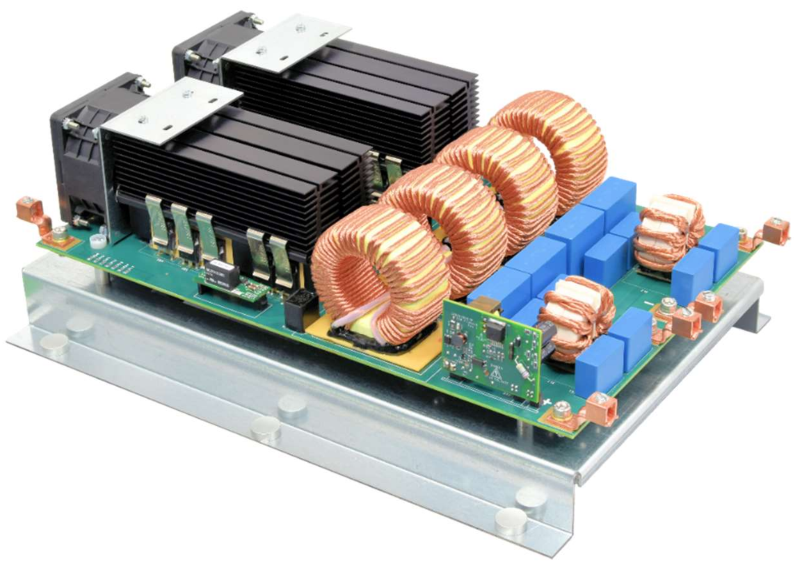
CRD-60DD12N
60kW Interleaved Boost Converter

CRD-60DD12N
60kW 交错升压转换器

CRD-60DD12N
60kW インターリーブドブーストコンバータ



Application Note

CPWR-AN23, Rev-

Cree Power Applications

Cree, Inc.	科税有限责任公司	クリー株式会社
4600 Silicon Drive	4600 硅驱动器	4600 シリコンドライブ
Durham, NC 27703 USA	Durham, NC 27703 USA	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.

CPWR-AN23, Rev -, 06-2018

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。

CPWR-AN23, Rev -, 06-2018

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。

CPWR-AN23, Rev -, 06-2018

Table of Contents

1. Introduction

There is a growing need for high efficiency DC/DC power converters in a variety of industrial power applications specifically in solar power generation. In solar power generation, the photovoltaic (PV) cells utilize the sun's energy to generate DC voltage which is usually in the range of 400VDC to 600VDC. This DC voltage needs to be boosted to 850VDC (approx.) so that an inverter (DC/AC) can generate 480VAC to feed the power of PV cells into the power grid (as shown in Figure. 1). Increasing the efficiency of the power conversion process enables designers to build smaller, lighter, and less expensive power converters.

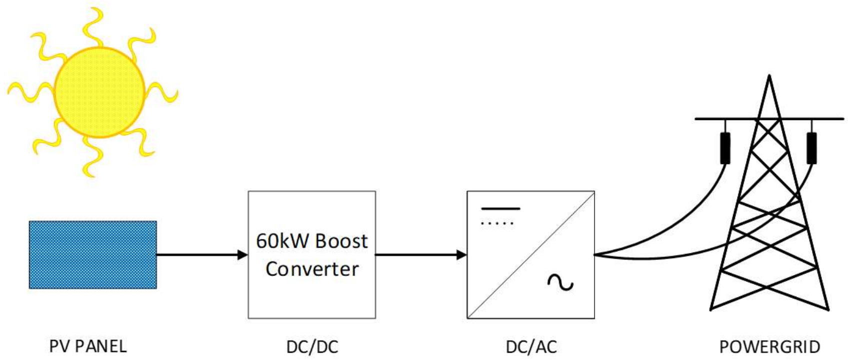


Figure 1. Solar Power Generation

In this application note, Cree has introduced a CRD-60DD12N, 60kW Interleaved Boost Converter (as shown in Figure 2) based on Cree's (C3M™) 1200V, 75mΩ SiC MOSFET (P/N: C3M0075120K) which comes in a TO-247-4 package with a Kelvin source availability. The availability of Kelvin source reduces the inductance of gate and Kelvin source path which in turn reduces the overall switching losses.

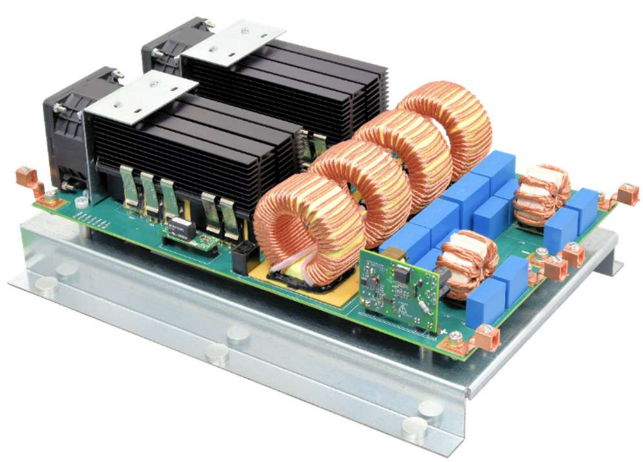


Figure 2. Cree's CRD-60DD12N, 60kW Interleaved Boost Converter

In addition to that, Cree's CRD-60DD12N, 60 kW interleaved boost converter utilizes Cree's newly developed CGD15SG00D2 isolated gate driver board which is tailored to the drive requirements of the Cree's generation 3 (C3M™) SiC MOSFETs.

2. Design Specifications

The design specifications of Cree's CRD-60DD12N, 60kW interleaved boost converter are listed in Table 1.

Parameters	Values
Input voltage range	470VDC-800VDC
Output voltage	850VDC
Output Power	60kW (Vin ≥ 600V) 50kW (Vin < 600V)
Switching frequency	78kHz
Efficiency	99.5%
Power Density	127W/in^3
Topology	Interleaved DC/DC Boost
Power device package	TO-247-4

Table 1: Design Specifications of Cree's CRD-60DD12N, 60kW Interleaved Boost Converter

3. Physical Dimensions and Pinouts

The Physical dimensions and the pinouts of Cree's CRD-60DD12N, 60kW Interleaved Boost Converter are shown in Figure 3 and Figure 4.

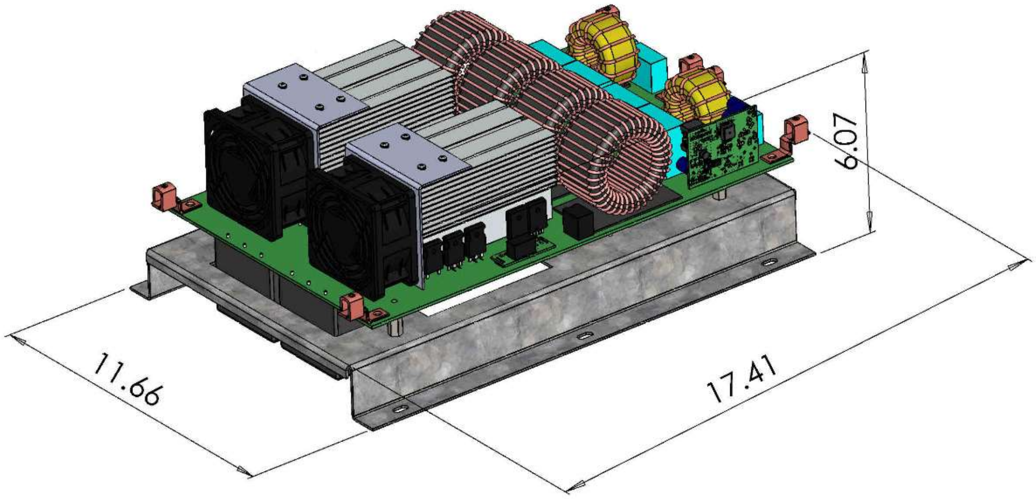


Figure 3. Physical Dimensions of Cree's CRD-60DD12N, 60kW Interleaved Boost Converter

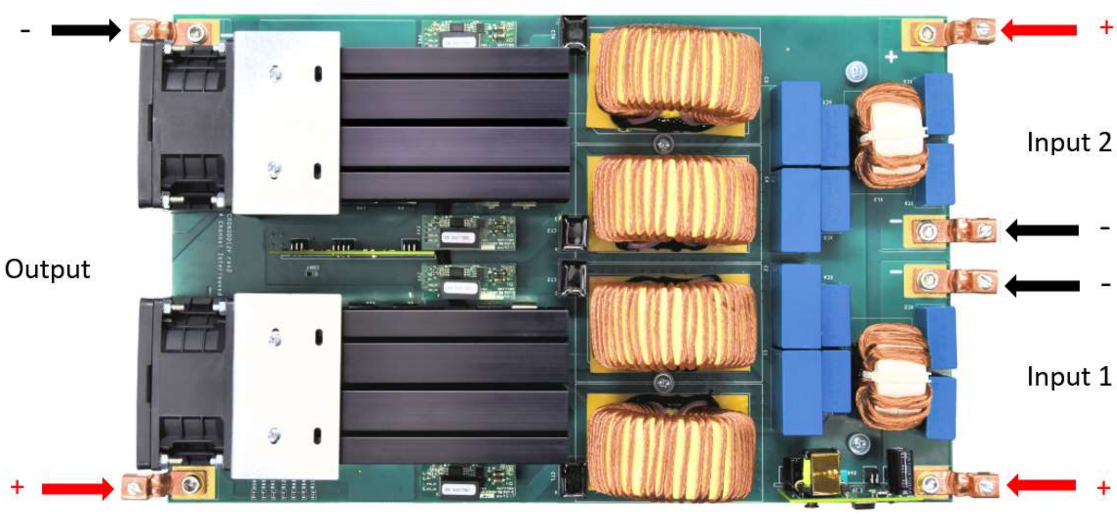


Figure 4. Pinouts of Cree's CRD-60DD12N, 60kW Interleaved Boost Converter

4. Electrical Operation

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 ELECTRCIAL 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

高圧危険

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。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

Cree's CRD-60DD12N, 60kW Interleaved Boost Converter consist of four interleaved 15kW Boost Converters (as shown in Figure 5). Each 15kW Boost Converter is based on Cree's (C3M™) 1200V, 75mΩ SiC MOSFET (P/N: C3M0075120K). To make the whole system more efficient, Cree's C4D10120D SiC Schottky diodes have been utilized as well specifically due to their low voltage drop and zero reverse recovery features.

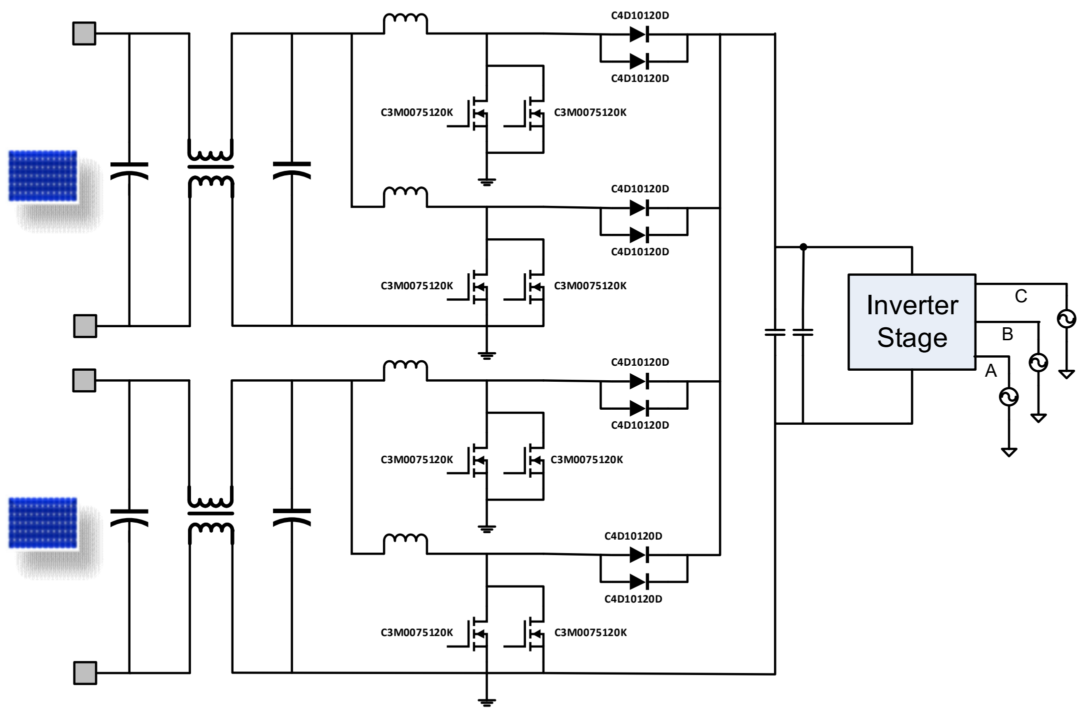


Figure 5. Top-level diagram of Cree's CRD-60DD12N, 60 kW boost converter (with four channels)

Cree's CRD-60DD12N, 60kW Interleaved Boost Converter PCB board has been divided into two sections, one is the boost control board (schematic shown in Figure 6) and the other is the boost power board (schematic shown in Figure 7). Two of the Texas Instrument's UCC2822 Interleaved Dual PWM Controllers have been used on the boost control board. Each controller IC provide PWM switching signals to the two of the interleaved boost stages of Cree's CRD-60DD12N, 60kW Interleaved Boost Converter (as shown in Figure 6). The boost power board mainly consist of power switching devices, passive elements (including boost inductor and capacitor) and voltage/current sensing circuitry. There are three pin header connectors (CON217, CON218, CON219) that plug boost control board into the boost power board (as shown in Figure 7).

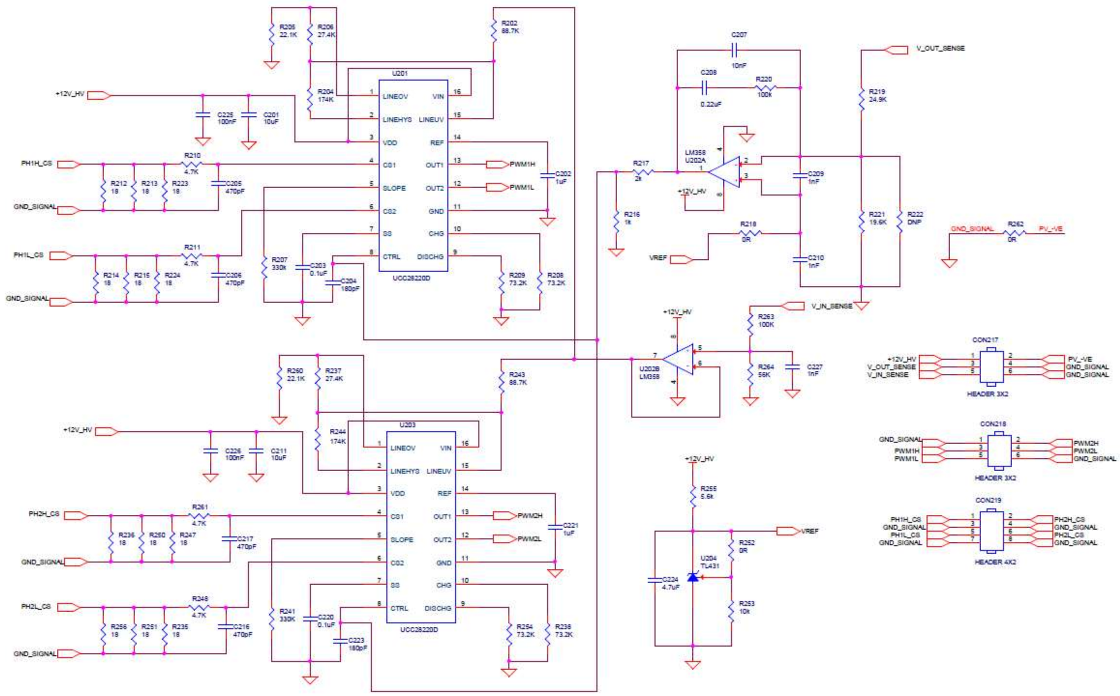


Figure 6. Boost Control Board Schematic

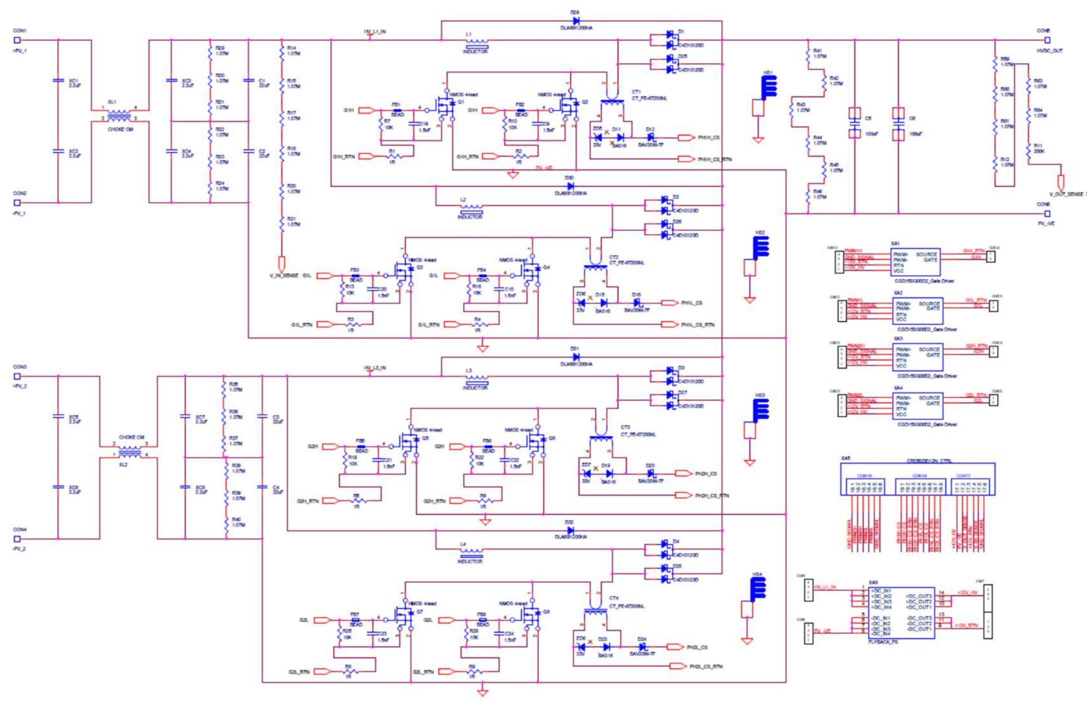


Figure 7. Boost Power Board Schematic

A couple of good engineering design practices have been followed during the design of Cree's CRD-60DD12N, 60kW Interleaved Boost Converter. Some of them are mentioned below:

Gate Layout:

A good clean gate layout is vital to minimize ringing and to help facilitate good current sharing. Since two MOSFETs are being paralleled, it is important that the gate traces and the Kelvin source return traces are as symmetrical as possible. They (gate and Kelvin source traces) should be overlapped on opposite layers to minimize parasitic inductance.

Figure 8 shows an example of a clean symmetrical gate and Kelvin source layout. The gate traces are on the bottom side of the PC board. The source trace is in the form of a plane on an internal layer (closest to the bottom side of pc board). The source plane is made wide enough to completely overlap the gate trace; therefore, minimizing the inductance. The length of the gate and Kelvin source runs from the gate driver output (CON14) to each MOSFET, it should have to be as close in length as possible.

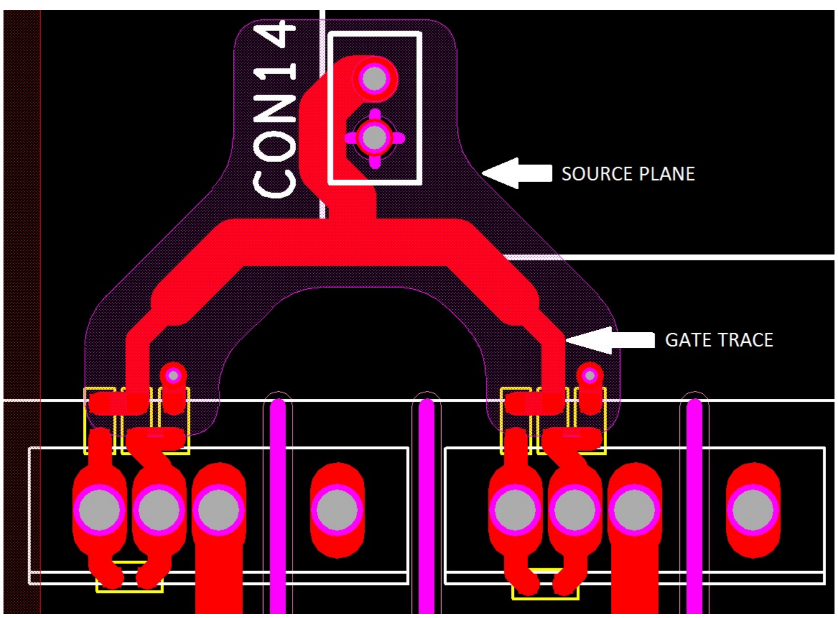


Figure 8. MOSFET Gate and Source Layout

Current Sharing:

Another practice that is critical for good current sharing is to make the power current paths through each MOSFET as similar in total length as possible. If the layout is ideal, the MOSFET's parameters ($R_{DS(on)}$, V_{TH}) will determine current sharing.

The current paths out of the MOSFET sources are shown in Figure 9. The left MOSFET (Q1) has a shorter path back to the input capacitors than the right MOSFET (Q2). To balance out the impedance in these paths, the trace connecting the MOSFET drains can be made a little longer for Q1 relative to Q2.

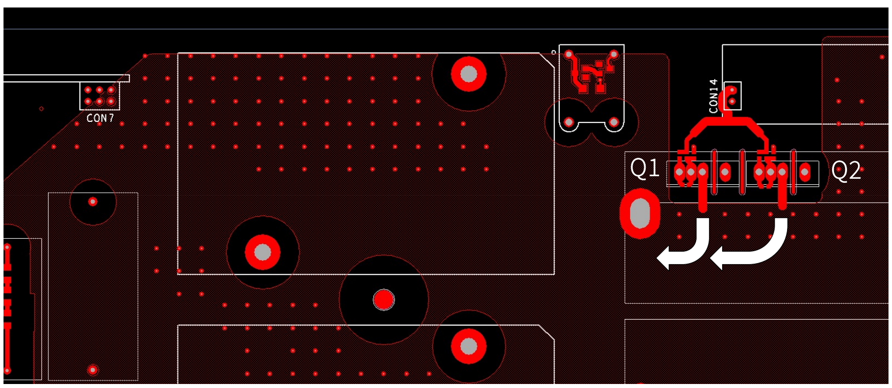


Figure 9. MOSFET Source Current Paths

The drain current path for Q1 is highlighted with the white arrow (as shown in Figure. 10). It is slightly longer than the drain current path for Q2, compensating for the shorter current source path. If the total impedance through each MOSFET is the same, then the current sharing will be determined by the device's parameters ($R_{DS(on)}$, V_{TH}).

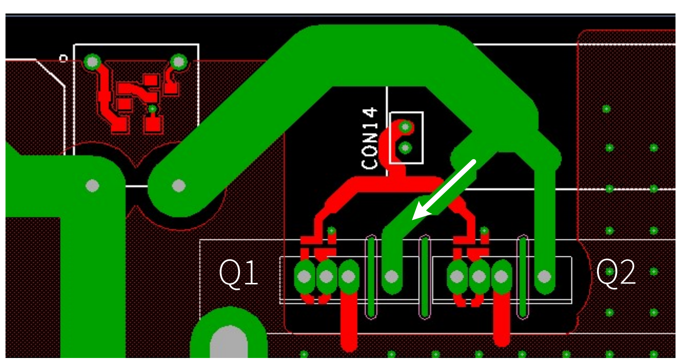


Figure 10. MOSFET Drain Current Paths

To prove this, two MOSFETs were selected with very different parameters. The parameters for the MOSFETs can be seen in Table 2. For the first test, the MOSFET with the higher $R_{DS(on)}$, and higher threshold voltage was placed in the Q1 position. The MOSFET with the lower $R_{DS(on)}$ and lower threshold voltage was placed in the Q2 position. Channel 1 was run by itself with 6kW of load.

Parameter	Q1	Q2
$R_{DS(on)}$	81.82mΩ	67.96mΩ
V_{th}	3.006V	2.666V

Table 2. MOSFET Parameters

The waveforms are shown in Figure 11. The RMS (root mean square) current through Q1 (scope channel 4) was 3.64A. The RMS current through Q2 (scope channel 3) was 4.01A. This equates to Q1 carrying 47.6% of the total current and Q2 carrying 52.4% of the total current.

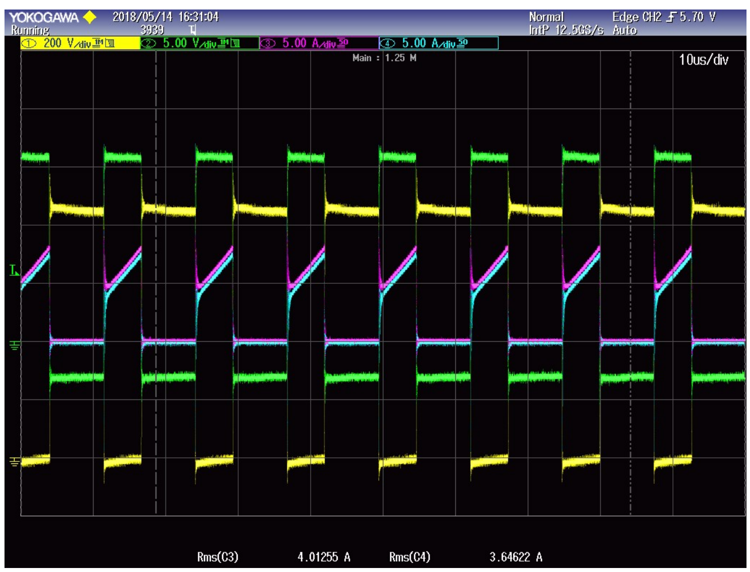


Figure 11. MOSFET Current Sharing

Next, the two MOSFETs were swapped and placed in opposite positions and the same measurements were taken under the same conditions. The resulting currents are shown in Figure 12.

.

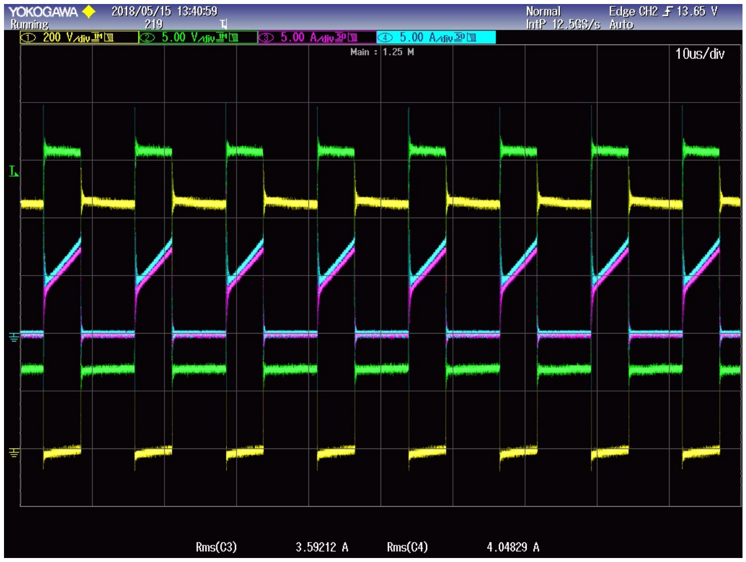


Figure 12. MOSFET currents after swapping

The RMS current through Q1 (scope channel 4) was 4.05A. The RMS current through Q2 (scope channel 3) was 3.59A. This equates to Q1 carrying 53.0% of the total current and Q2 carrying 47.0% of the total current. The currents are completely opposite of the first test scenario, proving that the current sharing is driven by the device parameters and not the layout.

5. Board Assembly and Testing Procedure

The Boost Power Board assembly of Cree's CRD-60DD12N, 60kW Interleaved Boost Converter consist of multiple sub-boards. Before turning the boost power board ON, these sub-boards need to be plugged into the main board. The first sub-board is the Cree's CRD-15DD17P, 15W flyback power supply board (as shown in Figure 14) which is used to provide the necessary 12V control power. This is very convenient because the flyback board derives its power from the DC input of the boost converter. Once the input voltage exceeds 230VDC, the flyback starts and supplies the 12V to all the logic and the isolated gate drivers. The second sub-board is the boost control board (as shown in Figure 14) which is carrying all the controller IC's.

The third category of sub-boards (Quantity = 4) is the Cree's CGD15SG00D2, isolated gate driver boards. Four of these boards (as shown in Figure 13) is plugged into the boost power board to provide optimum gate drive signals to each of the Cree's (C3M^{TM}) 1200V, 75mΩ SiC MOSFET (P/N: C3M0075120K).

<u>The process of assembling Cree's CRD-60DD12N, 60kW Interleaved Boost Converter:</u>

When setting up the Cree's CRD-60DD12N, 60kW Interleaved Boost Converter, it is important to verify that all four of the Cree's CGD15SG00D2, isolated gate driver boards are plugged into the boost power board (as shown in Figure 13).

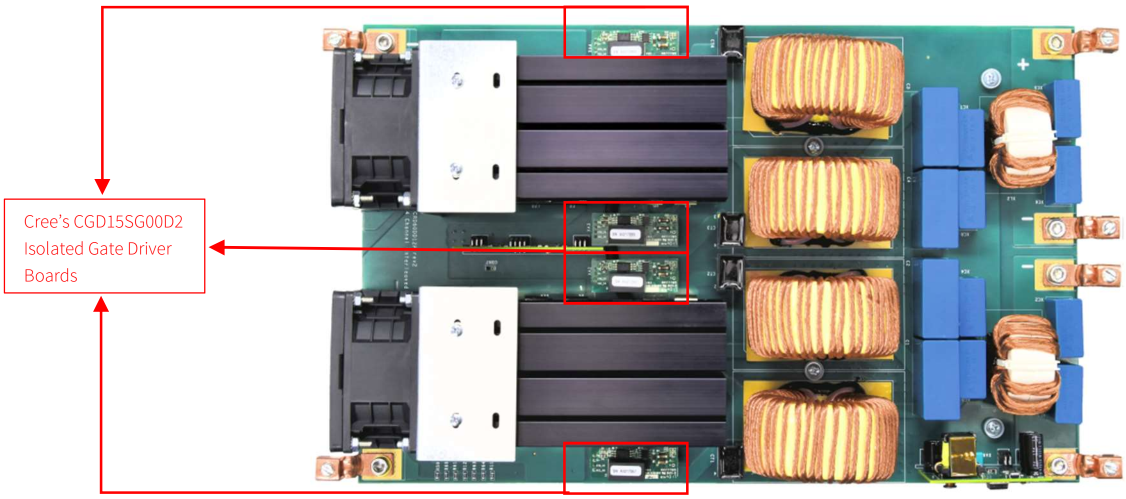


Figure 13. Location of Cree's CGD15SG00D2 Isolated Gate Driver Boards

Next, verify that the Cree's CRD-15DD17P, 15 W flyback power supply board and the boost control board are plugged into their receptacles (as shown in Figure 14). If a single DC power source will be used to power the boost converter, it will need to be connected to both inputs lugs (1&2) and the load will be connected the output lugs (as shown in Figure 14).

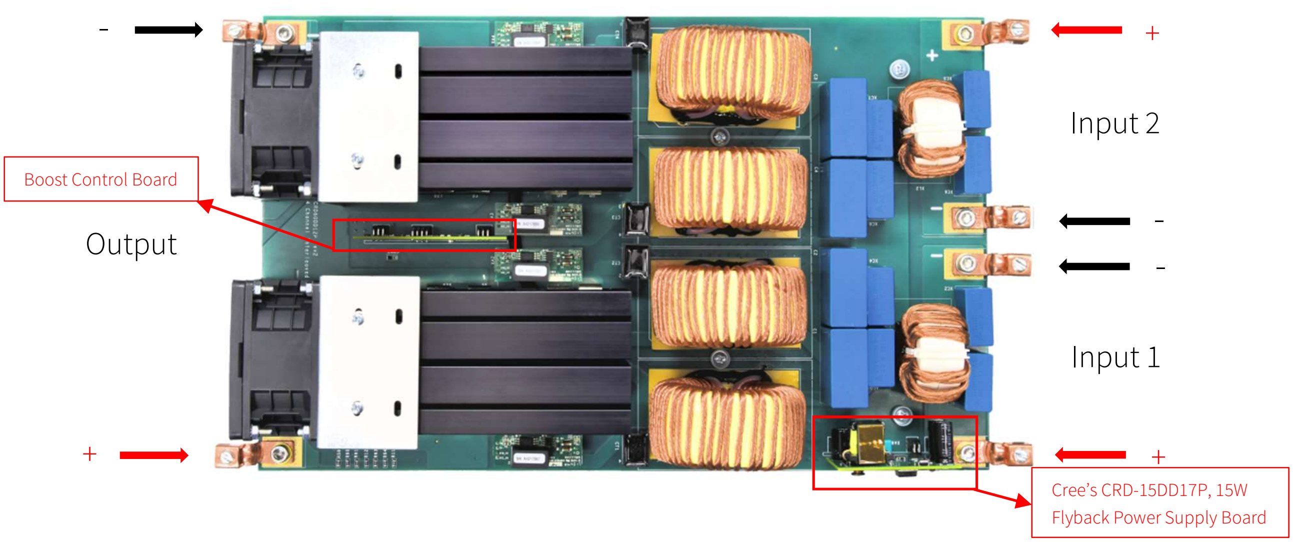


Figure 14. Location of Cree's CRD-15DD17P, 15W Flyback Power Supply Board and the Boost Control Board

Cree's CRD-60DD12N, 60kW Interleaved Boost Converter do have two fans on the boost power board. These fans must be supplied with 12V and 2.75A each. Please note that the fan must be turned ON before applying power to the boost power board.

Testing Procedure of Cree's CRD-60DD12N, 60kW Interleaved Boost Converter:

To safely operate the unit, bring the input voltage up to 500V. The flyback power supply turns on when the input is approximately 230V. The input voltage ramp rate should be controlled to not exceed 1V per millisecond.

The control system of Cree's CRD-60DD12N, 60kW Interleaved Boost Converter have a DC input over voltage (OV) and a DC input under voltage (UV) setting with hysteresis. The boost converter will not turn-on until the input voltage exceeds 470-480VDC. Once the boost converter turns on, it will stay on as long as the input voltage exceeds approximately 410VDC. If the input voltage drops below 410VDC, the boost converter turns off. The DC input overvoltage turns the boost converter off if the input voltage exceeds 925V approximately and it remains off until the input voltage drops below 865V approximately.

Please note, the DC UV and DC OV circuits will protect the unit from many but not all potential scenarios where the product might be operated outside its specification. The unit's specifications for input voltage (470V-800V) and maximum power ((50kW, $V_{IN} \geq$ 470VDC) & (60kW, $V_{IN} \geq$ 600VDC)) must be followed to ensure product reliability.

6. Performance data

I. Efficiency

The efficiency of Cree's CRD-60DD12N, 60kW Interleaved Boost Converter was measured under various load conditions (10 kW – 60 kW) while keeping the input voltage constant at 600VDC (as shown in Figure 15). The maximum efficiency achieved by Cree's CRD-60DD12N, 60kW Interleaved Boost Converter was 99.5 %

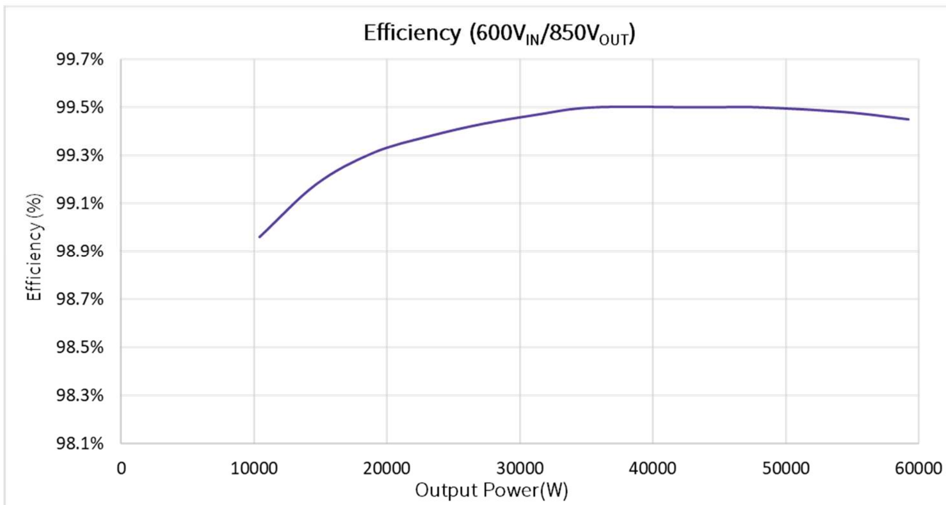


Figure 15. Efficiency measurements of Cree's CRD-60DD12N, 60kW Interleaved Boost Converter

II. Waveforms at various operating conditions

The performance of Cree's CRD-60DD12N, 60kW Interleaved Boost Converter can be evaluated by using drain to source voltage (V_{DS}), gate to source voltage (V_{GS}) and inductor current ($I_{INDUCTOR}$) waveforms (as shown in Figure 16). In addition to that, the performance of Cree's (C3M^{TM}) 1200V, 75mΩ SiC MOSFET (P/N: C3M0075120K) and Cree's CGD15SG00D2, isolated gate driver board can be evaluated by using MOSFET switching waveforms with negligible ringing (as shown in Figure 17 (a) and Figure 17 (b).

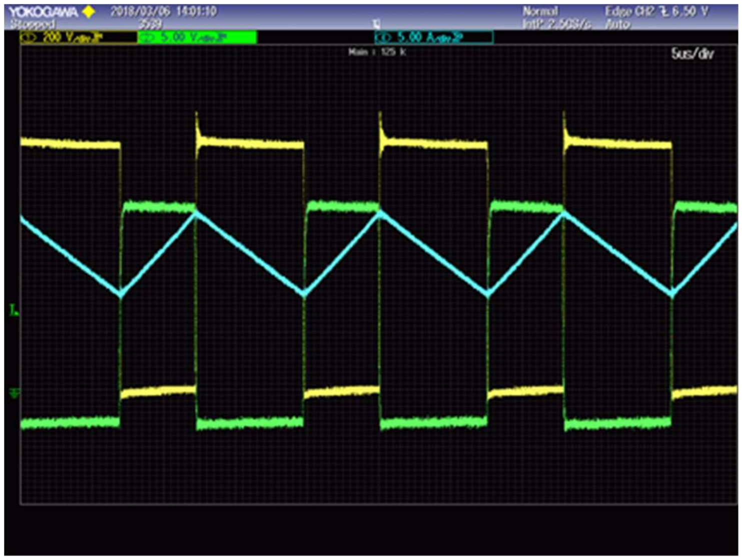


Figure 16. Drain to Source Voltage (V_{DS}) (Yellow), Gate to Source Voltage (V_{GS}) (Green) and Inductor Current ($I_{INDUCTOR}$) (Cyan) Waveforms

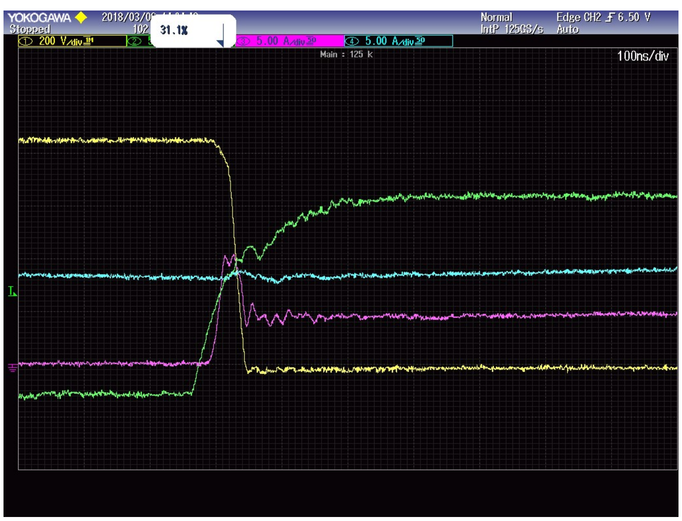


Figure 17 (a)

Figure 17 (b)

Figure 17 (a). MOSFET Turn-on Waveforms (Drain to Source Voltage (V_{DS}) (Yellow), Gate to Source Voltage (V_{GS}) (Green), Drain current (I_D) (Purple) and Inductor Current ($I_{INDUCTOR}$) (Cyan))
Figure 17 (b). MOSFET Turn-off Waveforms (Drain to Source Voltage (V_{DS}) (Yellow), Gate to Source Voltage (V_{GS}) (Green), Drain current (I_D) (Purple) and Inductor Current ($I_{INDUCTOR}$) (Cyan))

III. Thermal Measurements

Thermal measurements of Cree's CRD-60DD12N, 60kW Interleaved Boost Converter were taken at various loading conditions. Figure 18-21 show the thermal scans of MOSFETs and Diodes at 60 kW load with a 600 VDC input. Figure 22-25 show the thermal scans of MOSFETs and Diodes at 50 kW load with a 500 VDC input. All the measurements are well below the rated temperature range.

(V_{IN} = 600V, V_{OUT} = 850V)

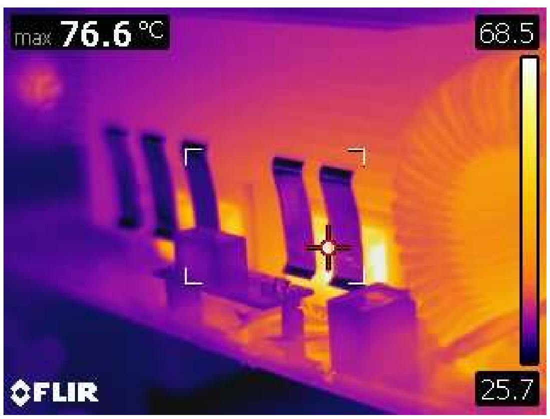


Figure 18. MOSFET Case Temperature (Q2)

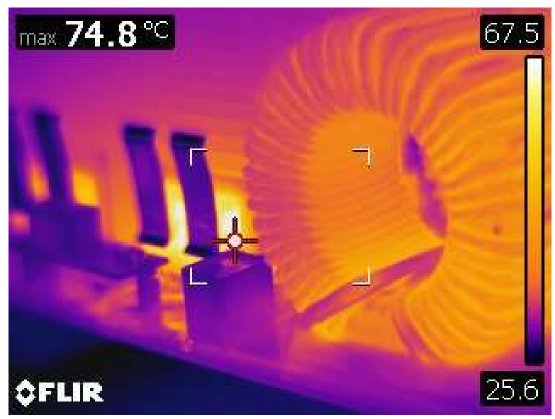


Figure 19. MOSFET Case Temperature (Q1)

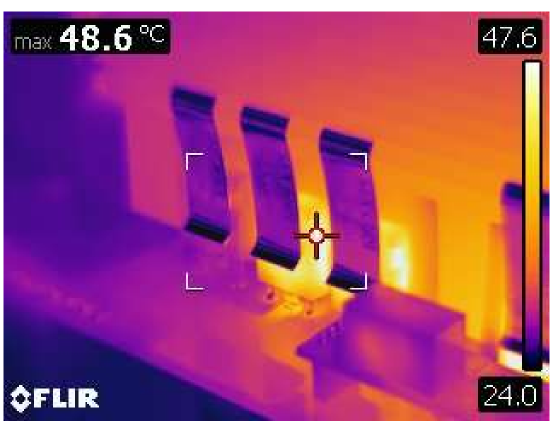


Figure 20. Diode Case Temperature (D25)

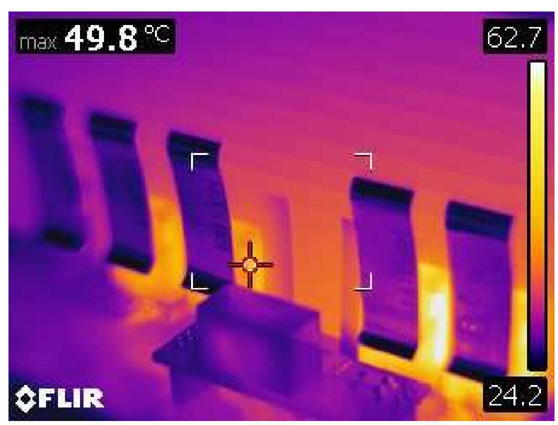


Figure 21. Diode Case Temperature (D1)

(V_{IN} = 500V, V_{OUT} = 850V)

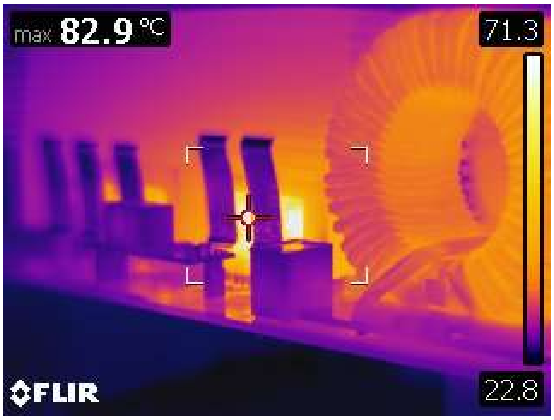


Figure 22. MOSFET Case Temperature (Q2)

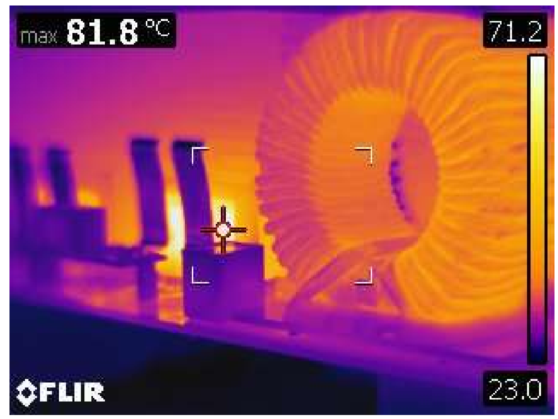
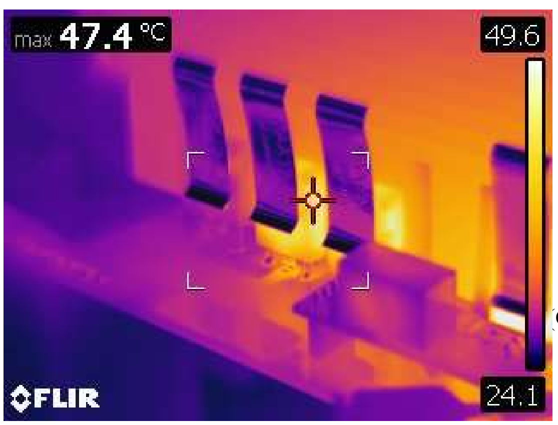


Figure 23. MOSFET Case Temperature (Q1)



(Q2)

Figure 24. Diode Case Temperature (D25)

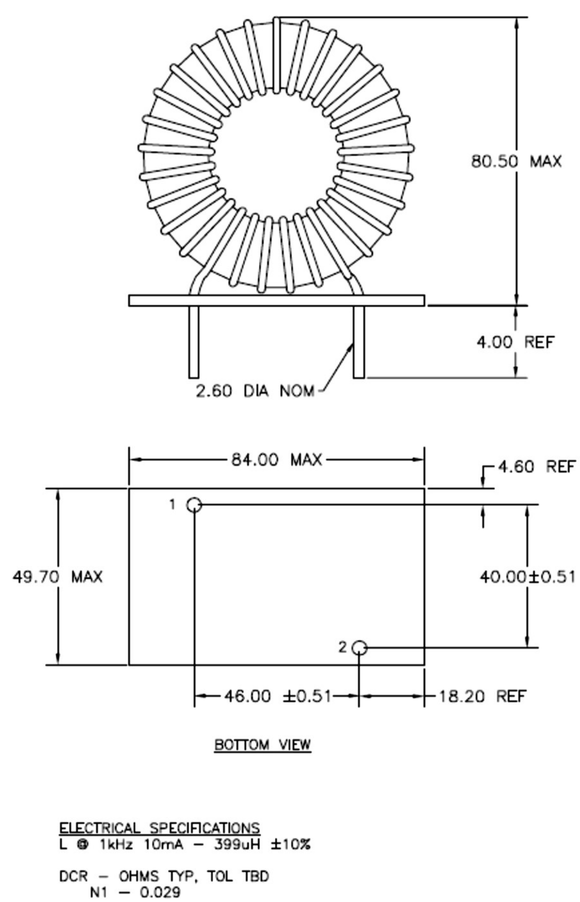
Figure 25. Diode Case Temperature (D1)

7. Appendix

Boost Inductor Specification

The boost inductor design uses KDM core part number# KAM290060A with 18 strand 25 AWG copper wire with polyurethane / Nylon coating (44 turns). The switching frequency is 78khz. The minimum inductance at full power will be 280uH. All the calculation are as follows:

Pout =	12500	W	Dmax =	0.447059	
Vinmin =	470	V	Dmin =	0	
Vinmax =	850	V			
Vout =	850	V	Iavg =	26.9	A
Fsw =	80000	Hz			
Eff =	0.99		ΔI =	9.40	A
Lboost =	0.000279	H			
Irms =	27.4	A			
Ipeak =	31.6	A			



PCB Layout:

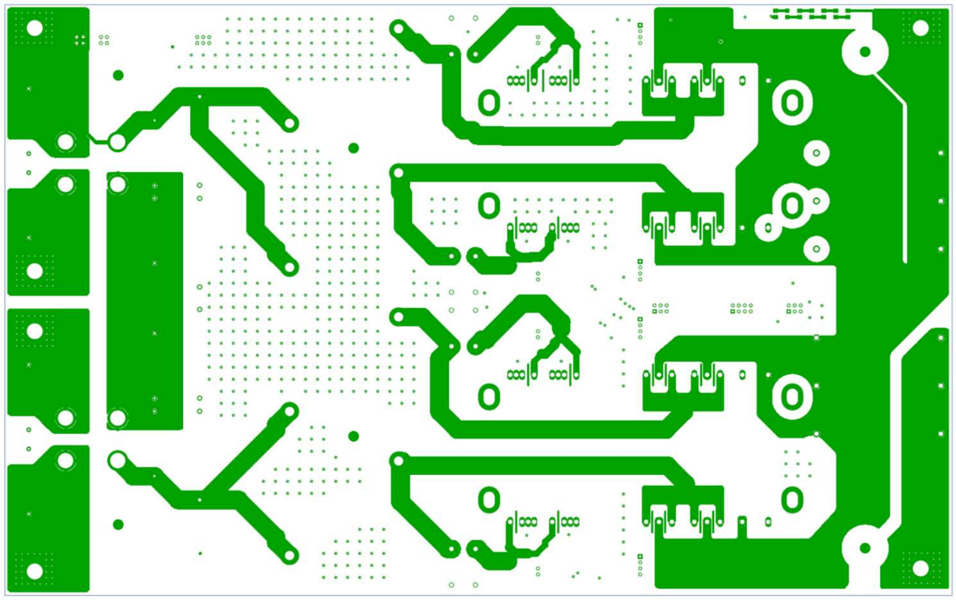


Figure 26. Power Board Top Copper Layer

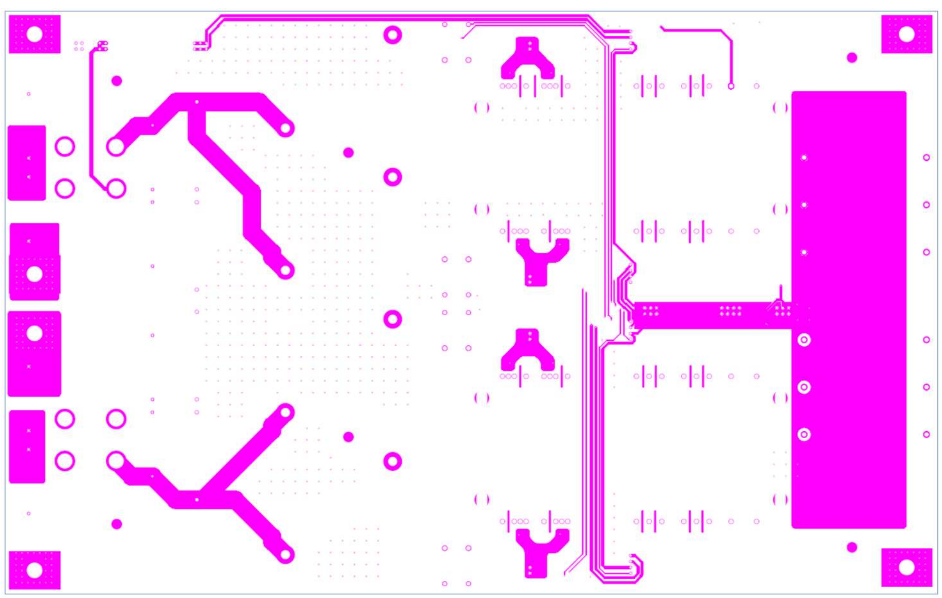


Figure 27. Power Board Inner Copper Layer 2

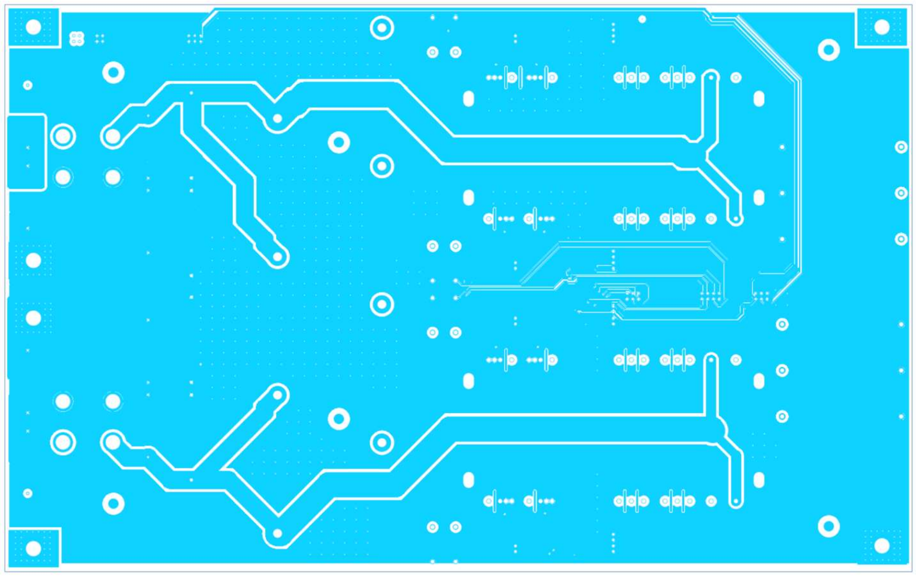


Figure 28. Power Board Bottom Copper Layer 3

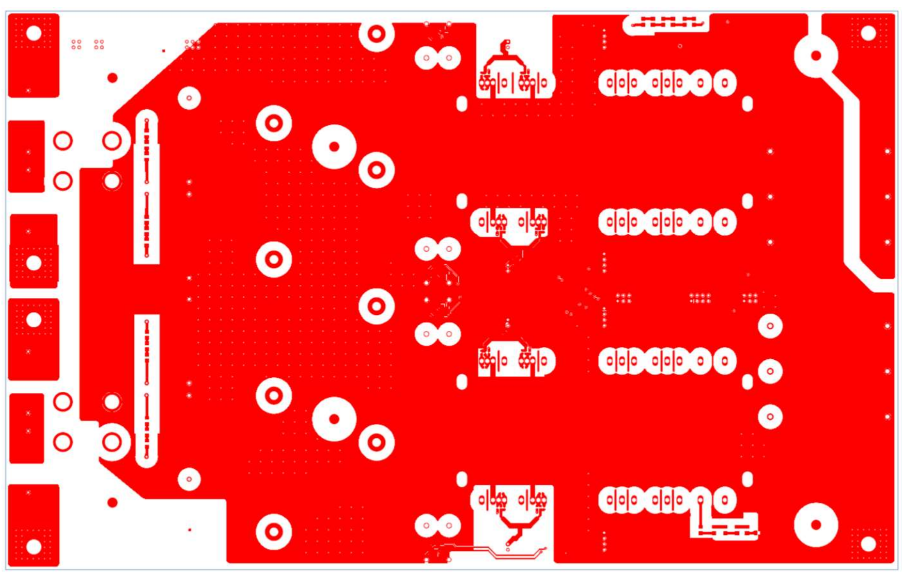


Figure 29. Power Board Inner Copper Layer 4

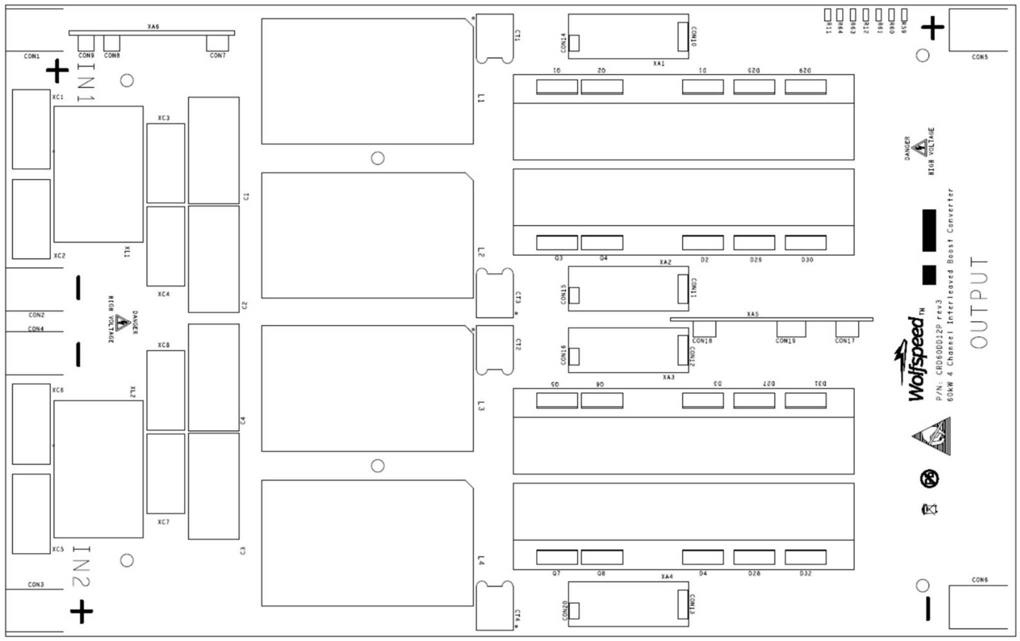


Figure 30. Power Board Top Layer Silkscreen

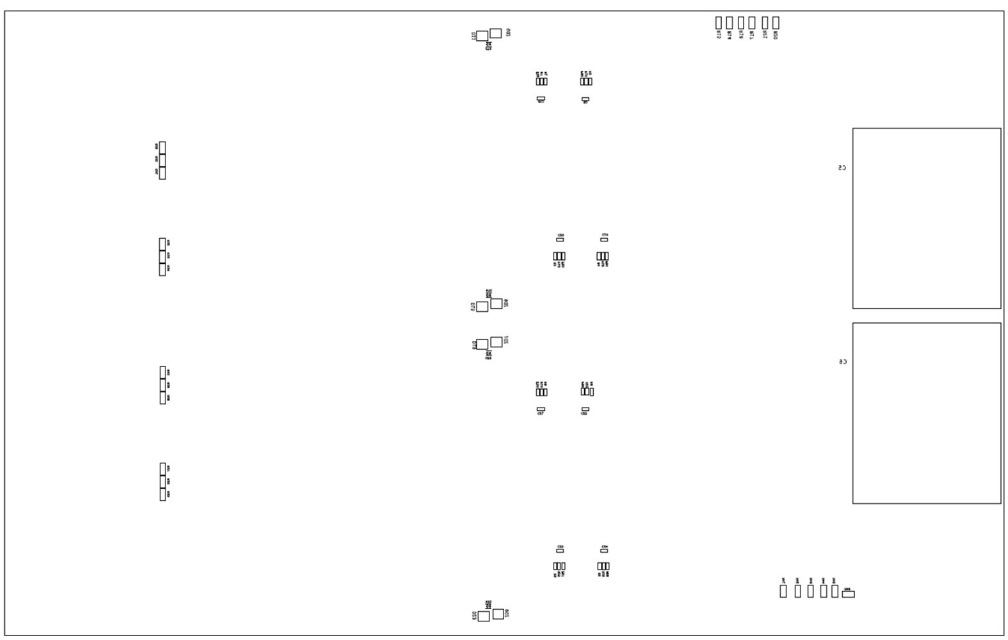


Figure 31. Power Board Bottom Layer Silkscreen

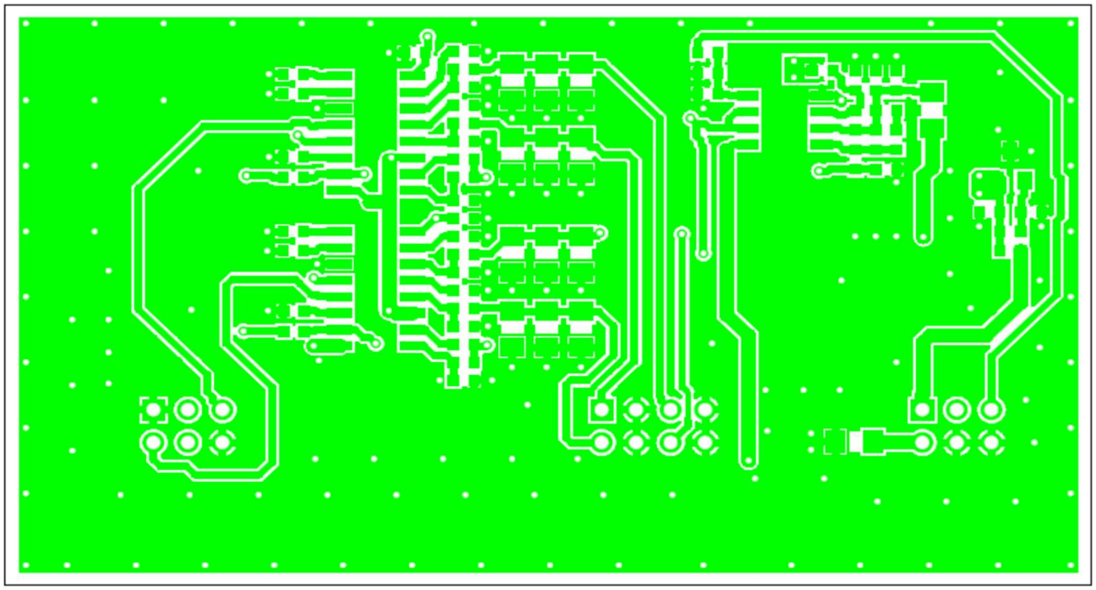


Figure 32. Boost Control Board Bottom Copper Layer

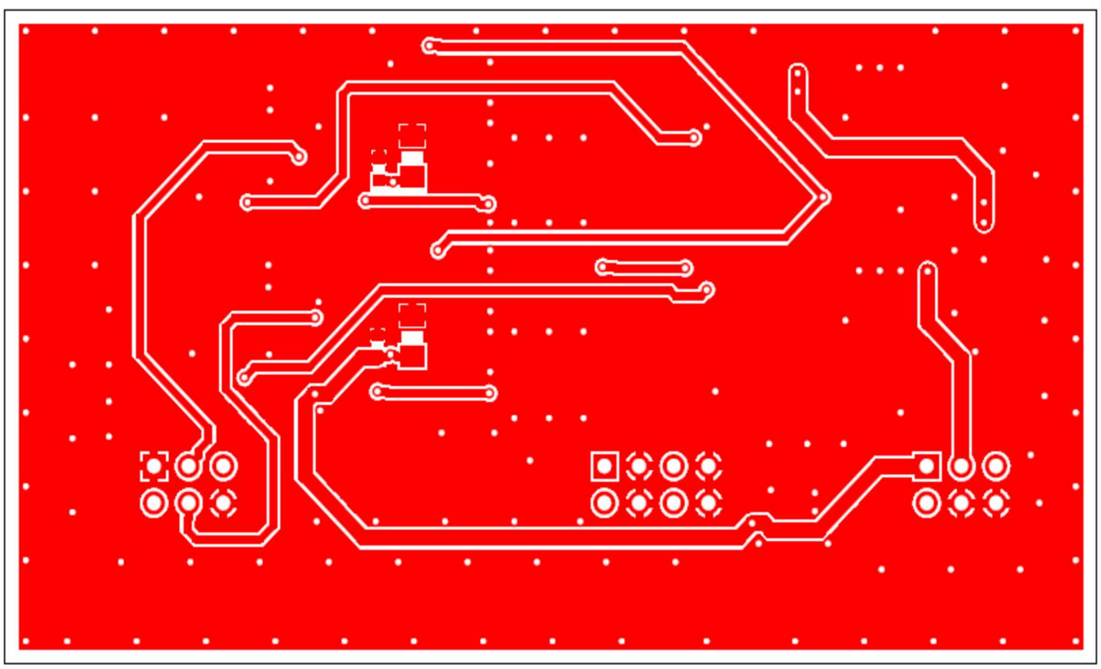


Figure 33. Boost Control Board Bottom Copper Layer

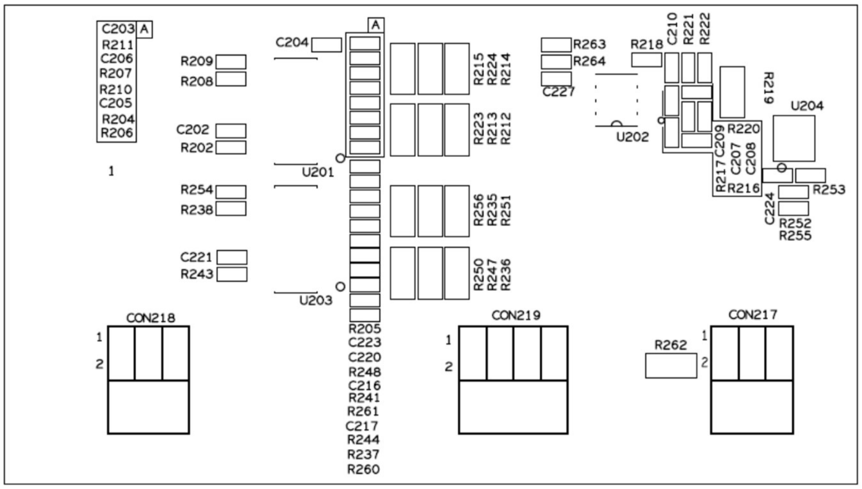


Figure 34. Boost Control Board Top Layer Silkscreen

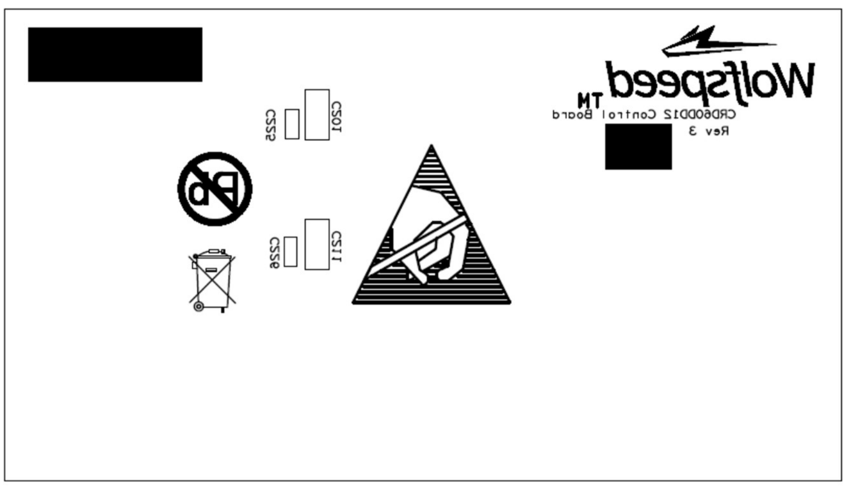


Figure 35. Boost Control Board Bottom Layer Silkscreen

Bill of Materials (BOM):

Boost Power Board

Item	Qty	Reference	Description	Part	Manufacturer
1	6	CON1-CON6	LUG TERMINALS 8AWG-2AWG	CB70-14-CY	Panduit Corp
2	2	CON8, CON9	CONN RCPT 4 POS .100" DUAL VERTICAL	BCS-102-L-D-TE	Samtec
3	3	CON7, CON17, CON18	CONN RCPT 6POS .100" DBL GOLD	68683-303LF	Amphenol FCI
4	1	CON19	CONN RCPT 8POS .100" DBL GOLD	68683-304LF	Amphenol FCI
5	4	CON10, CON11, CON12, CON13	CONN HEADER FEMALE 4POS .1" GOLD	PPPC041LFBN-RC	Sullins Connector Solutions
6	4	CON14, CON15, CON16, CON20	CONN HEADER FEMALE 2POS .1" GOLD	PPPC021LFBN-RC	Sullins Connector Solutions
7	4	CT1,CT2,CT3,CT4	CURRENT SENSE TRANSFORMER	PE-67200NL	Pulse Electronics Power
8	4	C1,C2,C3,C4	CAP FILM 22UF 630VDC RADIAL	B32796E2226K	EPCOS
9	2	C5,C6	CAP FILM 100uF 5% 1000Vdc 6Pin	MKP1848C71010JY	Vishay
10	8	C9,C10,C19,C20,C21,C22,C23,C24	CAP CER 1500PF 50V X7R 0603 10%		
11	8	D1,D2,D3,D4,D25,D26,D27,D28	SIC SCHOTTKY DIODE 1200V, 2x5A	C4D10120D	Cree
12	4	D11,D15,D19,D23	DIODE GEN PURP 100V 215MA SOT23	BAS16LT1G	On Semiconductor
13	4	D12,D16,D20,D24	DIODE GEN PURP 150V 200MA SOD123	BAV20W-7F	Diodes Incorporated
14	4	D29,D30,D31,D32	1200V, 60A Standard Recovery Rectifier	DLA60I1200HA or VS-60EPF12PBF	IXYS or Vishay
15	8	FB1,FB2,FB3,FB4,FB5,FB6,FB7,FB8	FERRITE BEAD 22 OHM 0603	FBMJ1608HS220NT	Taiyo Yuden
16	4	HS1,HS2,HS3,HS4		HEAT_SINK	Aavid
17	4	L1,L2,L3,L4	399uH INDUCTOR	T26586	Cramer
18	8	Q1,Q2,Q3,Q4,Q5,Q6,Q7,Q8	MOSFET 1200V 75mohm TO-247-4	C3M0075120K	Cree
19	8	R1,R2,R3,R4,R5,R6,R8,R9	RES SMD 1 OHM 1% 1/10W 0603	RC0603FR-071RL	Yageo
20	8	R7,R10,R13,R16,R19,R22,R25,R28	RES SMD 10K OHM 1% 1/10W 0603		
21	1	R11	RES SMD 200K OHM 1% 1/4W 1206		
22	30	R12,R14,R15,R17,R18,R20,R21,R29,R30,R31,R32,R33,R34,R35,R36,R37,R38,R39,R40,R41,R42,R43,R44,R45,R46,R59,R60,R61,R63,R64	RES SMD 1.07M OHM 1% 1/4W 1206		
23	4	XA1,XA2,XA3,XA4	Cree Gen 3 Isolated Gate Driver	CGD15SG00D2	Cree
24	1	XA5	Cree 50kW boost control	60kW boost control	Cree
25	1	XA6	Cree 15W Flyback Supply	CRD015DD17P	Cree
26	8	XC1,XC2,XC3,XC4,XC5,XC6,XC7,XC8	CAP FILM 2.2UF 630VDC RADIAL	B32674D6225K	EPCOS
27	2	XL1,XL2	DC COMMON MODE CHOKE	T46592	Cramer

Table 3: Bill of Materials (BOM) of Boost Power Board

Boost Control Board

Item	Qty	Reference	Description	Part	Manufacturer
1	2	CON217,CON218	CONN HEADER 6POS .100 R/A 30AU	68021-106HLF	Amphenol FCI
2	1	CON219	CONN HEADER 8POS .100 R/A 30AU	68021-108HLF	Amphenol FCI
3	2	C201,C211	CAP CER 10UF 35V X7R 1206		
4	4	C202,C203,C220,C221	CAP CER 1UF 50V X7R 0603		
5	2	C225,C226	CAP CER .1UF 50V X7R 0603		
6	2	C204,C223	CAP CER 180PF 50V X7R 0603		
7	4	C205,C206,C216,C217	CAP CER 470PF 50V X7R 0603		
8	1	C207	CAP CER 10NF 50V X7R 0603		
9	0	C208	DO NOT POPULATE		
10	3	C209,C210,C227	CAP CER 1NF 50V X7R 0603		
11	1	C224	CAP CER 4.7UF 35V X5R 0603		
12	2	R202, R243	RES SMD 88.7K OHM 1% 1/10W 0603		
13	2	R204, R244	RES SMD 174K OHM 1% 1/10W 0603		
14	2	R205, R260	RES SMD 22.1K OHM 1% 1/10W 0603		
15	2	R206,R237	RES SMD 27.4K OHM 1% 1/10W 0603		
16	2	R207, R241	RES SMD 330K OHM 1% 1/10W 0603		
17	4	R208, R209, R238, R254	RES SMD 75K OHM 1% 1/10W 0603		
18	4	R210, R211, R248, R261	RES SMD 4.7K OHM 1% 1/10W 0603		
19	12	R212-R215, R223, R224, R235, R236, R247,R250, R251, R256	RES SMD 18 OHM 1% 1/4W 1206		
20	1	R216	RES SMD 1K OHM 1% 1/10W 0603		
21	1	R217	RES SMD 2K OHM 1% 1/10W 0603		
22	2	R218, R252	RES SMD 0 OHM 1% 1/10W 0603		
23	1	R219	RES SMD 28K OHM 1% 1/10W 1206		
24	2	R220, R263	RES SMD 100K OHM 1% 1/10W 0603		
25	1	R221	RES SMD 19.6K OHM 1% 1/10W 0603		
26	1	R253	RES SMD 10K OHM 1% 1/10W 0603		
27	1	R255	RES SMD 5.6K OHM 1% 1/10W 0603		
28	1	R264	RES SMD 56K OHM 1% 1/10W 0603		
29	2	U201, U203	PWM CTRLR MULT TOP 16SOIC	UCC28220D	Texas Instruments
30	1	U202	OP-AMP 8SOIC	LM358DR	Texas Instruments
31	1	U204	IC VREF SHUNT ADJ SOT23-3	TL431AIDBZR	Texas Instruments
32	0	R222	DO NOT POPULATE		
33	1	R262	RES SMD 0 OHM 1% 1/8W 1206		

Table 4: Bill of Materials (BOM) of Boost Control Board

8. Revision History

Date	Revision	Changes
06/01/2018	-	1st Issue

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 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 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 schematic. Users should contact Cree at 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 .

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.