# 1.6kW Server Power Supply

# Reference Guide

## RD001-RGUIDE-02

TOSHIBA ELECTRONIC DEVICES & STORAGE CORPORATION

# Table of Contents

# 1. Introduction

This reference guide describes the specification, operating method and performance of the 1.6 kW server power supply (this power supply). This power supply provides 1.6 kW power at 12 VDC. The AC input (90 to 264 V) is converted into 12 VDC by a semi-bridgeless PFC circuit and an isolated phase-shift full-bridge (PSFB) circuit. This power supply contains an ORing circuit and can be used for the designing of a power supply that requires an N+1 redundant operation. This power supply is designed to fit in a 1U rack shelf and is suitable for power supply applications of various sizes and purposes, including a general 1U server power supply. Incorporating Toshiba's fast-switching MOSFETs as switching devices, this power supply provides high efficiency.

# 2. Specification

## 2.1. Specification

The following table is the input and output specification of this power supply.

**Table 2.1.1 1.6kW Sever Power Supply Specification**

| Parameter | Condition | Min | Typ. | Max | UNIT |
|---|---|---|---|---|---|
| Input characteristics | | | | | |
| AC input voltage (rms) | | 90 | | 264 | V |
| AC input current (rms) | VinAC = 90 V, Iout = 66.7 A | | | 12 | A |
| AC input frequency | | 47 | | 63 | Hz |
| Primary side 12V power supply voltage | | 11.4 | 12.0 | 12.6 | V |
| Primary side 12V power supply current | | | | 400 | mA |
| Secondary side 12V power supply voltage | | 11.4 | 12.0 | 12.6 | V |
| Secondary side 12V power supply current | | | | 400 | mA |
| | | | | | |
| Semi-bridgeless PFC circuit output characteristics (internal characteristics) | | | | | |
| Output voltage | | | 380 | | V |
| Output current | VinAC = 230 V | | 4.7 | | A |
| | VinAC = 115 V | | 2.4 | | |
| Maximum output power | VinAC = 230 V | | | 1.6 | kW |
| | VinAC = 115 V | | | 0.8 | kW |
| Switching frequency | | | 60 | | kHz |
| | | | | | |
| Output characteristics (PSFB circuit) | | | | | |
| Output voltage | | 11.4 | 12.0 | 12.6 | V |
| Output current | VinAC = 230 V | | | 133 | A |
| | VinAC = 115 V | | | 66.7 | A |
| Maximum output power | VinAC = 230 V | | | 1.6 | kW |
| | VinAC = 115 V | | | 0.8 | kW |
| Output ripple voltage | Ta=25℃ | | | 200 | mV |
| Switching frequency | | | 60 | | kHz |

## 2.2. Outline

The following image shows this power supply.


**Fig. 2.2.1　1.6kW Server Power Supply**

Outline size

307mm x 133mm x 43mm(including the base plate under PCB and the cover plate over heatsink)

## 2.3. Block Diagram

The following is the block diagram of this power supply. It is simplified to make it easy to understand the entire circuit from the AC input section to the 12 VDC output section. Note, therefore, that it differs from the actual circuit. Refer to RD001-SCHEMATIC-01 for the actual circuit diagram. This power supply requires external auxiliary 12 V power supplies on both the primary and secondary sides. To develop an actual product, it is necessary to generate 12 V power from an AC source according to its specification.

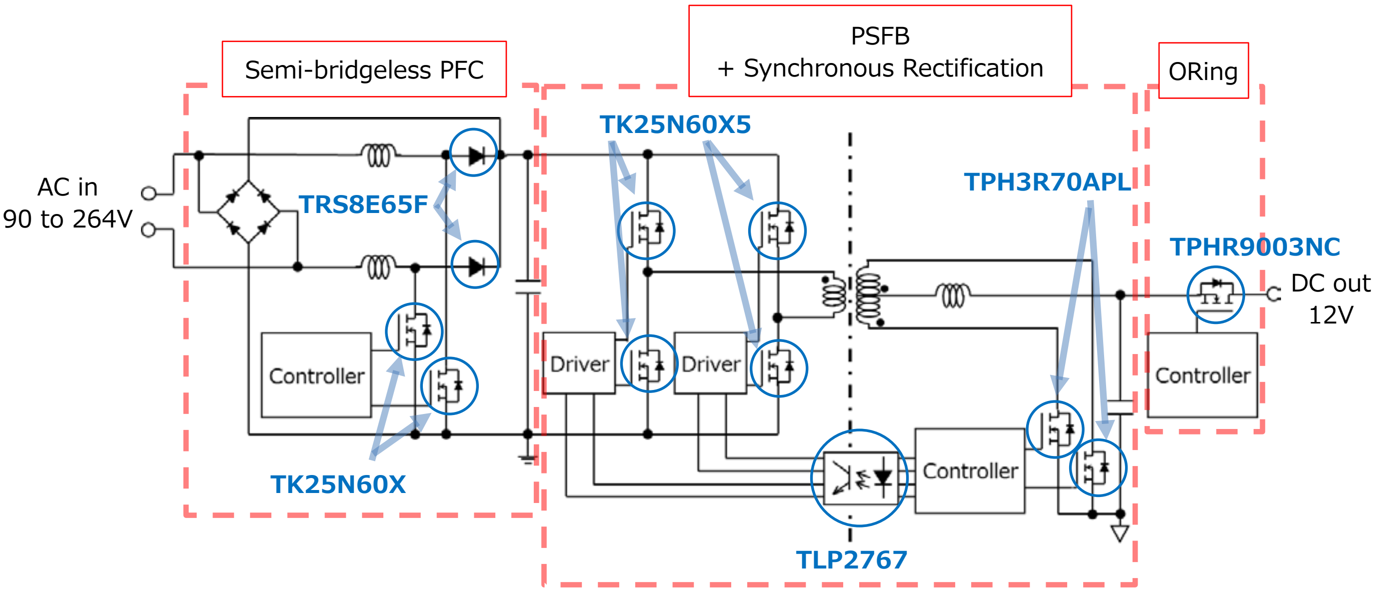


**Fig. 2.3.1 Block Diagram**

## 2.4. Bill of Material

The following table is a bill of material for this power supply.

**Table 2.4.1 Bill of Material**

| Item No. | Designator | Quantity | Value | Part Number | Manufacturer | Description | Package | Not Mounted |
|---|---|---|---|---|---|---|---|---|
| 1 | C1, C7 | 2 | 330 uF | 450MXH330 | RUBYCON | Aluminum Electrolytic, 450 V, ±20% | | |
| 2 | C101 | 1 | 220 pF | DE2B3KY221KA3BM02F | MURATA | Disc Ceramic, 250 V, ±10 % | | |
| 3 | C18, C19, C23, C42, C47, C71-C74, C92-C98, C100, C102 | 18 | 100 nF | | | Ceramic, 25 V, ±10 % | 1005 | |
| 4 | C21 | 1 | 18 nF | | | Ceramic, 25 V, ±10 % | 1005 | |
| 5 | C22 | 1 | 1800 pF | | | Ceramic, 50 V, ±10 % | 1005 | |
| 6 | C24, C55, C58, C60-C62, C67, C70, C99 | 9 | 1 uF | | | Ceramic, 25 V, ±20 % | 1005 | |
| 7 | C25 | 1 | 150 nF | | | Ceramic, 25 V, ±10 % | 1005 | |
| 8 | C26, C59, C75, C76 | 4 | 2.2 nF | | | Ceramic, 50 V, ±10 % | 1005 | |
| 9 | C27, C51 | 2 | 220 nF | | | Ceramic, 25V, ±10 % | 1005 | |
| 10 | C2-C6 | 5 | 1500 uF | 25ZLQ1500MEFC10X25 | RUBYCON | Aluminum Electrolytic, 25 V, ±20 % | | |
| 11 | C30 | 1 | 470 nF | LE474-M | OKAYA | Polypropylene Film, 275 V, ±10 % | | |
| 12 | C31, C32, C63, C64 | 4 | 2.2 nF | DE2E3KY222MN3AM02F | MURATA | Disc Ceramic, 250 V , ±20 % | | |
| 13 | C33, C65 | 2 | 2.2 uF | 890324026034CS | WURTH | Polypropylene Film, 275 V, ±10 % | | |
| 14 | C34, C36 | 2 | 4.7 pF | | | Ceramic, 50 V, ±0.1 pF | 1005 | |
| 15 | C35, C37 | 2 | 47 nF | | | Ceramic, 25 V, ±10 % | 1005 | |
| 16 | C38, C39 | 2 | 1.2 nF | | | Ceramic, 50 V, ±10 % | 1005 | |
| 17 | C40 | 1 | 120 nF | | | Ceramic, 25 V, ±10 % | 1608 | |
| 18 | C41 | 1 | 1 uF | | | Ceramic, 25 V, ±10 % | 2012 | |
| 19 | C43, C45, C80, C81 | 4 | 1 nF | | | Ceramic, 50 V, ±10 % | 1005 | |
| 20 | C44, C46 | 2 | 3.3 nF | | | Ceramic, 25 V, ±10 % | 1005 | |
| 21 | C48 | 1 | 22 uF | | | Ceramic, 25 V, ±10 % | 3216 | |
| 22 | C49 | 1 | 470 nF | | | Ceramic, 25 V, ±10 % | 1005 | |
| 23 | C50 | 1 | 2.7 nF | | | Ceramic, 50 V, ±10 % | 1005 | |
| 24 | C52 | 1 | 220 nF | LE224-M | OKAYA | Polypropylene Film, 275 V, ±10 % | | |
| 25 | C66 | 1 | 10 uF | | | Ceramic, 25 V, ±20 % | 1608 | |
| 26 | C78, C79 | 2 | 100 pF | DE2B3KY101KA3BM02F | MURATA | Disc Ceramic, 250 V, ±10 % | | |
| 27 | C82-C91 | 10 | 10 uF | | | Ceramic, 25 V, ±10 % | 3216 | |
| 28 | fan1 | 1 | | 9CRB0412P5S201 | SANYO DENKI | Counter Rotating FAN | | |
| 29 | CN1 | 1 | 15 A | AC-P05CP24 | ECHO ELECTRIC | 250 V | | |
| 30 | CN10 | 1 | | A2-2PA-2.54DSA | HIROSE | | | |
| 31 | CN2-CN5 | 4 | 3 A | A2-1PA-2.54DSA | HIROSE | 200 V | | |

| Item No. | Designator | Quantity | Value | Part Number | Manufacturer | Description | Package | Not Mounted |
|---|---|---|---|---|---|---|---|---|
| 32 | CN6, CN7 | 2 | | OP-1100 | OSADA | | | |
| 33 | CN8 | 1 | | 5045-02A | MOLEX | | | |
| 34 | | 1 | | 51191-0200 | MOLEX | | Housing (for CN8) | |
| 35 | D1, D2 | 2 | | TRS8E65F | TOSHIBA | | | |
| 36 | D12-D14, D30-D33 | 7 | | 1SS352(TPH3,F)1-1E1A | TOSHIBA | | | |
| 37 | D16-D19 | 4 | | CMF01 | TOSHIBA | | | |
| 38 | D20, D21, D34, D35 | 4 | | CMH01 | TOSHIBA | | | |
| 39 | D22-D29 | 8 | | TBAT54 | TOSHIBA | | | |
| 40 | D3 | 1 | | GSIB2580 | VISHAY | | | |
| 41 | D36-D47, D51-D58 | 20 | | CUS01(TE85L,Q) | TOSHIBA | | | |
| 42 | D48 | 1 | | BAS316 | TOSHIBA | | | |
| 43 | D50 | 1 | | MMSZ4699T1G | ON Semiconductor | | | |
| 44 | D8, D9 | 2 | | CRG04 | TOSHIBA | | | |
| 45 | F1 | 1 | 15 A | 0215015.MXEP | Littelfuse | | | |
| 46 | FB1, FB2 | 2 | | FBMJ3216HS800-T | TAIYO YUDEN | | | |
| 47 | HS1-HS4 | 4 | | HOLE2.8 | - | | Through Hole | |
| 48 | IC1 | 1 | | HF81 | MPS | | | |
| 49 | IC10 | 1 | | UCC28950PWR | TEXAS | | | |
| 50 | IC11 | 1 | | TLV70433DBVT | TEXAS | | | |
| 51 | IC13-IC16 | 4 | | TLP2767 | TOSHIBA | | | |
| 52 | IC2, IC6, IC7 | 3 | | UCC27524AD | TEXAS | | | |
| 53 | IC20 | 1 | | ALKG8210 | PANASONIC | | | |
| 54 | IC21-IC24 | 4 | | TC7SZ04FU | TOSHIBA | | | |
| 55 | IC3 | 1 | | UCC28070A | TEXAS | | | |
| 56 | IC4, IC5 | 2 | | UCC27714DR | TEXAS | | | |
| 57 | IC8 | 1 | | TPS2412D | TEXAS | | | |
| 58 | L1, L2 | 2 | 230 uH/ 350 uH (Rated Current/Idc=0) | THN23/14V-08231 | TMP | | 29 × 18 | |
| 59 | L11, L12 | 2 | 13 mH | SCF27-10-1300 | TOKIN | 10 A | 34.5 × 25.5 | |
| 60 | L3 | 1 | Terminals are shorted by 22AWG Cable | | | 22AWG Cable | | |
| 61 | L5, L6 | 2 | 3.5 uH | TR-AG1341 | TOKYO SEIDEN | 90 A, ±25 % | | |
| 62 | Q1, Q2 | 2 | | TK25N60X | TOSHIBA | | | |
| 63 | Q15-Q24 | 10 | | TPHR9003NC | TOSHIBA | | | |
| 64 | Q3-Q6 | 4 | | TK25N60X5 | TOSHIBA | | | |
| 65 | Q7-Q14, Q25-Q28 | 12 | | TPH3R70APL | TOSHIBA | | | |

| Item No. | Designator | Quantity | Value | Part Number | Manufacturer | Description | Package | Not Mounted |
|---|---|---|---|---|---|---|---|---|
| 66 | R1, R89, R91, R92, R94, R95 | 6 | 1 M | | | 100 mW, ±5 % | 1608 | |
| 67 | R100 | 1 | 124 k | | | 100 mW, ±1 % | 1608 | |
| 68 | R101 | 1 | 187 k | | | 100 mW, ±1 % | 1608 | |
| 69 | R102 | 1 | 30 k | | | 100 mW, ±1 % | 1608 | |
| 70 | R114, R115 | 2 | 2.2 | | | 500 mW, ±5 % | 3225 | |
| 71 | R116, R118, R120-R125 | 8 | 1 | | | 100 mW, ±5 % | 1608 | |
| 72 | R126, R127, R132-R137 | 8 | 0 | | | 500mW | 3216 | |
| 73 | R138 | 1 | 10_5W-FUSE | RF-5-4 10ΩJ | TAKMAN | | | |
| 74 | R149-R152, R227, R228 | 6 | 680 | | | 100 mW, ±1 % | 1608 | |
| 75 | R178, R179 | 2 | 300 k | | | 1 W, ±5 % | 6432 | |
| 76 | R18, R20, R23, R24, R212-R215 | 8 | 3.01 | | | 500 mW, ±1 % | 3216 | |
| 77 | R185 | 1 | 20 | | | 250 mW, ±5 % | 3216 | |
| 78 | R19, R21, R22, R25, R28, R29, R31, R33, R71, R73 | 10 | 10 k | | | 100 mW, ±5 % | 1608 | |
| 79 | R194-R197 | 4 | 620 | | | 100 mW, ±1 % | 1608 | |
| 80 | R199 | 1 | 680 | | | 1 W, ±1 % | 6432 | |
| 81 | R2, R90 | 2 | 23.2 k | | | 100 mW, ±1 % | 1608 | |
| 82 | R42 | 1 | 9.09 k | | | 100 mW, ±1 % | 1608 | |
| 83 | R43-R45 | 3 | 2.37 k | | | 100 mW, ±1 % | 1608 | |
| 84 | R62, R69, R110-R113, R117, R153-R157, R160, R163, R166, R204-R206, R216-R219 | 22 | 0 | | | 100 mW | 1608 | |
| 85 | R47 | 1 | 8.25 k | | | 100 mW, ±1 % | 1608 | |
| 86 | R49 | 1 | 22.6 | | | 100 mW, ±1 % | 1608 | |
| 87 | R51, R52 | 2 | 22 k | | | 100 mW, ±1 % | 1608 | |
| 88 | R53, R104, R186-R193 | 10 | 100 k | | | 100 mW, ±5 % | 1608 | |
| 89 | R54 | 1 | 15 k | | | 100 mW, ±5 % | 1608 | |
| 90 | R56 | 1 | 127 k | | | 10 0mW, ±1 % | 1608 | |
| 91 | R57 | 1 | 100 k | | | 100 mW, ±1 % | 1608 | |
| 92 | R6 | 1 | 2.2 | | | 100 mW, ±5 % | 1608 | |

| Item No. | Designator | Quantity | Value | Part Number | Manufacturer | Description | Package | Not Mounted |
|---|---|---|---|---|---|---|---|---|
| 93 | R60 | 1 | 47 k | | | 100 mW, ±5 % | 1608 | |
| 94 | R61 | 1 | 330 | | | 125 mW, ±5 % | 1608 | |
| 95 | R63, R130, R172, R173 | 4 | 100 | | | 125 mW, ±5 % | 1608 | |
| 96 | R64, R65, R66, R98, R99 | 5 | 6.8 k | | | 100 mW, ±5 % | 1608 | |
| 97 | R67, R81, R85, R169, R170 | 5 | 1 k | | | 125 mW, ±5 % | 1608 | |
| 98 | R7, R8 | 2 | 33 | | | 500 mW, ±5 % | 3225 | |
| 99 | R72, R74, R108, R109 | 4 | 5.11 | | | 500 mW, ±1 % | 3216 | |
| 100 | R75 | 1 | 49.9 | | | 125 mW, ±1 % | 1608 | |
| 101 | R76, R105 | 2 | 100 k | | | 250 mW, ±1 % | 3216 | |
| 102 | R77, R106 | 2 | 1 k | | | 3 W, ±5 % | | |
| 103 | R79, R80 | 2 | 75 k | | | 500 mW, ±1 % | 3225 | |
| 104 | R82, R86 | 2 | 1.78 k | | | 100 mW, ±1 % | 1608 | |
| 105 | R83, R87 | 2 | 3.56 k | | | 100 mW, ±1 % | 1608 | |
| 106 | R9 | 1 | 2 k | | | 100 mW, ±5 % | 1608 | |
| 107 | R93, R103 | 2 | 115 k | | | 100 mW, ±1 % | 1608 | |
| 108 | R96 | 1 | 3.9 k | | | 100 mW, ±5 % | 1608 | |
| 109 | R97 | 1 | 3.65 k | | | 100 mW, ±1 % | 1608 | |
| 110 | RV1 | 1 | 560 V | TND14V-561KB00AAA0 | NIPPON CHEMICON | | | |
| 111 | T2, T3 | 2 | 1:200 | P009-203 | PONY | | | |
| 112 | T4 | 1 | 1:100 | PE-63587 | PULSE | | | |
| 113 | T5, T6 | 2 | 20:1:1 | TR-AN0536 | TOKYO SEIDEN | | | |
| 114 | TP1-TP15, TP17-TP40, TP44 | 40 | | HK-2-S | MAC8 | | | |
| 115 | TP41, TP42 | 2 | | LC-22-S-BLACK | MAC8 | | | |
| 116 | TP43, TP45 | 2 | | LC-22-S-WHITE | MAC8 | | | |
| 901 | C20, C77 | 2 | 100 pF | | | Ceramic, 50 V, ±5 % | 1608 | Not Mounted |
| 902 | C53, C54, C56, C57 | 4 | 220 pF | | | Ceramic, 50 V, ±5 % | 1608 | Not Mounted |
| 903 | D49 | 1 | | CRZ15 | TOSHIBA | | | Not Mounted |
| 904 | R46, R48, R55, R58, R59, R70, R171, R174-R177, R180-R182, R184, R198, R207-R209, R220-R225 | 25 | 0 | | | 100 mW | 1608 | Not Mounted |
| 905 | R50 | 1 | 825 k | | | 100 mW, ±1 % | 1608 | Not Mounted |
| 906 | R78, R107, R128, R129 | 4 | 1 k | | | 3 W, ±5 % | | Not Mounted |

| Item No. | Designator | Quantity | Value | Part Number | Manufacturer | Description | Package | Not Mounted |
|---|---|---|---|---|---|---|---|---|
| 907 | R200-R203 | 4 | 680 | | | 1W,±1% | 6432 | Not Mounted |
| 908 | R210, R211 | 2 | 6.8 k | | | 100 mW, ±5 % | 1608 | Not Mounted |

## 2.5. Printed Wiring Board (PWB) Layout

The following image shows the layout of Layer 1 of the PWB of this power supply.

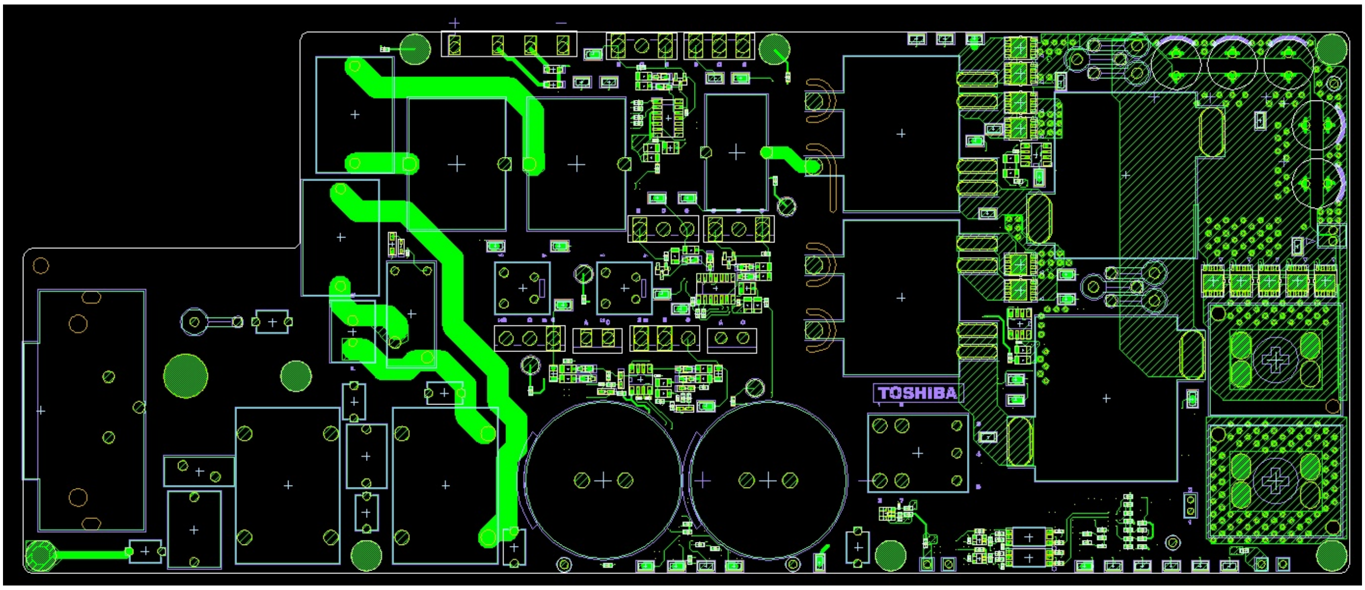


**Fig. 2.5.1 Layer1**

The following image shows the layout of Layer 2 of the PWB of this power supply.

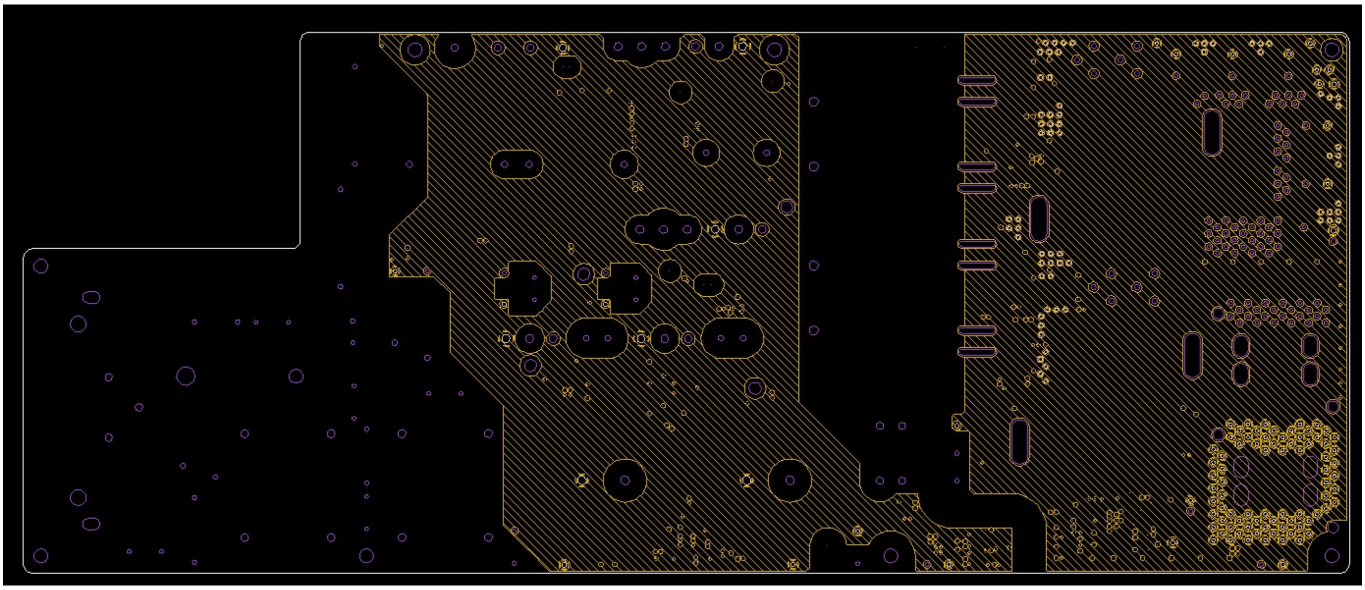

**Fig. 2.5.2 Layer2**

The following image shows the layout of Layer 3 of the PWB of this power supply.

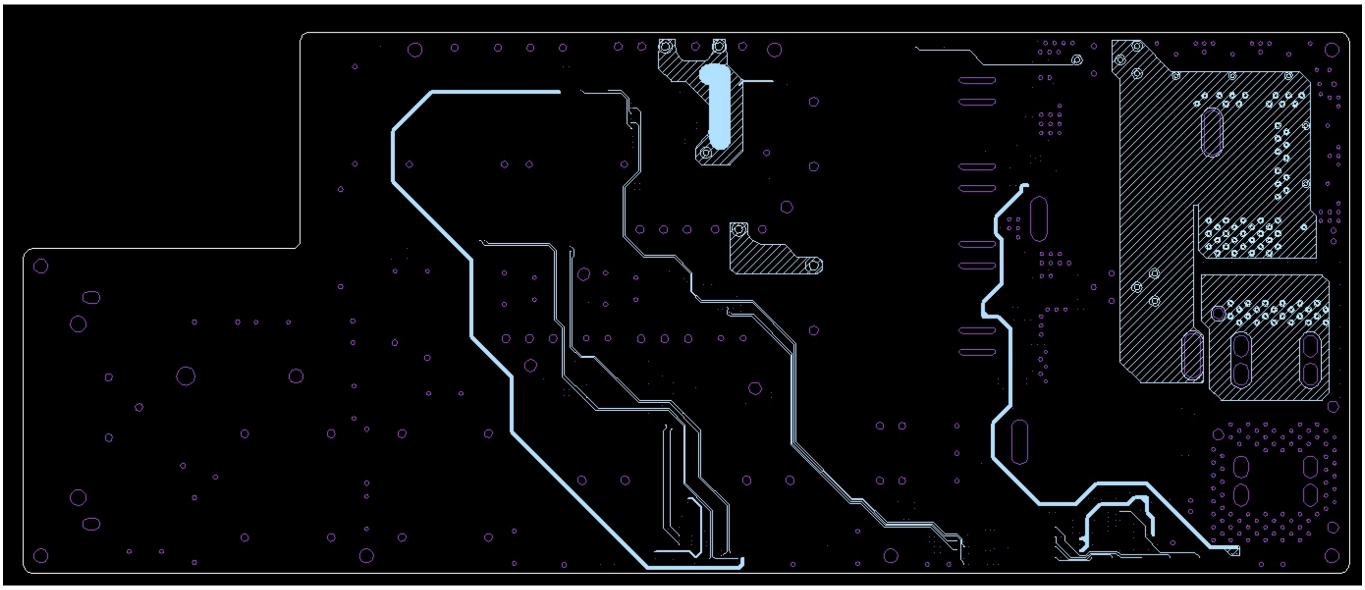

**Fig. 2.5.3 Layer3**

The following image shows the layout of Layer 4 of the PWB of this power supply.

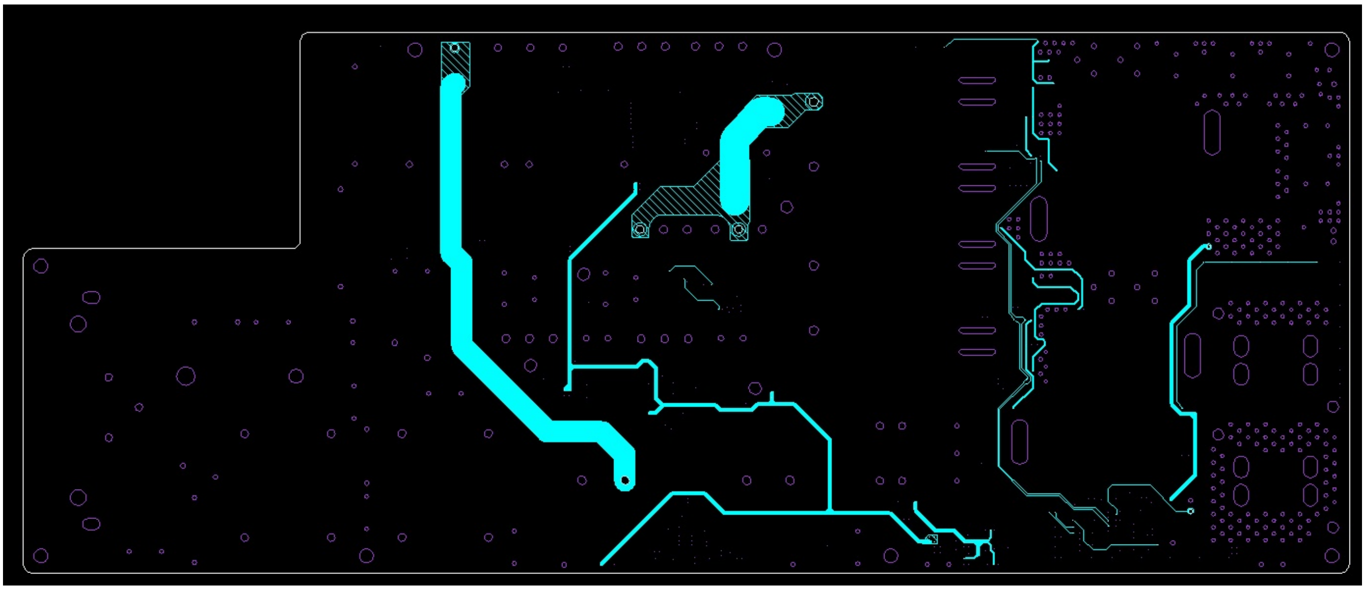

**Fig. 2.5.4 Layer4**

The following image shows the layout of Layer 5 of the PWB of this power supply.

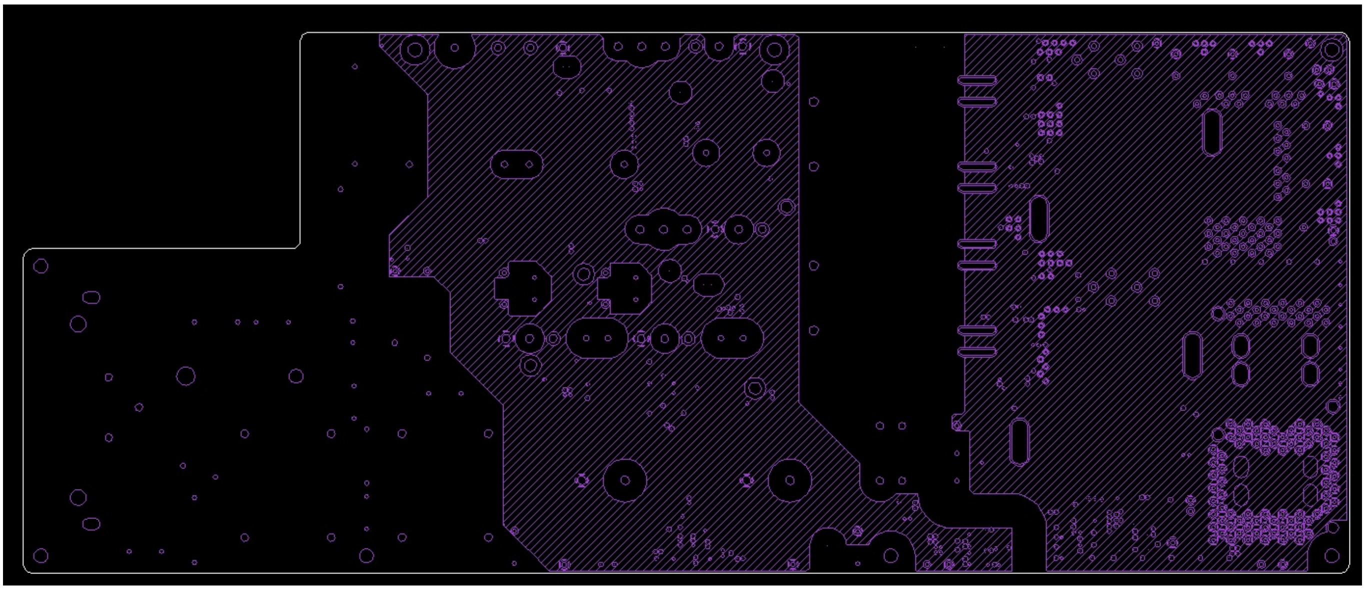

**Fig. 2.5.5 Layer5**

The following image shows the layout of Layer 6 of the PWB of this power supply.

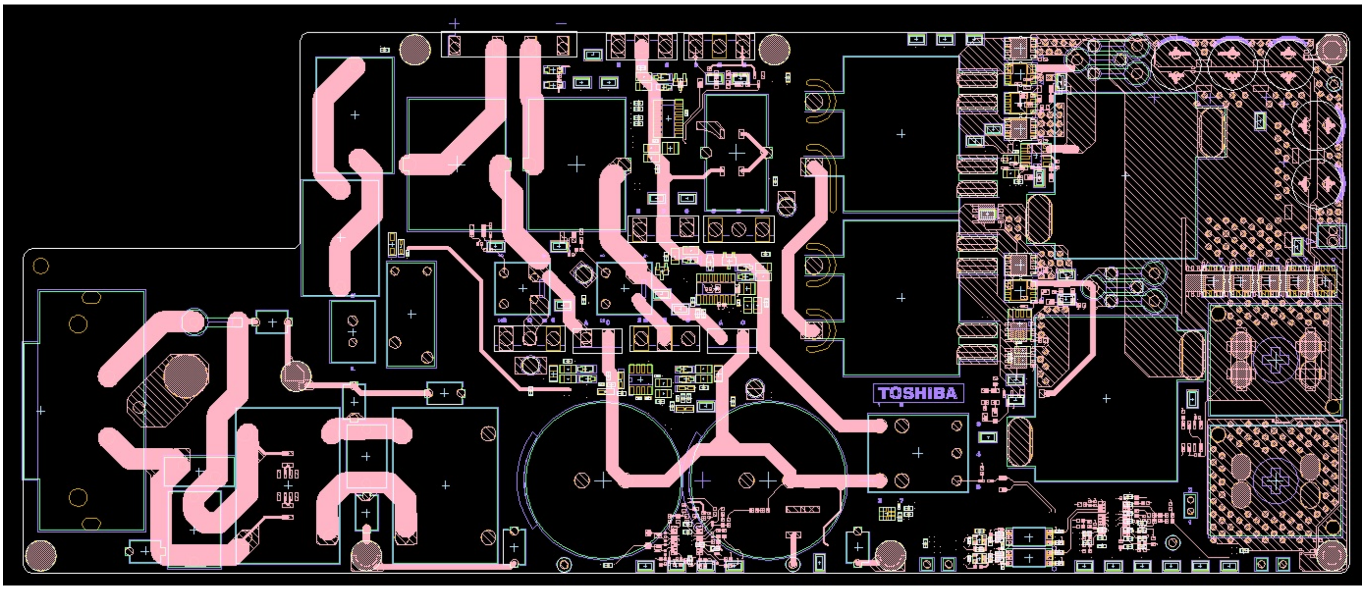


**Fig. 2.5.6 Layer6**

# 3. Operating Procedure

This section describes the operating procedure of this power supply.

## 3.1. Connection with External Equipment

Fig. 3.1.1 shows the connections of this power supply with external equipment. Red rectangles indicate terminals connected to external power supplies. Connect an AC plug to the AC inlet. Connect the 12 V input terminal on the primary side and the 12 V input terminal on the secondary side to external power supplies using jumpers. Choose appropriate power supplies, jumpers, cables and connectors that meet the specification shown in Section 2.1, "Specification." Blue rectangles indicate 12 V output terminals. A load is connected to these terminals as needed. Choose an appropriate load, cables and connectors that meet the specification shown in Section 2.1, "Specification."

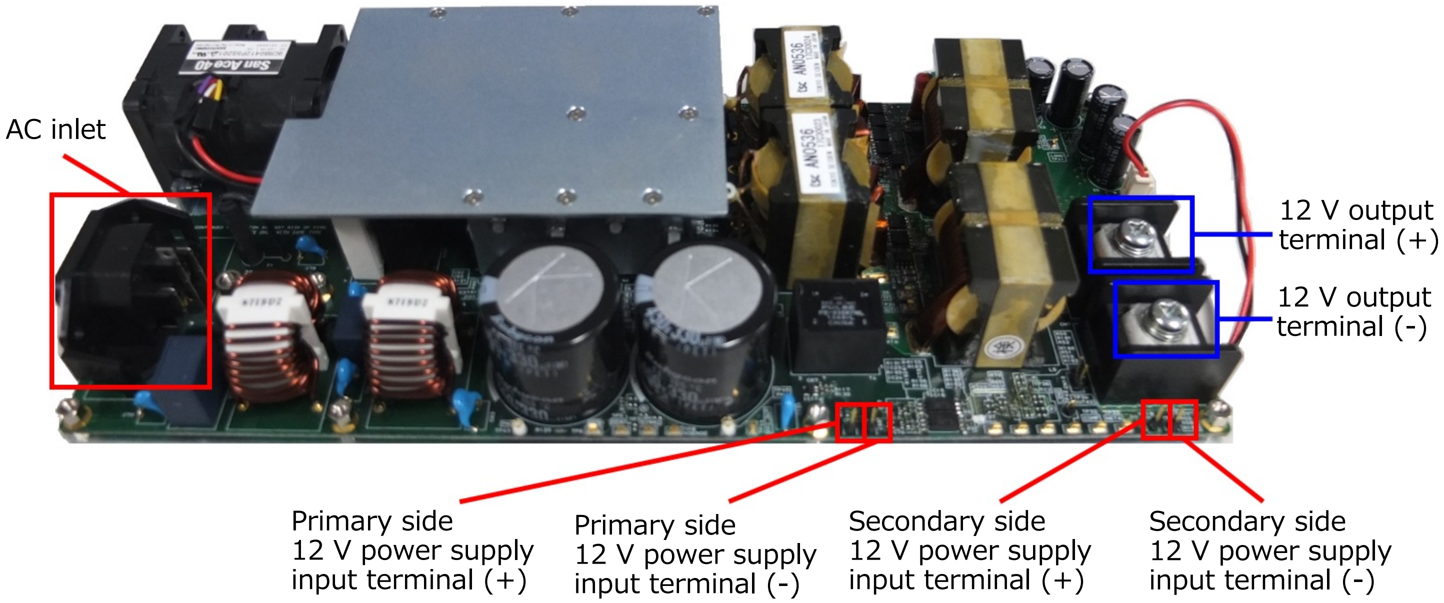


**Fig. 3.1.1 Terminals for External Equipment**

## 3.2. Power-Up Procedure

For power-up, make sure that the 12 V output, the PFC output, and the 12 V power supply outputs on the primary and secondary sides are at 0 V and follow the steps shown below. Allow an interval of at least 500 ms between each step.

1. Turn on the AC input power.
2. Turn on the 12 V power supply on the primary side.
3. Turn on the 12 V power supply on the secondary side.

If this sequence is not followed, components inside this power supply can be permanently damaged by an inrush current from the AC power.

For power-off, follow the steps shown below. Allow an interval of at least 500 ms between each step. Note that, even after power-off, electric shock hazards exist because electric charge remains in capacitors.

1. Turn off the 12 V power supply on the secondary side.
2. Turn off the 12 V power supply on the primary side.
3. Turn off the AC input power.

### 3.3. Precautions for Evaluation (Electric Shock, Burn Injury, etc.)

You can receive an electric shock if you touch the primary side while AC power is being applied to this power supply. Don't touch any portion on the primary side regardless of the status of the 12 V power supplies on the primary and secondary sides while AC power is being applied to this power supply. The red dashed line in Fig. 3.3.1 indicates the boundary between the primary and secondary sides. Be careful when measuring waveforms. You can also receive an electric shock even after power-off because electric charge remains in the PFC output capacitor and other capacitors. Make sure that the voltage at each portion of the PCB is low enough before you touch it.

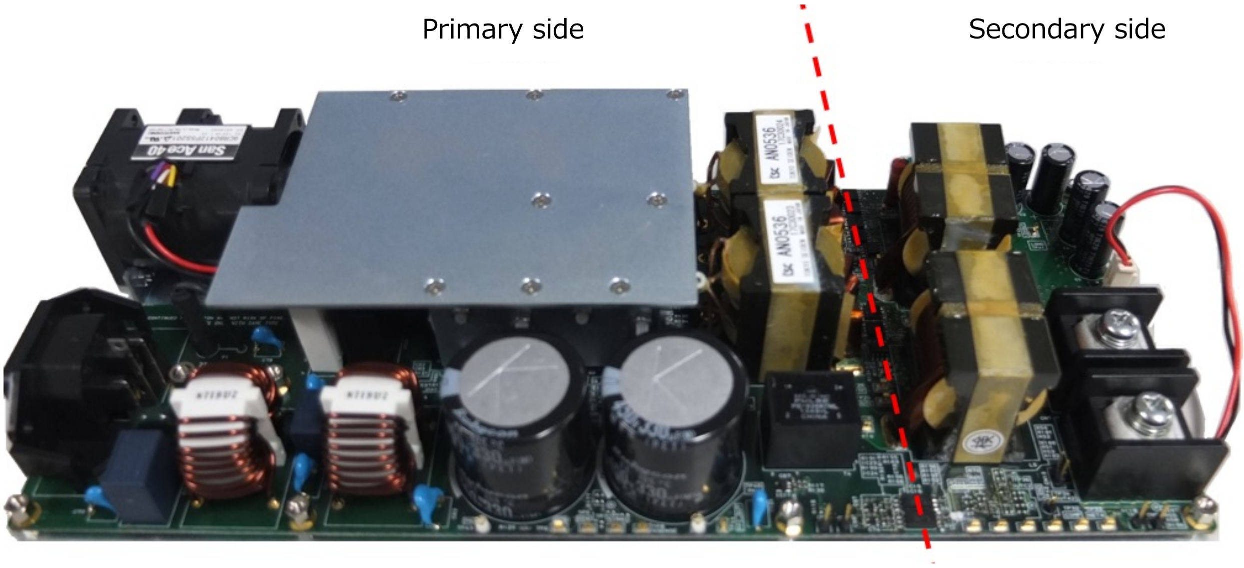


**Fig. 3.3.1 Primary Side Area / Secondary Side Area**

Semiconductor devices, transformers and other components on printed wiring board can heat up while the 1.6 kW server power supply is on. The portions highlighted by red dashed lines in Fig. 3.3.2 dissipate much heat. Don't touch these areas while the power supply is on. Doing so causes a burn hazard.

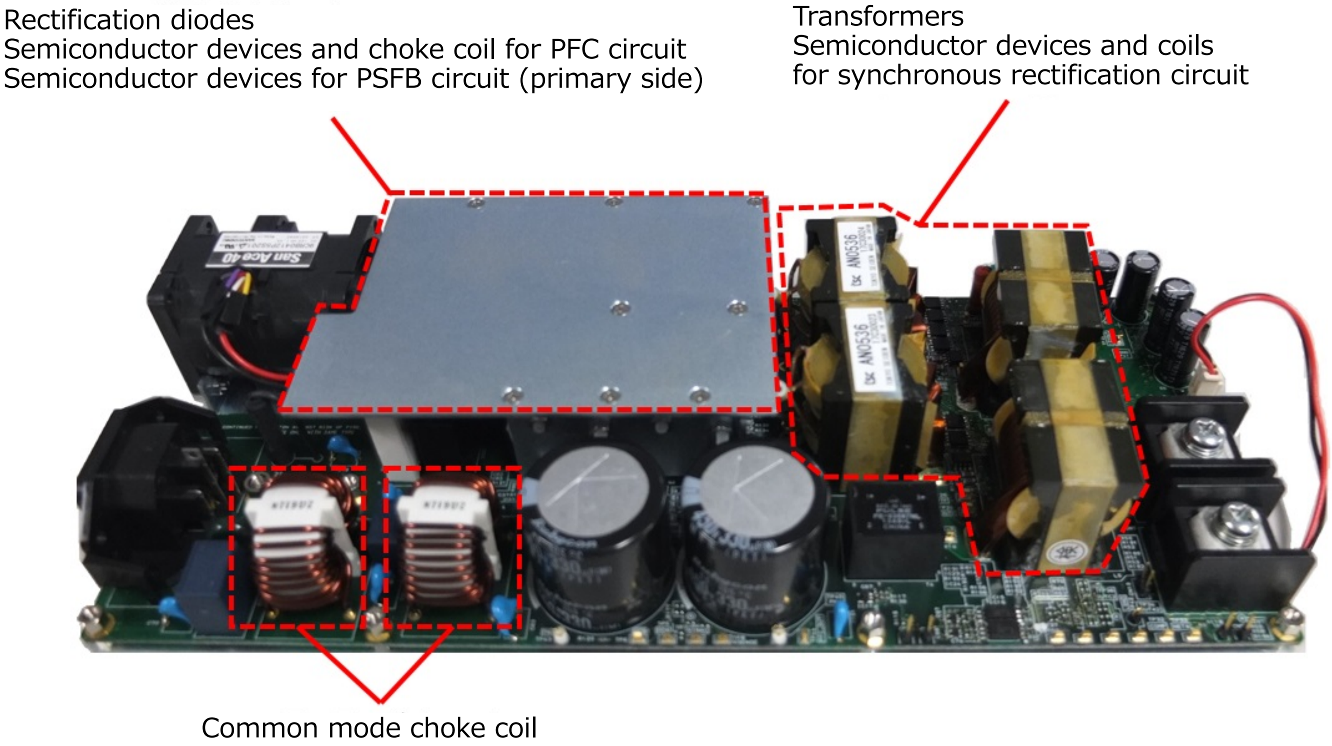


**Fig. 3.3.2 Components Subject to High Temperature**

# 4. Performance

This section describes the efficiency of this power supply.

## 4.1. Efficiency

This power supply requires external 12 V power supplies on both the primary and secondary sides. The results of efficiency measurement shown below were calculated, assuming the efficiencies of 12 V power supplies on the primary and secondary sides are 50%. Note that, if the efficiencies of the 12 V power supplies in an actual product are less than 50%, the actual efficiency will be lower than shown below. Obviously, if the 12 V power supplies in an actual product have an efficiency of more than 50%, the actual efficiency will be higher than shown below. This power supply contains redundancy with an ORing circuit at the output stage. If a non-redundant configuration is adopted, the ORing circuit is unnecessary. If the ORing circuit is deleted, the actual efficiency will be higher than the results shown below because a power loss caused by the ORing circuit loss disappears.

Measurements were taken at VinAC = 115 V and VinAC = 230 V. The maximum output power at VinAC = 115 V is 800 W, and the maximum output power at VinAC = 230 V is 1.6 kW according to this power supply specification.

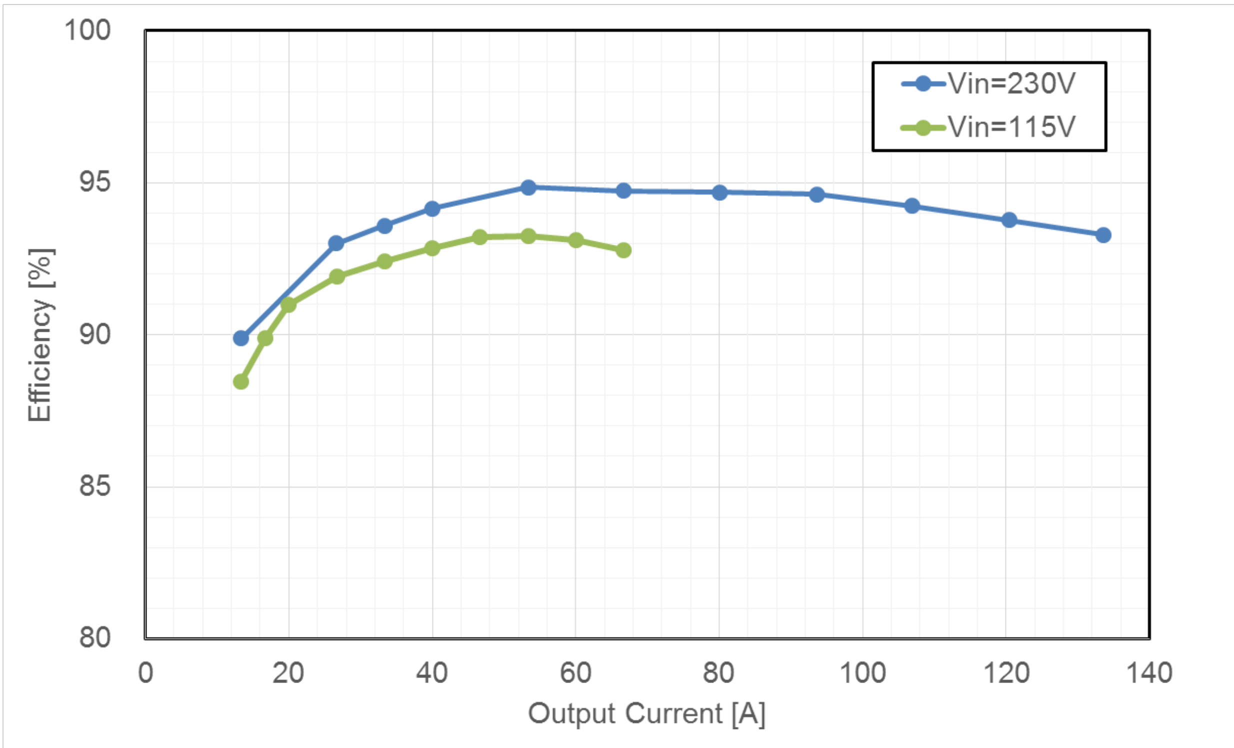


**Fig. 4.1.1 Efficiency Result (VinAC = 115 V, VinAC = 230 V)**

Graphs that compare 80 PLUS criteria are shown below for reference. These graphs are intended only as a guide to show the 80 PLUs certification level of this power supply. The 80 PLUS efficiency levels shown in the graphs are as of May 2017. The criteria for these certification levels may vary; check the latest information.

This power supply is not certified to 80 PLUS. If an 80 PLUS certification is necessary, you need to measure the efficiency of an actual product and apply for a certification.

Fig. 4.1.2 shows the efficiency measured at VinAC=115 V and the thresholds necessary to obtain an 80 PLUS certification for the 115V Internal Non-Redundant type.

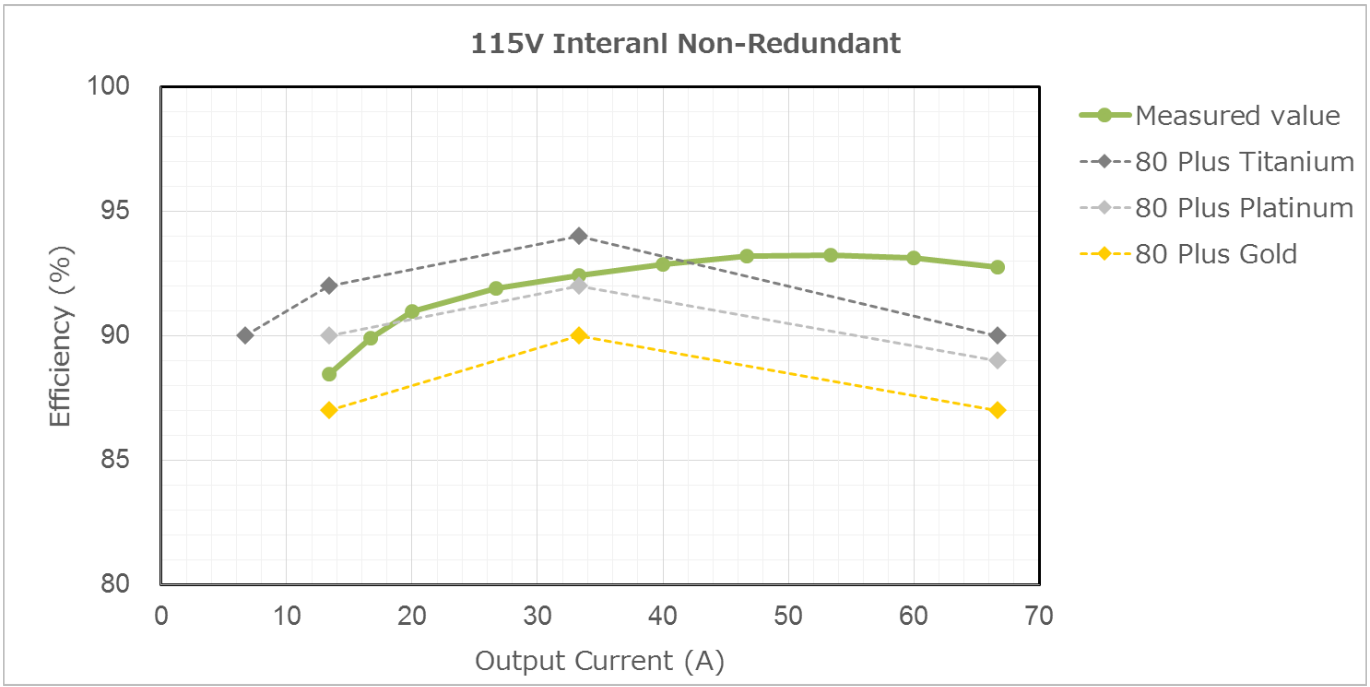


**Fig. 4.1.2 Efficiency Result (VinAC = 115 V, 80 PLUS: 115V Internal Non-Redundant)**

Fig. 4.1.3 shows the efficiency measured at VinAC=115 V and the thresholds necessary to obtain an 80 PLUS certification for the 115V Industrial type.

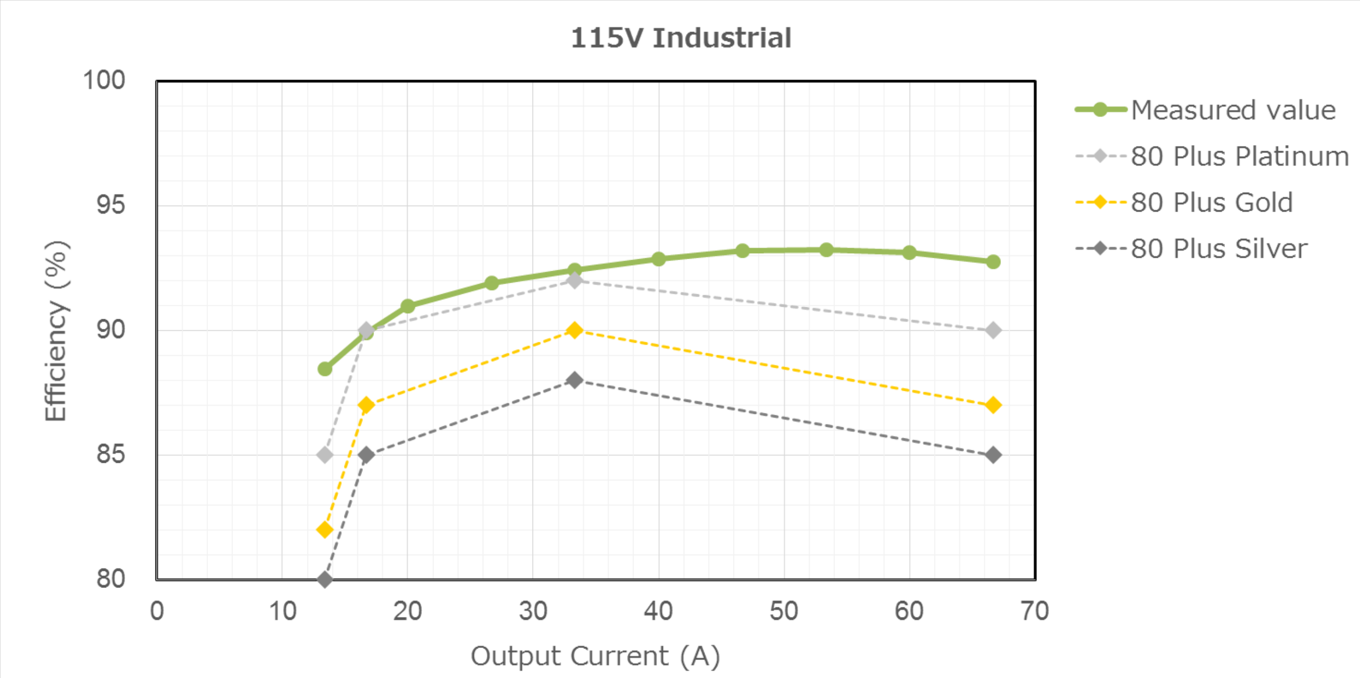


**Fig. 4.1.3 Efficiency Result (VinAC = 115 V, 80 PLUS: 115V Industrial)**

Fig. 4.1.4 shows the efficiency measured at VinAC = 230 V and the thresholds necessary to obtain an 80 PLUS certification for the 230V EU Internal Non-Redundant type.

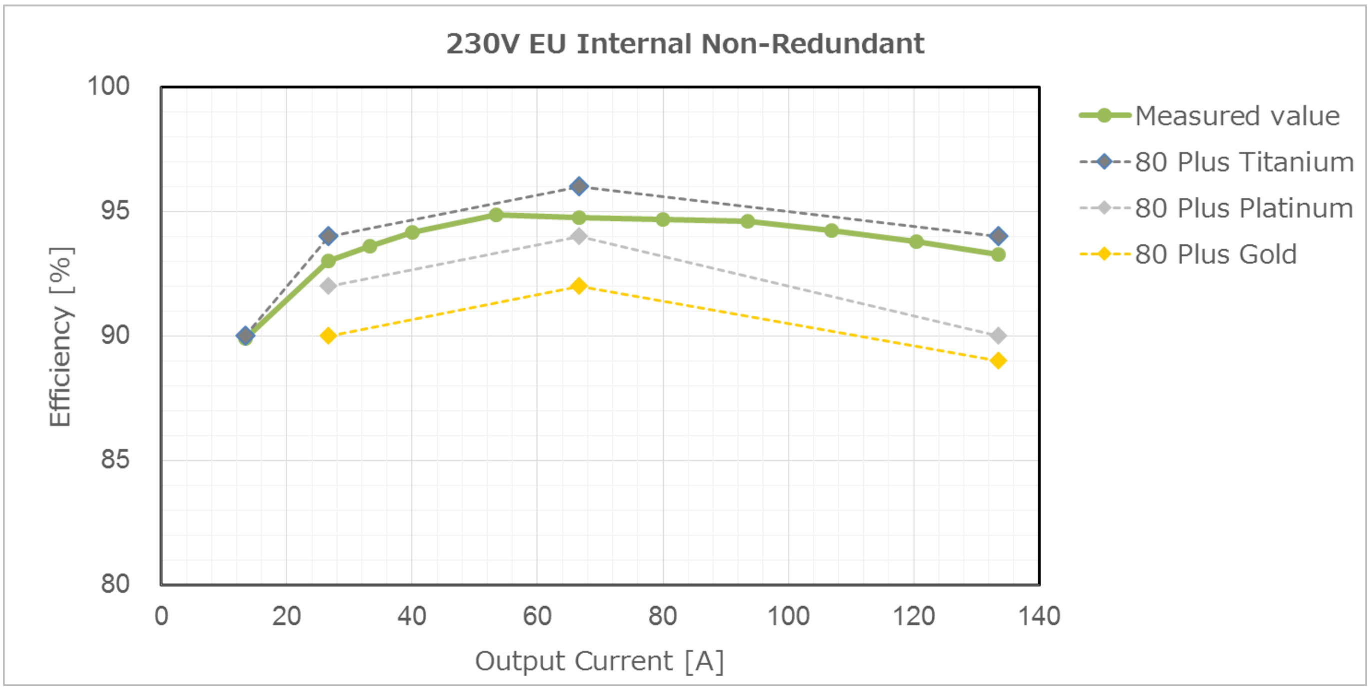


**Fig. 4.1.4 Efficiency Result (VinAC = 230 V, 80 PLUS: 230V EU Internal Non-Redundant)**

Fig. 4.1.5 shows the efficiency measured at VinAC = 230 V and the thresholds necessary to obtain an 80 PLUS certification for the 230 V Internal Redundant type.

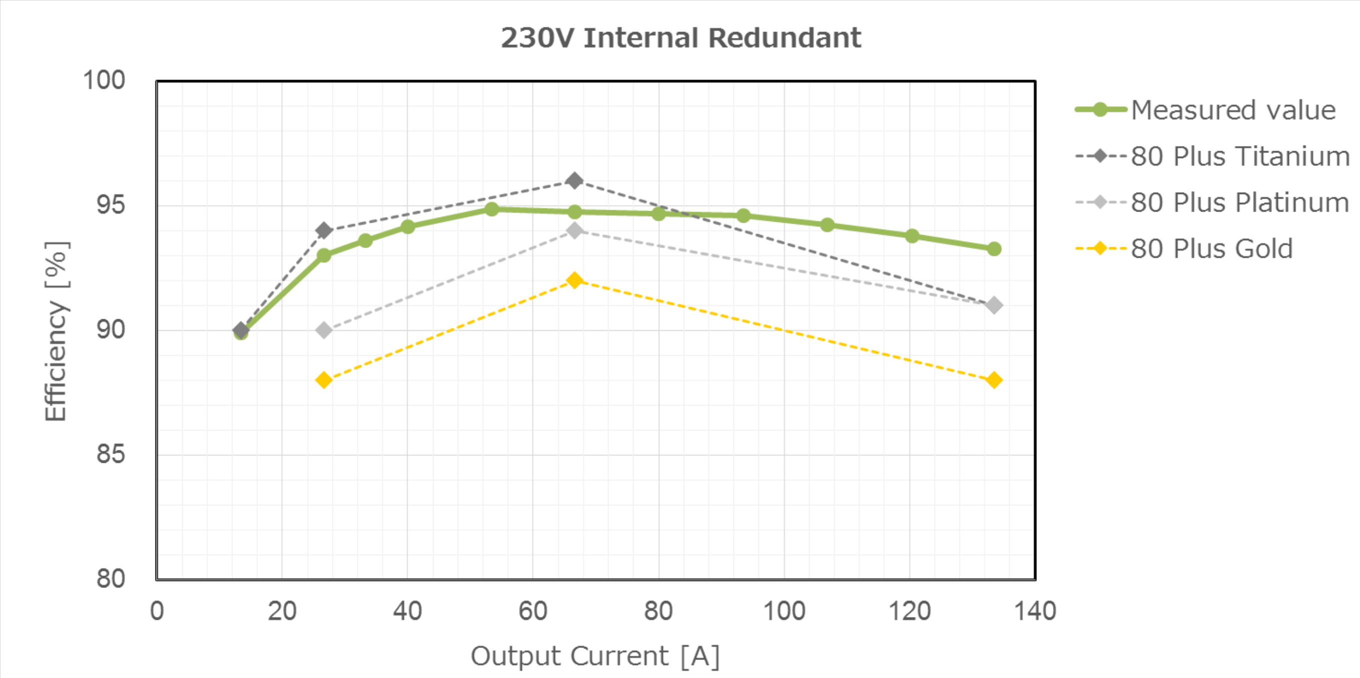


**Fig. 4.1.5 Efficiency Result (VinAC=230 V, 80 PLUS: 230V Internal Redundant)**

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