1.1kW ITTF (Interleaved Two Transistor Forward) AC-DC Converter for Servers

Reference Guide

RD226-RGUIDE-01

Toshiba Electronic Devices & Storage Corporation

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1. Introductions

This design guide explains the specifications and operating procedures of a 1.1kW AC-DC converter for servers using the ITTF (Interleaved Two Transistor Forward) topology, hereafter referred to as "this design.

This design is an AC-DC converter for servers that generates DC 12V from an input of AC 90 to 264V and outputs up to 1.1kW. It is equipped with an output ORing circuit, enabling redundant operation. Components are selected with consideration for height during board mounting, making it applicable to 1U-size power supplies. To improve power efficiency, it adopts a totem-pole PFC circuit that does not use a diode bridge and an ITTF topology DC-DC converter, achieving efficiency exceeding the 80 PLUS Platinum standard under 230V input conditions.

In this design, the high-frequency switching element of the totem-pole PFC circuit uses the SiC MOSFET TW107Z65C, and the low-frequency switching element uses the power MOSFET TK024N60Z1. In the ITTF topology DC-DC converter circuit, the primary side uses the power MOSFET TK165V60Z1, and the secondary side uses the power MOSFETs TPH1R204PL and TPH1R306PL. For isolated gate signal transmission from the primary-side controller, the digital isolator DCL541A01 is used. Additionally, the output ORing circuit uses the power MOSFET TPHR6503PL. These latest Toshiba devices contribute to reduced losses and high-efficiency operation.

※80 PLUS: An efficiency standard for power supply units used in computers such as servers.

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2. Appearance and Specifications

2.1. Specifications

Table 2.1 lists the main specifications of this design.

Table. 2.1 1.1kW ITTF AC-DC Converter for Servers

Item	Conditions	Min.	Typ.	Max.	Unit
Input characteristics					
AC input voltage (rms)		90		264	V
AC input current (rms)	Vin = AC 90V, Iout = 92A			14	A
Input frequency		47		63	Hz
Internal characteristics (Interleaved PFC circuit)					
Output voltage			385		V
Maximum output power	Vin = AC 230V			1.2	kW
Switching frequency			65		kHz
Output characteristics (ITTF DC-DC Converter circuit)					
Output voltage		11.4	12	12.6	V
Output current				96.5	A
Maximum output power				1.1	kW
Switching frequency			80		kHz
Output ripple voltage	Ta = 25℃			240	mV
Other					
Protective functions	Output overvoltage protection, output overcurrent protection, and output short-circuit protection				
Board layer configuration	Main Board: FR-4 4-layer structure, copper foil thickness 105µm Control Board：FR-4 4-layer structure, copper foil thickness 35µm				

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2.2. Block Diagram

Fig. 2.2 shows the block diagram of this design.

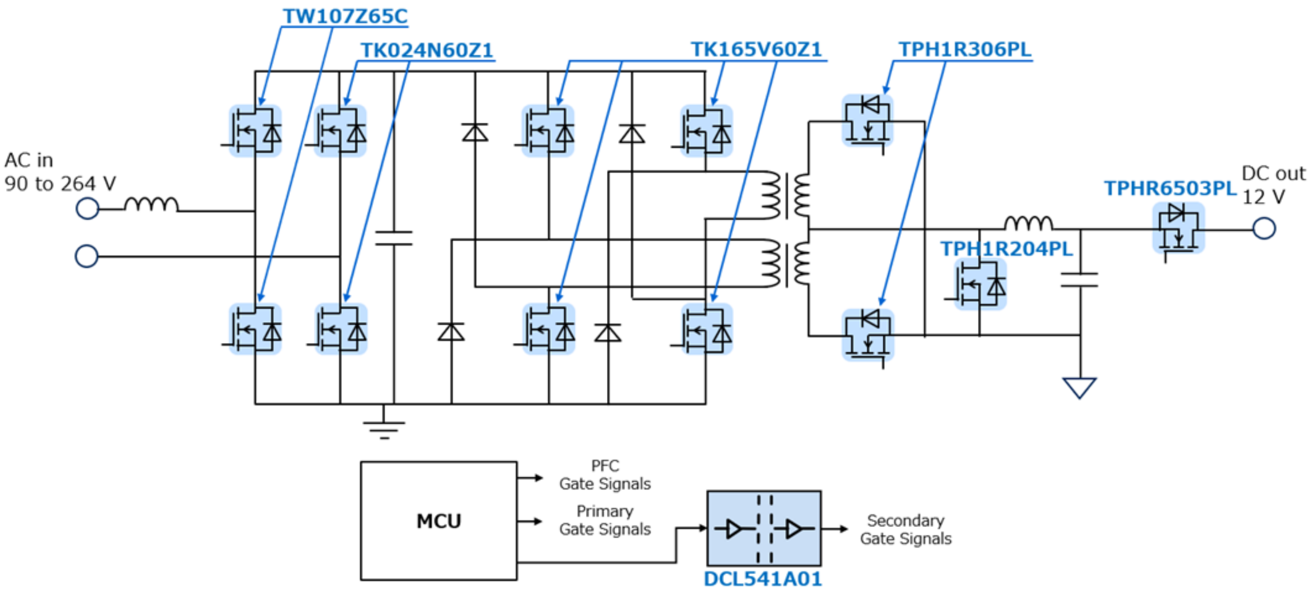

Fig. 2.1 1.1kW ITTF AC-DC Converter for Servers Block Diagram

This design is a high-efficiency 1.1kW AC-DC converter that delivers a DC 12V output from an AC input. It incorporates a totem-pole power factor correction (PFC) circuit and utilizes the Interleaved Two Transistor Forward (ITTF) topology.

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2.3. Appearance

This design features a configuration in which the control board is mounted on top of the main board. Figure 2.2 shows the external view of this design, and Figure 2.3 shows the external view of the control board.

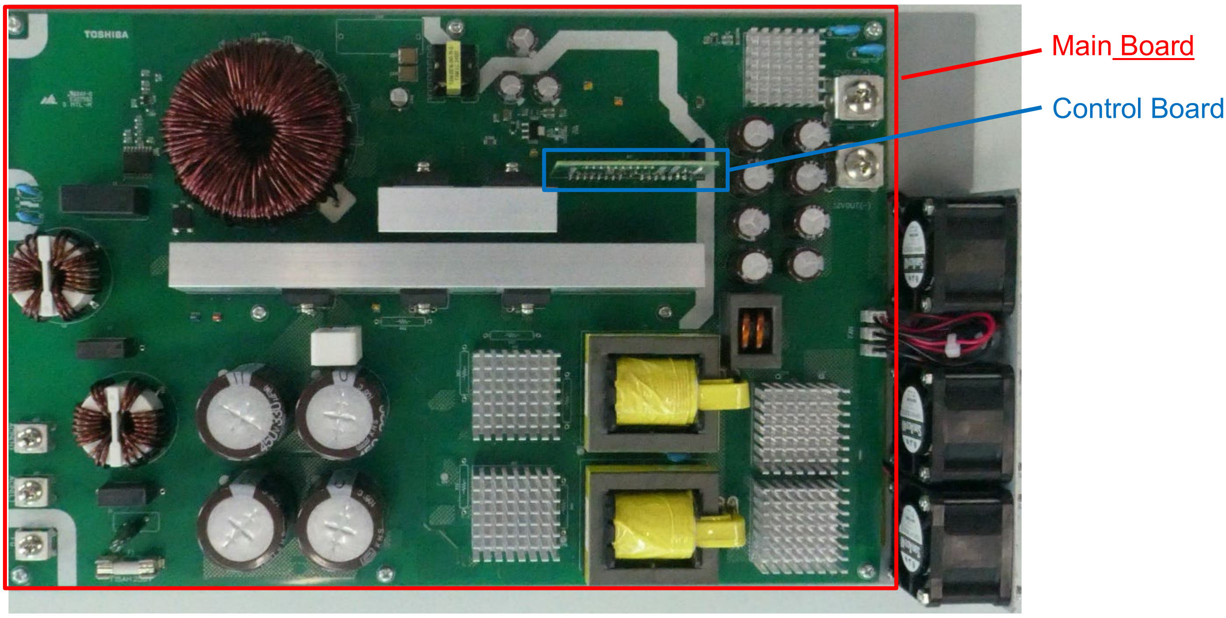
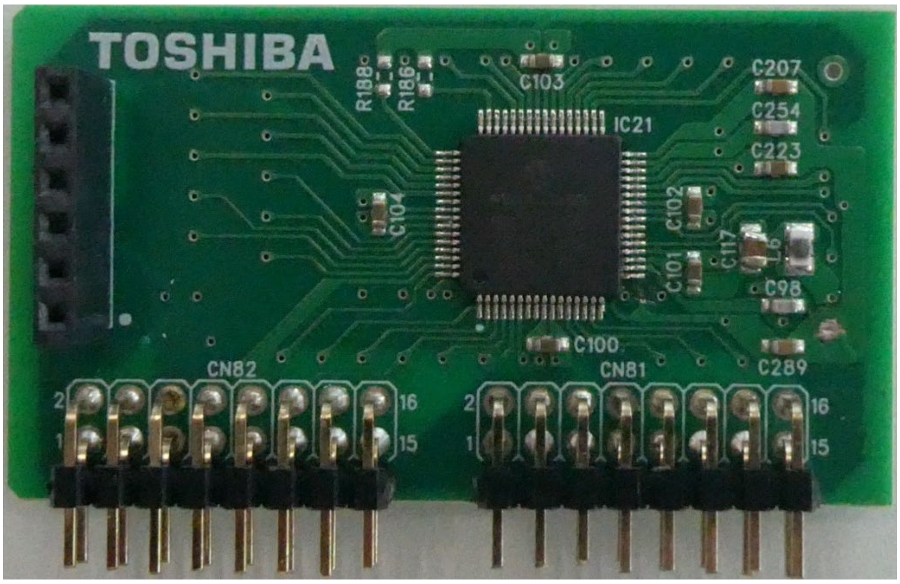


Fig. 2.2 1.1kW ITTF AC-DC Converter for Servers (Front View)



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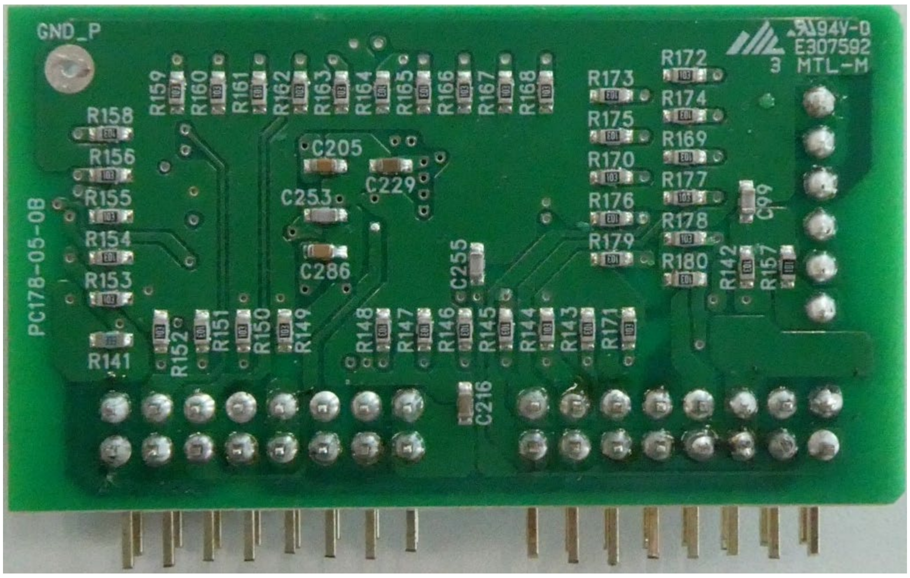

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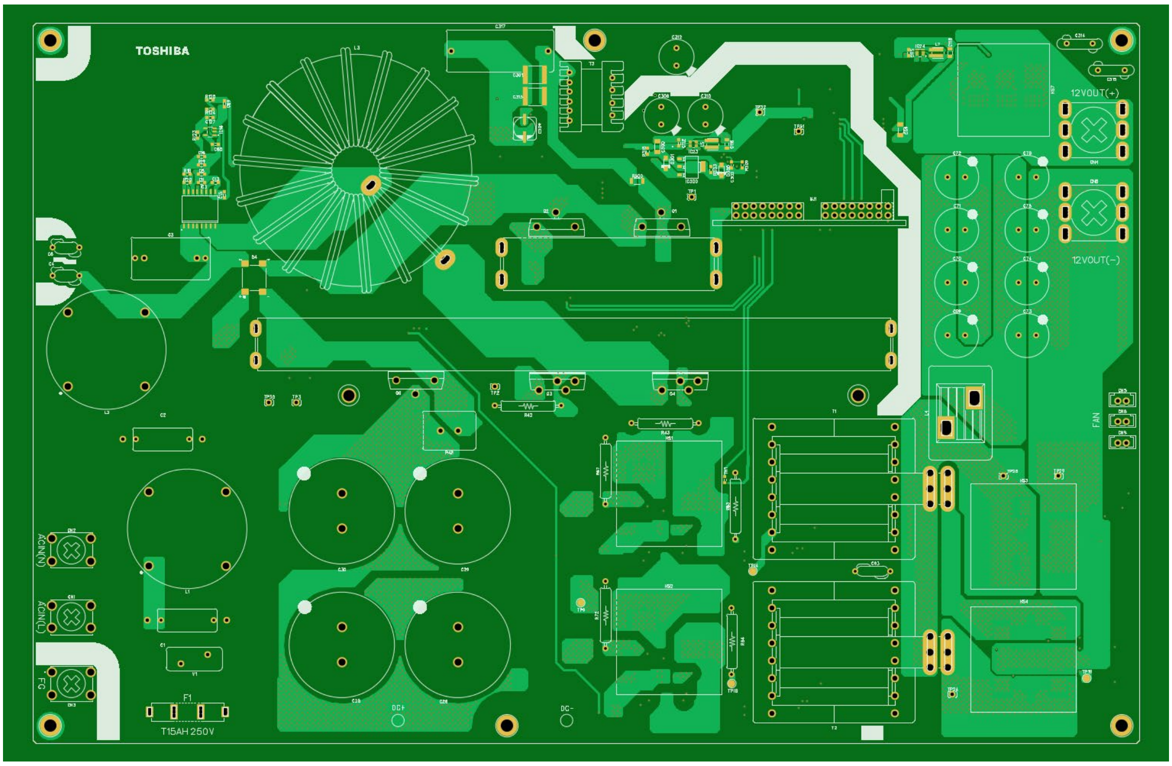
Fig. 2.3 Control Board

2.4. PCB Component Layout

Figure 2.4 shows the component layout of the main board, and Figure 2.5 shows the component layout of the control board.



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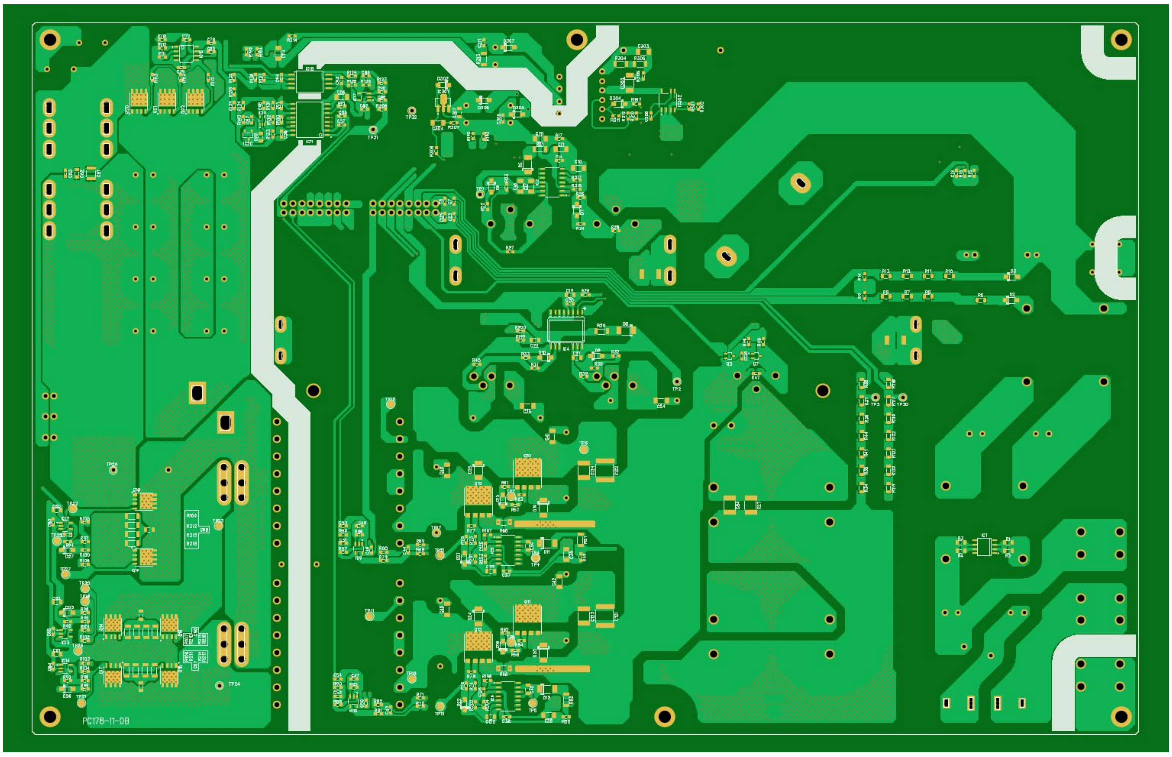

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Fig. 2.4 Component Layout of Main Board

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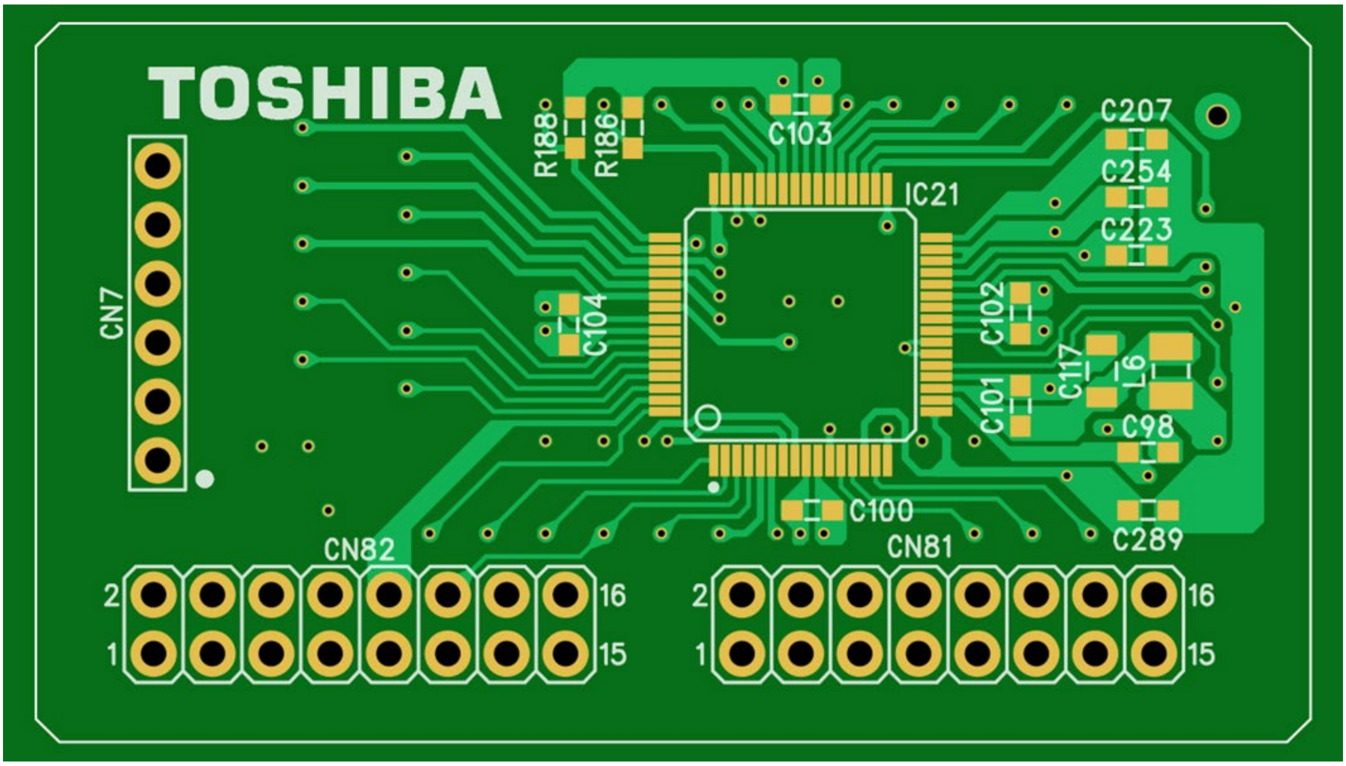

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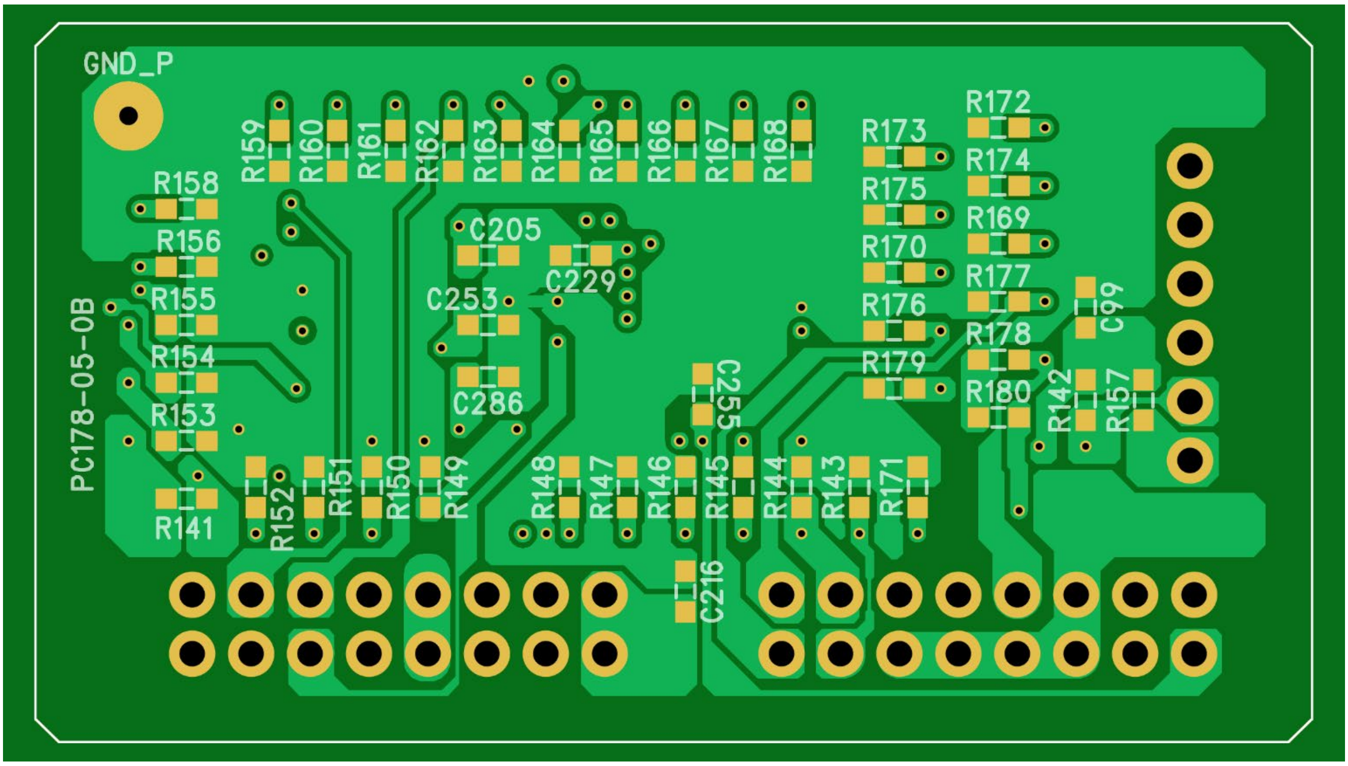

Fig. 2.5 Component Layout of Control Board

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

3.1. Schematic

Refer to following files:

Main Board : RD226-SCHEMATIC1-xx.pdf

Control Board : RD226-SCHEMATIC2-xx.pdf

(xx is the revision number.)

3.2. Bill of Materials

Refer to following files:

Main Board : RD226-BOM1-xx.pdf

Control Board : RD226-BOM2-xx.pdf

(xx is the revision number.)

3.3. PCB Pattern Diagram

Refer to following files:

Main Board : RD226-LAYER1-xx.pdf

Control Board : RD226-LAYER2-xx.pdf

(xx is the revision number.)

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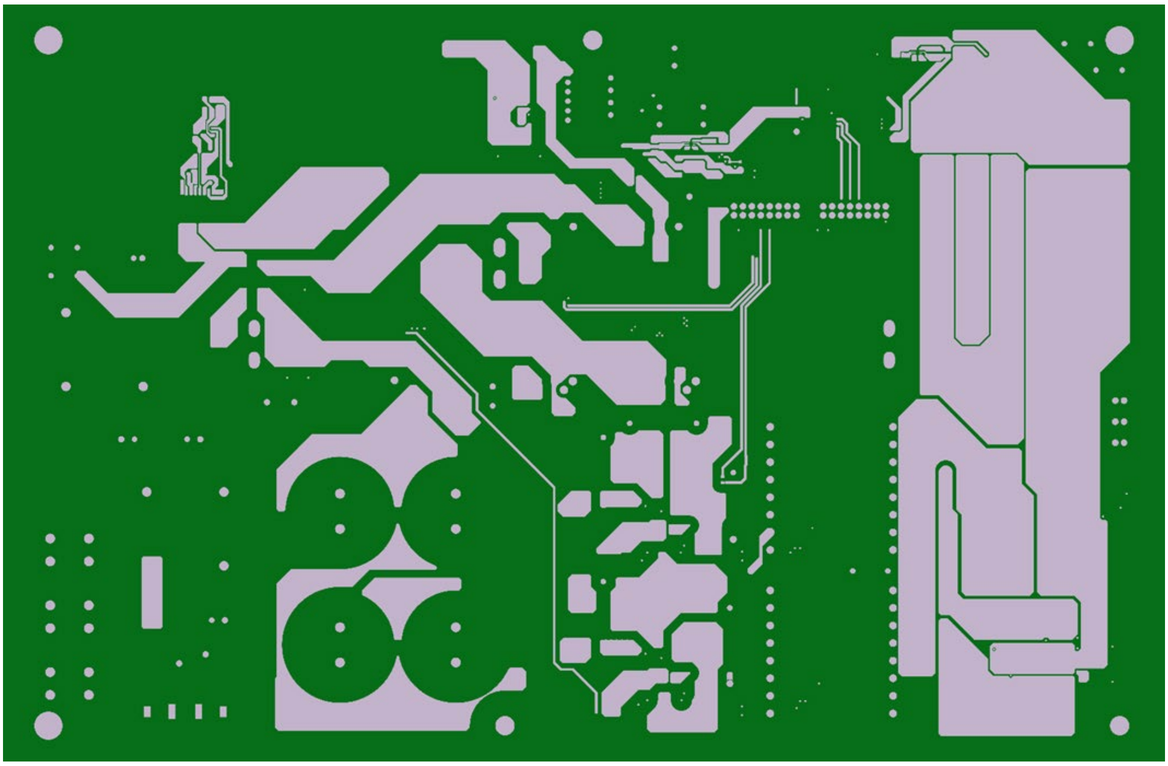

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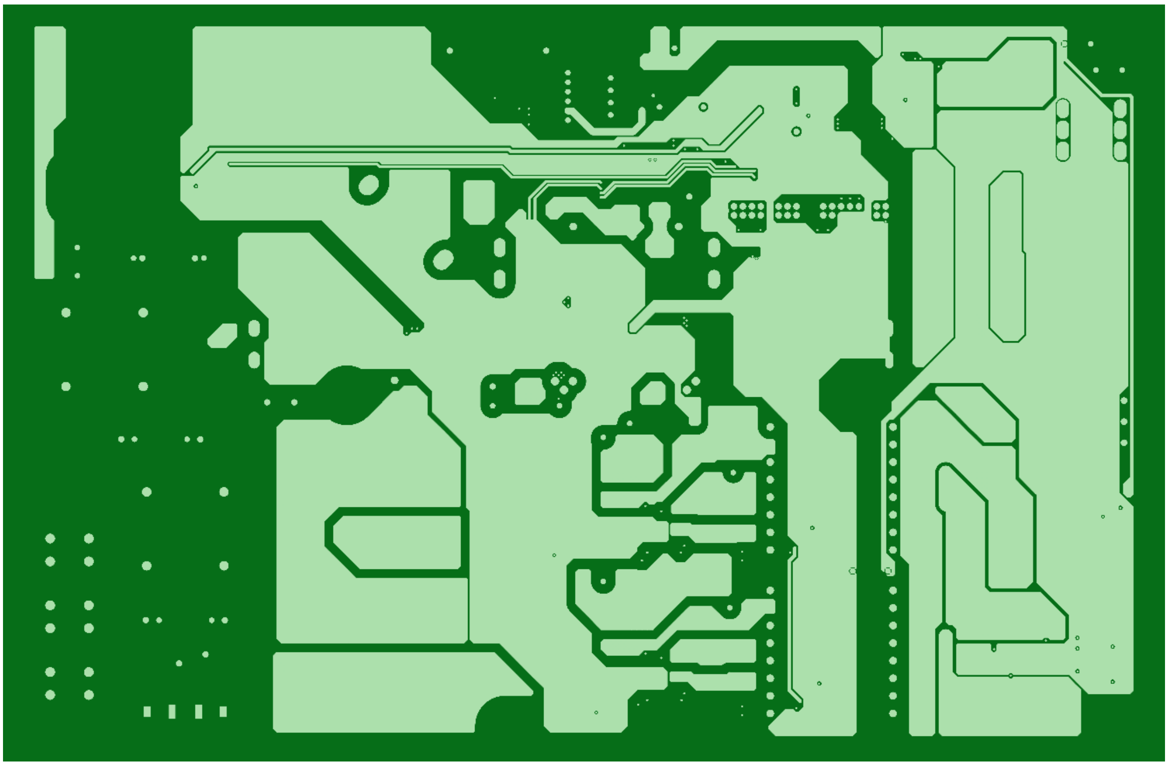

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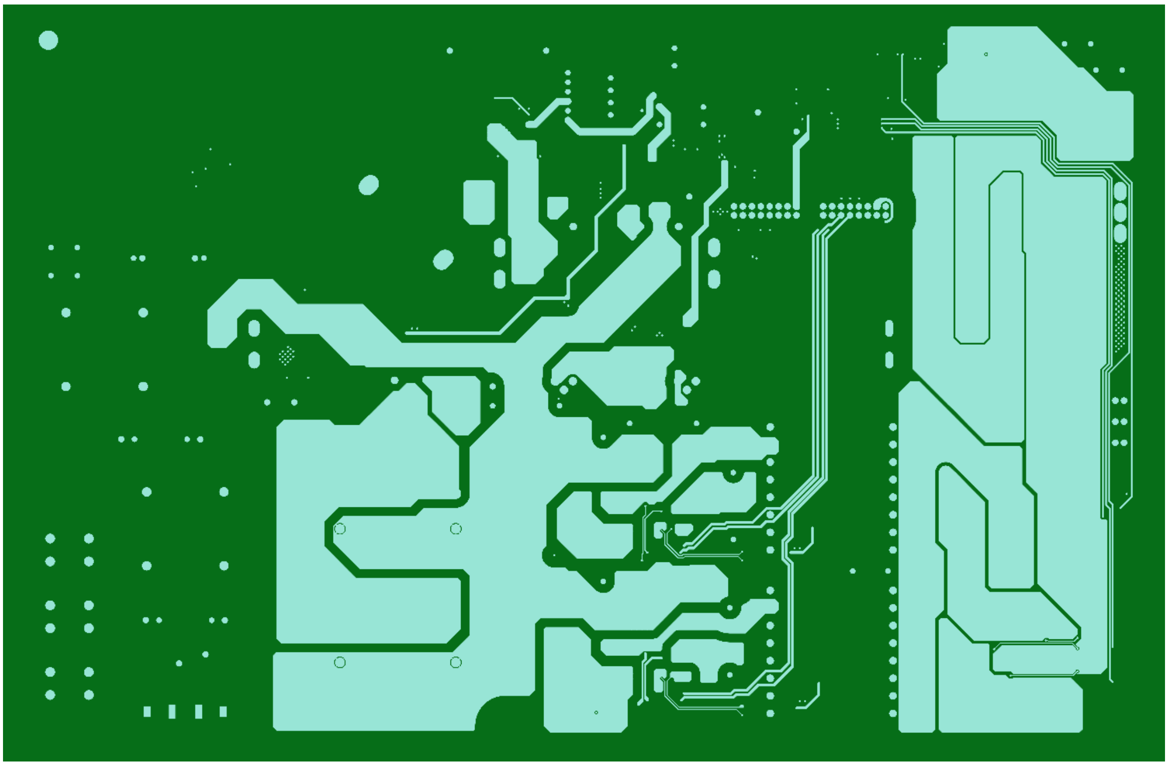

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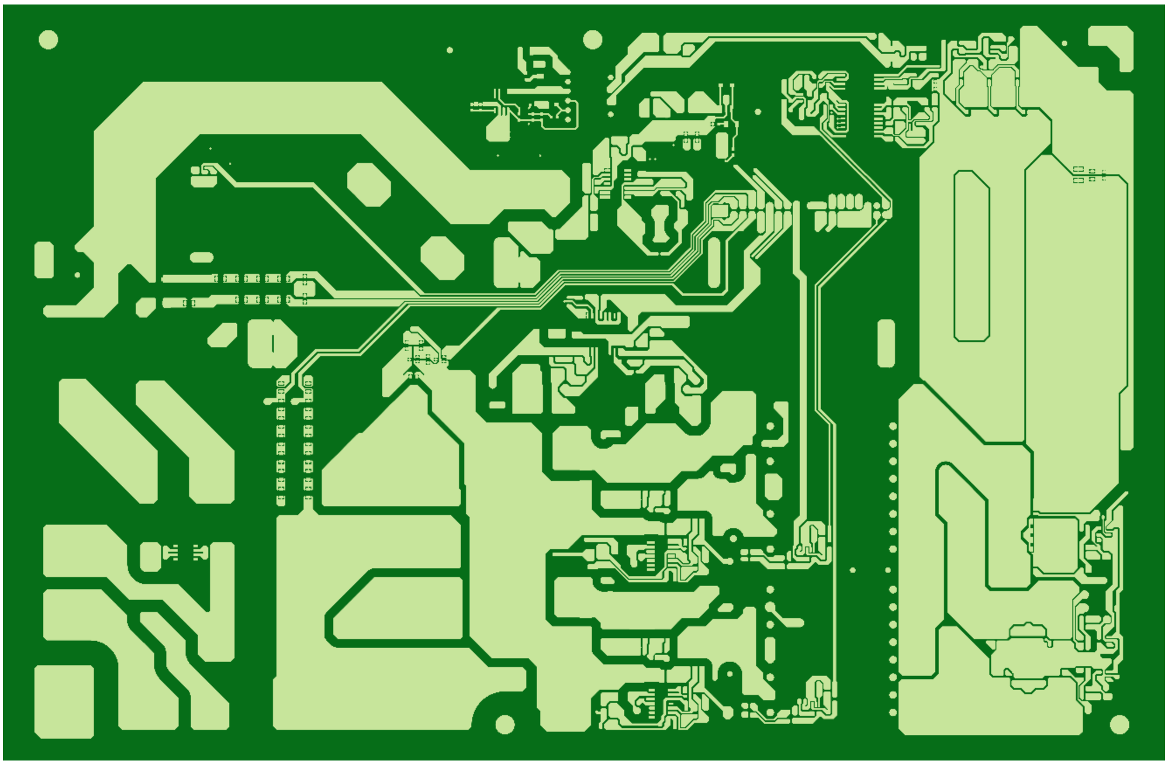

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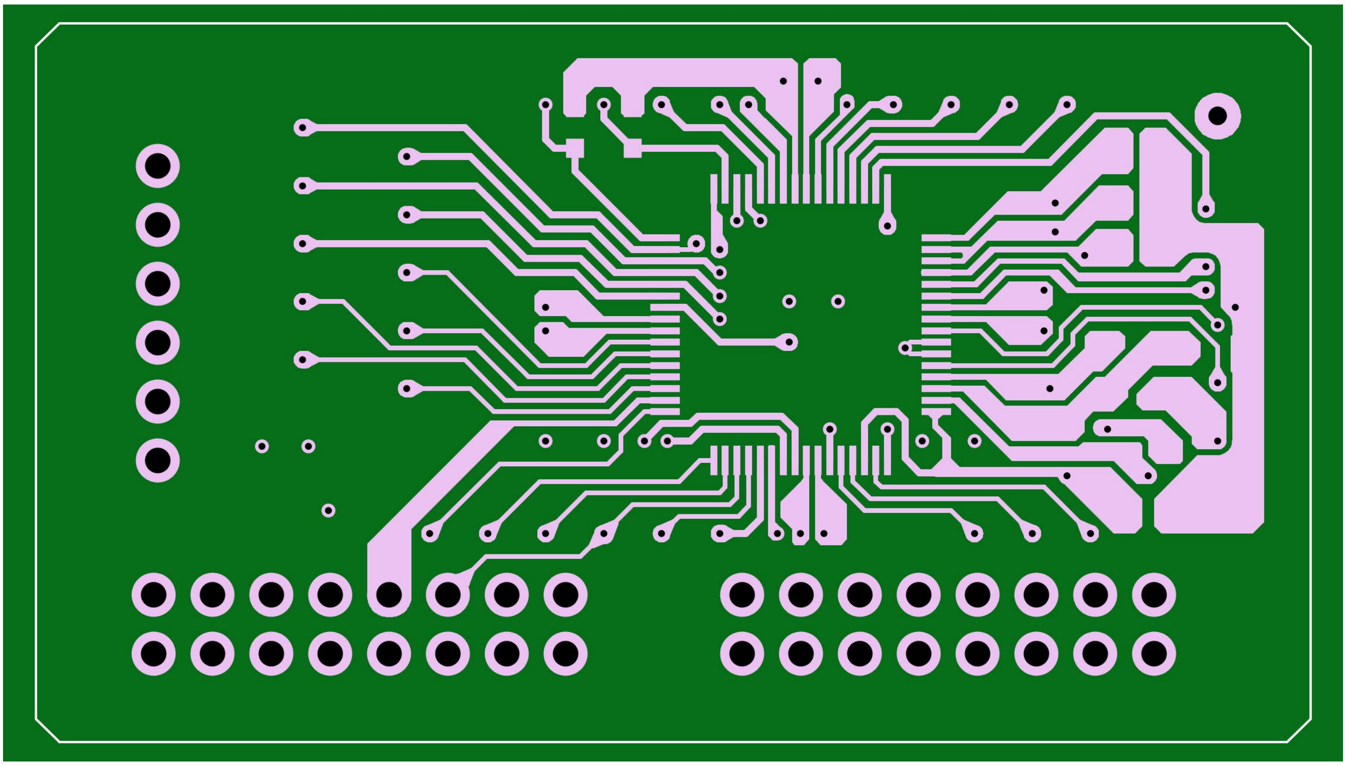
Fig. 3.1 Main Board Pattern Diagram (Top View)



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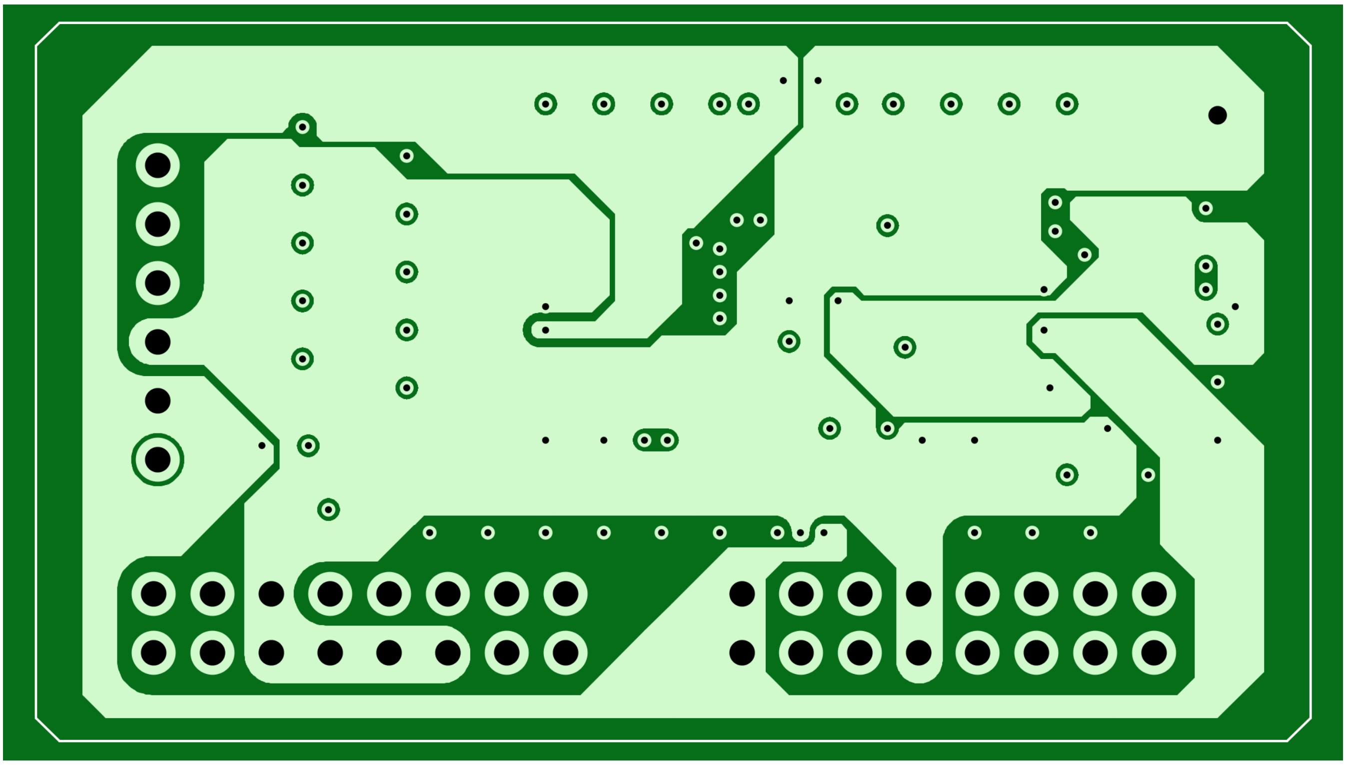

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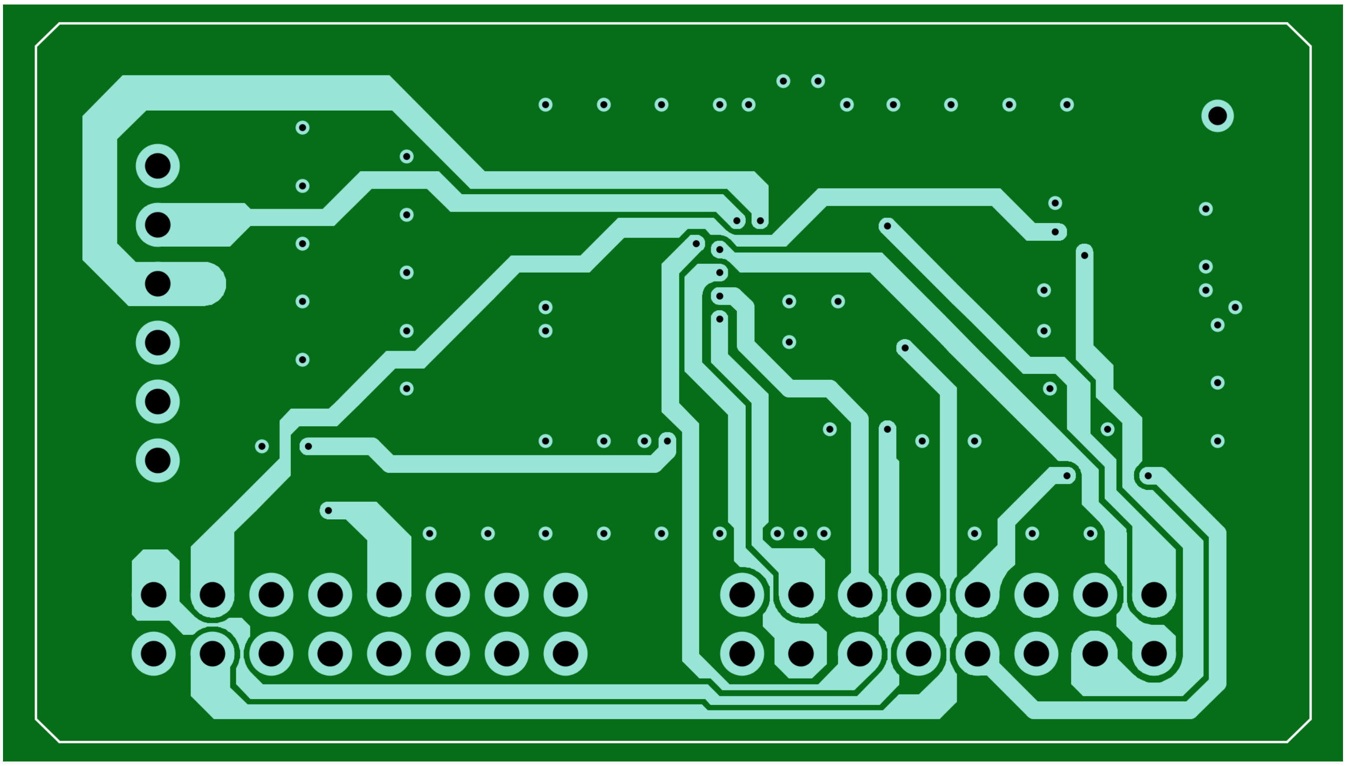

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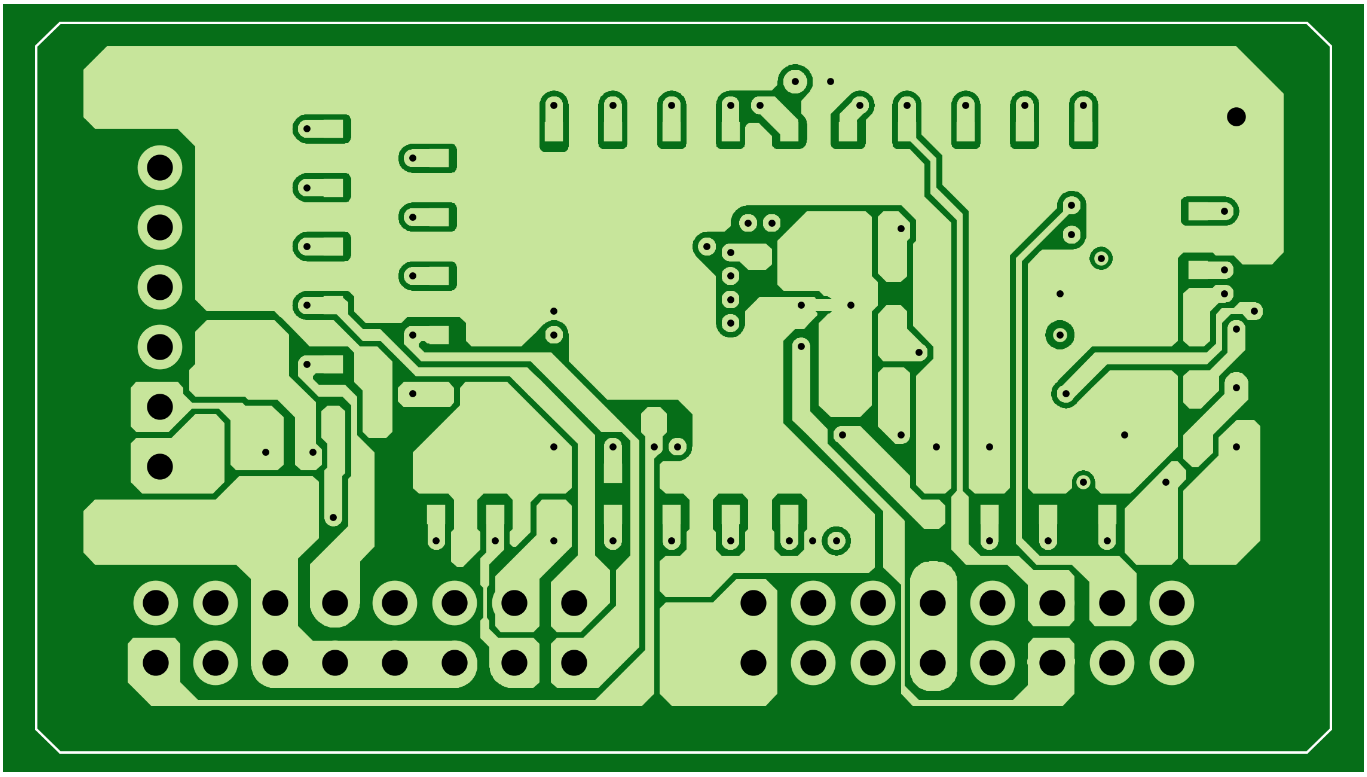

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Fig. 3.2 Control Board Pattern Diagram (Top View)

4. Operating Procedure

4.1. Connection to External Devices

Figure 4.1 shows the external connection terminals of this design. The area outlined in red indicates the AC input terminals, while the area outlined in blue indicates the DC output terminals.

Connect the positive side of the DC load to the DC Output (+) terminal, and the negative side (GND potential) to the DC Output (-) terminal. For the AC input, connect the AC Input (N) terminal to the Neutral side of the AC regulated power supply, and the AC Input (L) terminal to the Live side. If necessary, connect the FG pin to earth (frame ground). Please ensure that all connected load devices and cables meet the power supply specifications.

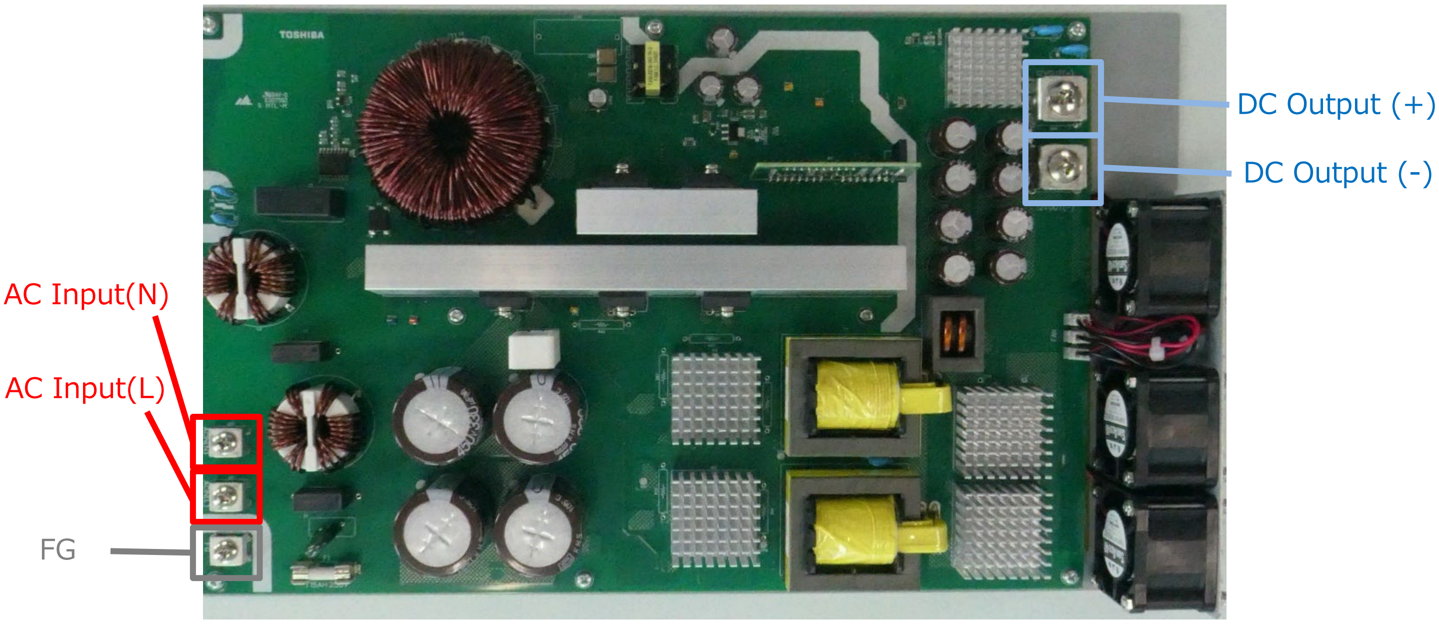

Fig. 4.1 External Connections

4.2. Start and Stop Procedure

Make sure all external terminals are 0V before starting.

[Starting Procedure]

1. Turn on the AC stabilized power supply.

[Stopping Procedure]

1. Turn off the AC stabilized power supply.

4.3. Evaluation Precautions (To Prevent Electric Shocks, Burns, etc.)

Be careful of electric shock when connecting the power supply. Do not touch any component of the power supply directly while it is energized. Be very careful when observing waveforms. Even after this power supply is shut down, there is a danger of electric shock due to residual charge of various capacitors. Make sure that the voltage of each component has dropped sufficiently before touching the BOARD.

In addition, the semiconductor devices and inductors of this power supply may generate heat according to the load current. This power supply assumes forced air cooling. Use an air-cooling device that enables heat-generating components to stay within the rated temperature range under high load. Do not touch any component of the power supply while the power supply is in operation as it may cause burns.

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5. Power Supply Characteristics

This section describes the efficiency measurement results of the power supply in this design.

Measurements were conducted with the input voltage set to either AC 115V or AC 230V. The maximum output power of this design is 1.1kW under both input conditions. In addition to the PFC circuit and the Interleaved Two Transistor Forward (ITTF) circuit required for AC-DC conversion, this design also includes an ORing output circuit. The efficiency values presented here reflect the performance of the entire system, including all these circuits. It should be noted that redesigning non-AC-DC related circuits or removing the ORing circuit may lead to improved power conversion efficiency.

Efficiency measurements were performed with the cooling fan powered by an external power source. If the fan is powered by the internal supply, the measurement results may vary.

5.1. Efficiency

Figure 5.1 shows the power conversion efficiency measurement results at input voltages of AC 115V and AC 230V. This design achieves high efficiency of 91.57% at 1.1kW output with 115V input, and 93.18% with 230V input.

Figures 5.2 through 5.5 show a comparison between the efficiency requirements of the 80 PLUS power supply certification and the efficiency of this design.

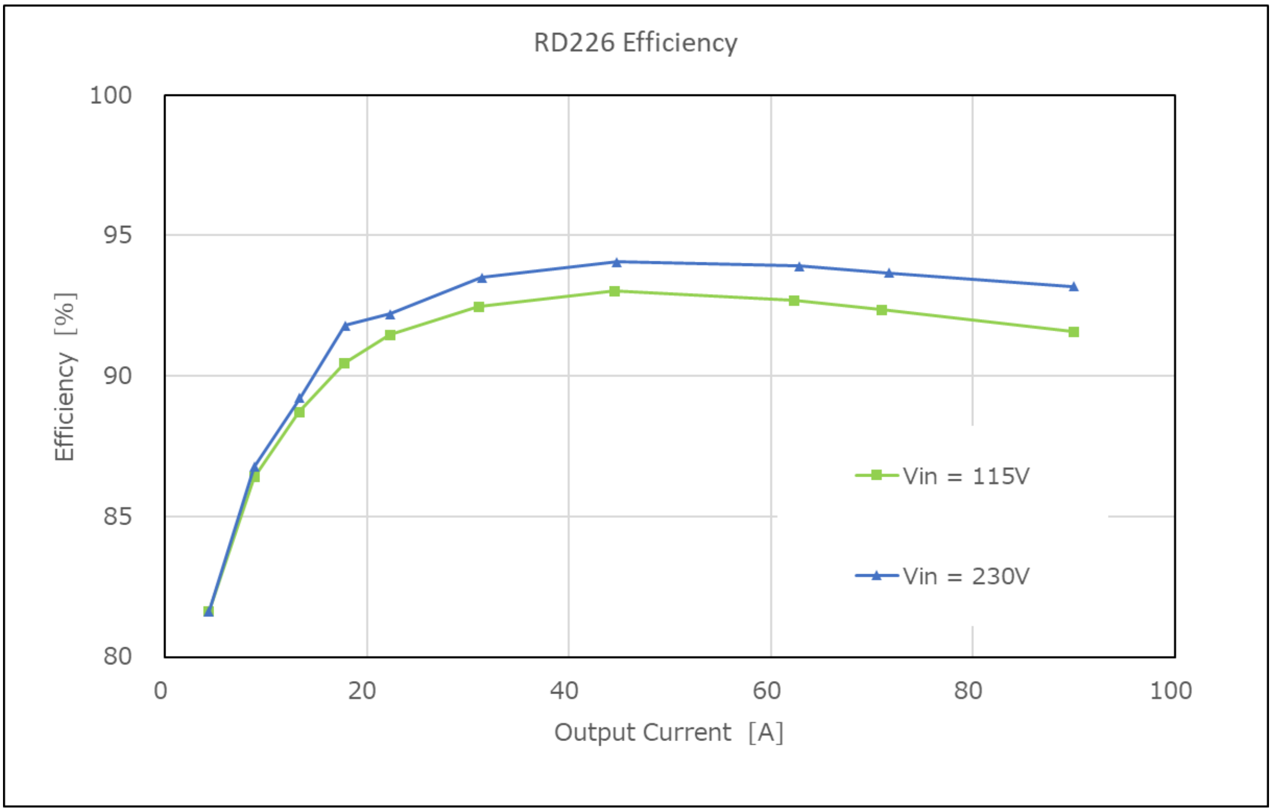

Fig. 5.1 Efficiency Measurement Result (Vin = 115V, Vin = 230V)

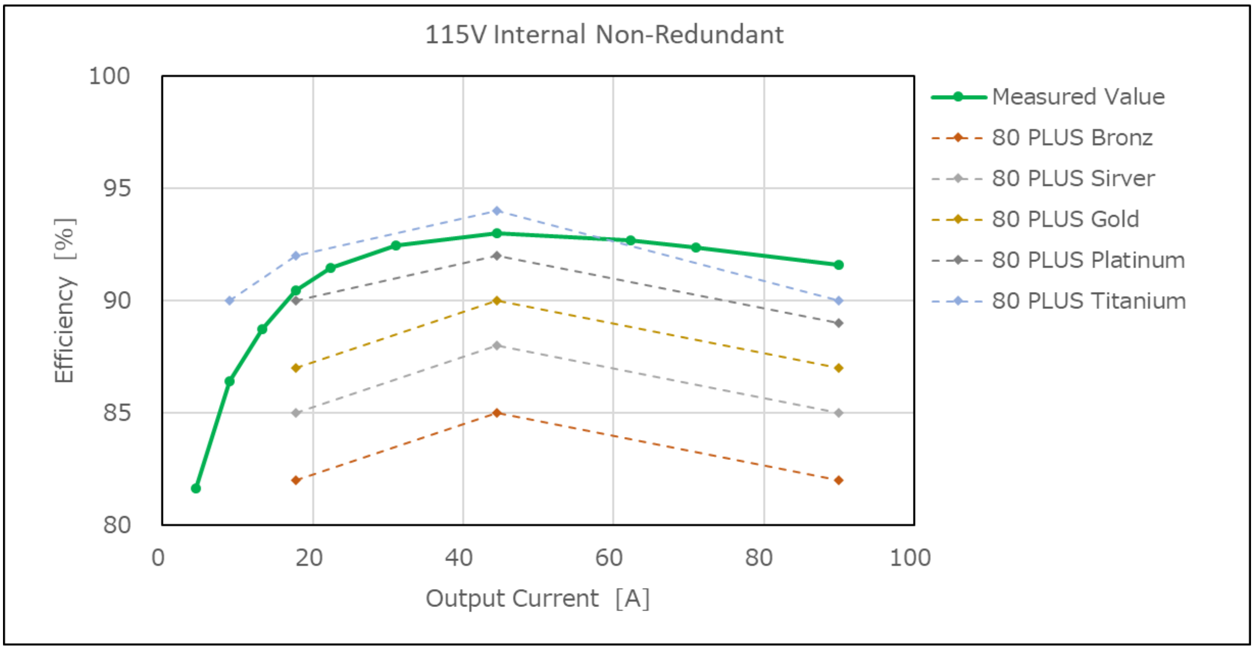

Fig. 5.2 Efficiency Measurement Result (80 PLUS 115V Internal Non-Redundant)

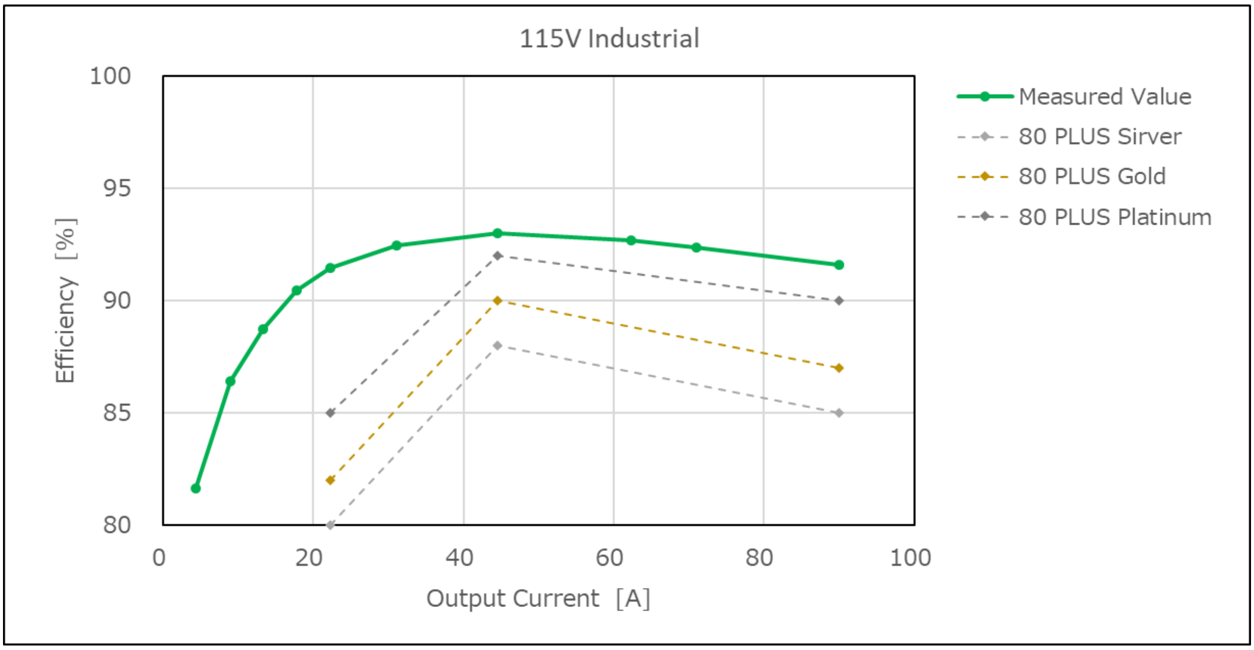

Fig. 5.3 Efficiency Measurement Result (80 PLUS 115V Industrial)

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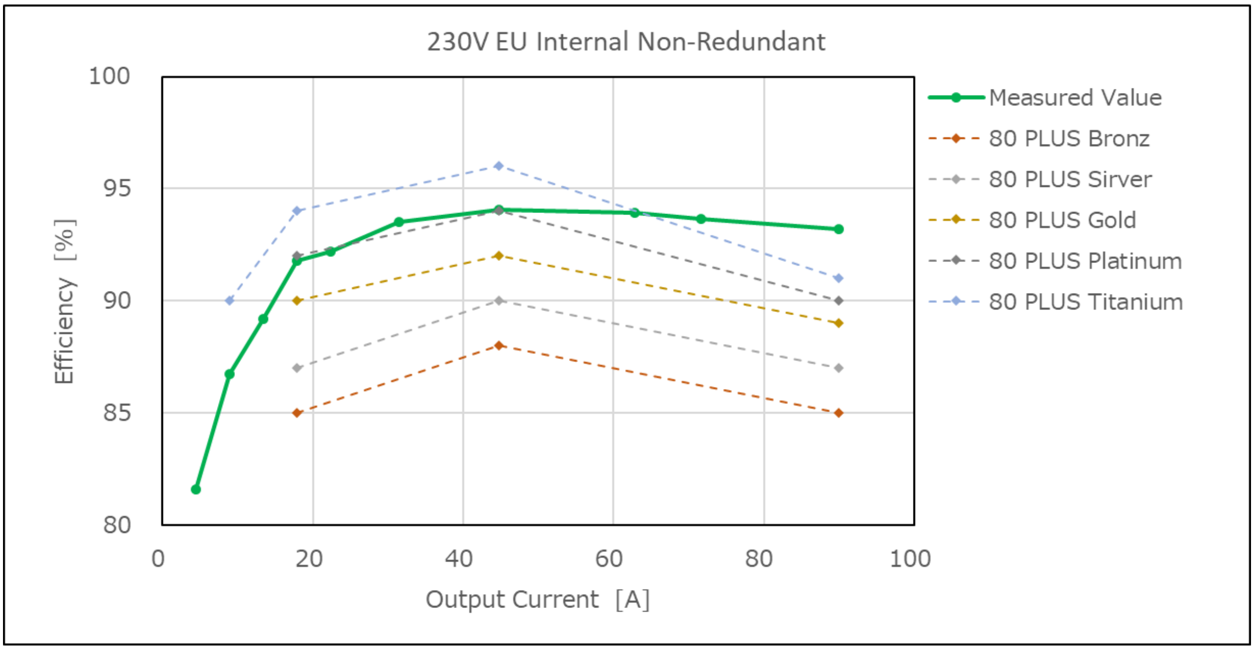

Fig. 5.4 Efficiency Measurement Result (80 PLUS 230V EU Internal Non-Redundant)

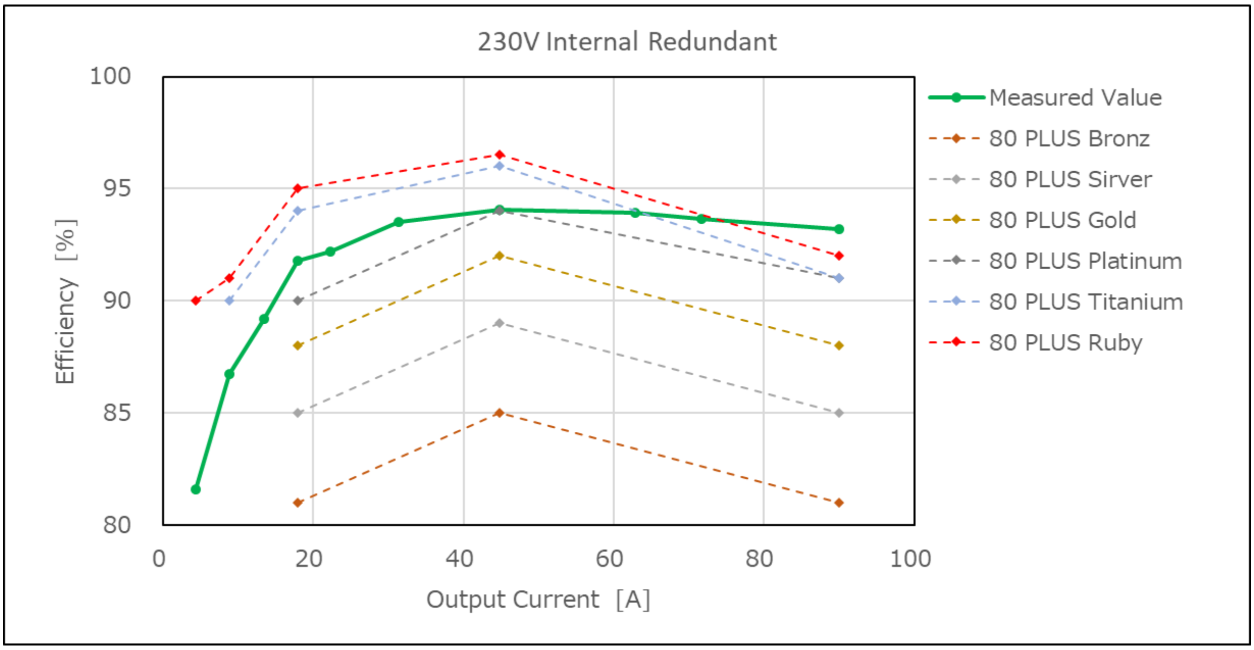

Fig. 5.5 Efficiency Measurement Result (80 PLUS 230V Internal Redundant)

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