Automotive Buck-Boost DC-DC Converter for USB PD

Reference Guide

RD227-RGUIDE-01

TOSHIBA ELECTRONIC DEVICES & STORAGE CORPORATION

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1. Introduction

This Reference Guide (hereafter referred to as this Guide) describes the specifications and operation procedures of the Automotive Buck-Boost DC-DC Converter for USB PD (hereafter referred to as this Power Supply).

Recently, USB Power Delivery (hereafter referred to as USB PD) power supply (for recharging) has become popular for smart phones, tablets, laptop PC, etc. In response to the growing demand for power supply not only indoors but also inside vehicles, USB Type-C® connectors have been installed, and power supply by USB PD has become popular. Since the output voltage is determined by the power receiving device in USB PD, DC-DC converter for automotive USB PD requires a buck-boost converter to generate the output voltage from the vehicle battery voltage. This power supply is an H-bridge type buck-boost DC-DC converter with four switching elements. By using our small-package automotive MOSFETs as switching devices, we have realized an automotive buck-boost DC-DC converter that is highly efficient and has a small board mounting area.

We have prepared two types of automotive MOSFETs which are used in the H-bridge buck-boost DC-DC converter section of this power supply. Option 1 uses a XPN7R104NC, and Option 2 uses a SSM6K804R. In addition, our automotive MOSFET XPN3R804NC is used as a switching device in reverse-connection protection circuit and shield short-circuit protection circuit.

2. Specifications

Table 2.1 lists the main specifications of this power supply.

Table 2.1 Specifications of Automotive Buck-Boost DC-DC Converter for USB PD

Item	Specifications
Power Topology	H-bridge buck-boost circuit
Input Voltage	DC 5 to 18 V, 12.6 V (Typ.)
Output Voltage	DC 3.3 to 21 V
Rated Power	60 W (Max.)
Switching Frequency	400 kHz (Typ.)
Protective Function	Reverse connection protection Overvoltage, overcurrent, and shield short-circuit protection (controlled by the controller)
Cooling System	Convection cooling
Board Size	90 x 40 mm
Substrate Layer Configuration	Four-layer through-hole (surface layer: 70 μm, inner layer: 70 μm)

2.1. Circuit Block Diagram

Fig. 2.1 shows the block diagram of this power supply.

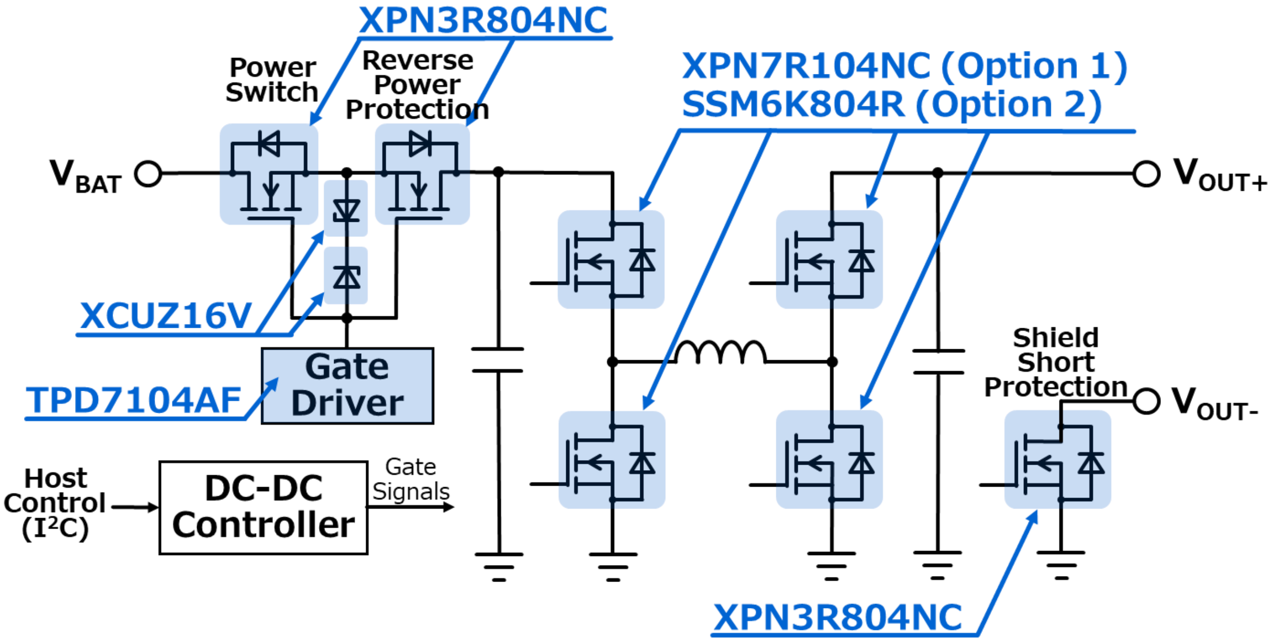
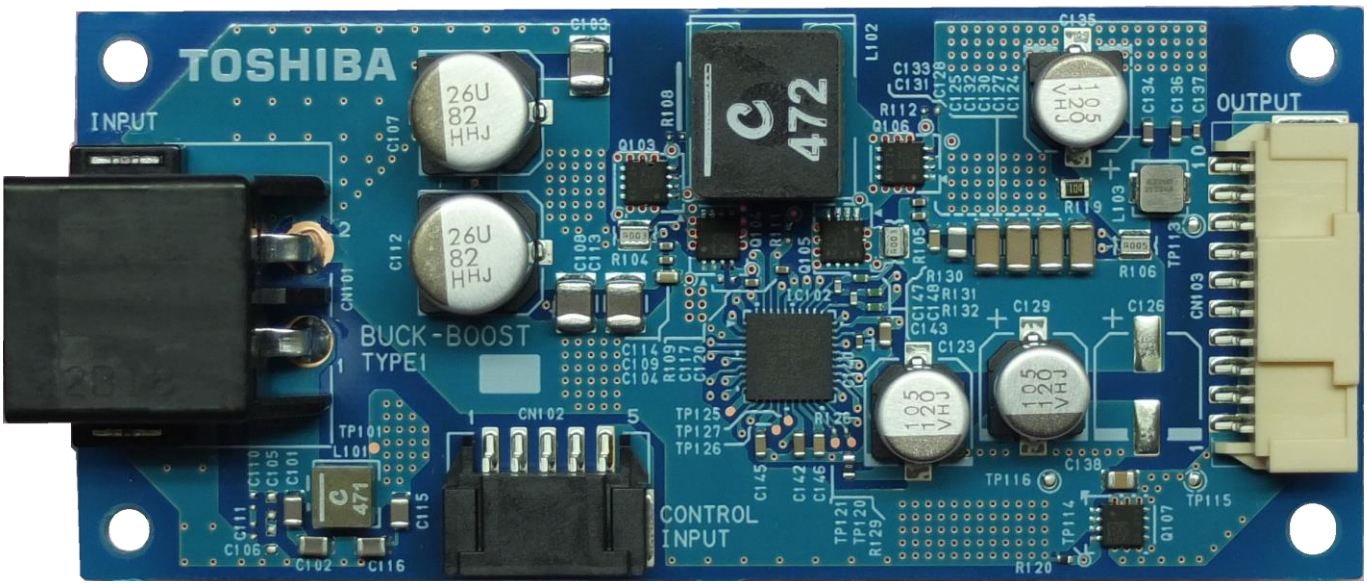


Fig. 2.1 Block Diagram of Automotive Buck-Boost DC-DC Converter for USB PD

2.2. Appearance and Component Arrangement

Fig. 2.2 and Fig. 2.3 show the appearance of this power supply, and Figs. 2.4 and 2.5 show the layout of main components.



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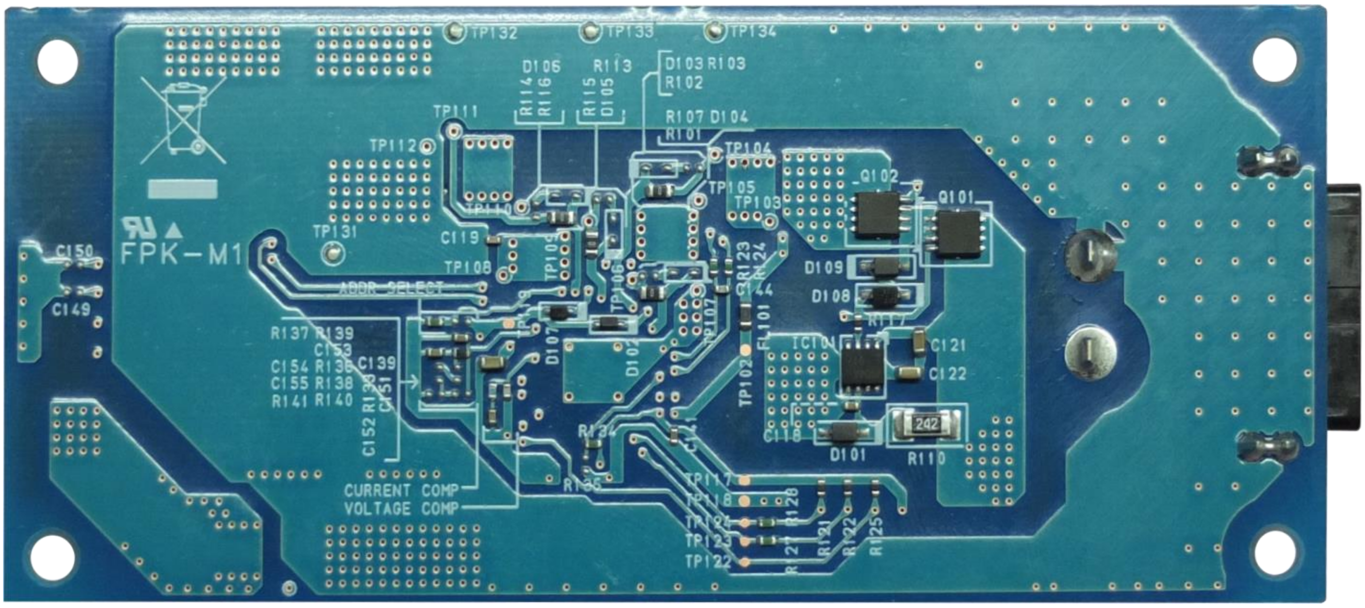

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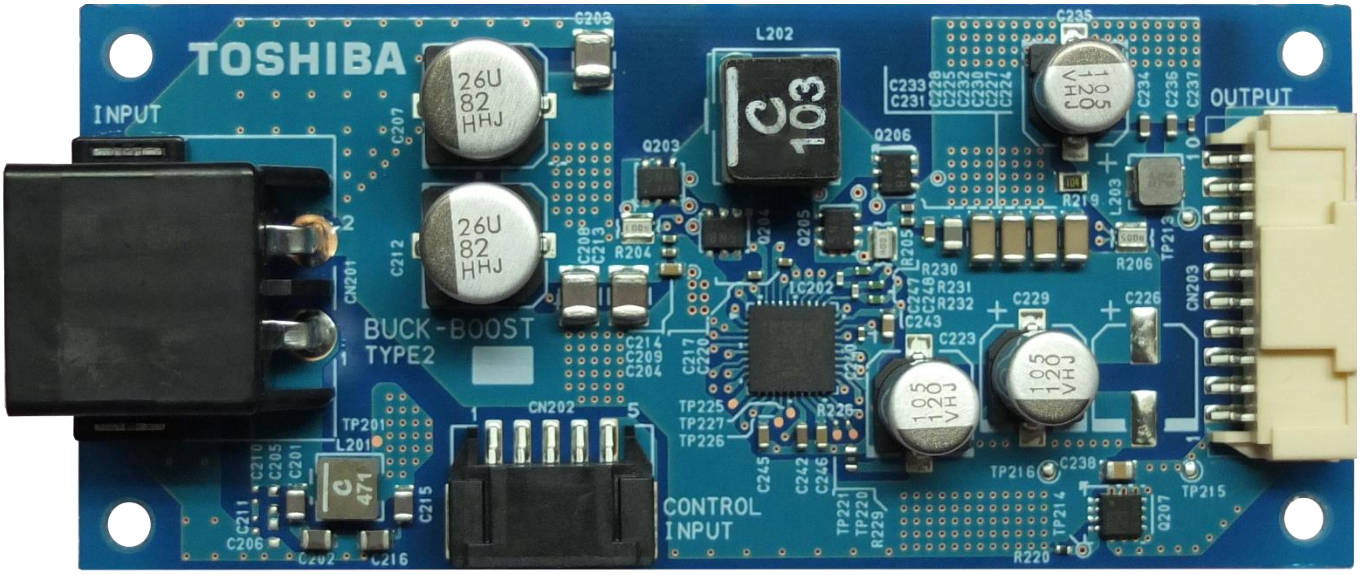
Fig. 2.2 Board Appearance (Option 1)



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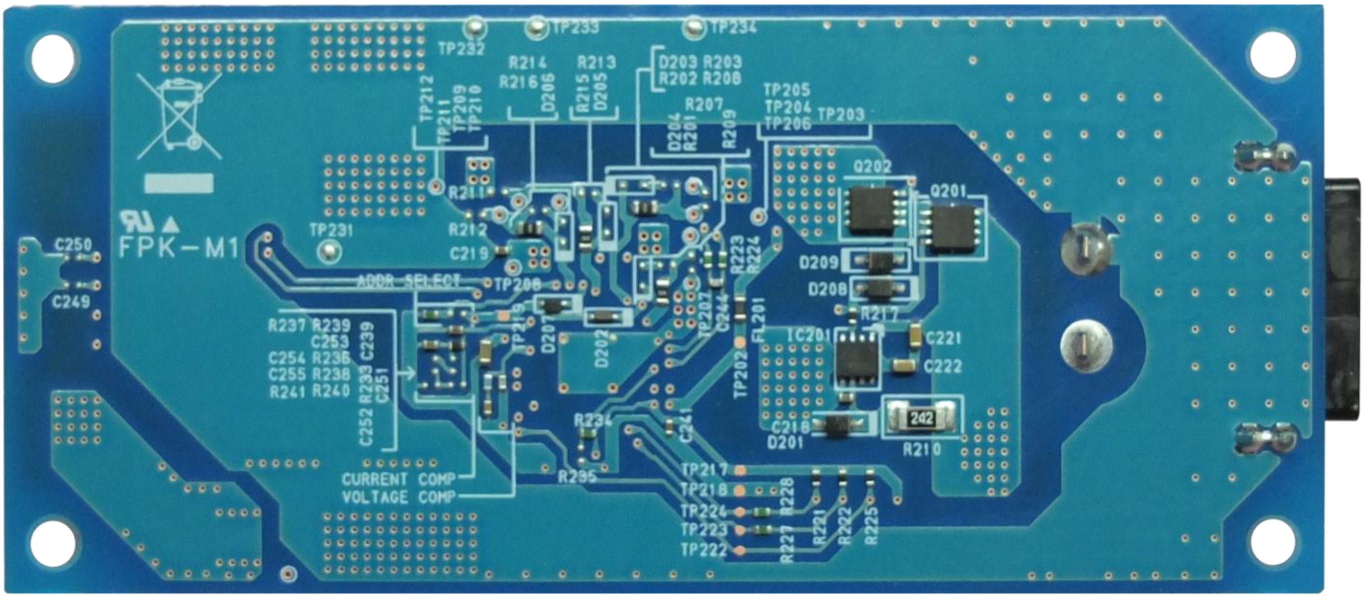

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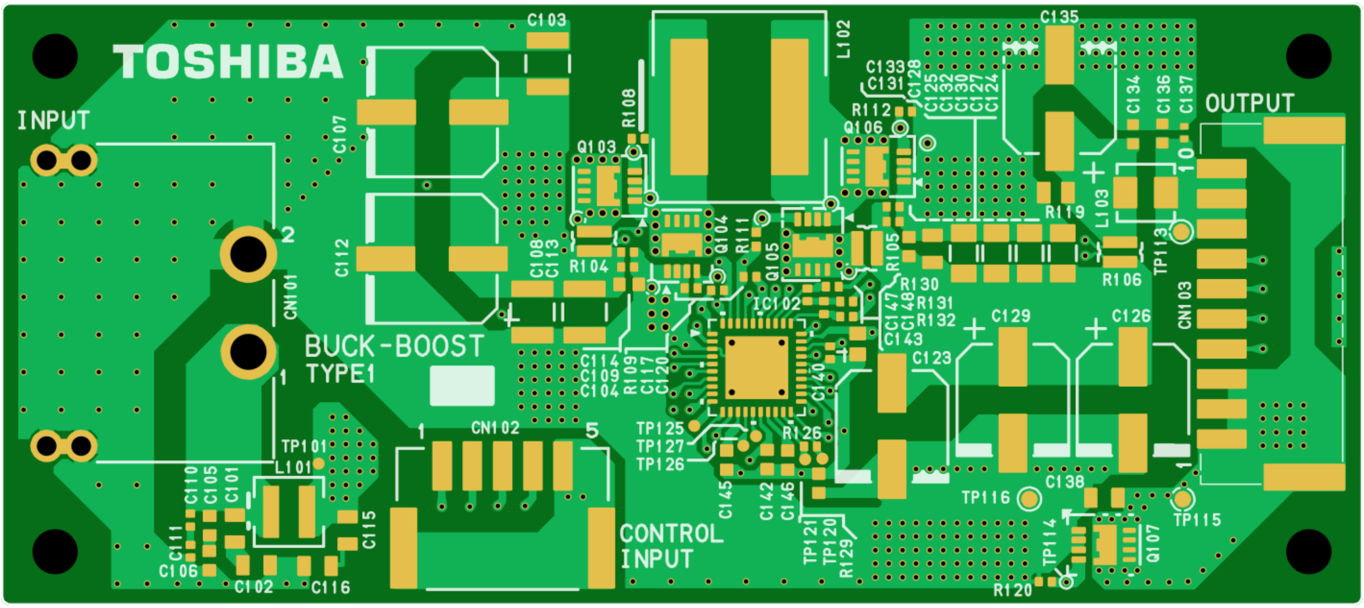
Fig. 2.3 Board Appearance (Option 2)



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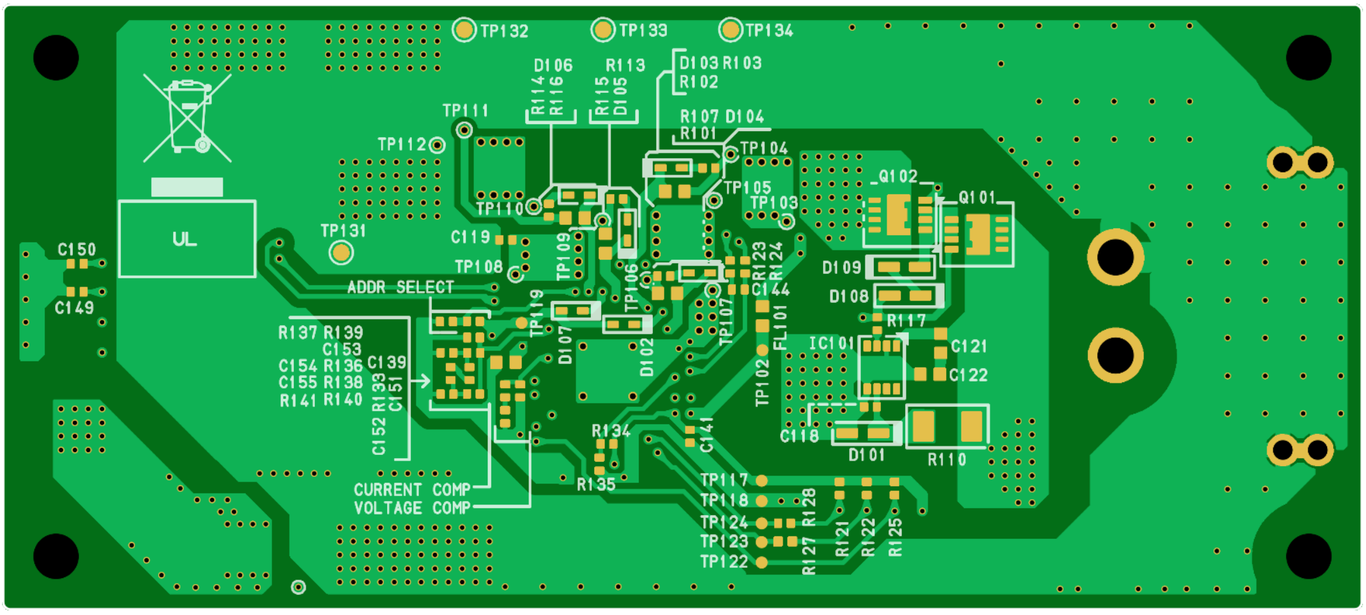

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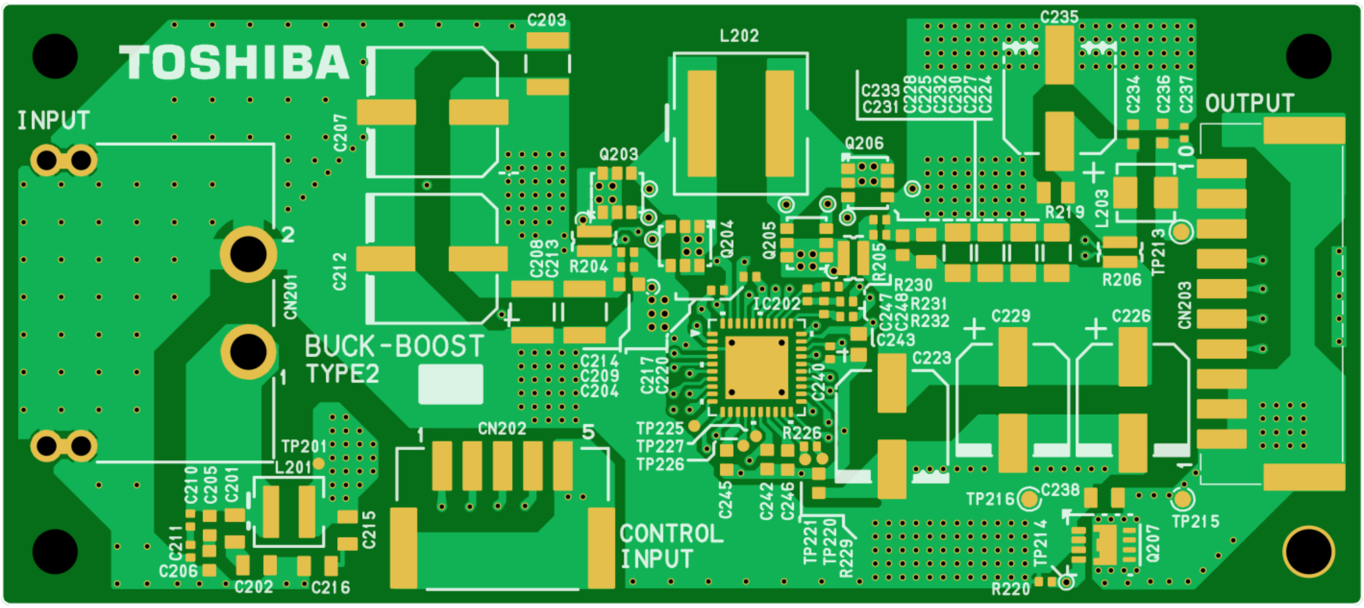
Fig. 2.4 Main Component Layout (Option 1)



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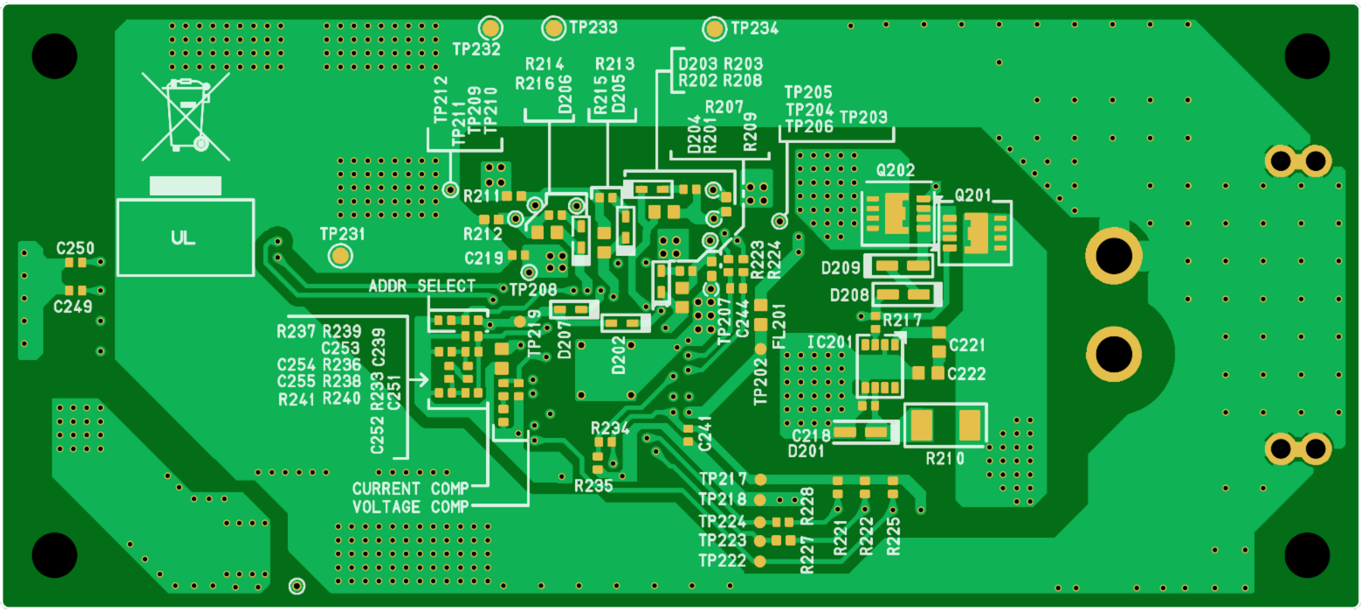

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Fig. 2.5 Main Component Layout (Option 2)

3. Schematic, Bill of Material, and PCB Pattern

3.1. Schematic

Refer to the following files:

RD228-SCHEMATIC1-xx.pdf (optional 1, using XPN7R104NC)
RD228-SCHEMATIC2-xx.pdf (optional 2, using SSM6K804R)
(xx is the revision number.)

3.2. Bill of Material

Refer to the following files:

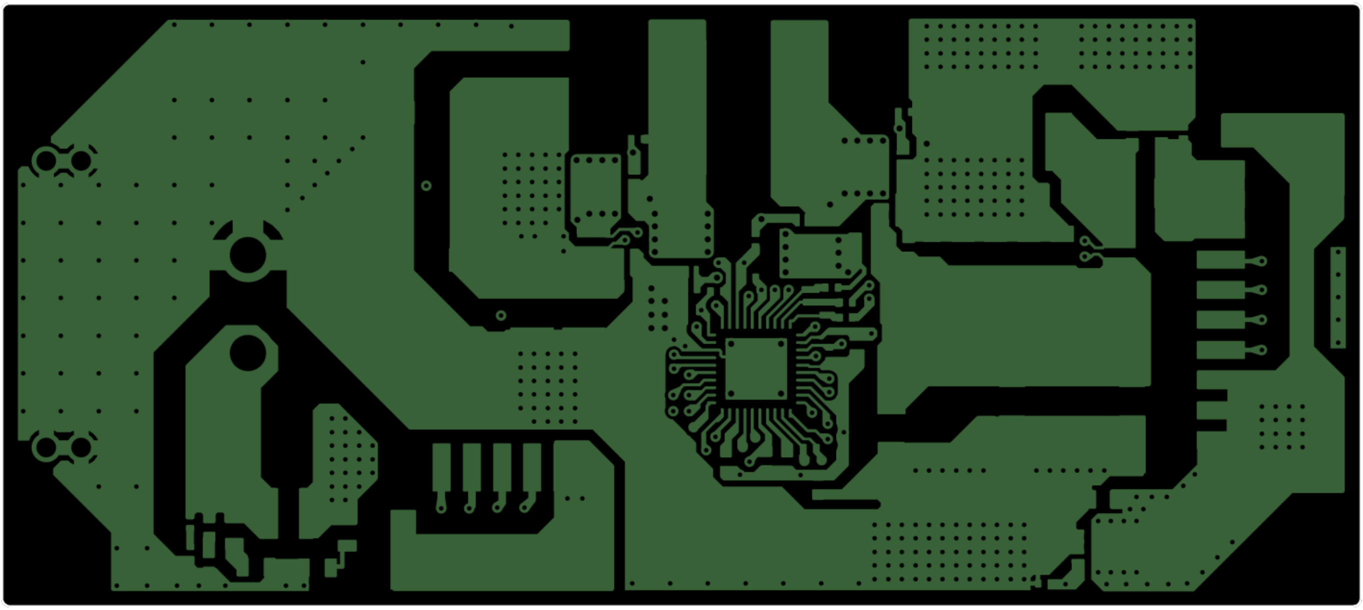
RD228-BOM1-xx.pdf (optional 1, using XPN7R104NC)
RD228-BOM2-xx.pdf (optional 2, using SSM6K804R)
(xx is the revision number.)

3.3. PCB Pattern

Fig. 3.1 and Fig. 3.2 show the PCB pattern of this power supply.

Also, refer to the following files:

RD228-LAYER1-xx.pdf (optional 1, using XPN7R104NC)
RD228-LAYER2-xx.pdf (optional 2, using SSM6K804R)
(xx is the revision number.)



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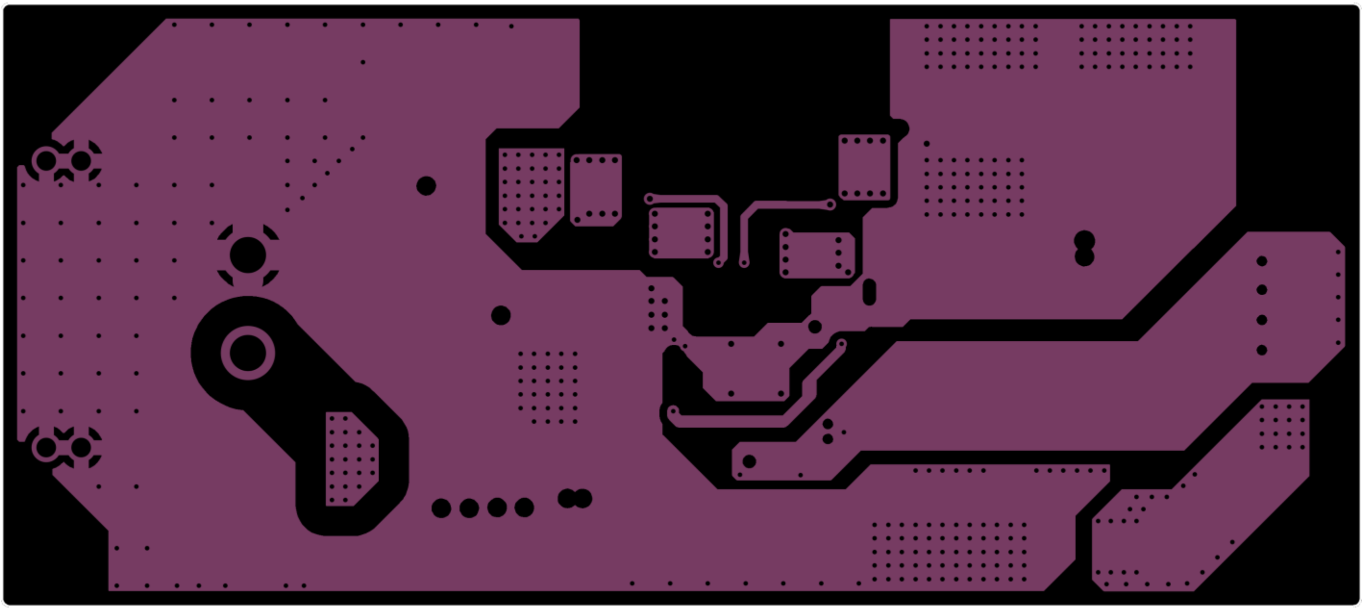

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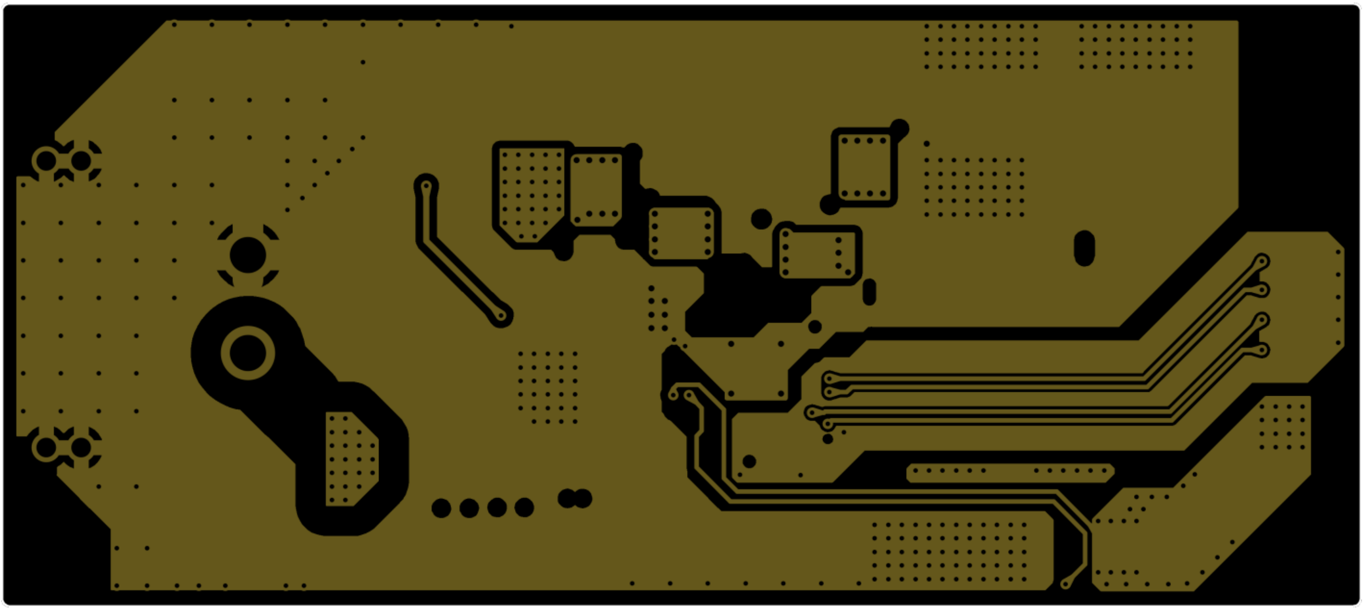

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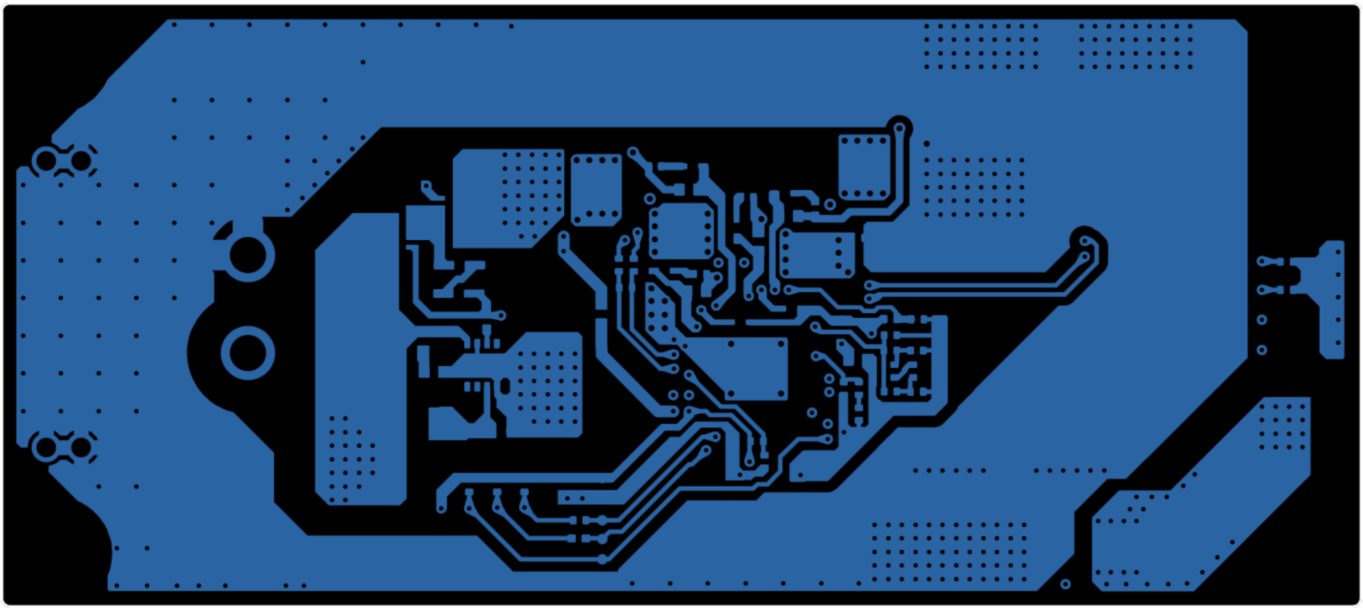

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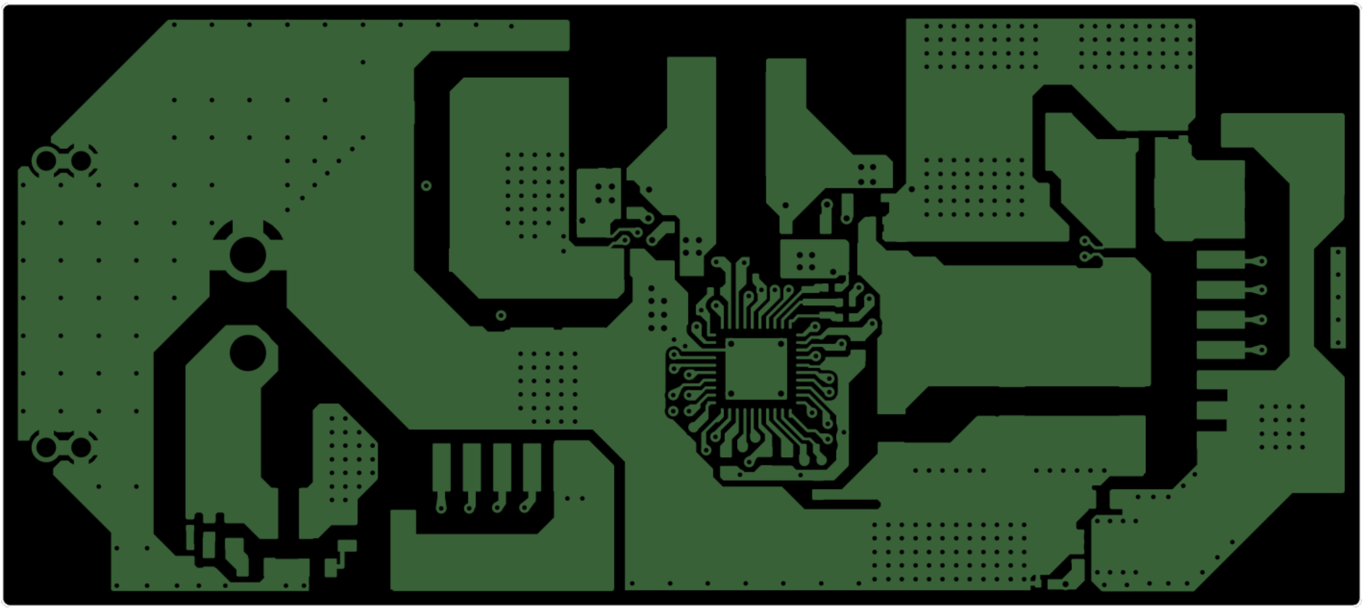
Fig. 3.1 PCB Pattern (Front View) (Option 1)



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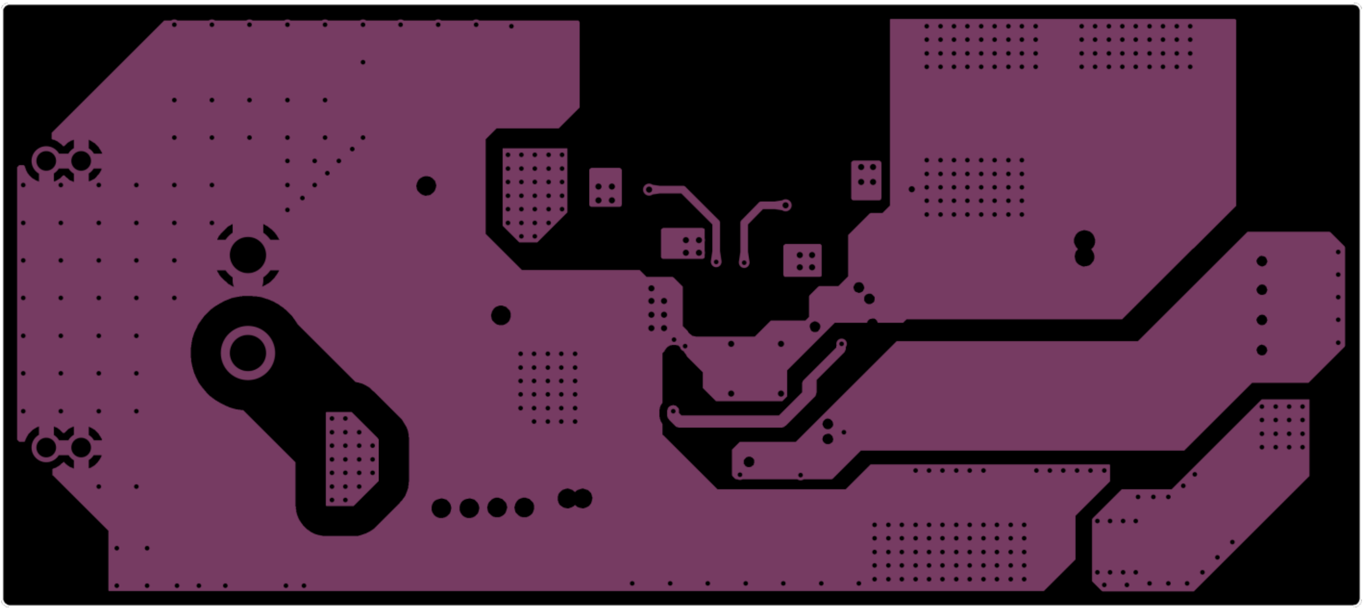

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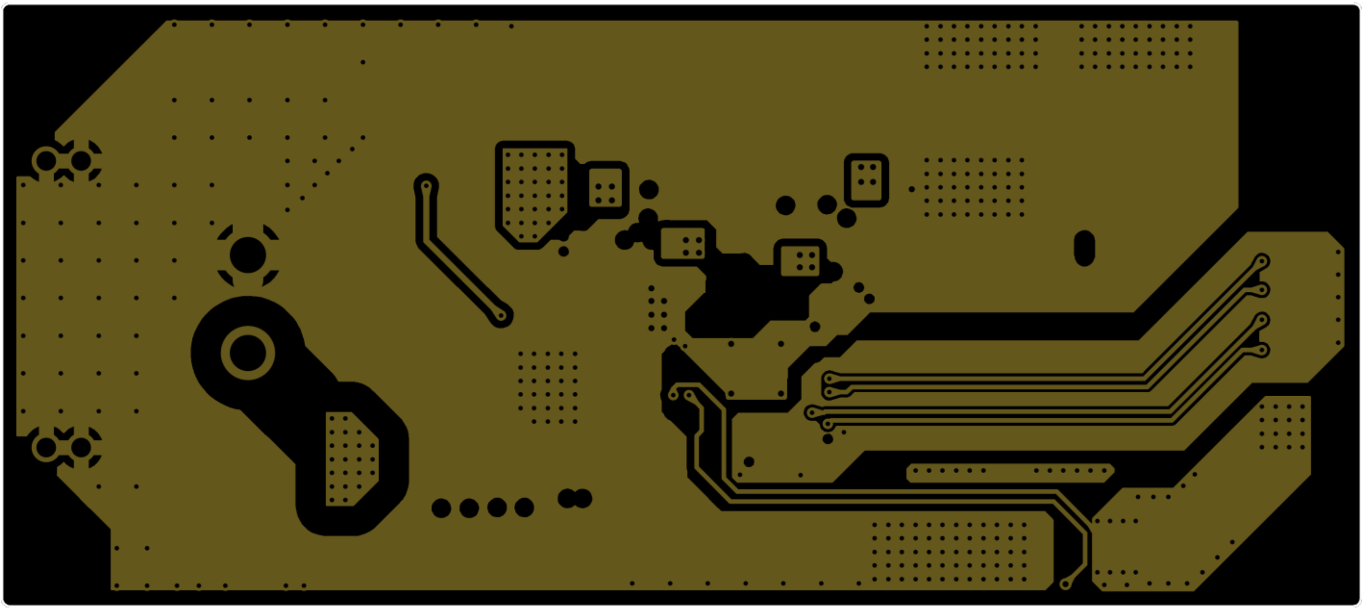

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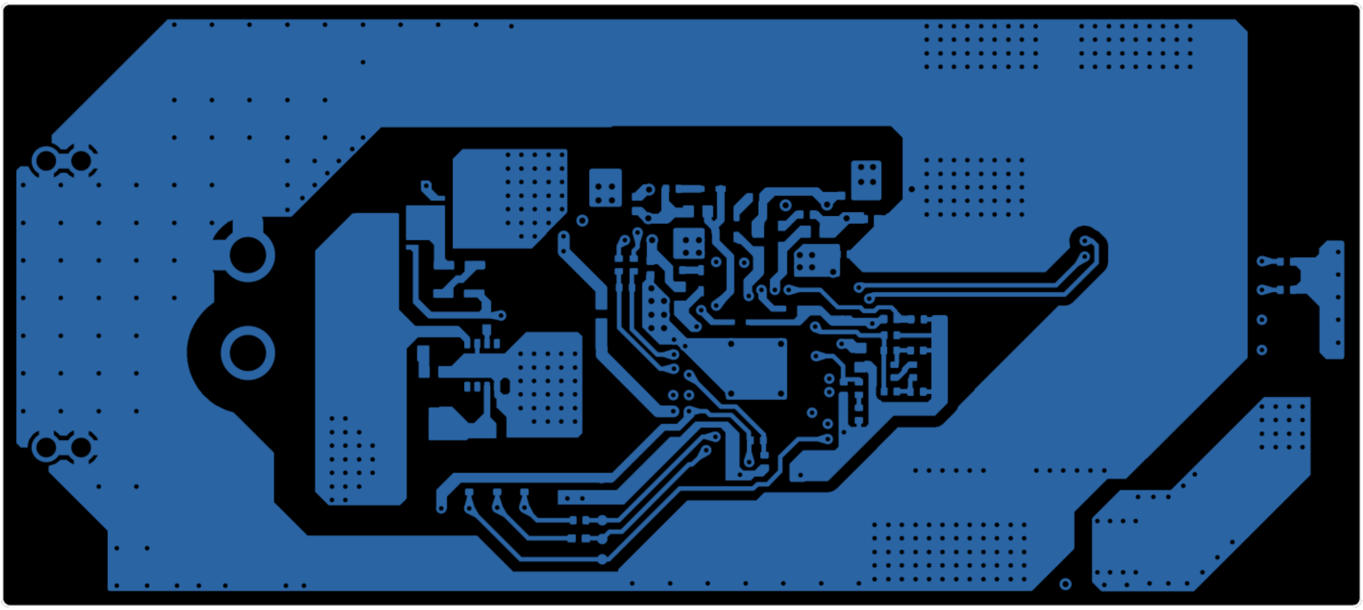

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Fig. 3.2 PCB Pattern (Front View) (Option 2)

4. Operation

4.1. Name and Function of Components

4.1.1. Power Input Connector (CN101, CN201)

This connector is used to input power. HVH-280-2P-6.5DS (Hirose) is being used.

Fig. 4.1 Power Input Connector

Table 4.1 Power Input Connector Specifications

Pin	Net name	Description
1	VIN	Power input (+)
2	GND_P	Power Input (-)

4.1.2. Power Output Connector (CN103, CN203)

This connector is used to output power. 502352-1000 (Molex) is being used. To control the power with USB Power Delivery, connection to the specified terminal of the external USB Type-C® connector is required.

Fig. 4.2 Power Output Connector

Table 4.2 Power Output Connector Specifications

Pin	Net name	Description
1	SHLD_SNS	Power Output (-)
2		
3		
4	HVDP	Connect to USB Type-C® connector D+ terminal
5	HVDM	Connect to USB Type-C® connector D- terminal
6	HVCC2	Connect to USB Type-C® connector CC2 terminal
7	HVCC1	Connect to USB Type-C® connector CC1 terminal
8	VBUS	Power Output (+)
9		
10		

4.1.3. Host Connector (CN102, CN202)

It is used to connect to a host such as an external MCU. 502352-0501 (Molex) is being used. It connects I^{2}C interface between the host and the controller mounted on the power supply. I^{2}C address defaults to 50 (hexadecimal), but I^{2}C address can be changed by setting the resistor on the board. A control power supply (3.3 V or 5 V) is required to operate the controller installed in this power supply.

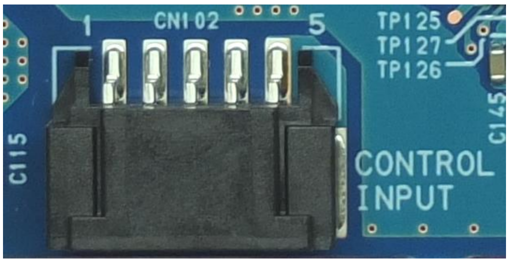

Fig. 4-3 Host Connector

Table 4-3 Host Connector Specifications

Pin	Net name	Description
1	VDD	Control power (3.3 V or 5.5 V)
2	ALERT	Error signal output (L output at error)
3	SCL	I2C Clock-Signal Input (SCL)
4	SDA	I2C Input/Output (SDA)
5	GND_A	Control Power/Signal Ground

4.2. Operation Checking Procedure

4.2.1. Preparation

Connect a host device to the host connector. A host device could be a MCU board that controls the controller mounted on this power supply. For details, refer to the data sheet of the installed controller. Connect the battery or other input power to the power input connector. Connect USB Type-C® connector to the power output connector.

4.2.2. Operation Procedure

Apply control power (3.3 V or 5 V) to pin 1 of the host connector. Initialize the controller mounted on this power supply from the host. By connecting a USB Power Delivery load device (Sink Device) to USB Type-C® connector connected to the power output connector, the power is controlled by USB Power Delivery and the required power is supplied to the load device.

4.2.3. Operation During Error Detection

When the controller mounted on this power supply detects an error, the ALERT (pin 2) of the host connector is set to low.

4.3. Precautions (To Prevent Electric Shock, Burn Injury, etc.)

Pay special attention to the following when operating.

- Make sure the polarity of the connector is correct before supplying power.
- When checking the operation, cover the BOARD with an acrylic case for safety.
- MOSFET and other components generate heat during operation. Some components of the circuit board contain high voltage. Be very careful of burns and electric shocks when handling the circuit board.

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