5 kW Isolated Bidirectional DC-DC Converter

Reference Guide

RD167-RGUIDE-01

TOSHIBA ELECTRONIC DEVICES & STORAGE CORPORATION

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1. Introduction

This reference guide describes the specifications, usage, and properties of the 5 kW Isolated Bidirectional DC-DC Converter (hereafter referred to as this power supply). This power supply is a bi-directional DC-DC converter, capable of supplying up to 5 kW of power. It takes voltage from the high-voltage side and outputs voltage to the low-voltage side, or takes voltage from the low-voltage side and outputs voltage to the high-voltage side. This power supply adopts the DAB (Dual Active Bridge) method with emphasis on efficiency. The DAB method has a full-bridge configuration on both the high-voltage side and low-voltage side, and can handle higher power compared to the half-bridge method. In addition, soft switching is possible because of power transfer by phase shifting, and a highly efficient DC-DC converter can be realized. It can be applied to various industrial equipment such as charging systems for electric vehicles (EVs) and inverters for photovoltaic power generation.

The high-voltage input/output is assumed to be 750 V, and therefore the device must withstand switching voltage of 1000 V or higher, so IGBT is generally selected. However, when IGBT is used, the switching losses are large, and therefore no significant improvements are expected. This power supply uses TW070J120B, which is 1200 V SiC MOSFET, to achieve both high-power conversions and high-efficiency conversions. On the low-voltage side, 400 V input/output is assumed, and TK49N65W5, which is a 650 V MOSFET with reduced switching losses due to the super junction structure and an integrated high-speed diode, is used to achieve high-efficiency.

The gate driver has a 4 A sink-source current capability that can drive the gate charging/discharging current sufficiently when the 1200 V SiC MOSFET is switched, and uses a smart gate driver coupler TLP5214A equipped with an overcurrent protecting function and a UVLO function. The voltage-sensor circuitry, which requires isolation, uses an optically coupled isolation amplifier TLP7920 with high linearity accuracy and high common-mode transient.

2. Specifications

2.1. Power Supply Specifications

Table 2.1 lists the main specifications of this power supply.

Table 2.1 Main Specifications of 5 kW Isolated Bidirectional DC-DC Converter

Parameters	Conditions	Minimum	Typical	Maximum	Unit
Input/Output Characteristics					
High-voltage side voltage	During input operation	732	750	768	V
Low-voltage side voltage	During output operation	396	400	404	V
Low-voltage side current	During output operation			13	A
Rated power				5	kW
Switching frequency			50		kHz

2.2. External View of Power Supply

Fig. 2.1 and Fig. 2.2 show the appearance of this power supply.

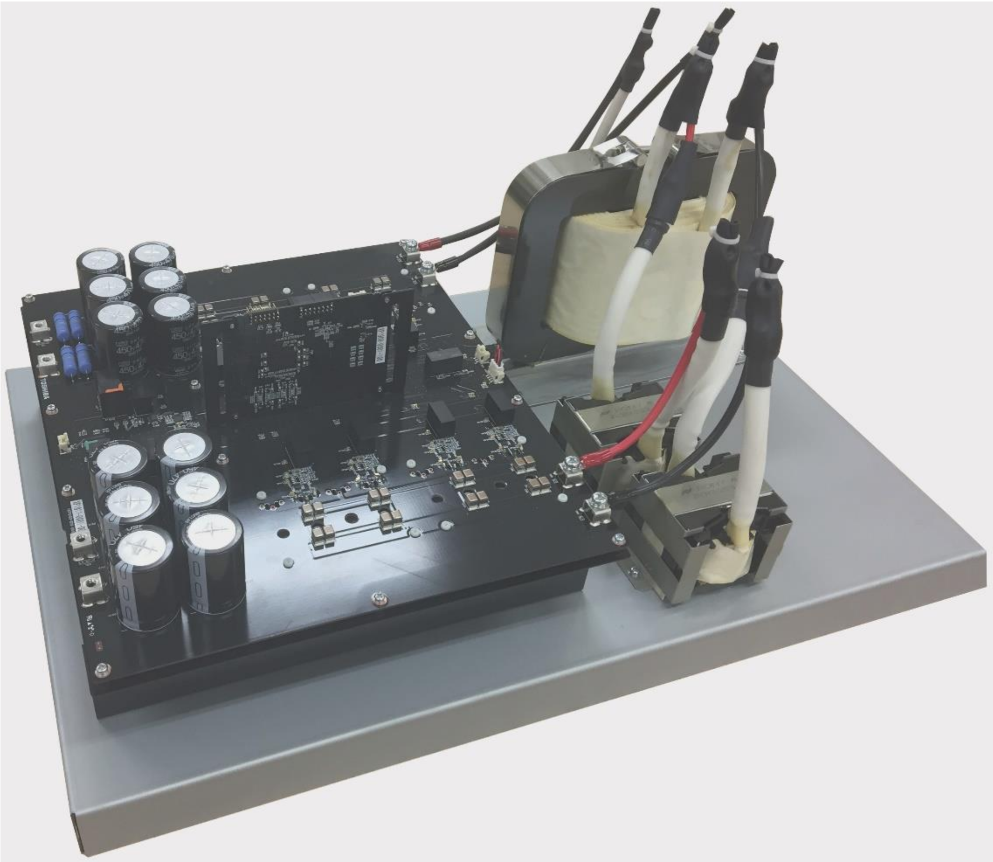

Fig. 2.1 Side View of 5 kW Isolated Bidirectional DC-DC Converter

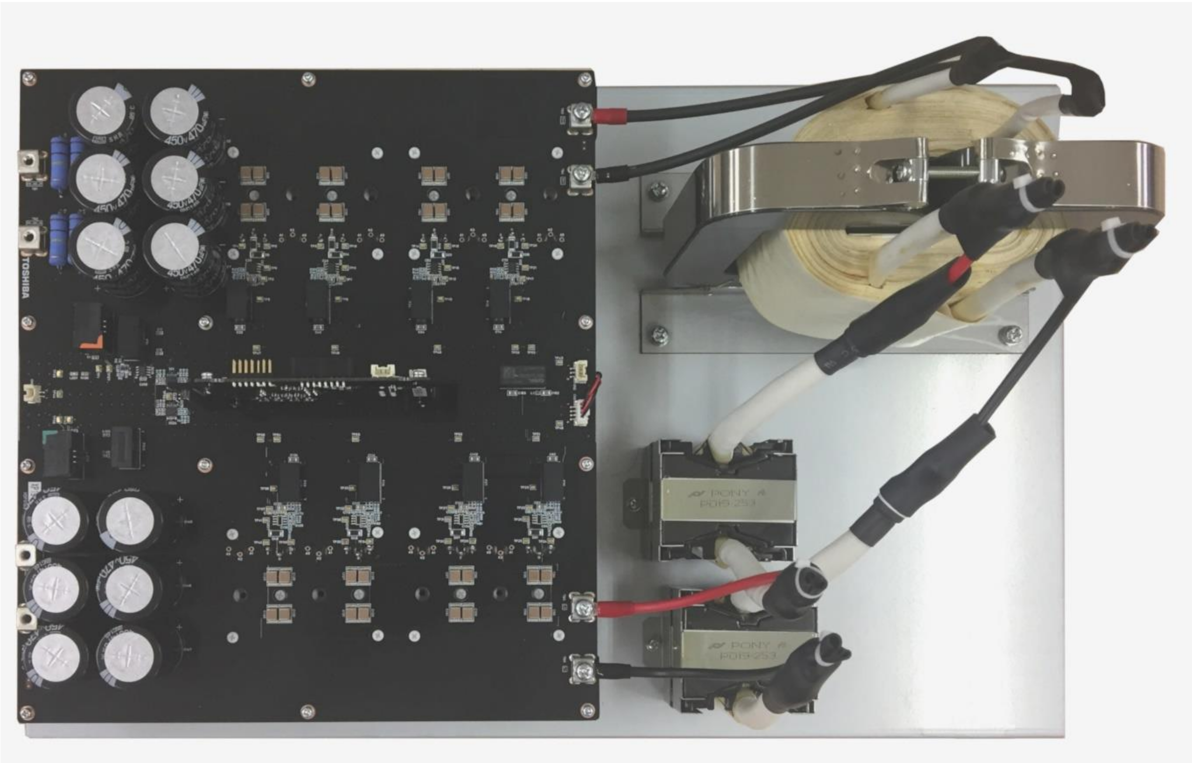

Fig. 2.2 Top View of 5 kW Isolated Bidirectional DC-DC Converter

2.3. Block Diagram

Fig. 2.3 shows a block diagram for explaining the function operation. For the circuit diagram of the main circuit board, refer to the circuit diagram (RD167-SCHEMATIC) of the main circuit board of the "5 kW Isolated Bidirectional DC-DC Converter" reference design. For the circuit diagram of the control board, refer to the circuit diagram (RD044-SCHEMATIC2) of the control board of the "3-Phase AC 400 V Input PFC Converter" reference design.

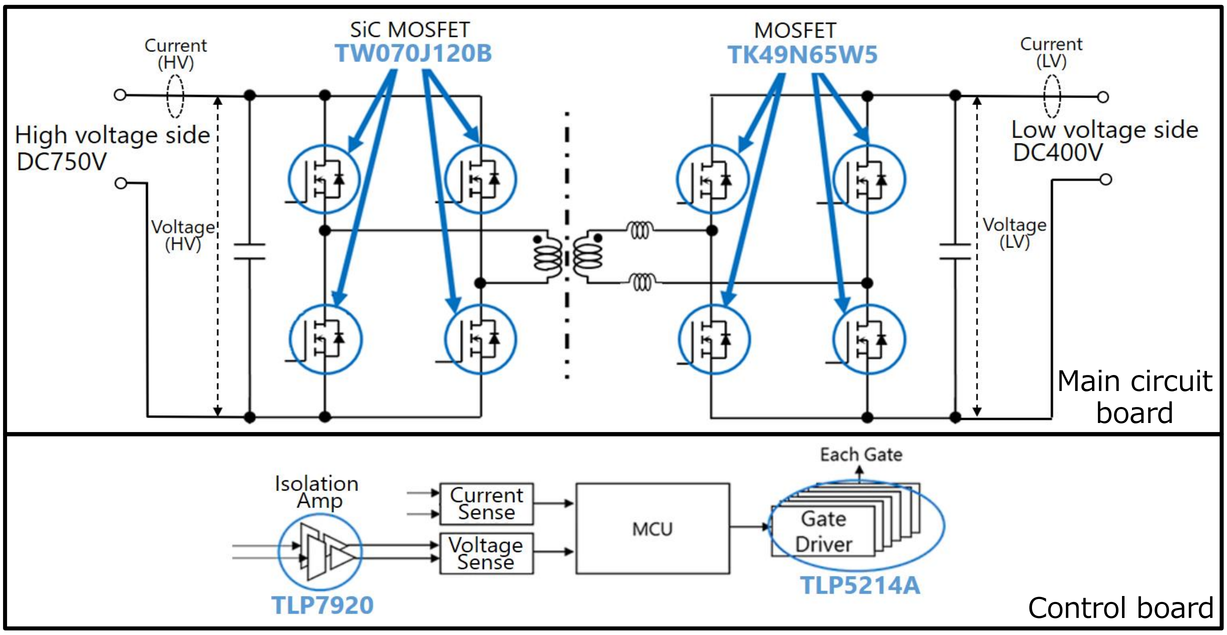

Fig. 2.3 Block Diagram

3. Operating Procedure

3.1. Wiring Connection

Make connection to this power supply according to the connection diagram shown in Fig. 3.1.

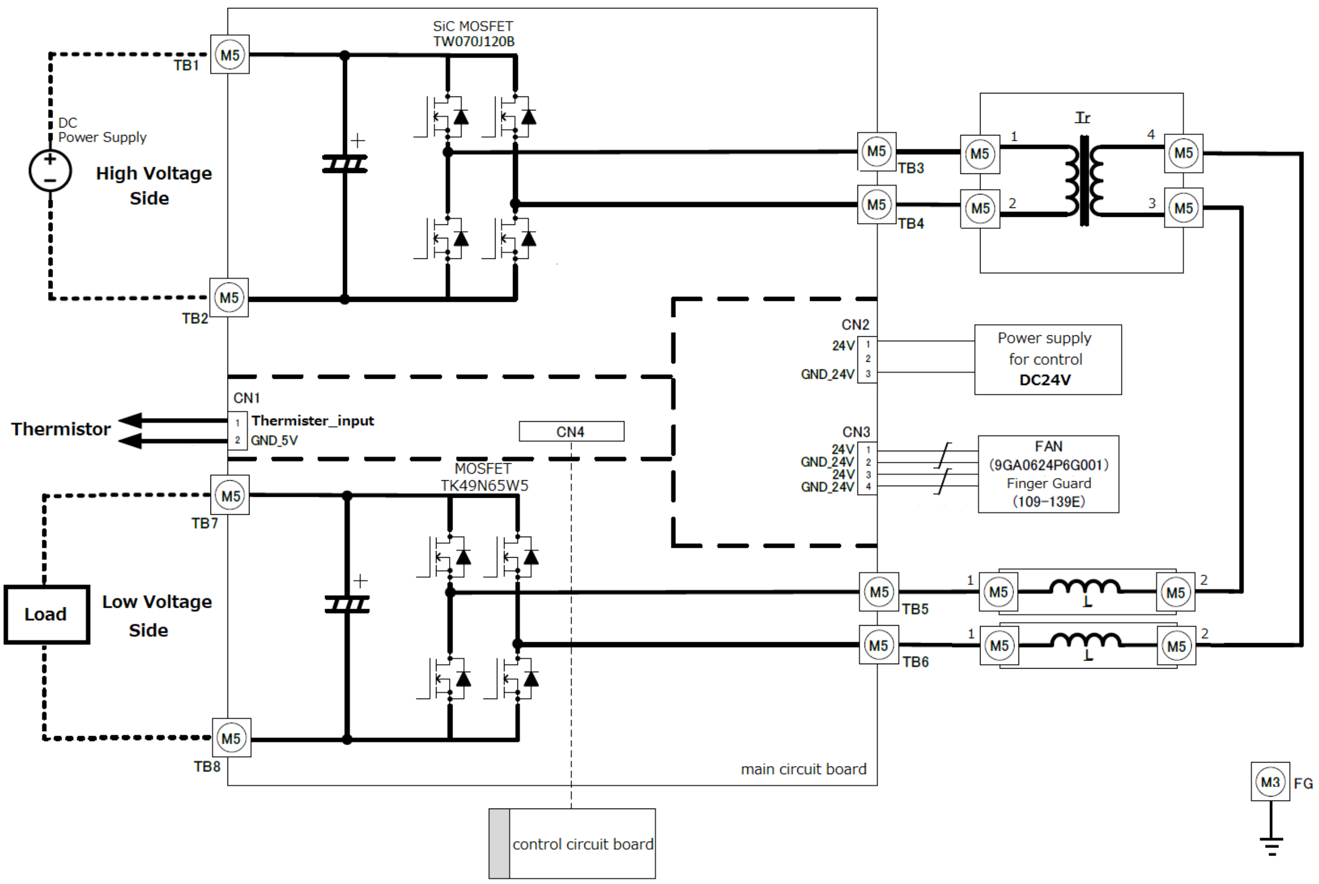

Fig. 3.1 Wiring Connection Diagram

3.2. Connection Example with External Device

Connect a stabilized power supply (DC750 V) to the high voltage side input/output terminals (TB1/+ side and TB2/-side) of this power supply and a load device (TB7/+ side and TB8/-side) to the low voltage side input/output terminals. Also, connect the DC24 V control power supply to the main circuit board (CN2).

3.3. Start and Stop Procedures

Before starting up the power supply, check that the terminal voltages of the high-voltage side input/output terminals and the low-voltage side input/output terminals are all 0 V.

[Startup Procedure]

1. Turn on the DC24 V control power supply
2. Turn on the stabilized power supply

[Stop Procedure]

1. Shut down the stabilized power supply
2. Shut down the DC24 V control power supply

3.4. Evaluation Precautions (to Prevent Electric Shock, Hot Burns, etc.)

Be careful of electric shock when connecting a stabilized power supply. Do not touch each part of the power supply directly while the power is on. Be very careful when observing the waveform. Even after this power supply is stopped, there is a risk of electric shock due to the residual charge of various capacitors. Confirm that the voltage of each part has decreased sufficiently before touching the board.

In addition, the semiconductor or inductor of this power supply generates heat according to the load current. Do not touch any part of the power supply while the power supply is in operation, as there is a risk of burns.

4. Power Characteristics

The power supply efficiency measurement results of this power supply are described below.

4.1. Efficiency

Fig. 4.1 shows the power supply efficiency measurement results of this power supply. It indicates the efficiency of the low-voltage side input to high-voltage side output and of high-voltage side input to low-voltage side output, respectively. Both the high-voltage and low-voltage sides are DABs (Dual Active Bridge) with full-bridges, enabling high-efficiency in a wide load-power range for both input and output operations. The efficiency is 97 % when the input voltage is 750 V and the load power is 100 %.

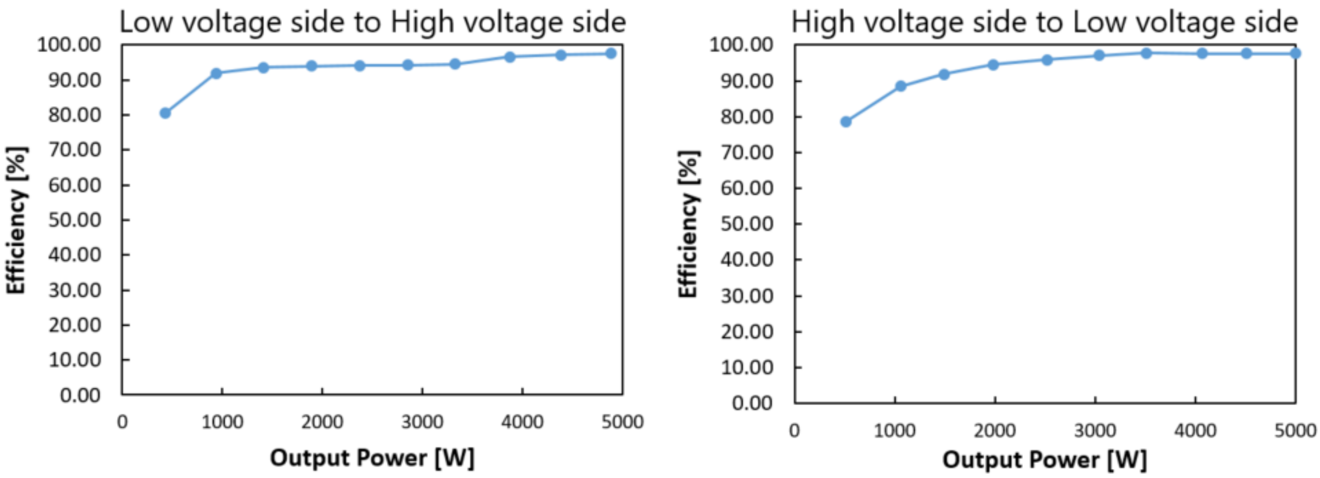

Fig. 4.1　Efficiency Measurement Results

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