost Converter topology (as shown in Figure 17 (a)), the SMA to BNC adapter should be connected to J4 (VGS lower MOSFET) which is located at the bottom of the PCB Board. A 10X passive oscilloscope probe with a BNC connector is then attached with J4 to monitor the VGS on the lower MOSFET (as shown in Figure 17 (b)). A 10mΩ current viewing resistor from T&M Research (P/N: SDN-414-01) is populated at J5 (as shown in Figure 17 (b)) to get current measurements through the lower MOSFET. To get VDS voltage waveform, a 50X high voltage differential probe is attached to the drain and power source of the lower MOSFET. The switching waveforms are shown in Figure 18.

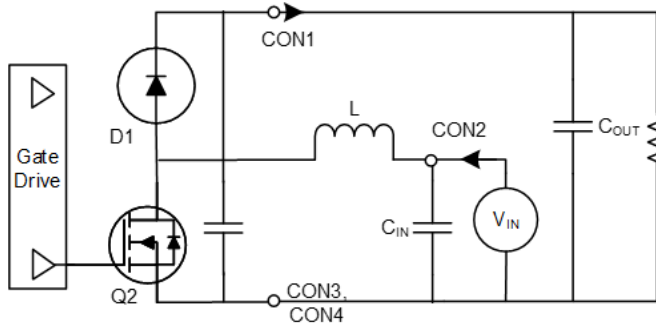


Figure 17 (a)

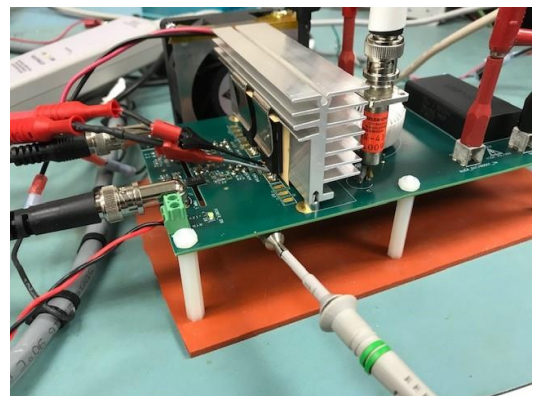


Figure 17 (b)

Figure 17 (a). Asynchronous Boost Converter Topology

Figure 17 (b). Asynchronous Boost Converter setup on Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit



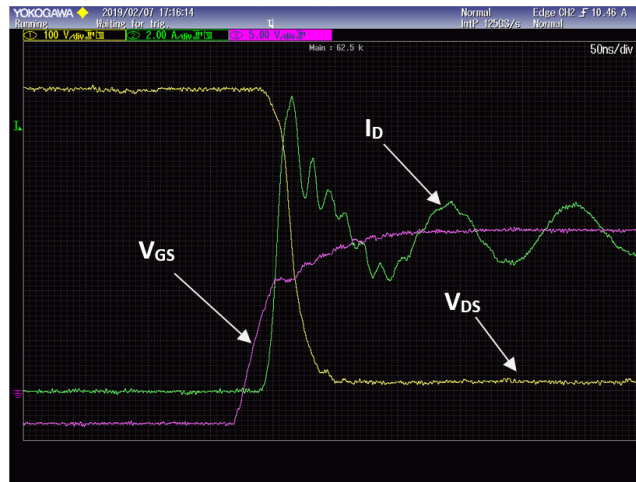


Figure 18. Switching Waveforms of Boost Converter

## 12. Example Application 2 (Buck Converter)

Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit can be arranged in the form of a buck converter in both the synchronous mode (turning on lower MOSFET channel for current freewheel) (as shown in Figure 19 (a)) and in the asynchronous mode (current freewheels through lower MOSFET's body diode only with the lower MOSFET channel turned off) (as shown in Figure 19 (b)).

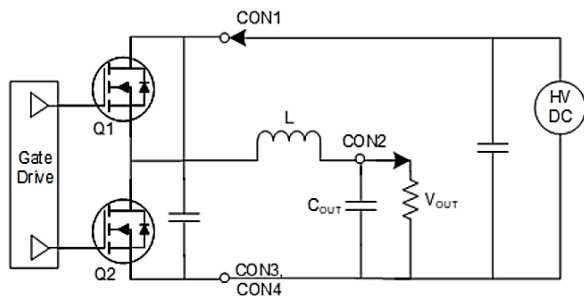


Figure 19 (a)

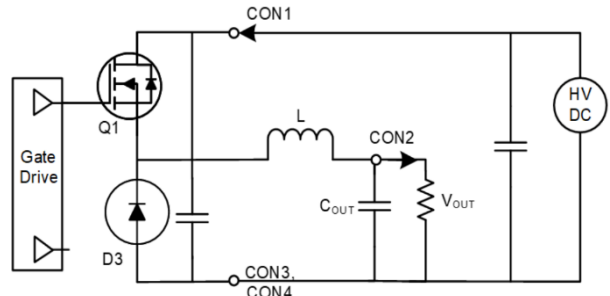


Figure 19 (b)

Figure 19 (a). Synchronous Buck Converter Topology

Figure 19 (b). Asynchronous Buck Converter Topology

In the synchronous mode, the current will freewheel through the lower MOSFET's body diode during the deadtime ( $\approx 200\text{ns}$ ) between switch transitions. The efficiency curves of synchronous and asynchronous topologies implemented on Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit are shown in Figure 20.

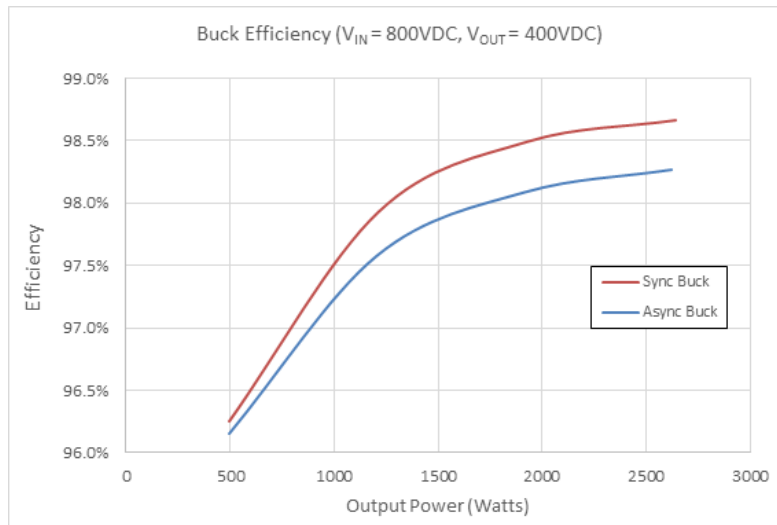


Figure 20. Efficiency Curves of Synchronous and Asynchronous Buck Converter Topologies

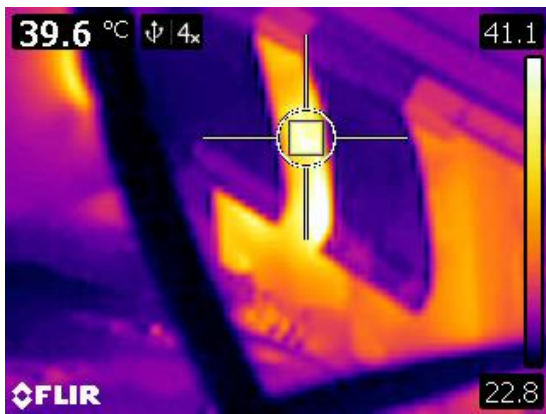


Figure 21. Thermal Scan of MOSFET



Figure 22. Thermal Scan of Inductor

Figures 21 & 22 show the thermal scans of a MOSFET and the inductor while running at full load condition (2.5 kW). These thermal scans indicate that the inductor is running at 50.7°C and the upper MOSFET is running at 39.6°C. In addition to that the lower MOSFET also runs at low temperature during the full load condition (2.5 kW). These thermal scans illustrate that higher power levels can be achieved with Cree's KIT-CRD-3DD12P, Buck-Boost Evaluation Kit. However, an inductor capable of more DC current would be needed to achieve these higher power levels, as the inductor included in the standard evaluation kit would saturate if the user exceeds the specified maximum power (2.5 kW).

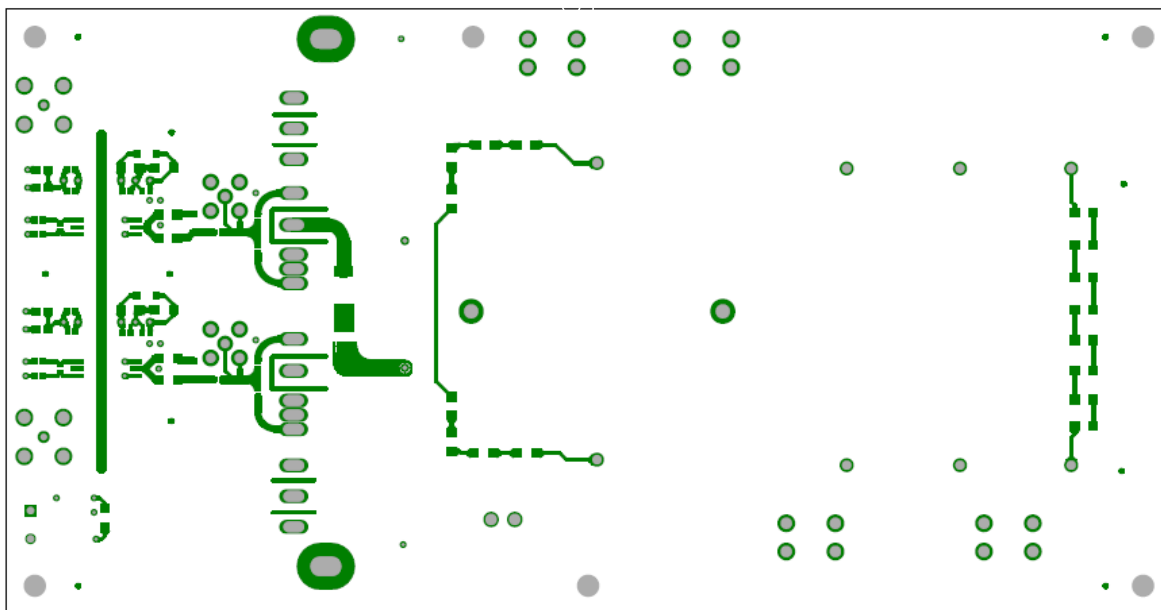




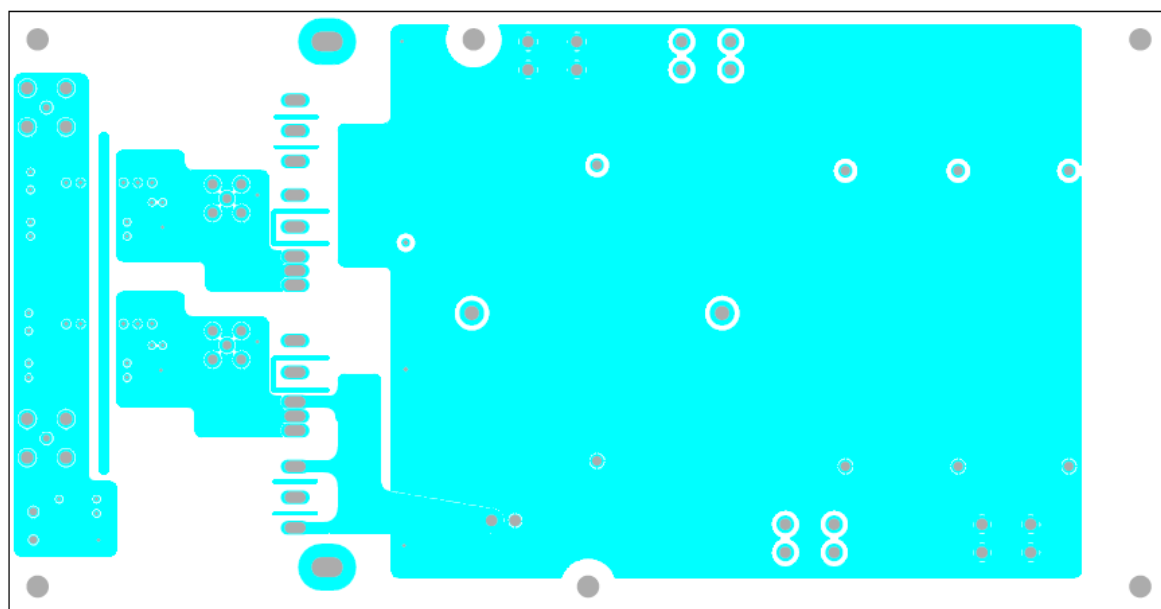
## II. **PCB Layout:**

**Note:** a larger copy of the PCB layout may be obtained upon request by contacting Cree at [sic\\_power@cree.com](mailto:sic_power@cree.com)

### Power Board Top Copper Layer



### Power Board Inner Copper Layer 2



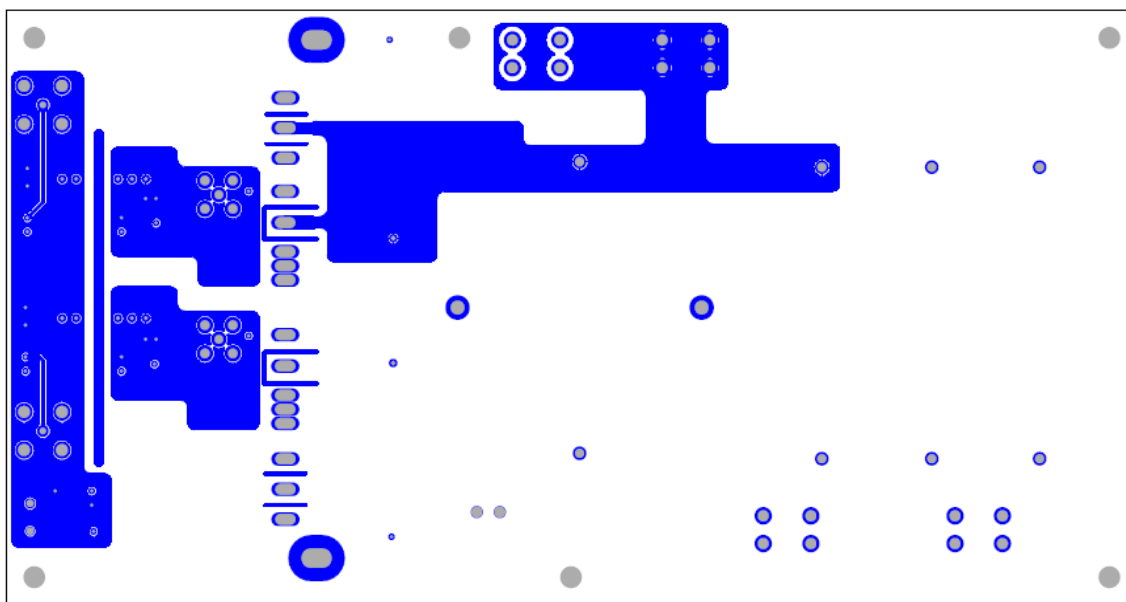
CPWR-AN27, Rev A, 04-2019

Copyright © 2019 Cree, Inc. All rights reserved.

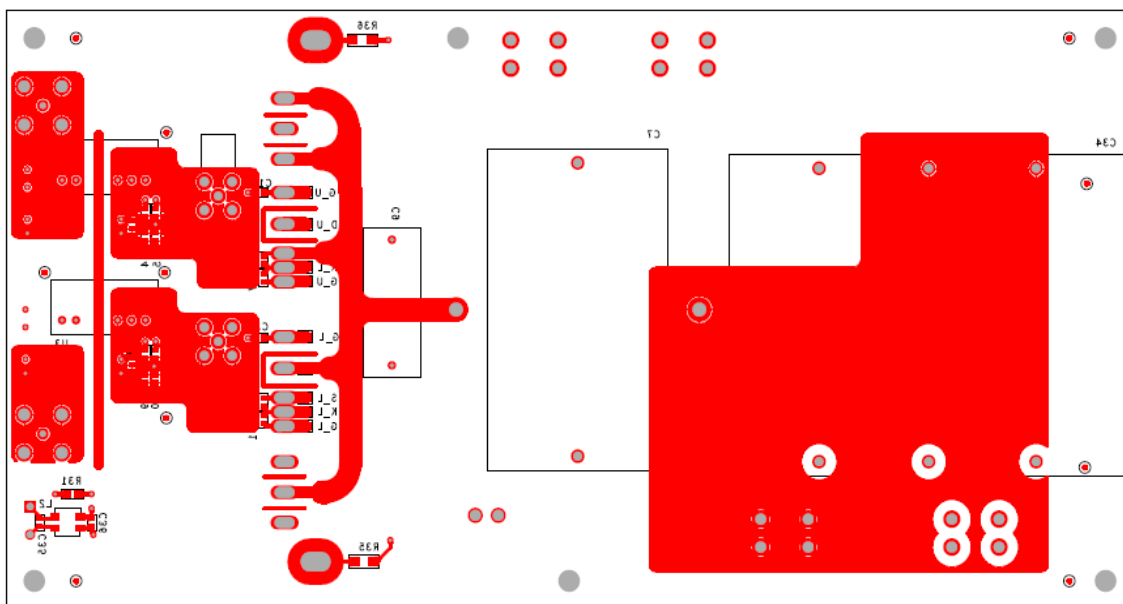
The information in this document is subject to change without notice.

Cree, the Cree logo, and Zero Recovery are registered trademarks of Cree, Inc.

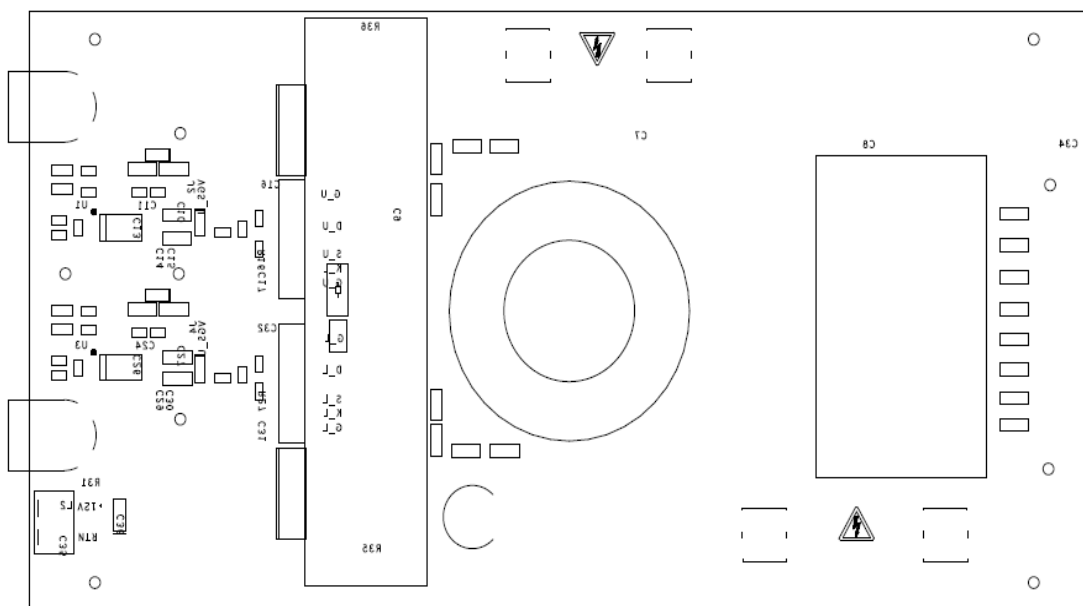
## Power Board Inner Copper Layer 3



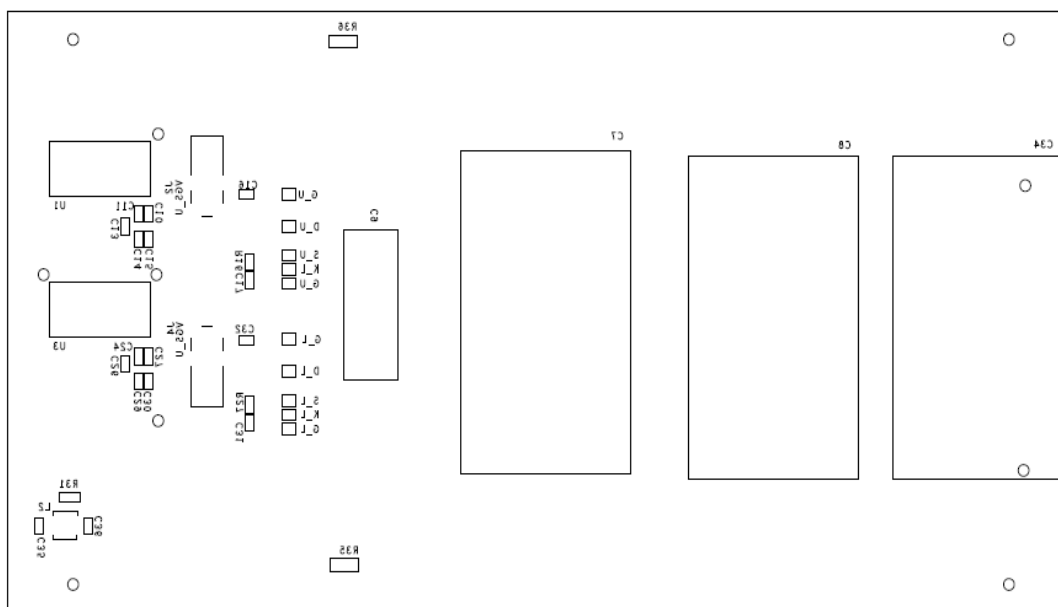
## Power Board Bottom Copper Layer



## Power Board Top Layer Silkscreen

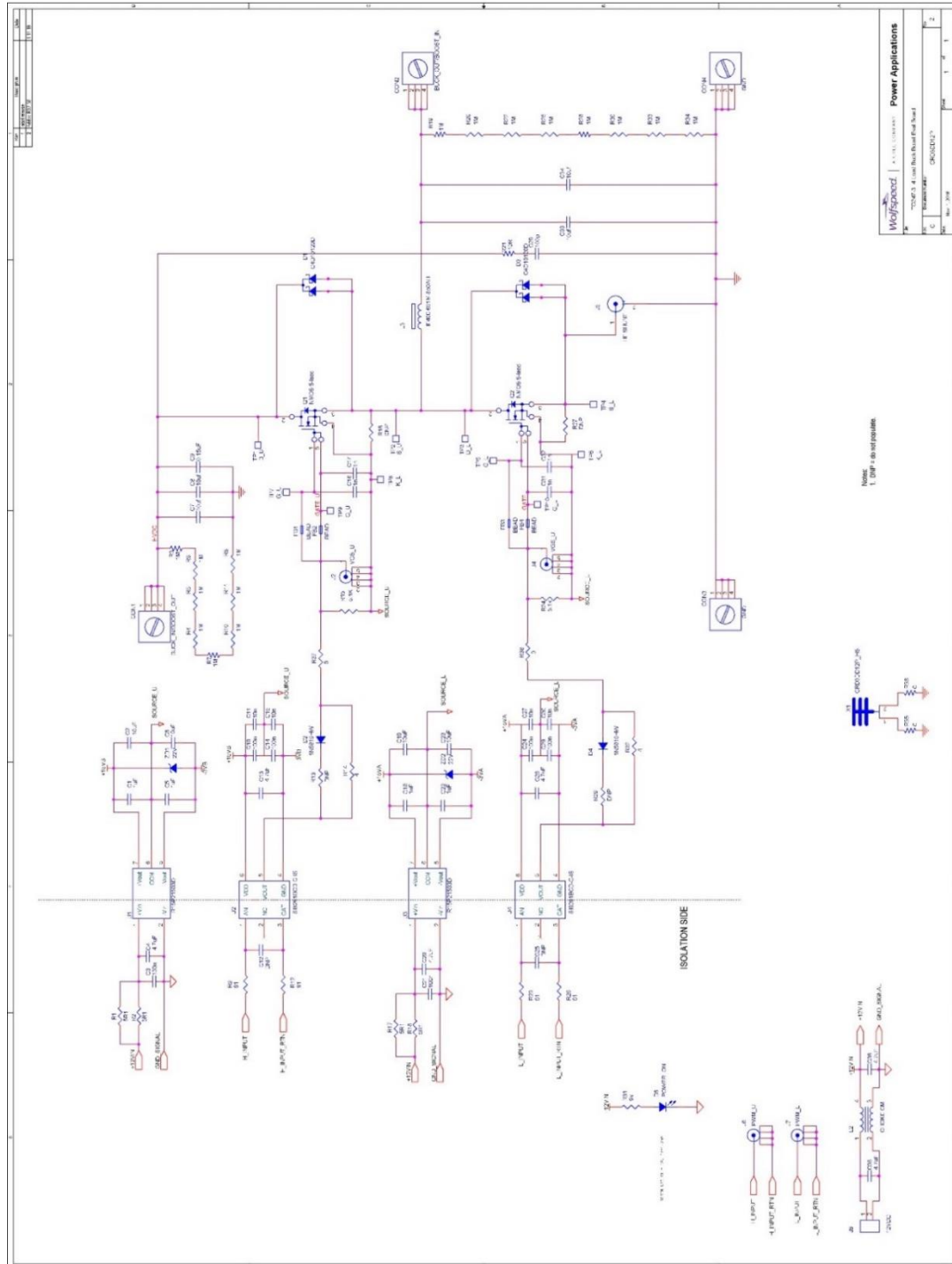


## Power Board Bottom Layer Silkscreen



## III. Schematic

**Note:** a larger copy of the schematic may be obtained upon request by contacting Cree at [sic\\_power@cree.com](mailto:sic_power@cree.com)



CPWR-AN27, Rev A, 04-2019

Copyright © 2019 Cree, Inc. All rights reserved.

The information in this document is subject to change without notice.

Cree, the Cree logo, and Zero Recovery are registered trademarks of Cree, Inc.

## IV. Bill of Materials

Item	Qty	Reference Designator	Description	Manufacturer	Manufacturer P/N
1	4	CON1,CON2,CON3,CON4		KEYSTONE	8174
2	4	C1,C5,C18,C22	CAP CER 1UF 50V 10% X7R 0603	Taiyo Yuden	UMK107AB7105KA-T
3	4	C2,C6,C19,C23,	CAP CER 10UF 35V X7R 1206	TDK or Taiyo Yuden	CGA5L1X7R1V106K160AE GMK316AB7106KL-TR
4	4	C7,C8,C33,C34	Film Capacitors 10uF 1000volt 5% 2pin 52.5mm LS	VISHAY	MKP1848S61010JY2B
5	6	C3,C10,C14,C21,C24,C29	CAP CER 0.1UF 50V 10% X7R 0603	AVX or Samsung	MM035C104KC22A or CL10B104KB8SFNC
6	6	C4,C13,C20,C26,C35,C36	CAP CER 4.7UF 35V 10% X5R 0603	MURATA or TDK	ZRB18AR6YA475KE05L or C1608X5R1V475M080AC
7	1	C9	CAP FILM 0.15UF 20% 1.5KVDC RAD	EPCOS	B32023A3154M
8	4	C11,C15,C27,C30	CAP 10000pF ±10% 50V Ceramic X7R 0603	KEMET	C0603C103K5RACTU
9	0	C12,R13,R16,C25,R27,R29		DNP	
10	4	C16,C17,C31,C32	CAP CER 1000PF 50V 10% X7R 0603	KEMET	C0603C102K5RECTU
11	0	C28		DNP	
12	0	D1,D3		DNP	
13	0	D2,D4		DNP	
14	1	D6	LED GREEN CLEAR CHIP SMD	LITE-ON INC	LTST-C230KGKT
15	4	FB2,FB4,R37,R38	RES SMD 0 OHM 1% JUMPER 1/10W 0603	YAGEO	RC0603JR-070RL
16	2	J2,J4	CONN SMA JACK R/A 50 OHM PCB	TE Connectivity	5-1814400-1
17	0	J5		DNP	
18	2	J6, J7	BNC CONN JACK, FEMALE SOCKET 500HM THROUGH HOLE, RIGHT ANGLE SOLDER	TE Connectivity	5-1634513-1
19	1	J8	TERM BLK 2POS SIDE ENTRY 5MM PCB	Phoenix Contact	1935161
20	1	L2	Common Mode Chokes / Filters 50V 1.2A 0.06ohms	TDK	ACM4520V-901-2P-T00
21	1	L3	Toroidal Power Inductor 650uH, 8 Amp	CWS	CWS-15N-12877
22	0	FB1,FB3		DNP	
23	4	R1,R2,R17,R18	RES SMD 5.1 OHM 5% 1/8W 0805	YAGEO	RC0805JR-075R1L
24	16	R3,R4,R5,R6,R7,R8,R10,R11, R19,R20,R22,R25,R28,R30, R33,R34	RES SMD 1M OHM 1% 1/4W 1206	YAGEO	ERJ-8ENF1004V
25	4	R9,R12,R23,R26	RES SMD 91 OHM 1% 1/10W 0603	YAGEO	RC0603FR-0791RL
26	2	R14,R32	RES SMD 4.02 OHM 1% 1206	RMCF1206FT4R 02	STACKPOLE ELECTRONICS
27	2	R15,R24	RES SMD 5.1K OHM 5% 1/10W 0603	YAGEO	RC0603JR-075K1L
28	0	R21			DNP
29	1	R31	RES SMD 9.1K OHM 1% 1/8W 0805	YAGEO	RC0805FR-079K1L
30	2	R35,R36	RES SMD 0R OHM 1% 1/4W 1206	YAGEO	RC1206JR-070RL
31	10	TP1-TP10	PC TEST POINT TIN SMD	Harwin	S2751-46R
32	2	U1,U3	Isolated DC/DC Converter 2W 15Vin 15/- 3Vout	RECOM	R15P21503D
33	2	U2,U4	DGTL ISO 5KV GATE DRIVER 6SDIP	Silicon Labs	SI8261BCD-C-IS
34	2	ZD1,ZD2	Zener Diode 22V 500mW ±5% Surface Mount SOD-123	Diodes Incorporated	MMSZ5251B-7-F

## 14. Revision History

Date	Revision	Changes
04/15/2019	Rev. A	1 <sup>st</sup> Issue

## 15. IMPORTANT NOTES

### Purposes and Use

Cree, Inc. (on behalf of itself and its affiliates, “Cree”) 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 CREE 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 CREE (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 Cree’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 Cree at [sic\\_power@cree.com](mailto:sic_power@cree.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 Cree at [sic\\_power@cree.com](mailto:sic_power@cree.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

CPWR-AN27, Rev A, 04-2019

Copyright © 2019 Cree, Inc. All rights reserved.

The information in this document is subject to change without notice.

Cree, the Cree logo, and Zero Recovery are registered trademarks of Cree, Inc.

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 the board schematic. Users should contact Cree at [sic\\_power@cree.com](mailto:sic_power@cree.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 Cree at [sic\\_power@cree.com](mailto:sic_power@cree.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 CREE BE LIABLE FOR ANY DAMAGES OF ANY KIND ARISING FROM USE OF THE BOARD. CREE'S AGGREGATE LIABILITY IN DAMAGES OR OTHERWISE SHALL IN NO EVENT EXCEED THE AMOUNT, IF ANY, RECEIVED BY CREE IN EXCHANGE FOR THE BOARD. IN NO EVENT SHALL CREE 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 CREE MAY BE BROUGHT AGAINST CREE 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 Cree by contract with respect to product safety, product liability, or intellectual property infringement do not apply to the board.