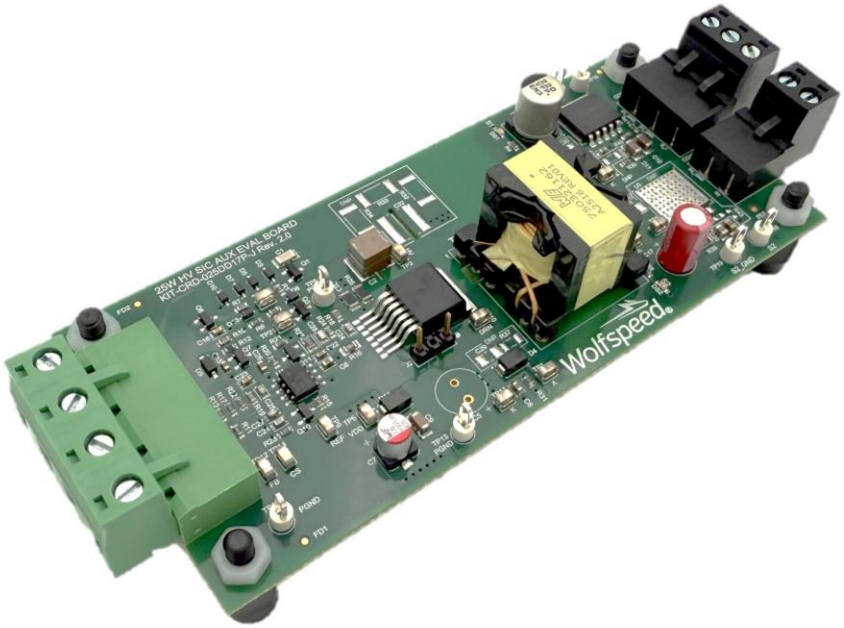
User Guide PRD-09375

KIT-CRD-025DD17P-J: 25W Auxiliary Power Flyback Evaluation Platform User Guide



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KIT-CRD-025DD17P-J: 25W Auxiliary Power Flyback Evaluation Platform User Guide

The KIT-CRD-025DD17P-J evaluation platform demonstrates the use of 1700V silicon carbide (SiC) MOSFETs in a single-switch flyback configuration and provides a flexible design that can be used to evaluate and optimize the performance of the flyback converter, SiC MOSFET, and transformer. The C3M00900170x MOSFET family utilized in this design has a wide operating gate-source voltage (Vgs) range of 12-18V, making it an easy and low-cost drop-in compatible with existing Si or SiC single-switch designs. This primary-side-regulated converter (with an auxiliary winding) eliminates the need for an opto-coupler and provides a space- and cost-optimized solution for industrial applications like solar inverters, electric vehicle charging, motor drive and HVAC applications, etc. This user guide provides an overview of KIT-CRD-025DD17P-J including key system specifications, schematics, hardware setup, and test results.

Contents

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。

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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105℃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。ハードウエアの輸送中の保護について質問があれば、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 PAGES, AS THEY CONTAIN 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，在操作板子前应使大容量电容器的电荷完全释放。接通电源后，该评估板上通常会存在危险的高电压，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，上述情况可能会短时持续，直至大容量电容器电量完全释放。

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。通电时禁止接触板子。所有测试与测量探针或附件必须在板子通电前连接。通电时，禁止使板子处于无人看护状态，且禁止操作板子。必须确保在操作板子前，大容量电容器已释放了所有电量。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 KIT-CRD-025DD17P-J platform offers a flexible and efficient solution for engineers aiming to evaluate and optimize flyback converters, SiC MOSFETs, transformers, and related components. It operates from 60VDC-1000VDC input voltage, accommodating a broad spectrum of high-voltage applications like solar inverters, electric vehicle charging, motor drives, heat pumps and air conditioning, and other energy storage systems. It has a typical regulated output of around 15V up to 25W. It also provides the user with an option to add and utilize a second secondary output.

The single-switch flyback topology shown in Figure 1 and utilized in this KIT is a primary-side-regulated converter that eliminates the need for an opto-coupler and provides a space- and cost-optimized solution. This KIT is flexible, providing the user with ample test points, an option to add and second secondary isolated output, footprints to test different clamp circuit options like the RCD or the ZD clamp, and footprints for optimizing snubber components.

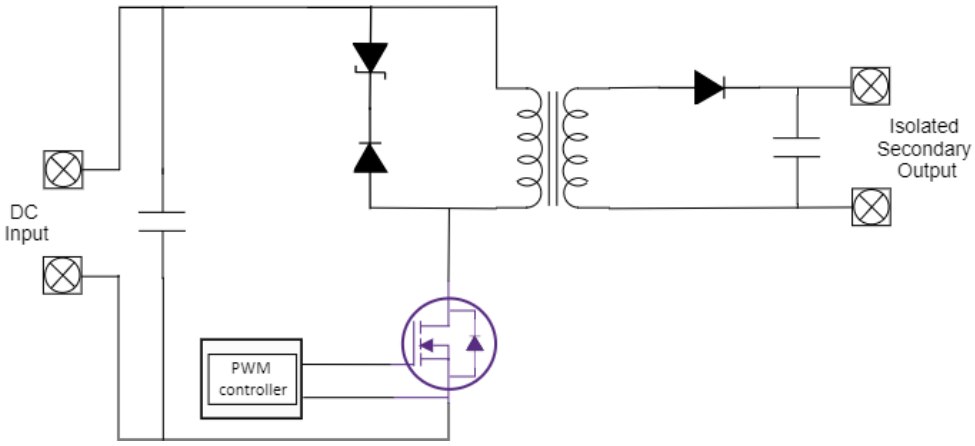


Figure 1: Single-Switch Flyback Topology

2. Description

2.1 Key Electrical Specifications

Parameter	Test Condition	Min.	Typ.	Max.	Unit
Input Voltage		60	-	1000	V
Output Voltage	No load, Vin= 1000V	-	15.1	-	V
	50% load, Vin= 1000V	-	15	-	V
	100% load, Vin= 1000V	-	14.7	-	V
Maximum Output Current	60V<Vin<100V	-	1.2*	-	A
	100V<Vin<300V	-	1.5*	-	

	300<Vin<1000V	-	1.67*	-	A
Maximum Output Power	300<Vin<1000V	-	-	25*	W
Load Regulation		-2	-	+1	%
Switching Frequency	V_{in} = 800V, I_{out} = 1.67A	-	42.5	-	kHz
Peak Efficiency	Vin= 400V, I_{out} = 1.67A		81.5		%
Full-Load Efficiency	Vin= 1000V, I_{out} = 1.67A		75.4		%
*Output power is limited by the thermals of the system. The KIT is tested at an ambient temperature of 25^{0}C. Consider appropriate derating if KIT operated at higher ambient temperatures.					

2.2 Board and Connectors Overview

Figure 2 shows the board dimensions. The board stand-offs and external input and output female connectors are not included as a part of the dimensions.

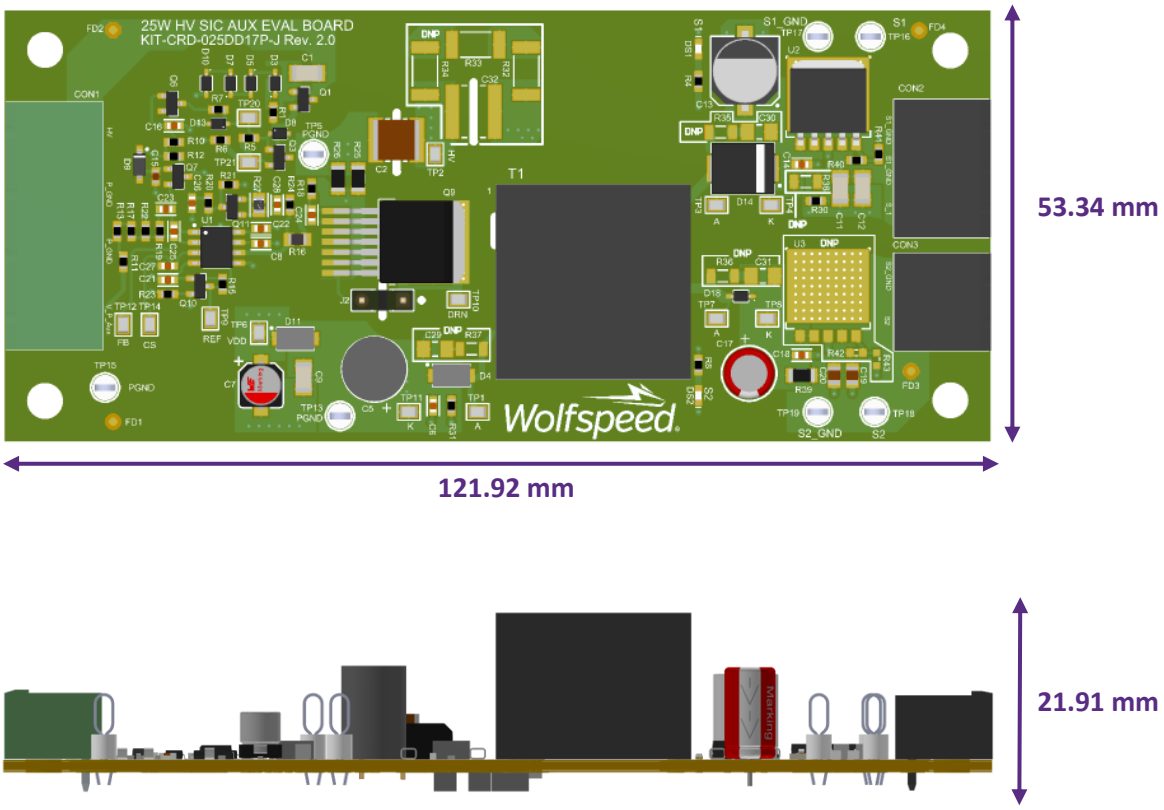


Figure 2: KIT-CRD-025DD17P-J Product Dimensions: Top view (top) and Front View (bottom)

Table 1 and figure 3 overview the main components of the KIT.

Item	Description
1	Input High-Voltage and Primary Auxiliary Voltage Connector
2	High-Voltage Start-up for VDD
3	PWM Controller and Control Circuit
4	Primary SiC Switch- C3M0900170J
5	Flyback Transformer
6	Main Secondary (1) Output Stage
7	Secondary 1 Voltage Connector
8	Optional Secondary (2) Output Stage
9	Optional Secondary 2 Voltage Connector

Table 1: KIT-CRD-025DD17P-J Board Overview Description

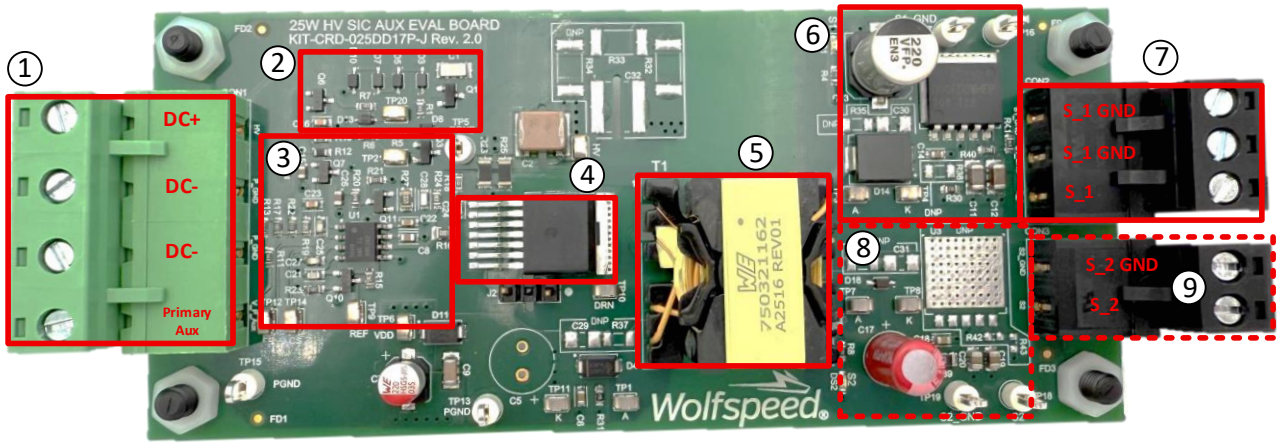


Figure 3: KIT-CRD-025DD17P-J Board Overview

3. Schematic Diagram

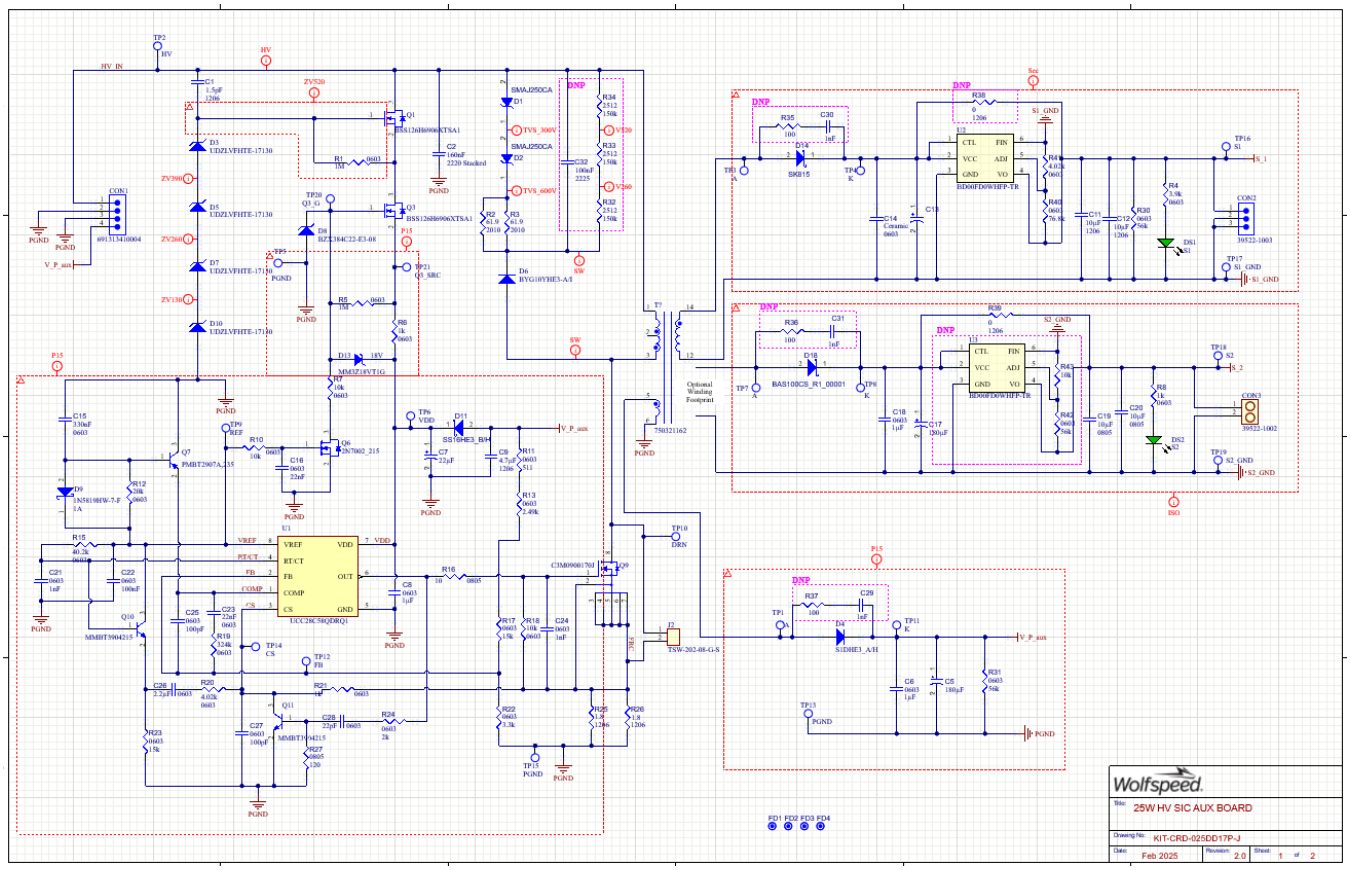


Figure 4: KIT-CRD-025DD17P-J Schematic Diagram

4. Hardware Set-up & Testing

4.1 Hardware Equipment

DC Input Source: The input source must be an adjustable DC source whose output can be adjusted up to the maximum bus voltage desired for testing. It must be capable of supplying at least 2A of current that is needed for start-up.

DC Load: A programmable electronic load or a resistor bank may be used. Both should be capable of supporting at least 20V with 0 to 2A of output current.

Power Meter: A power analyzer from Yokogawa Test and Measurement Corporation (P/N: WT 5000) or any other equivalent power analyzer can be used. The current and voltage measurement range can be set to “Auto”, so it chooses the correct resolution for measuring the low voltage and current output.

Oscilloscope: A 4-channel 500 MHz or greater oscilloscope with HV probes for the input and at least 1 differential voltage probe for the output voltage is recommended.

Thermal Camera: Optional, but useful to monitor the temperature of the KIT.

4.2 Connection Diagram

CON1 is the input high voltage male connector on the board and CON2 is the low voltage male connector for the main secondary output. KIT-CRD-025DD17P-J comes with the compatible female connectors- H11 and H10 for CON1 and CON2 respectively for a quick connection. These connectors can be used to connect to the input high-voltage supply and output load as shown in figure 5.

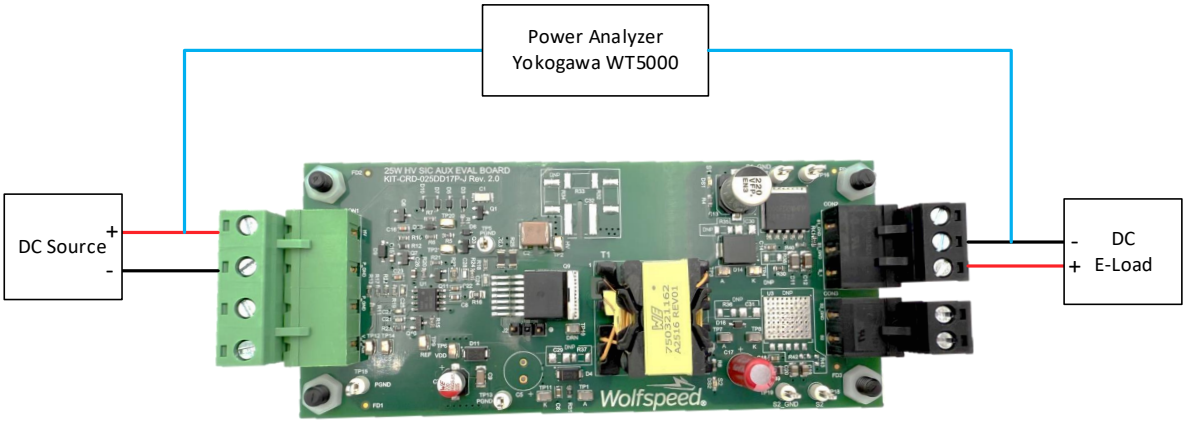


Figure 5: Connection Diagram for testing KIT-CRD-025DD17P-J

4.3 Test Points

Table 2 gives an overview of the test points on KIT-CRD-025DD17P-J.

Designator	Description	Designator	Description
J2	Primary MOSFET Q9 Drain-Source Voltage	**TP10**	DRN- Q9 MOSFET Drain (Switch Node)
TP1	Transformer Auxiliary Winding Output	**TP11**	S2 rectifier output (Optional)
TP2	HV- Input Voltage	**TP12**	FB- Inverting input to the error amplifier
TP3	Transformer S1 Winding Output	**TP14**	CS- Current Sense Pin
TP4	S1 rectifier output	**TP16**	S1- S1 Output Voltage
TP5, TP13, TP15	PGND- Primary Ground	**TP17**	S1_GND- Isolated Ground for S1
TP6	VDD- PWM Controller Bias Supply	**TP18**	S2- S2 Output Voltage (Optional)
TP7	Transformer S2 Winding Output (Optional)	**TP19**	S2_GND- Isolated Ground for S2

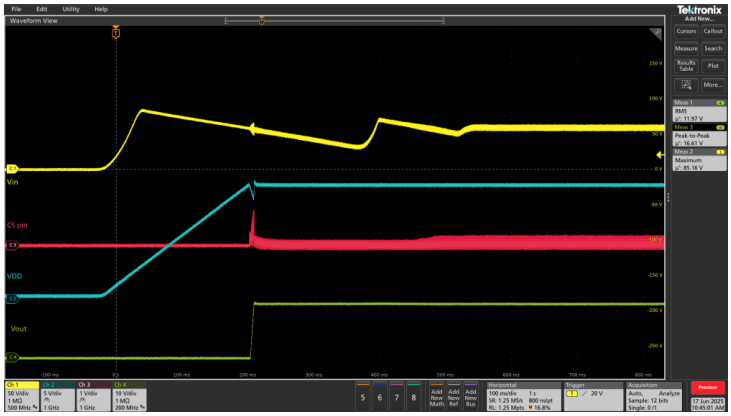
TP8	S2 rectifier output	**TP20**	Start-up MOSFET Q3 gate
TP9	VREF- Controller Reference Output	**TP21**	Start-up MOSFET Q3 source

Table 2: KIT-CRD-025DD17P-J Test Point Description

4.4 Testing the Unit

The steps below for powering on the KIT should be followed in the order in which they are listed:

- Connect the KIT as shown in figure 5. If not using a power analyzer, use digital multimeters with appropriate rating to connect to TP2 (+) and TP5 (-) for input voltage measurement and TP16 (+) and TP17(-) for isolated output voltage measurement.
- Connect a high-voltage probe to measure the input voltage and low-voltage probes to measure the VDD voltage and CS pin voltage.
- Connect a differential probe between S1 and S1_GND to measure the output voltage.
- Set the oscilloscope to single trigger on Vin rising at 30V. Set the time scale to 100ms/div.
- Set the load to 0.1A current.
- Turn-on the input voltage supply at 60V with a 2A current limit for inrush current. The scope should trigger, and the user can observe the waveform that should be like figure 6.



- *Figure 6: Start-up waveform at V_{in}=60V and I_{out} = 0.1A*

- The user can verify some test-point voltages at this time:
  - S1 (V_{out}) ≈ 15.1 V
  - VDD ≈ 16.2 V
  - VREF ≈ 5V
  - FB ≈ 2.5V
- The output current can now be increased to 1.2A. The V_{out} will decrease to approximately 14.95V.
- The above steps can be repeated at 300V input voltage with a 1.5A load current. The V_{out} will approximately be 14.88V.

- If the above steps go smoothly, the user can proceed to test the KIT at various test conditions listed in the following sections and compare the waveforms to the typical waveforms listed in Section 5.5.

5. Test Results

5.1 Load Regulation

Figure 7 shows the load regulation for KIT-CRD-025DD17P-J at different input voltages. The overall regulation stays within +1% to -2% of 15V output voltage across all load conditions.

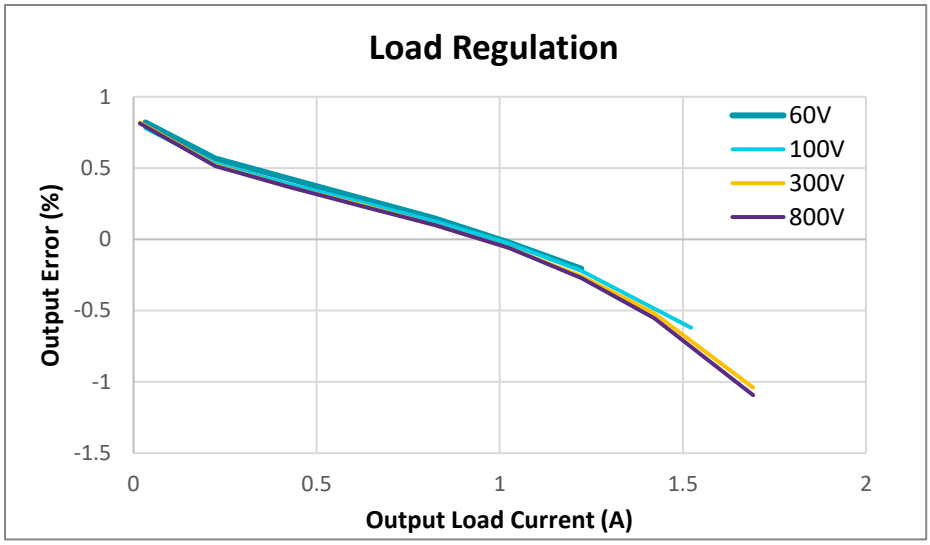


Figure 7: Load Regulation at different Input Voltages

5.2 Line Regulation

Figure 8 shows the line regulation for KIT-CRD-025DD17P-J at different output currents. The overall regulation stays within +1% to -2% of 15V output voltage across the input voltage range.

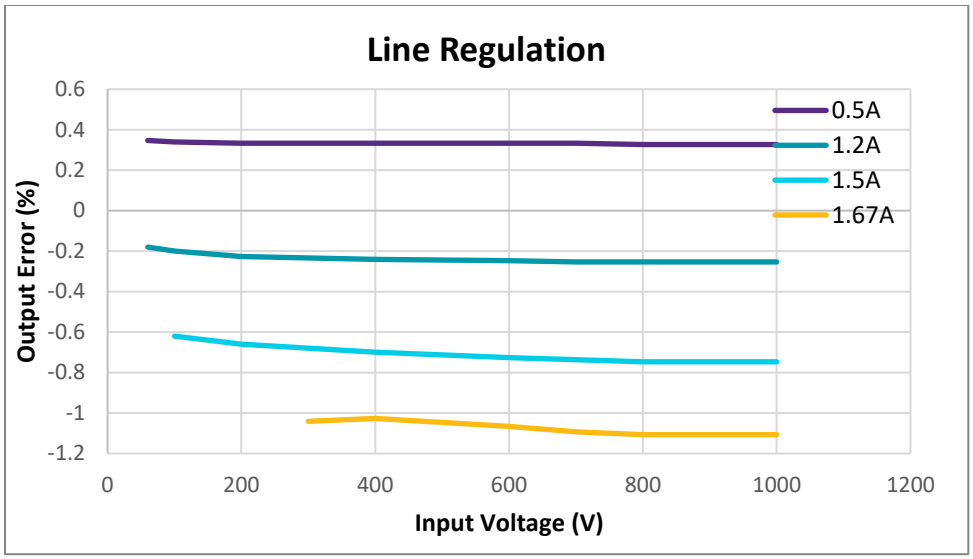


Figure 8: Line Regulation at different Output Currents

5.3 Efficiency

Figure 9 shows the efficiency curves of KIT-CRD-025DD17P-J for different input voltages. The peak efficiency of the design is greater than 80% at 300V input voltage.

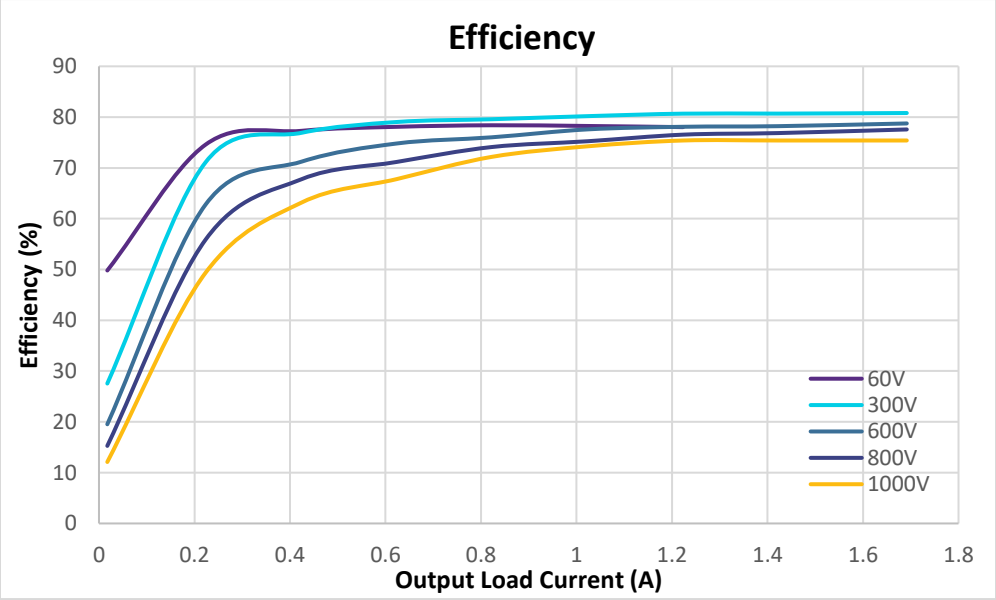


Figure 9: Efficiency vs Output Load Current at Different Input Voltages

5.4 Thermal Performance

KIT-CRD-025DD17P-J was placed in a protective enclosure for this test. This enclosure does not provide any forced air cooling. The thermal measurements were taken using a thermal camera. Figure 10 shows the thermal

image of KIT-CRD-025DD17P-J at 60V input voltage and 1.2A output current. The temperatures of the primary SiC MOSFET, transformer, and the output stage can be noted from this image. The temperature of the output rectifier is the bottleneck for maximum output power achieved.

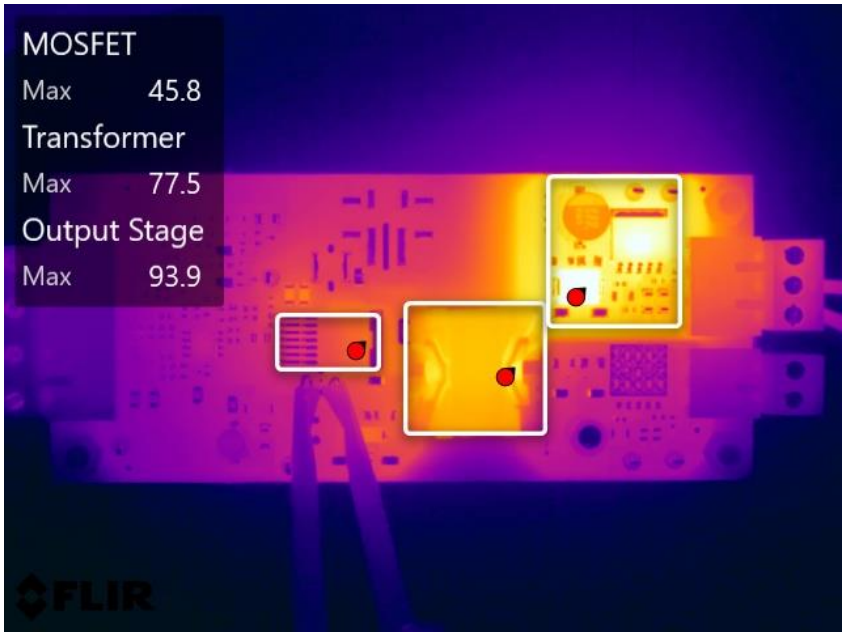


Figure 10: Thermal Image at Steady-Stage V_{in}=60V, I_{out}= 1.2A

Figure 11 shows the worst-case thermals for KIT-CRD-025DD17P-J at 1000V input voltage and 1.67A output current. The temperature of the output rectifier rises to about a 120^{0}C and the transformer is at 95^{0}C.

Figure 11: Thermal Image at Steady-Stage V_{in}=1000V, I_{out}= 1.67A

Figure 12 shows the temperature plot for the primary SiC MOSFET, transformer, and output rectifier with respect to the output current.

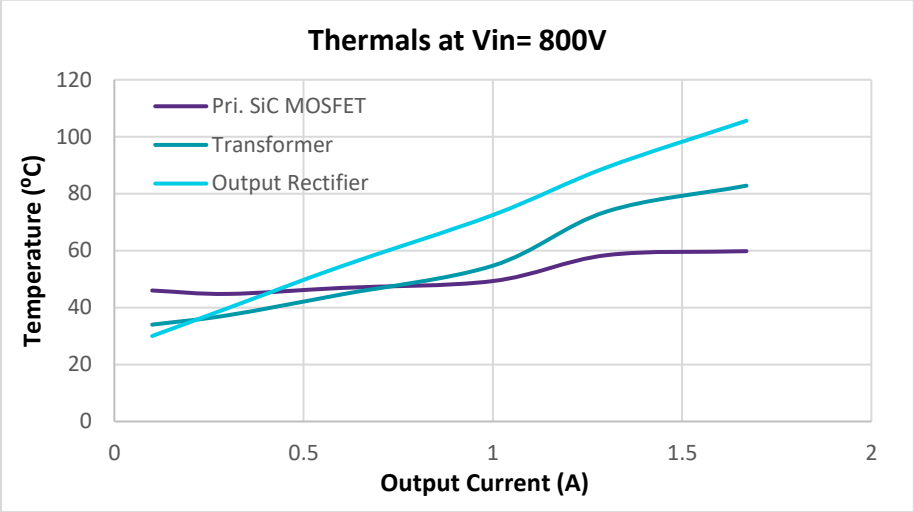
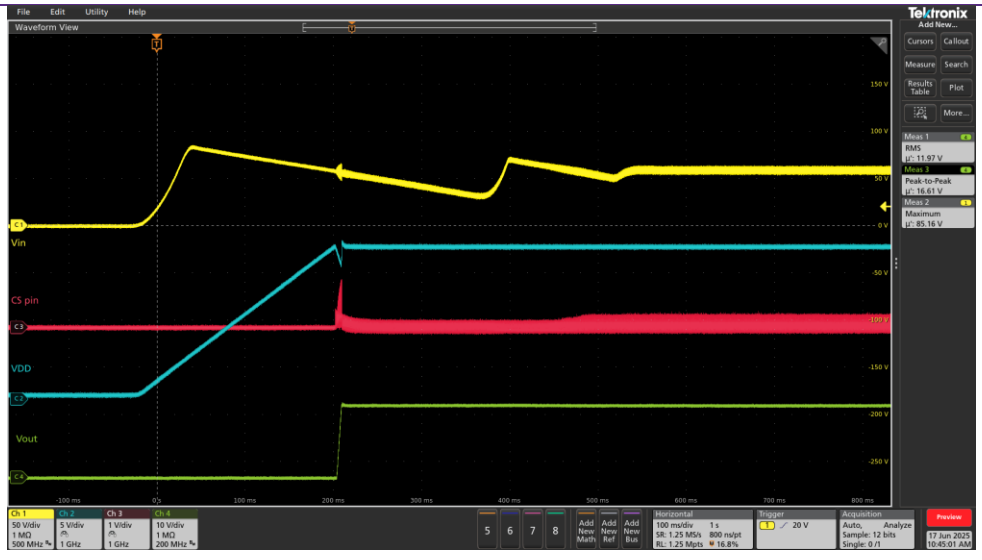
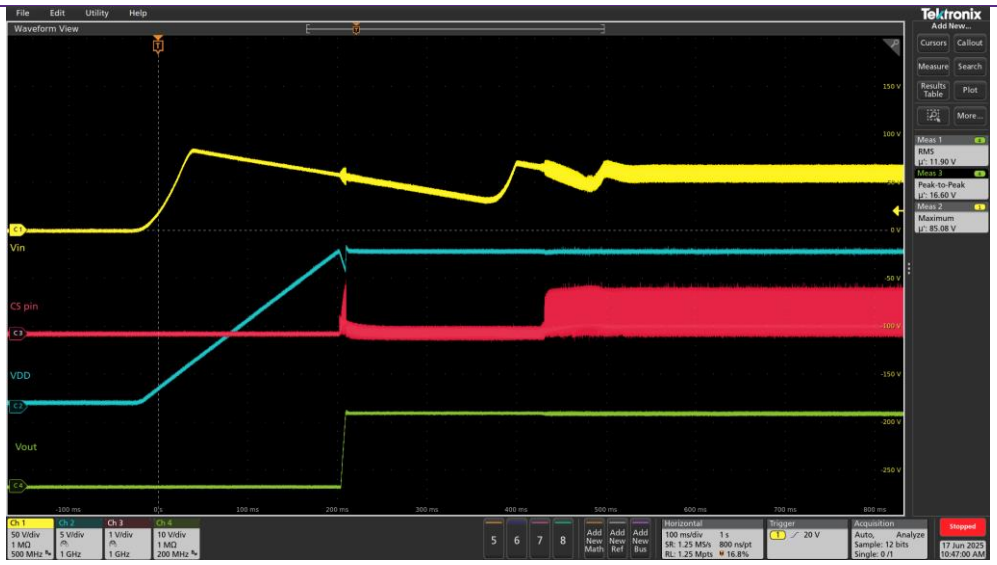
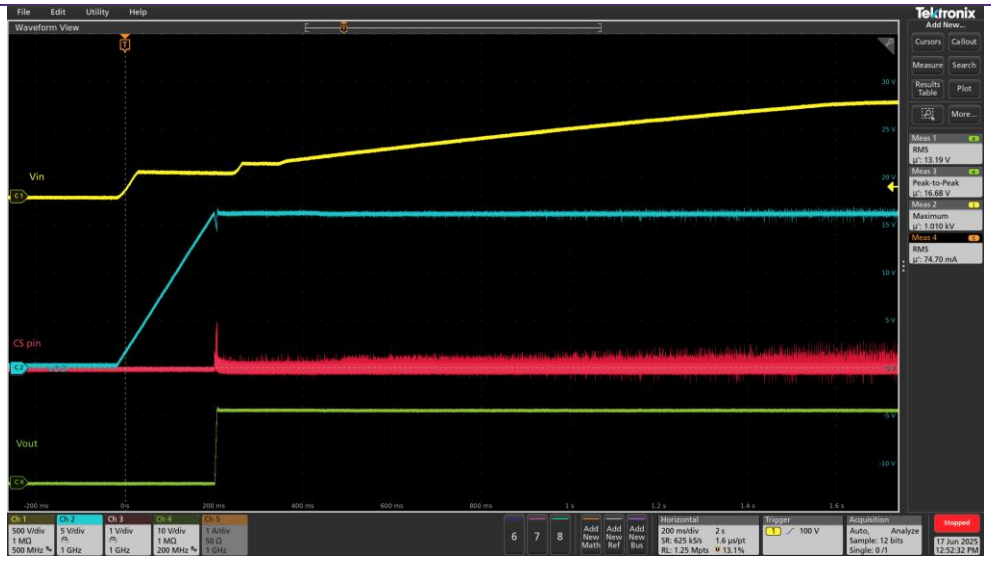
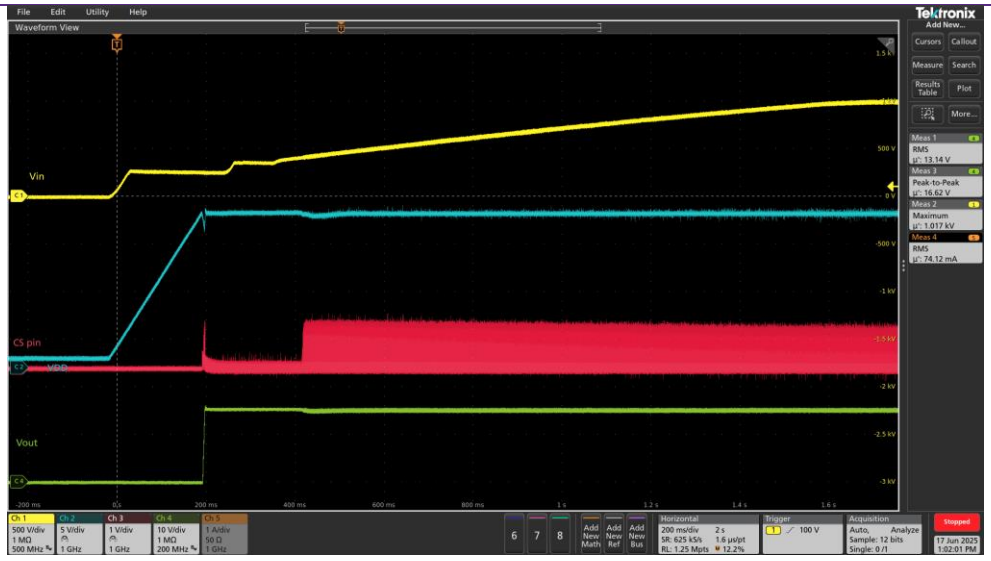


Figure 12: Component Temperature vs Output Current at V_{in} = 800V

Note: The ambient temperature for all testing is 25°C. If the user wishes to operate at higher ambient temperatures, the output power should be derated accordingly.

5.5 Typical Waveforms

Description	Waveform
Start-up Waveforms	
V_{in}= 60V, I_{out}= 0.1A CH1- Input Voltage CH2- VDD CH3- CS pin CH4- Vout	

V_{in}= 60V, I_{out}= 1.2A CH1- Input Voltage CH2- VDD CH3- CS pin CH4- Vout	
V_{in}= 1000V, I_{out}= 0.2A CH1- Input Voltage CH2- VDD CH3- CS pin CH4- Vout	
V_{in}= 1000V, I_{out}= 1.67 A CH1- Input Voltage CH2- VDD CH3- CS pin CH4- Vout	

Shut-down Waveforms

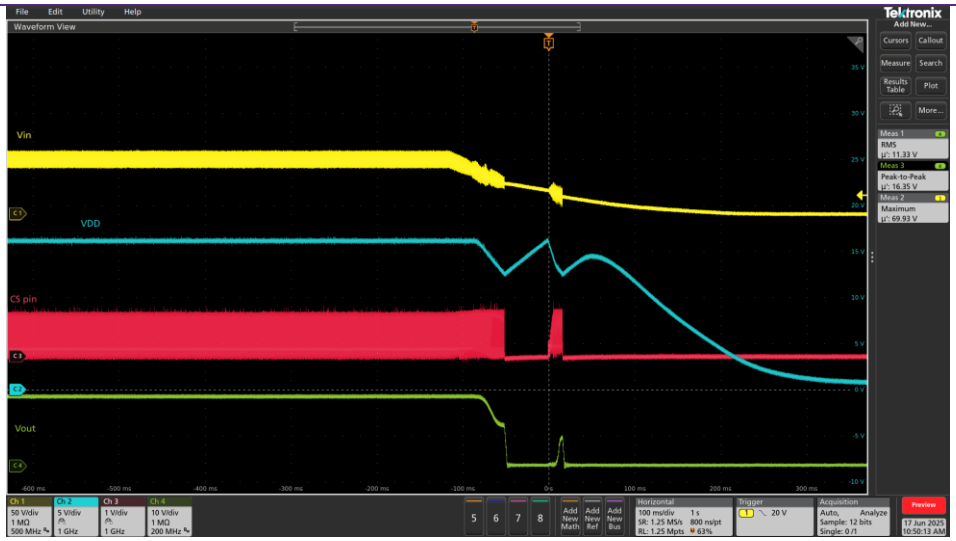
V_{in}= 60V, I_{out}= 1.2A

CH1- Input Voltage

CH2- VDD

CH3- CS pin

CH4- Vout



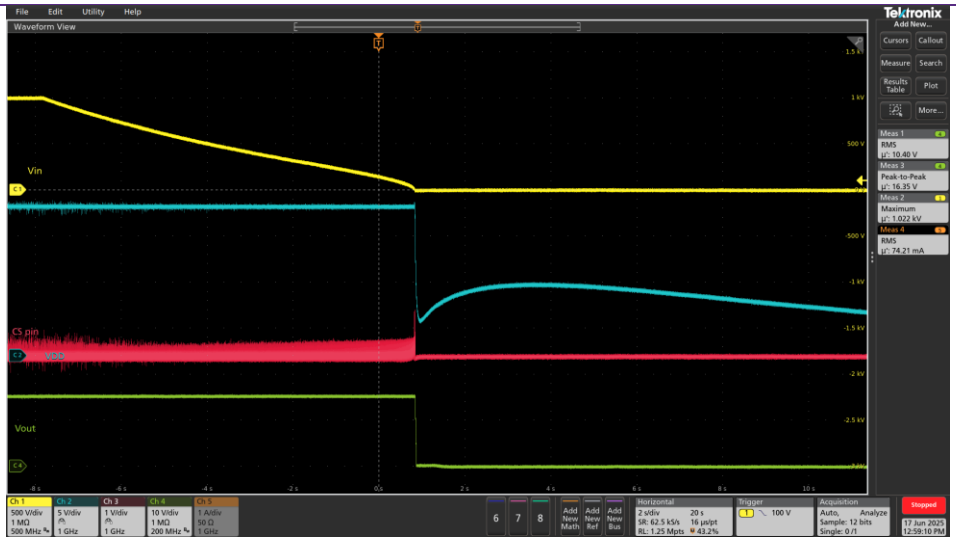
V_{in}= 1000V, I_{out}= 0.2A

CH1- Input Voltage

CH2- VDD

CH3- CS pin

CH4- Vout



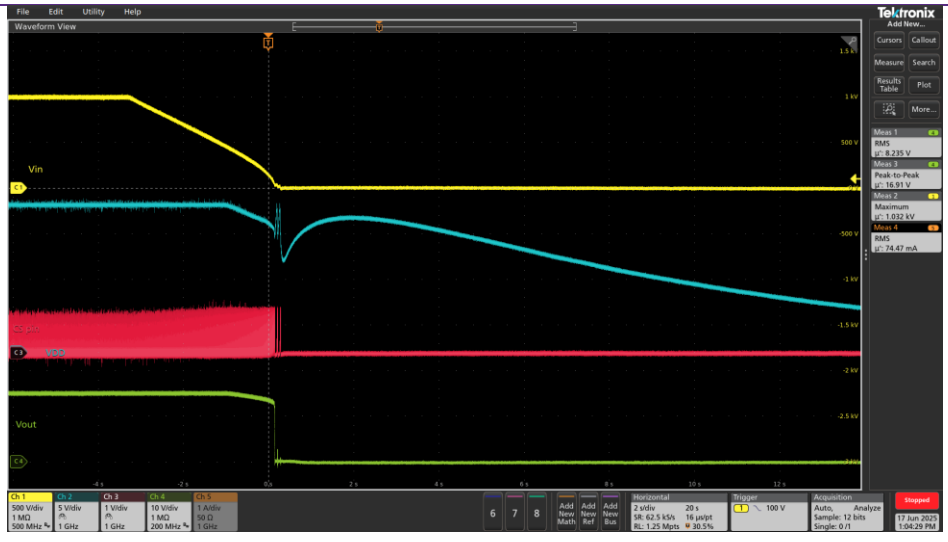
V_{in}= 1000V, I_{out}= 1.67A

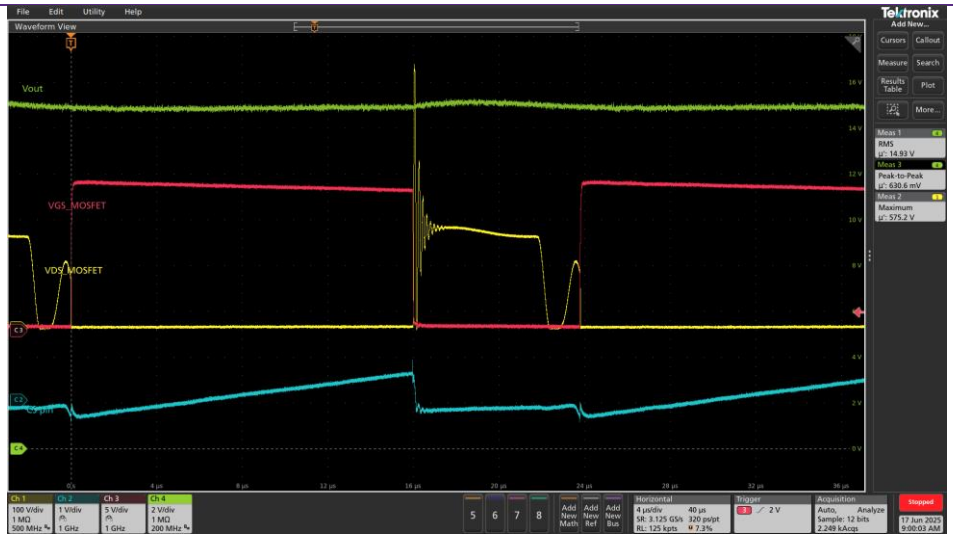
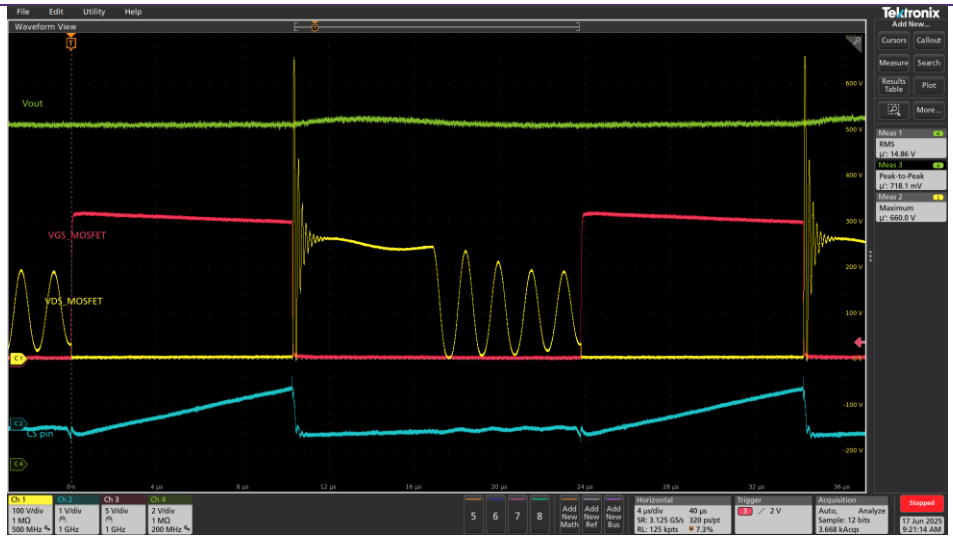
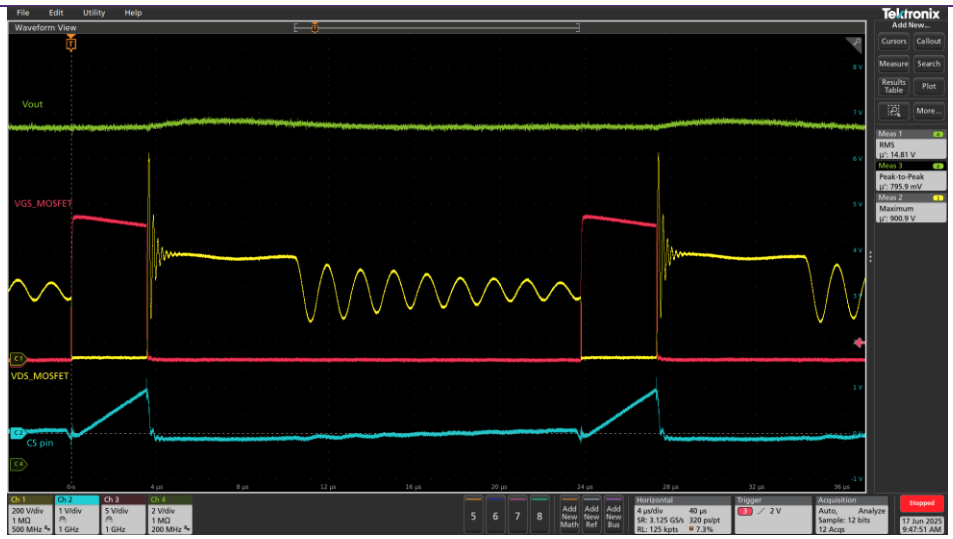
CH1- Input Voltage

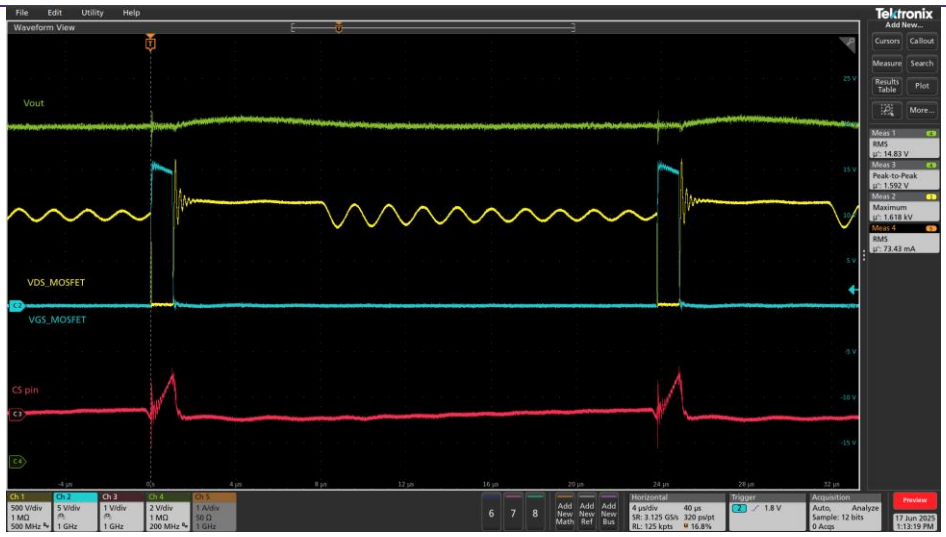
CH2- VDD

CH3- CS pin

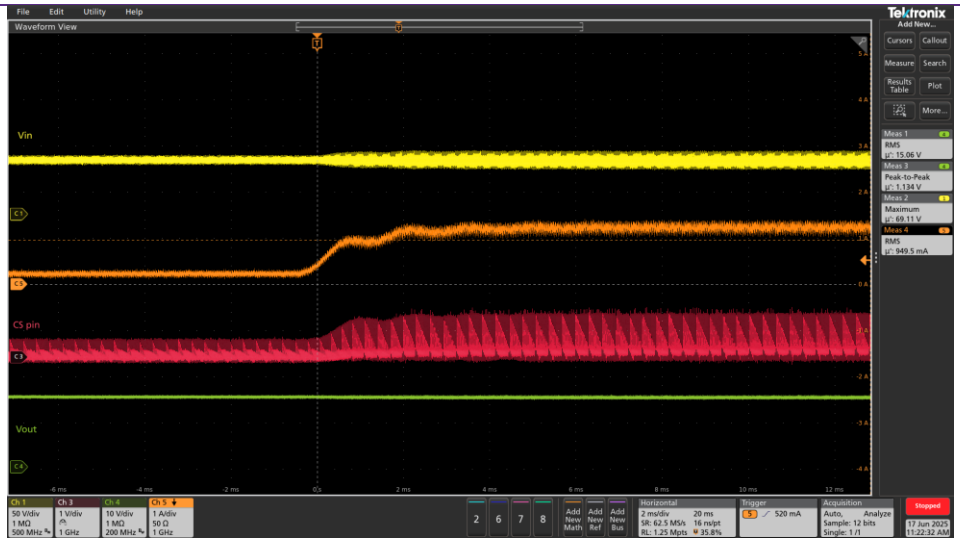
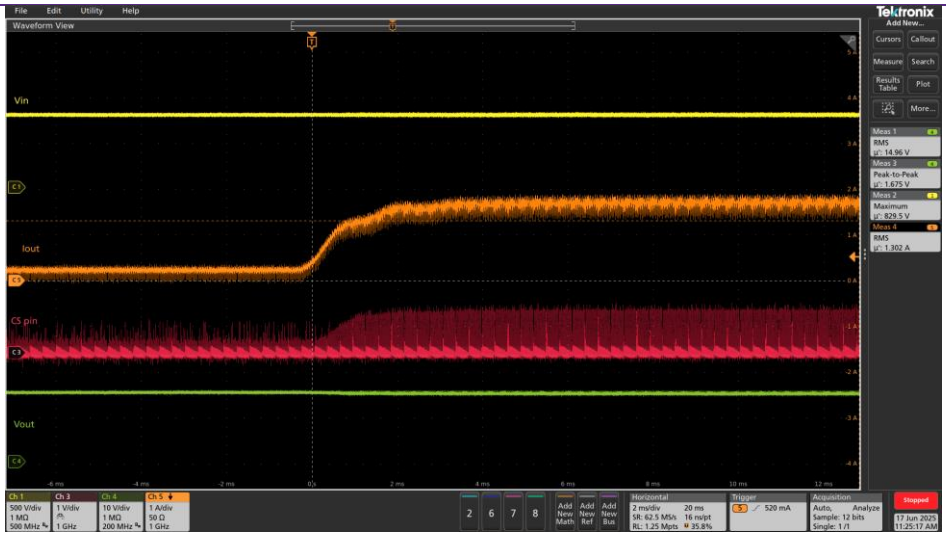
CH4- Vout



Steady-State Waveforms	
V_{in}= 60V, I_{out}= 1.2A CH1- MOSFET drain-source voltage (SW node) CH2- CS pin CH3- MOSFET gate-source voltage CH4- Vout	
V_{in}= 100V, I_{out}= 1.5A CH1- MOSFET drain-source voltage (SW node) CH2- CS pin CH3- MOSFET gate-source voltage CH4- Vout	
V_{in}= 300V, I_{out}= 1.67A CH1- MOSFET drain-source voltage (SW node) CH2- CS pin CH3- MOSFET gate-source voltage CH4- Vout	

V_{in}= 1000V, I_{out}= 1.67A CH1- MOSFET drain-source voltage (SW node) CH2- CS pin CH3- MOSFET gate-source voltage CH4- Vout	

Transient Waveforms

V_{in}= 60V, I_{out}= 0.2 to 1.2A CH1- Input Voltage CH3- CS pin CH4- Vout CH5- Output Current	
V_{in}= 800V, I_{out}= 0.2 to 1.67A CH1- Input Voltage CH3- CS pin CH4- Vout CH5- Output Current	

Revision History

Date	Revision	Changes
July 2025	1	Initial Release

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 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 schematic. Users should contact Wolfspeed 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 end 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.