User's Manual

MCI-HV-2-3PH User's Manual

Renesas Electronics
www.renesas.com

Rev.1.00 March 1, 2025

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.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall be responsible for determining what licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products, if required.
5. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
6. Renesas Electronics products are classified according to the following two quality grades: “Standard” and “High Quality”. The intended applications for each Renesas Electronics product depends on the product’s quality grade, as indicated below.
   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.
   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

   Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user’s manual or other Renesas Electronics document.
7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INVULNERABLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION (“Vulnerability Issues”). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.
8. When using Renesas Electronics products, refer to the latest product information (data sheets, user’s manuals, application notes, “General Notes for Handling and Using Semiconductor Devices” in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
12. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
14. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) “Renesas Electronics” as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.
(Note2) “Renesas Electronics product(s)” means any product developed or manufactured by or for Renesas Electronics.

(Rev.5.0-1 October 2020)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

Contact information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:
www.renesas.com/contact/.

For Your Safety

Be sure to read the precautions and instructions in this manual before using this product.

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 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 to persons or physical damage.

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. • The product contains high-temperature components that could be dangerous. Do not touch the product 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. • 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.

■ Warning Items

Warning	
	High voltage is applied to the terminals during operation and for 30 seconds after power shutdown. Do not touch the terminals or the product during this period.
	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.
	In this product, the ground of the main power supply circuit is connected to the ground of the CPU board. When the user evaluates the product, be aware that the product and the measuring instruments may be damaged depending on the connection method of the measuring instruments.
	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. The user must cover the product for safety protection. 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.

Contents

1. Overview

MCI-HV-2-3PH is a motor control evaluation inverter kit. Motor control can be performed easily by using this product with Renesas CPU board and communication board.

Features

(1) Supports over current detection, over voltage protection, over temperature detection.
(2) Supports AC input power supply (3-phase AC200-240V 50/60Hz)
(3) Reinforced isolation between high voltage domain and user interface domain
(4) Supports 3-phase current in-line sensing
(5) Supports HALL sensor and Encoder signal input with reinforced isolation

1.1 Presupposition and precautions of this document

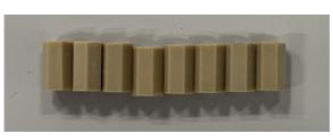
1. Experience of using tools: This document assumes that the user has used terminal emulation program of Integrated Development Environment (IDE) such as e^2 studio before.
2. Knowledge about the development subject: This document assumes that the user has a basic knowledge to modify the sample project 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. This product is intended for use in the laboratory by engineers with knowledge of motor control and high voltage handling.
5. When using this product, be sure to follow the safety instructions in this manual (see section 5). Use of this product without taking safety measures may result in electric shock or burns.

1.2 Product Contents

This product consists of the following parts.

1. Inverter Board (RTK0EM0000B16030BJ) x1
2. 10mm standoff x 8
3. M3 Screw x 16

1. Inverter board



2. 10mm Standoff x8

3. M3 Screw x 16

Fig. 1-1 MCI-HV-2-3PH product contents

2. Hardware configuration

2.1 Hardware specification

Table 2-1 MCI-HV-2-3PH overview

Item	Specification
Product name	MCI-HV-2-3PH
Board Part No.	RTK0EM0000B16030BJ
External view	 Note: The actual product may differ from this photo.
Product size	335 mm(W) x 238 mm(L) x 75 mm(H)
Environmental conditions	Indoor use only Altitude: up to 2000m Operating temperature range : 0 to 40℃ Operating humidity: 0 to 75% RH Mains supply voltage fluctuations: ±10% Over Voltage Category II Pollution Degree 2
Low Voltage Directive	EN61010-1
EMC Directive	EN61326-1:2021 EMI: Class A EMS: Industrial Electromagnetic environment

Table 2-2 MCI-HV-2-3PH specification

Item		Specification
Rated input		AC:200-240V 50/60Hz 10A (3-phase) 3.5kVA
Rated output *1		12A, 2.2kW
Switching frequency		8kHz (typical), 20kHz (max)
Current sensing		3 phase in-line sensing with HALL CT
Voltage sensing		Bus voltage
Protection function	Over current	I_{total}(Current flowing through R27 and R26): 66.7A I_U,I_V,I_W : 41.25A
	Over voltage	416V
	Over-temperature	81.2 °C
Supporting sensor		HALL sensor, Encoder(A/B/Z-phase)

Table 2-3 MCI-HV-2-3PH performance

Item	Specification
No load standby power	6.9W
Inverter efficiency	95.7% at rated output power

2.2 Function block diagram

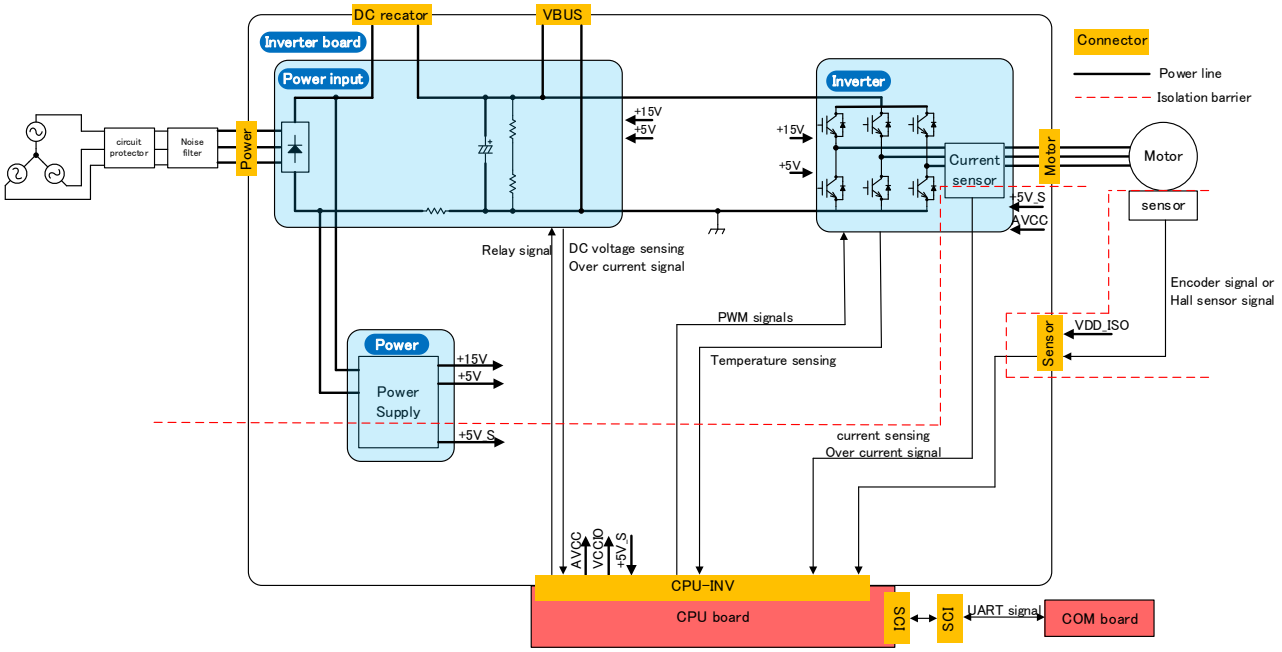


Fig. 2-1 MCI-HV-2-3PH function block diagram

2.3 Board Layout

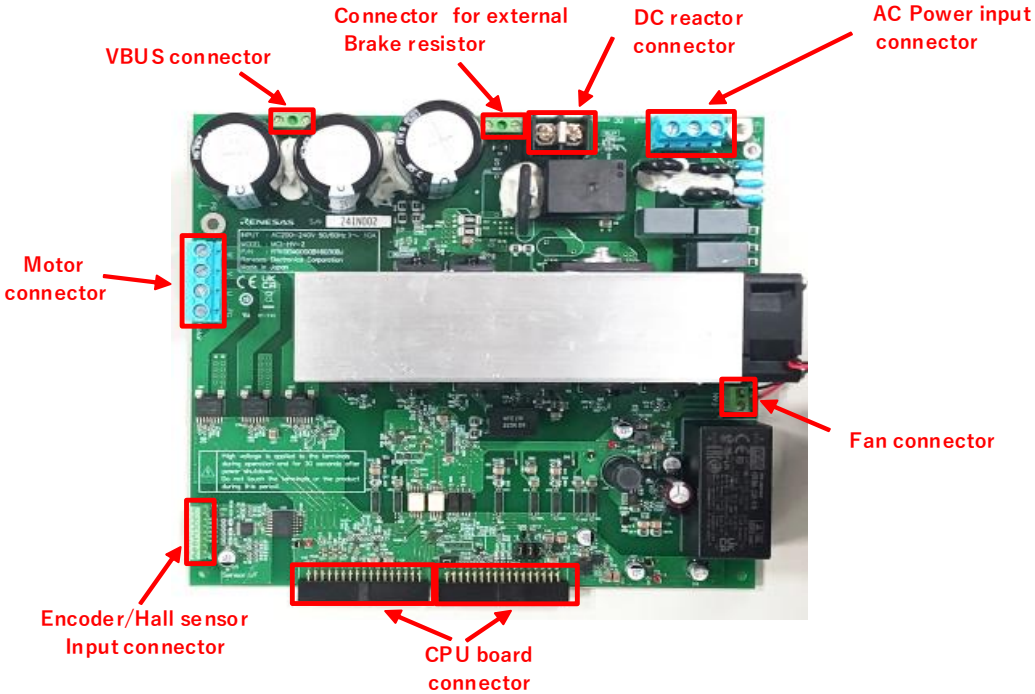


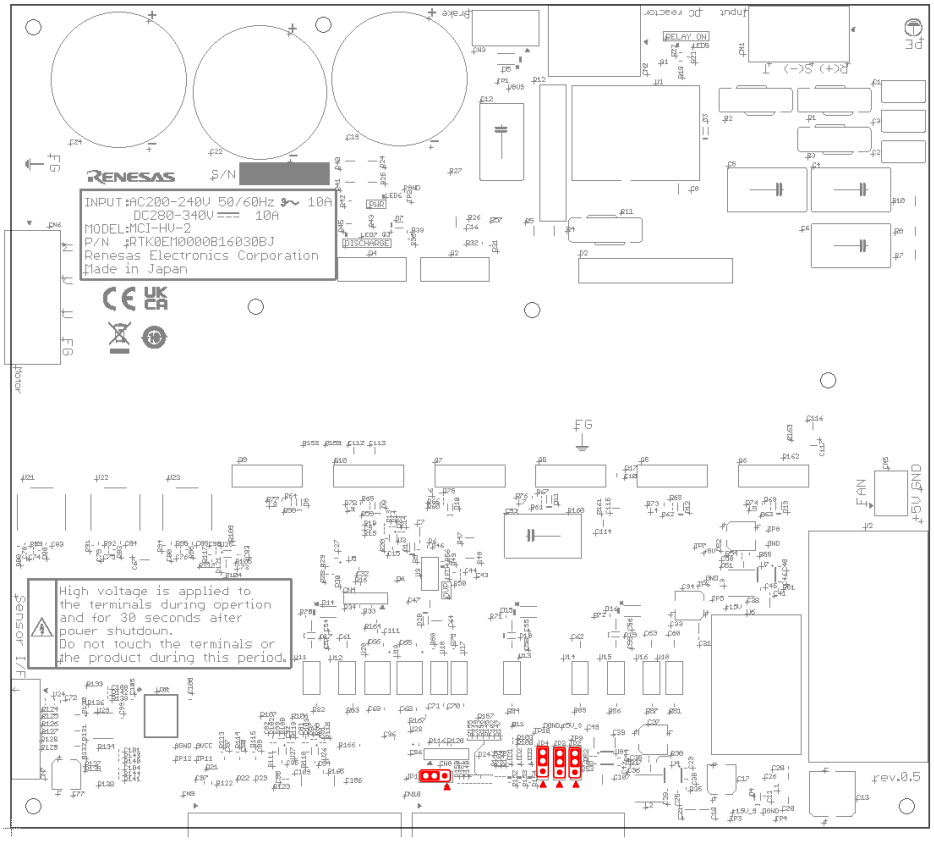
Fig. 2-2 Inverter board layout

2.4 Jumper setting

Default setting and function of the jumpers (JP1~JP4) are as follows.

Table 2-4 Jumper setting of inverter board

Jumper pin	Default setting	Function
JP1	2-3pin short	1-2pin short: SW1 level HIGH 2-3pin short: SW1 level LOW
JP2, JP3, JP4	2-3pin short	1-2pin short: HALL signal input 2-3pin short: Encoder signal input



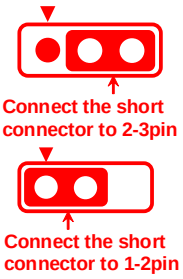
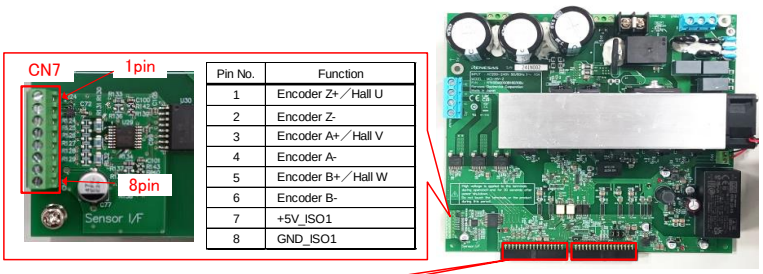


Fig. 2-3 Default jumper pin setting of inverter board

2.5 Pin assignment of connector



Pin No.	Function
1	Encoder Z+／Hall U
2	Encoder Z-
3	Encoder A+／Hall V
4	Encoder A-
5	Encoder B+／Hall W
6	Encoder B-
7	+5V_ISO1
8	GND_ISO1

CN9

Pin No.	Signal name	Function
1,17	TEMP_AD	Temperature sensing
2,4,6,8,10,14,18,21,22	AGND	Analog GND
3	VDC_AD	VBUS Voltage Detection
5	IU_AD	U-phase current sencing
7	IV_AD	V-phase current sencing
9	IW_AD	W-phase current sencing
11,12,13,15,16	-	N.C.
19,20	AVCC	Analog VCC
23,24	VCCIO	Digital VCC
25,26,28,30,32,34	DGND	Digital GND
27	UL_PWM_IN	PWM U phase (Lower)
29	UH_PWM_IN	PWM U phase (Upper)
31	VL_PWM_IN	PWM V phase (Lower)
33	VH_PWM_IN	PWM V phase (Upper)

CN10

Pin No.	Signal name	Function
1	WL_PWM_IN	PWM W phase (Lower)
2,4	DGND	Digital GND
3	WH_PWM_IN	PWM W phase (Upper)
5,6,7,8,9,14,24,25,28,30	-	N.C.
10	INV_CONNECTED	Detection of Inverter connection
11	SAFE_LOCK	Safety interlock signal
12	OC#_1	Over current signal Wired OR for current sensor and detection circuit
13	OC#_2	Over current signal from detection circuit (N/A as default)
15	RELAY_IN	Inrush current prevention relay drive signal
16	SW1_OUT	Switch 1 signal
17	THERMAL_OUT	Overtemperature detection
18	LED1#	LED1
19	LED2#	LED2
20	LED3#	LED3
21	HALL_U	Hall Sensor signal U
22	HALL_V	Hall Sensor signal V
23	HALL_W	Hall Sensor signal W
26	ENC_Z	Encoder Z-phase signal
27	ENC_A	Encoder A-phase signal
29	ENC_B	Encoder B-phase signal
31,32	GND	GND
33,34	5V	+5V

Fig. 2-4 Pin assignment of connector

3. Setup guide

3.1 Hardware setup

When using this product, prepare equipment listed in Table **3-1** and setup according to the procedure (1)~(10).
Do not apply main power to the board before you have verified the settings and completed procedures.
Note that RTK0EMA270C00000BJ is used as the CPU board in this setup guide, please refer to the Renesas website for supported CPU boards. Listed DC reactor and circuit protector, motor are reference examples. Please select appropriate products according to your evaluation environment (power, current, etc.).

Table 3-1 Setup items list

Item	Specification, product example
Inverter board	RTK0E0000B16030BJ (this product)
CPU board (controller board)	RTK0EMA270C00000BJ (Renesas)
Communication board	RTK0EMXC90Z00000BJ (Renesas)
Motor	IM : MLU1107D (Fuji Electric)
	BLDC : BXM6200-A (Oriental Motor)
Power supply unit	Output: AC200~240V (3-Phase), 50/60Hz, >10A 3.5kVA Isolated stabilized power supply or isolation transformer
DC reactor*1	195E20 (Hammond)
Circuit protector	CP30FI-3P020 (Fuji Electric)
Noise filter	JAC-20-103-H (COSEL)
PC	Windows10 or later, with USB port
Communication cable	0151370402 (Molex) Included in RTK0EMXC90S00000BJ
USB cable	Type C

*1 Options for power factor correction

For hardware setup, use wiring that meets the following specifications.

For CN1,CN6:
- Power wiring diameter: AWG14 (2mm^2) ~ AWG10 (5.5mm^2)
- Strip length: 8mm
- Use 3000Vac/1min to satisfy the insulation requirements even if the wiring is accessible

For PE:
- Protective earth wire diameter: AWG14 (2mm^2) ~ AWG10 (5.5mm^2)
- Color: Green/Yellow.

(1) Remove the 12 screws securing the main unit cover and open the main unit cover.

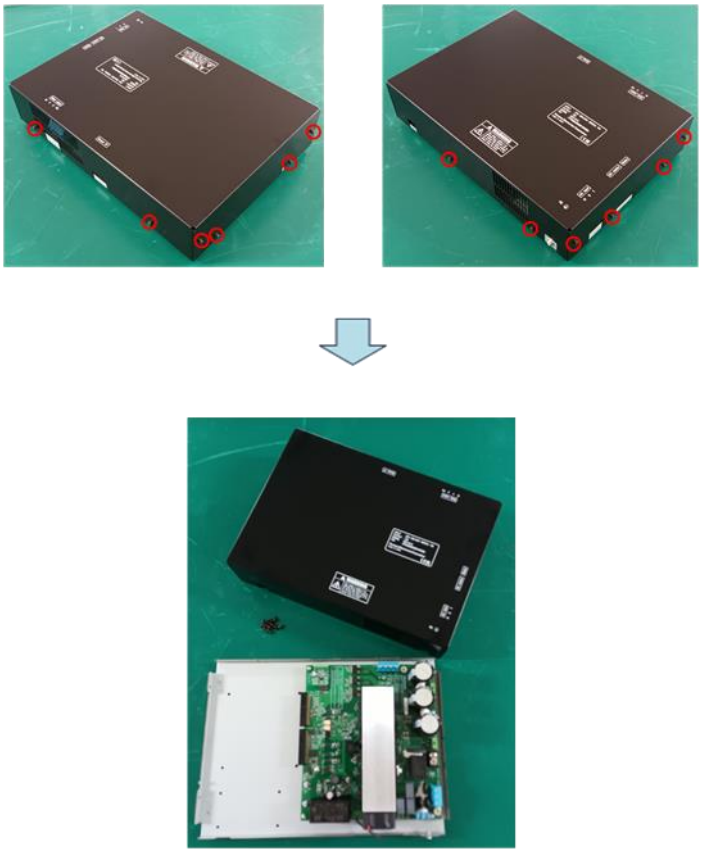


Fig. 3-1 Removing the main body cover

(2) Replace the standoff on the CPU board and communication board with the included flame-retardant standoff.

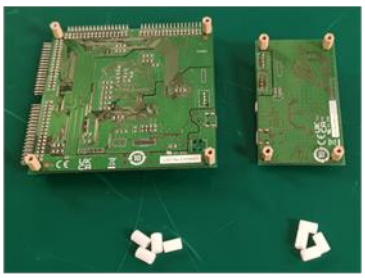


Fig. 3-2 Standoff replacement

(3) Connection between the CPU board and the inverter board

Connect the CPU board to the inverter board with CN9 and CN10. Please write the software to the CPU board beforehand. (Please refer to the manual for each CPU board for how to write the software.)

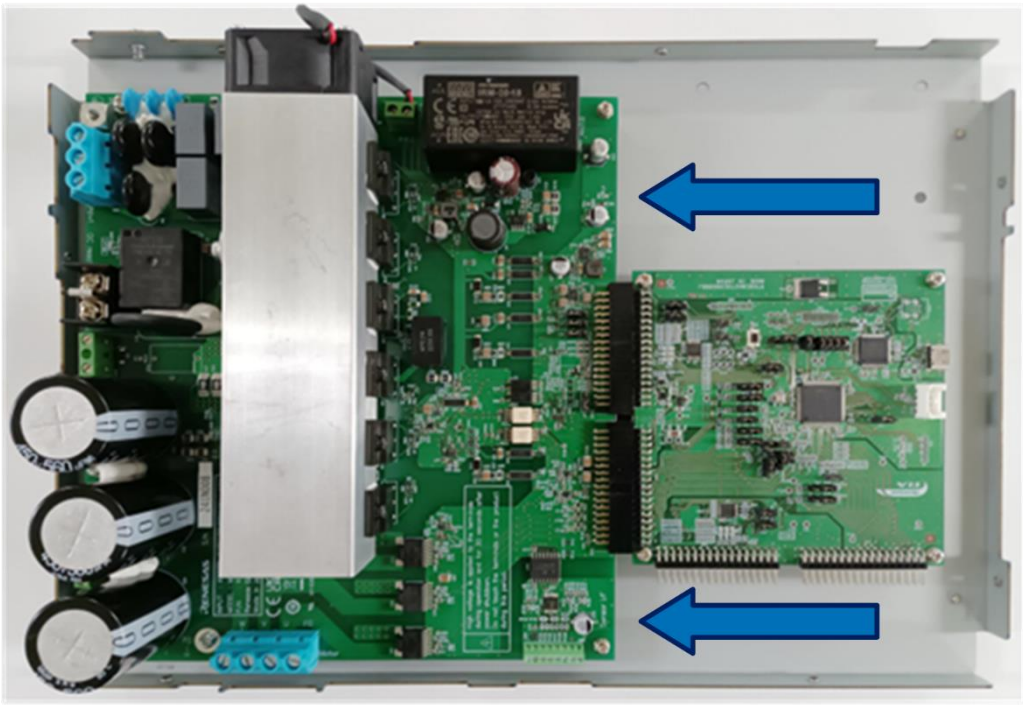


Fig. 3-3 Board Connection (Inverter board, CPU board)

(4) Connect the communication board to the CPU board with a communication cable.

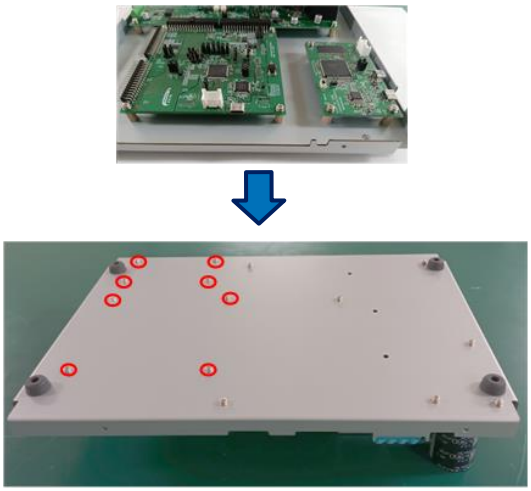


Fig. 3-4 Installation on the base plate (communication board, CPU board)

(5) Connect the communications board to the CPU board with a communications cable and then connect the communications board to the PC with a USB cable.

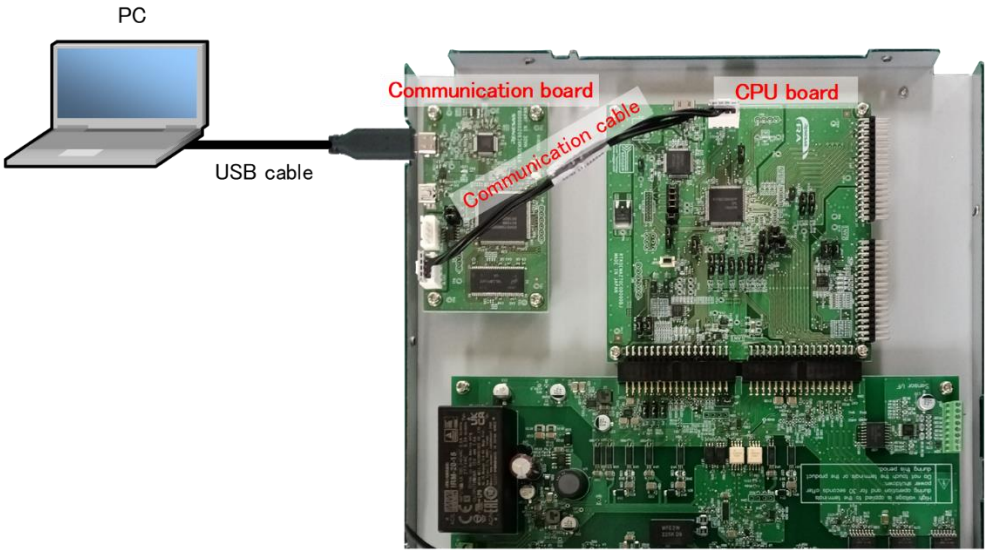


Fig. 3-5 Board Connection (Communication board, PC)

(6) Connect the motor to the inverter board

Connect the U, V, W phases of the motor cable to the motor connector (CN6) as shown in Fig. **3-6**, and FG of the motor cable to the FG on the board as shown in Fig. **3-7**.

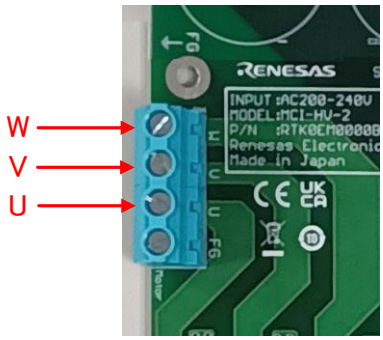


Fig. 3-6 Motor Connection

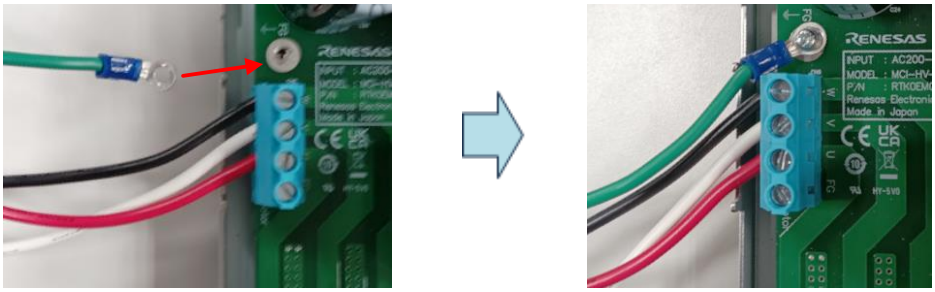


Fig. 3-7 Motor FG Connection

(7) Connect a protective earth cable

Connect the protective earth cable to the PE terminal on the chassis ("PE" mark on chassis) using a conductor with crimp terminal with the M4 screw. The M4 screw is pre-installed on the board.
The protective earth cable should be fixed in place and the insulation distance from the surroundings should be at least 3 mm.

Fig. 3-8 PE connection

(8) Power supply connection

Connect AC power supply to the power connector on the inverter board (CN1) via a circuit protector and a noise filter.
In case of connecting a DC reactor, remove a jumper from CN2 and connect a DC reactor to CN2.

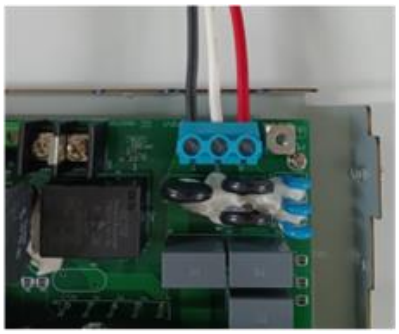


Fig. 3-9 AC Power Connector

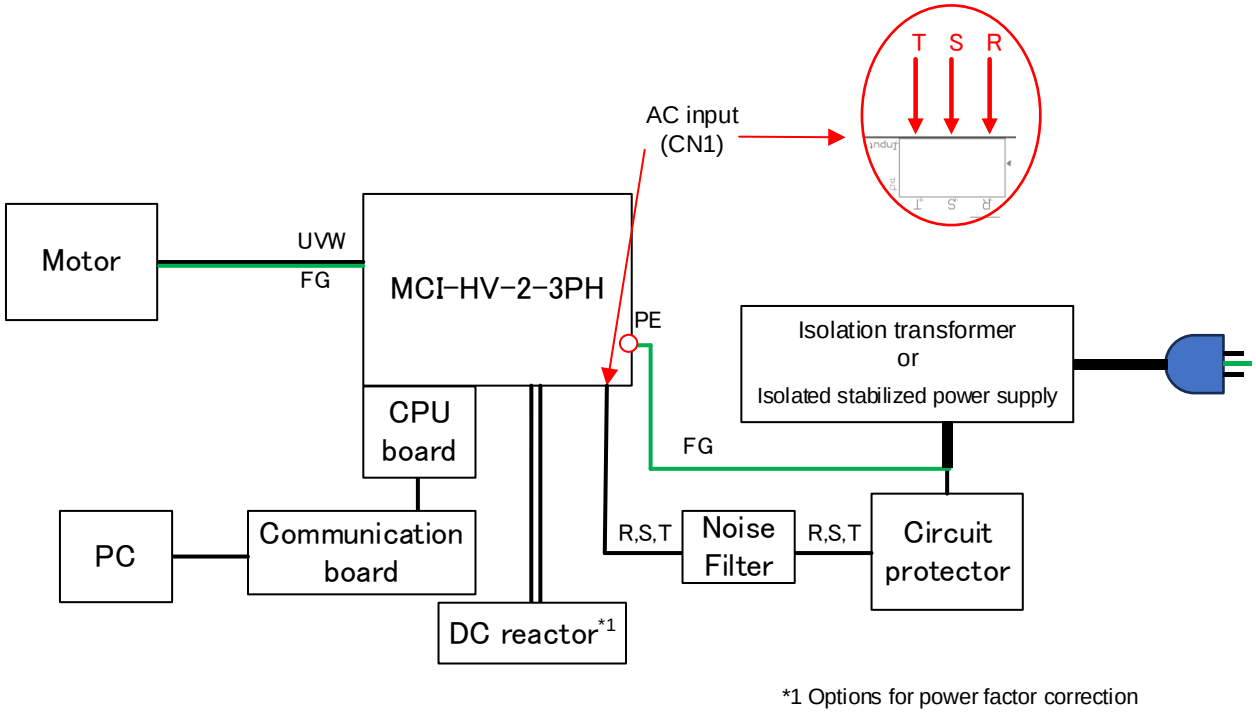


Fig. 3-10 AC power supply connection

(9) Put the body cover back in place and securely reattach the screws.

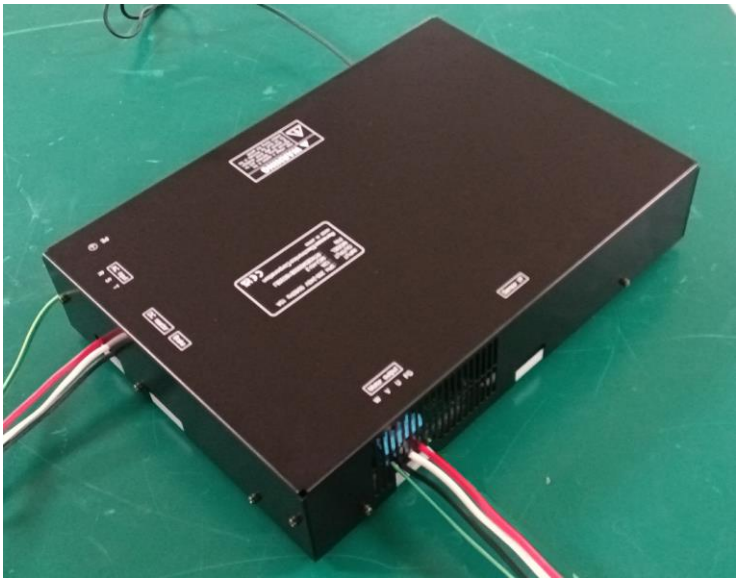


Fig. 3-11 Assembling the main body cover

(10) Cover the system for safety

In order to use this product safely, as shown in Fig. **3-12**, be sure to cover the inverter board and the noise filter with a strong metal or flame-retardant material housing so that they do not come into direct contact with each other, fix it to the floor, and provide a slit for heat protection and a hole for the cable to pass through. And the circuit breaker (circuit protector) should be properly placed as follows.

- Do not locate it so that it is difficult to operate the device.
- It must be suitably located and easily reached.
- It must be marked as the disconnecting device for this product.

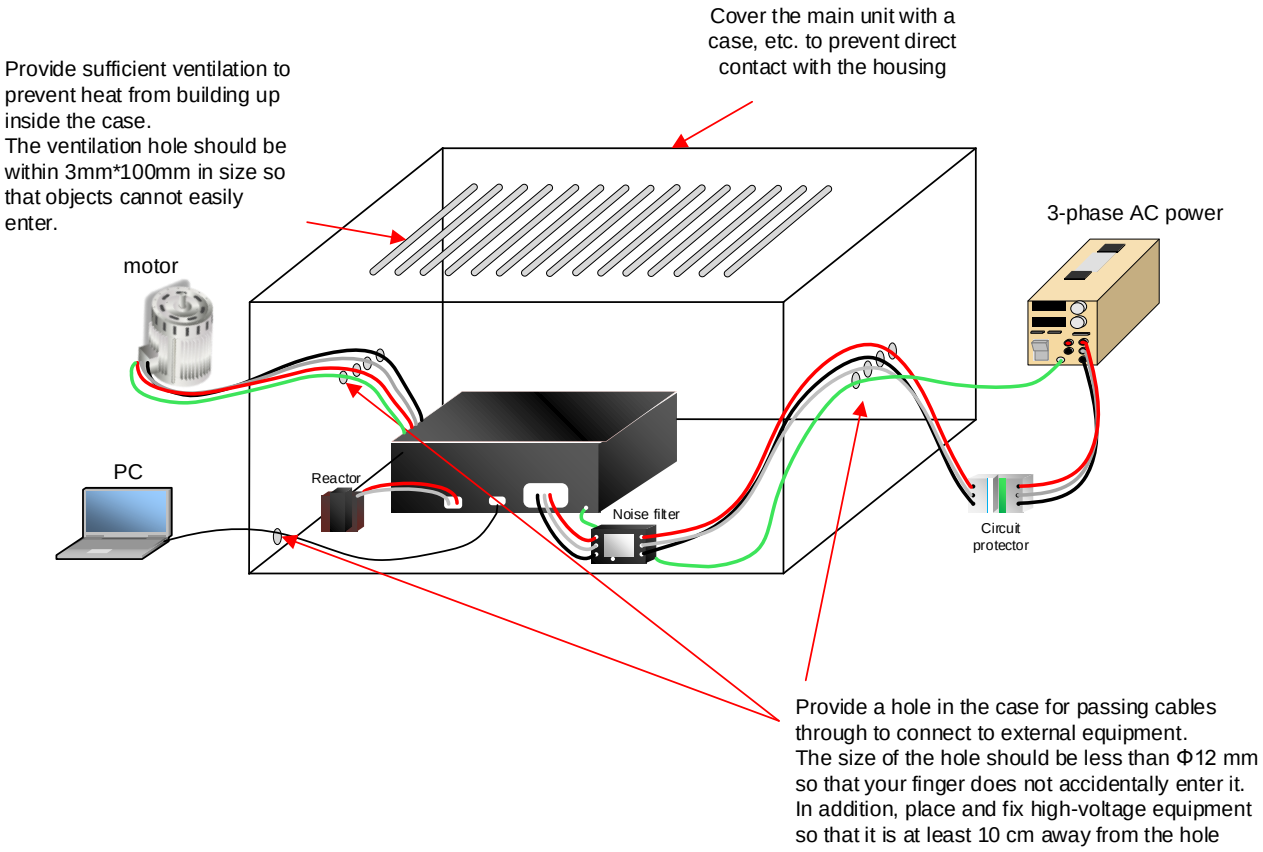


Fig. 3-12 Setup for safe operation

3.2 Motor control operation

The specific method of controlling the motor using this product depends on the specifications of the software written on the CPU board connected to this product. Please refer to the application note of the software for details on the control operation.

4. Hardware detail

This section describes each functional block configuration. Refer to the schematic when necessary.

4.1 Power supply

4.1.1 Voltage regulator

This product generates DC15V and DC5V for primary circuit, and DC5V for secondary circuit, internally. Table **4-1**shows detail of each power supply.

Table 4-1 Regulated voltages

Voltage	Domain	Rated current	Application
DC15V	Primary	0.4A	Generates DC5V Drives IGBT module and relay Drives gate drivers
DC5V	Primary	3A*1	Drives FAN
DC5V	Secondary	3A	Control circuit and CPU board

*1 The actual maximum current is limited by the output power of the DC/DC converter of DC15V.

4.1.2 Voltage sensing

Bus voltage (VBUS) is sensed with the circuit shown in Fig. **4-1** . VBUS voltage is divided and passed through an isolation amplifier and a differential amplifier, and then input to the CPU board as VDC_AD.

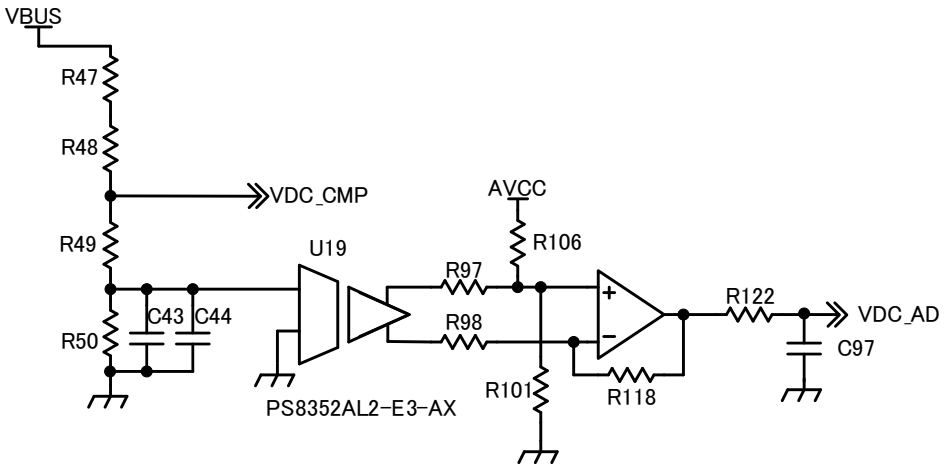


Fig. 4-1 Bus voltage sensing circuit

4.1.3 Discharge control

When main power is shut off, the discharge switch is turned on and the bus voltage is discharged through an IGBT.

LED7 (labeled “DISCHARGE”) turns on during discharging. Do not touch the product until LED7 turns off again after the power is shut off, as voltage is applied internally and there is a risk of electric shock.

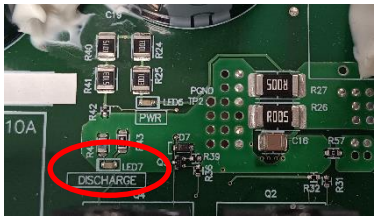


Fig. 4-2 Discharging LED

4.2 Inverter

4.2.1 Phase current sensing

For current sensing, U, V and W-phase currents (IU, IV, IW) are sensed with in-line HALL CT, and are output to CPU board connector according to the following equations.

$$\mathrm{IU\_AD} = \mathrm{IU} \times 0.05333 + \frac{\mathrm{AVCC}}{2}$$

$$\mathrm{IV\_AD} = \mathrm{IV} \times 0.05333 + \frac{\mathrm{AVCC}}{2}$$

$$\mathrm{IW\_AD} = \mathrm{IW} \times 0.05333 + \frac{\mathrm{AVCC}}{2}$$

4.3 Protection

4.3.1 Inrush current protection

This circuit prevents inrush current at power on. Relay signals are isolated by U10.

When the signal “RELAY_IN” from CPU board is LOW, the relay (U1) is turned off and the bus voltage is charged through the thermistor (R12).

When “RELAY_IN” is HIGH, the relay (U1) is turned on.

User should control “RELAY_IN” to be LOW at the startup and to be HIGH after charging up the bus voltage. “RELAY_IN” is input from pin 15 of CN10.

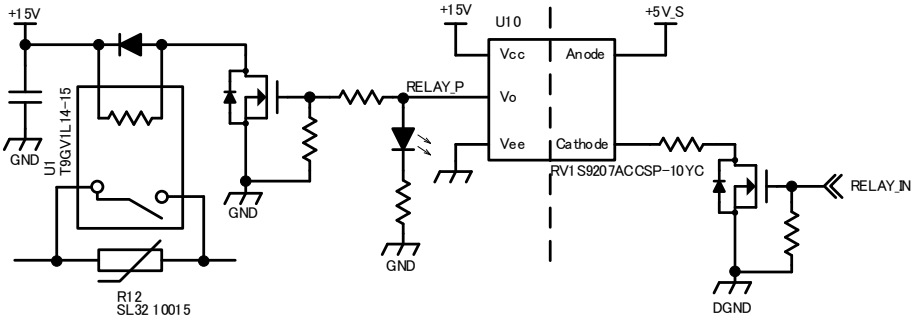


Fig. 4-3 Inrush current protection circuit

4.3.2 Over temperature protection

If the temperature around the IGBT exceeds 81.2°C, the OT#_S signal falls to LOW and inverter operation stops (All PWM signals keep LOW). OT# signal is also output to pin 17 of CN10.

4.3.3 Overvoltage protection

When the bus voltage (VBUS) becomes higher than 416V, control signal OVP_G rises and MOSFET Q2 turns on. Once OVP_G rises, it only falls when VBUS becomes lower than 402V.

By installing an external regenerative absorption resistor on CN3, it is possible to suppress the VBUS from rising above 416V. (See Fig. **4-4**)

For example, attach a metal-clad resistor with a resistance value of 100 Ω or more/power rating of 200 W, etc.

Avoid attaching resistors of less than 100Ω. The internal absorption circuit may be damaged.

When decelerating from high speed operation, the regenerative absorption resistor must dissipate heat sufficiently, and it must be confirmed that the heat generated by the resistor is within the allowable range.

Note that a brake resistor is not included in this product and must be installed by the user if overvoltage during motor deceleration and so on is to be prevented.

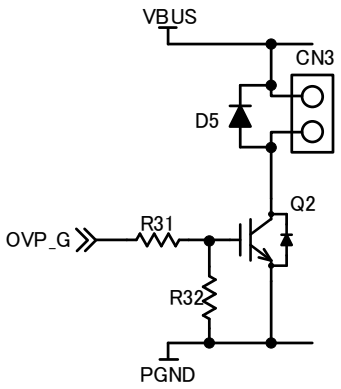


Fig. 4-4 Over voltage protection

4.3.4 Over current Protection

Two types of overcurrent protection are provided: the Itotal overcurrent detection circuit and the IU, IV, IW overcurrent detection circuit. The Itotal overcurrent detection circuit detects the current flowing through R26 and R27 using a shunt resistor, and this is input to the CPU board as a signal named "OC#_1" via the differential amplifier circuit (U3), comparator (U5), and isolator (U18). In addition, the IU, IV, IW overcurrent detection circuit detects the current flowing through the current sensors (U21, U22, U23), and this is also input to the CPU board as a signal named "OC#_1". Both the Itotal overcurrent detection circuit and the IU, IV, IW overcurrent detection circuit have open-drain outputs and are connected in a wired-OR fashion.

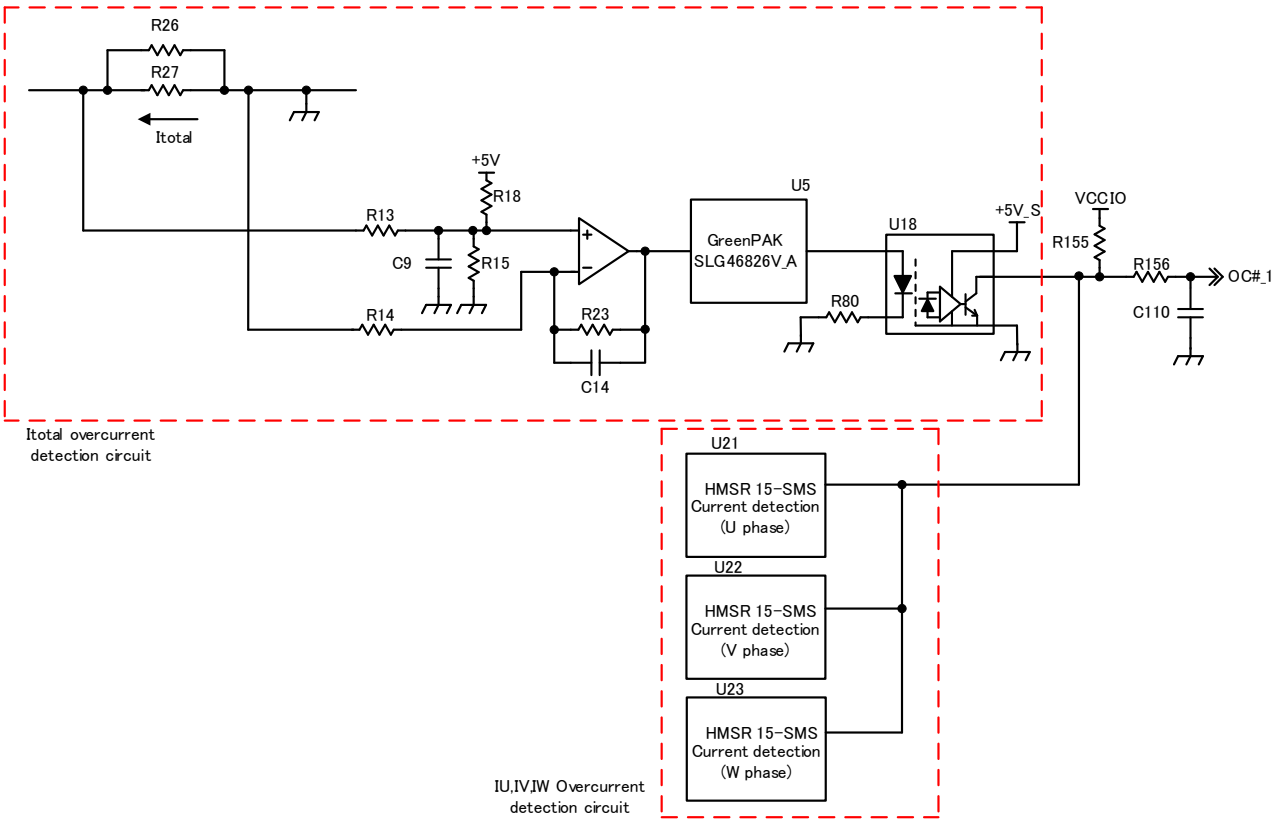


Fig. 4-5 Over current protection

4.3.5 PWM signal overwrap protection

U28 provides overwrap protection for PWM signals to control IGBTs. When lower side PWM signal (UL_PWM_P, VL_PWM_P and WL_PW_P) is HIGH, upper side PWM signal (UH_PWM_P, VH_PWM_P and WH_PWM_P) is always LOW. (lower side signal has priority)

4.4 Sensor I/F

This sensor I/F supports hall sensor and encoder.
Fig. **4-6** shows sensor I/F circuit. The digital isolator (U30) provides reinforced isolation between this product and external devices such as encoder sensor. The power for the sensor I/F must be externally supplied to pin 7 of CN7.
Regarding encoder signals, it supports single-end input and differential input. However, when using differential inputs, the jumper resistors must be switched.
Hall signal input and encoder signal input share the sensor I/F connector CN7. Pin assignments is shown in Fig. **2-4**. JP2, JP3, and JP4 are used to switch whether the signal is output to the CPU board connector as hall sensor signals or encoder signals. See Table **2-4** for details of the settings.

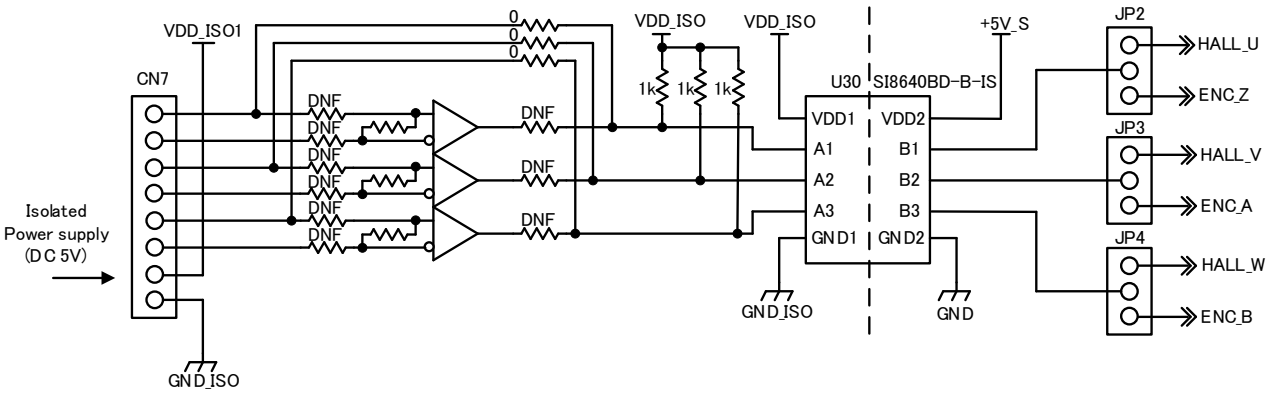


Fig. 4-6 Sensor I/F circuit

5. Safety notice

- Use of this product in a way not specified in this document or the safety manual may result in a loss of safety protection provided by this product. Be sure to use this product in accordance with the ways specified in this document and the safety manual.
- High voltages are applied during operation of this product. Touching this product during operation may cause electric shock, be sure to take safety measures as shown in 3.1(10).
- Do not perform wiring work while the power is on. There is a risk of electric shock or damage to the circuit. Please do so with the power turned off.
- When inputting main power supply from the power connector (CN1), be sure to connect a circuit protector and noise filter.
- The protective earth terminal (PE) must be grounded. See3.1(7).
- When connecting a resistor to the connector (CN3) for over voltage protection, please select a power resistor of 100 Ω or more and rated power of 200W or more that matches the evaluation environment.
- When connecting a reactor to the connector(CN2) for improving power factor, please select a reactor of 2mH or more and rated current of 20A or more that matches the evaluation environment, the reactor should be fixed to the floor.
- Regarding the disconnecting device (circuit protector), it should be properly located as follows.

  - Do not locate it so that it is difficult to operate the device.

  - It must be suitably located and easily reached.

  - It must be marked as the disconnecting device for this product.
- Please read this manual carefully before handling. Incorrect jumper settings may cause damage to the circuit.

6. Regulatory information

This product complies with the following directives.

- Low Voltage Directive : 2014/35/EU (EN61010-1)
- EMC Directive : 2014/30/EU (EN61326-1:2021)

  EMI : Class A
  EMS : Industrial Electromagnetic Environment

7. Website and Support

You can obtain information on the design and manufacture of this product from renesas.com.
In order to learn, download tools and documents, apply technical support for the kit, visit the below Web site.
• Renesas Support renesas.com/support

Revision History

Rev.	Date	Description	
		page	Summary
1.00	March 1, 2025	–	First edition

MCI-HV-2-3PH User's Manual

Renesas Electronics Corporation

R12UZ0170EJ0100