1.6kW 48V Output Telecommunication Equipment Power Supply (Upgraded)

Reference Guide

RD250-RGUIDE-01

Toshiba Electronic Devices & Storage Corporation

Table of Contents

1. Introduction

This reference guide describes the specifications, usage, and characteristics of the 1.6kW 48V Power Supply for Telecommunications Equipment (hereafter referred to as “this design”).

This design is a power supply for telecommunications equipment that converts an AC input voltage of 90V to 264V into a 48V DC output with a maximum power rating of 1.6kW. It employs a semi-bridgeless Power Factor Correction (PFC) topology and an isolated Phase Shift Full Bridge (PSFB) converter to achieve highly efficient power conversion.

In addition, the output stage incorporates an ORing circuit, enabling highly reliable operation in an N+1 redundant power system configuration. By utilizing compact components, the design can be adapted to a variety of form factors and applications, including standard 1U power supplies. High-speed switching Toshiba power MOSFETs are used as the switching devices, enabling both high efficiency and high power density.

The semi-bridgeless PFC stage employs the TK125N60Z1 power MOSFET as the switching device and the TRS8A65F SiC Schottky Barrier Diode (SBD) in the boost section. The PSFB converter uses the TK095N65Z5 power MOSFETs on the primary side and the TPM7R10CQ5 power MOSFETs for secondary-side synchronous rectification. Signal transmission between the primary and secondary sides of the PSFB converter is achieved using the DCL540C01 digital isolator. The output ORing circuit utilizes the TPM1R908QM power MOSFET.

By incorporating these latest Toshiba devices, this design achieves higher efficiency than the previous 1.6 kW 48V Power Supply for Telecommunications Equipment, which employed the same circuit topology and was released in March 2021, resulting in an even more efficient power supply solution.

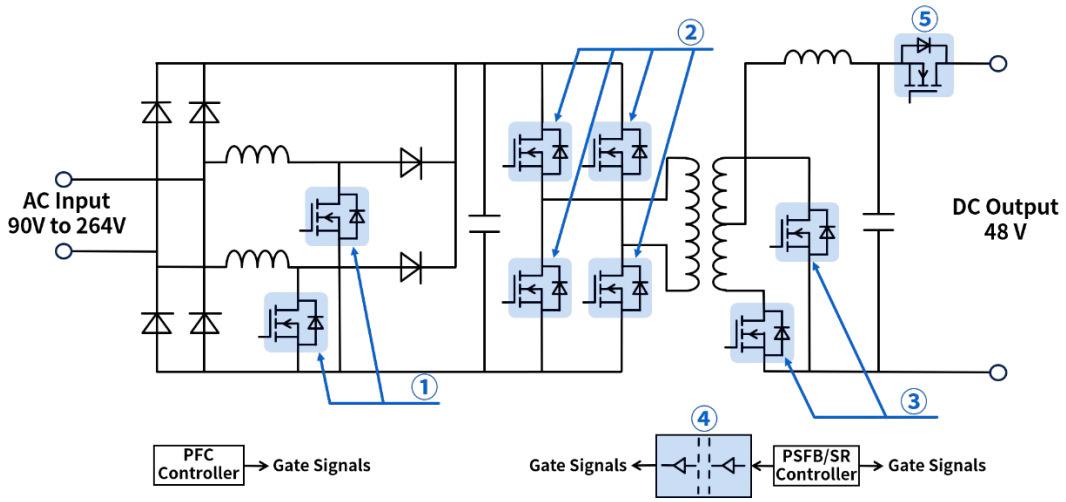


Figure 1.1 Block Diagram

Table 1.1 Updated Toshiba Devices

No.	Existing design	This upgraded design	Updates
①	TK25N60X	TK125N60Z1	DTMOS IV→VI
②	TK25N60X5	TK095N65Z5	DTMOS IV→VI
③	TPH2900ENH	TPM7R10CQ5	UTMOS VIII→X
④	TLP2767	DCL540C01	Photocoupler → Digital Isolator
⑤	TPH2R408QM	TPM1R908QM	Lower $R_{DS(on)}$ device (same generation)

Table 1.1 lists the major Toshiba devices that were updated in this upgraded design.

By optimizing the primary-side and secondary-side switching devices and their associated components, the conversion efficiency under the conditions of V_{in} = 230V and 100% load improved from 94.46% to 95.52%, achieving approximately a 1% increase in efficiency. In addition, power loss was reduced by approximately 20%, resulting in a more efficient 48V output power supply.

2. Appearance and Specifications

2.1. Specifications

Table 2.1 lists the characteristics of this design.

Table 2.1 Specifications

Parameters	Conditions	Min	Typ.	Max	Unit
Input Characteristics					
AC Input Voltage (rms)		90		264	V
AC Input Current (rms)	V_{in} = AC 90V, I_{out} = 16.67A			10	A
Input Frequency		47		63	Hz
Internal Characteristics (Semi-Bridgeless PFC Circuit)					
Output Voltage			391		V
Output Current	V_{in} = AC 230V		4.5		A
	V_{in} = AC 115V		2.2		A
Switching Frequency			60		kHz
Output Characteristics (PSFB Circuit)					
Output Voltage		45.6	48.0	50.4	V
Output Current	V_{in} = AC 230V			33.33	A
	V_{in} = AC 115V			16.67	A
Maximum Output Power	V_{in} = AC 230V			1.6	kW
	V_{in} = AC 115V			0.8	kW
Output Ripple Voltage	T_a = 25℃			480	mV
Switching Frequency			97.05		kHz
Others					
Protection	Output Overvoltage Protection, Output Overcurrent Protection, Output Short-Circuit Protection, and Overtemperature Protection				
Substrate Structure	FR-4, 6 layers (through vias), t = 1.6mm, Copper thickness: 70µm (outer layers), 35µm (inner layers)				

2.2. Block Diagram

Figure 2.1 shows a block diagram to understand the function.

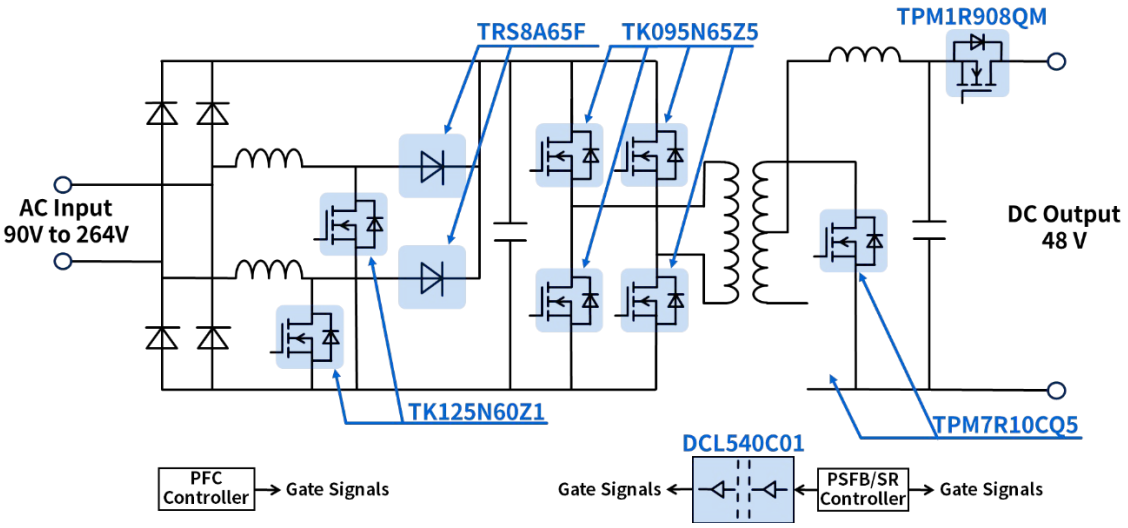


Figure 2.1 Block Diagram

2.3. Appearance

Figure 2.2 shows the appearance of this design.

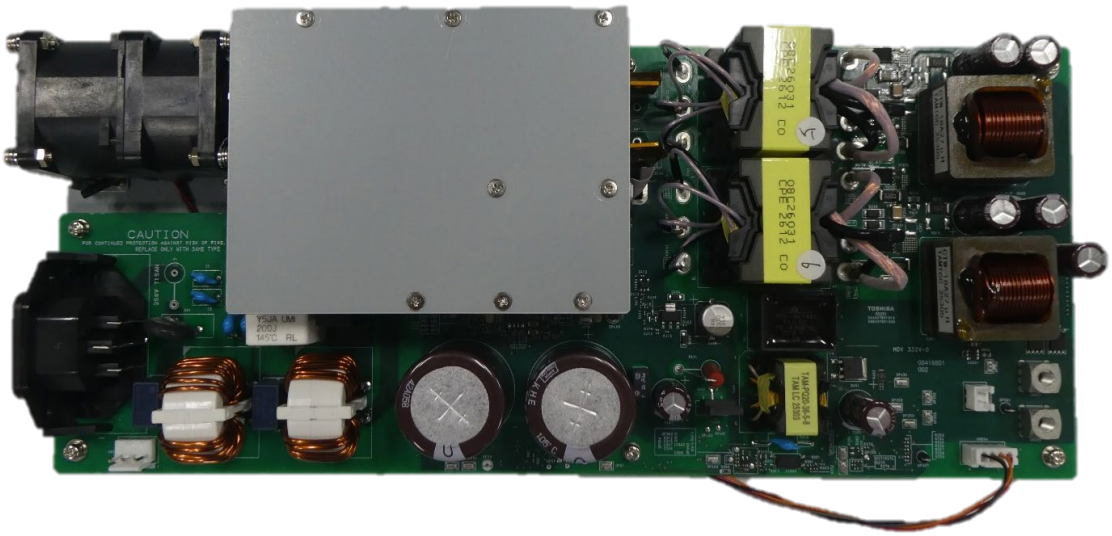
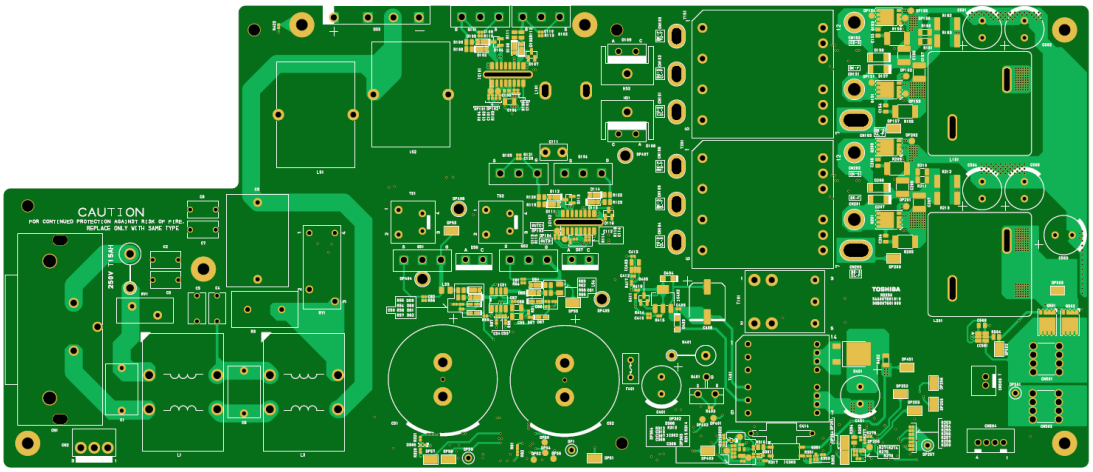


Figure 2.2 External View of This Design

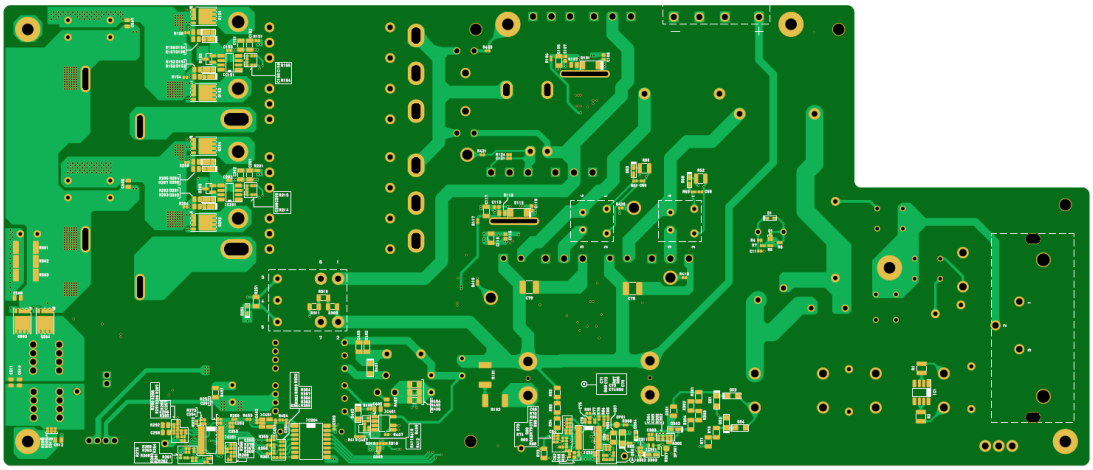
Dimensions: 300mm × 150mm × 54mm

2.4. PCB Component Layout

Figure 2.3 shows the component layout of the main board.



<Front Side>



<Back Side>

Figure 2.3 PCB Component Layout

3. Schematic, BOM, and PCB Layers

3.1. Schematic

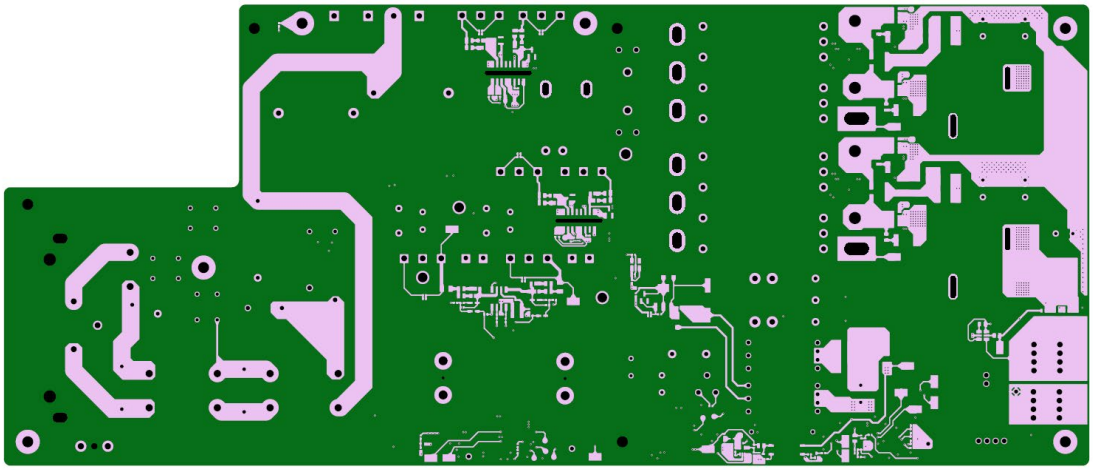
Refer to following files:
RD250-SCHEMATIC-xx.pdf
(xx is the revision number.)

3.2. BOM (Bill of Materials)

Refer to following files:
RD250-BOM-xx.pdf
(xx is the revision number.)

3.3. PCB Layers

Figure 3.1 shows PCB layers of the main board.
Refer to following files:
RD250-LAYER-xx.pdf
(xx is the revision number.)



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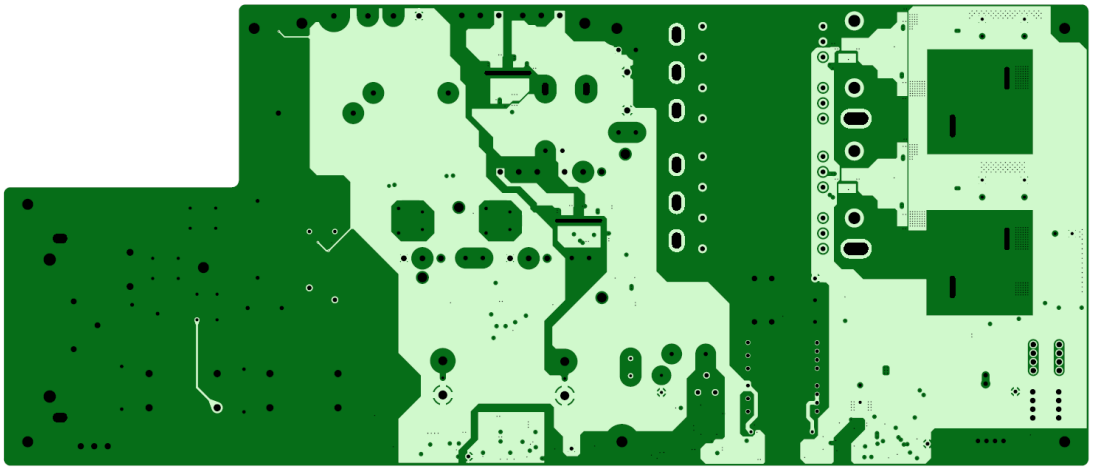

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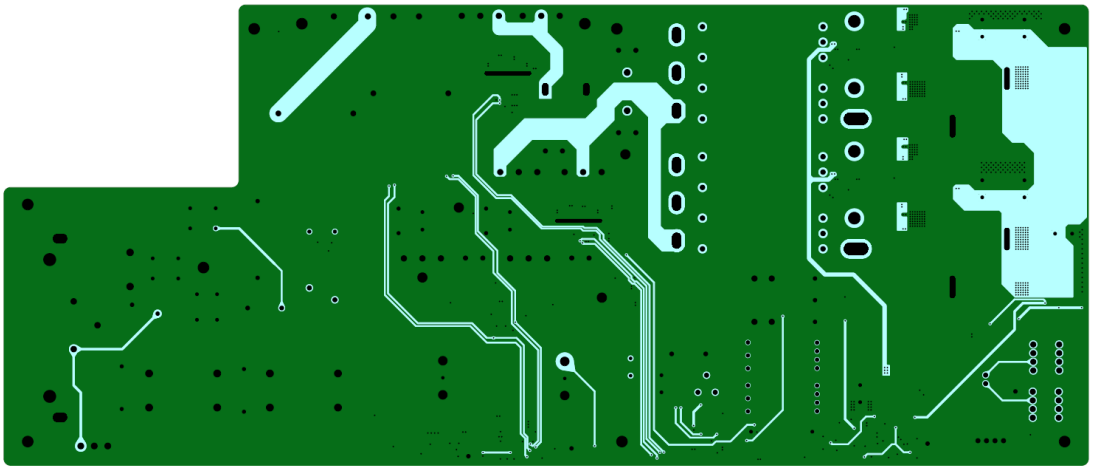

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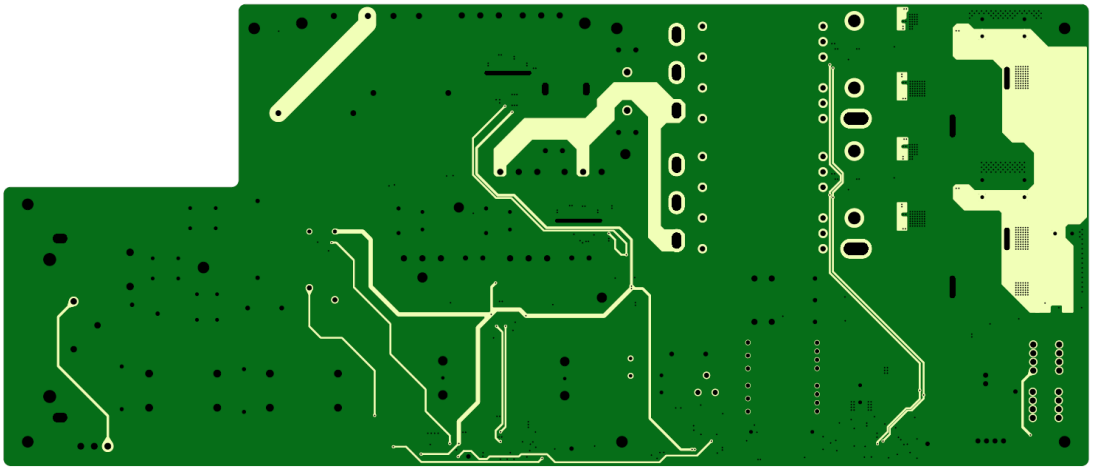

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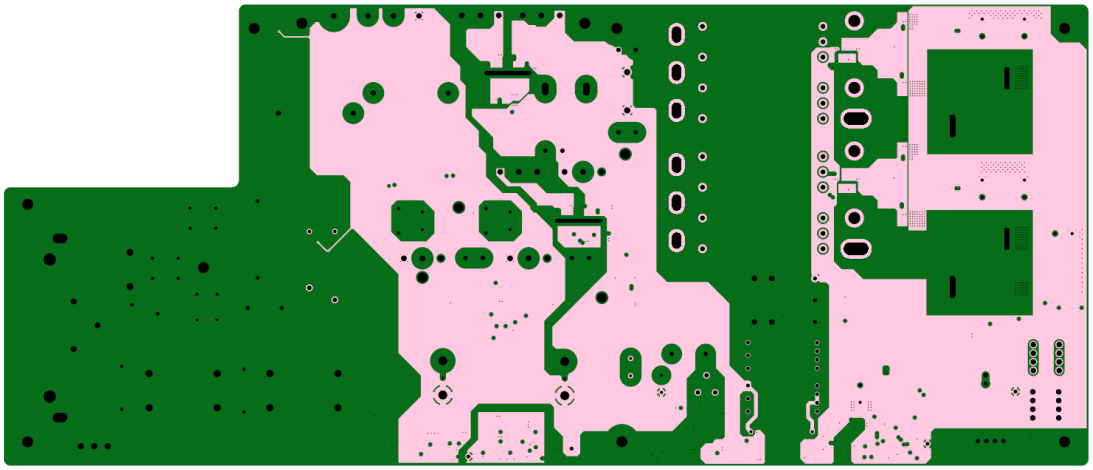
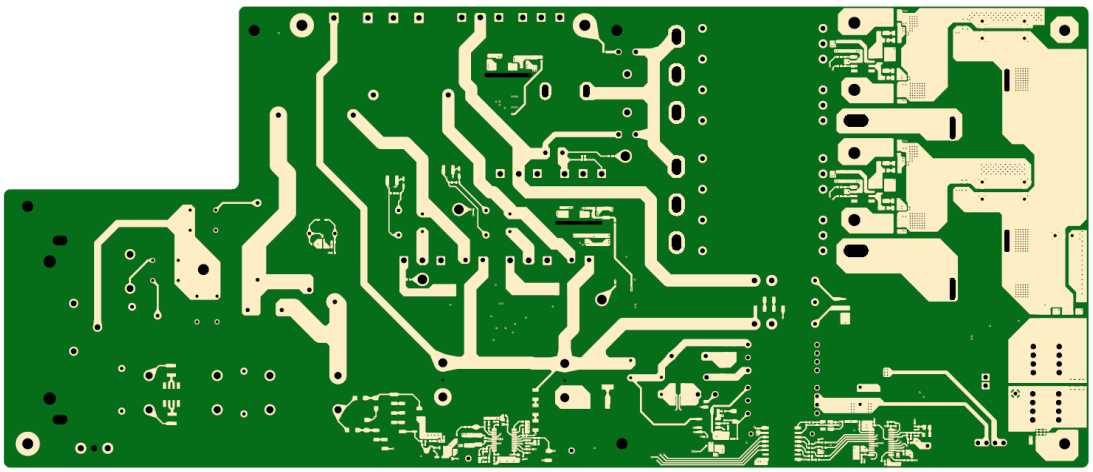


<L5>



<L6 (Bottom Layer)>

Figure 3.1 PCB Layer Pattern (Top View)

4. Operating Procedure

This section describes the operating procedure of this design.

4.1. Connections to External Equipment

Figure 4.1 shows the external connection terminals of this design. The area highlighted in red indicates the AC input terminal (CN1), while the area highlighted in blue indicates the DC output terminals (CN501 and CN502).

Connect an AC power cord to the AC inlet of CN1, and then connect the AC plug to an AC power source. Connect the positive terminal of the DC load to CN501 and the negative terminal of the DC load to CN502.

Ensure that the power source, load equipment, and cables used satisfy the electrical requirements specified for this power supply.

Fig 4.1 External Connection Terminals

4.2. Start and Stop Procedures

Before powering up this power supply, verify that the voltages at all input and output terminals are 0V.

[Start Procedure]

1. Turn on the AC power source.

[Stop Procedure]

1. Turn off the AC power source.

4.3. Safety Precautions (Electric Shock, Hot Surface Burns, etc.)

Take precautions to avoid electric shock when connecting the power supply. Do not touch any part of the power supply while it is energized. Exercise extreme caution when probing signals or measuring waveforms.

Even after the power supply has been turned off, electric shock may occur due to residual charge stored in capacitors. Before touching the board, ensure that all capacitors have been sufficiently discharged.

In addition, power semiconductor devices, inductors, and other components may generate significant heat depending on the load current. This power supply is designed for use with forced-air cooling. Use an appropriate cooling system to maintain all heat-generating components within their specified operating temperature range, especially under high-load conditions.

To avoid burns, do not touch any part of the power supply while it is in operation.

5. Power Supply Characteristics

This section describes the efficiency measurement results of the power supply.

5.1. Efficiency

The efficiency was measured with the output voltage of the programmable AC power source set to either 115V or 230V. As shown in Figure 5.1, the power supply achieves a high conversion efficiency of 95.52% at 230V input and 100% load.

Please note that the efficiency measurements were performed with the cooling fan powered by an external power supply. The measured efficiency may vary when the cooling fan is powered by the internal power supply.

In addition, this design incorporates an ORing circuit at the output stage. Further efficiency improvement may be achieved if the ORing circuit is removed.

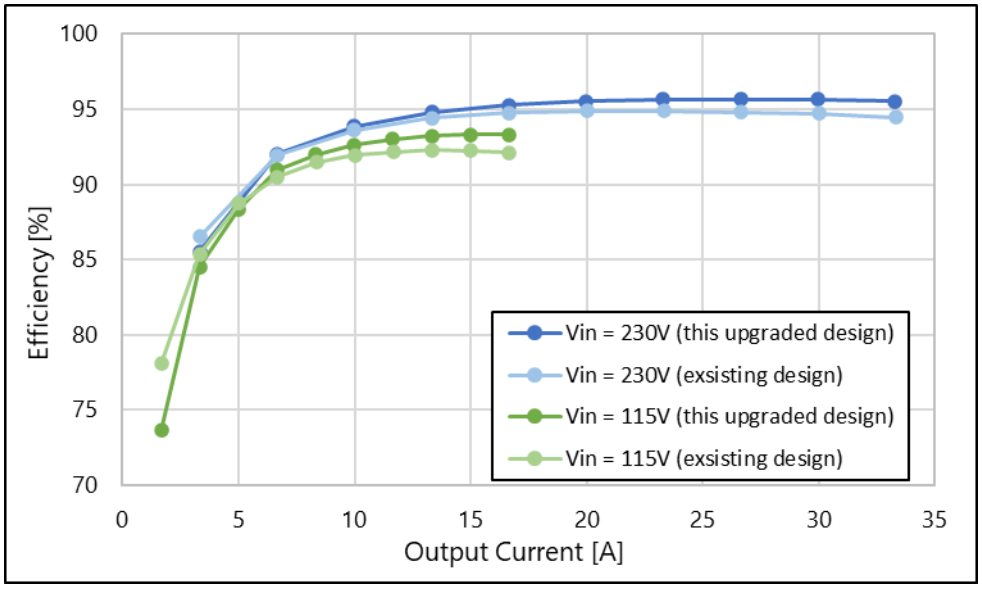


Figure 5.1 Efficiency vs. Load (AC 115V / AC 230V Input)

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**.

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