

# MCI-LV-1 User's Manual

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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

MCI-LV-1 is a inverter board kit for motor control evaluation. By using this product in combination with CPU board, motor control can be performed easily.

MCI-LV-1 has characteristics shown below.

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

## 2. Product Contents

This kit consists of the following parts.

1. Inverter Board (RTK0EM0000B12020BJ) x1
2. Brushless DC Motor (R42BLD30L3) x1
3. Screw x4
4. Standoff x4

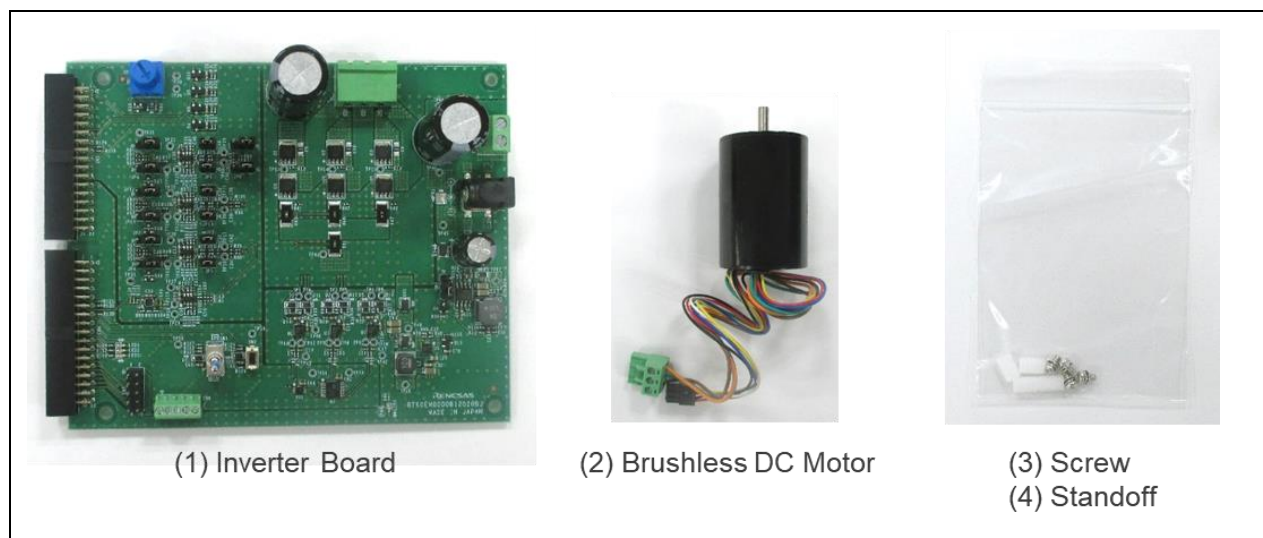


Figure 2-1 Product contents

## 3. Product Order Information

Product No. to order MCI-LV-1 : RTK0EM0000S04020BJ

## 4. Hardware Configuration and Default Setting

### 4.1 Hardware configuration

MCI-LV-1 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 MCI-LV-1 specification (1/2)

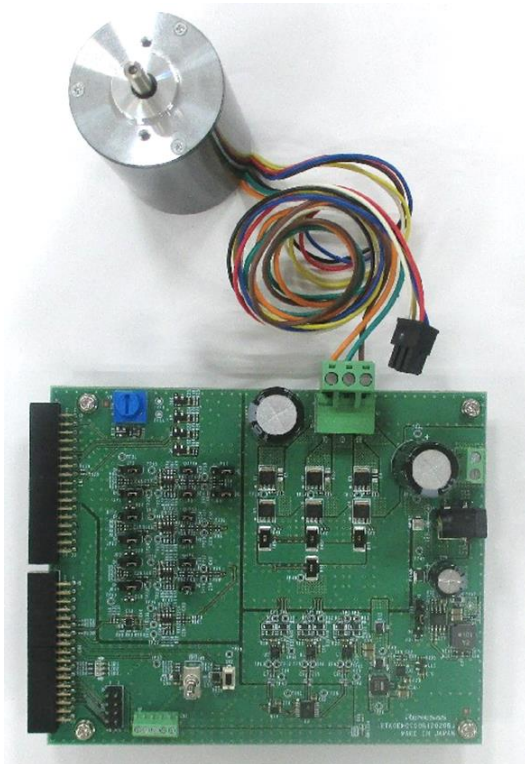

Item	Specification	
Product name	MCI-LV-1	
Kit product No.	RTK0EM0000S04020BJ	
Kit configuration	Inverter Board	RTK0EM0000B12020BJ
	Brushless DC Motor	R42BLD30L3 (MOONS') Rated voltage : 36[V] Rated current : 1.67[A]
External view	 <p>Note: The actual product may differ from this photo.</p>	
Board size	Inverter board : 133 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	



Table 4-2 MCI-LV-1 specification (2/2)

Item	Specification
Product name	Inverter board
Board product No.	RTK0EM0000B12020BJ
External view	 <p>Note: The actual product may differ from this photo.</p>
Power supply	2 ways <ul style="list-style-type: none"> <li>From DC jack or Power supply connector (DC 12~48V) *1</li> <li>From CPU board (DC 5V)</li> </ul>
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	<ul style="list-style-type: none"> <li>CPU card connector</li> <li>Motor connector</li> <li>Power input connector</li> <li>HALL sensor connector</li> <li>Encoder/Inductive position sensor connector</li> </ul>
Switch	<ul style="list-style-type: none"> <li>Toggle switch x1</li> <li>Push switch x1</li> </ul>
LED	<ul style="list-style-type: none"> <li>LED x3</li> <li>Power LED</li> </ul>

\*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.

## 4.2 Block diagram

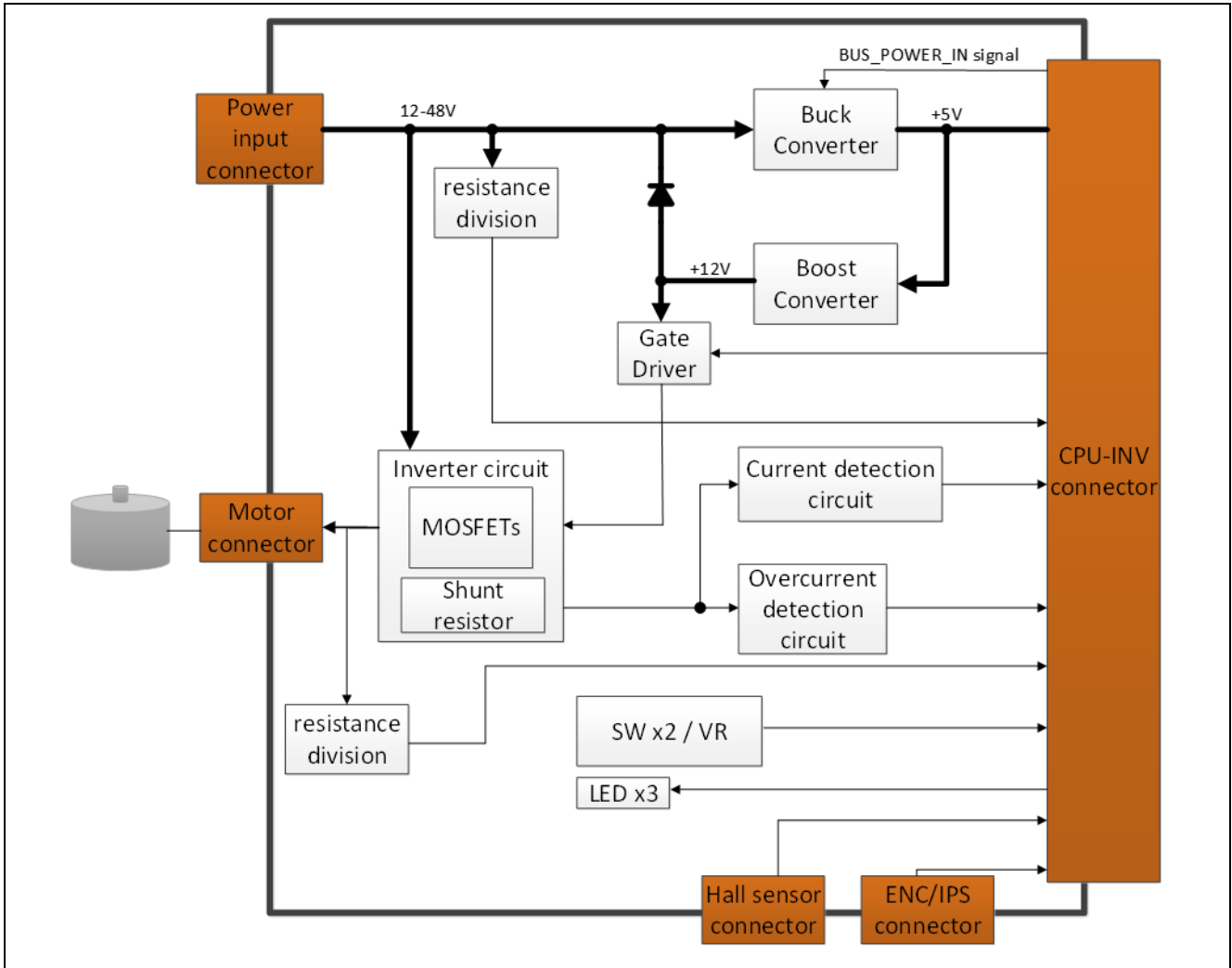


Figure 4-1 Block Diagram of Inverter Board

### 4.3 Board Layout

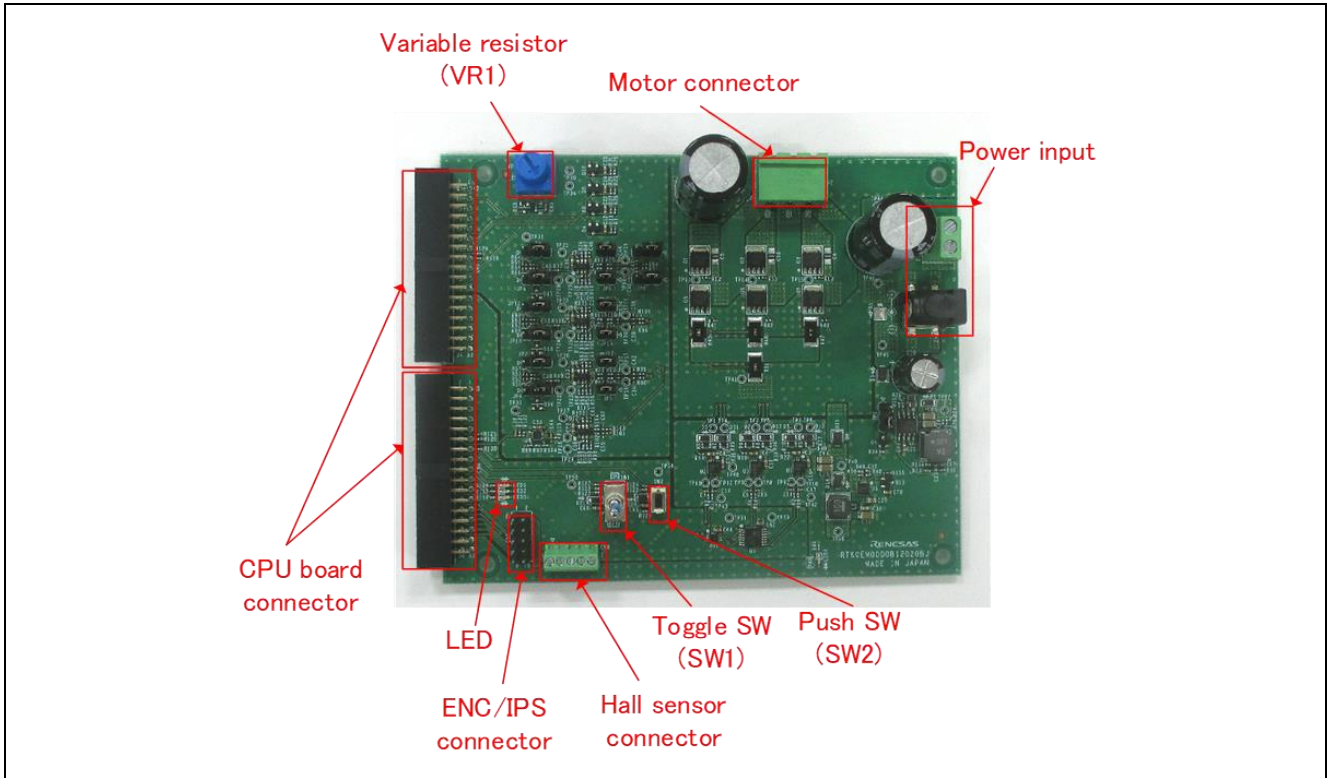


Figure 4-2 Inverter Board Layout

### 4.4 Standoffs and Screws

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

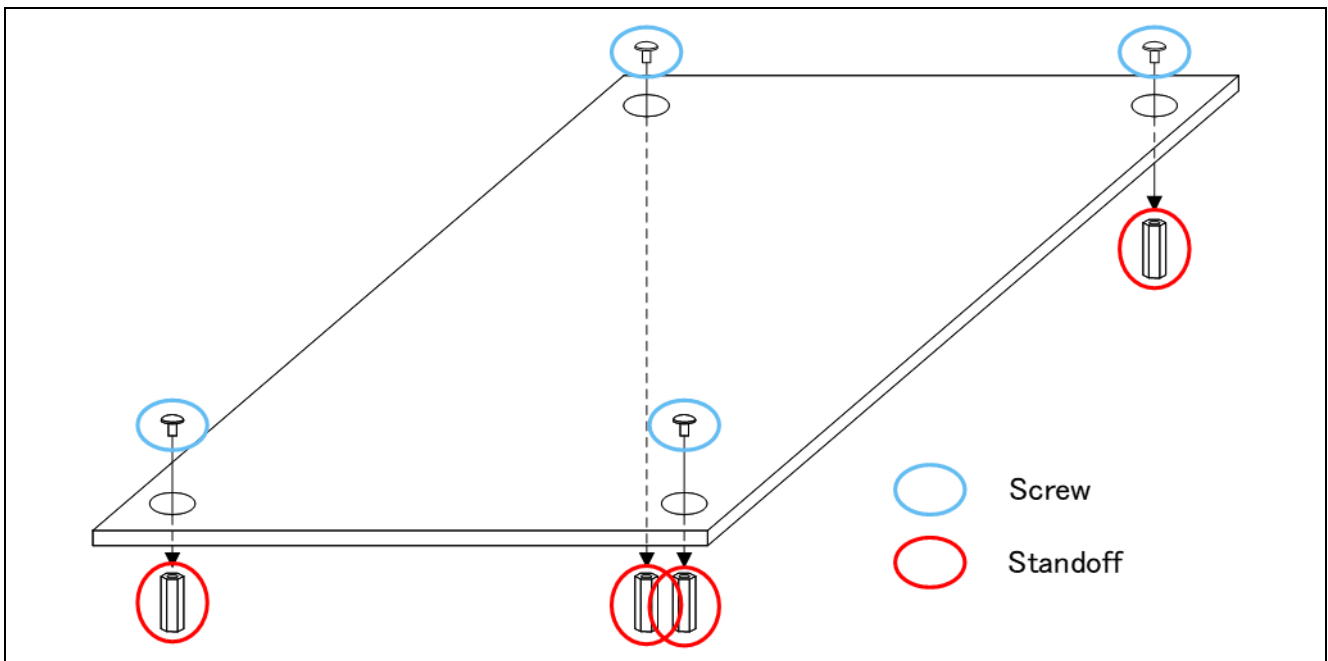


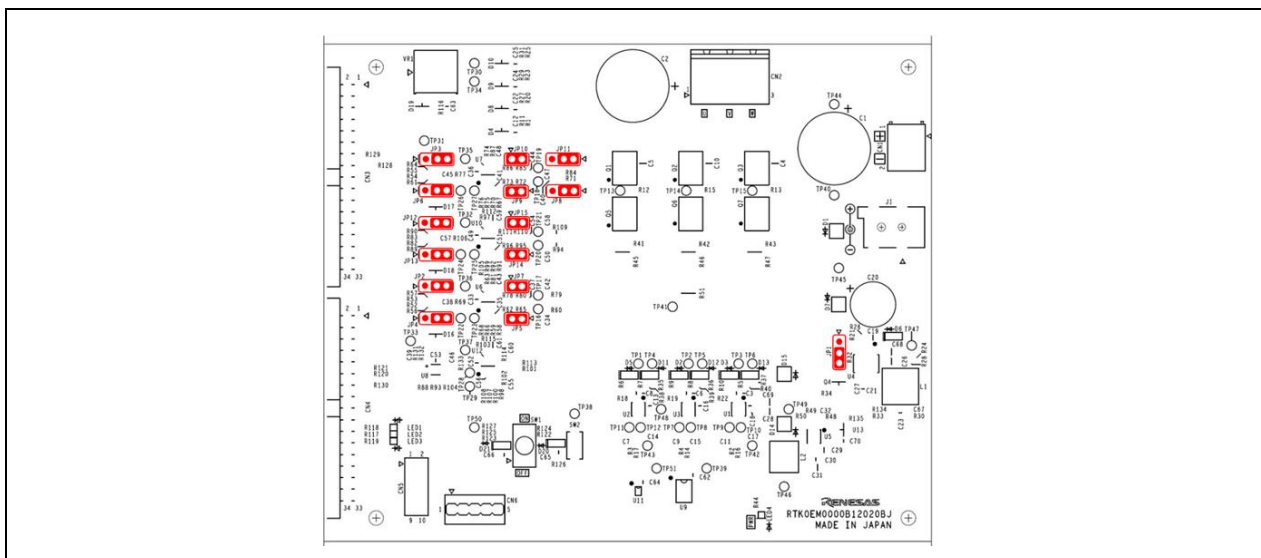
Figure 4-3 Standoffs and Screws assembly

### 4.5 Jumper pin setting

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

**Table 4-3 Jumper pin setting**

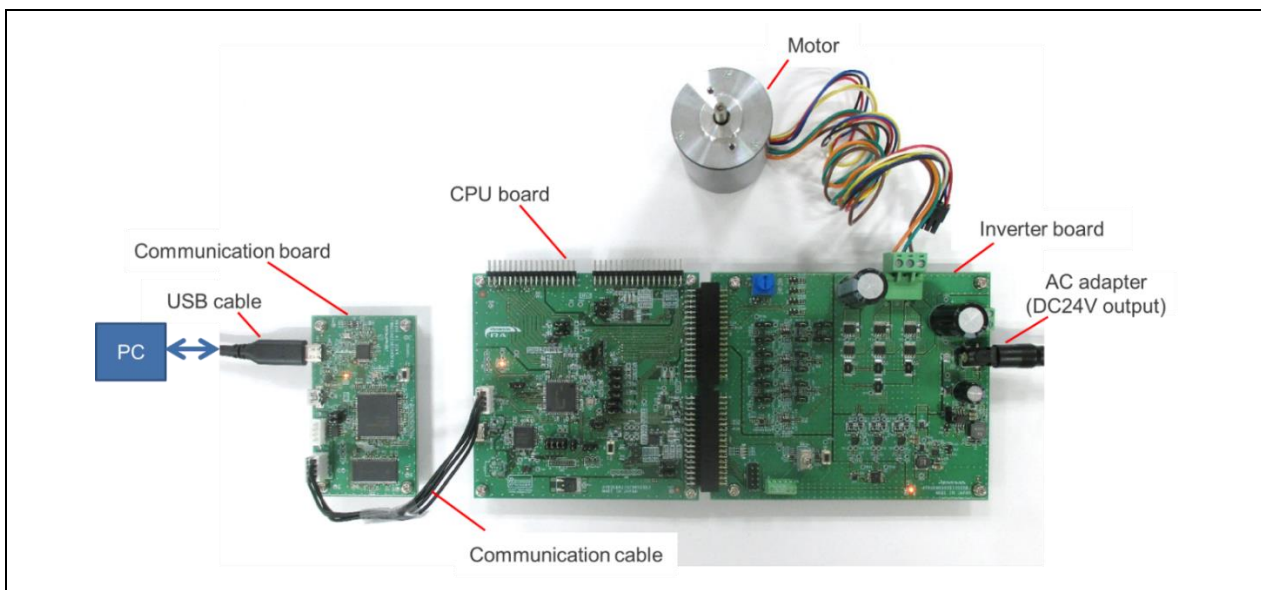
Jumper pin	Default setting	Function
JP1	2-3pin short	1-2pin short : Disable 5V regulator 2-3pin short : Enable 5V regulator
JP2, JP3, JP4, JP6, JP12, JP13	2-3pin short	1-2pin short : Disable current detection amplifiers 2-3pin short : Enable current detection amplifiers
JP5, JP7, JP9, JP10, JP14, JP15	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 4-4 Default jumper pin setting**

### 4.6 Connection Example

Figure 4-5 shows a connection example when using this product in combination with a Renesas CPU board and a communication board (MC-COM, P/N: RTK0EMXC90S0000BJ).



**Figure 4-5 Connection Example**

## 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.

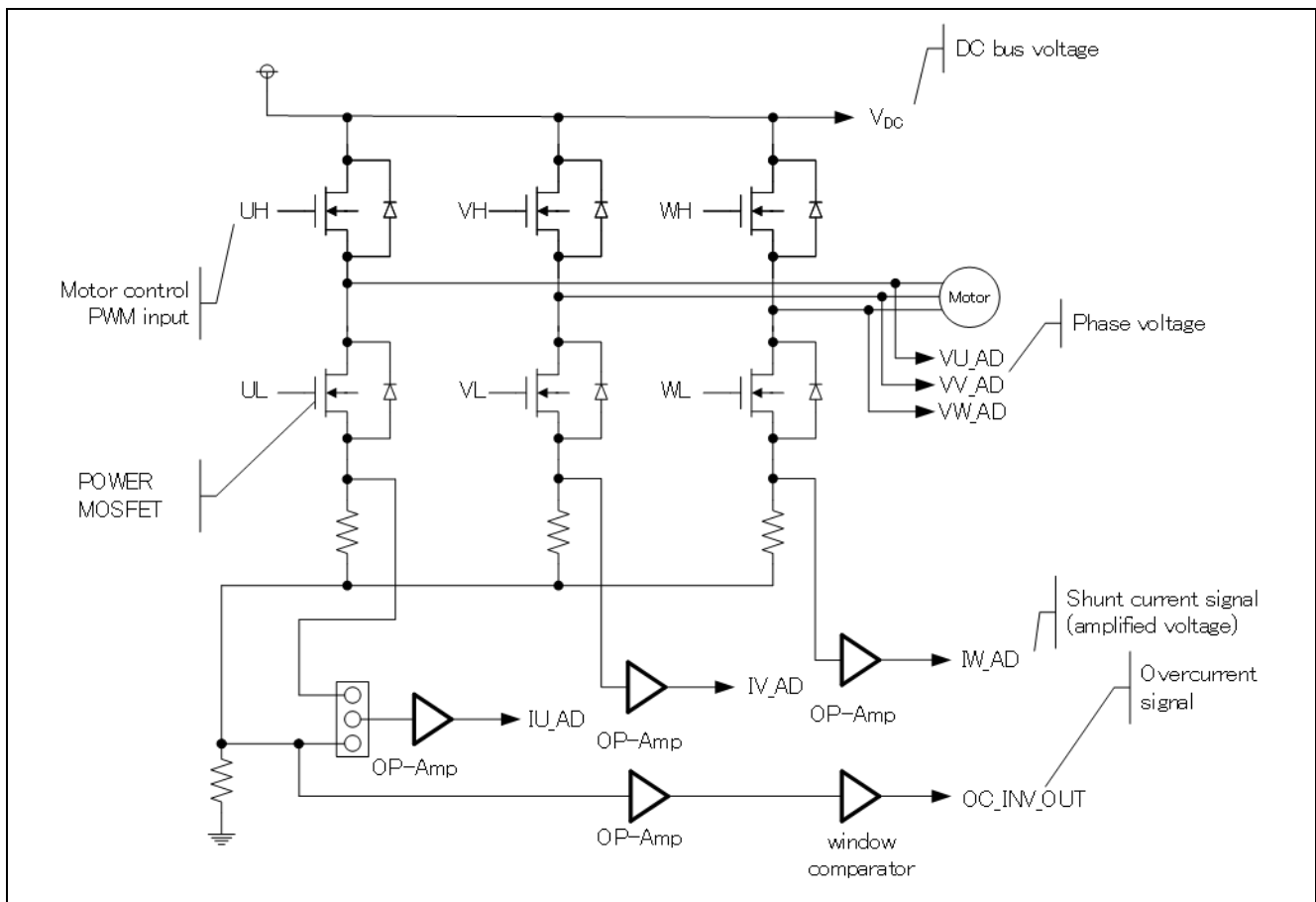


Figure 5-1 Illustration of inverter control circuit block

### 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  $I_{in}$  flowing through the shunt resistor and the voltage  $V_{out}$  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.

$$\text{Amplifier gain 10x : } V_{out}[V] = I_{in}[A] \times R_s[\Omega] \times 10 + AVCC/2 \quad (1)$$

$$\text{Amplifier gain 20x : } V_{out}[V] = I_{in}[A] \times R_s[\Omega] \times 20 + AVCC/2 \quad (2)$$

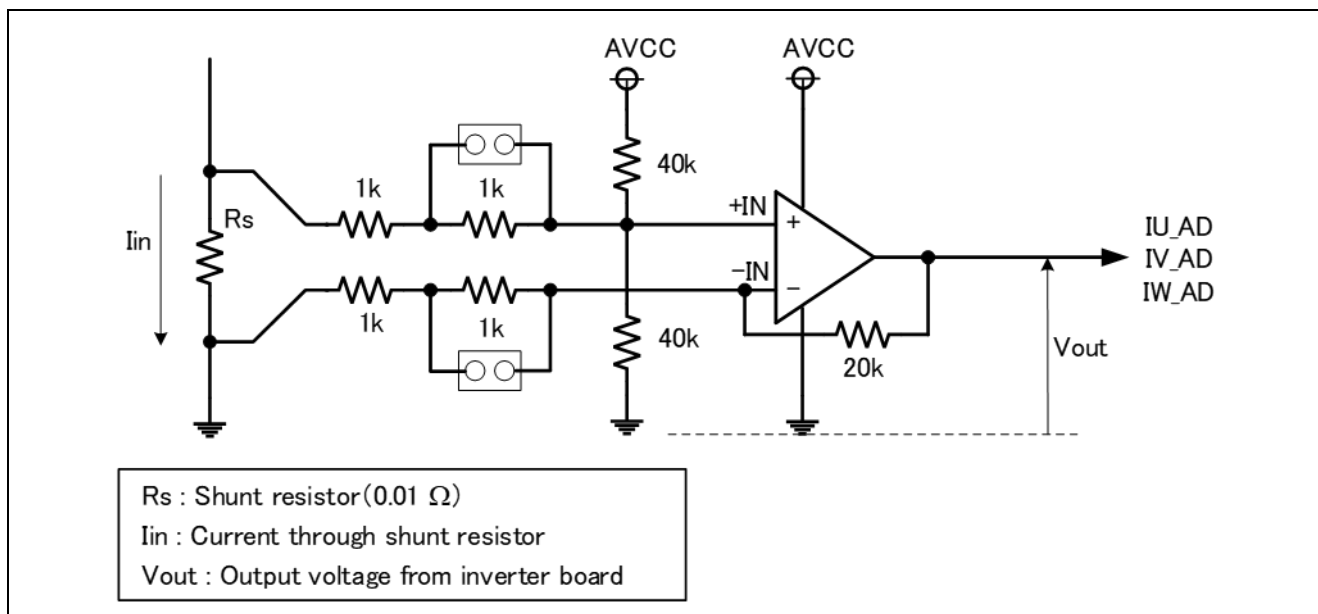


Figure 5-2 Current detection circuit

### 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  $R_s$  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.

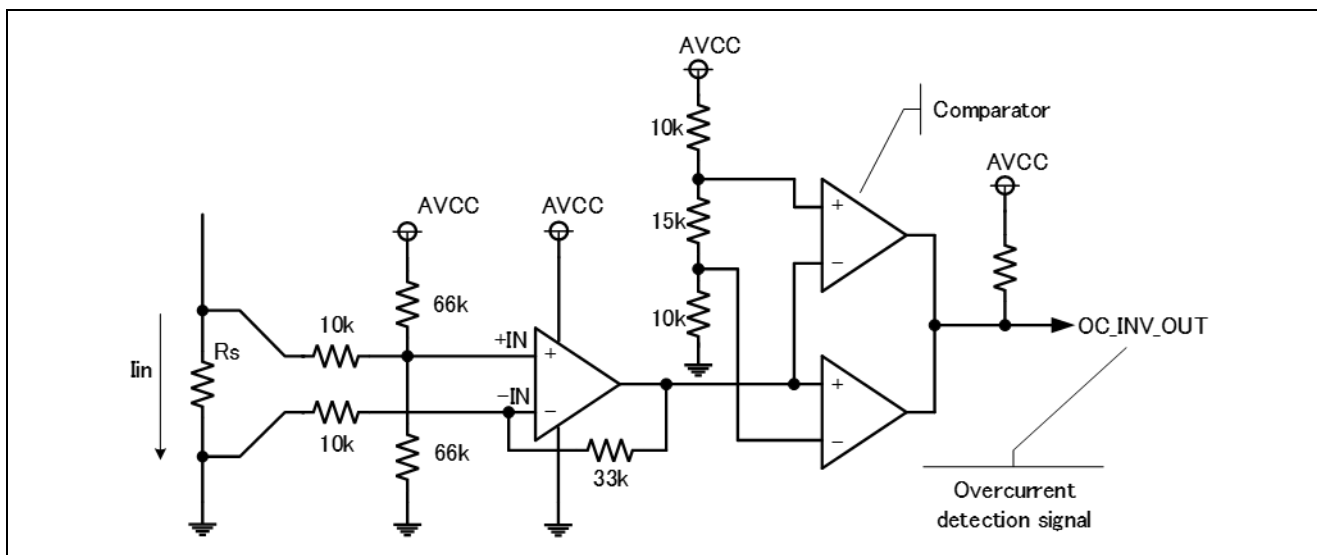


Figure 5-3 Overcurrent detection circuit

#### 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).

$$V_{out}[V] = \frac{470}{10 \times 10^3 + 470} \times V_{in}[V] \quad (3)$$

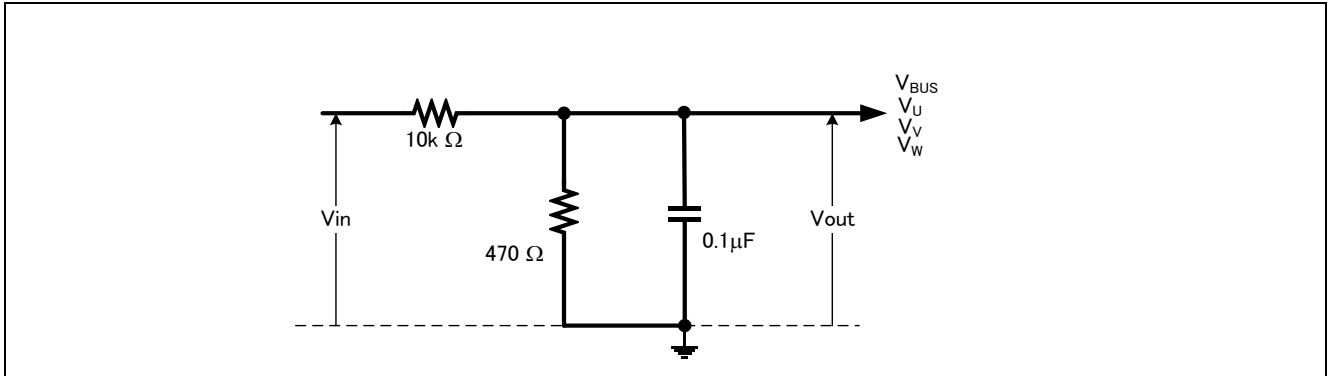


Figure 5-4 Output voltage detection circuit

#### 5.1.5 Voltage generation circuit

The INV-BRD generates the gate driver voltage ("+12V" in the schematic) from the 5V power supply ("+5V" in the schematic). Also, if 5V is not supplied from the CPU board, 5V is generated on the INV-BRD.

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	-



### 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 $\Omega$

## 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

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

### 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

## 6. Design and Manufacture Information

You can obtain information on the design and manufacture of this product from [renesas.com](https://www.renesas.com).

## 7. 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](https://www.renesas.com/ra)
- Renesas Support [renesas.com/support](https://www.renesas.com/support)

**Revision History**

Rev.	Date	Description	
		Page	Summary
1.00	August 3, 2021	-	First edition
1.10	October 28, 2022	14	Revised Table 5-3
1.20	December 20, 2023	6, 12	Corrected overcurrent threshold (21.4A for AVCC=3.3V, 32.4A for AVCC=5.0V)
		17	Corrected a typo (CN7 → CN5)

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