Renesas Solution Starter Kit
24V Motor Control Evaluation System for RX23T (Motor RSSK)

R20UT3697EJ0120
Rev.1.20
Feb. 15, 2019

User's Manual

For Your Safety

Do not fail to read this manual before using the 24V Motor Control Evaluation System for RX23T (RTK0EM0006S01212BJ) (the product).

- Follow the indications in this manual when using the product.
- Keep this manual near the product so you can refer to it whenever necessary.
- Transfer or sale of the product to third parties is prohibited without written approval.
- The purchaser or importer of the product is responsible for ensuring compliance with local regulations. In addition, the customer is responsible for ensuring that the product is handled correctly and safely, in accordance with the laws of the customer's country (region).
- All information contained in this manual represents information on products at the time of publication of this manual. Please note that the product data, specification, sales offices, contents of website, address, etc., are subject to change by Renesas Electronics Corporation without notice due to product improvements or other reasons. Please confirm the latest information on Renesas Electronics website.
- The manual for the product, and specification (the documents) are the tool that was developed for the function and performance evaluation of Renesas Electronics semiconductor device (Renesas Electronics device) mounted on the product, and not guarantee the same quality, function and performance.
- By purchasing the product or downloading the documents from Renesas Electronics website, the support services provided from Renesas Electronics is not guaranteed.

Meaning of Notations

In this manual items related to the safe use of the product are indicated as described below.

The degree of injury to persons or damage to property that could result if the designated content in this manual is not followed is indicated as follows.

⚠ **Danger**	Indicates content that, if not followed, could result in death or serious injury*1 to the user, and which is highly urgent.
⚠ **Warning**	Indicates content that, if not followed, could result in death or serious injury to the user.
⚠ **Caution**	Indicates content that, if not followed, could result in injury*2 to persons or physical damage.*3

Note 1. Serious injury refers to conditions resulting in persistent after-effects and for which treatment would necessitate hospitalization or regular hospital visits, such as loss or impairment of eyesight, burns (high- or low-temperature), electric shock, bone fracture, or poisoning.

Note 2. Injury refers to conditions for which treatment would necessitate hospitalization or regular hospital visits.

Note 3. Physical damage refers to damage affecting the wider surroundings, such as the user's home or property.

Requirements related to the handling of the product are classified into the following categories.

- Marks indicating that an action is prohibited.

	General Prohibition The indicated action is prohibited.		Example: Do Not Touch! Touching the specified location could result in injury.

- Marks indicating that an action is prohibited.

	General Caution Indicates a general need for caution that is not specified.		Example: Caution – Hot! Indicates the possibility of injury due to high temperature.

- Marks directing that the specified action is required.

	General Instruction The specified action is required.		Example: Turn Off (Disconnect) Power Supply! Instructs the user to turn off (disconnect) the power supply to the product.

Warnings Regarding Use of the Product

■ Danger Items

Danger	
  	• The product should be used only by persons (users) having a thorough knowledge of electrical and mechanical components and systems, a full knowledge of the risks associated with handling them, and training in inverter motor control and handling motors, or equivalent skills. Users should be limited to persons who have carefully read the Caution Items contained in this manual. • Unlike typical equipment, the product has no protective case to ensure safety, and it contains moving parts and high-temperature components that could be dangerous. Do not touch the evaluation board or cables while power is being supplied. • Carefully check to make sure that there are no pieces of conductive materials or dust adhering to the board, connectors, and cables. • There are moving parts, driven by a motor. Do not touch the motor while power is being supplied. • Ensure that the motor is insulated and placed in a stable location before supplying power.
	Do Not Connect Load to Motor! • This could cause fire, burns, or injury.

■ Warning Items

⚠ Warning	
	Caution – Rotating Parts! • The system includes a motor. Touching the rotating shaft could cause high-temperature burns or injury.
	Always insert plugs, connectors, and cables securely, and confirm that they are fully inserted. • Incomplete connections could cause fire, burns, electric shock, or injury.
	Use the power supply apparatus specified in the manual. • Failure to do so could cause fire, burns, electric shock, injury, or malfunction.
	Disconnect the power supply and unplug all cables when the system will not be used for a period of time or when moving the system. • Failure to do so could cause fire, burns, electric shock, or malfunction. • This will protect the system against damage due to lightning.
	Use a mechanism (switch, outlet, etc.) located within reach to turn off (disconnect) the power supply. • In case of emergency, it may be necessary to cut off the power supply quickly.
	Turn off the power supply immediately if you notice abnormal odor, smoke, abnormal sound, or overheating. • Continuing to use the system in an abnormal condition could cause fire, burns, or electric shock.
	Do Not Disassemble, Modify, or Repair! • Doing so could cause fire, burns, electric shock, injury, or malfunction.
	Do not use the product for any purpose other than initial evaluation of motor control in a testing room or lab. Do not integrate the product or any part of it into other equipment. Do not insert or remove cables or connectors when the product is powered on. • The product has no safety case. • Failure to observe the above could cause fire, electric shock, burns, or malfunction. • The product may not perform as expected if used for other than its intended purpose.

■ Caution Items

⚠ Caution	
	Caution – Hot! • The motor gets hot. Touching it could cause high-temperature burns.
	Follow the procedure specified in the manual when powering the system on or off. • Failure to do so could cause overheating or malfunction.
	Caution – Static Electricity • Use the antistatic band. Failure to do so could cause malfunction or unstable motion.
	Use the ferrite core "near this product" on cable between the power supply and this product. (Example) SEIWA ELECTRIC MFG.CO.,LTD Ferrite core E04SR150718 • Failure to do so could cause inhibition of motion to other equipment.

Overview

The Renesas Solution Starter Kit 24V Motor Control Evaluation System for RX23T (Motor RSSK) (RTK0EM0006S01212BJ) is a motor control evaluation kit.

The motor control board of the product consists of two parts: an inverter board and a CPU card. Each product version is equipped with a CPU card on which the designated microcontroller model is mounted.

This user's manual describes the proper handling of the product.

Target Device

RX23T microcontroller

Related Documents

- INV-BRD
  - Schematic: R12TU0011EJ
  - BOM List: R12TU0001EJ
  - PWB Pattern Drawing: R12TU0005EJ
- RX23T-CRD
  - Schematic: R12TU0010EJ
  - BOM List: R12TU0009EJ
  - PWB Pattern Drawing: R12TU0006EJ
- Related to Motor Control Development Support Tool "Renesas Motor Workbench"
  - User's Manual: R21UZ0004EJ

Package Contents

Refer to the sheet "Included Items," which is included in the package.

Abbreviations

Abbreviations	Full Name	Remarks
Motor RSSK	24V Motor Control Evaluation System for RX23T	This product Product No.: RTK0EM0006S01212BJ
INV-BRD	24V Inverter Board	Inverter board supplied with motor control evaluation kit for RX23T Product No.: RTK0EM0001B00012BJ
RX23T-CRD	RX23T CPU Card	CPU card populated with RX23T Product No.: RTK0EM0013C01201BJ
Support Tool	Motor Control Development Support Tool "Renesas Motor Workbench V.x.xx"	Renesas Electronics supports this tool. ("V.x.xx" is release version.)

Contents

1. Features

1. Supports the RX23T motor control microcontroller.
2. Supports permanent magnet synchronous motors.
3. Supports three-shunt current detection.
4. Equipped with USB mini-B connector for Support Tool communication.
5. Overcurrent protection function using overcurrent detection circuit.

2. Specifications

2.1 Specification

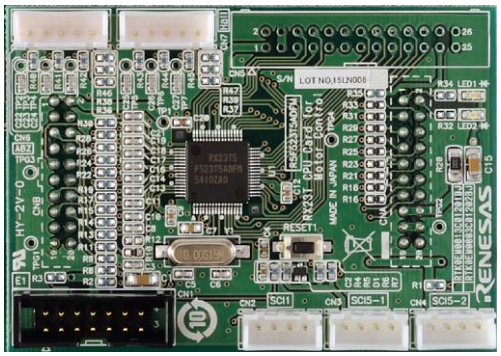
Table 2.1 Overview of 24V Motor Control Evaluation System for RX23T Specifications (1/3) (Kit specifications)

Item	Specification	
Series	24V Motor Control Evaluation System for RX23T	
Kit product No.	RTK0EM0006S01212BJ	
Kit contents	24 V Inverter Board	RTK0EM0001B00012BJ
	RX23T CPU Card	RTK0EM0013C01201BJ
	Permanent magnet synchronous motor	TG-55L-KA (manufactured by Tsukasa Electric Co., Ltd.) Rated voltage: 24 [V] Rated current: 0.42 [A]
Inverter circuit and CPU card	Not isolated	
Exterior view		
Operating temperature	Room temperature	
Operating humidity	No condensation	
Electromagnetic Compatibility (EMC) Directive	2014/30/EU EN61326-1 : 2013 Class A	

Table 2.2 Overview of 24V Motor Control Evaluation System for RX23T Specifications (2/3) (24V Inverter Board specifications)

Item	Specification
Product name	24V Inverter Board
Board product No.	RTK0EM0001B00012BJ
Exterior view	
Operating input voltage	DC 24 V (±5%) Selectable between the following: • Faston terminals • Center-positive DC jack
Max. input power	50 W
Rated output capacity	60 VA
Rated output current	AC 2 A (effective value)
Switching frequency	2 kHz to 20 kHz (reference value)
Dead time	2.0 μs and more
Current detection method	3 shunt method
Shunt resistor	50 mΩ
PWM logic	Positive logic with upper and lower arms
DC bus voltage detection	Detection by resistance division (5 V to 24 V)
Three-phase voltage detection	Detection by resistance division (0 V to 24 V)
Three-phase current detection	Voltage detection using shunt resistor (-2 A to 2 A)
Overcurrent detection function	User settable using variable resistor
Communication interface	USB mini-B Note: The" Support Tool" from Renesas Electronics is required for communication with a PC.
Connectors	• CPU card connectors × 2 • USB mini-B connector • External AD input connector • +12 V input connector
Switches	• Toggle switches for user control × 2 • Inverter circuit control current cutoff switch
LEDs	• LEDs for user control × 3 (of which 2 are synchronized with the LEDs on the RX23T-CRD) • LED for Inverter circuit control power supply

**Table 2.3 24V Motor Control Evaluation System for RX23T Specifications (3/3)
(RX23T CPU Card specifications)**

Item		Specification
Product name		RX23T CPU Card
Board product No.		RTK0EM0013C01201BJ
Exterior view		
Microcontroller	Product Group	RX23T group
	Product No.	R5F523T5ADFM
	CPU max. operating frequency	40 MHz
	Bit count	32 bits
	Package / Pin count	LFQFP / 64 pins
	ROM	128 KB
	RAM	12 KB
MCU input clock		Crystal resonator 10 MHz
Input power supply voltage		DC 5 V Selectable among the following: • Power supply from supported inverter board • Power supply from E1
Supported sensors		Hall sensor, encoder (through holes provided for signal monitoring test pins)
Supported emulator		E1 emulator
Connectors		• INV-BRD connectors × 2 • SCI connectors × 3 • E1 connector • Hall sensor signal input connector • Encoder signal input connector
Switch		MCU external reset switch
LEDs		User control LEDs × 2 (synchronized with LEDs on INV-BRD)

2.2 Information

2.2.1 European Union regulatory notices

This product complies with the following EU Directives. (These directives are only valid in the European Union.)

CE Certifications:

・Electromagnetic Compatibility (EMC) Directive 2014/30/EU

EN61326-1 : 2013 Class A

WARNING: This is a Class A product. This equipment can cause radio frequency noise when used in the residential area. In such cases, the user/operator of the equipment may be required to take appropriate countermeasures under his responsibility.

・Information for traceability

・Authorised representative

Name: Renesas Electronics Corporation

Address: Toyosu Foresia, 3-2-24, Toyosu, Koto-ku, Tokyo 135-0061, Japan

・Manufacturer

Name: Renesas Electronics Corporation

Address: Toyosu Foresia, 3-2-24, Toyosu, Koto-ku, Tokyo 135-0061, Japan

・Person responsible for placing on the market

Name: Renesas Electronics Europe GmbH

Address: Arcadiastrasse 10, 40472 Dusseldorf, Germany

・Trademark and Type name

Trademark: Renesas

Product name: Motor Control Evaluation System for RX23T

Type name: RTK0EM0006S01212BJ

Environmental Compliance and Certifications:

・Waste Electrical and Electronic Equipment (WEEE) Directive 2012/19/EU

3. Block Diagram

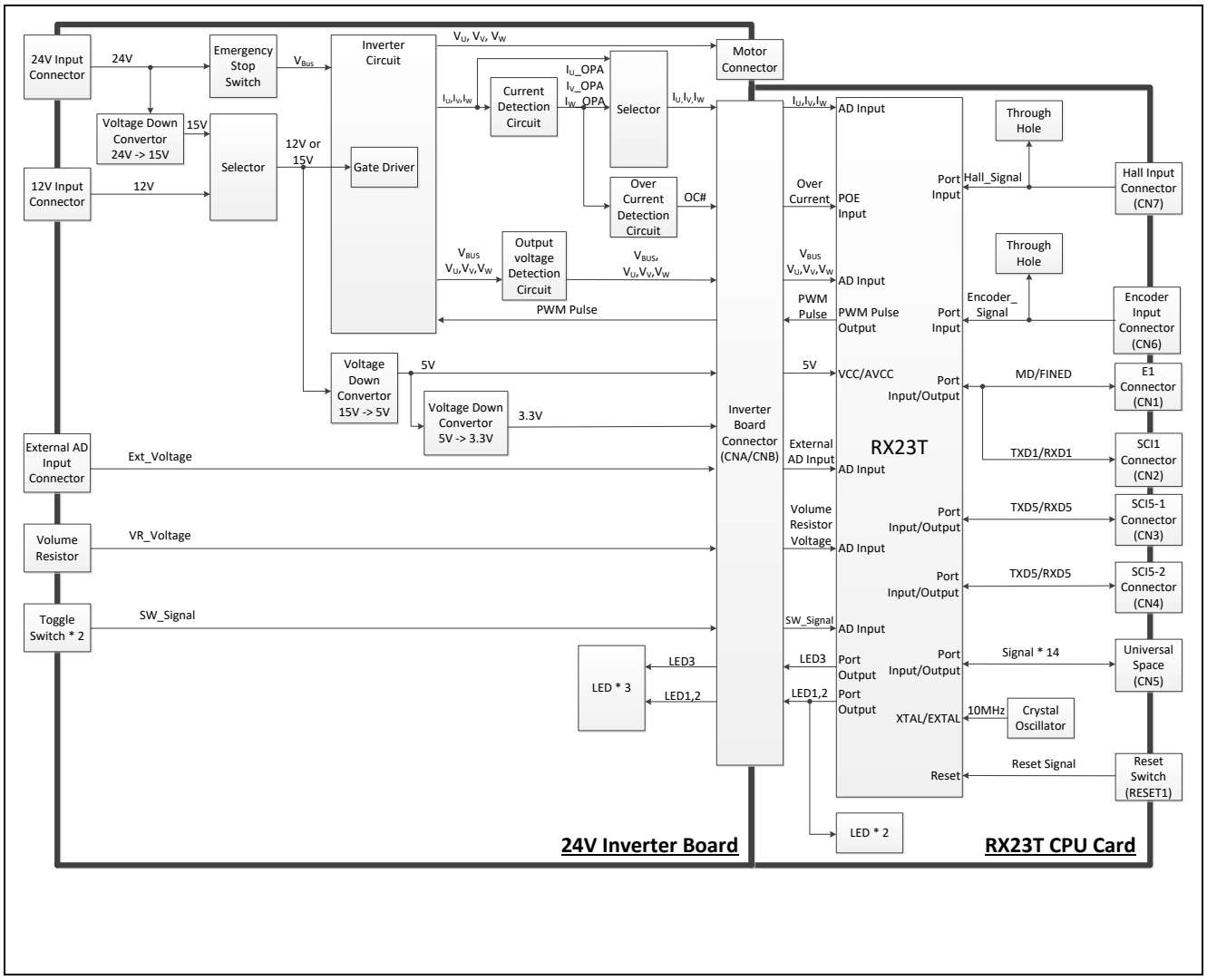


Figure 3.1 24V Motor Control Evaluation System for RX23T Block Diagram

4. Layout

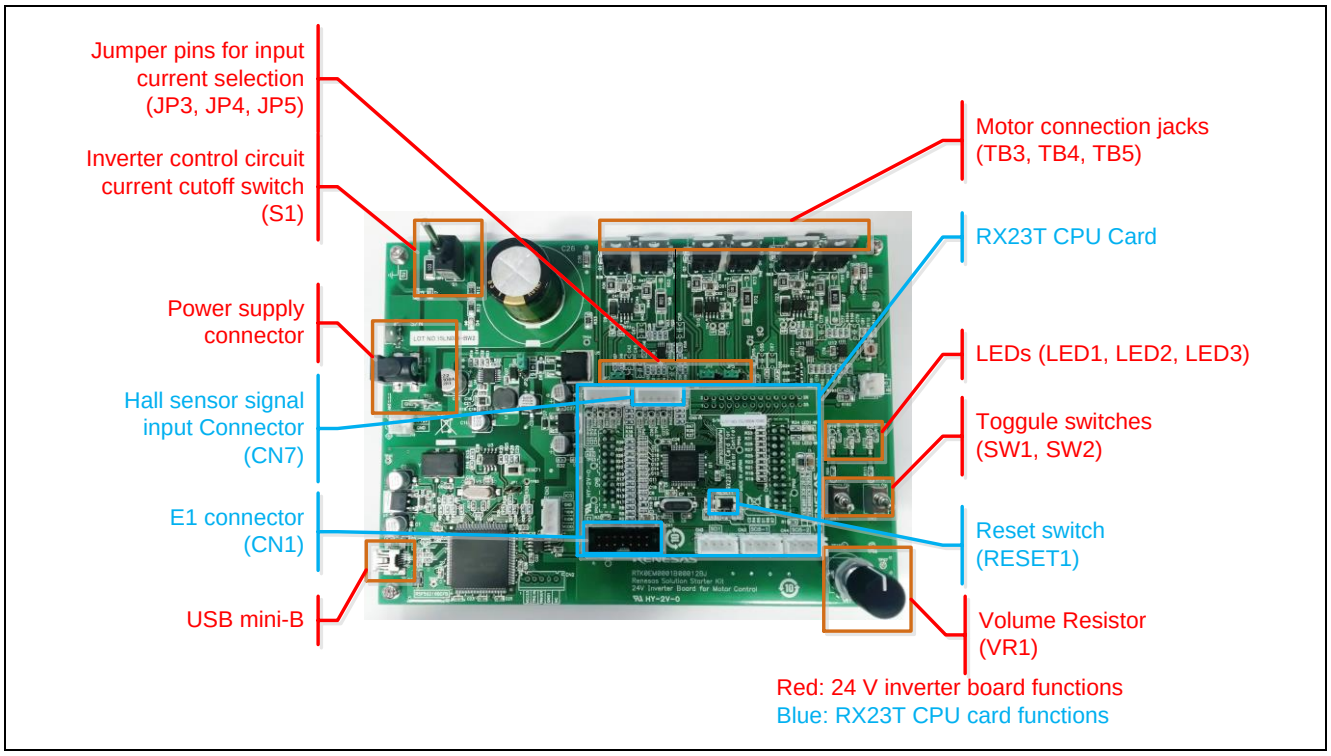


Figure 4.1 Layout

5. Usage

5.1 Quick Start

This chapter describes the quick start procedure for the product with the default software. Perform steps (1) to (9) in that order. Regarding the procedure with sample codes published on our web site, please refer the application notes of those codes.

The product includes a TG-55L-KA permanent magnet synchronous motor manufactured by Tsukasa Electric Co., Ltd. Use the supplied motor when performing the steps described in this chapter.

Motors conforming to the inverter specifications listed in chapter 2 can be connected to the product. When using motors other than the one included with the product, make sure to check the motor specifications carefully.

Use the antistatic band. Failure to do so could cause malfunction or unstable motion.

Table 5.1 Quick Start Procedure

Step	Item
(1)	Check the jumper pins.
(2)	Connect the motor to the board.
(3)	Connect the stabilized power supply and cable.
(4)	Check the inverter control circuit current cutoff switch.
(5)	Supply power.
(6)	Enable motor rotation.
(7)	Confirm changes in the motor rotation speed.
(8)	Stop motor rotation.
(9)	Finish the operation check.

Preparation for Quick Start

Please prepare the following.

- Stabilized power supply: Output voltage is DC 24[V] and more, Output Current limit is 2[A].
- Power supply cables × 2: Current limit is 2[A] and more. (For the connection of the stabilized power supply and the INV-BRD.)

If an Error Occurs

LED2 on the INV-BRD and RX23T-CRD turns on and motor rotation stops. To recover, it is necessary to turn on toggle switch SW2 while toggle switch SW1 is in the off state, and then turn off toggle switch SW2 again.

5.1.1 Checking the Jumper Pins

Confirm that the jumper pins (JP1, JP2, JP3, JP4, and JP5) are in the following state:

Table 5.2 State of Jumper Pins

Jumper Pin	State
JP1	Open
JP2	Pins 1 and 2 shorted
JP3	Pins 1 and 2 shorted
JP4	Pins 1 and 2 shorted
JP5	Pins 1 and 2 shorted

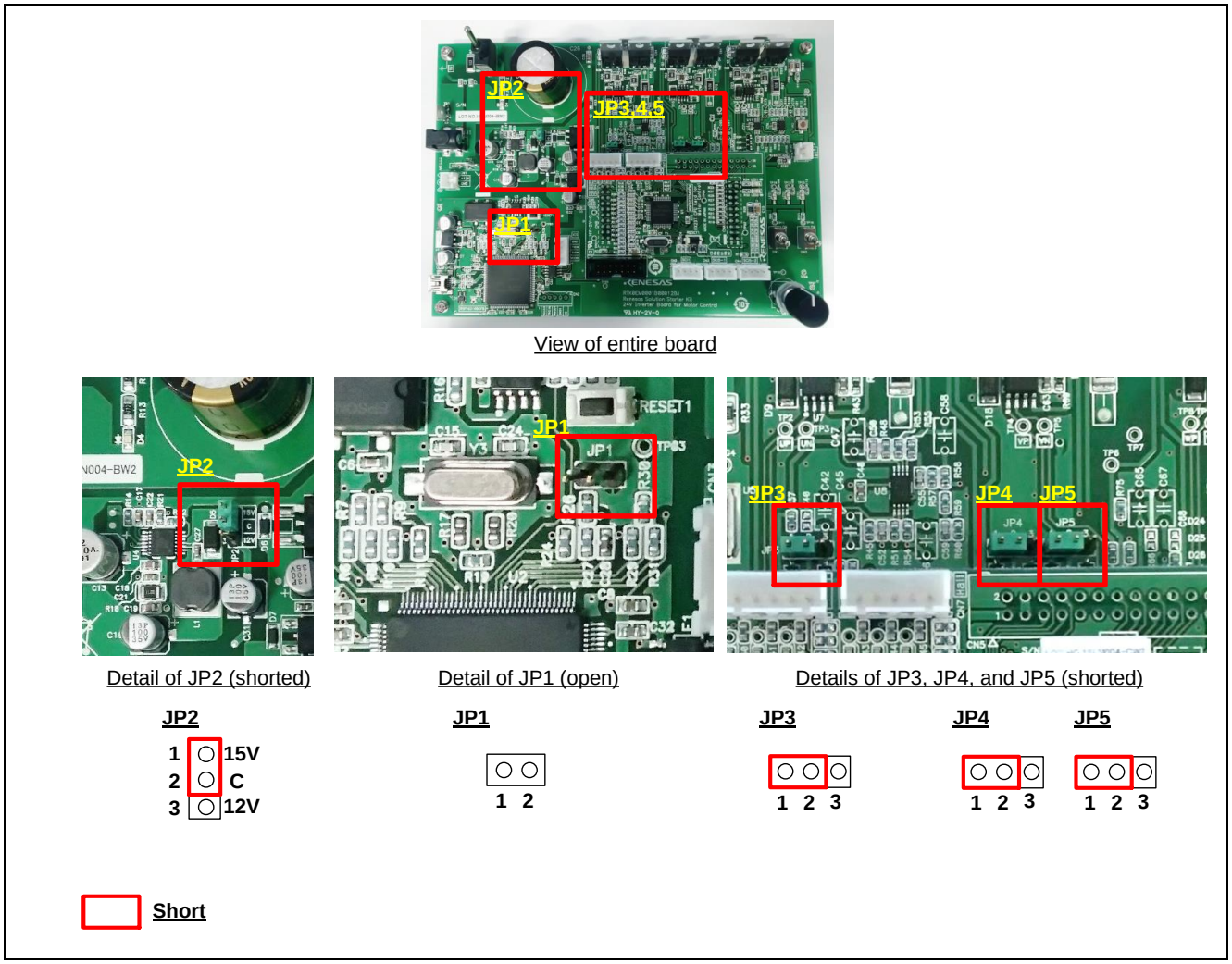


Figure 5.1 Checking the Jumper Pins

5.1.2 Connecting the Motor to the Board

First, connect the supplied motor and cable. Next, connect the motor's three phase wire terminals (U, V, and W) to the inverter board and the Hall sensor signal wire terminal to the CPU card.

The diagram below shows connections for the supplied TG-55L-KA motor

The initial software operation included the product is no use hall sensor signal.

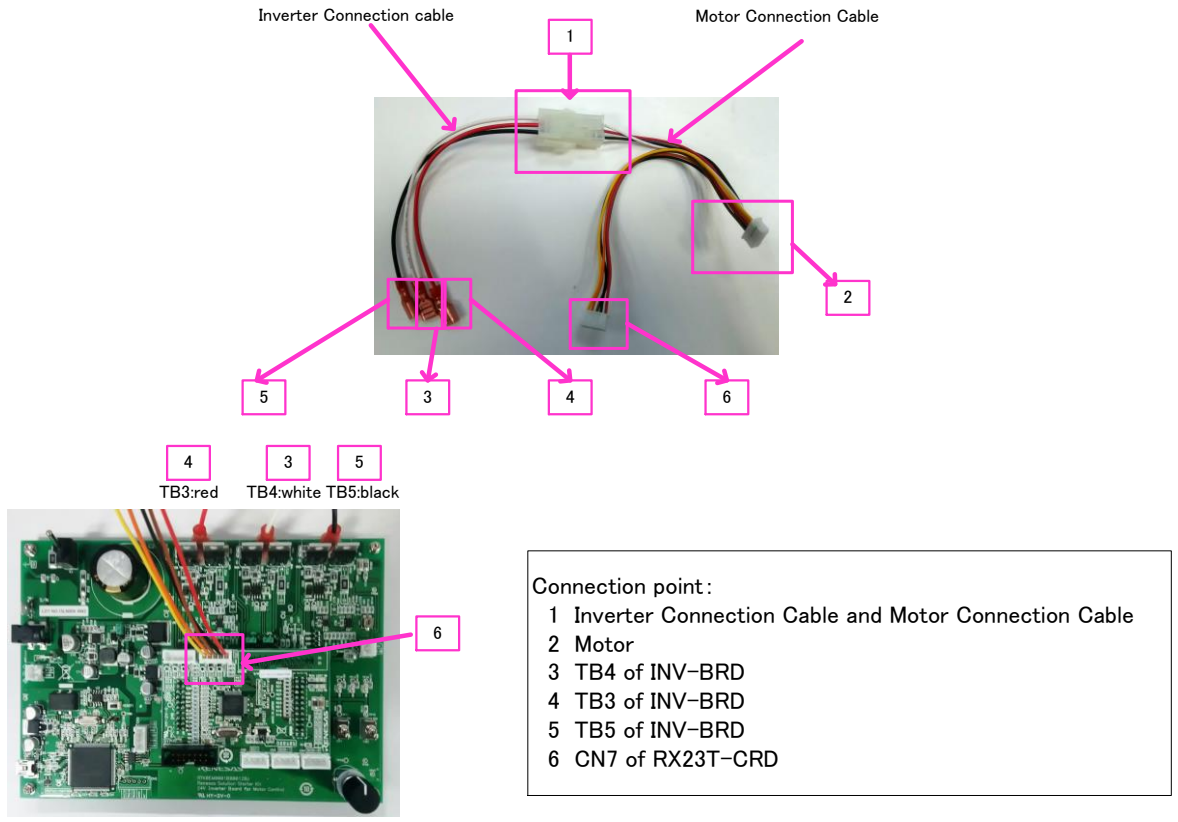


Figure 5.2 Cable Connection Diagram

5.1.3 Connecting the Stabilized Power Supply and Cable

Refer to figure 5.3, use the ferrite core which was included in this product "near this product" on cable between the power supply and this product.

The product uses Faston terminals (TB1 and TB2) as connectors for supplying power to the board. Use a stabilized power supply, and set the output voltage to 24 [V] and the limit current to 2 [A]. If the voltage drops even momentarily, the drop in the CPU's power supply will cause a reset to be generated, and program execution will be halted.

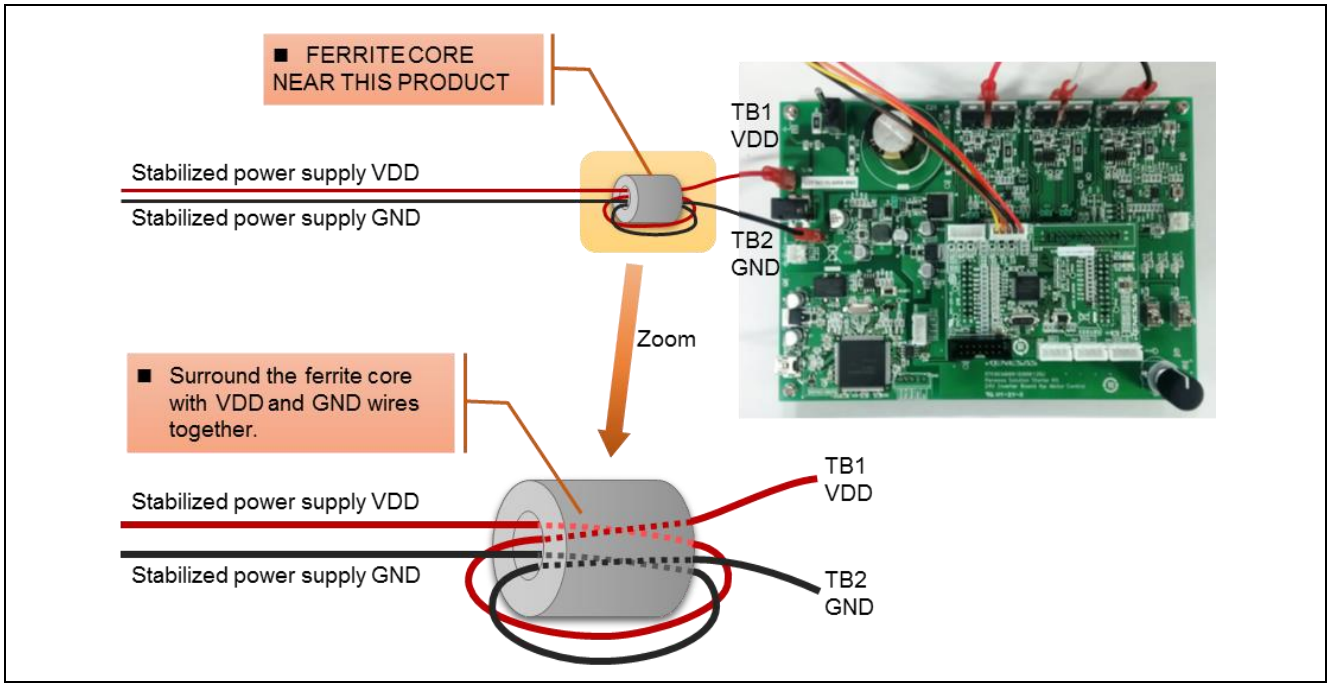


Figure 5.3 How to Use Ferrite Core and Power Supply Connectors

5.1.4 Checking the Inverter Control Circuit Current Cutoff Switch

Check to make sure the inverter control circuit current cutoff switch (S1) is in the ON position, as shown below.

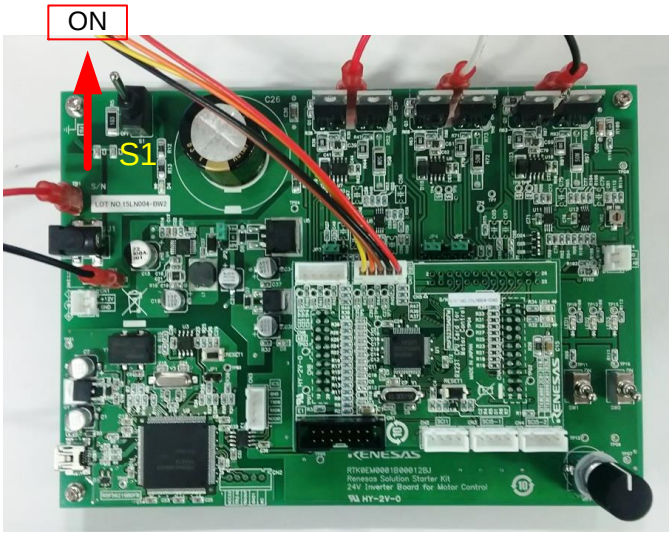


Figure 5.4 Inverter Control Circuit Current Cutoff Switch

5.1.5 Checking the Variable Resistor

Check to make sure the variable resistor (VR1) is in the center position. (The knob clicks into place in the center position.)

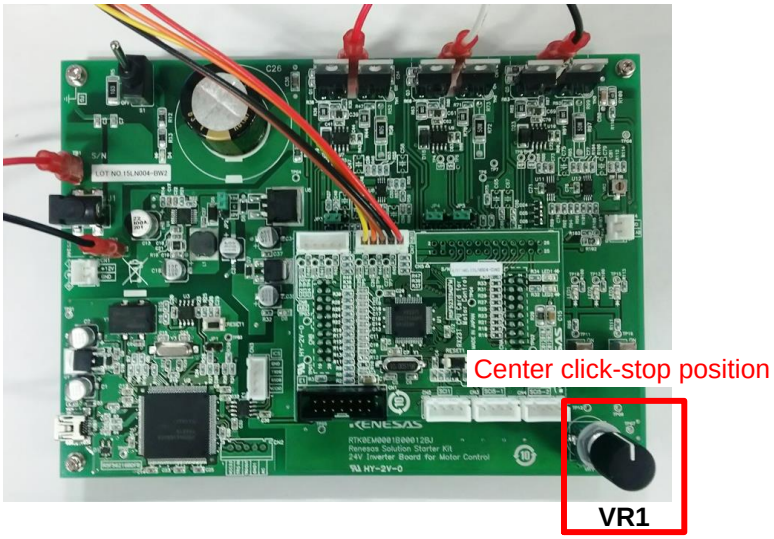


Figure 5.5 Checking the Variable Resistor

5.1.6 Supplying Power

Using a stabilized power supply, set the output voltage to 24 [V] and the limit current to 2 [A], and switch power on. If the voltage drops even momentarily, the drop in the RX23T's power supply will cause a reset to be generated, and program execution will be halted.

5.1.7 Enabling Motor Rotation

To enable motor rotation, flip the toggle switch (SW1) to the ON position, as shown below.

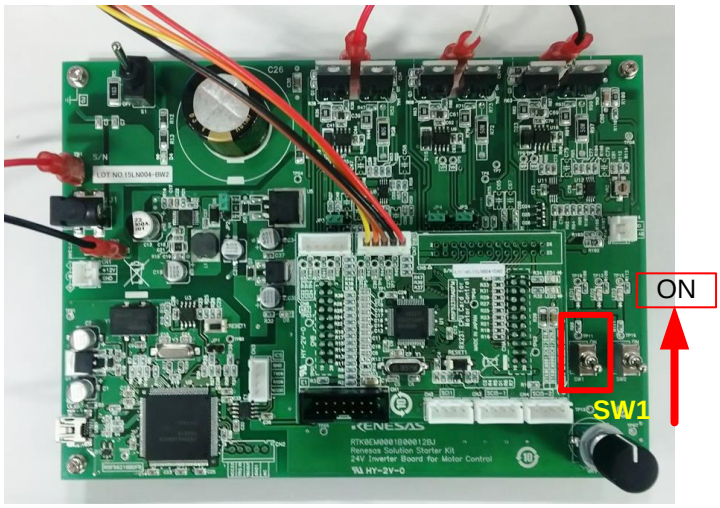


Figure 5.6 Enabling Motor Rotation

5.1.8 Confirming Motor Rotation Speed Changes

Confirm that the motor's rotation speed changes when you turn the variable resistor (VR1).

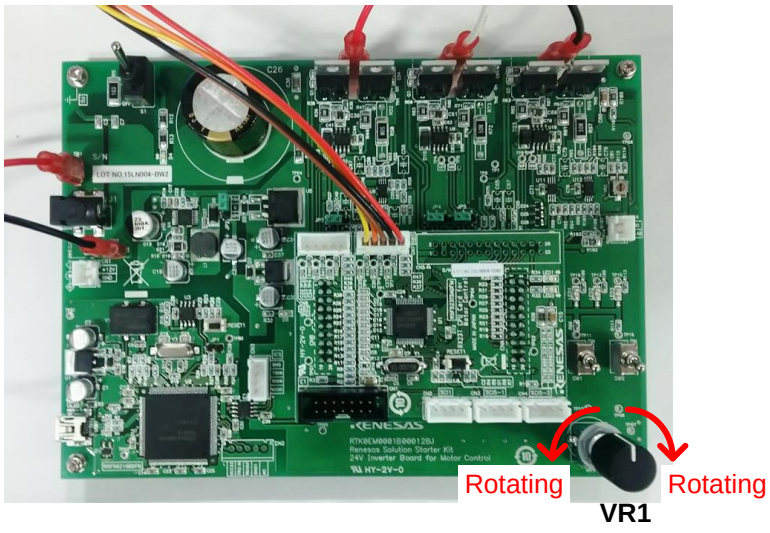


Figure 5.7 Changing the Motor Rotation Speed

5.1.9 Stopping Motor Rotation

To stop motor rotation, flip toggle switch SW1 to the OFF position.

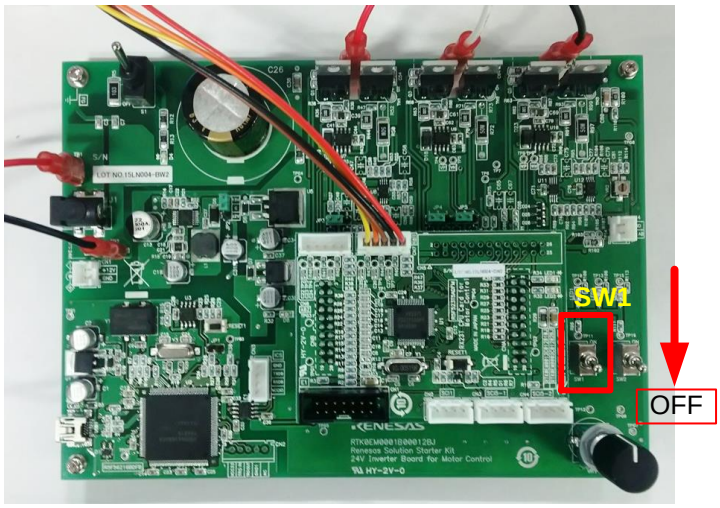


Figure 5.8 Stopping Motor Rotation

5.1.10 Finishing the Operation Check

To complete the operation check procedure, confirm that the motor shaft is not rotating and switch off output from the stabilized power supply.

5.2 Default Software Specifications

The default software specifications of the product when shipped from the factory are as follows: (*1)

Item	Specification
Control method	Sensor-less vector control
VR1	Clockwise turn: Motor shaft rotates clockwise. Counterclockwise turn: Motor shaft rotates counterclockwise.
SW1	ON: Motor rotation enabled OFF: Motor rotation disabled
SW2	Cancels error state : OFF → ON → OFF after an error
LED1	On: SW1 ON and normal status Off: SW1 OFF or error status
LED2	On: Error state Off: normal operating state
Support Tool	Not available

*1 Regarding the procedure with sample codes published on our web site, please refer the application notes of those codes.

5.3 Preparing to Use the Support Tool

The product supports the Support Tool from Renesas Electronics. It is equipped with a USB mini-B connector as the communication interface. To use the Support Tool, connect the INV-BRD to a PC with a USB cable.

(1) Connecting the communication cable

Use the communication cable supplied with the product to connect SCI connector CN4 on the CPU card to connector CN3 on the inverter board.

(2) Connecting the USB cable

Use the USB cable supplied with the product to connect USB mini-B connector USB1 on the inverter board to your PC.

For instructions on using the tool, refer to the user's manual of the Motor Control Development Support Tool "Renesas Motor Workbench V.x.xx". ("V.x.xx" is release version.)

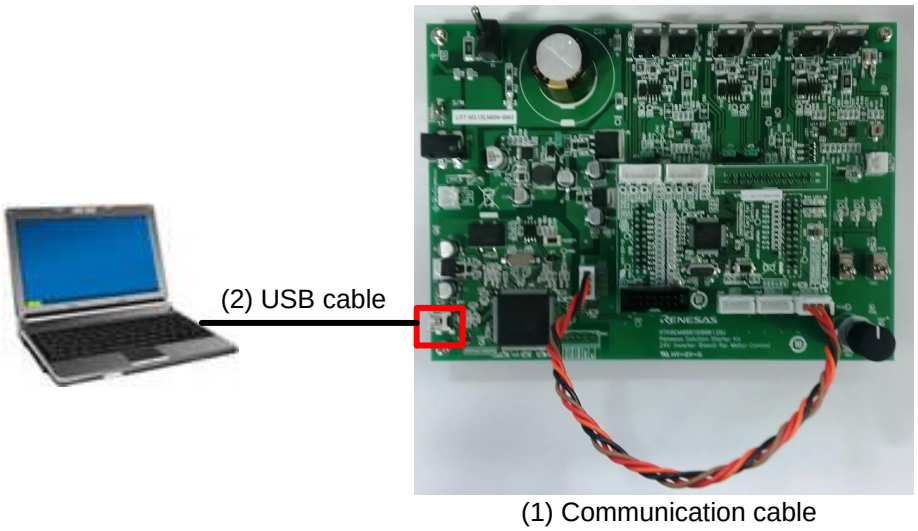


Figure 5.9 Cable Connections

5.4 Dealing with Errors

5.4.1 Dealing with Abnormal Odor, Smoke, Abnormal Sounds, Overheating, Etc.

The INV-BRD is equipped with a toggle switch (S1) to cut off current flow to the inverter. Should an abnormal condition (abnormal odor, smoke, abnormal sounds, overheating, etc.) occur, flip S1 to the OFF position to cut off current flow to the inverter.

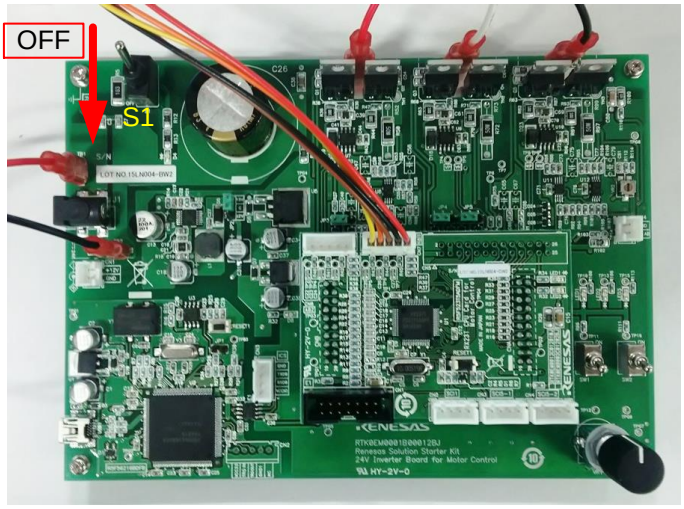


Figure 5.10 Cut off current

6. Individual Board Specifications

6.1 24V Inverter Board

This chapter describes the specifications of the INV-BRD. A general circuit diagram can be downloaded from the following URL:

6.1.1 Outline

The INV-BRD is an inverter board that can be used to operate a motor by connecting a CPU card from Renesas Electronics.

6.1.2 Layout

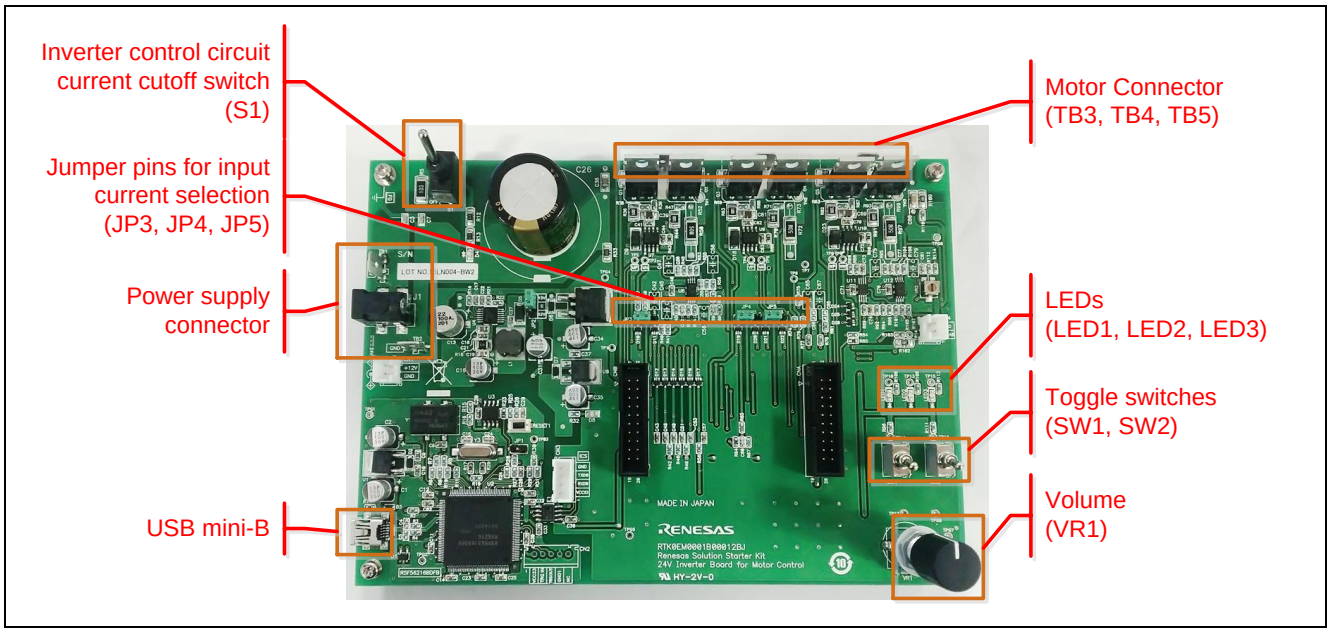


Figure 6.1 Layout

6.1.3 Functions

6.1.3.1 Inverter Control Circuit Block

The INV-BRD has a inverter control circuit block consisting of six power MOS-FETs for motor control. The microcontroller controls the power MOS-FETs using six-phase timer output function.

From the inverter control circuit block the output on the DC bus voltage pin; the U, V, and W phase voltage pins; and the shunt current pins is input on the A/D pins of the microcontroller. This makes possible measurement of the analog voltage and shunt current values. Current detection is described in 6.1.3.2 and voltage detection in 6.1.3.4. There is also a function for detecting when the shunt current of the U, V, or W phase is in an overcurrent state. See 6.1.3.3 for details.

Figure 6.2 is an illustration of the inverter control circuit block. In the actual circuit, inputs on the A/D pins are via voltage dividers, offsets, etc. Refer to the circuit diagram for details.

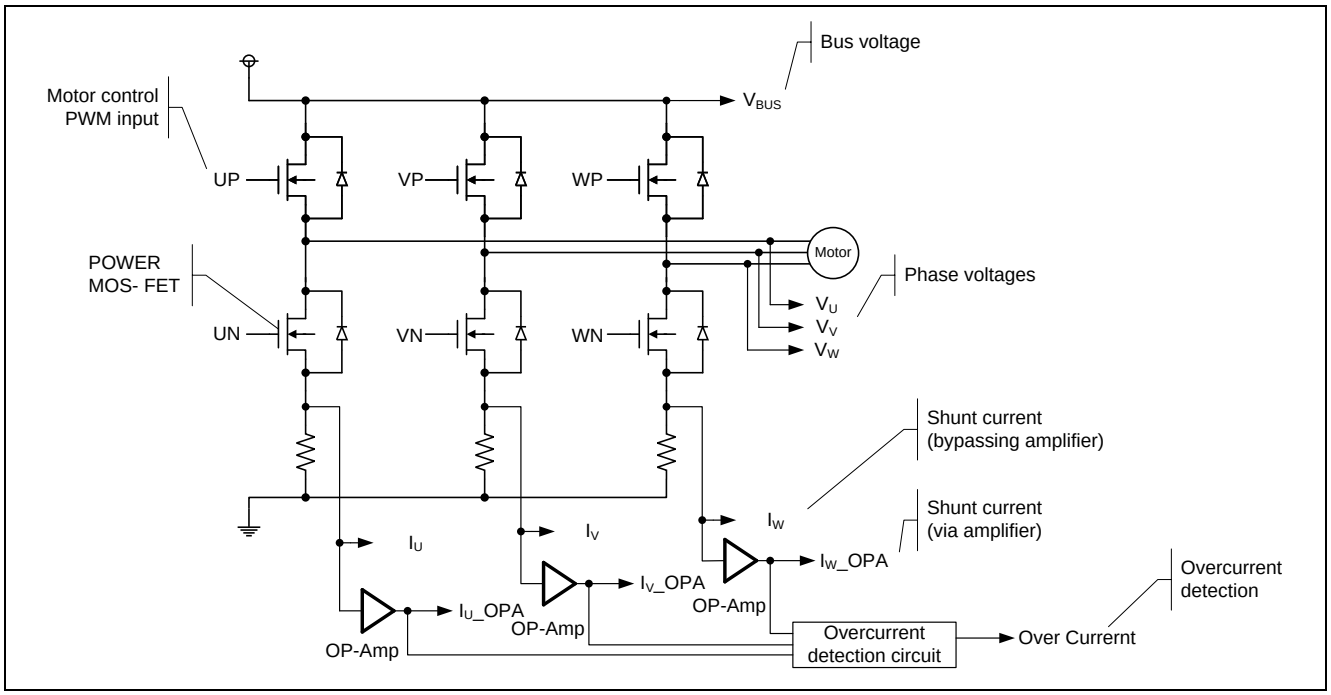


Figure 6.2 Inverter Control Circuit

6.1.3.2 Current Detection Circuits

The INV-BRD has current detection circuits to measure the U, V, and W phase currents. The U phase, V phase, and W phase are each equipped with a shunt resistor forming part of a current detection circuit. An op-amp amplifies the voltage drop resulting from the current flow to the shunt resistor (Iin), and the result is input to the microcontroller. The relationship between the current flow to the shunt resistor and the voltage input to the microcontroller (Vout) is expressed by the following equation:

$$\mathrm{Vout[V]} = \mathrm{Iin[A]} \times \mathrm{Rs[\Omega]} \times 5 + 2.5 \quad (1)$$

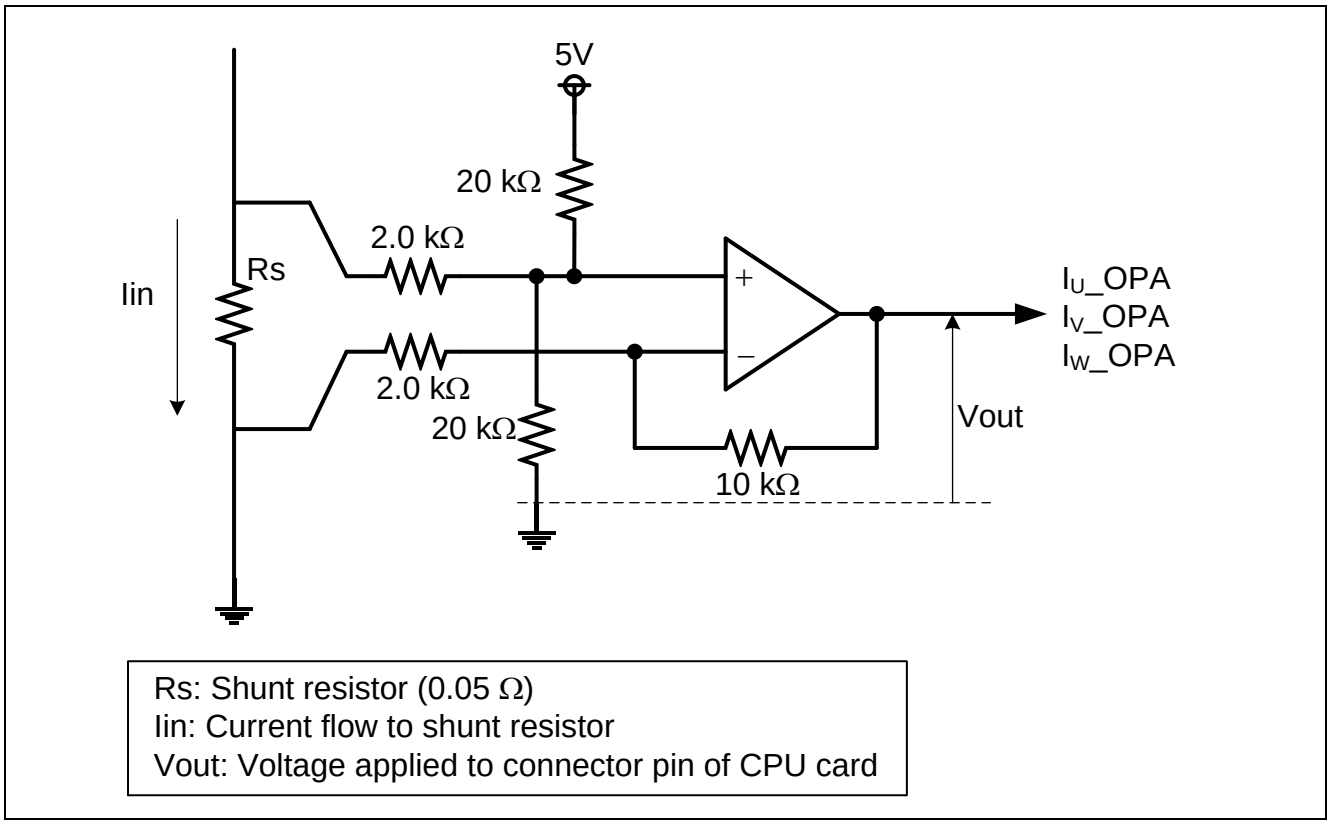


Figure 6.3 Current Detection Circuit

Table 6.1 Relationship between Current Flow to Shunt Resistor and Voltage Input to CPU Card

Iin [A]	Vout [V]
10	5
2	3
0	2.5
−2	2
−10	0

There is also a circuit on the inverter board that inputs the shunt current to the microcontroller, bypassing the op-amp. If required for your application, you can use it by shorting the appropriate jumper pins on the INV-BRD.

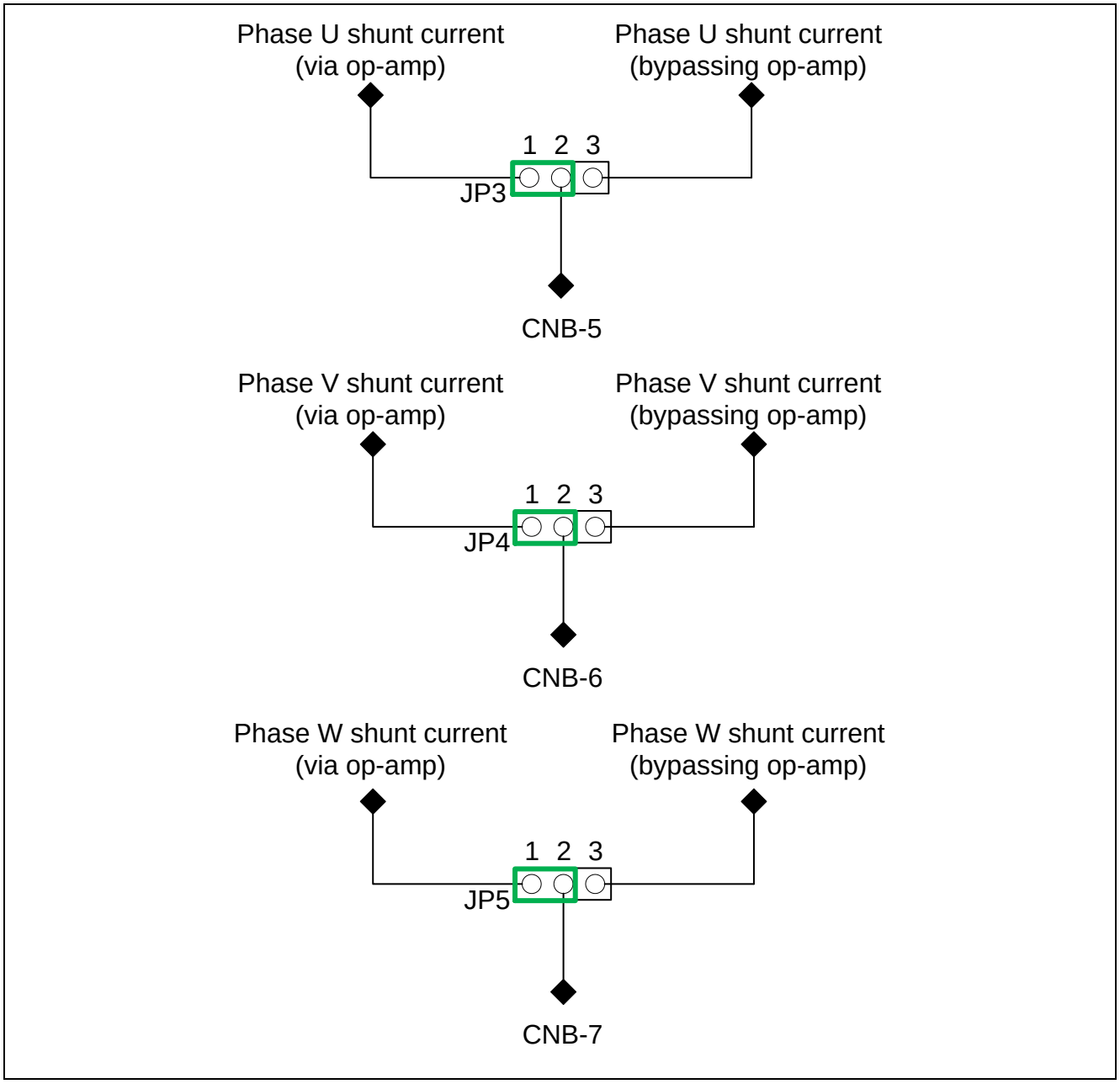


Figure 6.4 Jumper Pins for Selecting Whether or Not Op-Amp Is Used

6.1.3.3 Overcurrent Detection Circuit

Figure 6.5, below, shows the overcurrent detection circuit used to detect overcurrent in the shunt currents of the U, V, and W phases. The overcurrent detection circuit judges that an overcurrent state has occurred when any among the U, V, and W phase currents exceeds the threshold.

The threshold is determined by variable resistor VR2, which is initially turned all the way clockwise. Adjust the threshold setting to match your application by turning VR2.

OC is high-level when the current values are all within the threshold range, and it goes low-level when an overcurrent is detected. Therefore, you can protect the board and the motor by monitoring the OC pin and forcing the timer output pin into the Hi-Z state when OC is low.

The overcurrent detection circuit does not provide direct protection of the board and the motor. It is necessary to perform appropriate processing on the microcontroller, etc., to provide protection. Note that the default software initially programmed on the CPU board already implements this processing.

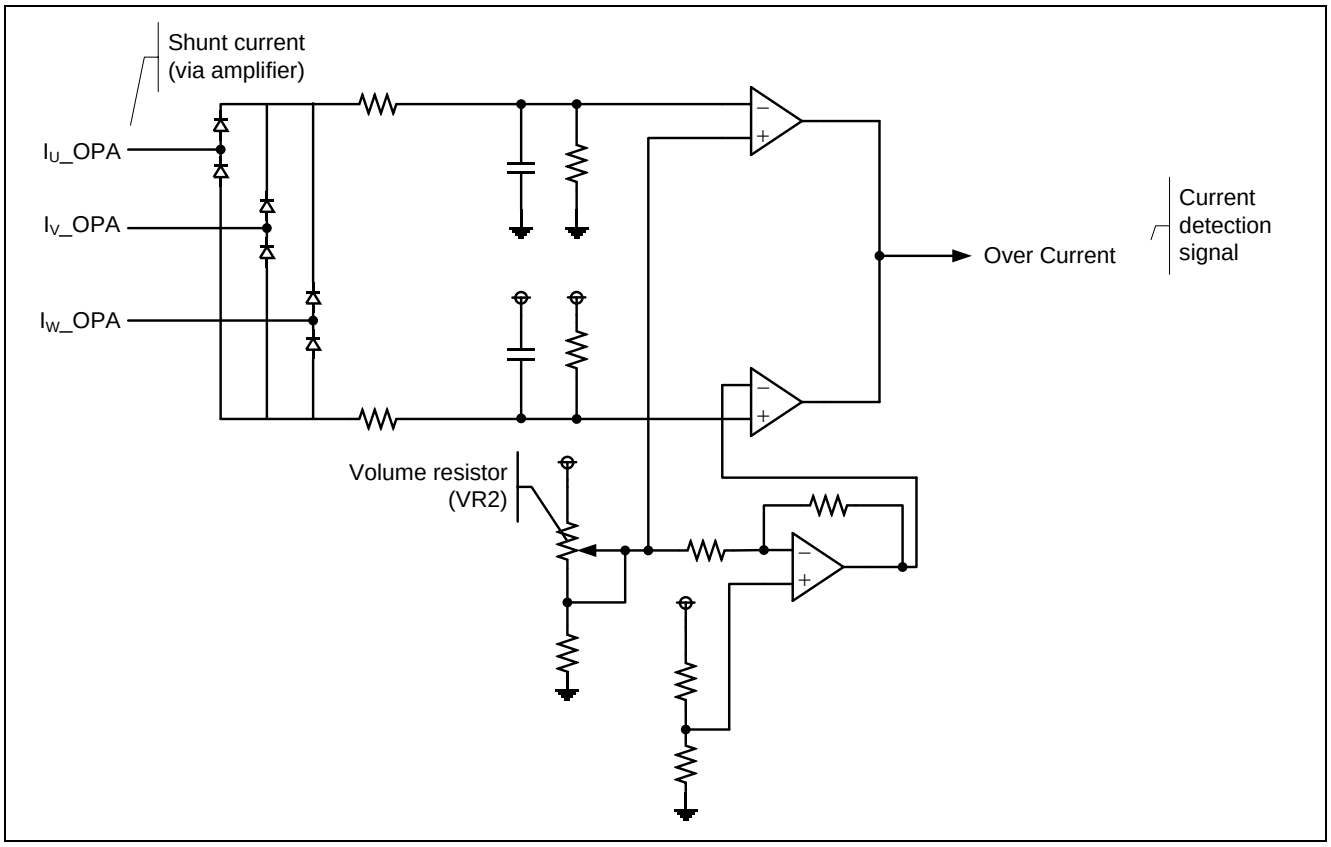


Figure 6.5 Overcurrent Detection Circuit

Table 6.2 Relationship Between Variable Resistor Setting and Overcurrent Detection Current Value (Reference Values)

Variable Resistor Value [Ω]	Overcurrent Detection Current Value [A]
0 (turned all the way clockwise)	±12
10 k (turned all the way counterclockwise)	±2

6.1.3.4 Output Voltage Detection Circuits

The INV-BRD has circuits that input, via a resistive voltage divider, the bus voltage and three phase voltages (U phase, V phase, and W phase) to the AC pins of the microcontroller. The relationship between the three phase voltages, bus voltage, and detection voltage is expressed by the following equation (2):

$$\mathrm{Vout}[V] = \frac{470}{10 \times 10^3 + 470} \times Vin[V] \quad (2)$$

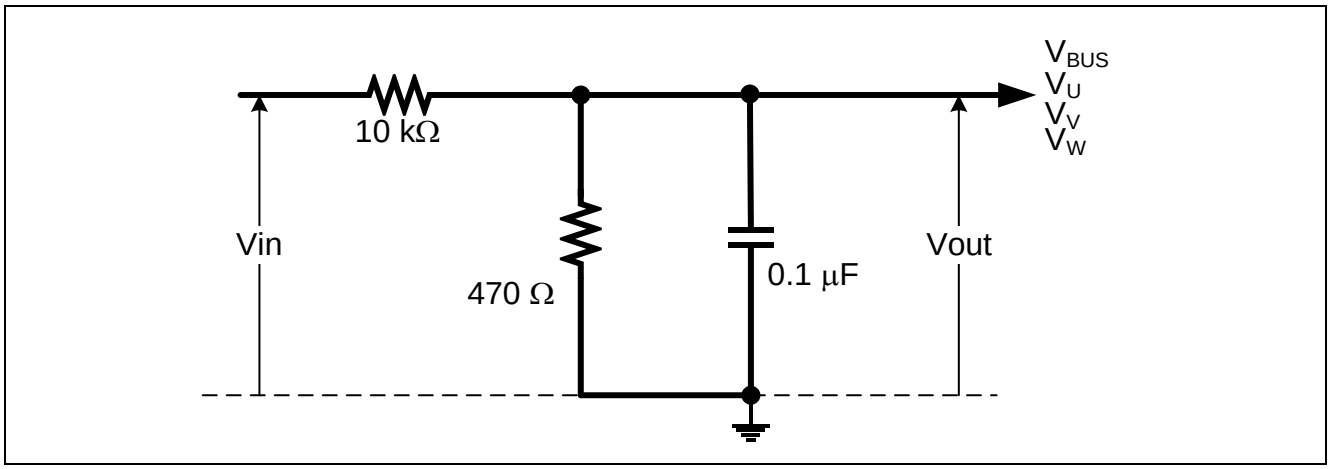


Figure 6.6 Output Voltage Detection Circuit

6.1.3.5 Voltage Generator Circuit

The INV-BRD generates voltages of 15 V, 5 V, and 3.3 V from the main power supply (24 V).

Table 6.3 Voltage Generator Circuit

Item	Input Voltage (Typ.) [V]	Output Voltage (Typ.) [V]	Output Current (Max.) [A]	Application
15 V generation	24	15	1.5	• 5 V generation • Gate driver IC
5 V generation	15	5	1.5	• MCU power supply • 3.3 V generation
3.3 V generation	5	3.3	1	MCU power supply*1

Note 1. Not used by the RX23T CPU card, which operates on a 5 V power supply.

6.1.3.6 External AD Input Function

The INV-BRD supports input of user-specified analog information to the microcontroller via an RC filter circuit.

Table 6.4 External AD Input Voltage Range

Item	Specification
Input Voltage Range [V]	0 to AVCC

6.1.3.7 Inverter Control Circuit Block Current Cutoff Function

The INV-BRD is equipped with a toggle switch (S1) to cut off current flow to the inverter. Should an abnormal condition (abnormal odor, smoke, abnormal sounds, overheating, etc.) occur, flip S1 to the OFF position to cut off current flow to the inverter.

6.1.3.8 LEDs

The INV-BRD has three LEDs mounted on it. You can control the LEDs from the microcontroller. LED1 and LED2 are synchronized with LED1 and LED2 on the RX23T-CRD.

Table 6.5 LEDs

Pins Corresponding to CPU Card Connector		LED1	LED2	LED3	Ports Corresponding to RX23T
CNA-1	Hi	Off	—	—	P00
	Low	On	—	—	
CNA-2	Hi	—	Off	—	P01
	Low	—	On	—	
CNA-3	Hi	—	—	Off	P31
	Low	—	—	On	

6.1.3.9 Toggle Switches

The INV-BRD has two toggle switches (SW1 and SW2) mounted on it. These are connected to the CPU card. You can make use of these switches as you like.

Table 6.6 Toggle Switches

		CPU Card connector	
		CNA-13 (P91)	**CNA14** (P92)
Toggle Switches			
SW1	ON	Low	—
	OFF	Hi	—
SW2	ON	—	Low
	OFF	—	Hi

6.1.3.10 Variable Resistor

The INV-BRD has a variable resistor (VR1) mounted on it. You can make use of these switches as you like.

Table 6.7 Variable Resistor Specifications

Item	Specification
Input voltage range	0 to AVCC
Variable resistor range	0 to 10 kΩ

6.2 RX23T CPU Card

6.2.1 Features

1. Populated with RX23T 32-bit microcontroller suitable for inverter control.
2. CPU card designed specifically for use with the product.
3. Supports programming of software in flash memory using the E1 emulator.
4. Equipped with Hall sensor input connector and encoder input connector.
5. Equipped with SCI connector (enabling use of the Support Tool.)

6.2.2 Layout

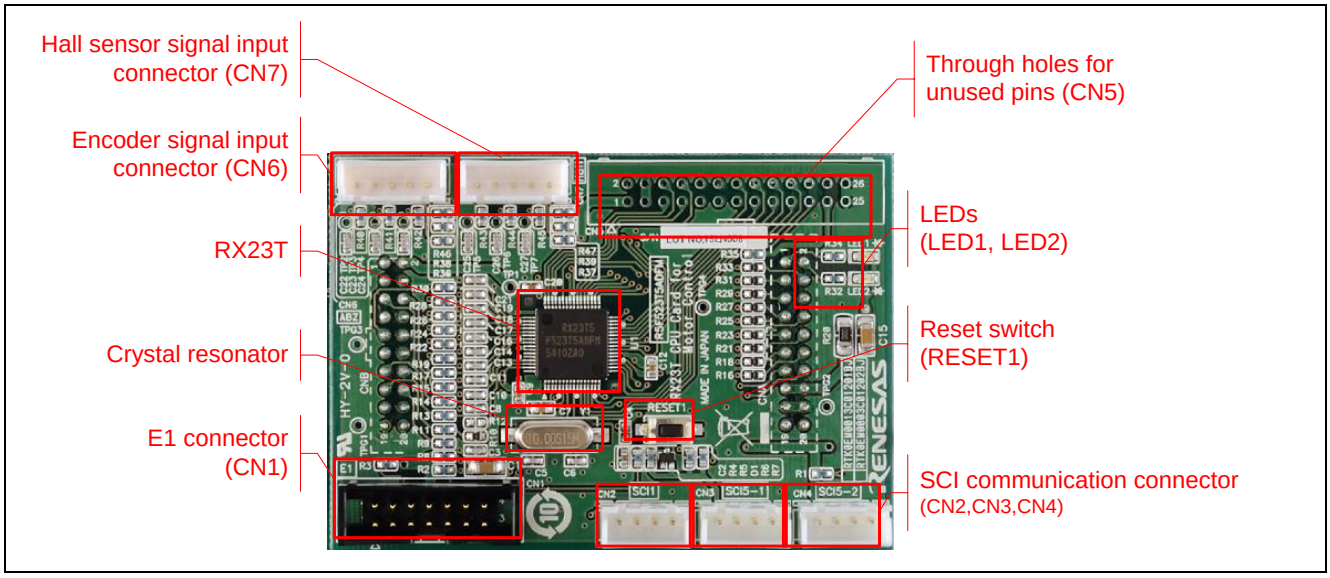


Figure 6.7 RX23T CPU Card Layout (Top View)

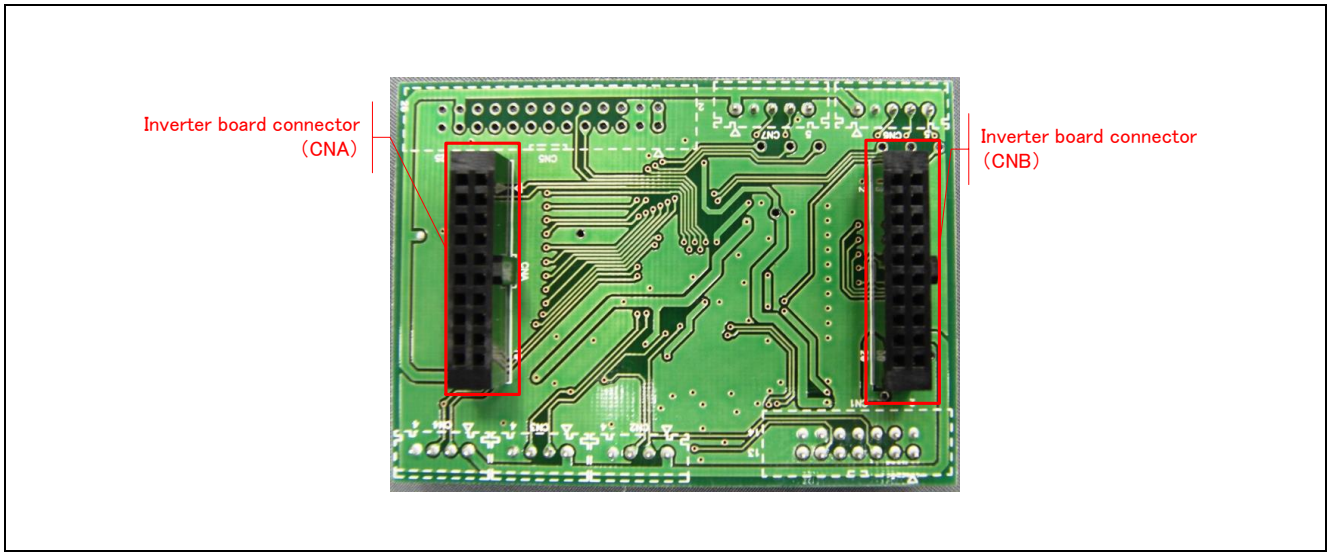


Figure 6.8 RX23T CPU Card Layout (Bottom View)

6.2.3 Functions

6.2.3.1 Power Supply

The RX23T-CRD does not have a dedicated power supply connector. When connected to the INV-BRD it draws power via the connector. When not connected to the INV-BRD, it can draw power via the E1 connector. The RX23T-CRD is not allowed to draw power via the E1 connector when it is connected to the INV-BRD.

6.2.3.2 Connecting the E1 Emulator

The E1 on-chip debugging emulator from Renesas Electronics is used to write software (program) to the flash memory of the RX23T. Software will be downloaded into the product via E1 emulator. It is also necessary to make the settings shown in Table 6.8 in the integrated development environment to enable the emulator to supply power to the product. Table 6.9 lists the pin assignments of the E1 connector.

Table 6.8 E1 Emulator Power Supply Settings

Connection to INV-BRD	RX23T Connection Pins
Connected	Power supply not allowed*1
Not connected	5 V power supply

Note 1. When connected to the INV-BRD, the product must draw power from the INV-BRD.

Table 6.9 E1 Connector Pin Assignments (CN1)

E1 Connector Pin No.	Pin Function	RX23T Connection Pins	E1 Connector Pin No.	Pin Function	RX23T Connection Pins
1	NC	—	2	GND	VSS
3	NC	—	4	NC	—
5	TXD	PD3/TXD1	6	NC	—
7	MD/FINED	MD/FINED	8	VCC	VCC
9	NC	—	10	NC	—
11	RXD	PD5/RXD1	12	GND	VSS
13	RESET	RES#	14	GND	VSS

Note: See r20ut0399ej0801_e1e20_rx.pdf, a supplement to the E1/E20 emulator user's manual.

6.2.3.3 Connecting the Inverter Board

The RX23T-CRD connects to the INV-BRD via the inverter board connectors (CNA and CNB). The pin assignments of the inverter connectors are listed below.

Table 6.10 Pin Assignments of Inverter Connector (CNA)

Pin No.	Pin Function	RX23T Connection Pins	Pin No.	Pin Function	RX23T Connection Pins
1	#LED1	P00	2	#LED2	P01
3	PFC_G1	P31	4	VRL	PB4
5	#FO1	P70/POE0#	6	NC	—
7	WN1	P76/MTIOC4D	8	VN1	P75/MTIOC4C
9	UN1	P74/MTIOC3D	10	WP1	P73/MTIOC4B
11	VP1	P72/MTIOC4A	12	UP1	P71/MTIOC3B
13	#SW1	P91	14	#SW2	P92
15	5V	VCC	16	5V	VCC
17	GND	VSS	18	GND	VSS
19	3.3V	—	20	3.3V	—

Table 6.11 Pin Assignments of Inverter Connector (CNB)

Pin No.	Pin Function	RX23T Connection Pins	Pin No.	Pin Function	RX23T Connection Pins
1	AVCC	AVCC	2	AVCC	AVCC
3	NC	—	4	NC	—
5	IU1	P40/AN000	6	IV1	P41/AN001
7	IW1	P42/AN002	8	VPN	P43/AN003
9	TEMP1	P47/AN007	10	VU1	P44/AN004
11	VV1	P45/AN005	12	VW1	P46/AN006
13	VAC	P11/AN016	14	IPFC	P10/AN017*1
15	VR1	P10/AN017*1	16	RSVIN1	—
17	VCCIO	VCC	18	VCCIO	VCC
19	GND	VSS	20	GND	VSS

Note 1. P10/AN017: Selectable between IPFC and VR1 (default: VR1).

6.2.3.4 Connecting the SCI

The RX23T-CRD communicates with the SCI via the SCI connectors. The pin assignments of the SCI connectors are listed below.

Table 6.12 Pin Assignments of SCI Connectors CN2, CN3, and CN4

Connector No.	Pin No.	Pin Function	RX23T Connection Pins
CN2 SCI1*1	1	5V	VCC
	2	RX23T transmit side	PD3/TXD1
	3	RX23T receive side	PD5/RXD1
	4	GND	VSS
CN3 SCI5-1	1	5V	VCC
	2	RX23T transmit side	PB5/TXD5
	3	RX23T receive side	PB6/RXD5
	4	GND	VSS
CN4 SCI5-2	1	5V	VCC
	2	RX23T transmit side	PB2/TXD5
	3	RX23T receive side	PB1/RXD5
	4	GND	VSS

Note 1. The SCI1 TXD and RXD pins are also used by E1, so it is not possible to use CN2 when the product is connected to the E1 connector.

6.2.3.5 Hall Sensor Signal Input

The Product is equipped with a Hall sensor signal input connector. Using this connector it is possible to input the Hall sensor signal from the motor supplied with the product directly to the RX23T-CRD. The signal input to RX23T-CRD is pulled up to 5 V and passed through an RC filter before being input to the RX23T. Table 6.13 lists the pin assignments of the Hall sensor signal input connector, and Table 6.14 lists connector information.

Table 6.13 Pin Assignments of Hall Sensor Signal Input Connector (CN7)

Pin No.	Pin Function	RX23T Connection Pins
1	5V	VCC
2	GND	VSS
3	HU	P93/IRQ0
4	HV	P94/IRQ1
5	HW	PA2/IRQ4

Table 6.14 Hall Sensor Signal Input Connector Information

Part	Product No.	Manufacturer
Connector	XHP-5	J.S.T. Mfg. Co. Ltd. (JST)

6.2.3.6 Encoder Signal Input

The RX23T-CRD is equipped with an encoder signal input connector. This makes it possible to input the encoder signal to the RX23T. The signal input to the RX23T-CRD is pulled up to 5 V and passed through an RC filter before being input to the RX23T. Table 6.15 lists the pin assignments of the signal input connector, and Table 6.16 lists connector information.

Table 6.15 Pin Assignments of Encoder Signal Input Connector

Pin No.	Pin Function	RX23T Connection Pins
1	5V	VCC
2	GND	VSS
3	A phase	P33/MTCLKA
4	B phase	P32/MTCLKB
5	Z phase	PA5

Table 6.16 Encoder Signal Input Connector Information

Part	Product No.	Manufacturer
Connector	XHP-5	J.S.T. Mfg. Co. Ltd. (JST)

6.2.3.7 Extension of Unused Pins

To facilitate general use of the RX23T-CRD, the unused pins of the RX23T are extended through universal connector through holes in the board. Table 6.17 lists the pin assignments of the universal connector through holes.

Table 6.17 Pin Assignments of CN5

Pin No.	RX23T Connection Pins	Pin No.	RX23T Connection Pins
1	AVCC	2	AVCC
3	GND	4	GND
5	P22	6	P23
7	P24	8	P30
9	PA4	10	P02
11	NC	12	NC
13	NC	14	PA3
15	PB0	16	PB3
17	PB7	18	PD4
19	PD6	20	PD7
21	PE2	22	NC
23	UVCC	24	UVCC
25	GND	26	GND

6.2.3.8 Reset Circuit

The RX23T-CRD is equipped with a reset circuit for resetting the microcontroller at power-on and by means of external reset. To apply an external reset to the microcontroller, press the pushbutton (RESET1).

6.2.3.9 Crystal Resonator

The microcontroller mounted on the RX23T-CRD is connected to a 10 MHz crystal resonator.

6.2.3.10 LEDs

Two LEDs are mounted on the CPU card for use in debugging programs and general system applications. Each turns on when the output on the corresponding port is low-level and turns off when the output is high-level. LED1 and LED2 are synchronized with LED1 and LED2 on the INV-BRD.

Table 6.18 RX23T CPU Card LED Connection Pin Assignments

Corresponding RX23T Pin Port		LED1	LED2
P00	High-level output	Off	—
	Low-level output	On	—
P01	High-level output	—	Off
	Low-level output	—	On

6.2.4 List of RX23T Pin Functions

Table 6.19 List of RX23T Pin Functions

Pin No.	Port	Function
1	P02/CTS1#/RTS1#/SS1#/ADST0/IRQ5	—
2	P00/IRQ2	LED1
3	VCL	Connects to capacitor for stabilizing external voltage
4	P01/CACREF/IRQ4	LED2
5	MD/FINED	E1 emulator connector
6	RES#	E1 emulator connector, reset
7	XTAL	Crystal resonator
8	VSS	GND
9	EXTAL	Crystal resonator
10	VCC	Vcc
11	PE2/POE10#/NMI	—
12	PD7/TMRI1/SSLA1	—
13	PD6/TMO1/SSLA0/CTS1#/RTS1#/SS1#/ADST0/IRQ5	—
14	PD5/TMRI0/RXD1/SMISO1/SSCL1/IRQ3	E1 emulator connector
15	PD4/TMCI0/SCK1/IRQ2	—
16	PD3/TMO0/TXD1/SMOSI1/SSDA1	E1 emulator connector
17	PB7/SCK5	—
18	PB6/RXD5/SMISO5/SSCL5/IRQ5	—
19	PB5/TXD5/SMOSI5/SSDA5	—
20	VCC	Vcc
21	PB4/POE8#/IRQ3	—
22	VSS	GND
23	PB3/MTIOC0A/CACREF/SCK5/RSPCKA	—
24	PB2/MTIOC0B/ADSM0/TXD5/SMOSI5/SSDA5/SDA0	Communication port
25	PB1/MTIOC0C/RXD5/SMISO5/SSCL5/SCL0/IRQ2	Communication port
26	PB0/MTIOC0D/MOSIA	—
27	PA3/MTIOC2A/SSLA0	—
28	PA2/MTIOC2B/CTS5#/RTS5#/SS5#/SSLA1/IRQ4	Hall sensor W
29	P94/MTIOC0C/TMO1/MISOA/IRQ1	Hall sensor V
30	P93/MTIOC0B/TMRI1/SCK5/RSPCKA/IRQ0	Hall sensor U
31	P92/TMCI1/SSLA2	Toggle switch SW2
32	P91/SSLA3	Toggle switch SW1
33	P76/MTIOC4D	W – phase PWM output
34	P75/MTIOC4C	V – phase PWM output
35	P74/MTIOC3D	U – phase PWM output
36	P73/MTIOC4B	W + phase PWM output
37	P72/MTIOC4A	V + phase PWM output
38	P71/MTIOC3B	U + phase PWM output
39	P70/POE0#/IRQ5	Overcurrent detection signal (OC)
40	P33/MTIOC3A/MTCLKA/SSLA3	Encoder A
41	P32/MTIOC3C/MTCLKB/SSLA2	Encoder B
42	VCC	Vcc
43	P31/MTIOC0A/MTCLKC/SSLA1	LED3
44	VSS	GND
45	P30/MTIOC0B/MTCLKD/SSLA0	—

Pin No.	Port	Function
46	P24/MTIC5U/TMCI2 RSPCKA/COMP0/IRQ3	—
47	P23/MTIC5V/CACREF/TMO2/MOSIA/COMP1/IRQ4	—
48	P22/MTIC5W/TMRI2/MISOA/COMP2/IRQ2	—
49	P47/AN007/CMPC12/CMPC22	General-purpose A/D input CN4
50	P46/AN006/CMPC02	Phase W voltage
51	P45/AN005/CMPC21	Phase V voltage
52	P44/AN004/CMPC11	Phase U voltage
53	P43/AN003/CMPC01	DC voltage
54	P42/AN002/CMPC20	Phase W shunt current (selection of op-amp use/bypass)
55	P41/AN001/CMPC10	Phase V shunt current (selection of op-amp use/bypass)
56	P40/AN000/CMPC00	Phase U shunt current (selection of op-amp use/bypass)
57	AVCC0	V_{CC}
58	VREFH0	V_{CC}
59	VREFL0	GND
60	AVSS0	GND
61	P11/MTIOC3A/MTCLKC/TMO3/IRQ1/AN016/CVREFC0	—
62	P10/MTCLKD/TMRI3/IRQ0/AN017/CVREFC1	Variable resistor VR1
63	PA5/MTIOC1A/TMCI3/MISOA	Encoder Z
64	PA4/MTIOC1B/RSPCKA/ADTRG0#	—

7. Usage Notes

Important points to observe when using the product are listed below:

- To ensure that the frame ground (FG) of the product functions effectively, mount metal feet on the four corners of the inverter board.
- Some of the unused pins of the product have not been processed in any way. Make sure to process these pins as appropriate for the application.

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Revision History

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	Mar. 31, 2016	-	First edition issued
1.10	Apr. 5, 2017	3	Add the item about cautions (Static Electricity and Ferrite core)
		11	Add the information about CE Certification
		14	Add the sentence about caution (Use the antistatic band)
		17	Add the sentence and information about using the ferrite core
		-	Chang the tool name BEFORE: Motor RSSK Support Tool AFTER: Motor Control Development Support Tool "Renesas Motor Workbench" or abbreviation (Support Tool)
		4	Add "Support Tool" to the abbreviation
		4	Chang the document number BEFORE: R20UT3740EJ AFTER: R21UZ0004EJ
		31	Correct Table 6.5) Connection port of CNA-3: P02 -> P31
1.20	Feb. 15, 2019	14	Add description
		21	Correct Table 5.2
		34	Correct Table 6.11
		35	Correct Table 6.12

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   除非是瑞萨电子数据表或其他瑞萨电子文档中明确指定为高可靠性产品或用于恶劣环境的产品，否则瑞萨电子产品不能用于、亦未授权用于可能对人类生命造成直接威胁的产品或系统及可能造成人身伤害的产品或系统（人工生命维持装置或系统、植埋于体内的装置等）中，或者可能造成重大财产损失的产品或系统（太空系统、海底增音机、核能控制系统、飞机控制系统、关键装置系统、军用设备等）中。对于用户或任何第三方因使用不符合瑞萨电子数据表、使用说明书或其他瑞萨电子文档的瑞萨电子产品而遭受的任何损害或损失，瑞萨电子概不承担任何责任。
6. 使用瑞萨电子产品时，请参阅最新产品信息（数据表、使用说明书、应用指南、可靠性手册中的“半导体元件处理和使用一般注意事项”等），并确保使用条件在瑞萨电子指定的最大额定值、电源工作电压范围、散热特性、安装条件等范围内使用。对于在上述指定范围之外使用瑞萨电子产品而产生的任何故障、失效或事故，瑞萨电子概不承担任何责任。
7. 虽然瑞萨电子一直致力于提高瑞萨电子产品的质量和可靠性，但是，半导体产品有其自身的具体特性，如一定的故障发生率以及在某些使用条件下会发生故障等。除非是瑞萨电子数据表或其他瑞萨电子文档中指定为高可靠性产品或用于恶劣环境的产品，否则瑞萨电子产品未进行防辐射设计。用户负责执行安全保护措施，以避免因瑞萨电子产品失效或发生故障而造成身体伤害、火灾导致伤害或损害和/或其他对公众构成危险的事故。例如进行软硬件安全设计（包括但不限于冗余设计、防火控制以及故障预防等）、适当的老化处理或其他适当的措施等。由于对微机软件单独进行评估非常困难且不实际，所以请用户自行负责对最终产品或系统进行安全评估。
8. 关于环境保护方面的详细内容，例如每种瑞萨电子产品的环境兼容性等，请与瑞萨电子的营业部门联系。用户负责仔细并充分查阅对管制物质的使用或含量进行管理的所有适用法律法规（包括但不限于《欧盟RoHS指令》），并在使用瑞萨电子产品时遵守所有适用法律法规。对于因用户未遵守相应法律法规而导致的损害或损失，瑞萨电子概不承担任何责任。
9. 不可将瑞萨电子产品和技术用于或者嵌入日本国内或海外相应的法律法规所禁止生产、使用及销售的任何产品或系统中。也不可将瑞萨电子产品或技术用于(1)与大规模杀伤性武器（例如核武器、化学武器、生物武器或运送此等武器的导弹，包括无人机(UAV)）的开发、设计、制造、使用、存储等相关的任何目的；(2)与常规武器的开发、设计、制造或使用相关的任何目的；(3)扰乱国际和平与安全的任何其他目的，并且不可向任何第三方销售、出口、租赁、转让、或让与瑞萨电子产品或技术，无论直接或间接知悉或者有理由知悉该第三方或任何其他方将从事上述活动。用户必须遵守对各方或交易行使司法管辖权的任意国家/地区政府所公布和管理的任何适用出口管制法律法规。
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（注1） 瑞萨电子：在本文档中指瑞萨电子株式会社及其控股子公司。
（注2） 瑞萨电子产品：指瑞萨电子开发或生产的任何产品。

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