SiC MOSFET (TOLL Package)
Half-bridge Board

Reference Guide

RD262-RGUIDE-01

Toshiba Electronic Devices & Storage Corporation

Table of Contents

1. Introduction

This reference guide describes the specifications, usage, and characteristics of the SiC MOSFET (TOLL package) Half-bridge Board (hereafter referred to as “this design”).

This design is a half-bridge board equipped with two SiC MOSFETs. Two types of boards were developed, each mounting 650V SiC MOSFETs. As shown in Fig. 1.1, this design can be connected to the Power Daughter Card Interface (board socket) of the Half-Bridge Motherboard of the SpeedVal Kit™ provided by Wolfspeed. By inserting this design into the Half-Bridge Motherboard, evaluation of our latest SiC MOSFETs can be performed conveniently. In this design, characteristic evaluation was conducted using a boost DC-DC converter configuration assuming PFC applications.

In this design, the same device is mounted on both the high-side and low-side positions for each of the TW027U65C and TW048U65C boards. By replacing the board, SiC MOSFETs with different specifications can be evaluated under the same evaluation conditions.

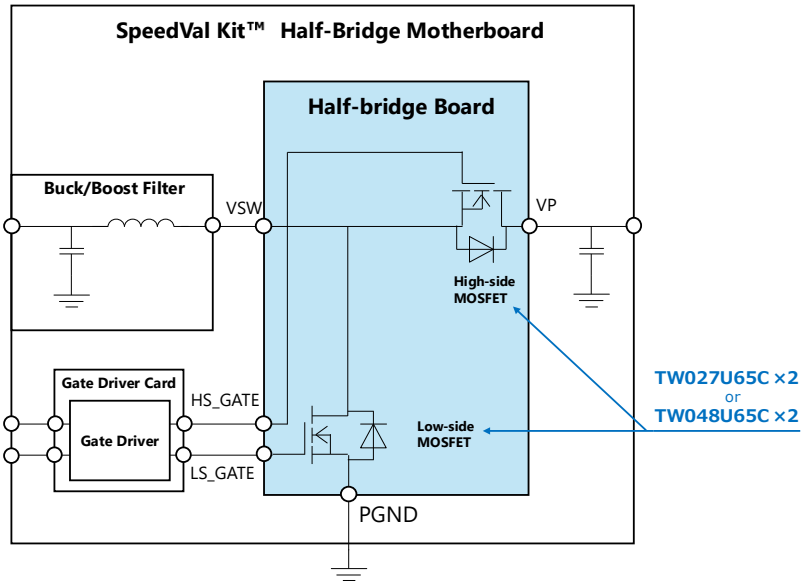


Fig. 1.1 Example of Usage of This Design

2. Specifications

2.1. Mounted Device Specifications

Tables 2.1 and 2.2 show the devices used in this design. For each half-bridge board, the same device is mounted on both the high-side and low-side positions.

Table 2.1 Devices Used in This Design (Absolute Maximum Ratings)

Characteristics	Symbol	Rating		Unit
		TW027U65C	TW048U65C	
Drain-Source voltage	V_{DSS}	650	650	V
Gate-Source voltage	V_{GSS}	+25/-2.5	+25/-2.5	V
Drain current	I_D	57	39	A
Power Dissipation	P_D	156	132	W

Table 2.2 Devices Used in This Design (Electrical Characteristics)

Characteristics	Symbol	Value		Unit
		TW027U65C	TW048U65C	
Gate threshold voltage (Max)	V_{th}	5	5	V
Gate threshold voltage (Min)	V_{th}	3	3	V
Drain-Source on-resistance (Typ.)	$R_{DS(ON)}$	27	48	mΩ
Input capacitance (Typ.)	C_{iss}	2288	1362	pF
Total gate charge (Typ.)	Q_g	65	41	nC

2.2. Block Diagram

Fig. 2.1 shows a simplified functional block diagram.

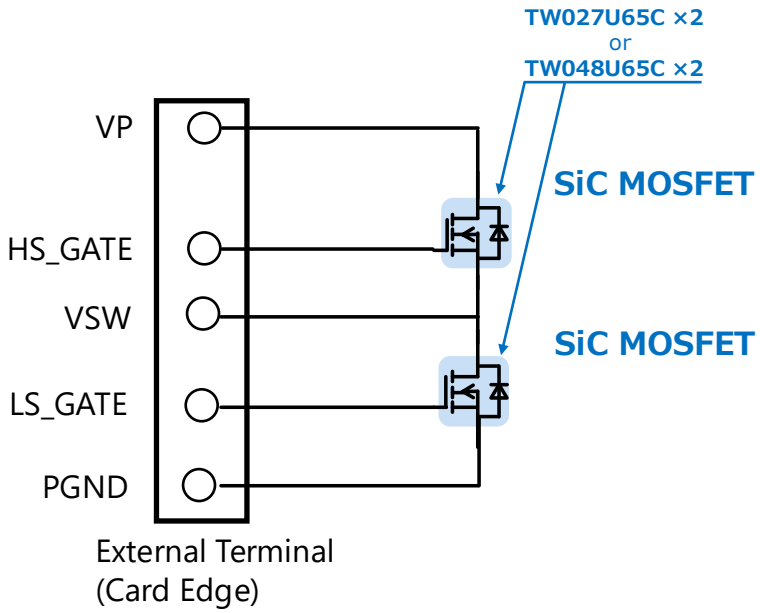


Fig. 2.1 Block Diagram

2.3. Board Specifications

Fig. 2.2 shows the external appearance of this design, and Table 2.3 lists the board specifications. The area outlined in red indicates the card edge, which can be connected to the Power Daughter Card Interface (board socket) of the Half-Bridge Motherboard of the SpeedVal Kit™. The pin assignment of the card edge is shown in Table 2.4.

Fig. 2.2 External View of This Design

External dimensions: 110 × 65 × 30mm
(including back-side heat sink)

Table 2.3 Board Specifications

Board Name	TW027U65C-Mounted Board	TW048U65C-Mounted Board
Mounted Device	TW027U65C	TW048U65C
Substrate Structure	FR-4, 4-Layers (through-hole via), t1.6mm Cu Thickness 155µm (outer layers), 140µm (inner layers)	
Functions	Miller Clamp (High-Side / Low-Side) Thermistor for Board Temperature Measurement	

Table 2.4 Card Edge Pin Assignment

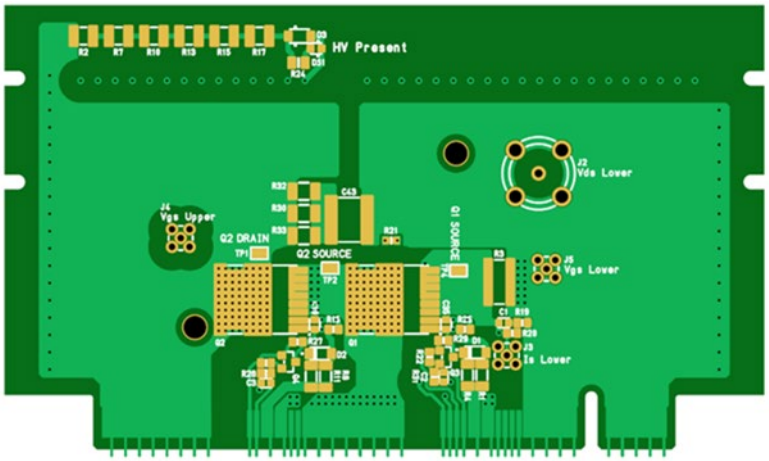
Pin	Signal	Type	Examples of Use	Pin	Signal	Type	Examples of Use
A1	-	-	-	B1	-	-	-
A2	PGND	PWR	Ground	B2	VP	PWR	High-side drain
A3	PGND	PWR	Ground	B3	VP	PWR	High-side drain
A4	PGND	PWR	Ground	B4	VP	PWR	High-side drain
A5	PGND	PWR	Ground	B5	VP	PWR	High-side drain
A6	PGND	PWR	Ground	B6	VP	PWR	High-side drain
A7	PGND	PWR	Ground	B7	VP	PWR	High-side drain
A8	PGND	PWR	Ground	B8	VP	PWR	High-side drain
A9	PGND	PWR	Ground	B9	VP	PWR	High-side drain
A10	PGND	PWR	Ground	B10	VP	PWR	High-side drain
A11	-	-	-	B11	-	-	-
A12	-	-	-	B12	-	-	-
A13	PGND	PWR	Ground	B13	VP	PWR	High-side drain
A14	PGND	PWR	Ground	B14	VP	PWR	High-side drain
A15	PGND	PWR	Ground	B15	VP	PWR	High-side drain
A16	PGND	PWR	Ground	B16	VP	PWR	High-side drain
A17	PGND	PWR	Ground	B17	VP	PWR	High-side drain
A18	PGND	PWR	Ground	B18	VP	PWR	High-side drain
A19	PGND	PWR	Ground	B19	VP	PWR	High-side drain
A20	PGND	PWR	Ground	B20	VP	PWR	High-side drain
A21	-	-	-	B21	-	-	-
A22	-	-	-	B22	-	-	-
A23	-	-	-	B23	-	-	-
A24	-	-	-	B24	-	-	-
A25	LS_SOURCE	PWR	Low-side source	B25	-	-	-
A26	LS_SOURCE	PWR	Low-side source	B26	-	-	-
A27	LS_GATE	Input	Low-side source gate input	B27	-	-	-
A28	LS_GATE	Input	Low-side source gate input	B28	-	-	-
A29	LS_MNR_CLMP_VSS	PWR	Low-side mirror clamp MOSFET source	B29	-	-	-
A30	LS_MLR_CLMP_GATE	Input	Low-side mirror clamp MOSFET gate	B30	-	-	-
A31	NTC_2	I/O	Connect to thermistor	B31	-	-	-
A32	NTC_1	I/O	Connect to thermistor	B32	-	-	-
A33	-	-	-	B33	-	-	-
A34	-	-	-	B34	-	-	-
A35	-	-	-	B35	VSW	PWR	Half-bridge midpoint
A36	-	-	-	B36	VSW	PWR	Half-bridge midpoint
A37	-	-	-	B37	VSW	PWR	Half-bridge midpoint
A38	VSW	PWR	Half-bridge midpoint	B38	VSW	PWR	Half-bridge midpoint
A39	VSW	PWR	Half-bridge midpoint	B39	VSW	PWR	Half-bridge midpoint
A40	VSW	PWR	Half-bridge midpoint	B40	VSW	PWR	Half-bridge midpoint
A41	VSW	PWR	Half-bridge midpoint	B41	VSW	PWR	Half-bridge midpoint
A42	VSW	PWR	Half-bridge midpoint	B42	VSW	PWR	Half-bridge midpoint
A43	VSW	PWR	Half-bridge midpoint	B43	VSW	PWR	Half-bridge midpoint
A44	VSW	PWR	Half-bridge midpoint	B44	VSW	PWR	Half-bridge midpoint
A45	VSW	PWR	Half-bridge midpoint	B45	VSW	PWR	Half-bridge midpoint
A46	VSW	PWR	Half-bridge midpoint	B46	VSW	PWR	Half-bridge midpoint
A47	VSW	PWR	Half-bridge midpoint	B47	VSW	PWR	Half-bridge midpoint
A48	VSW	PWR	Half-bridge midpoint	B48	VSW	PWR	Half-bridge midpoint
A49	VSW	PWR	Half-bridge midpoint	B49	VSW	PWR	Half-bridge midpoint
A50	VSW	PWR	Half-bridge midpoint	B50	VSW	PWR	Half-bridge midpoint
A51	VSW	PWR	Half-bridge midpoint	B51	VSW	PWR	Half-bridge midpoint
A52	VSW	PWR	Half-bridge midpoint	B52	VSW	PWR	Half-bridge midpoint

Table2.4 Card Edge Pin Assignment (continued)

Pin	Signal	Type	Examples of Use	Pin	Signal	Type	Examples of Use
A53	-	-	-	B53	-	-	-
A54	-	-	-	B54	-	-	-
A55	HS_SOURCE	PWR	High-side source	B55	-	-	-
A56	HS_SOURCE	PWR	High-side source	B56	-	-	-
A57	HS_GATE	Input	High-side source gate input	B57	-	-	-
A58	HS_GATE	Input	High-side source gate input	B58	-	-	-
A59	HS_MLR_CLMP_VSS	PWR	High-side mirror clamp MOSFET source	B59	-	-	-
A60	HS_MLR_CLMP_GATE	Input	High-side mirror clamp MOSFET gate	B60	-	-	-
A61	-	-	-	B61	-	-	-
A62	-	-	-	B62	-	-	-
A63	-	-	-	B63	-	-	-
A64	-	-	-	B64	-	-	-
A65	-	-	-	B65	-	-	-
A66	VP	PWR	High-side drain	B66	PGND	PWR	Ground
A67	VP	PWR	High-side drain	B67	PGND	PWR	Ground
A68	VP	PWR	High-side drain	B68	PGND	PWR	Ground
A69	VP	PWR	High-side drain	B69	PGND	PWR	Ground
A70	VP	PWR	High-side drain	B70	PGND	PWR	Ground
A71	VP	PWR	High-side drain	B71	PGND	PWR	Ground
A72	VP	PWR	High-side drain	B72	PGND	PWR	Ground
A73	VP	PWR	High-side drain	B73	PGND	PWR	Ground
A74	VP	PWR	High-side drain	B74	PGND	PWR	Ground
A75	VP	PWR	High-side drain	B75	PGND	PWR	Ground
A76	VP	PWR	High-side drain	B76	PGND	PWR	Ground
A77	VP	PWR	High-side drain	B77	PGND	PWR	Ground
A78	VP	PWR	High-side drain	B78	PGND	PWR	Ground
A79	VP	PWR	High-side drain	B79	PGND	PWR	Ground
A80	VP	PWR	High-side drain	B80	PGND	PWR	Ground
A81	VP	PWR	High-side drain	B81	PGND	PWR	Ground
A82	-	-	-	B82	-	-	-

2.4. PCB Component Layout

Fig.2.3 shows the component layout of the board.



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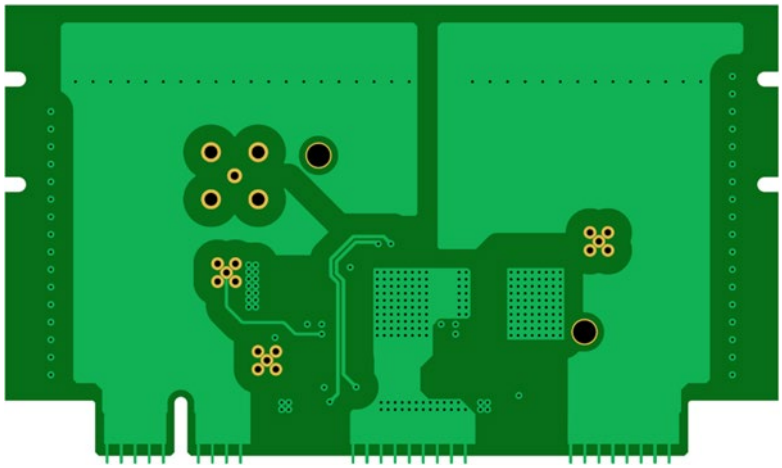


<Back Side>

Fig. 2.3 PCB Component Layout

3. Schematic, Bill of Materials, and PCB Pattern Diagram

3.1. Schematic

Refer to following files:
TW027U65C-Mounted Board：RD262-SCHEMATIC1-xx.pdf
TW048U65C-Mounted Board：RD262-SCHEMATIC2-xx.pdf
(xx is the revision number.)

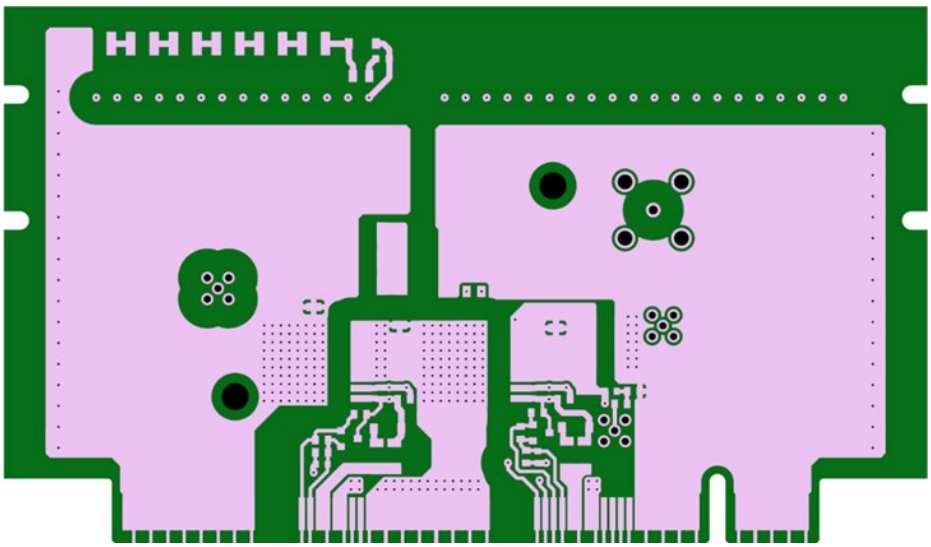
3.2. Bill of Materials

Refer to following files:
TW027U65C-Mounted Board：RD262-BOM1-xx.pdf
TW048U65C-Mounted Board：RD262-BOM2-xx.pdf
(xx is the revision number.)

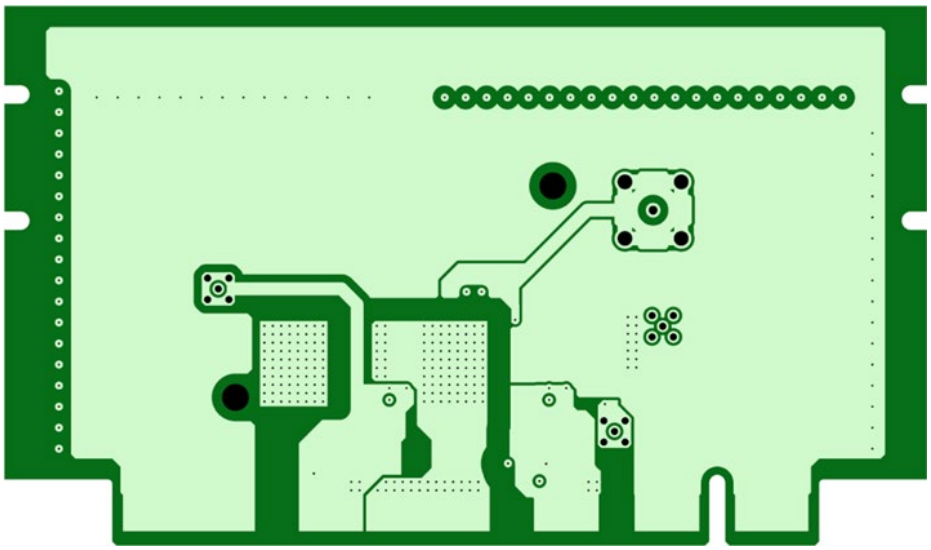
3.3. PCB Pattern Diagram

Fig. 3.1 shows PCB pattern diagram. The PCB pattern is common to both the TW027U65C-mounted board and the TW048U65C-mounted board.

Refer to following files:
RD262-LAYER-xx.pdf
(xx is the revision number.)



L1 (Top Layer)



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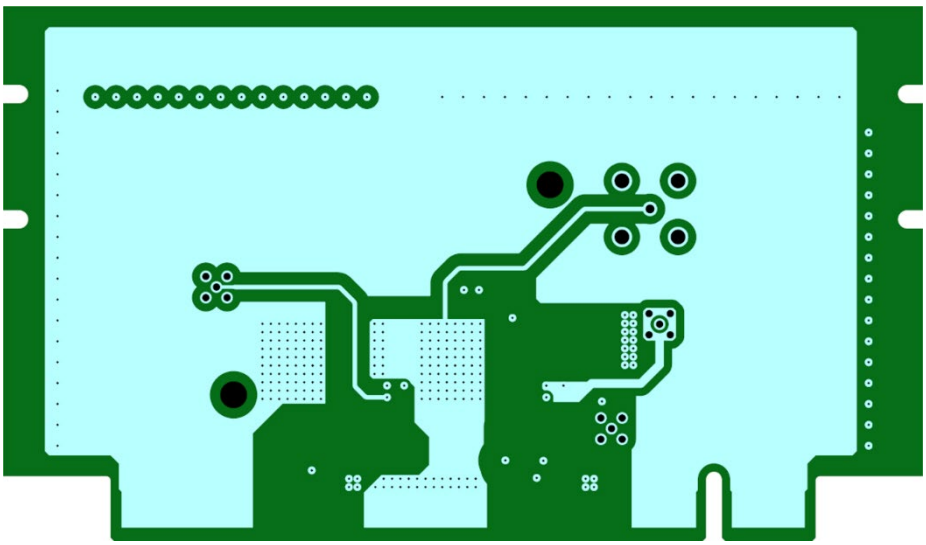
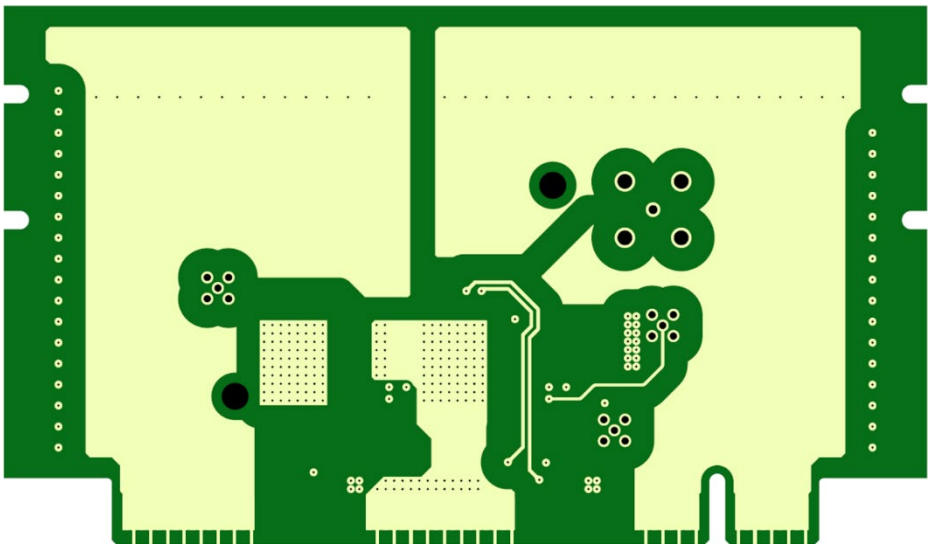


L3



L4 (Bottom Layer)

Fig. 3.1 PCB Pattern Diagram (Top View)

4. Example of Operating Procedure

4.1. Connection to External Devices

An example of the evaluation connection for this design is shown in Fig. 4.1. In this section, a general synchronous rectification type boost DC-DC converter is used as a circuit example.

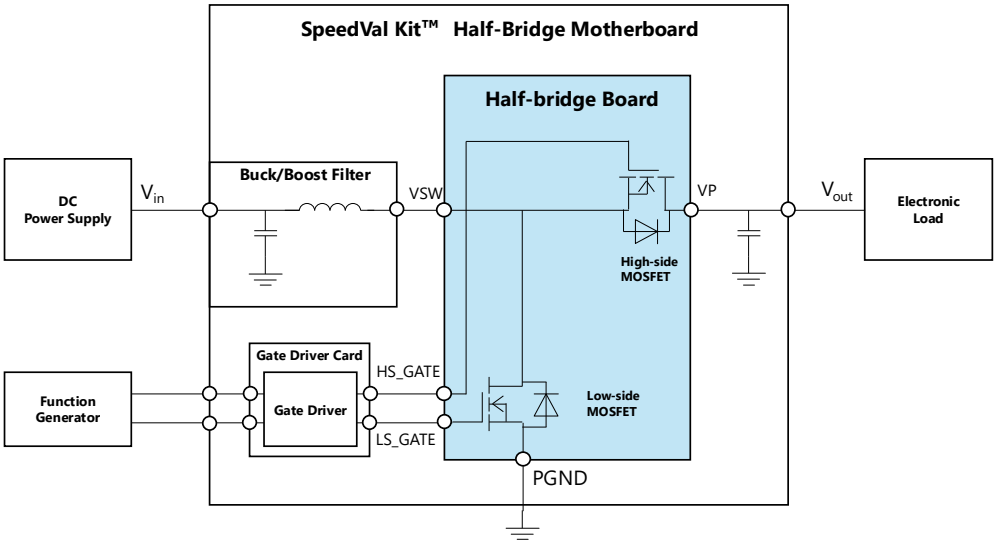


Fig. 4.1 Wiring Connection Diagram

Please connect a DC stabilized power supply to the VSW terminal of this design through the Buck/Boost filter, and connect an electronic load via the VP terminal. Connect the high-side gate drive signal to the HS_GATE terminal, and connect the low-side gate drive signal to the LS_GATE terminal.

4.2. Start and Stop Procedures

Before starting this design, confirm that the terminal voltages of all input and output terminals are 0V.

[Starting Procedure]

1. Turn on the DC power supply.
2. Start the electronic load.
3. Apply the gate drive signals.

[Stopping Procedure]

1. Stop the gate drive signals.
2. Turn off the DC power supply.
3. Stop the electronic load.

5. Common Precautions for Evaluation

Please read and follow the precautions below to ensure safe evaluation work.

- **Precautions for Electric Shock Prevention**
  - Before applying power, **confirm that the polarity of connectors, terminals, and wiring is correct**.
  - Some parts of the board may be exposed to high voltage. **Do not touch the board or components while power is applied**.
  - Even after the power is turned off, capacitors may retain residual charge. **Ensure that all capacitors are fully discharged before touching the board**.
  - When measuring voltage or current waveforms, **take sufficient precautions to avoid electric shock and maintain a safe distance**.
- **Precautions for Burn Prevention (High-Temperature Components)**
  - MOSFETs, diodes, inductors, coils, and semiconductor devices may become **very hot during operation**. Handle them carefully to avoid burns.
  - Under high load conditions, heat generation increases. **Use appropriate cooling (such as fans)**.
  - Component temperatures may remain high immediately after power-off. **Allow sufficient cooling time before touching**.
- **Precautions for the Evaluation Environment**
  - During operation checks, implement safety measures such as **covering the board with a non-conductive enclosure** if necessary **(e.g., acrylic case)**.
  - When using motors or other moving parts, **take measures to prevent contact during operation**.
  - For designs with shunt or jumper settings, **verify that the settings are correct before operation**.
- **Other Precautions**
  - Loads connected to output terminals may generate heat. **Pay attention to load temperature rise**.
  - Keep flammable and conductive materials away during evaluation to **avoid short circuits and accidents**.

6. Power Characteristics

The power efficiency measurement results obtained when this design is operated as a synchronous rectification type boost DC-DC converter are shown below.

The results presented here were measured on the Half-bridge Mother Board of the SpeedVal Kit™ provided by Wolfspeed.

6.1. Efficiency

The efficiency measurement results of the synchronous rectification type boost DC-DC converter using this design, as shown in Fig. 4.1, are presented below. Table 6.1 lists the evaluation conditions. Assuming a boost converter for PFC applications, the input power supply voltage (V_{in}) was set to four DC levels—141V, 163V, 282V, and 325V—corresponding to the rectified output of a diode bridge, and measurements were performed with the output voltage (V_{out}) set to DC 380V. For Vin conditions of 163V and 325V, efficiency measurements were conducted with the switching frequency varied between 65kHz and 100kHz.

Table 6.1 Measurement Conditions

Measurement Conditions	(Assuming AC 100V System)	(Assuming AC 200V System)
Input Voltage	DC 141V (Equivalent to AC 100V) DC 163V (Equivalent to AC 115V)	DC 282V (Equivalent to AC 200V) DC 325V (Equivalent to AC 230V)
Output Voltage	380V	
Output Power	1500W 10% step	3000W 10% step
Switching Frequency	65kHz / 100kHz	
Gate Drive Voltage	0 to 18V	
Gate Signal Deadtime	200ns	
Inductor Used	190µH (SpeedVal Kit™ Buck/Boost Filter Board)	

6.1.1. TW027U65C-Mounted Board

Fig. 6.1 shows the efficiency curves for DC 141V and DC 163V input conditions, assuming an AC 100V system.
An efficiency of 98.9% is achieved at an input voltage of 163V, a switching frequency of 65kHz, and an output power of 1500W.

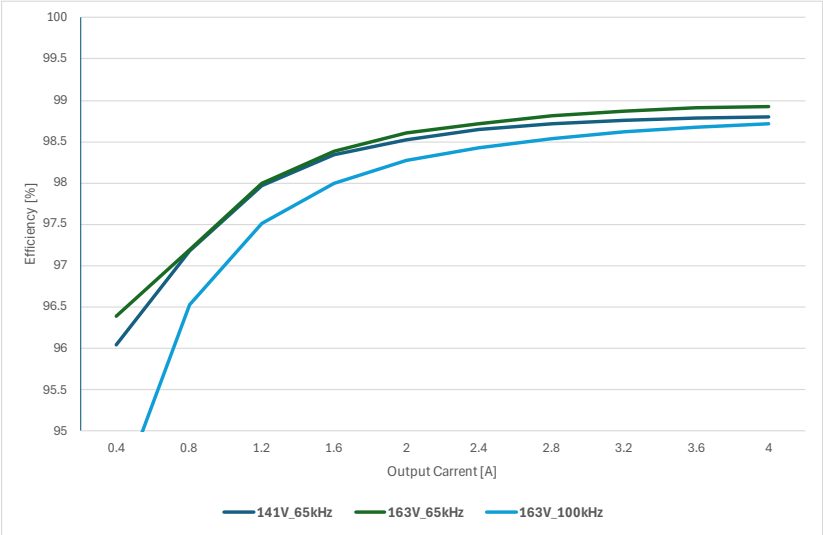


Fig. 6.1 Efficiency Measurement Results (Assuming AC 100V System)

Fig. 6.2 shows the efficiency curves for DC 282V and DC 325V input conditions, assuming an AC 200V system.
An efficiency of 99.5% is achieved at an input voltage of 325V, a switching frequency of 65kHz, and an output power of 3000W.

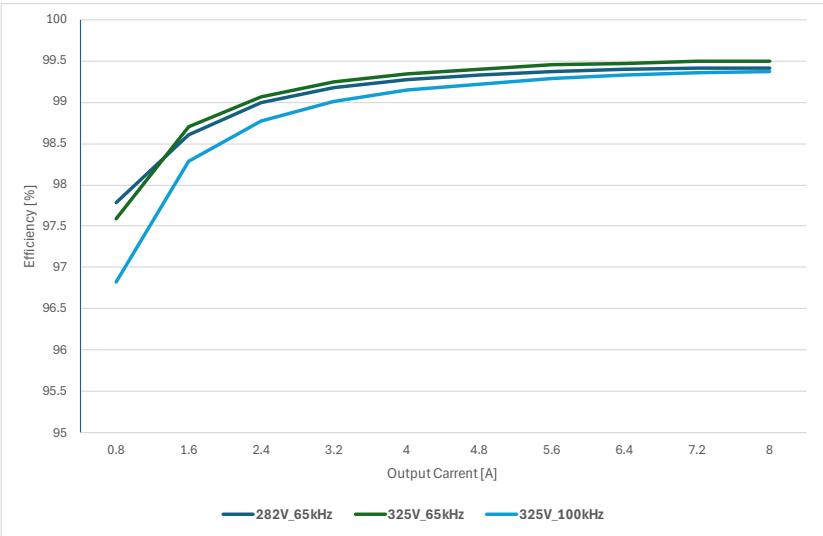


Fig. 6.2 Efficiency Measurement Results (Assuming AC 200V System)

6.1.2. TW048U65C-Mounted Board

Fig. 6.3 shows the efficiency curves for DC 141V and DC 163V input conditions, assuming an AC 100V system.

An efficiency of 98.9% is achieved at an input voltage of 163V, a switching frequency of 65kHz, and an output power of 1500W.

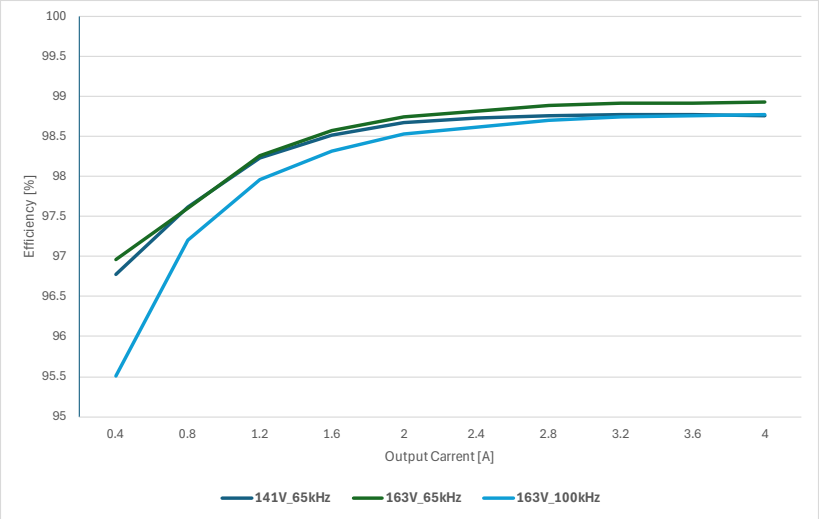


Fig. 6.3 Efficiency Measurement Results (Assuming AC 100V System)

Fig. 6.4 shows the efficiency curves for DC 282V and DC 325V input conditions, assuming an AC 200V system.

An efficiency of 99.5% is achieved at an input voltage of 325V, a switching frequency of 65kHz, and an output power of 3000W.

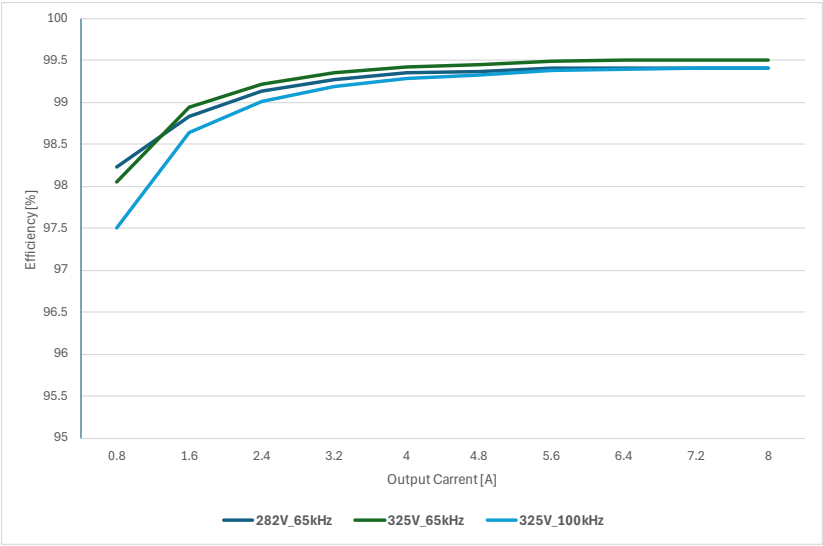


Fig. 6.4 Efficiency Measurement Results (Assuming AC 200V System)

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