User's Manual

RA6T3 Group

MCK-RA6T3 User's Manual

Renesas RA Family
RA6 Series

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General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on

   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state

   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins

   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals

   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin

   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses

   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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1. Overview

MCK-RA6T3 is a motor control evaluation kit. By using this product, motor control with RA6T3 can be performed easily.

MCK-RA6T3 has characteristics shown below.

（1） Supports Brushless DC motor.

（2） Supports 1-/2-/3-shunt current detection.

（3） Supports Motor Control Development Support Tool.

（4） Provides overcurrent protection function using overcurrent detection circuit.

1.1 Presupposition and precautions of this document

1. Experience of using tools: This document assumes that the user has used terminal emulation program of Integrated Development Environment (IDE) such as e2 studio before.
2. Knowledge about the development subject: This document assumes that the user has a basic knowledge to modify the sample project regarding MCU and embedded system.
3. Before using this product, wear an antistatic wrist strap. If you touch this product with static charge on your body, a device failure may occur, or operation may become unstable
4. All screen shots provided in this document is for reference. Actual screen displays may differ depending on the software and development tool version which you use.

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2. Product Contents

This kit consists of the following parts.

1. Inverter Board (RTK0EM0000B12020BJ) x1
2. CPU Board (RTK0EMA330C00000BJ) x1
3. Brushless DC Motor (R42BLD30L3) x1
4. USB Cable x1
5. Screw x8
6. Standoff x8

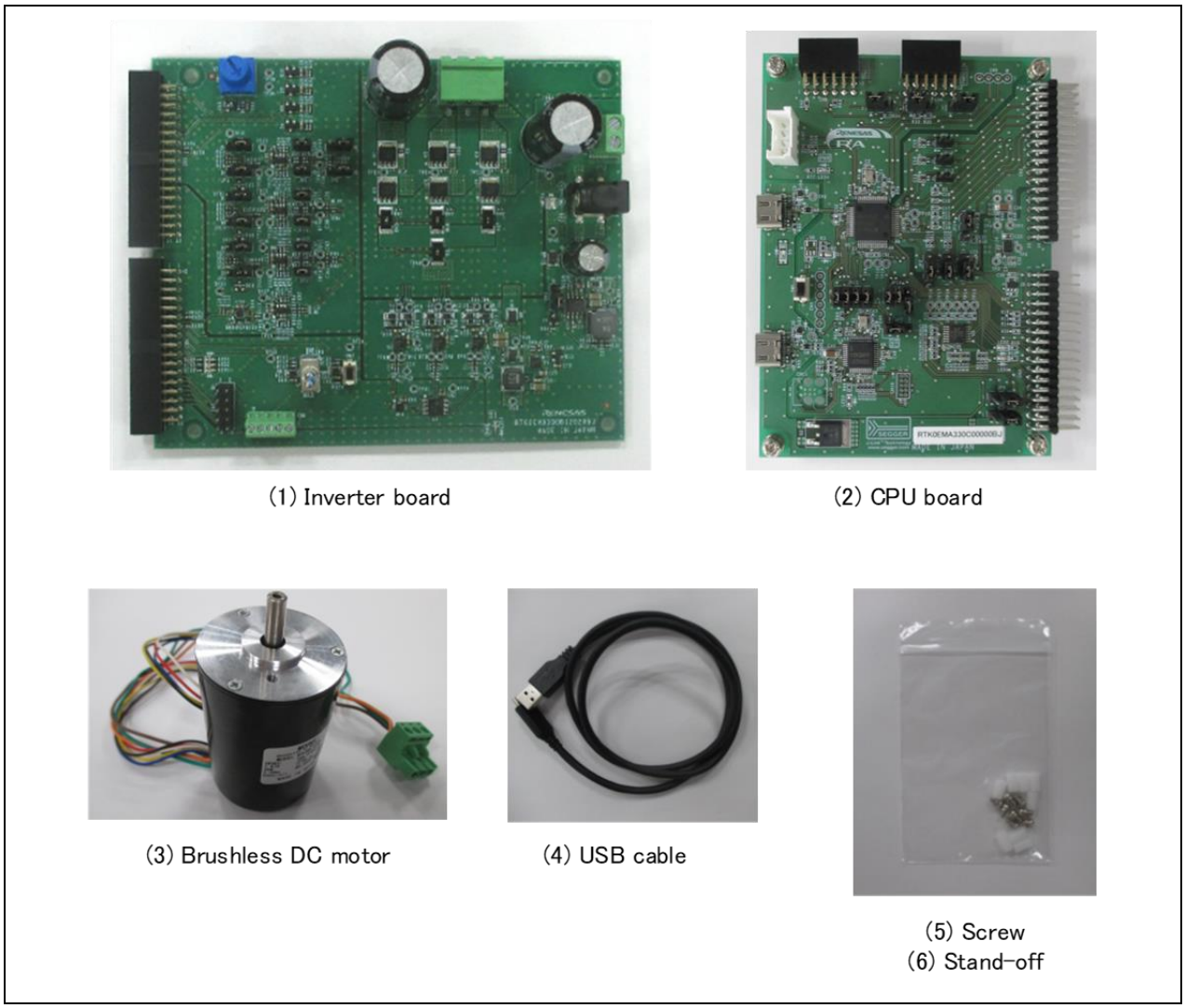


Figure 2-1 Product contents

3. Product Order Information

Product number to order MCK-RA6T3 : RTK0EMA330S00020BJ

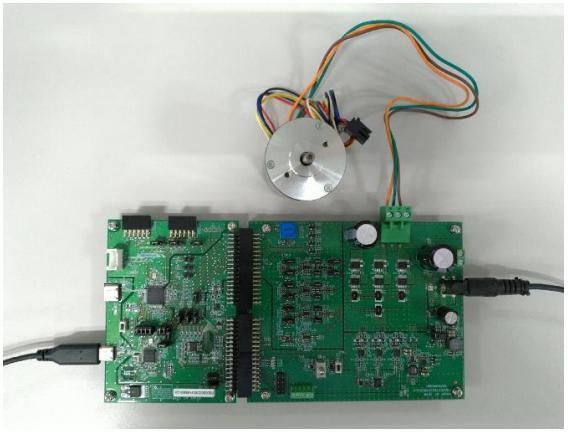
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4. Hardware Configuration and Default Setting

4.1 Hardware configuration

MCK-RA6T3 consists of the inverter board, the CPU board and the communication board. Specifications as a kit and for the relevant boards are listed below.

Table 4-1 MCK-RA6T3 specification (1/3)

Item	Specification	
Kit product name	MCK-RA6T3	
Kit product No.	RTK0EMA330S00020BJ	
Kit configuration	Inverter Board	RTK0EM0000B12020BJ
	CPU Board	RTK0EMA330C00000BJ
	Brushless DC Motor	R42BLD30L3 (MOONS') Rated voltage：36[V] Rated current：1.67[A]
Isolation	Inverter board - CPU board : Non-isolated	
External view	 Note: The actual product may differ from this photo.	
Board size	Inverter board : 133 mm (W) x 109 mm (L) CPU board : 109 mm (W) x 109 mm (L)	
Operating temperature	Room temperature	
Operating humidity	No condensation allowed	
EMC Directive	EN61326-1:2021 EMI：Class A EMS：Basic Electromagnetic environment	

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Table 4-2 MCK-RA6T3 specification (2/3)

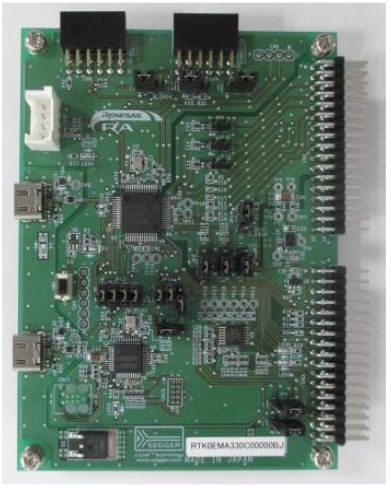
Item	Specification
Product name	Inverter board
Board part No.	RTK0EM0000B12020BJ
External view	 Note: The actual product may differ from this photo.
Power supply	2 ways • From DC jack or Power supply connector (DC 12~48V) *1 • From CPU board (DC 5V)
Rated output current	AC 10 A (RMS value) *2
Switching frequency	20 kHz (typical)
Current detection method	1- / 2- / 3-shunt detection
Shunt resistor	10 mohm
PWM logic	Lower arm, Upper arm : Positive logic
DC bus voltage detection （bus voltage detection）	Detection by resistance division (0 V ~ 48 V)
3-phase output voltage detection	Detection by resistance division (0 V ~ 48 V)
3-phase output current detection	With shunt resistor
Overcurrent detection function	21.4 A for AVCC=3.3V 32.4 A for AVCC=5.0V
Supporting sensor	HALL sensor, Encoder
Connector	・ CPU card connector ・ Motor connector ・ Power input connector ・ HALL sensor connector ・ Encoder/Inductive position sensor connector
Switch	・ Toggle switch x1 ・ Push switch x1
LED	・ LED x3 ・ Power LED

*1 The polarity of the DC jack (J1) is center positive. The compatible plug has an inner diameter of 2.1 mm and an outer diameter of 5.5 mm.

*2 It is strongly recommended to attach a heat sink to the MOSFET when using over 5A.

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Table 4-3 MCK-RA6T3 specification (3/3)

item		Specification
Product name		CPU Board
Board part No.		RTK0EMA330C00000BJ
Compatible inverter board		RTK0EM0000B12020BJ
External view		 Note: The actual product may differ from this photo.
Mounted MCU	Product group	RA6T3 group
	Product No.	R7FA6T3BB3CFM
	CPU maximum operating frequency	200MHz
	Bit count	32 bit
	Package / Pin count	LFQFP / 64 pin
	ROM	256KB
MCU input clock		10MHz (Generate with external crystal oscillator)
Power supply		DC 5V Select one way automatically from the below • Power is supplied from compatible inverter board • Power is supplied from USB connector
Debugger		J-Link-OB (Onboard debugger circuit)
Connector		• Inverter board connector • USB connector for J-Link OB • USB connector for RA6T3 • SCI connector for Renesas Motor Workbench communication • Through hole for CAN communication • 10 pin through hole for Arm debugger • PMOD connectors
Switch		MCU reset switch
LED		User-controllable LED x2, Power LED x1

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4.2 Board Layout

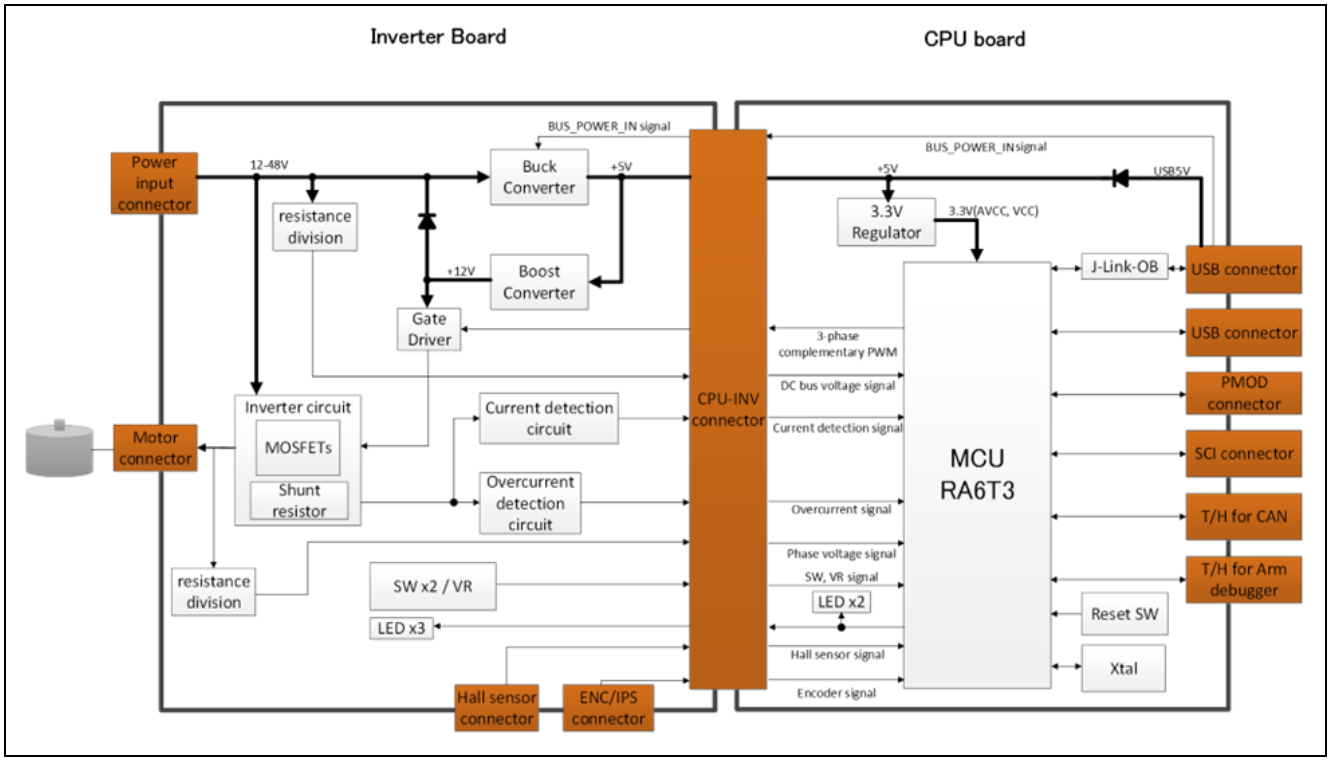


Figure 4-1 MCK-RA6T3 block diagram

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4.3 Board Layout

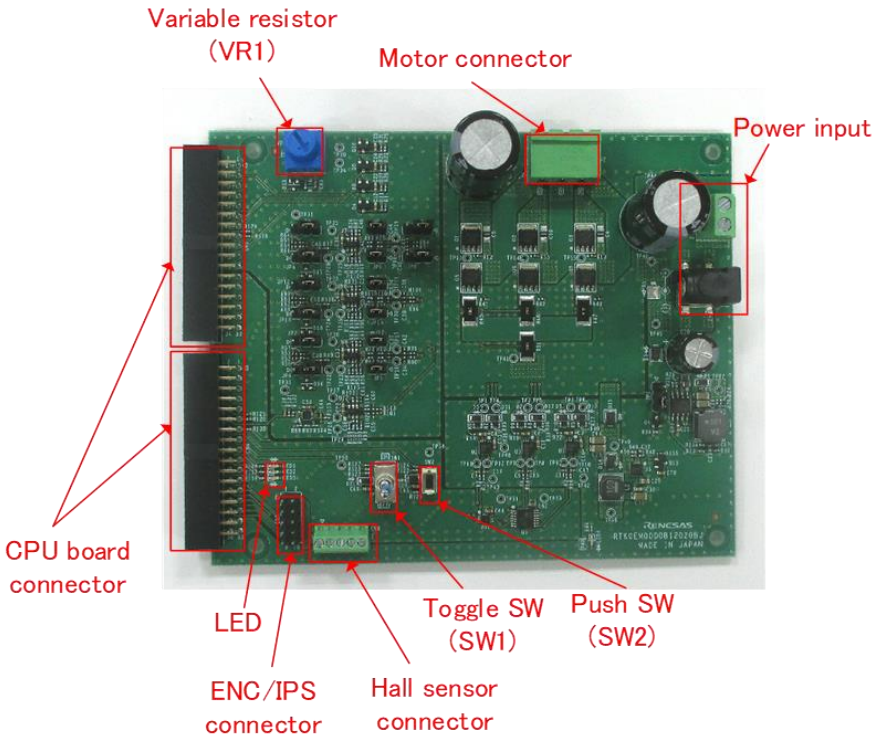


Figure 4-2 Inveter Board

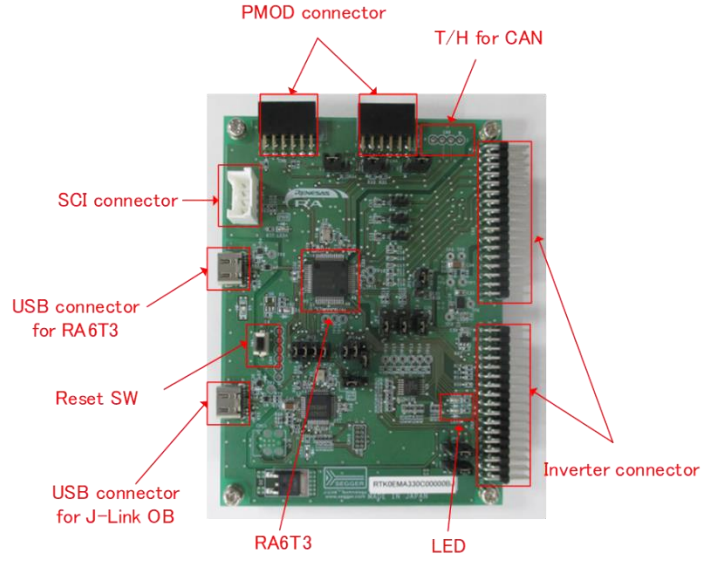


Figure 4-3 CPU Board

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4.4 Standoffs and Screws

Before using this product, assemble the included standoffs and screws as shown below.

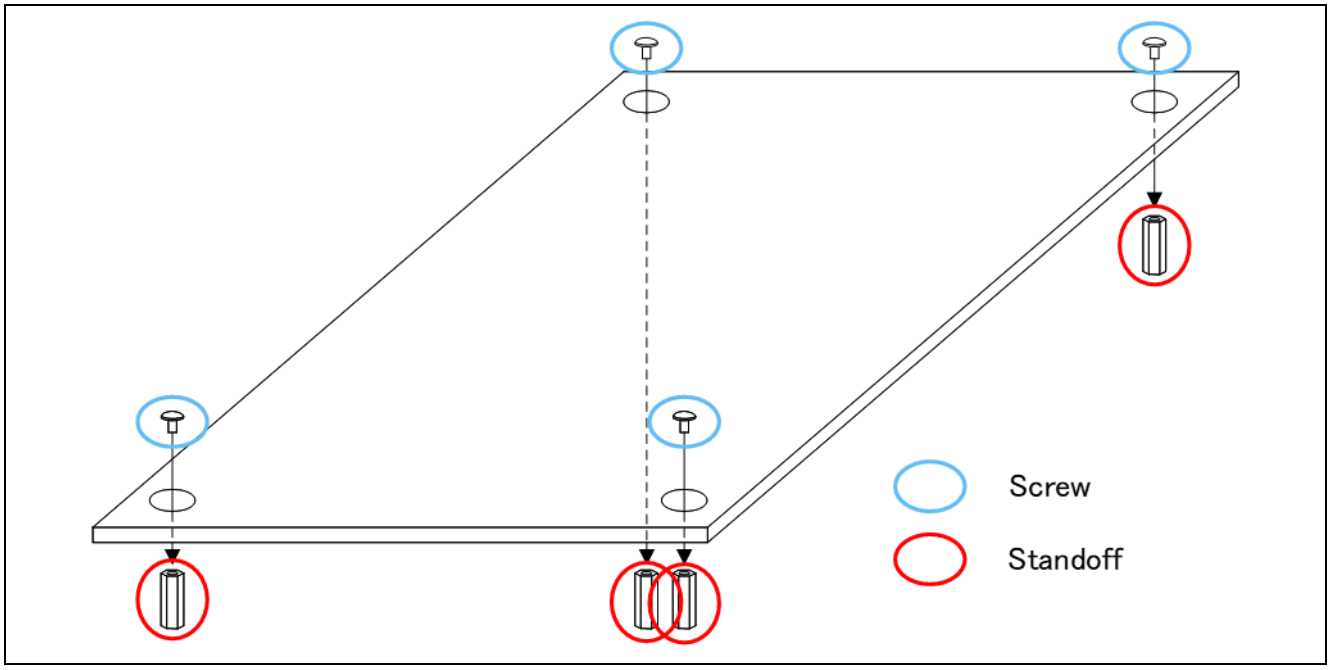


Figure 4-4 Standoffs and Screws assembly

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4.5 Jumper pin setting

4.5.1 Inverter Board

Default settings and functions of the jumper pins (JP1~JP15) are as follows.

Table 4-4 Jumper pin setting of inverter board

Jumper pin	Default setting	Function
JP1	2-3pin short	1-2pin short : Disable 5V regulator 2-3pin short : Enable 5V regulator
JP2, JP3, JP4, JP6, JP12, JP13	2-3pin short	1-2pin short : Disable current detection amplifiers 2-3pin short : Enable current detection amplifiers
JP5, JP7, JP9, JP10, JP14, JP15	1-2pin short	1-2pin short : Current detection amplifier gain = 20 1-2pin open : Current detection amplifier gain = 10
JP8, JP11	1-2pin short	1-2pin short : 2-/3-shunt current detection 2-3pin short : 1-shunt current detection

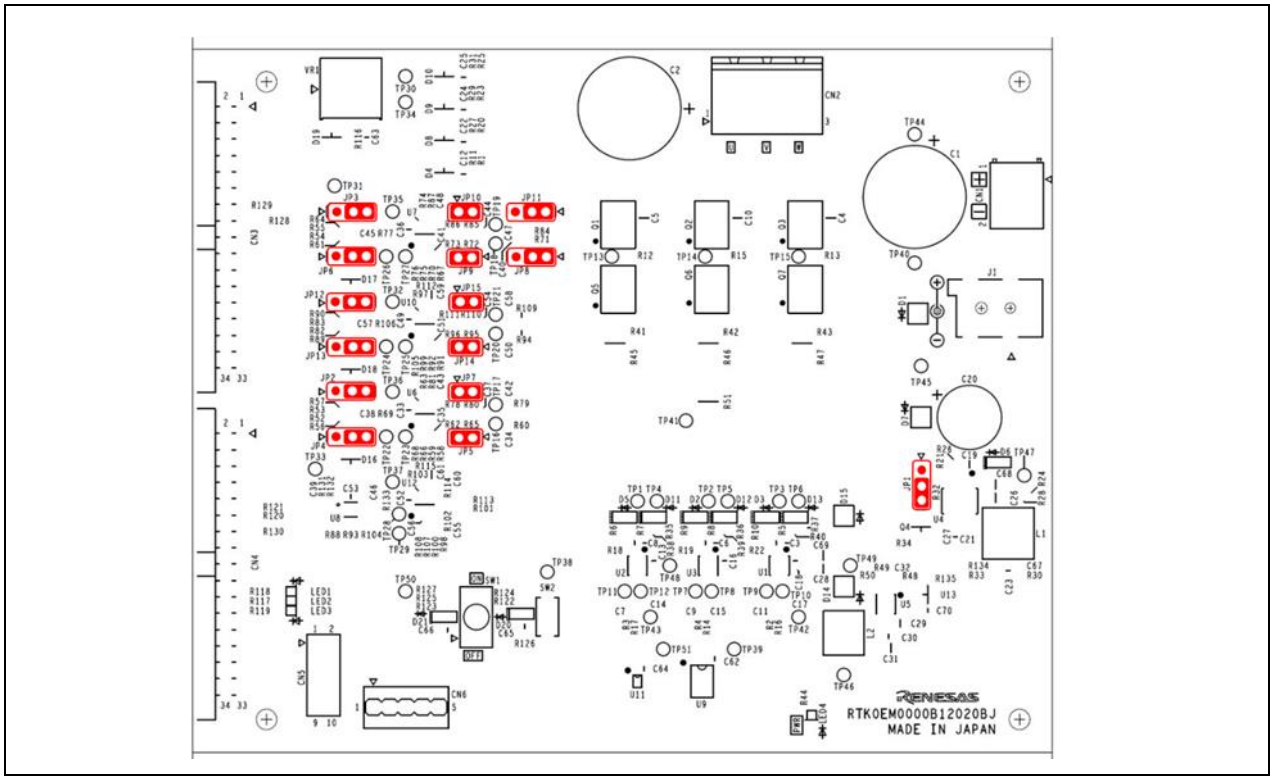


Figure 4-5 Default jumper pin setting

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4.5.2 CPU Board

Default settings and functions of the jumper pins (JP1~JP17) are as follows.

Table 4-5 Jumper pin setting of CPU board

JP No.	Function	Setting (function in use)			Default setting
		open	1-2 short	2-3 short	
1	IPS/VU select	N/A	VU	IPS	1-2 short
2	IPS/HALL select	N/A	HALL	IPS	1-2 short
3	IPS/HALL select	N/A	HALL	IPS	1-2 short
4	IPS/HALL select	N/A	HALL	IPS	1-2 short
5	IPS/ENC select	N/A	IPS	ENC	2-3 short
6	IPS/ENC select	N/A	IPS	ENC	2-3 short
7	Reset control for RA6T3	by SW1	by JLOB or SW1	Reset	1-2 short
8	IU sensing	CSA	PGA	N/A	open
9	PMOD Type2A/6A select	N/A	Type 2A	Type 6A	1-2 short
10	PMOD Type2A/6A select	N/A	Type 2A	Type 6A	1-2 short
11	PMOD Type2A/6A select	N/A	Type 6A	Type 2A	2-3 short
12	IV sensing	CSA	PGA	N/A	open
13	IW sensing	CSA	PGA	N/A	open
14	Debugger connection	Not connected	Connected (1-2, 3-4 short)	N/A	1-2, 3-4 short
15	UART connection	PMOD	VCOM port (1-2, 3-4, 5-6, 7-8 short)	N/A	1-2, 3-4, 5-6, 7-8 short
16	MD port pull-down	open	Pull-down	N/A	open
17	Enable/disable JLOB	Enabled	Disabled	N/A	open

CSA : with current sensing amplifier on inverter board
PGA : with programmable gain amplifier in MCU
IPS : Inductive Position Sensor
ENC : Encoder
HALL : HALL sensor

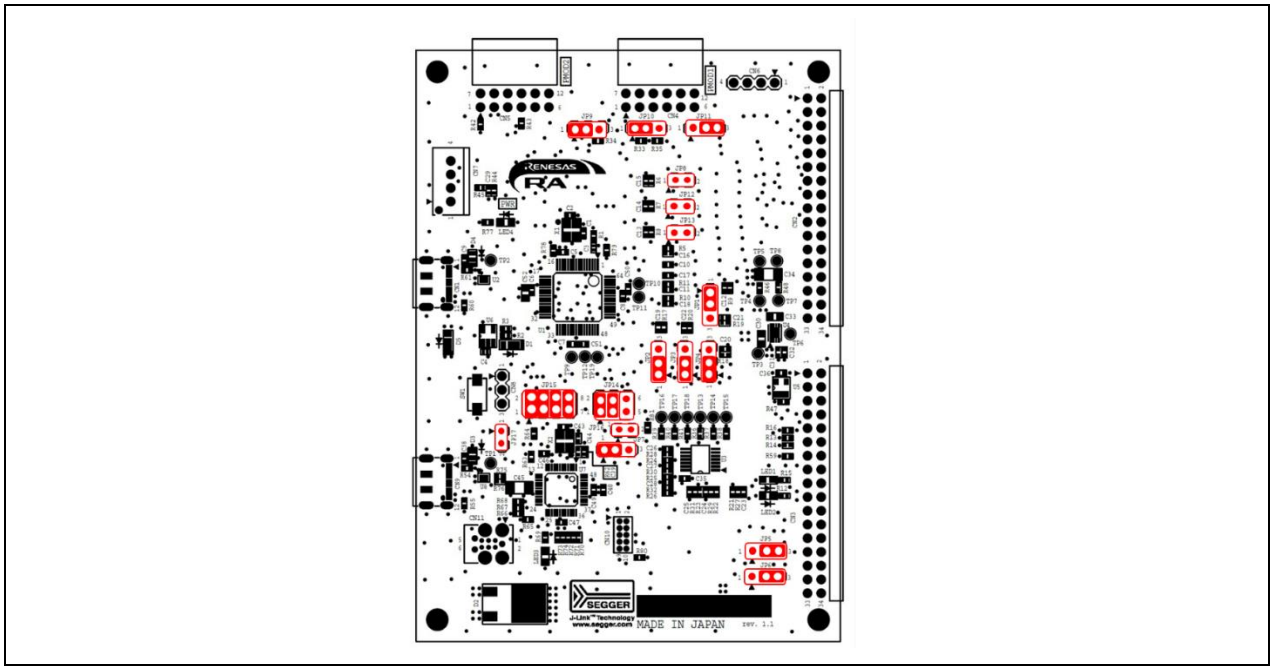


Figure 4-6 Default jumper pin setting of CPU board

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4.6 Hardware Setup

4.6.1 Board Connection

When using this product for motor control evaluation, connect the boards to PC via USB isolator as shown in Figure 4-7. By using a communication board (MC-COM) (sold separately), it is possible to connect as shown in Figure 4-8 for evaluation. Also, when writing programs to the CPU board, connect as shown in Figure 4-9. Note that the connector between the CPU board and the inverter board is a tight fit, so be careful not to bend the pins when connecting or disconnecting.
Please refer to 4.6.2 for the power supply method. In Figure 4-7 and Figure 4-8, the power is supplied from the AC adapter.

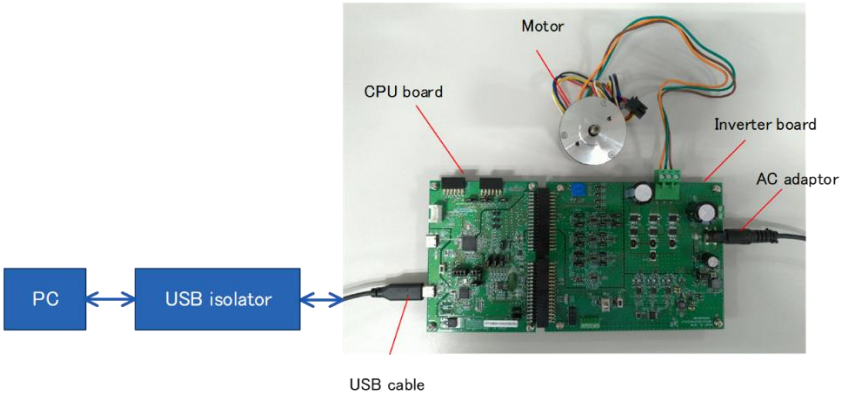


Figure 4-7 Board connection (using VCOM port)

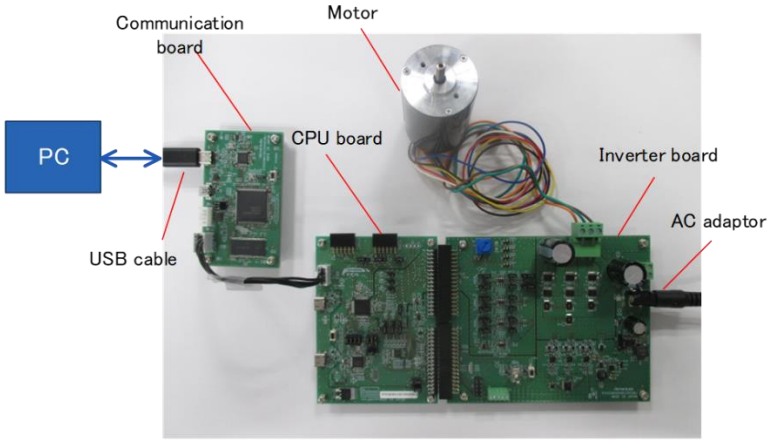


Figure 4-8 Board connection (using communication board)

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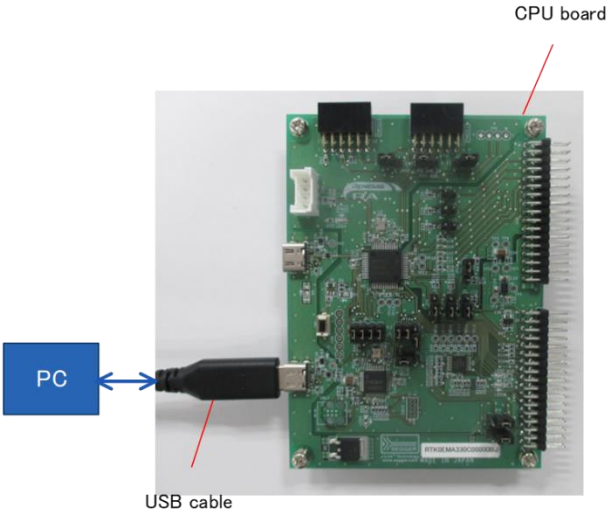


Figure 4-9 Board connection (CPU board only)

4.6.2 Power Supply

There are three ways to supply power to the CPU board and inverter board, and the power supply for the communication board is independent of the CPU board and inverter board and is supplied at 5V from the USB connector.

(1) From DC jack

Use an AC adapter or something similar to supply power from the DC jack (J1) on the inverter board. The compatible plug has an outer diameter of 5.5 mm, an inner diameter of 2.1 mm, and a polarity of center positive. The input voltage range is 12 to 48V.

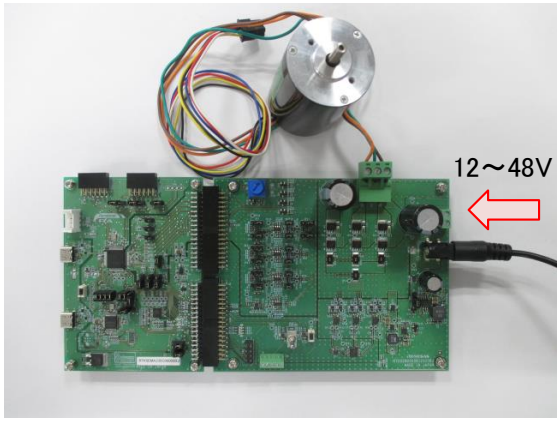


Figure 4-10 Power supply from DC jack

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(2) From terminal block

Supply power from the terminal block (CN1) of the inverter board using a DC stabilized power supply or the like. The polarity should follow the silk indication (“+”, “-“) on the board. The input voltage range is 12 to 48V.

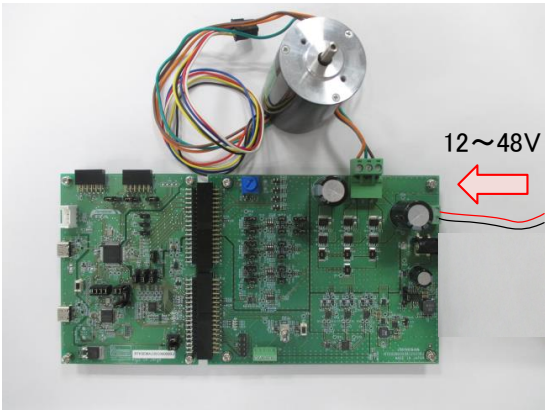


Figure 4-11 Power supply from terminal block

(3) From USB connector

5V power is supplied from the USB connector (Type-C) on the CPU board. Use a USB adapter capable of outputting 1A or more so that the motor can be driven sufficiently.

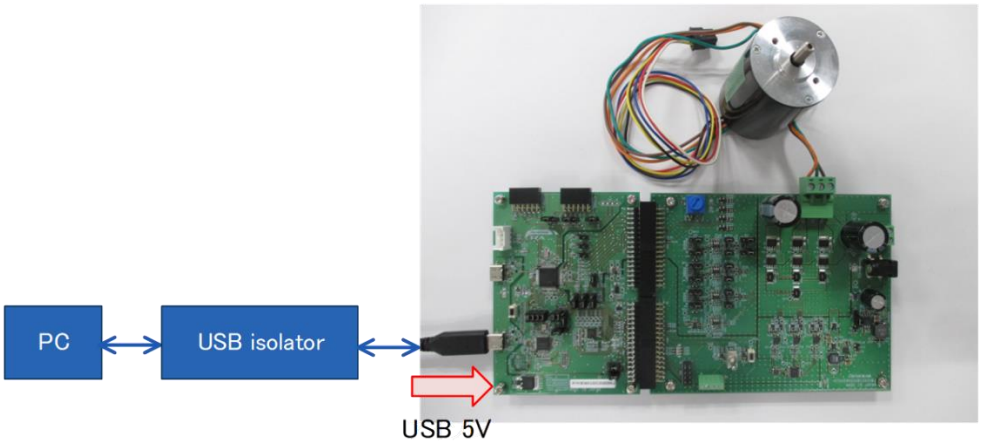


Figure 4-12 Power supply from USB connector (when using VCOM port)

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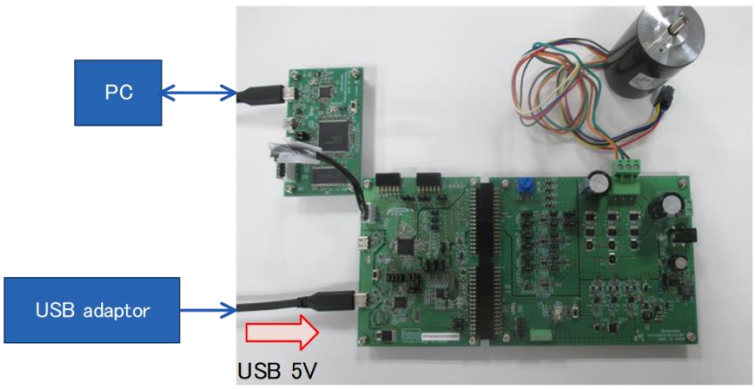


Figure 4-13 Power supply from USB connector (when using communication board)

It is also possible to supply power from the USB connector on the CPU board and the DC jack or terminal block on the inverter board at the same time. In this case, the MCU drive voltage of 3.3V and the gate driver drive voltage are generated from the USB supply of 5V, while the motor drive voltage is supplied from the DC jack or terminal block. Please refer to Table 4-6 for the power supply conditions and each voltage generation.

Table 4-6 Power supply and driving voltage generation

			Case 1	Case 2	Case 3
Power supply condition	CPU board	USB 5V	✓	-	✓
	Inverter board	External power (12~48V)	-	✓	✓
Power source for	CPU board	I/O (VCC, 3.3V)	[A]	[B]	[A]
		BUS (5V)	[A]	[B]	[A]
	Inverter board	I/O (VCC, 3.3V)	[A]	[B]	[A]
		BUS (5V)	[A]	[B]	[A]
		Gate driver (11.4V)	[A]	[B]	[A]
		Motor drive (11.4V or 12~48V)	[A]	[B]	[B]

Power supply condition:
✓: supplied
- : not supplied
Driving voltage generation
[A]: generated from USB 5V on CPU board
[B]: generated from external power on inverter board

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5. Inverter Board Specification

This section describes inverter board specification.

5.1 Functions

5.1.1 Inverter control circuit block

The inverter board has the inverter control circuit block which controls the motor with 6 POWER MOSFETs. POWER MOSFET is controlled with 6-phase timer output of MCU.

The inverter control circuit block outputs DC bus voltage, U, V and W phase voltage and shunt current to the connectors (CN3, CN4). By inputting these output voltages to A/D of MCU on the CPU card, analog values of the voltage and the shunt current of each phase can be measured. Refer to 5.1.2 and 5.1.4 for the current detection and the voltage detection, respectively. Also function to detect overcurrent from the input current is available. Refer to 5.1.3 for details.

An illustration of the inverter control circuit block is shown in Figure 5-1. In the actual circuit, some inputs on the A/D pins are via voltage dividers and offsets and so on. Refer to the circuit diagram for details.

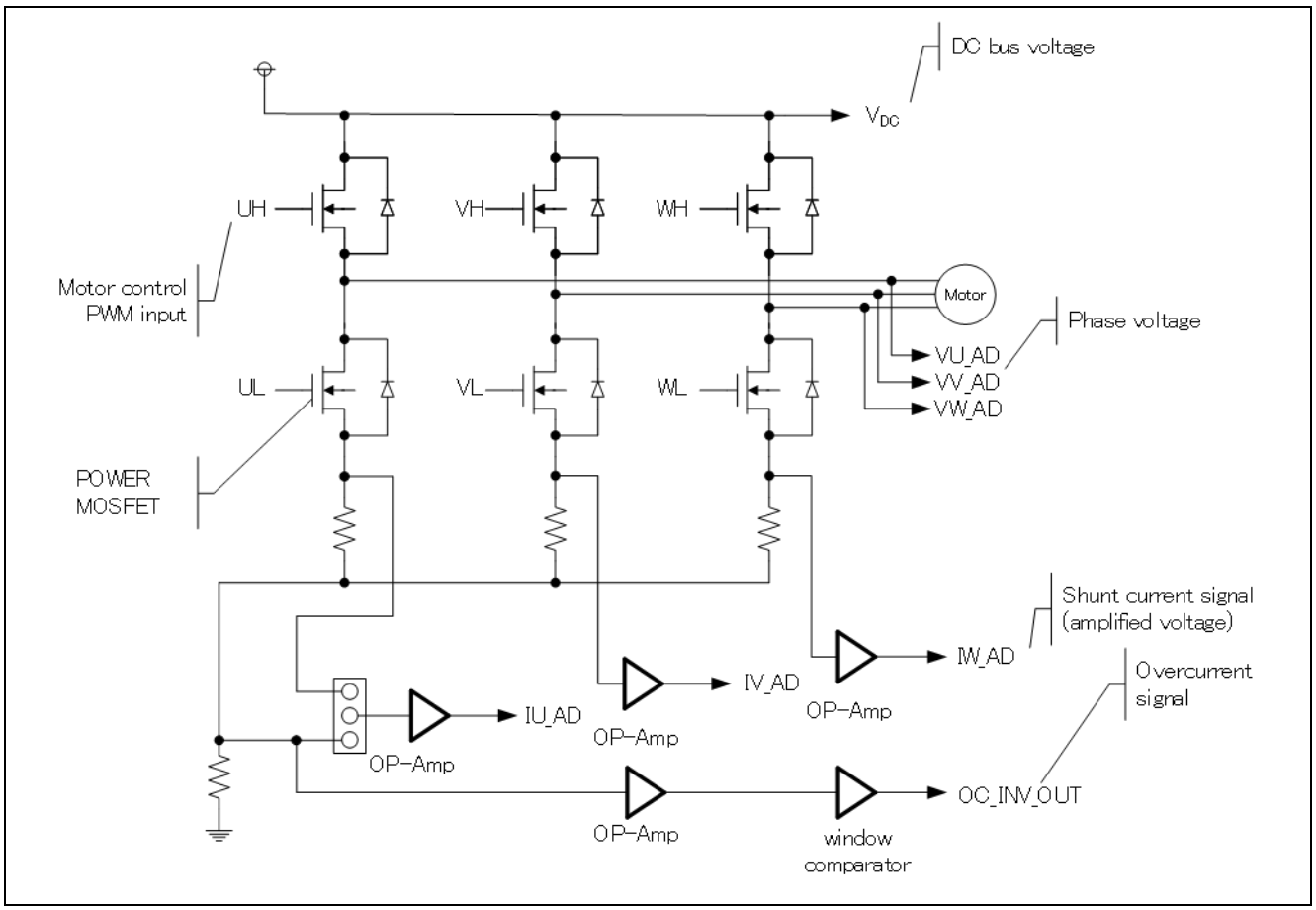


Figure 5-1 Illustration of inverter control circuit block

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5.1.2 Current detection circuit

The inverter board has the current detection circuit to measure the current at the U, V and W phase. The current detection circuit uses shunt resistor at each phase. Voltage drop caused by the current flowing through the shunt resistor is amplified by the current detection amplifier to output. The default gain of the current detection amplifier is set to 20x, but the gain can be changed to 10x by setting JP5, JP7, JP9, JP10, JP14, and JP15 to open. The relationship between the current Iin flowing through the shunt resistor and the voltage Vout output from the current detection circuit is shown in equations (1) and (2). In addition, by switching JP8 and JP11 to 2-3 pin short circuit, one shunt current detection can be supported.

$$\text{Amplifier gain 10x : } \mathrm{Vout[V]} = \mathrm{Iin[A]} \times \mathrm{Rs[\Omega]} \times 10 + \mathrm{AVCC}/2 \quad (1)$$

$$\text{Amplifier gain 20x : } \mathrm{Vout[V]} = \mathrm{Iin[A]} \times \mathrm{Rs[\Omega]} \times 20 + \mathrm{AVCC}/2 \quad (2)$$

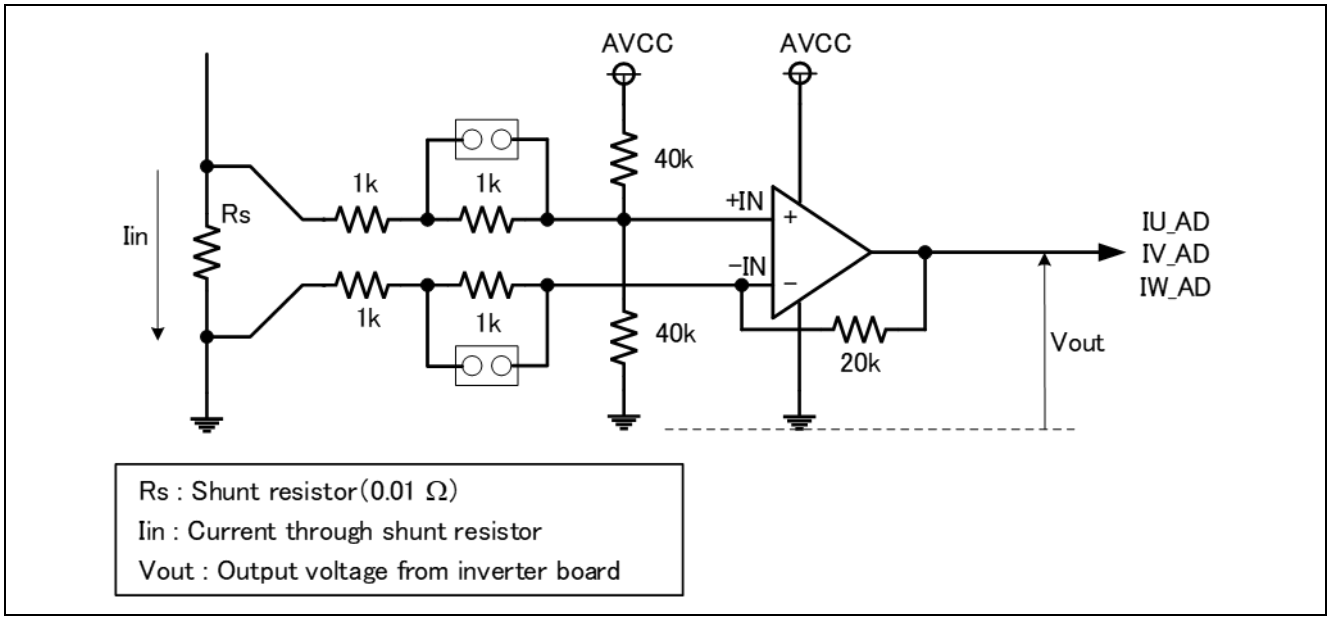


Figure 5-2 Current detection circuit

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5.1.3 Overcurrent detection circuit

Detect the overcurrent from the input current, using the overcurrent detection circuit illustrated in Figure 5-3. If the current value is within the range of threshold, OC_INV_OUT is HIGH, and this changes to LOW if overcurrent is detected. Therefore, you can protect the board and motor by monitoring the over current detection signal and setting PWM signals for gate driver to LOW or Hi-Z if the over current detection signal changes to LOW. As the value of the shunt resistor Rs is 10 mohm, the threshold current for over current detection is 21.4A for AVCC=3.3V and 32.4A for AVCC=5.0V, respectively.

The overcurrent detection circuit does not directly protect the board and motor. Protect them by performing appropriate processing with equipment such as microcontroller.

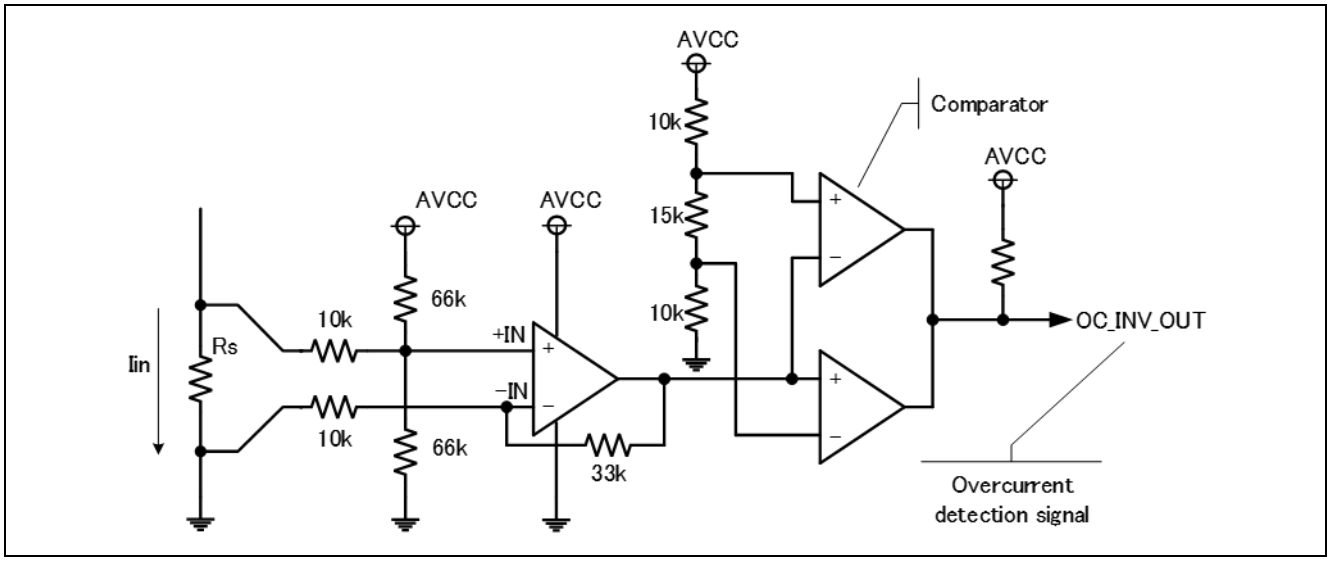


Figure 5-3 Overcurrent detection circuit

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5.1.4 Output voltage detection circuit

The INV-BRD has the circuit that inputs bus voltage and three-phase output voltage (U, V and W phase) into the AD pin of the microcontroller through resistive voltage divider. Relation between the three-phase output voltage, the bus voltage and the detection voltage is described by the below equation (3).

$$\mathrm{Vout}[V] = \frac{470}{10 \times 10^3 + 470} \times Vin[V] \quad (3)$$

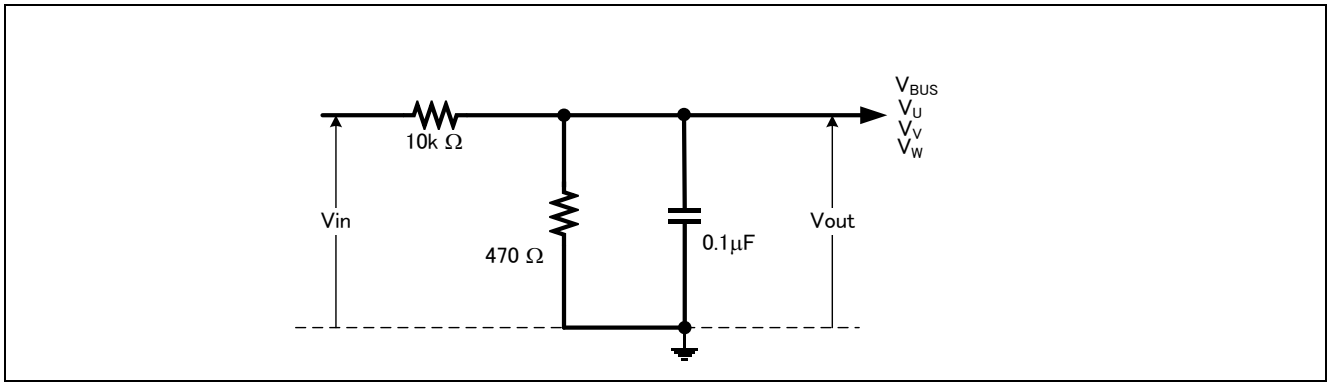


Figure 5-4 Output voltage detection circuit

5.1.5 Voltage generation circuit

On the INV-BRD, the gate driver voltage ("+12V" in the schematic) is generated from the 5V power supply ("+5V" in the schematic) with the boost converter. If 5V is not supplied from the CPU board, the buck converter on the INV-BRD generates 5V from the voltage input (12 to 48V) from the DC jack or terminal block.

Table 5-1 Voltage generation

Item	Input voltage [V]	Output voltage (TYP.) [V]	Output current (Max) [A]
5V generation	12~48	5	0.6
Gate driver voltage generation	5	11.4	-

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5.1.6 LED

The INV-BRD has three LEDs which the user can control. The LED ON/OFF is controlled by the pin state.

Table 5-2 LED

Connector pin		LED1	LED2	LED3
CN4-18	HIGH	OFF	-	-
	LOW	ON	-	-
CN4-19	HIGH	-	OFF	-
	LOW	-	ON	-
CN4-20	HIGH	-	-	OFF
	LOW	-	-	ON

5.1.7 Toggle switch and push switch

The INV-BRD has toggle switch (SW1) and push switch (SW2). The pin voltage is controlled by the state of them.

Table 5-3 Toggle switch and push switch

Connector pin		SW1	SW2
CN4-16	HIGH	ON	-
	LOW	OFF	-
CN4-17	HIGH	-	RELEASE
	LOW	-	PUSH

5.1.8 Variable resistor

The INV-BRD has a variable resistor (VR1). If turning the variable resistor clockwise, terminal voltage of the variable resistor (CN3-17) becomes low. If turning it counterclockwise, the voltage becomes high.

Table 5-4 Variable resistance specification

Item	Specification
Input voltage range	0~AVCC
Variable resistor range	0~10k Ω

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5.2 Pin assignment

5.2.1 CPU board connector

Table 5-5 CPU board connector (CN3)

Pin No.	Output direction	Signal
1	-	SPARE1
2	-	AGND
3	To CPU	DC bus voltage detection
4	-	AGND
5	To CPU	U-phase current detection
6	To CPU	U-phase current detection (PGAVSS)
7	To CPU	V-phase current detection
8	To CPU	V-phase current detection (PGAVSS)
9	To CPU	W-phase current detection
10	To CPU	W-phase current detection (PGAVSS)
11	To CPU	U-phase voltage detection
12	To CPU	V-phase voltage detection
13	To CPU	W-phase voltage detection
14	-	AGND
15	To CPU	VPFC_AD
16	To CPU	IPFC_AD
17	To CPU	VR1
18	-	AGND
19	-	AVCC
20	-	AVCC
21	-	AGND
22	-	AGND
23	-	VCC
24	-	VCC
25	-	DGND
26	-	DGND
27	To INV	PWM U-phase (Lower)
28	-	DGND
29	To INV	PWM U-phase (Upper)
30	-	DGND
31	To INV	PWM V-phase (Lower)
32	-	DGND
33	To INV	PWM V-phase (Upper)
34	-	DGND

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Table 5-6 CPU board connector (CN4)

Pin No.	Output direction	Signal
1	To INV	PWM W-phase (Lower)
2	-	DGND
3	To INV	PWM W-phase (Upper)
4	-	DGND
5	-	SPARE2
6	-	SPARE3
7	-	SPARE4
8	-	SPARE5
9	To INV	Bus power signal from CPU board
10	To CPU	Inverter connected signal
11	To CPU	Save interlock signal
12	To CPU	Over current detection
13	To CPU	OC_PFC_OUT
14	To INV	PWM_IN
15	To INV	RELAY_IN
16	To CPU	SW1
17	To CPU	SW2
18	To INV	LED1
19	To INV	LED2
20	To INV	LED3
21	To CPU	HALL U
22	To CPU	HALL V
23	To CPU	HALL W
24	To CPU	IPS_SIO_SDA
25	To CPU	IPS_SCK_SCL
26	To CPU	IPS_CSN_IRQN/Encoder Z
27	To CPU	IPS_A/ Encoder A
28	To CPU	IPS_A#/ Encoder A#
29	To CPU	IPS_B/ Encoder B#
30	To CPU	IPS_B#/ Encoder B#
31	-	AGND
32	-	AGND
33	-	+5V
34	-	+5V

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5.2.2 Hall sensor signal input

This product has connector for hall sensor signal input. Pin assignment of it is listed in Table 5-7.

Table 5-7 Connector for hall sensor signal input (CN6) pin assignment

Pin No.	Pin Function
1	DGND
2	+5V
3	HALL_W
4	HALL_V
5	HALL_U

5.2.3 Encoder/Inductive position sensor signal input

This product has pins for encoder/inductive position sensor signal input. Pin assignment for them is listed in Table 5-8

Table 5-8 Pins for encoder/inductive position sensor signal input (CN5) pin assignment

Pin No.	Pin function
1	VCC
2	+5V
3	CSN_IRQN/ENC_Z
4	SIO_SDA
5	SCK_SCL
6	IPS_A/ENC_A
7	IPS_A#/ENC_A#
8	IPS_B/ENC_B
9	IPS_B#/ENC_B#
10	DGND

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6. CPU Board Specification

This section describes the specification of the CPU Board.

6.1 Functions

6.1.1 Power supply

When not connected to the inverter board, power should be supplied from the USB connector (CN9). When connecting to the inverter board, power supply from the USB connector or from the inverter board will be automatically selected. USB power supply has priority.

6.1.2 Onboard debugger

This product has the onboard debugger circuit, J-Link On-Board (hereinafter called “J-Link-OB”). You can write a program (firmware) of RA6T3 with it. When you write a program, connect the CPU board to PC with USB cable. J-Link-OB operates as debugger equivalent to J-Link. If connecting from Integrated Development Environment or flash programing tool (e.g. J-Flash Lite by SEGGER), set the type of debugger (tool) to “J-Link”.

6.1.3 J-Link Virtual COM Port

This product supports J-Link Virtual COM Port. To enable this function, short 1-2, 3-4, 5-6, and 7-8 pins of JP15. By connecting to a PC with USB connector (CN9), a virtual COM port via USB is available.

6.1.4 USB I/F

This product has a USB connector (CN1) for the USB Full-Speed module in RA6T3.

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6.1.5 Inverter board connector

An inverter board can be connected to this board with CN2 and CN3. The pin assignments of the connectors are shown in Table 6-1, Table 6-2. Note that these tables show default connection setting for the ports with jumper switches.

Table 6-1 Inverter board connector (CN2) pin assignment

Pin No.	Pin Function	RA6T3 Pin	Pin No.	Pin Function	RA6T3 Pin
1	NC	-	2	AGND	- (AVSS)
3	VPN	P004/AN004	4	AGND	- (AVSS)
5	IU	P000/AN000	6	PGAVSS	P003/PGAVSS000
7	IV	P001/AN001	8	NC	-
9	IW	P002/AN002	10	NC	-
11	VU	P500/AN016	12	VV	P014/AN012
13	VW	P013/AN011	14	AGND	- (AVSS)
15	NC	-	16	NC	-
17	VR	P005/AN005	18	AGND	- (AVSS)
19	AVCC	- (AVCC)	20	AVCC	- (AVCC)
21	AGND	- (AGSS)	22	AGND	- (AVSS)
23	VCC	- (VCC)	24	VCC	- (VCC)
25	GND	- (VSS)	26	GND	- (VSS)
27	UN	P408/GTIOC1B_B	28	GND	- (VSS)
29	UP	P409/GTIOC1A_B	30	GND	- (VSS)
31	VN	P102/GTIOC2B_A	32	GND	- (VSS)
33	VP	P103/GTIOC2A_A	34	GND	- (VSS)

Table 6-2 Inverter board connector (CN3) pin assignment

Pin No.	Pin Function	RA6T3 Pin	Pin No.	Pin Function	RA6T3 Pin
1	WN	P112/GTIOC3B_A	2	GND	- (VSS)
3	WP	P111/GTIOC3A_A	4	GND	- (VSS)
5	DRV_SCK	P302/RSPCKA_A	6	DRV_RXD	P207/MOSIA_A
7	DRV_TXD	P206/MISOA_A	8	DRV_CS	P301/SSLA0_A
9	BUS_POWER_IN	-	10	INV_CONNECTED	-
11	SAFE_LOCK	-	12	OC#	P104/GTETRGB_B
13	DRV_nFault	P400	14	DRV_EN	P403
15	CON_MOT_SEL	P407	16	SW1	P304
17	SW2	P200	18	LED1	P113
19	LED2	P106	20	NC	-
21	HALL_U	P008/IRQ12DS	22	HALL_V	P006/IRQ11_DS
23	HALL_W	P015/IRQ13_A	24	SIO_SDA	P206/SDA0_C
25	SCK_SCL	P205/SCL0_C	26	CSN_IRQN/ENC_Z	P105/GTETRGA_C
27	IPS_A ENC_A	P500/AN016 P101/GTIOC5A_D	28	IPS_A#	P008/AN008
29	IPS_B ENC_B	P006/AN006 P100/GTIOC5B_D	30	IPS_B#	P015/AN013
31	GND	- (VSS)	32	GND	- (VSS)
33	+5V	-	34	+5V	-

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6.1.6 Serial communication

For serial communication using Renesas Motor Workbench, the CPU board has SCI connector. Pin assignment for SCI connector is listed in Table 6-3.

Table 6-3 SCI connector (CN7) pin assignment

Pin No.	Pin Function	RA6T3 Connection Pin
1	GND	-
2	MCU RXD	P410/RXD0_B
3	MCU TXD	P411/TXD0_B
4	VCC	-

6.1.7 Reset circuit

This product has a reset circuit to enable power-on reset or external reset on MCU. Push the tact switch (SW1) to externally reset MCU.

6.1.8 LED

This product has 2 controllable LEDs, so that they can be used for program debug and the system. LED switches on when output from the corresponding port is “LOW” and switches off when output is “HIGH”. Pin assignment for corresponding LEDs is listed in Table 6-4.

Table 6-4 LED pin assignment

RA6T3 port		LED1	LED2
P113	Output HIGH	OFF	-
	Output LOW	ON	-
P106	Output HIGH	-	OFF
	Output LOW	-	ON

6.1.9 CAN Communication

This product has through holes for CAN communication. Note that CAN driver is not equipped. Pin assignment for CAN communication connector is listed in Table 6-5.

Table 6-5 CAN communication pin assignment (CN6)

Pin No.	RA6T3 pin
1	VCC
2	P401/CTX0_B
3	P402/CRX0_B
4	VSS

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6.1.10 PMOD

This product has two connectors for PMOD module connection. Pin assignments are shown in Table 6-6 and Table 6-8. CN4 is for both PMOD Type 2A/6A. Type 2A/6A can be switched by JP9,10 and 11. See Table 6-7 for settings.

Table 6-6 PMOD Type 2A/6A connector (CN4) pin assignment

No.	RA6T3 port	No.	RA6T3 port
1	P301_SSLA0/ P110_IRQ3_A	7	P400
2	P207_MOSIA	8	P403
3	P206_MISOA_A/ P205_SCL0	9	P407
4	P302_RSPCKA_A/ P206_SDA0_C	10	P208
5	VSS	11	VSS
6	VCC	12	VCC

Table 6-7 PMOD Type 2A/6A connector (CN4) jumper setting

JP No.	RA6T3 port		
	Open	1-2 short	2-3 short
9	N/A	Type2A	Type6A
10	N/A	Type2A	Type6A
11	N/A	Type6A	Type2A
15	PMOD	VCOM port (1-2, 3-4, 5-6, 7-8 short)	N/A

Table 6-8 PMOD Type 3A connector (CN5) pin assignment

No.	RA6T3 port	No.	RA6T3 port
1	P303_CTS9	7	P400
2	P109_TXD9	8	P403
3	P110_RXD9	9	P407
4	P301_CTS_RTS_D	10	P208
5	VSS	11	VSS
6	VCC	12	VCC

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6.2 RA6T3 pin function list

Table 6-9 RA6T3 pin function list

Pin number	RA6T3 pin function	Signal function
1	P400 / (IRQ0_A)	PMOD
2	CTX0_B	CAN
3	CRX0_B	CAN
4	P403 / (IRQ14DS)	PMOD
5	VCL0	Power
6	-	-
7	-	-
8	VSS	GND
9	XTAL	Crystal
10	EXTAL	Crystal
11	VCC	Power
12	TXD0_B	RMW communication
13	RXD0_B	RMW communication
14	GTIOC1A_B	U-phase upper arm
15	GTIOC1B_B	U-phase lower arm
16	P407	PMOD
17	VSS_USB	Power
18	USB_DM	USB
19	USB_DP	USB
20	VCC_USB	Power
21	MOSIA_A	PMOD Type2A(SPI)
22	MISOA_A / (SDA0_C)	PMOD Type2A(SPI) / (PMOD Type6A(I2C))
23	SCL0_C	PMOD Type6A(I2C)
24	P208	PMOD
25	RES#	ARM debugger
26	MD	ARM debugger
27	P200	SW2
28	P304	SW1
29	CTS9_D	PMOD Type3A(UART)
30	RSPCKA_A	PMOD Type2A(SPI)
31	SSLA0_A / (CTS_RTS9_D)	PMOD Type2A(SPI) / (PMOD Type3A(UART))
32	SWCLK	ARM debugger
33	SWDIO	ARM debugger
34	TXD9_B	PMOD Type3A(UART)
35	RXD9_B / (IRQ3_A)	PMOD Type3A(UART) / (PMOD Type6A(I2C))
36	GTIOC3A_A	W-phase upper arm
37	GTIOC3B_A	W-phase lower arm
38	P113	LED1
39	VCC	Power
40	VSS	Power
41	P107	-
42	P106	LED2
43	GTETRGA_C / (IRQ0_B)	Encoder Z-phase
44	GTETRGB_B	Over current detection
45	GTIOC2A_A	V-phase upper arm
46	GTIOC2B_A	V-phase lower arm
47	GTIOC5A_D	Encoder A-phase
48	GTIOC5B_D	Encoder B-phase
49	AN016	U-phase voltage sensing / IPS_A
50	IRQ12DS / (AN008)	HALL sensor U-phase / (IPS_A#)
51	IRQ11DS / (AN006)	HALL sensor V-phase / (IPS_B)
52	IRQ13_A / (AN013)	HALL sensor W-phase / (IPS_B#)
53	AN012	V-phase voltage sensing
54	AN011	W-phase voltage sensing
55	PGAVSS000	PGAGND for current sensing
56	AVCC0	Power

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Pin number	RA6T3 pin function	Signal function
57	AVSS0	Power
58	VREFL0	Power
59	VREFH0	Power
60	AN005	VR input
61	AN004	Bus voltage sensing
62	AN002	W phase current sensing
63	AN001	V phase current sensing
64	AN000	U phase current sensing

Note: Jumper switching is required to use the functions in parentheses.

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7. Design and Manufacture Information

You can obtain information on the design and manufacture of this product from renesas.com.

8. Website and Support

In order to learn, download tools and documents, apply technical support for RA family MCU and its kit, visit the below Web site.

· RA Product Information renesas.com/ra

· Renesas Support renesas.com/support

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Revision History

Rev.	Date	Description	
		Page	Summary
1.00	May 23, 2023	-	First edition
1.10	December 20, 2023	7, 20	Corrected overcurrent threshold (21.4A for AVCC=3.3V, 32.4A for AVCC=5.0V)

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