Motor Driving Circuit for Automotive Body Electronics Using SmartMCD™

Reference Guide

RD228-RGUIDE-01

Toshiba Electronic Devices & Storage Corporation

Table of Contents

1. Introduction

This reference guide document describes the specifications and operation procedure of the Motor Driving Circuit for Automotive Body Electronics Using SmartMCD™ (hereinafter referred to as this design).

We have developed the brushless motor control circuit required for automotive body systems using Toshiba's gate driver IC SmartMCD TB9M003FG with an in-built microcontroller. The sensorless vector control process required for motor control is performed by SmartMCD, and the gate drivers required for driving MOSFETs of the inverter are also incorporated in SmartMCD, so that MOSFETs constituting the inverter can be directly connected and a simple configuration can be used to realize an automotive body motor control.

This design has a 130 mm X 73 mm board with circuit required for controlling the body motors, as well as switches and potentiometers required for checking operation. We have also prepared an external inverter board that is the same size as the main board and can drive a large-current motor. The on-board inverter on the main board uses the small package MOSFETs SSM6K804R, and the external inverter board uses power MOSFETs TK1R4S04PB, XPH2R404PS, TPW1R104PB, XPN3R804NC.

2. Specifications

Table 2.1 lists the main specifications of this design.

Table 2.1 Specifications of the Motor Driving Circuit for Automotive Body Electronics Using SmartMCD

Item	Description
Input power supply	DC 12 V (Typ.)
Control power supply	DC 5 V, DC 3.3 V (internally generated)
Compatible motor and control method	3-phase brushless motor Sensorless vector control, etc.
Hardware protection features	Overcurrent indication (5.6 A when using the on-board inverter)
Board size	130 X 73 mm
Board configuration	Main board: FR-4, 4 layers, 1.6 mm thickness, copper thickness of outer layer is 17 μm and inner layer is 35 μm, double-sided silk, single-sided mounting External Inverter Board: FR-4, 4 layers, 1.6 mm thickness, copper thickness is 35 μm, double-sided silk, double-sided mounting
I/O interface	LIN: 1 ch USB: 1 ch (SmartMCD communication for UART) Debug USB: 1 ch (CMSIS-DAP for debugging) SWD input/output: 1 ch (for debugging) Push-switch: 1 piece. (E.g. for motorized Start/Stop) Slide switch: 1 piece (for switching motor rotation direction, etc.) Potentiometer: 1 piece (for motor speed adjustment, etc.) Temperature-sensor input: 1 ch LED: 3 pieces (Software-controlled status display), 3 pieces (Power ON display), 2 pieces (UART operation display), 1 piece (Overcurrent display), 2 pieces (CMCIS-DAP status display)

2.1. Block Diagram

Fig. 2.1 shows the block diagram of this design.

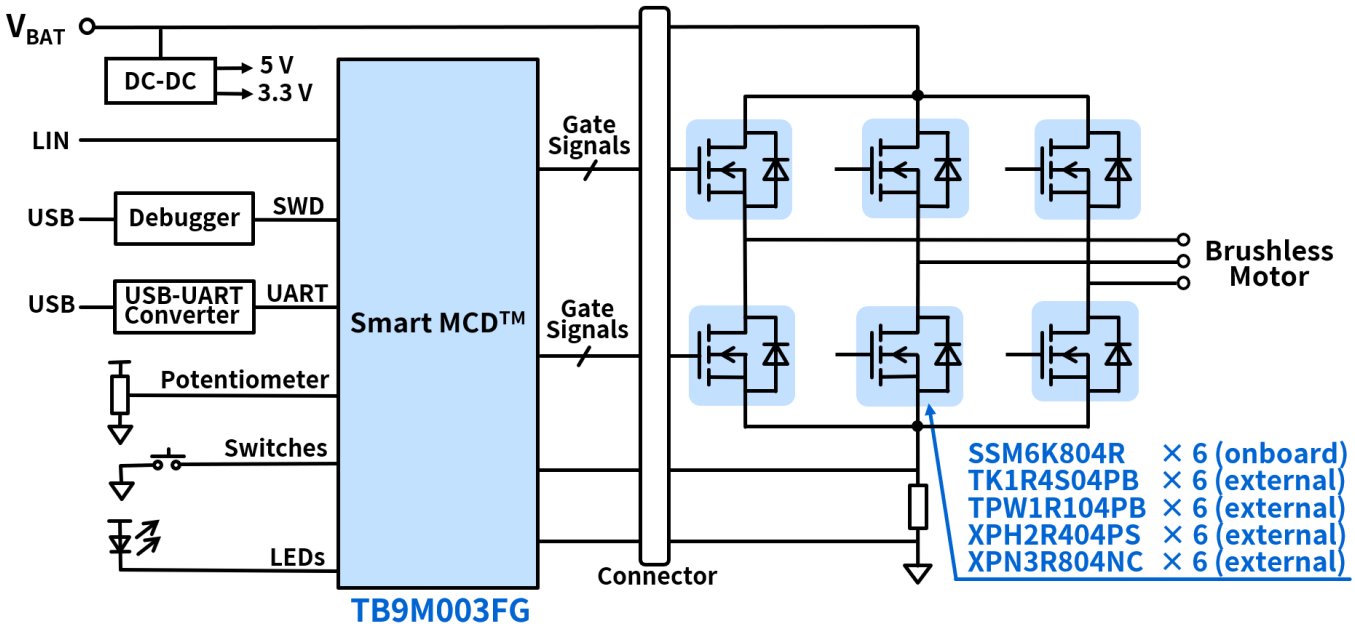


Fig. 2.1 Block Diagram of the Motor Driving Circuit for Automotive Body Electronics Using SmartMCD

2.2. Appearance and Component Layout

Fig. 2.2 to 2.11 show the external appearance of this design, and Fig. 2.12 to 2.15 show the board layout.

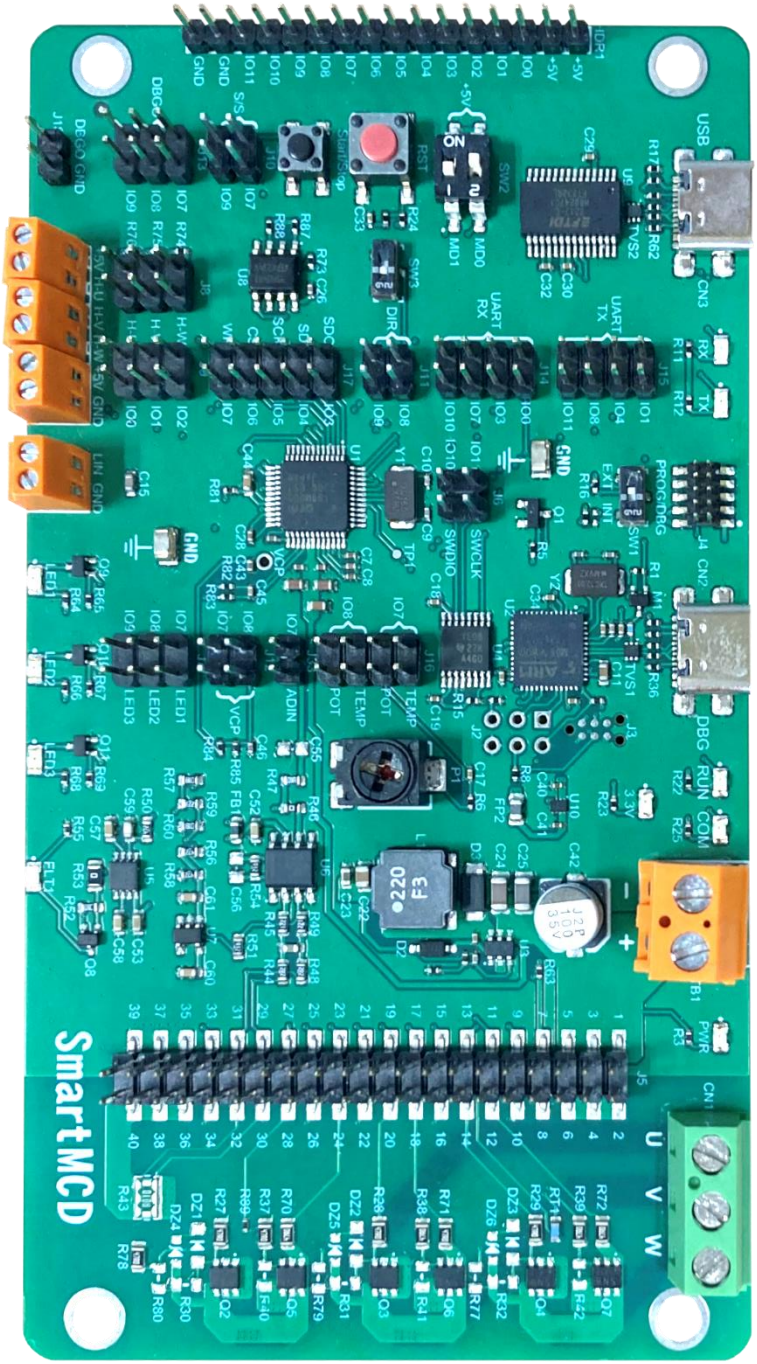


Fig. 2.2 Main Board of Motor Driving Circuit for Automotive Body Electronics Using SmartMCD (Top View)

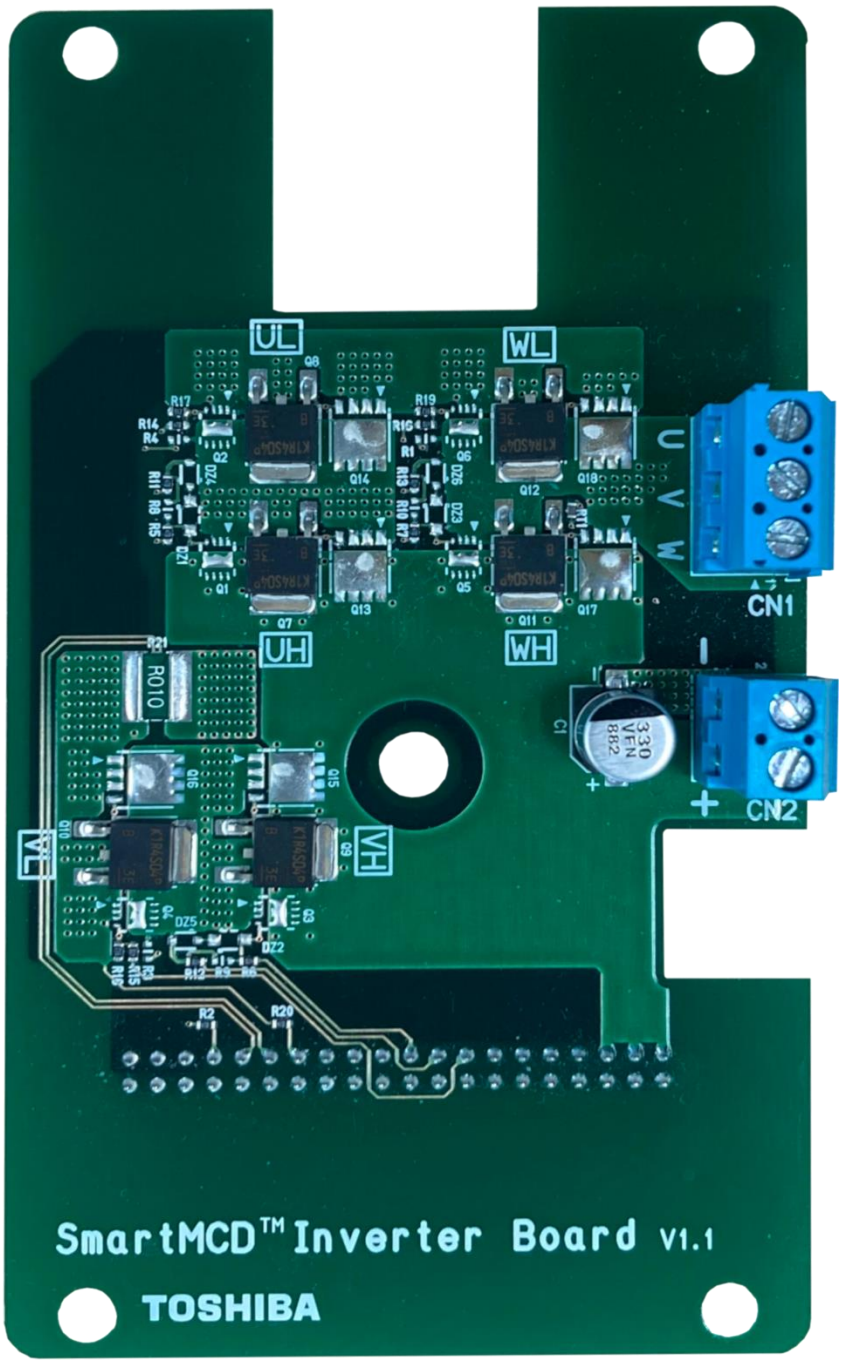


Fig. 2.3 External Inverter Board (TK1R4S04PB Version) of Motor Driving Circuit for Automotive Body Electronics Using SmartMCD (Top View)

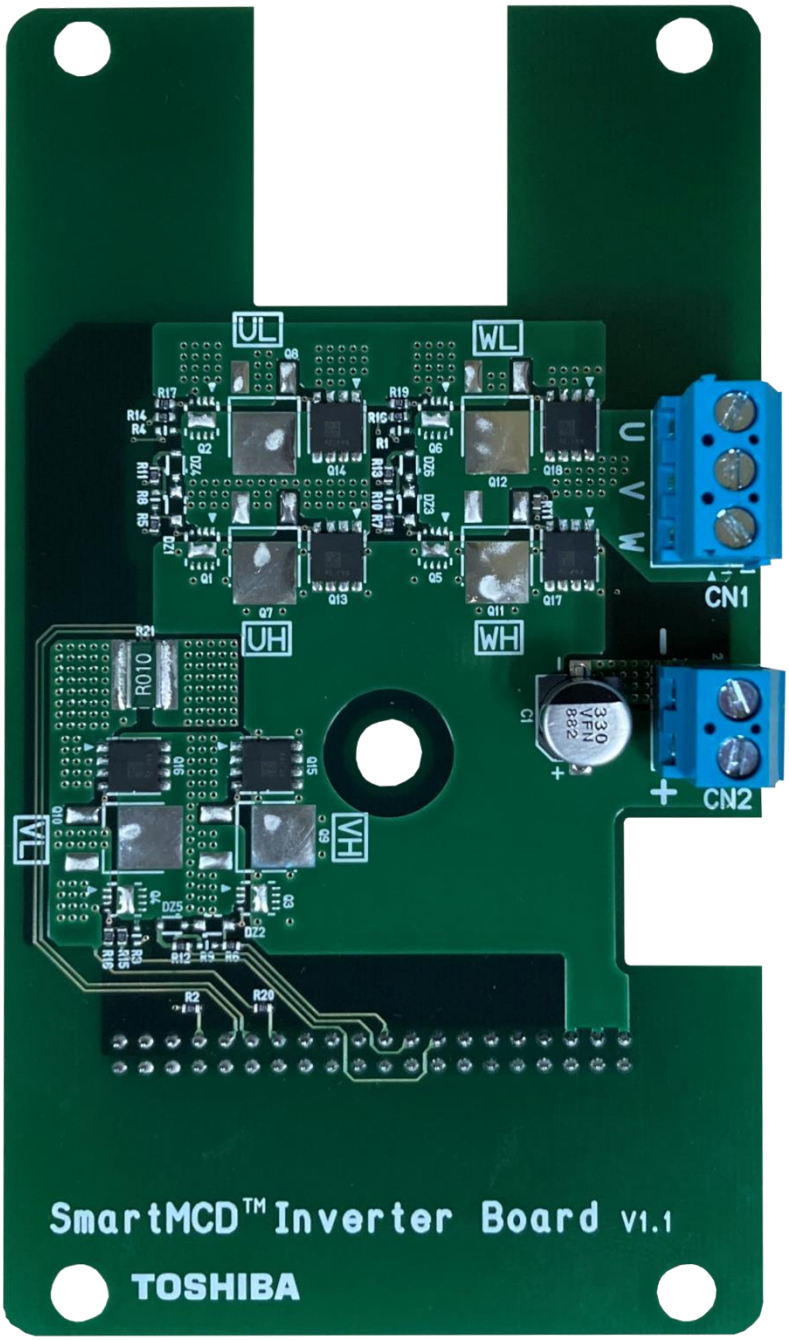


Fig. 2.4 External Inverter Board (XPH2R404PS Version) of Motor Driving Circuit for Automotive Body Electronics Using SmartMCD (Top View)

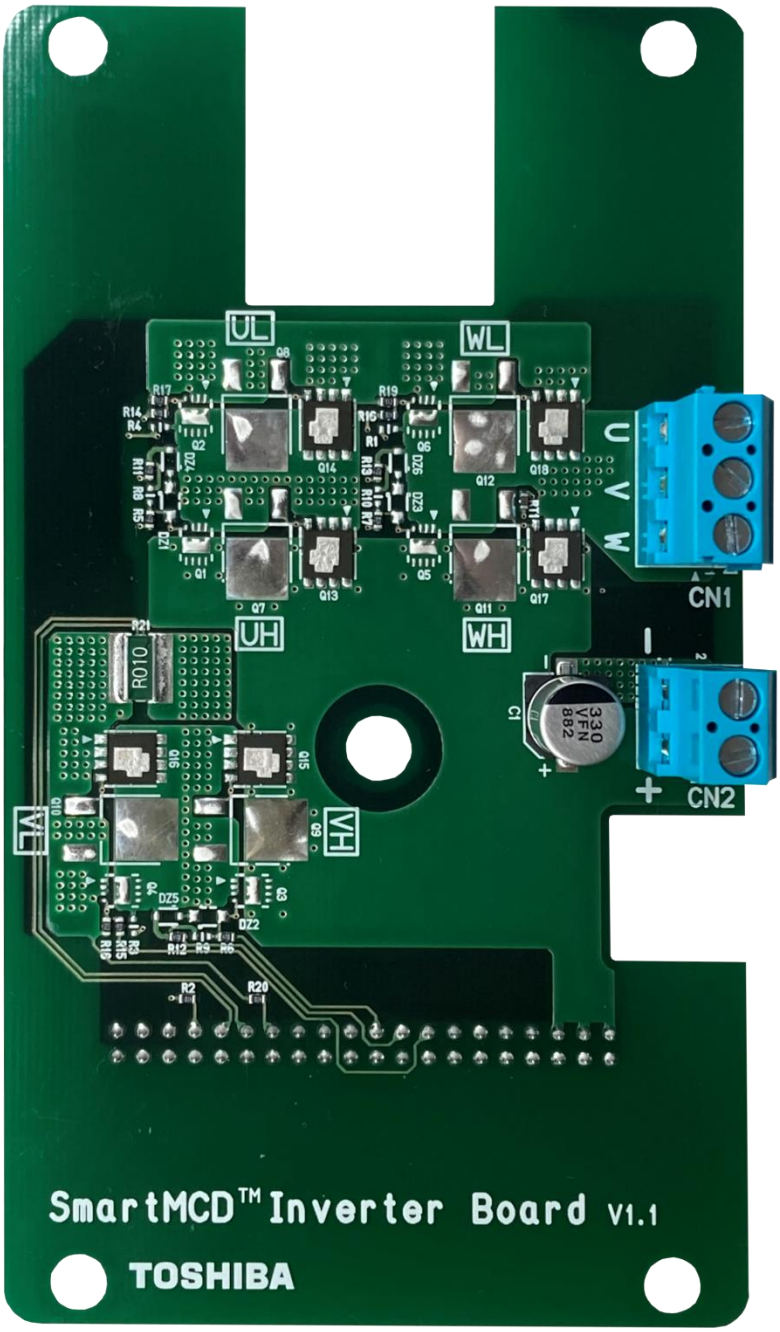


Fig. 2.5 External Inverter Board (TPW1R104PB Version) of Motor Driving Circuit for Automotive Body Electronics Using SmartMCD (Top View)

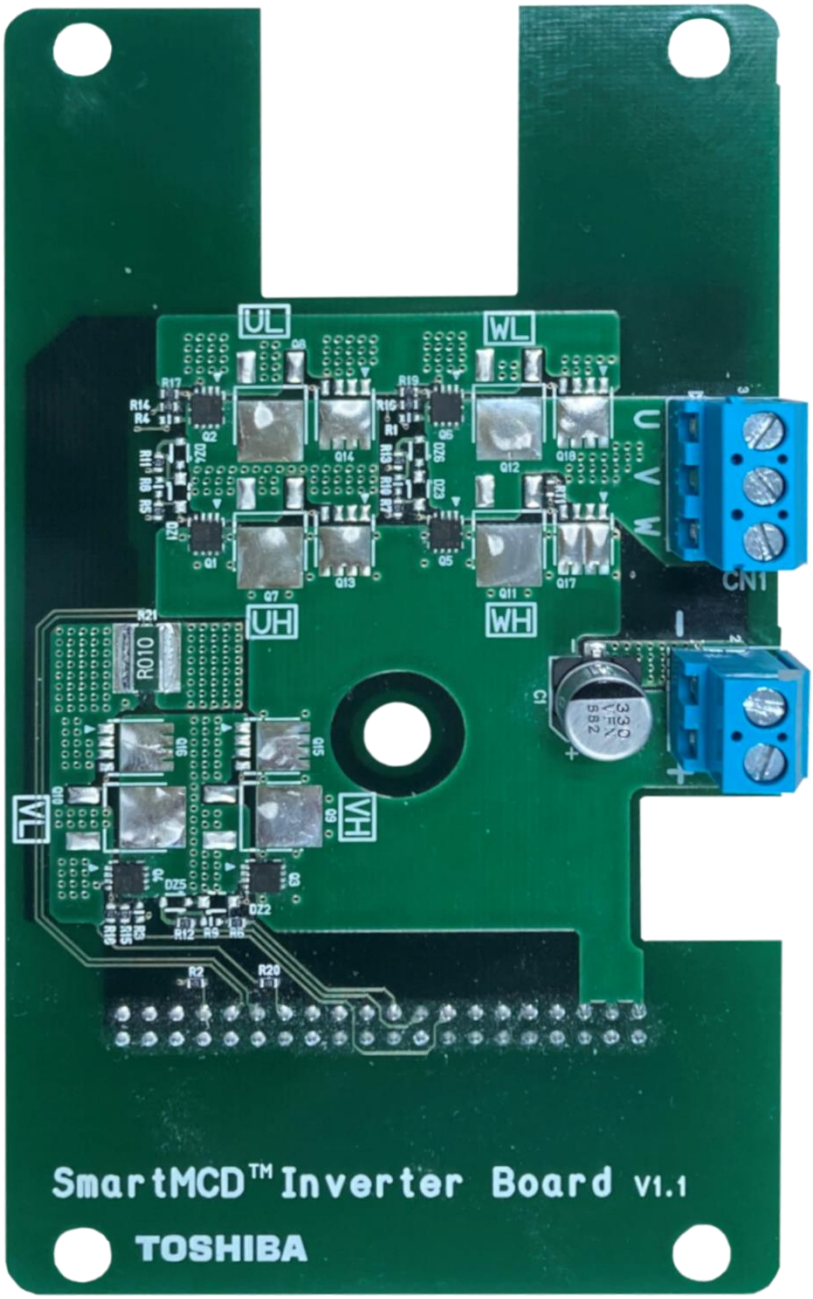


Fig. 2.6 External Inverter Board (XPN3R804NC Version) of Motor Driving Circuit for Automotive Body Electronics Using SmartMCD (Top View)

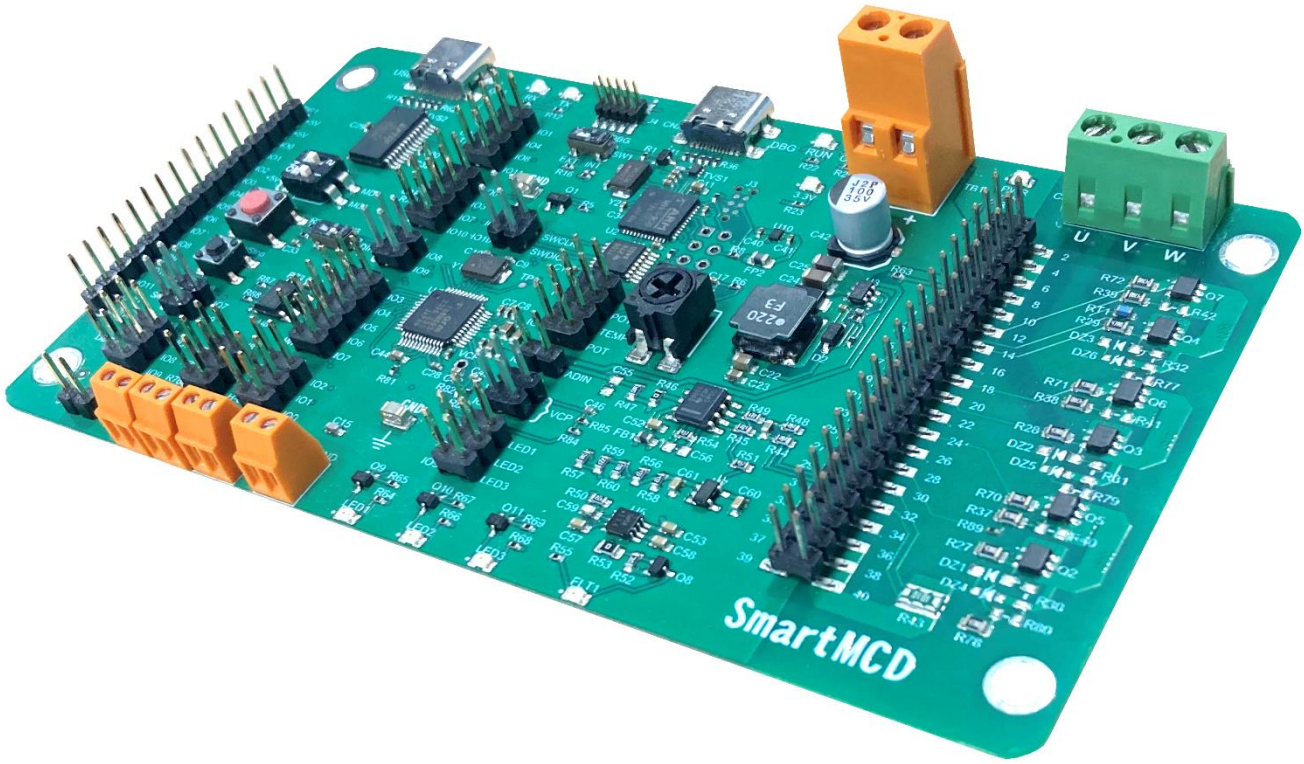


Fig. 2.7 Main Board of Motor Driving Circuit for Automotive Body Electronics Using SmartMCD (Side View)

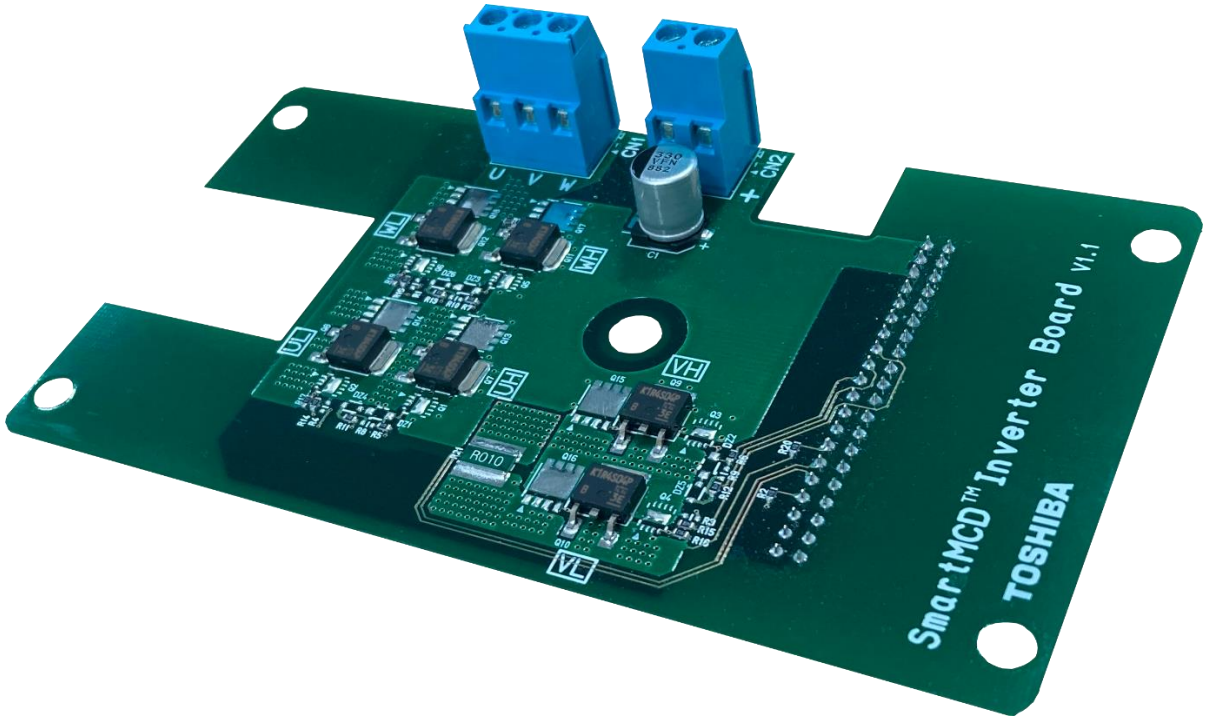


Fig. 2.8 External Inverter Board (TK1R4S04PB Version) of Motor Driving Circuit for Automotive Body Electronics Using SmartMCD (Side View)

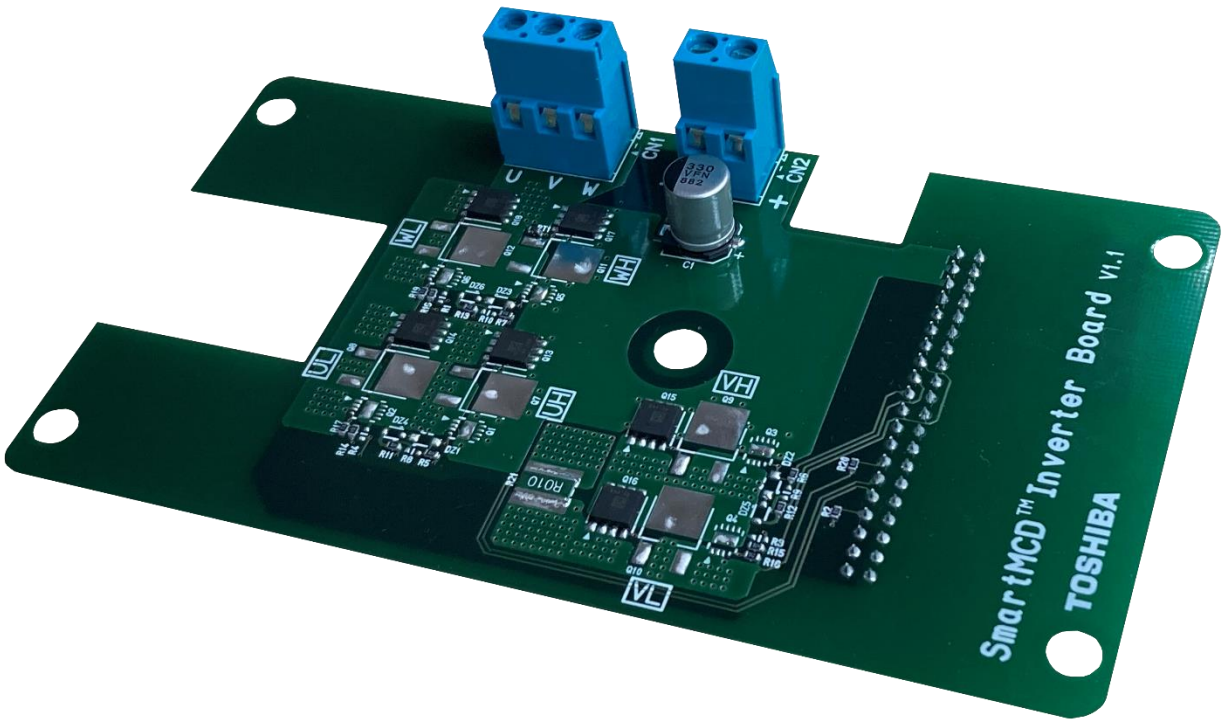


Fig. 2.9 External Inverter Board (XPH2R404PS Version) of Motor Driving Circuit for Automotive Body Electronics Using SmartMCD (Side View)

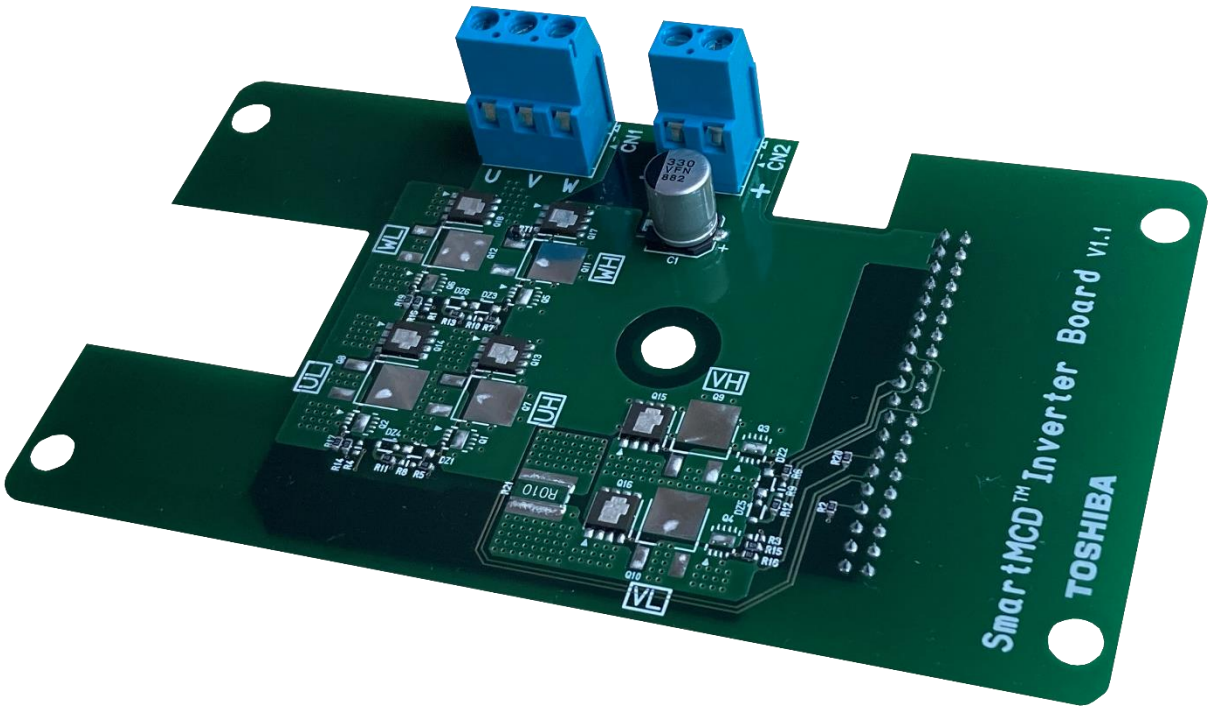


Fig. 2.10 External Inverter Board (TPW1R104PB Version) of Motor Driving Circuit for Automotive Body Electronics Using SmartMCD (Side View)

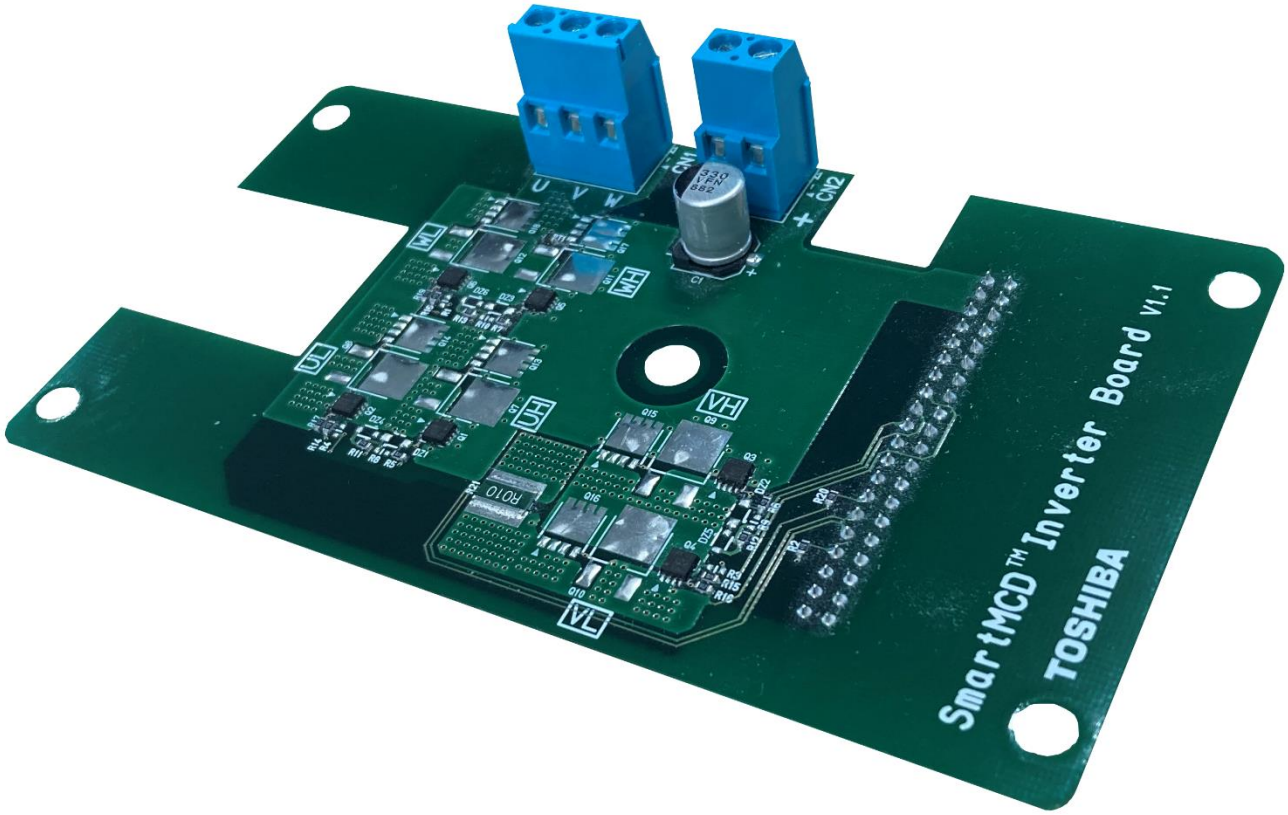


Fig. 2.11 External Inverter Board (XPN3R804NC Version) of Motor Driving Circuit for Automotive Body Electronics Using SmartMCD (Side View)

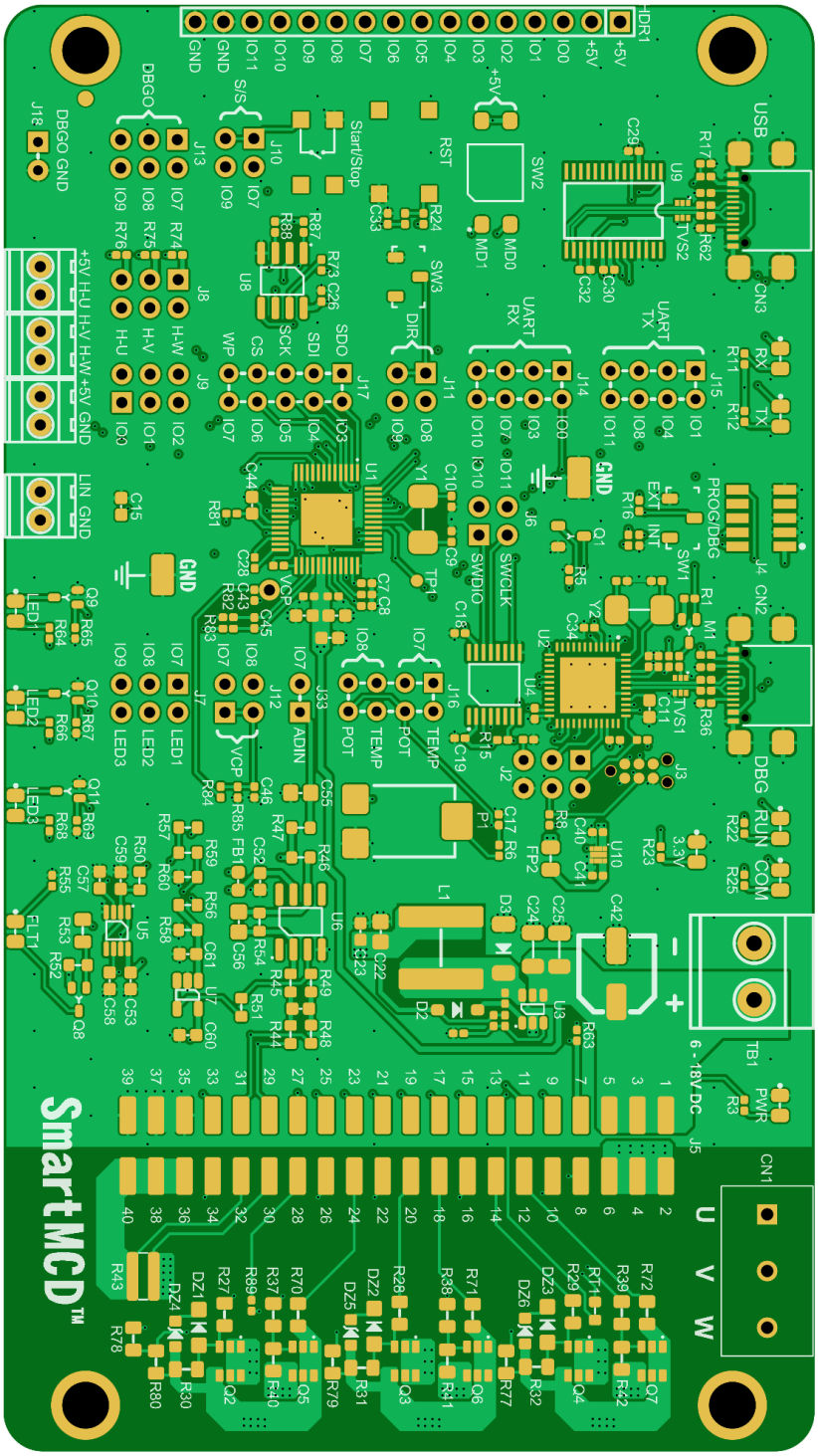


Fig. 2.12 Main Board Layout of Motor Driving Circuit for Automotive Body Electronics Using SmartMCD (Top Surface)

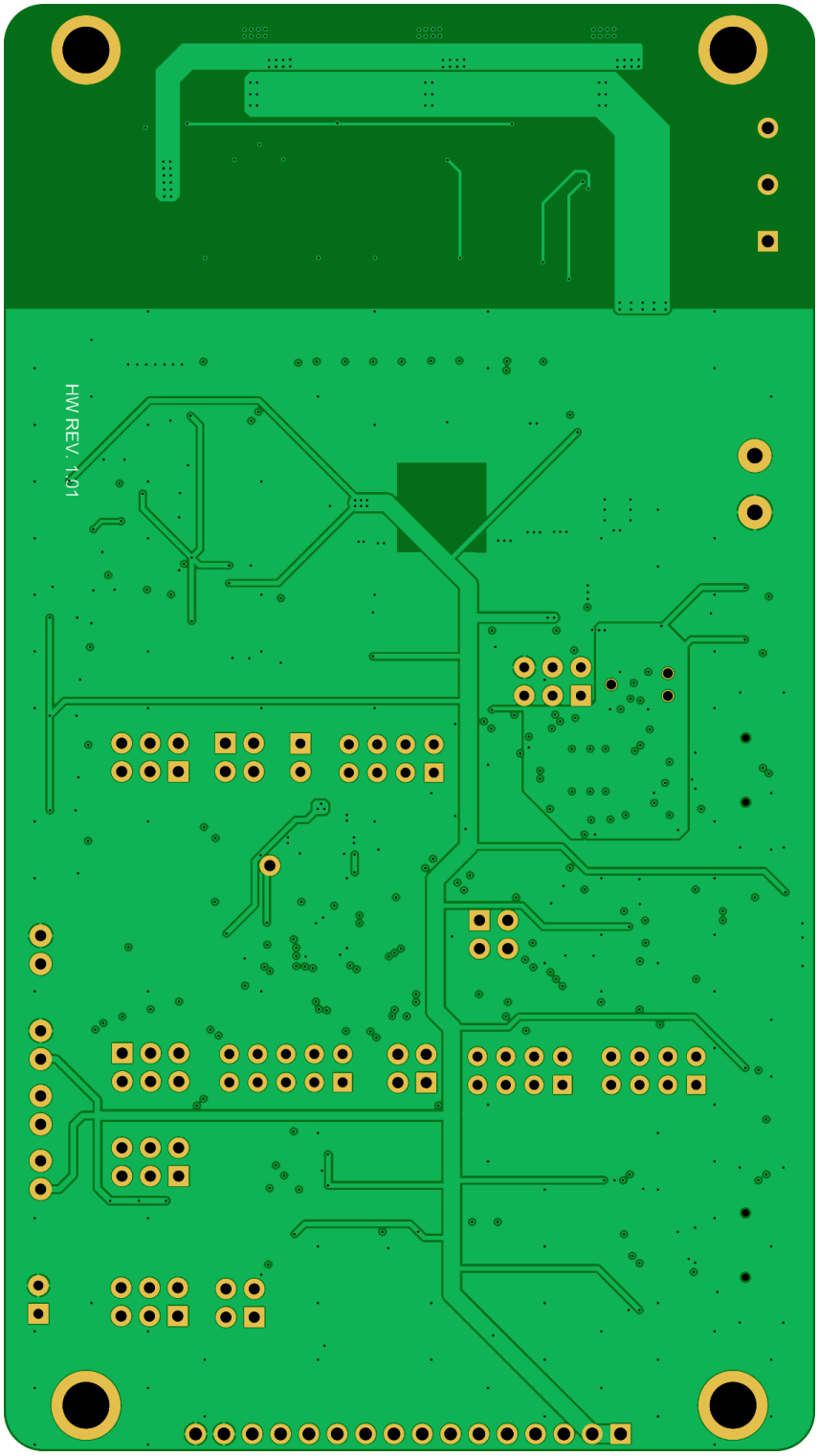


Fig. 2.13 Main Board Layout of Motor Driving Circuit for Automotive Body Electronics Using SmartMCD (Bottom Surface)

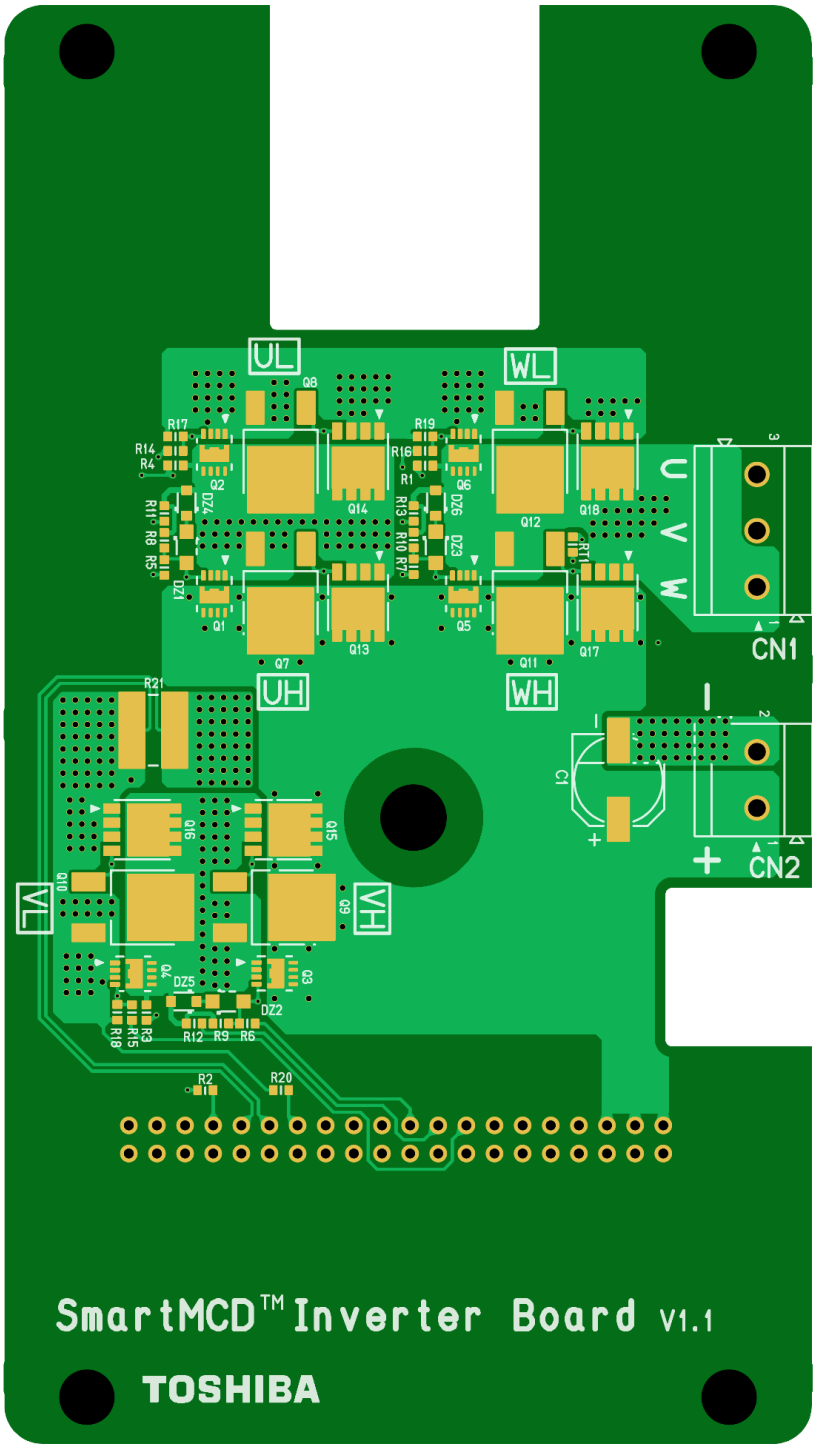


Fig. 2.14 External Inverter Board Layout of Motor Driving Circuit for Automotive Body Electronics Using SmartMCD (Top Surface)

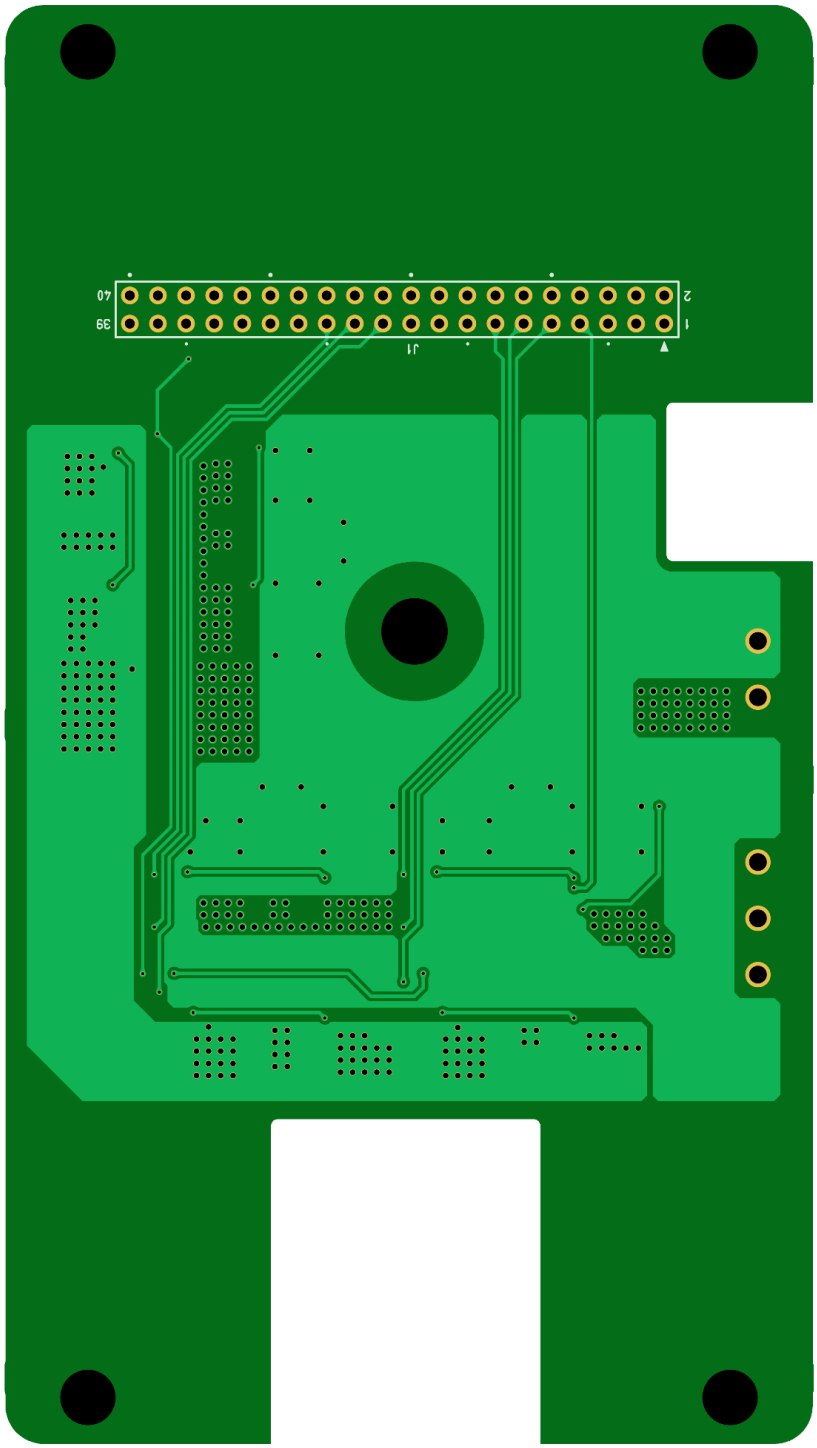


Fig. 2.15 External Inverter Board Layout Motor Driving Circuit for Automotive Body Electronics Using SmartMCD (Bottom Surface)

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

3.1. Schematic

Refer to the following files.

RD228-SCHEMATIC1-xx.pdf (main board)

RD228-SCHEMATIC2-xx.pdf (external inverter board)

(xx is the revision number.)

3.2. Bill of Materials

Refer to the following files.

RD228-BOM1-xx.pdf (main board)

RD228-BOM2-xx.pdf (external inverter board)

(xx is the revision number.)

3.3. PCB Pattern Diagram

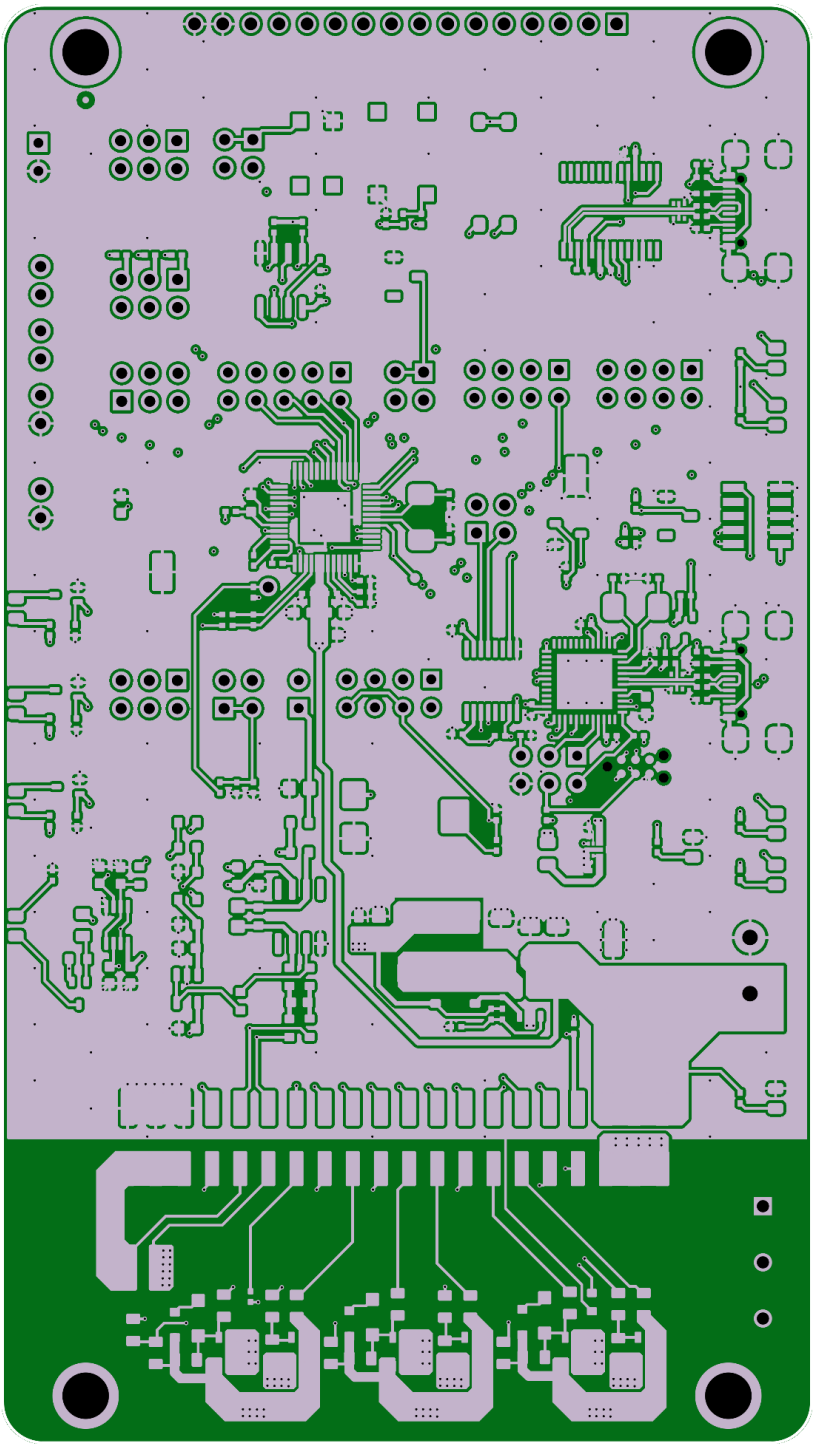
Fig. 3.1 shows the pattern diagram of the main board. Fig. 3.2 shows the pattern diagram of the external inverter board.

Refer to the following files.

RD228-LAYER1-xx.pdf (main board)

RD228-LAYER2-xx.pdf (external inverter board)

(xx is the revision number.)



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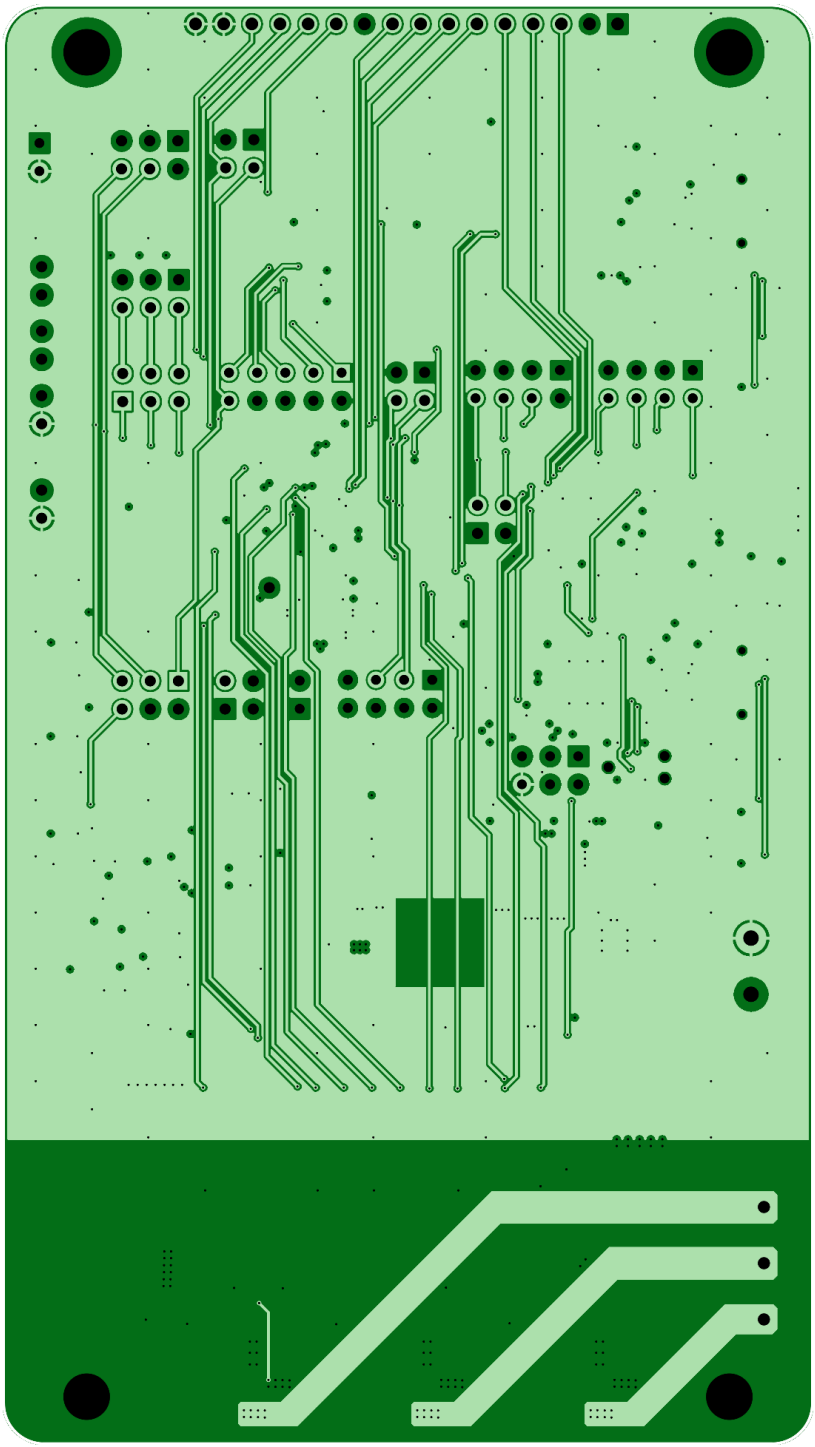

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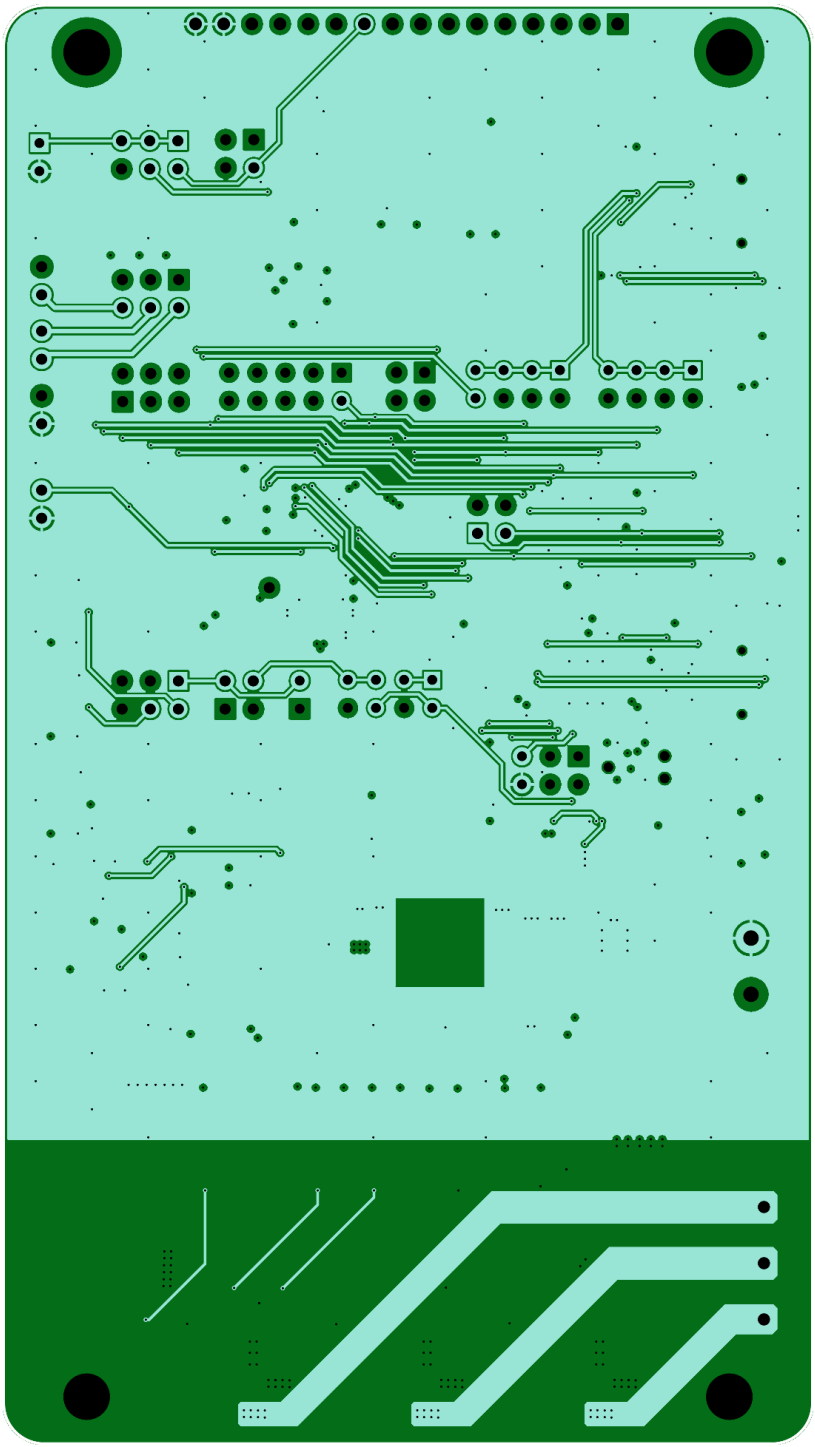

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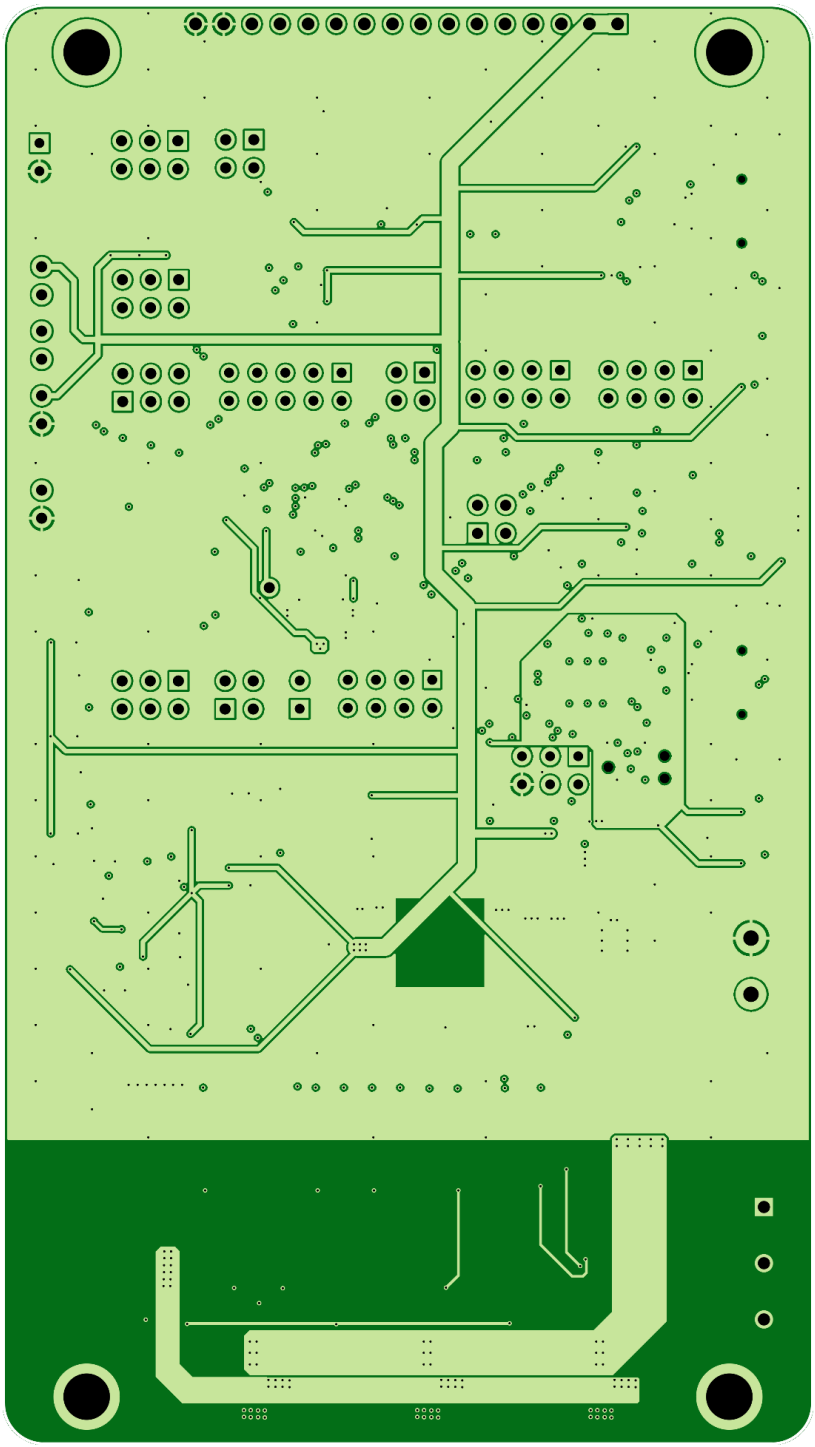

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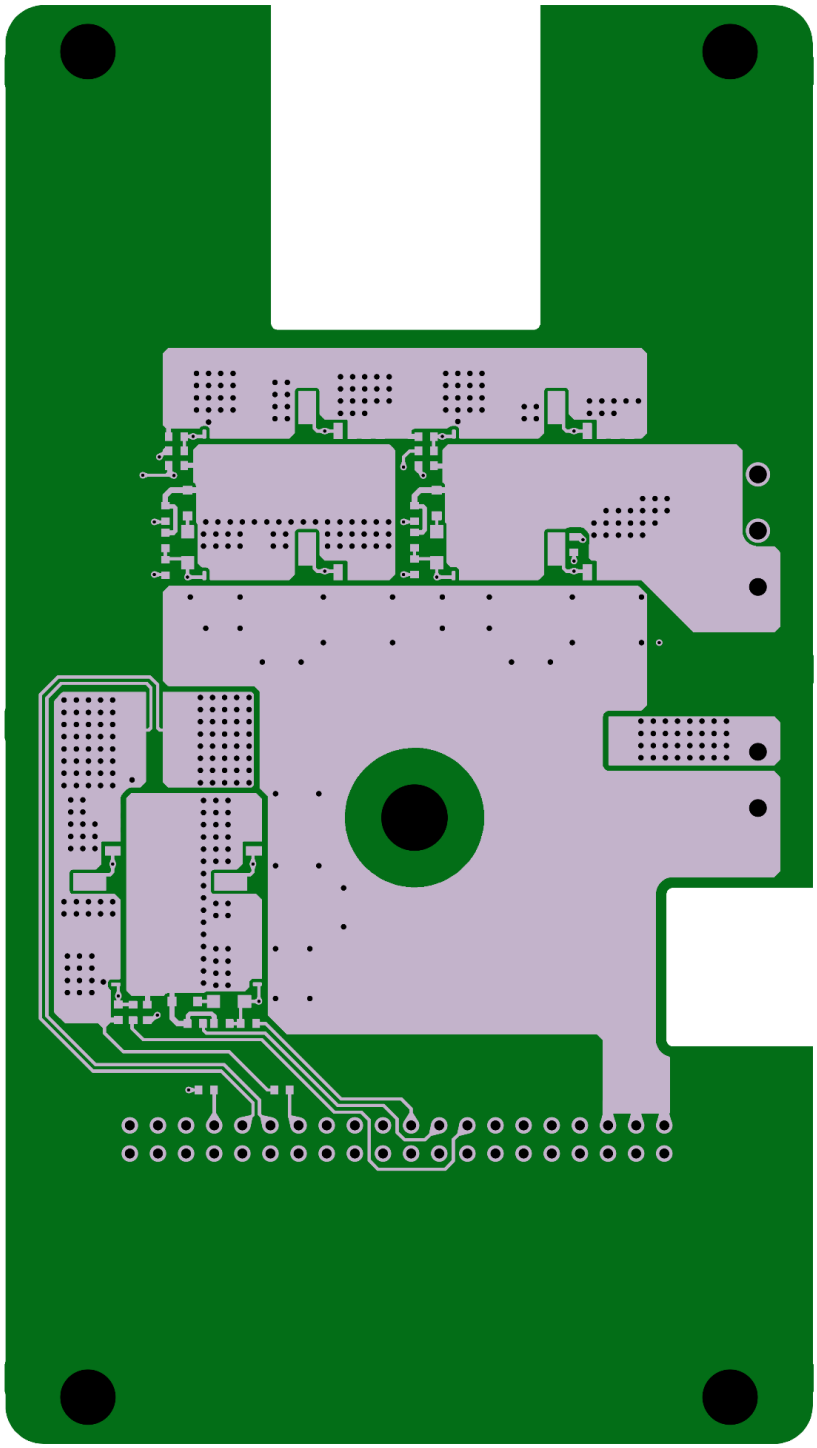
Fig. 3.1 Main Board Pattern Diagram (Top View)



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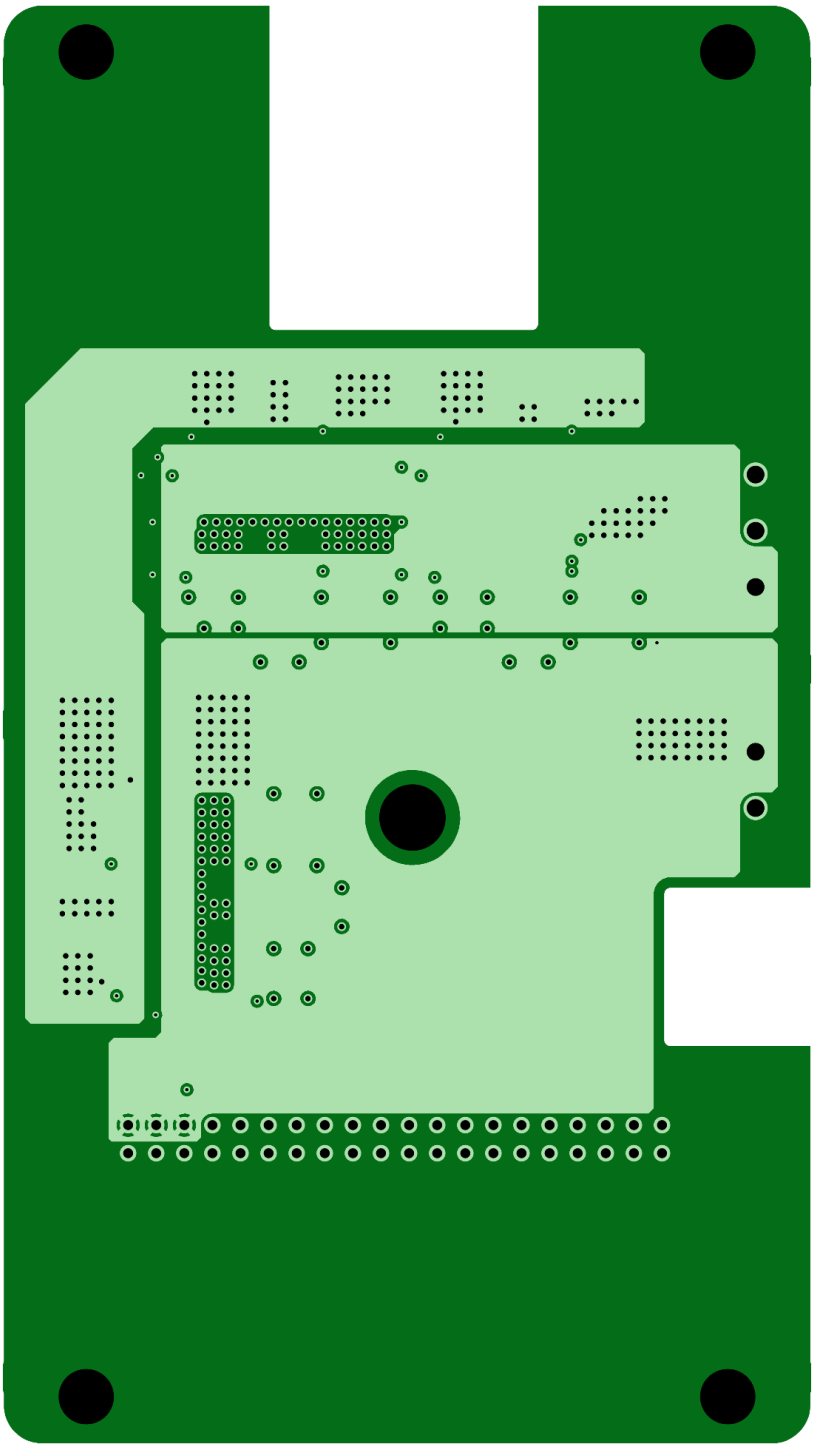

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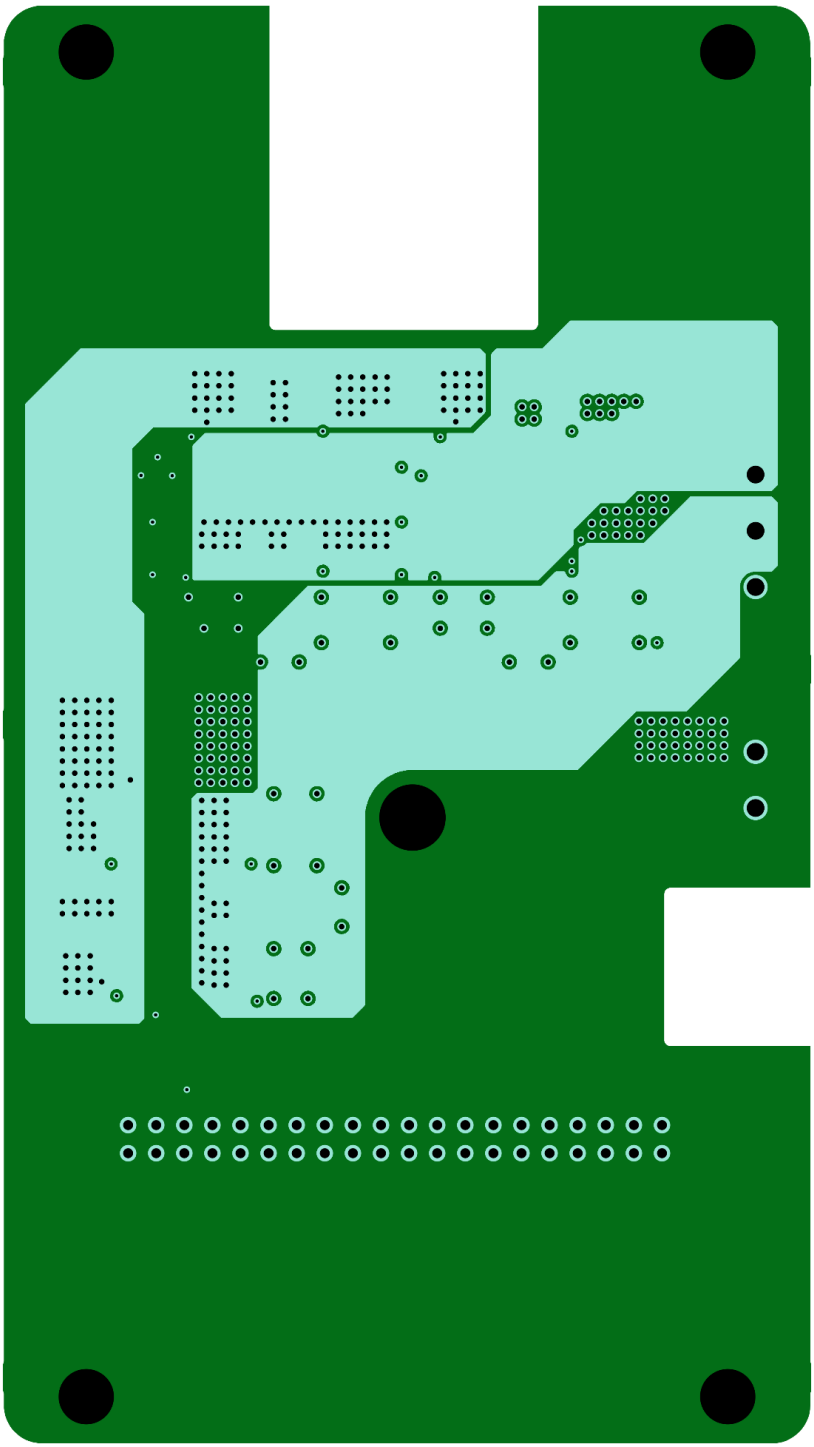

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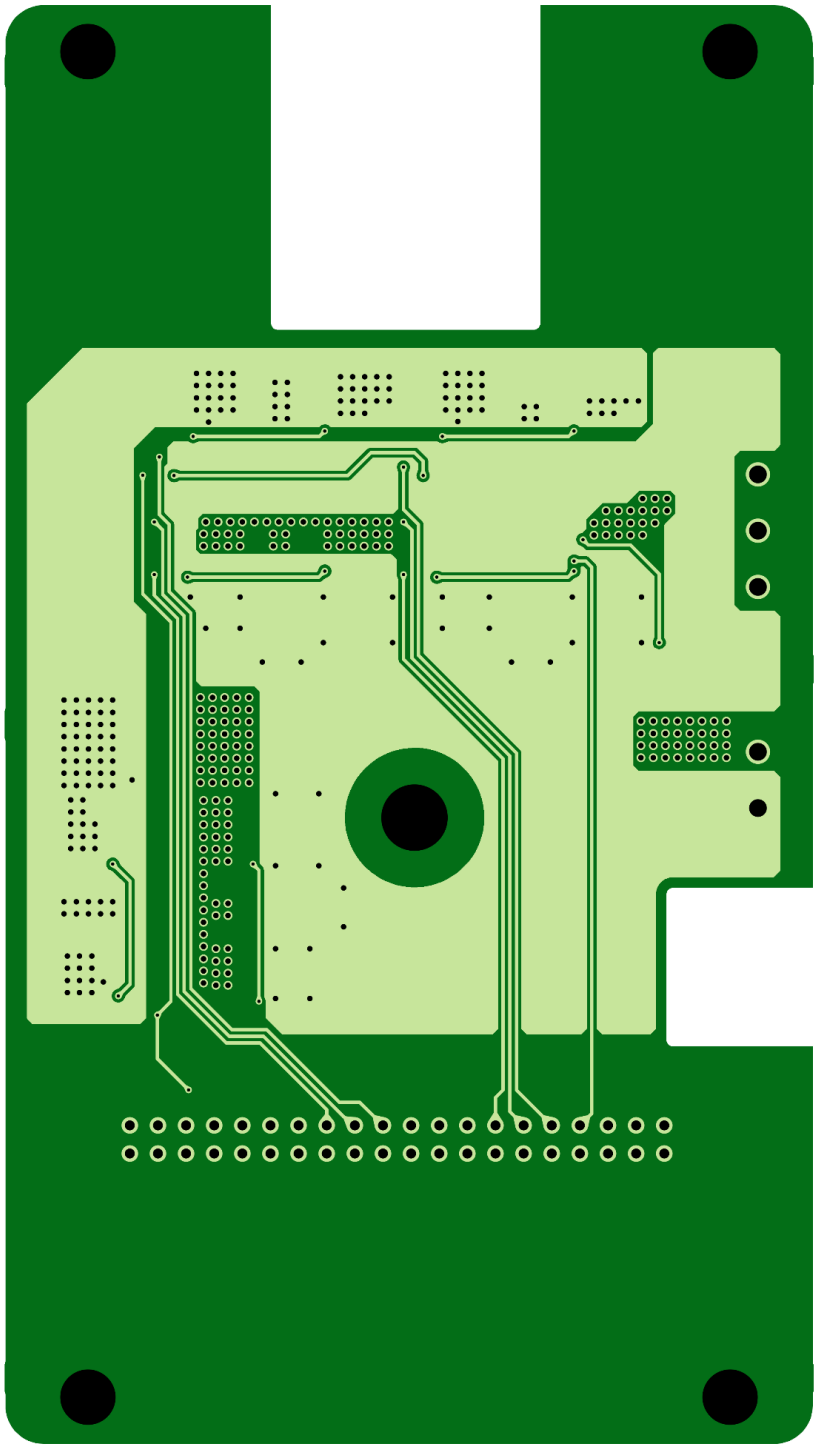

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Fig. 3.2 External Inverter Board Pattern Diagram (Top View)

4. Operation

4.1. Names and Functions of Components (Main Board)

4.1.1. Power Supply Input Terminal (TB1)

This is the power supply (V_{BAT}) input terminal for using the on-board inverter.

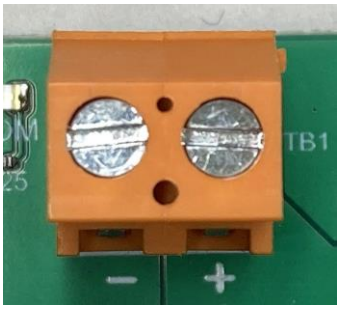

Fig. 4.1 Power Supply Input Terminal (TB1)

Table 4.1 Power Supply Input Terminal (TB1) Specifications

Terminal Name	Net Name	Function
+	VBAT	Power supply input (6 V to 18 V)
-	GND	Power supply input (GND)

4.1.2. LED (PWR)

PWR LED lights-up when V_{BAT} power is supplied.

Fig. 4.2 LED (PWR)

4.1.3. LED (3.3 V)

3.3 V LED lights-up when internal 3.3 V power supply is output.

Fig. 4.3 LED (3.3 V)

4.1.4. Reset switch (T1)

A push switch for resetting. Pressing it resets the SmartMCD (U1).

Fig. 4.4 Reset Switch (T1)

4.1.5. Push Switch (T2)

It is a Push switch. Press the switch to connect the switch's output (S/S) to GND. Connected to SmartMCD (U1) through jumper pin connector (J10). It is used for Start/Stop of the motor, etc. by the software.

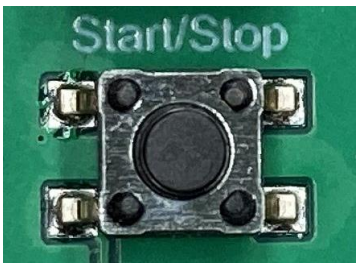

Fig. 4.5 Push-Switch (T2)

4.1.6. Push Switch Jumper Pin Connector (J10)

Jumper pins are used to connect the push-switch (T2) output (S/S) to IO7 or IO9 of SmartMCD (U1).

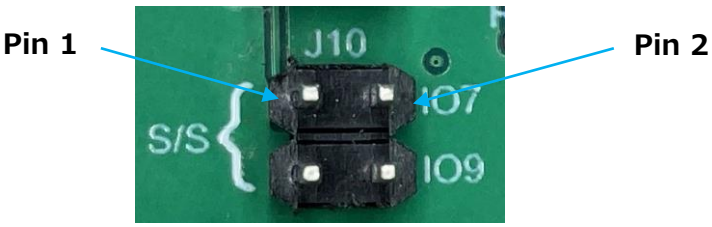

Fig. 4.6 Push Switch Jumper Pin Connector (J10)

Table 4.2 Push Switch Jumper Pin Connector (J10) Specifications

Jumper Pin Connector Pair				Function
Pin	Net Name	Pin	Net Name	
1	S/S	2	IO7	Connects the push-switch to IO7 of SmartMCD
3	S/S	4	IO9	Connects the push-switch to IO9 of SmartMCD

4.1.7. Slide Switch (SW3)

It is a slide switch. Depending on the slide switch setting, H or L is output to the switch output (DIR) which is connected to the SmartMCD (U1) via jumper pin connector (J11). It is used to change the motor rotation direction by software, etc.

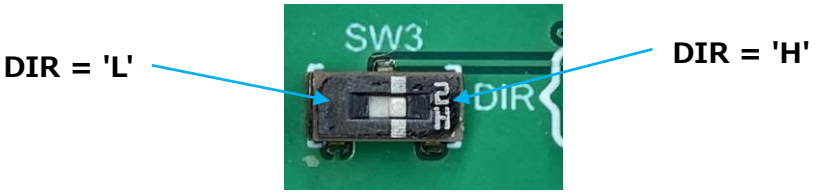

Fig. 4.7 Slide Switch (SW3)

4.1.8. Slide Switch Jumper Pin Connector (J11)

This jumper pin connector is used to connect DIR of SW3 to IO8 or IO9 of the SmartMCD (U1).

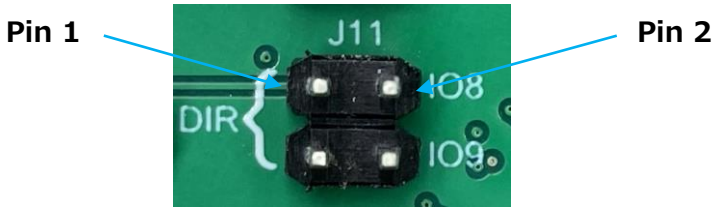

Fig. 4.8 Slide Switch Jumper Pin Connector (J11)

Table 4.3 Slide Switch Jumper Pin Connector (J11) Specifications

Jumper Pin Connector Pair				Function
Pin	Net Name	Pin	Net Name	
1	DIR	2	IO8	Connects the slide switch to IO8 of SmartMCD
3	DIR	4	IO9	Connects the slide switch to IO9 of SmartMCD

4.1.9. Start Mode Switch (SW2)

This switch is used to select the mode of SmartMCD (U1) at startup. Normal mode, Flash Download mode, and Debug mode are selected according to the setting of MD0, MD1 when the reset is released.

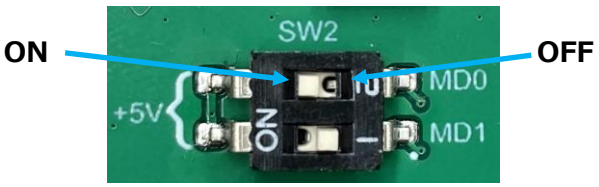

Fig. 4.9 Activation Mode Selection Switch (SW2)

Table 4.4 Start Mode Switch (SW2) Specifications

MD1	MD0	Mode
OFF	OFF	Normal
ON	OFF	Flash download
OFF	ON	Debug

4.1.10. Potentiometer (P1)

The voltage-output level (POT) of this potentiometer can be set between 0 V and 5 V depending on the rotational position. It is connected to the SmartMCD (U1) via jumper pin connector (J16). It is used to change the motor revolution by software, etc.

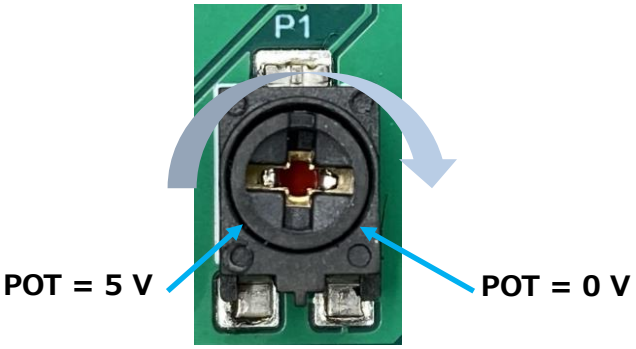

Fig. 4.10 Potentiometer (P1)

4.1.11. TEMP-POT Signal Jumper Pin Connector (J16)

By connecting the jumper pins, the voltage divider output (TEMP) of NTC (RT1 in case of using the on-board inverter) and the voltage output (POT) of the potentiometer (P1) are connected to IO7 or IO8 of SmartMCD (U1).

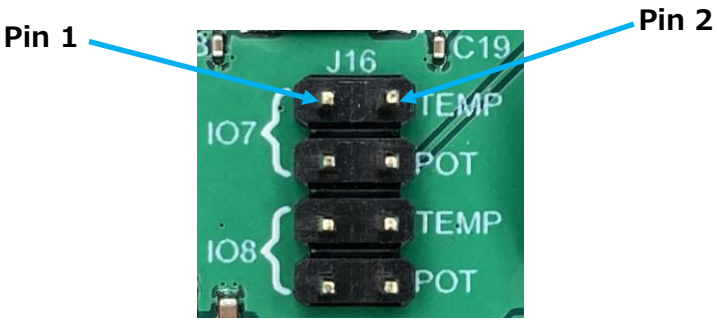

Fig. 4.11 TEMP-POT Signal Jumper Pin Connector (J16)

Table 4.5 TEMP-POT Signal Jumper Pin Connector (J16) Specifications

Jumper Pin Connector Pair				Function
Pin	Net Name	Pin	Net Name	
1	IO7	2	TEMP	Connects TEMP to IO7 of SmartMCD
3	IO7	4	POT	Connects POT to IO7 of SmartMCD
5	IO8	6	TEMP	Connects TEMP to IO8 of SmartMCD
7	IO8	8	POT	Connects POT to IO8 of SmartMCD

4.1.12. DBGO Signal Output Connector (J18)

This connector is used to externally monitor debug signal-out (DGBO) of on SmartMCD (U1).

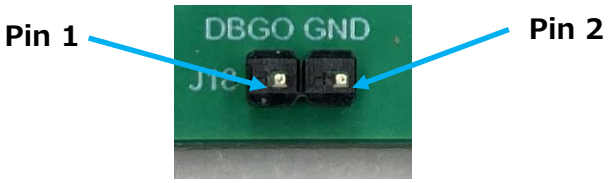

Fig. 4.12 DBGO Signal Output Connector (J18)

Table 4.6 DBGO Signal Output Connector (J18) Specifications

Pin	Net Name	Function
1	DBGO	DBGO output
2	GND	GND

4.1.13. DBGO Signal Jumper Pin Connector (J13)

It is used to select the debug signal (DBGO) output from IO7, IO8 or IO9 of SmartMCD (U1) and connect it to DBGO signal output connector (J18).

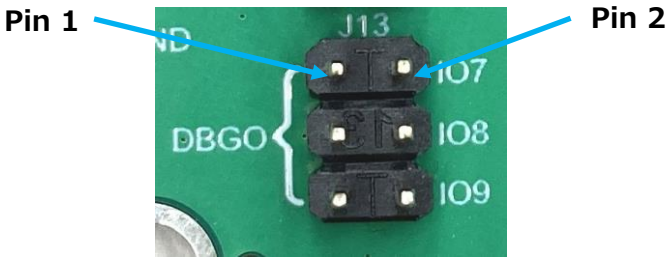

Fig. 4.13 DGBO Signal Jumper Pin Connector (J13)

Table 4.7 DGBO Signal Jumper Pin Connector (J13) Specifications

Jumper Pin Connector Pair				Function
Pin	Net Name	Pin	Net Name	
1	DBGO	2	IO7	Connects DBGO to IO7 of SmartMCD
3	DBGO	4	IO8	Connects DBGO to IO8 of SmartMCD
5	DBGO	6	IO9	Connects DBGO to IO9 of SmartMCD

4.1.14. SWD Connector (J4)

This connector is used to connect SWD interface from an external device to SmartMCD (U1). Connected to SmartMCD (U1) through SWD signal jumper pin connector (J6).

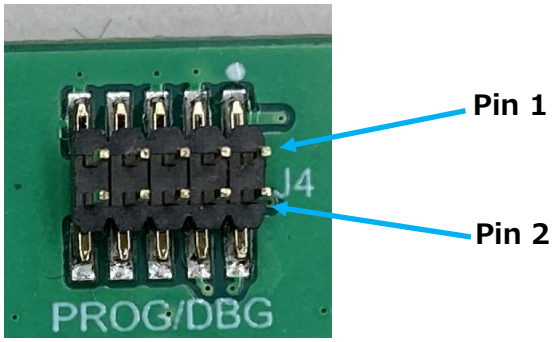

Fig. 4.14 SWD Connector (J4)

Table 4.8 SWD Connector (J4) Specifications

Pin	Net Name	Function
1	VCC-5V	5 V output
2	SWDIO	SWDIO
3	GND	GND
4	SWCLK	SWCLK
5	GND	GND
6	(n.c.)	
7	(n.c.)	
8	(n.c.)	
9	GND	GND
10	RESET#	Reset I/O signal

4.1.15. SWD Signal Jumper Pin Connector (J6)

This is used to connect SWDIO and SWCLK pins of SWD connector (J4) to IO10 and IO11 of SmartMCD (U1) respectively.

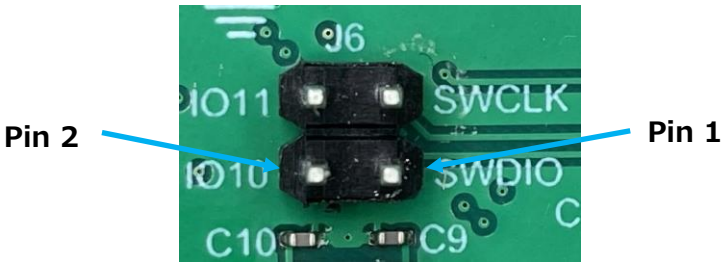

Fig. 4.15 SWD Signal Jumper Pin Connector (J6)

Table 4.9 SWD Signal Jumper Pin Connector (J6) Specifications

Jumper Pin Connector Pair				Function
Pin	Net Name	Pin	Net Name	
1	SWDIO	2	IO10	Connects SWDIO to IO10 of SmartMCD
3	SWCLK	4	IO11	Connects SWCLK to IO11 of SmartMCD

4.1.16. EEPROM Connection Jumper Pin Connector (J17)

It can be used to connect EEPROM (U8).

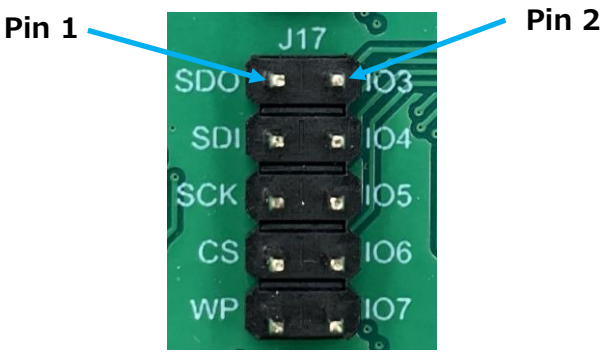

Fig. 4.16 EEPROM connect jumper pin connector (J17)

Table 4.10 EEPROM Jumper Pin Connector (J17) Specifications

Jumper Pin Connector Pair				Function
Pin	Net Name	Pin	Net Name	
1	SDO	2	IO3	Connects SDO of EEPROM to IO3 of SmartMCD
3	SDI	4	IO4	Connects SDI of EEPROM to IO4 of SmartMCD
5	SCK	6	IO5	Connects SCK of EEPROM to IO5 of SmartMCD
7	CS	8	IO6	Connects CS of EEPROM to IO6 of SmartMCD
9	WP	10	IO7	Connects WP of EEPROM to IO7 of SmartMCD

4.1.17. LED (LED1, LED2, LED3)

LED1, LED2, LED3 are used to display the operation status by the software. These are connected to SmartMCD (U1) through LED signal jumper pin connector (J7). LED lights up when LED1, LED2, LED3 signal of the corresponding LED is H-level.

Fig. 4.17 LED (LED1, LED2, LED3)

4.1.18. LED Signal Jumper Pin Connector (J7)

It can be used to connect LED1 to IO7, LED2 to IO8, and LED3 to IO9 of SmartMCD (U1).

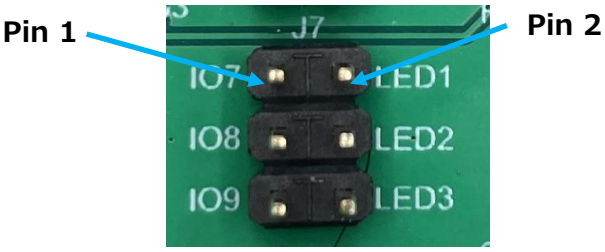

Fig. 4.18 LED Signal Jumper Pin Connector (J7)

Table 4.11 LED Signal Jumper Pin Connector (J7) Specifications

Jumper Pin Connector Pair				Function
Pin	Net Name	Pin	Net Name	
1	IO7	2	LED1	Connects LED1 to IO7 of SmartMCD
3	IO8	4	LED2	Connects LED2 to IO8 of SmartMCD
5	IO9	6	LED3	Connects LED3 to IO9 of SmartMCD

4.1.19. VCP Jumper Pin Connector (J12)

It is used to connect VCP (charge pump power supply output) to IO7 or IO8 of SmartMCD (U1).

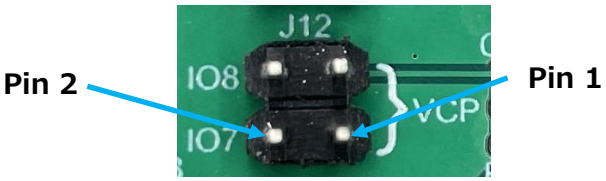

Fig. 4.19 VCP Jumper Pin Connector (J12)

Table 4.12 VCP Jumper Pin Connector (J12) Specifications

Jumper Pin Connector Pair				Function
Pin	Net Name	Pin	Net Name	
1	VCP_MON	2	IO7	Connects VCP to IO7 of SmartMCD
3	VCP_MON	4	IO8	Connects VCP to IO8 of SmartMCD

4.1.20. USB Connector for Serial Communication (CN3)

This mode is used when serial communication is performed from an external device to SmartMCD (U1) via a USB-UART converter (U9). USB Type-C® connector is being used.

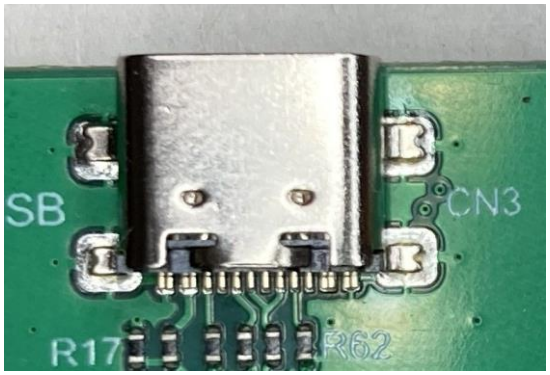

Fig. 4.20 USB Connector for Serial Communication (CN3)

Table 4.13 USB Connector for Serial Communication (CN3)

Pin	Net Name	Function
A4, B9	V-USB	VBUS
A1, B12	GND	GND
A5	CC1_1	CC1
A6	USB_P	DP1
A7	USB_N	DN1
A8	(n.c.)	SBU1
B5	CC2_1	CC2
B6	USB_P	DP2
B7	USB_N	DN2
B8	(n.c.)	SBUS
B4, A9	V-USB	VBUS
B1, A12	GND	GND

4.1.21. LED (TX, RX)

LED of TX, or RX lights-up when SmartMCD (U1) transmits or receives data serially.

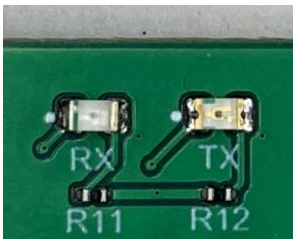

Fig. 4.21 LED (TX, RX)

4.1.22. UART-RX Signal Jumper Pin Connector (J14)

It connects UART-RX from USB-UART converter (U9) to IO0, IO3, IO7 or IO10 of SmartMCD (U1).

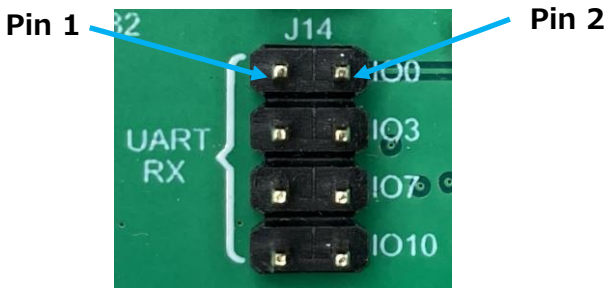

Fig. 4.22 UART-RX Signal Jumper Pin Connector (J14)

Table 4.14 UART-RX Signal Jumper Pin Connector (J14) Specifications

Jumper Pin Connector Pair				Function
Pin	Net Name	Pin	Net Name	
1	UART-RX	2	IO0	Connects UART-RX to IO0 of SmartMCD
3	UART-RX	4	IO3	Connects UART-RX to IO3 of SmartMCD
5	UART-RX	6	IO7	Connects UART-RX to IO7 of SmartMCD
7	UART-RX	8	IO10	Connects UART-RX to IO10 of SmartMCD

4.1.23. UART-TX Signal Jumper Pin Connector (J15)

It connects UART-TX of USB-UART converter (U9) to IO1, IO4, IO8 or IO11 of SmartMCD (U1).

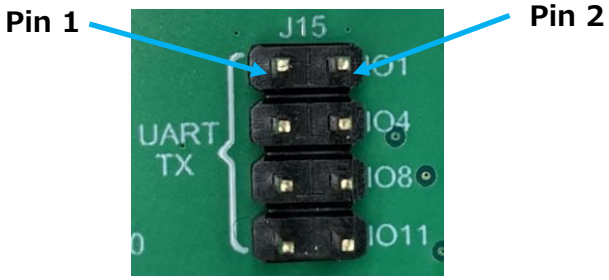

Fig. 4.23 UART-TX Signal Jumper Pin Connector (J15)

Table 4.15 UART-TX Signal Jumper Pin Connector (J15) Specifications

Jumper Pin Connector Pair				Function
Pin	Net Name	Pin	Net Name	
1	UART-TX	2	IO1	Connects UART-TX to IO1 of SmartMCD
3	UART-TX	4	IO4	Connects UART-TX to IO4 of SmartMCD
5	UART-TX	6	IO8	Connects UART-TX to IO8 of SmartMCD
7	UART-TX	8	IO11	Connects UART-TX to IO11 of SmartMCD

4.1.24. Hall Sensor Terminals (TB3, TB4, TB5)

These are used for hall sensor input and 5 V output. This design is able to control a built-in hall sensor motor with each phase hall sensor signal.

Fig. 4.24 Hall Sensor Terminals (TB3, TB4, TB5)

Table 4.16 Hall Sensor Terminal (TB3) Specifications

Terminal Name	Net Name	Function
+5 V	VCC-5V	5 V output
H-U	HALL-U	U phase Hall sensor input

Table 4.17 Hall Sensor Terminal (TB4) Specifications

Terminal Name	Net Name	Function
H-V	HALL-V	V-phase Hall sensor input
H-W	HALL-W	W-phase Hall sensor input

Table 4.18 Hall Sensor Terminal (TB5) Specifications

Terminal Name	Net Name	Function
+5 V	VCC-5V	5 V output
GND	GND	GND

4.1.25. Hall Sensor Connector Jumper Pin Connector (J8, J9)

J8 can be used to externally pull up the hall sensors (HALL-U, HALL-V, HALL-W) to 5 V. J9 can be used to connect HALL-U (TB3), HALL-V (TB4), and HALL-W (TB4) to IO0, IO1, and IO2 of SmartMCD (U1).

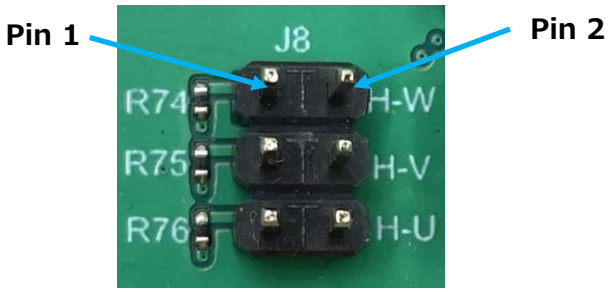

Fig. 4.25 Hall Sensor Connection Terminal Jumper Pin Connector (J8)

Table 4.19 Hole Sensor Connection Terminal Jumper Pin Connector (J8)

Jumper Pin Connector Pair				Function
Pin	Net Name	Pin	Net Name	
1	-	2	HALL-W	Pull up HALL-W to 5 V
3	-	4	HALL-V	Pull up HALL-V to 5 V
5	-	6	HALL-U	Pull up HALL-U to 5 V

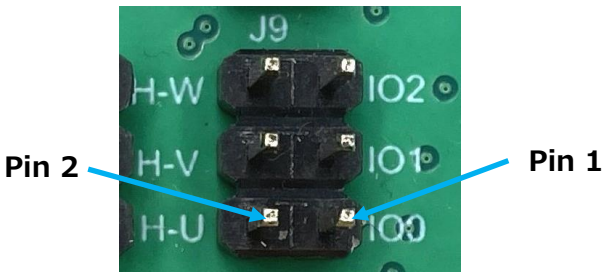

Fig. 4.26 Hall Sensor Connection Terminal Jumper Pin Connector (J9)

Table 4.20 Hole Sensor Connection Terminal Jumper Pin Connector (J9)

Jumper Pin Connector Pair				Function
Pin	Net Name	Pin	Net Name	
1	IO0	2	HALL-U	Connects HALL-U to IO0 of SmartMCD
3	IO1	4	HALL-V	Connects HALL-V to IO1 of SmartMCD
5	IO2	6	HALL-W	Connects HALL-W to IO2 of SmartMCD

4.1.26. Pin Header for Testing (HDR1)

These pin headers can be used to connect to IO0 to IO11 of SmartMCD (U1), 5 V power supply and GND.

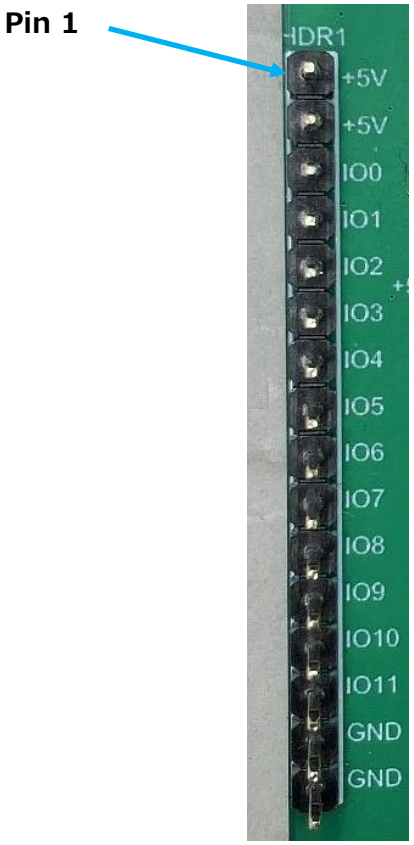

Fig. 4.27 Pin Header for Testing (HDR1)

Table 4.21 Pin Header for Testing (HDR1) Specifications

Pin	Net Name	Function
1	VCC-5V	5 V Power Output
2	VCC-5V	5 V Power Output
3	IO0	IO0 of SmartMCD
4	IO1	IO1 of SmartMCD
5	IO2	IO2 of SmartMCD
6	IO3	IO3 of SmartMCD
7	IO4	IO4 of SmartMCD
8	IO5	IO5 of SmartMCD
9	IO6	IO6 of SmartMCD
10	IO7	IO7 of SmartMCD
11	IO8	IO8 of SmartMCD
12	IO9	IO9 of SmartMCD
13	IO10	IO10 of SmartMCD
14	IO11	IO11 of SmartMCD
15	GND	GND
16	GND	GND

4.1.27. USB Connector for Debugging (CN2)

CMSIS-DAP (U2) is used for programming/debugging with SWD interface. USB Type-C® connector is being used.

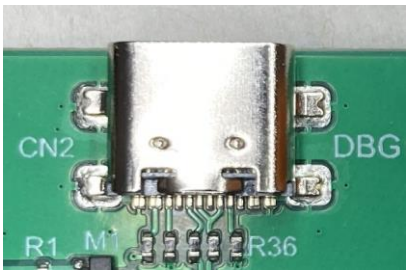

Fig. 4.28 USB Connector for Debugging (CN2)

Table 4.22 USB Connector for Debugging (CN2)

Pin	Net Name	Function
A4, B9	-	VBUS
A1, B12	GND	GND
A5	CC1_2	CC1
A6	P_USB_P	DP1
A7	P_USB_N	DN1
A8	(n.c.)	SBU1
B5	CC2_2	CC2
B6	P_USB_P	DP2
B7	P_USB_N	DN2
B8	(n.c.)	SBUS
B4, A9	-	VBUS
B1, A12	GND	GND

4.1.28. Serial Port Programming Connector for CMSIS-DAP (J2)

This connector can be used for writing program in Flash memory of CMSIS-DAP (U2) via serial port.

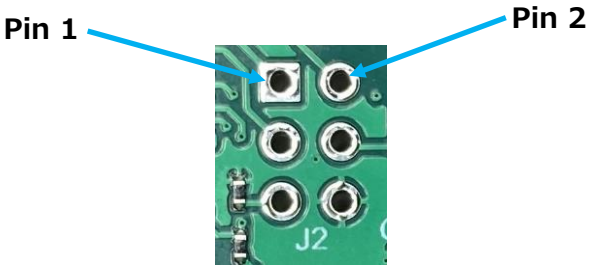

Fig. 4.29 Serial Port Programming Connector for CMSIS-DAP (J2)

Table 4.23 Serial Port Programming Connector for CMSIS-DAP (J2)

Pin	Net Name	Function
1	PROG_TXD	Transmit data for serial port programming
2	BOOT	Boot mode switching
3	PROG_RXD	Receive data for serial port programming
4	REST_OB#	Reset signal
5	DAPEN	CMSIS-DAP function enable (software-based operation)
6	GND	

4.1.29. SWD Connector for CMSIS-DAP (J3)

This connector can be used for debugging using SWD for CMSIS-DAP (U2).

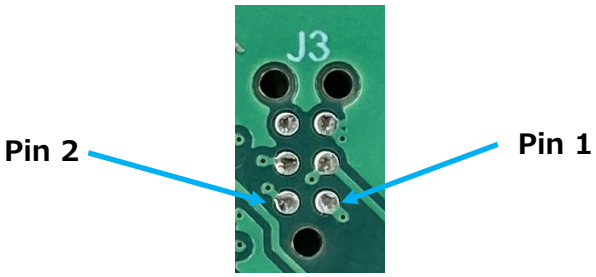

Fig. 4.30 SWD connector for CMSIS-DAP (J3)

Table 4.24 SWD connector for CMSIS-DAP (J3)

Pin	Net Name	Function
1	VCC-3.3V	3.3 V power output
2	SWDIO_OB	SWDIO
3	RESET_OB#	Reset signal input
4	SWCLK_OB	SDCLK
5	GND	GND
6	(n.c.)	

4.1.30. LED (RUN, COM)

RUN, COM LEDs display the operation status of CMSIS-DAP (U2).

Fig. 4.31 LED (RUN, COM)

4.1.31. Program/Debug Switch (SW1)

This switch is used to select from where to program/debug SmartMCD (U1).

Fig. 4.32 Program/Debug Switch (SW1)

Table 4.25 Program/Debug Switch (SW1) Specifications

Switch position	Operation
INT	Programming and debugging with CMSIS-DAP (U2)
EXT	Programming and debugging with SWD connector (J4)

4.1.32. Three-Phase Brushless Motor Terminal (CN1)

It is used to connect the 3-phase brushless motor when the on-board inverter is used.

Fig. 4.33 Three-Phase Brushless Motor Terminal (CN1)

Table 4.26 Three-Phase Brushless Motor Terminal (CN1) Specifications

Terminal Name	Net Name	Function
U	PHASE_U	U-phase output
V	PHASE_V	V-phase output
W	PHASE_W	W-phase output

4.1.33. LIN Input/Output Terminal (TB2)

This used for LIN input/output.

Fig. 4.34 LIN Input/Output Terminal (TB2)

Table 4.27 LIN Input/Output Terminal (TB2) Specifications

Terminal Name	Net Name	Function
LIN	LIN_BUS	LIN
GND	GND	GND

4.1.34. Inverter Circuit Jumper Pin Connector (J5)

This connector is used for connecting the inverter circuit. When all jumpers are connected, the on-board inverter on the main board is connected. To use an external inverter, remove all jumper pins and stack the external inverter board on the main board via this connector.

Fig. 4.35 Inverter Circuit Jumper Pin Connector (J5)

Table 4.28 Inverter Circuit Jumper Pin Connector (J5) Specifications

Jumper Pin Connector Pair				Function
Pin	Net Name	Pin	Net Name	
1	VBAT	2	VBAT_INT	Connects VBAT to the on-board inverter
3	VBAT	4	VBAT_INT	Connects VBAT to the on-board inverter
5	VBAT	6	VBAT_INT	Connects VBAT to the on-board inverter
7	TEMP	8	TEMP_INT	Connects TEMP to the on-board inverter
9	GLW	10	G_LS_W	Connects GLW to the on-board inverter
11	W	12	M_W	Connects W to the on-board inverter
13	GHW	14	G_HS_W	Connects GHW to the on-board inverter
15	GLV	16	G_LS_V	Connects GLV to the on-board inverter
17	V	18	M_V	Connects V to the on-board inverter
19	GHV	20	G_HS_V	Connects GHV to the on-board inverter
21	GLU	22	G_LS_V	Connects GLU to the on-board inverter
23	U	24	M_U	Connects U to the on-board inverter
25	GHU	26	G_HS_U	Connects GHU to the on-board inverter
27	SLC	28	SLC_INT	Connects SLC to the on-board inverter
29	RSH	30	RSH_INT	Connects RSH to the on-board inverter
31	RSL	32	RSL_INT	Connects RSL to the on-board inverter
33	COM	34	COM_INT	Connects COM to the on-board inverter
35	GND	36	GND_INT	Connects GND to the on-board inverter
37	GND	38	GND_INT	Connects GND to the on-board inverter
39	GND	40	GND_INT	Connects GND to the on-board inverter

4.1.35. LED (FLT1)

FLT1 LED lights-up when the bus current of the inverter circuit (on-board inverter, external inverter) detects an overcurrent.

Fig. 4.36 LED (FLT1)

4.1.36. Test Pins (GND)

The test pins are connected to the GND.

Fig. 4.37 Test-Pin (TP2)

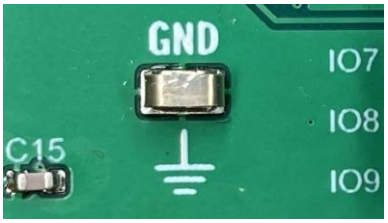

Fig. 4.38 Test-Pin (TP3)

4.2. Names and functions of Components (External Inverter Board)

4.2.1. Three-Phase Brushless Motor Terminal (CN1)

It is used to connect a 3-phase brushless motor when using an external inverter.

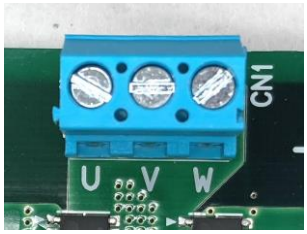

Fig. 4.39 Three-Phase Brushless Motor Terminal (CN1)

Table 4.29 Three-Phase Brushless Motor Terminal (CN1) Specifications

Terminal Name	Net Name	Function
U	PHASE_U	U-phase output
V	PHASE_V	V-phase output
W	PHASE_W	W-phase output

4.2.2. Power Input Terminal (CN2)

This is used to input the power supply (V_{BAT}) when using an external inverter.

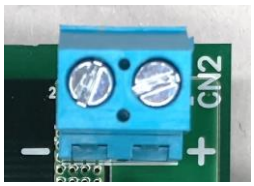

Fig. 4.40 Power Input Pin (CN2)

Table 4.30 Power Input Terminals (CN2) Specifications

Terminal Name	Net Name	Function
+	VBAT	Power input (6 V to 18 V)
-	GND	Power input (GND)

4.2.3. Main Board Connector (J1)

This connector is used to connect to the external inverter board to the main board. To connect both boards, this connector is connected to the inverter circuit jumper pin connector (J4) on the main board.

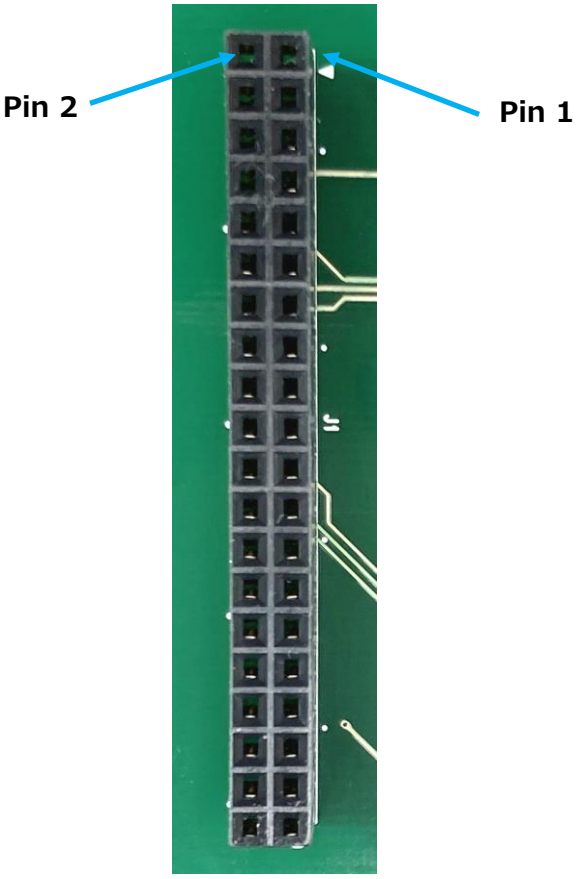

Fig. 4.41 Main Board Connector (J1)

Table 4.31 Main Board Connectors (J1)

Pin	Net Name	Function	Pin	Net Name
1	VBAT	V_{BAT} (supplied to mainboard)	2	(n.c.)
3	VBAT	V_{BAT} (supplied to mainboard)	4	(n.c.)
5	VBAT	V_{BAT} (supplied to mainboard)	6	(n.c.)
7	TEMP_INT	Signal from the main board	8	(n.c.)
9	G_LS_W	Signal from the main board	10	(n.c.)
11	M_W	Signal from the main board	12	(n.c.)
13	G_HS_W	Signal from the main board	14	(n.c.)
15	G_LS_W	Signal from the main board	16	(n.c.)
17	M_V	Signal from the main board	18	(n.c.)
19	G_HS_V	Signal from the main board	20	(n.c.)
21	G_LS_V	Signal from the main board	22	(n.c.)
23	M_U	Signal from the main board	24	(n.c.)
25	G_HS_U	Signal from the main board	26	(n.c.)
27	SLC_INT	Signal from the main board	28	(n.c.)
29	RSH_INT	Signal from the main board	30	(n.c.)
31	RSL_INT	Signal from the main board	32	(n.c.)
33	COM_INT	Signal from the main board	34	(n.c.)
35	GND	GND	36	(n.c.)
37	GND	GND	38	(n.c.)
39	GND	GND	40	(n.c.)

5. Operation

5.1. Preparation

5.1.1. Connecting the Debugger to SmartMCD (Using CMSIS-DAP)

- Using the start mode switch (SW2), set MD1 to ‘OFF’ and MD0 to 'ON'. (Debug mode)
- Set the program/debug switch (SW1) on the main board to 'INT'.
- Connect the USB cable from the debug USB connector (CN2) on the mainboard to PC that runs the debugger.

5.1.2. Connecting the Debugger to SmartMCD (Using SWD Cable)

- Using the start mode switch (SW2), set MD1 to ‘OFF’ and MD0 to 'ON'. (Debug mode)
- Set the program/debug switch (SW1) on the main board to 'EXT'.
- Connect both jumpers on SWD signal jumper pin connector (J6) on the mainboard. In addition, remove any other jumpers connected to the IO10 and IO11 of SmartMCD (U1).
- Connect the debugger's SWD cable to the J4 connector on the mainboard.

5.2. Operation Check Procedure

5.2.1. Motor Drive with On-Board Inverter

- Connect all the jumpers to the inverter circuit jumper pin connector (J5) on the main board.
- Connect the motor to the 3-phase brushless motor connector (CN1) on the main board.
- Connect the power supply to the power supply input terminal (TB1) on the mainboard and turn it on.

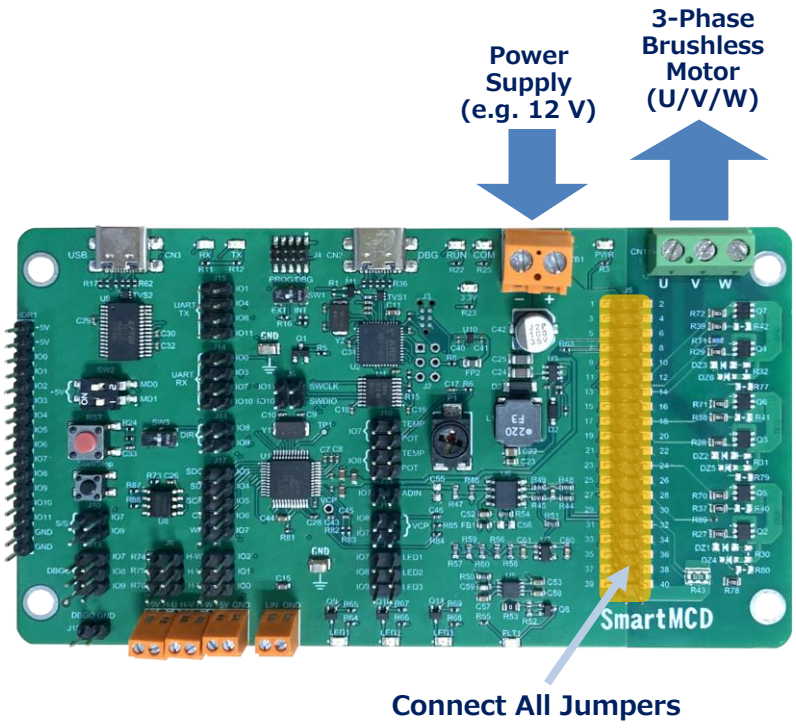

Fig. 5.1 Motor Drive with On-Board Inverter

5.2.2. Motor Drive with External Inverter

- Remove all the jumpers from the inverter circuit jumper pin connector (J5) on the main board.
- Stack the inverter board over the main board by connecting the inverter circuit jumper pin connector (J5) on the main board to the main board connector (J1) on the external inverter board.
- Connect the motor to the 3-phase brushless motor connector (CN1) on the external inverter board.
- Connect the power supply to the power input terminal (CN2) of the external inverter board and turn it on.

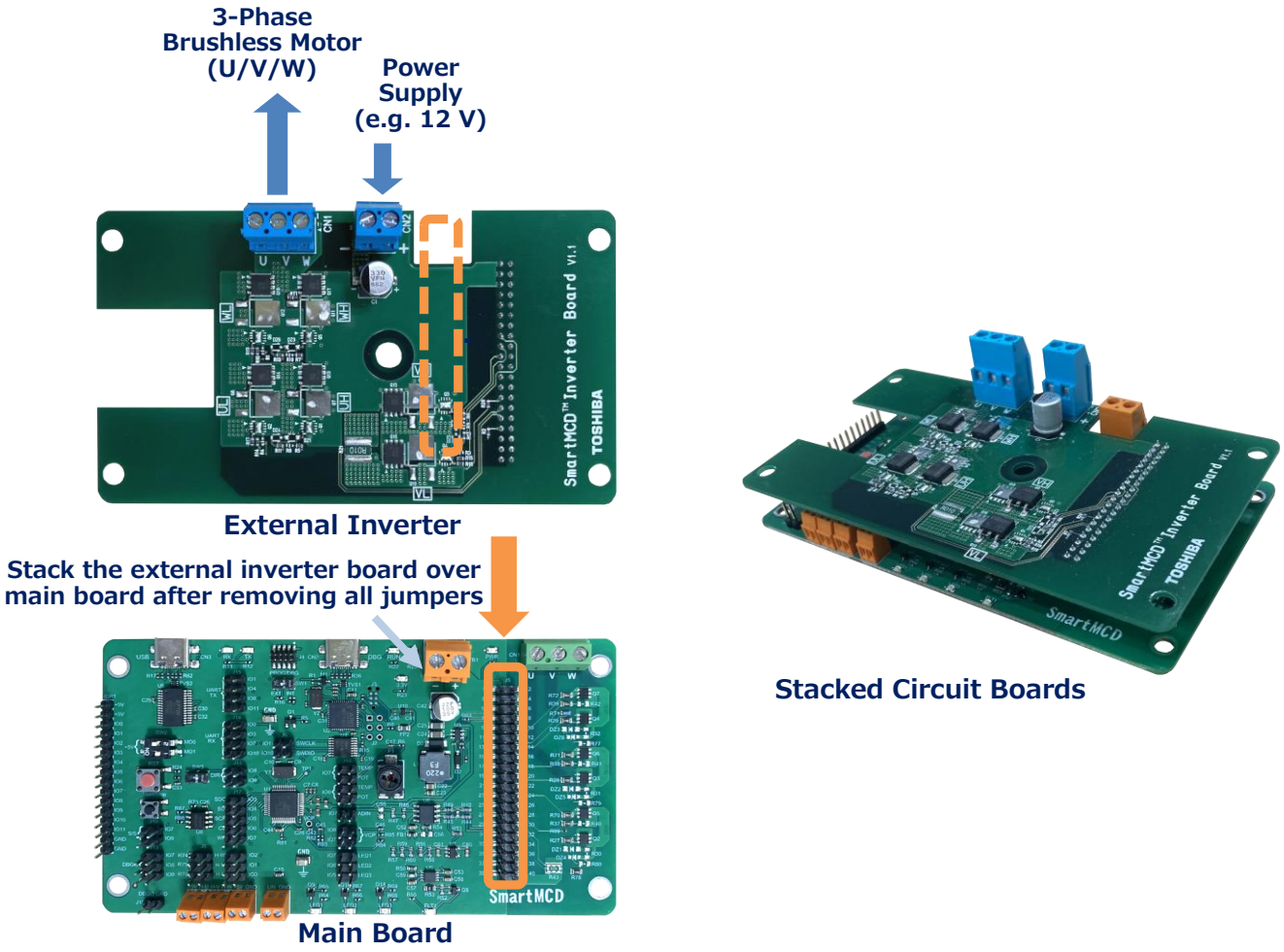

Fig. 5.2 Motor Drive with External Inverter

5.3. Precautions

Pay special attention to the following when operating.

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

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