AN003 – 800W LLC Converter for Server Power Supply

碳化硅MOSFET 800W 服务器电源
AZ-SiC-EVB-800W-LLC

About this document

Scope and purpose

This application note provides an overview of the evaluation board AZ-SiC-EVB-800W-LLC including its main features, key data, pin assignments and mechanical dimensions.

AZ-SiC-EVB-800W-LLC is a complete evaluation board including one half-bridge that is composed by two SiC switching devices, synchronous rectifier that is composed by multiple Si MOSFET and one ORing MOSFET. In combination with the control boards equipped with TI DSP TMS320F28379D, it features and demonstrates AZ Power's SiC MOSFETs for data center and telecom power supply applications.

The evaluation board AZ-SiC-EVB-800W-LLC was developed to support customers to speed up their product development during their initial hardware design with the SiC power devices. The used SiC power device has a rated blocking voltage of 1200 V. It is optimized for LLC resonant converters with very high switching frequency operation.

Intended audience

This application note is intended for power electronic engineers who wants to evaluate the performance of SiC devices in server power supply applications.

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1.Safety Precautions

	CAUTION: DURING THE OPERATION OF THE BOARD DO NOT TOUCH THE EVALUATION BOARD WHEN IT IS POWERED BY ANY EXTERNAL POWER SOURCE. AND NEVER LEAVE THE EVALUATION BOARD UNATTENDED. THERE MAY HAVE VERY HIGH VOLTAGE PRESENTS ON THE EVALUATION BOARD.
	CAUTION: BEFORE OPERATING THE BOARD THE EVALUATION BOARD MAY PRESENTS HIGH VOLTAGE DURING OPERATION. THE BULKY CAPACITORS WILL BE CHARGED BY EXTERNAL POWER SUPPLIES. BEFORE OPERATING THE BOARD, WAIT FOR 10 SECONDS TO ALLOW THE POWER SUPPLIES TO FULLY CHARGE ALL THE CAPACITORS AND GET THE WHOLE SYSTEM READY FOR OPERATION.
	CAUTION: AFTER POWERING DOWN THE BOARD THE EVALUATION BOARD MAY PRESENTS HIGH VOLTAGE DURING OPERATION. THE BULKY CAPACITORS WILL BE CHARGED BY EXTERNAL POWER SUPPLIES. BEFORE WORKING ON THE EVALUATION BOARD, ALLOW THE BULKY CAPACITORS DISCHARGING FOR THREE MINUTES.
	CAUTION: MEASUREMENT WHEN MEASUREMENT EQUIPMENTS ARE ABOUT TO CONNECT TO THE EVALUATION BOARD, USE HIGH-VOLTAGE DIFFERENTIAL PROBES. IF PASSIVE PROBES ARE INTENDED TO BE USED FOR MEASUREMENT, CONSULT POWER ELECTRONICS PROFESSIONALS FIRST. DO NOT CONNECT THE PROBE WHEN THE EVALUATION BOARD IS POWERED BY POWER SOURCE.
	CAUTION: CONSEQUENCES PLEASE MAKE SURE THAT ALL MENTIONED SAFTY PROCEDURES ARE FOLLOWED WHEN USING THE EVALUATION BOARD. FAILED TO FOLLOW THE INSTRUCTIONS MAY LEAD TO: • DEATH • HEAT BURN • SERIES INJURY • ELECTROCUTION • ELECTRICAL SHOCK • ELECTRICAL BURN

2.Introduction

The AZ-SiC-EVB-800W-LLC evaluation board is designed for the data center and telecom power supply application, based on LLC resonant converter topology.

The LLC resonant converter board is intended for use with a various of control boards. This evaluation board can be easily interfaced to control board via interface pin connectors.

This evaluation board is designed as an easy-to-use power stage based on AZ Power's Silicon Carbide power devices. The evaluation board includes a main power connector for connecting the high voltage DC bus, a main power connector for connecting the low voltage DC output, EMI filter, bulky capacitors and LLC resonant converter power stage. The power stage also contains isolated current and voltage sensing circuits.

The AZ-SiC-EVB-800W-LLC evaluation board is available via regular AZ Power distribution partners as well as on AZ Power's website. The features of this board are described in the design feature chapter of this document. The remaining paragraphs provide information enabling customers to copy, modify and qualify the design for production according to their own specific requirements.

Environmental conditions were considered in the design of the AZ-SiC-EVB-800W-LLC. The design was tested as described in this document, but not qualified in terms of safety requirements, manufacturing and operation over the entire operating temperature range or lifetime. The boards provided by AZ Power are subject to functional testing only.

Evaluation boards are not subject to the same procedures as regular products regarding returned material analysis, process change notification and product discontinuation. Evaluation boards are intended to be used under laboratory conditions and by trained specialists only.

The block diagram of the AZ-SiC-EVB-800W-LLC is depicted in Figure 1. This evaluation board includes EMI filters, a series of auxiliary power supply to provide 12V, 5V and 3.3V, a series of voltage sensing and current sensing circuits and the LLC resonant converter composed by silicon carbide and silicon power semiconductors. All the important control signals can be measured and observed via test points on the evaluation board. The hardware circuit relative to overcurrent protection can be implemented through programming the control board.

The signal processing circuitry of the evaluation board is fully isolated from the power circuitry by using isolated power supplies, isolated ICs and optocouplers. The design can be easily upgraded to a circuitry safe electrical insulation by replacing the present MOSFET drivers and the auxiliary power supplies that meets the safety requirement.

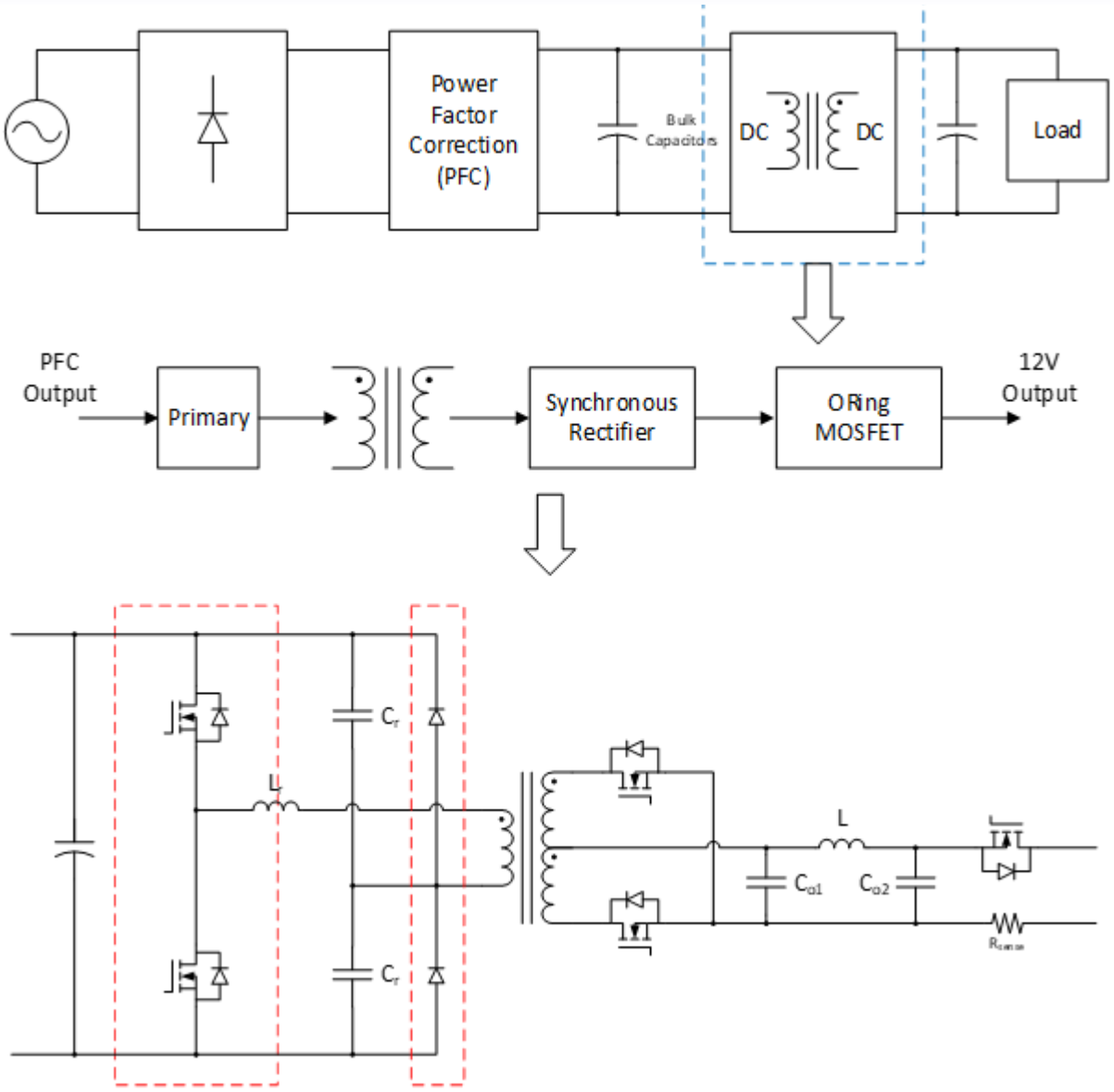

Figure 1. The schematic of the AZ-SiC-EVB-800W-LLC evaluation board

3.Design features

AZ-SiC-EVB-800W-LLC is an evaluation board for server power supply applications, which is composed of both silicon and silicon carbide power devices. By connecting to an appropriate control board that has compatible interface, it demonstrates AZ Power's silicon carbide power device technology.

Main features of the used power device from AZ Power:

- 1200 V SiC device with TO-220 package
- Lead-free terminal plating; RoHS compliant
- High reliability

The features of the evaluation board:

- High DC voltage input
- Nominal 800W DC power output
- Resonant operation
- On-board EMI filter
- Insulation between power circuitry and signal circuitry
- Isolated current sensing with current sense transformer
- Non-Isolated voltage and current sensing on the secondary side
- Over current protection through sensing resonant current and output current
- Auxiliary power needs to be provided separately in addition to the main AC power
- Measurement test points compatible with standard oscilloscope probes
- RoHS compliant
- Higher than 95% efficiency at full load

3.1. Detailed Specifications of The Evaluation Board

Parameters	Values	Comments
Input		
Input Voltage	390 VDC ~ 410 VDC	PFC output voltage
Output		
Nominal Output DC Voltage	12 VDC	Less than 5% voltage ripple
Nominal Output Current	66 A	
Nominal Output Power	800 W	Ta=25°C, forced air cooling
Switching Frequency		
Nominal Switching Frequency f_{nom}	150 kHz	
Maximum Switching Frequency f_{max}	200 kHz	
Current Feedback		
Analog Signal to DSP (Primary)	100 mV/A	Use current sense transformer
Analog Signal to DSP (Secondary)	20 mV/A	Based on paralleled 1mOhm shunt
DC-Link Voltage Feedback		
Analog Signal to DSP (Before ORing)	100 mV/V	
Analog Signal to DSP (After ORing)	100 mV/V	
On Board Power Supply		
12V	±5%	Used for cooling fans
5V	±5%	Used for analog circuits
3.3V	±2%	Used for analog circuits
System Environment		
Ambient Temperature	From 0 to 50°C	
PCB Information		
Material	FR4	
Dimension	TBA	

3.2. Functional Groups

The next two figures illustrate the functional groups on the top and bottom side of the evaluation board. And a third figure shows the side view of the evaluation board. The functional groups are explained in Table 1.

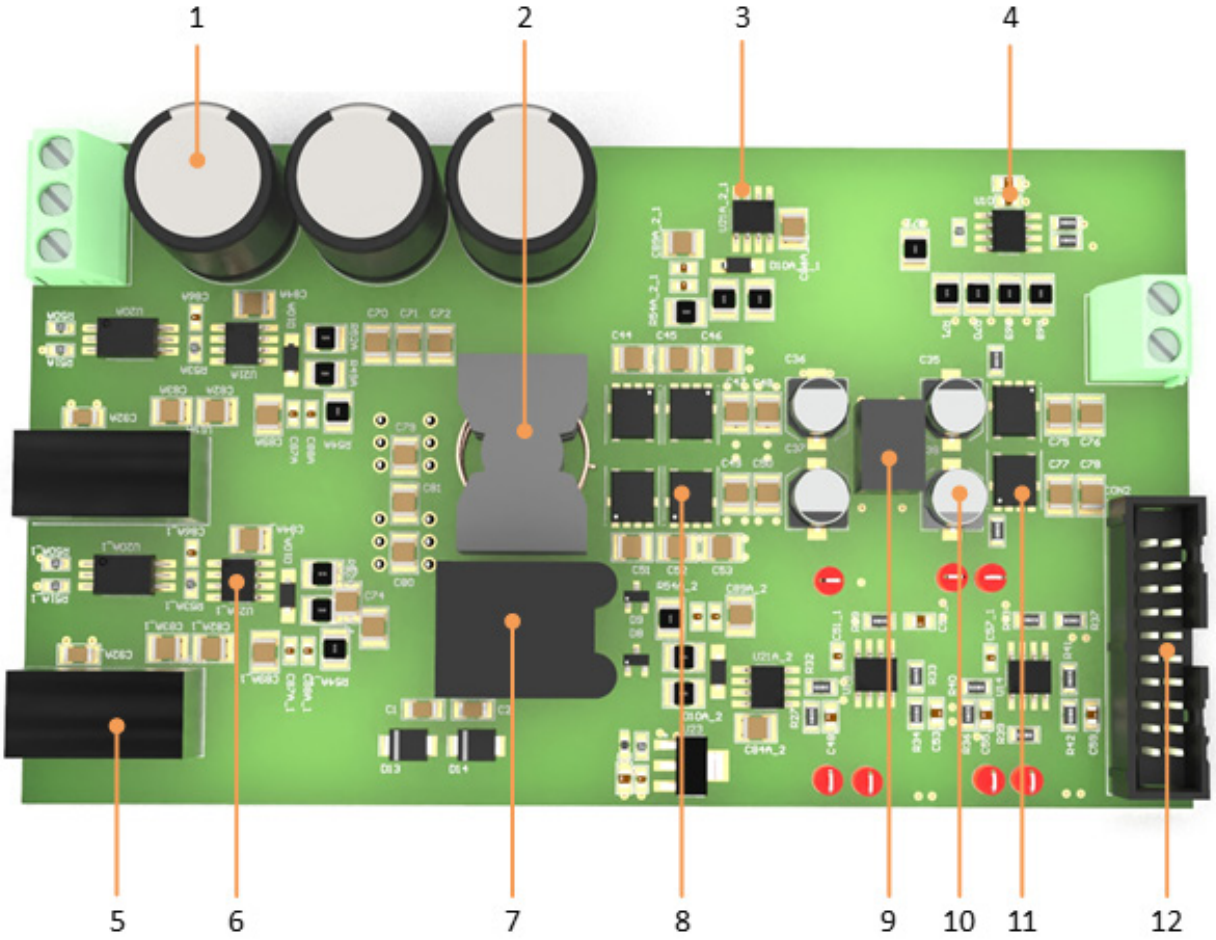

Figure 2. The top view of the AZ-SiC-EVB-800W-LLC evaluation board

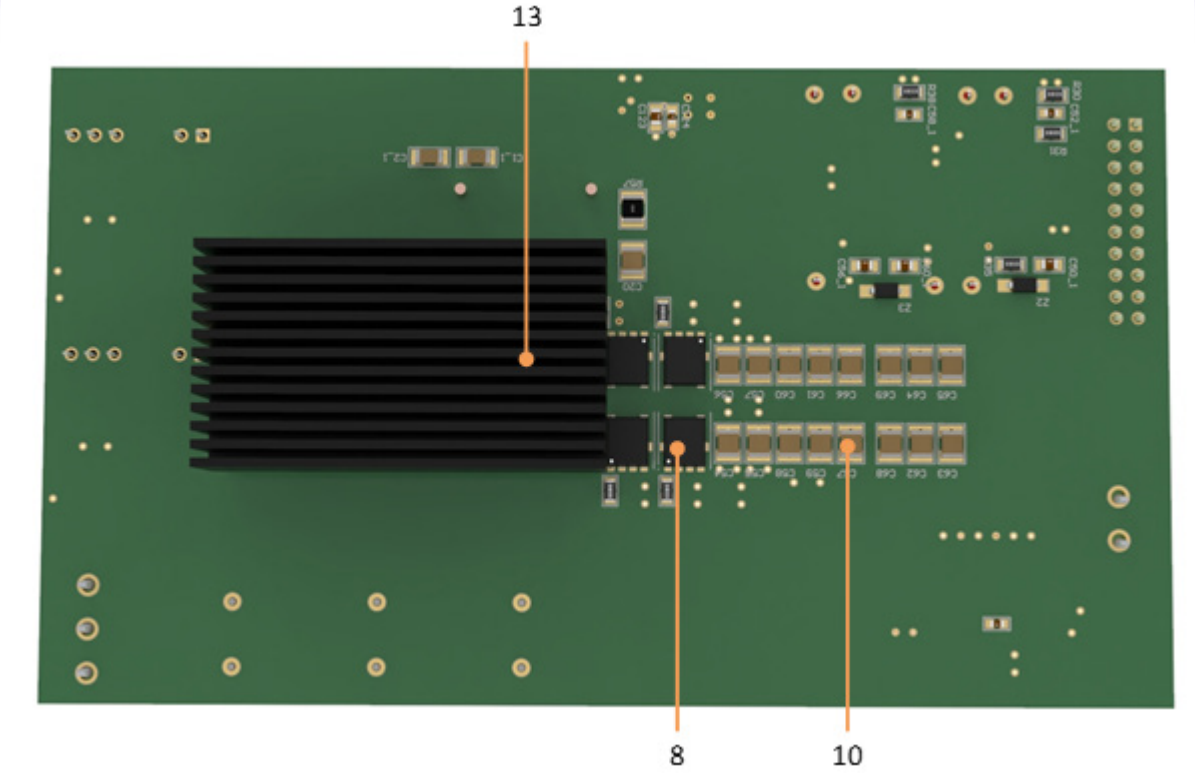

Figure 3. The bottom view of the AZ-SiC-EVB-800W-LLC evaluation board

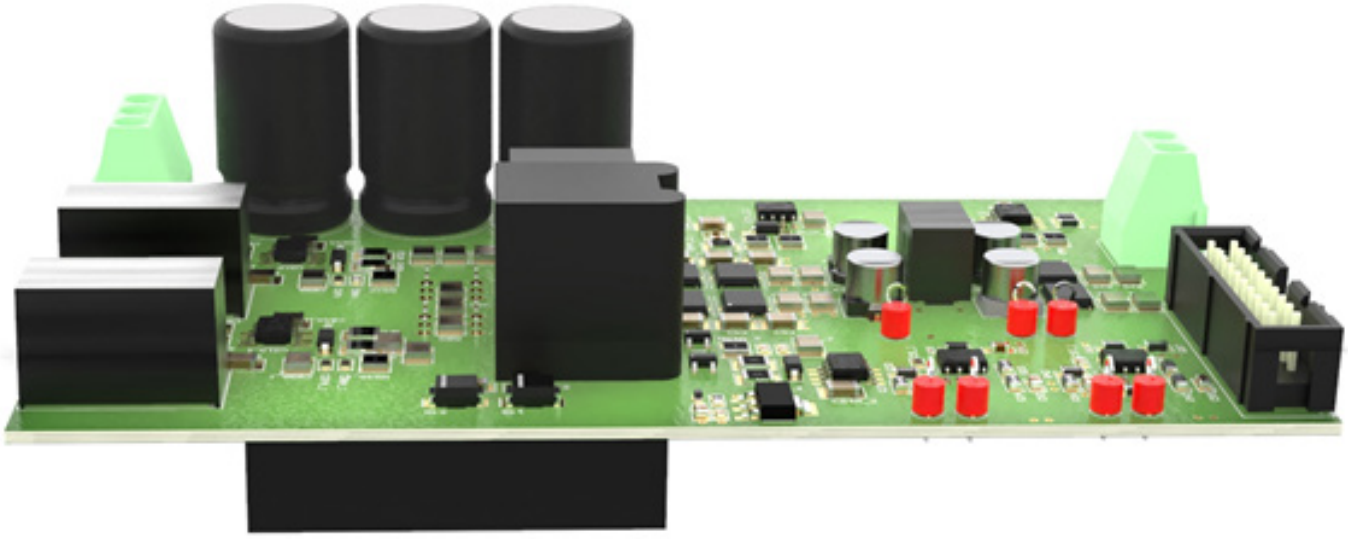

Figure 4. The side view of the AZ-SiC-EVB-800W-LLC evaluation board

Table 1. Functional Groups of The Evaluation Board

Number	Functional Group
1	Input DC-link capacitors
2	Resonant inductor and transformer
3	Secondary side gate driver
4	Signal conditioning circuitry for sensed signals
5	Isolated power supplies for gate driving circuitry
6	Primary side gate driver
7	Resonant current sensing circuitry
8	Synchronous rectifier
9	Output filter
10	Output DC-link capacitors
11	ORing MOSFETs
12	Control board interface
13	Heatsinks

3.3. Power Interface Pin Assignment

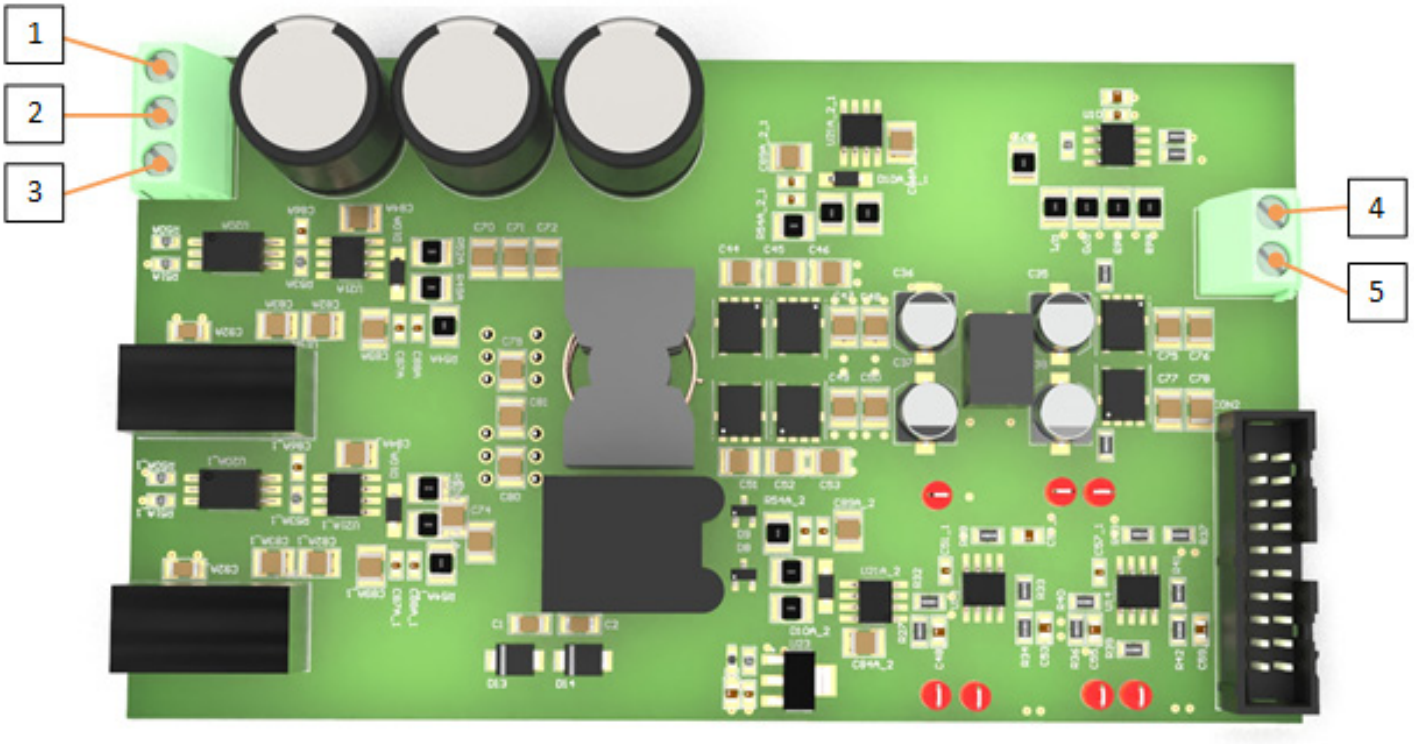

Figure 5. The power interface of the AZ-SiC-EVB-800W-LLC evaluation board

Number	Pin	Comments
1	Input_VDC+	DC voltage input postive
2	Input_VDC-	DC voltage input negative
3	Earth	Earth ground
4	Output_VDC+	DC voltage positive output
5	Output_VDC-	DC voltage negative output

3.4. Sensing for Closed-loop Control

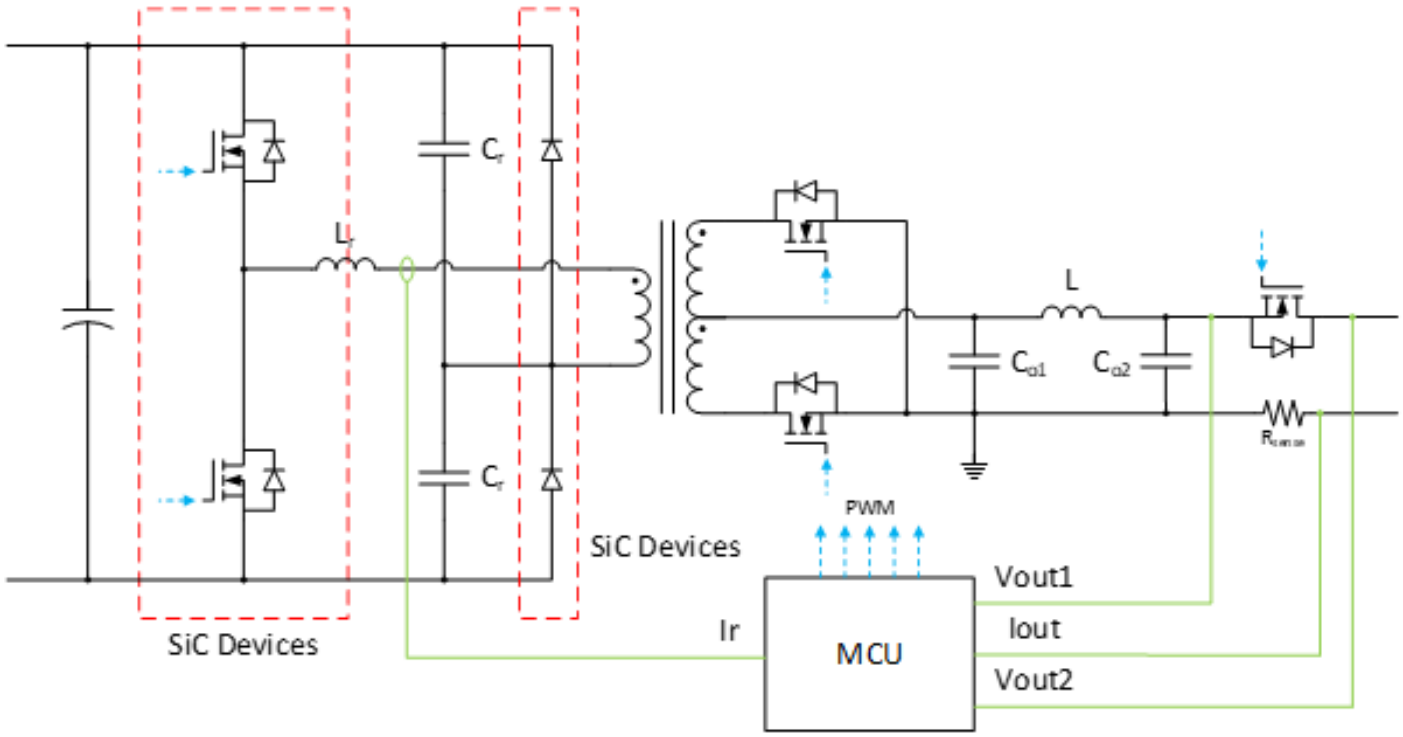

Figure 6. The sensed signals on AZ-SiC-EVB-800W-LLC evaluation board

4. Revision History

Major changes since last revision

Document version	Description of Change
1.0	Initial Version