![RENESAS]

RZ/T Series Inverter Board/Kit
User's Manual

Rev 1.00 Nov.15.2024

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/.

RENESAS

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.

RENESAS

■ 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.

RENESAS

RZ/T Series Inverter Board/Kit
User's Manual

Contents

1. Overview

RZ/T Series Inverter Board (abbr. Inverter Board) and RZ/T Series Inverter Board Kit (abbr. Kit) are an evaluation board and a kit including the board and a motor, which are used to evaluate BLDC motor control with RZ/T Series. By connecting this product and RZ/T Series Evaluation Board, you can easily evaluate motor control.
Inverter Board has the following features.

(1) Detects motor power supply voltage

(2) Equipped with an inverter circuit

(3) Supports the current detection method (3-shunt Delta Sigma Modulator)

(4) Detects overcurrent (1-shunt comparator)

(5) Supports absolute encoder and incremental encoder

For use of this product, RZ/T Series Evaluation Board is required

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 MPU 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 are for reference. Actual screen displays may differ depending on the software and development tool version which you use.

2. Product Contents

2.1 RZ/T Series Inverter Board (INVB-LV-RZT-I): RTK0EM0000B15010BJ

This product consists of the following parts.

1. Inverter Board: RTK0EM0000B15010BJ x1
2. Connector for motor x1 *Note1
3. Connector for absolute encoder x1 *Note2
4. 50-pin flat cable x1

　　Note1: Inserted into CN_MOT terminal on Inverter Board when shipped.
　　Note2: Inserted into CN_ENC_ABS0 terminal on Inverter Board when shipped.

3. Connector for absolute encoder

2. Connector for motor

1. Inverter Board

4. 50-pin flat cable x1
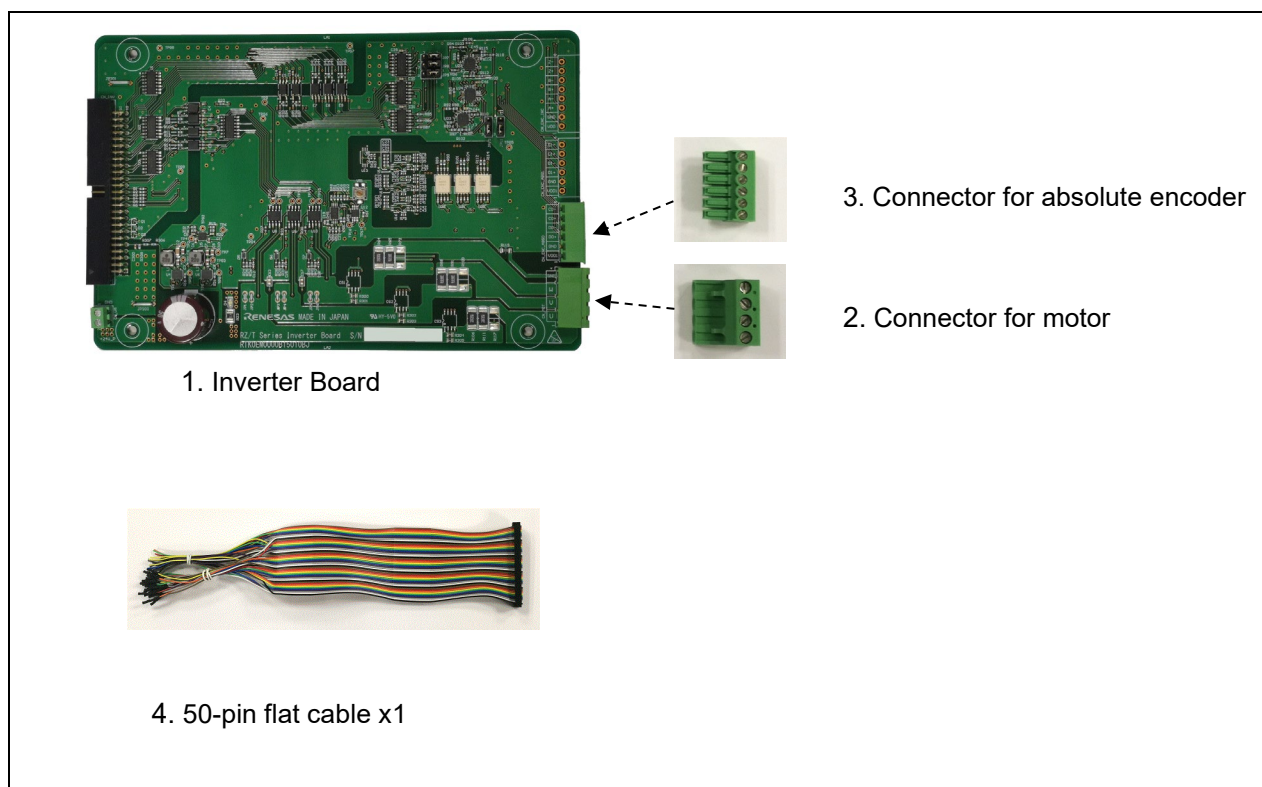
Figure 2-1 Product contents (RZ/T Series Inverter Board)

2.2   RZ/T Series Inverter Board Kit (INVB-LV-RZT-B): RTK0EM0000S05010BJ

This product consists of the following parts.

1. Inverter Board: RTK0EM0000B15010BJ x1
2. Connector for motor x1 *Note1
3. Connector for absolute encoder x1 *Note2
4. 50-pin flat cable x1
5. Motor: TSM3101N2001E020, TAMAGAWA SEIKI Co., Ltd x1

   Note1: Inserted into CN_MOT terminal on Inverter Board when shipped.
   Note2: Inserted into CN_ENC_ABS0 terminal on Inverter Board when shipped.
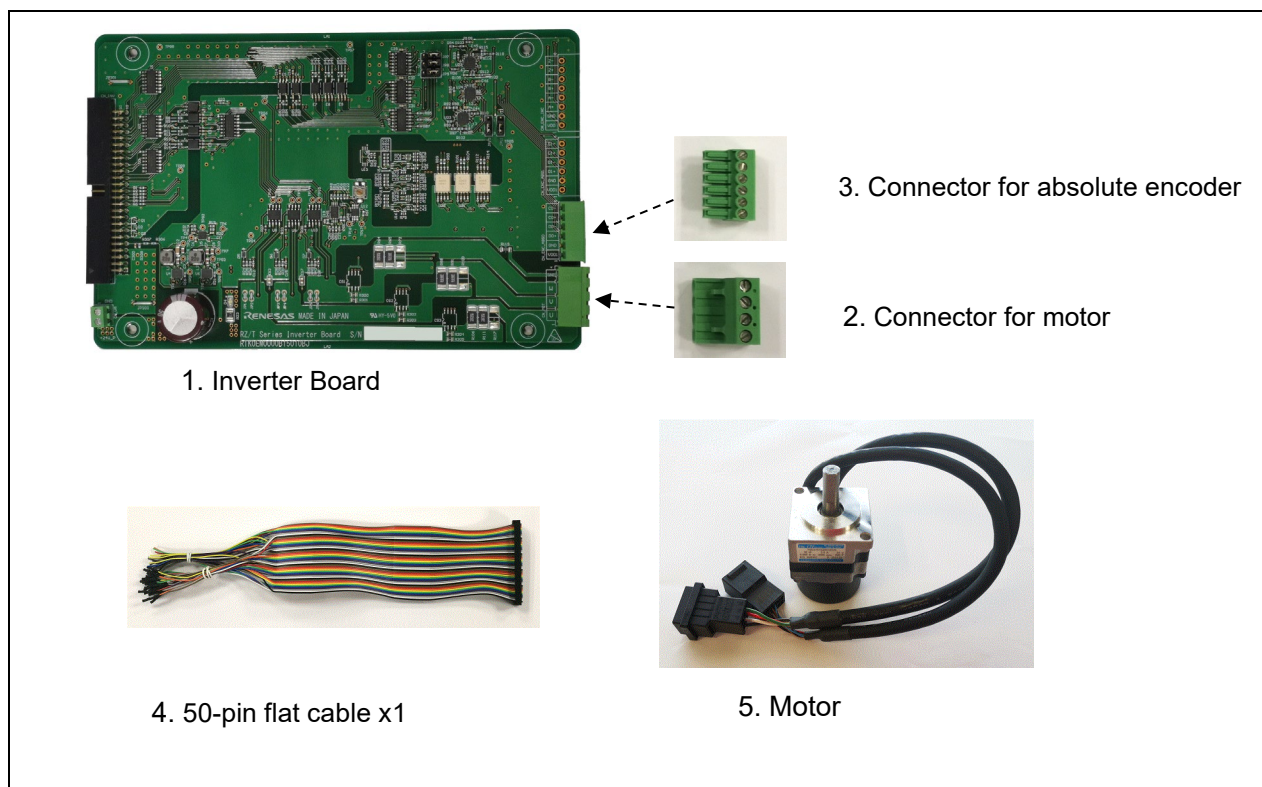
Figure 2-2 Product contents (RZ/T Series Inverter Board Kit)

3. Product Order Information

Target Products
- Product number to order RZ/T Series Inverter Board (INVB-LV-RZT-I): RTK0EM0000B15010BJ
- Product number to order RZ/T Series Inverter Board Kit (INVB-LV-RZT-B): RTK0EM0000S05010BJ

Related products
- Product number to order RZ/T2H Evaluation Board Kit (EVK-RZ/T2H): RTK9RZT2H0S00000BJ
- Product number to order Bus Board for RZ/T2H (BUSB-RZT2H-B): RTK0EM0000Z03000BJ

4.   Hardware Configuration and Default Settings

4.1   RZ/T Series Inverter Board

4.1.1   List of Specifications

Table 4-1 lists the specifications of RZ/T Series Inverter Board.

Table 4-1 RZ/T Series Inverter Board specifications (1/2)
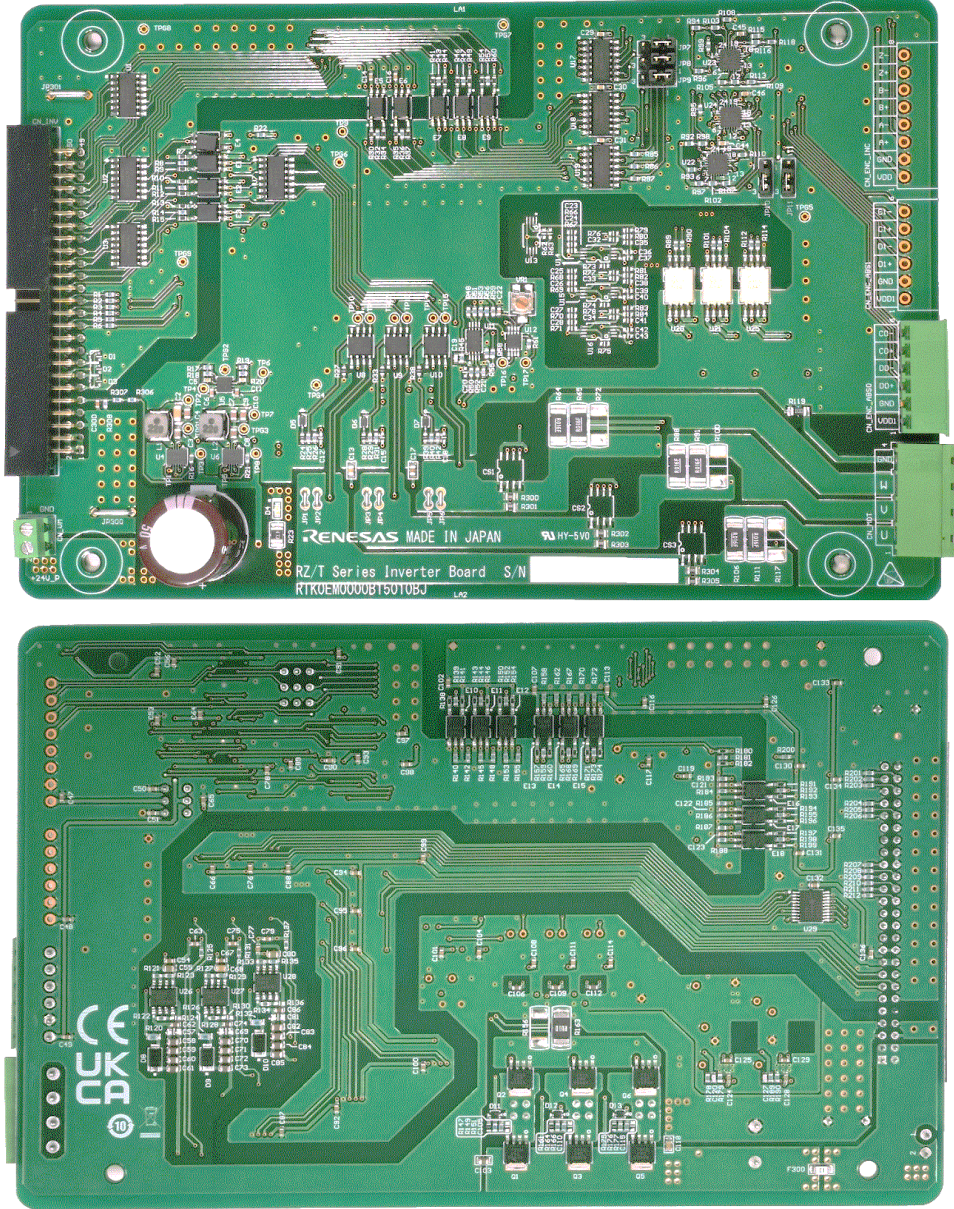
Item	Specification
Model Name	RZ/T Series Inverter Board
Product Number	RTK0EM0000B15010BJ
External view	 Note: The actual product may differ from this photo.
Board size	190mm (W) × 120mm (D)
Power supply specification	MPU I/O power supply: DC3.3V Motor power supply: DC24V/4A (rated)

Table 4-1 RZ/T Series Inverter Board specification (2/2)

Item	Specification
Operating temperature	Room temperature
Operating humidity	No condensation allowed
EMC Directive	EMC Directive: 2014/30/EU (EN61326-1:2021) EMI : Class A EMS : Industrial Electromagnetic Environment
Motor power supply voltage measurement	Detection by voltage divider
Overcurrent detection /protection	Power supply current detection with shunt resister / chip fuse (12A)
Terminal	• Terminal for MPU connection (50-pin) x1 • Power supply terminal x1 • Terminal for motor x1 • Terminal for encoder x3 (only CN_ENC_ABS0 is implemented)
LED	• Power LED x1

4.1.2 Block Diagram

Figure 4-1 shows a block diagram of Inverter Board.
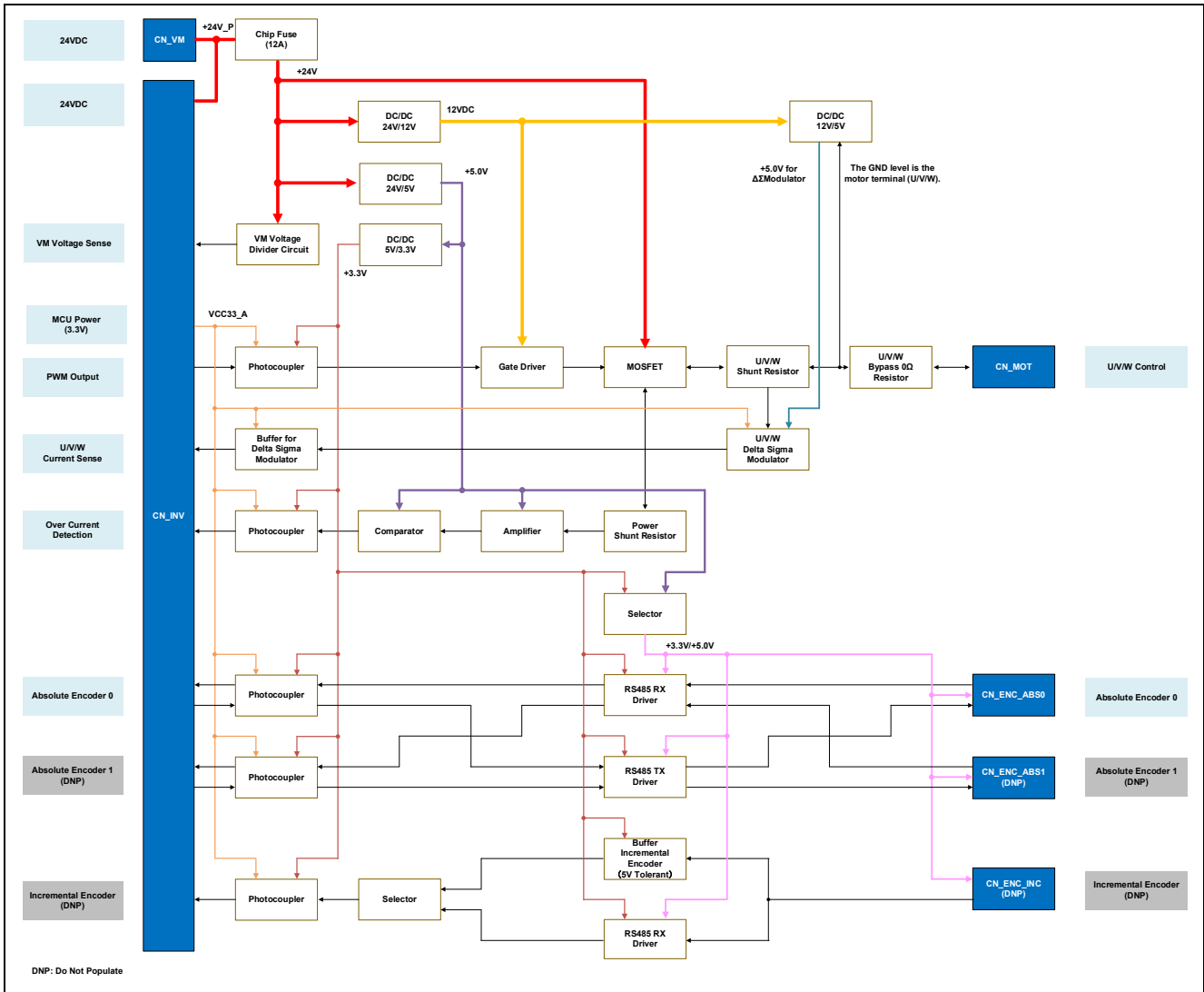
Figure 4-1 Inverter Board block diagram

4.1.3 Board Layout

Figure 4-2 and 4-3 show layouts of the main parts of Inverter Board.

Figure 4-2 Inverter Board layout (Top)

Figure 4-3 Inverter Board layout (Bottom)

4.1.4 Terminals and Cable

Table 4-2 through Table 4-7 list the pin functions of each terminal on Inverter Board and the cable.

Table 4-2 Pin function of CN_INV terminal and 50-pin flat cable (1/2)
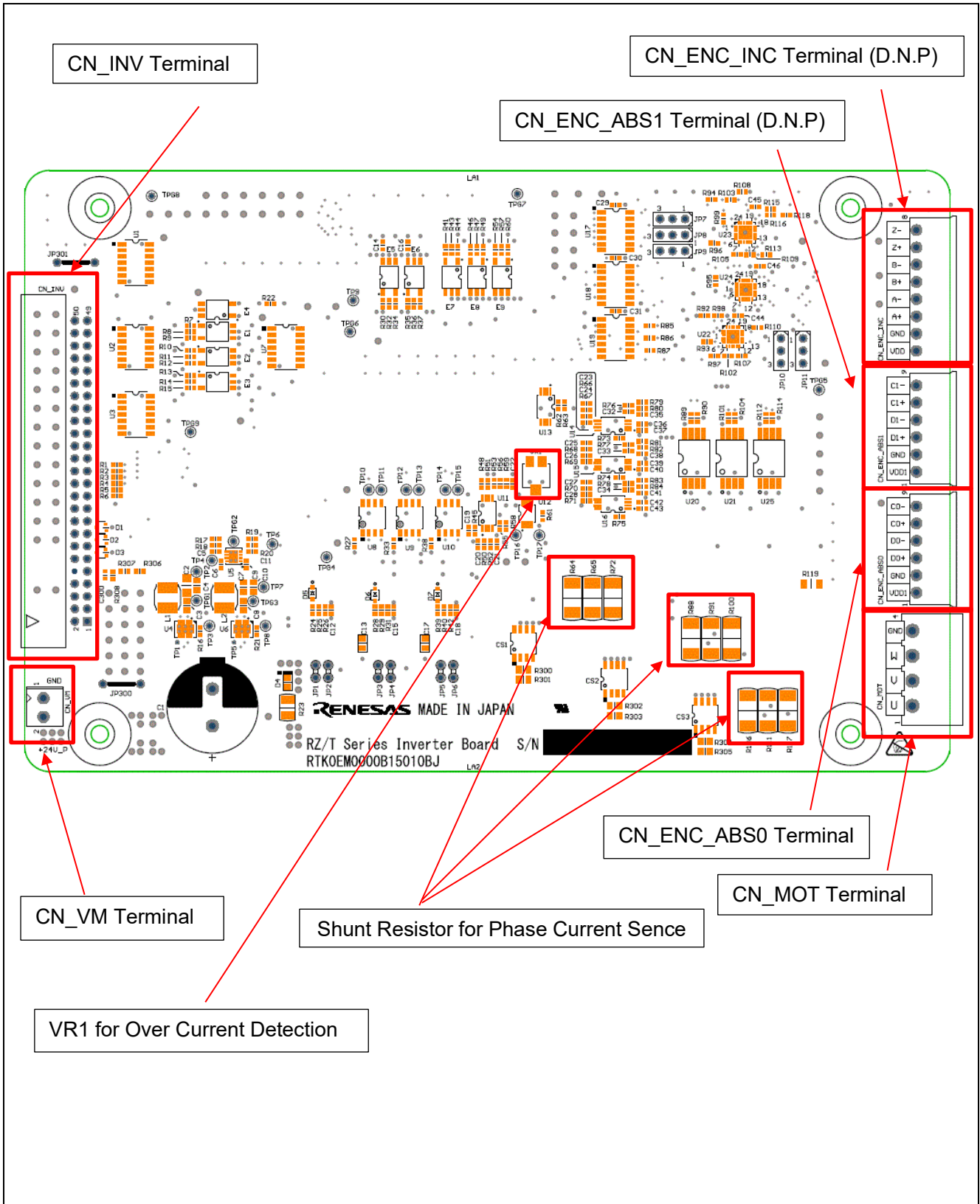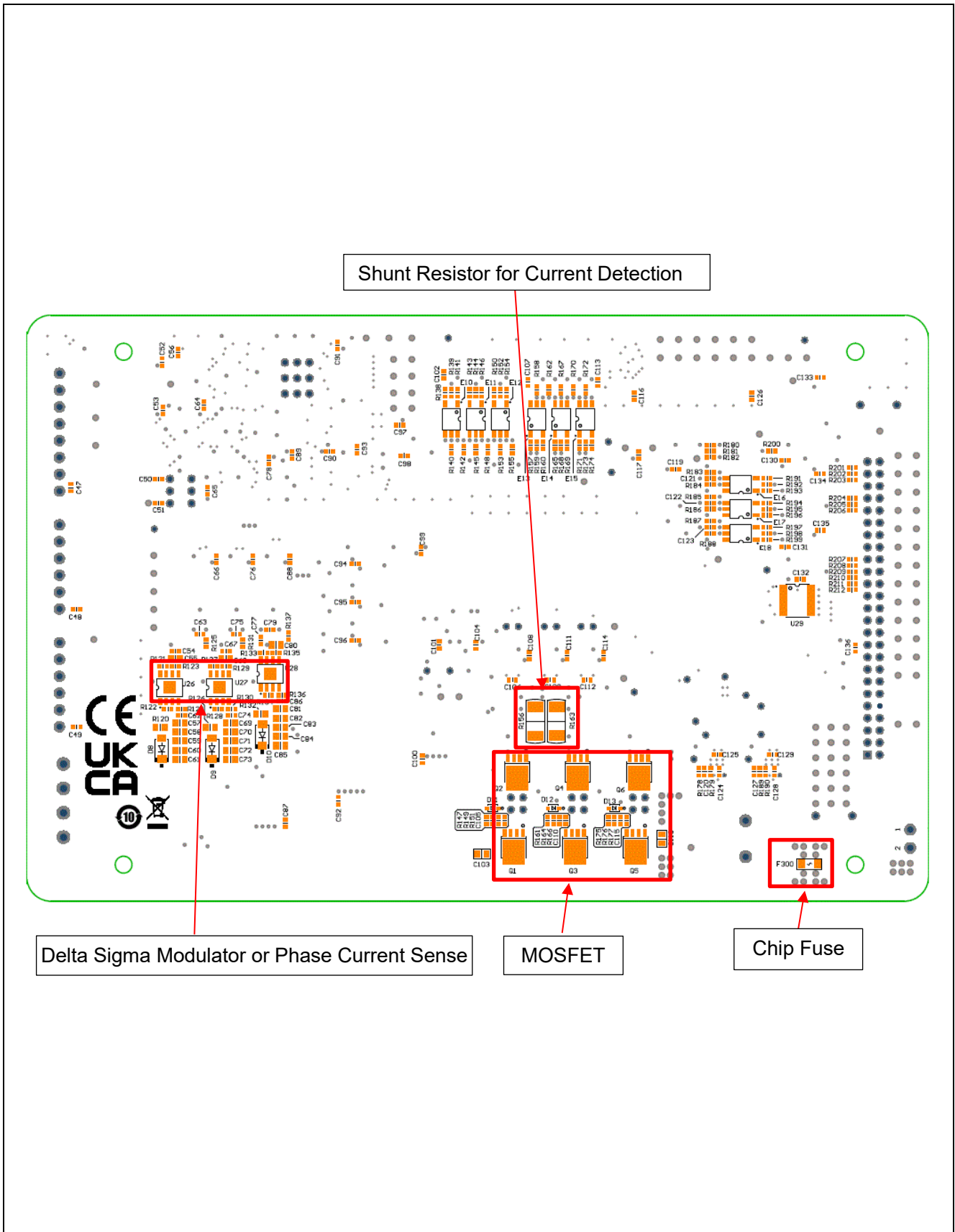
No	Pin name (abbr.)	I/O	Color	Contact	Function
1	+24V_P	Power supply	Brown	-	Motor power supply pin (DC24V input)
2	+24V_P	Power supply	Red	-	Motor power supply pin (DC24V input)
3	+24V_P	Power supply	Orange	-	Motor power supply pin (DC24V input)
4	+24V_P	Power supply	Yellow	-	Motor power supply pin (DC24V input)
5	GND	GND	Green	-	Motor GND pin
6	GND	GND	Blue	-	Motor GND pin
7	GND	GND	Purple	-	Motor GND pin
8	GND	GND	Gray	✓	Motor GND pin
9	VCC24_AD_BUS (VM_DIV)	Output	White	✓	Motor power supply voltage measurement pin. The output is referenced to GND. When using this pin, the GND of pin No.8 and GND_A should be common. Connect the motor GND of pin No.8 to MPU I/O GND
10	NC	NC	Black	-	Not used
11	VCC18_AVDDREF_ADC0 (VCC18_A)	Power supply	Brown		Not used
12	GND_A	GND	Red	✓	MPU I/O GND pin
13	AN000_IU (CT_IU)	Output	Orange	-	Not used
14	AN001_IV (CT_IV)	Output	Yellow	-	Not used
15	AN002_IW (CT_IW)	Output	Green	-	Not used
16	GND_A	GND	Blue	-	MPU I/O GND pin
17	VCC33_A	Power supply	Purple	✓	MPU I/O power supply pin (DC3.3V input)
18	VCC33_A	Power supply	Gray	✓	MPU I/O power supply pin (DC3.3V input)
19	GND_A	GND	White	-	MPU I/O GND pin
20	GND_A	GND	Black	-	MPU I/O GND pin
21	MCLK00_IU (DSIG_MC_IU)	Output	Brown	✓	U-phase current sense Delta Sigma Modulator clock pin
22	MDAT00_IU (DSIG_MD_IU)	Output	Red	✓	U-phase current sense Delta Sigma Modulator data pin
23	MCLK01_IV (DSIG_MC_IV)	Output	Orange	✓	V-phase current sense Delta Sigma Modulator clock pin
24	MDAT01_IV (DSIG_MD_IV)	Output	Yellow	✓	V-phase current sense Delta Sigma Modulator data pin
25	MCLK02_IW (DSIG_MC_IW)	Output	Green	✓	W-phase current sense Delta Sigma Modulator clock pin
26	MDAT02_IW (DSIG_MC_IW)	Output	Blue	✓	W-phase current sense Delta Sigma Modulator data pin
27	GND_A	GND	Purple	-	MPU I/O GND pin
28	GTIOC00_0A_UP (UP)	Input	Gray	✓	U-phase high-side PWM pin
29	GTIOC00_0B_UN (UN)	Input	White	✓	U-phase low-side PWM pin
30	GTIOC00_1A_VP (VP)	Input	Black	✓	V-phase high-side PWM pin

Table 4-2 Pin function of CN_INV terminal and 50-pin flat cable (2/2)

No	Pin name (abbr.)	I/O	Color	Contact	Function
31	GTIOC00_1B_VN (VN)	Input	Brown	✓	V-phase low-side PWM pin
32	GTIOC00_2A_WP (WP)	Input	Red	✓	W-phase high-side PWM pin
33	GTIOC00_2B_WN (WN)	Input	Orange	✓	W-phase low-side PWM pin
34	GND_A	GND	Yellow	-	MPU I/O GND pin
35	OC_DET_INV0_OUT_A (OC_DET)	Output	Green	✓	Overcurrent detection pin (Low: detected)
36	GND_A	GND	Blue	✓	MPU I/O GND pin
37	GTIOC00_3A_INC_A (INC_A)	Output	Purple	-	Incremental encoder A-phase data pin
38	GTIOC00_3B_INC_B (INC_B)	Output	Gray	-	Incremental encoder B-phase data pin
39	IRQ6_INC_Z (INC_Z)	Output	White	-	Incremental encoder Z-phase data pin
40	GND_A	GND	Black	-	MPU I/O GND pin
41	ENCIFCK00_ABS0 (ABS0_CK)	Input	Brown	-	Absolute encoder 0 clock pin
42	ENCIFOE00_ABS0 (ABS0_DOE)	Input	Red	✓	Absolute encoder 0 control data enable pin
43	ENCIFDO00_ABS0 (ABS0_DO)	Input	Orange	✓	Absolute encoder 0 control data pin
44	ENCIFDI00_ABS0 (ABS0_DI)	Output	Yellow	✓	Absolute encoder 0 detection data pin
45	GND_A	GND	Green	-	MPU I/O GND pin
46	ENCIFCK08_ABS08 (ABS1_CK)	Input	Blue	-	Absolute encoder 1 clock pin
47	ENCIFOE08_ABS08 (ABS1_DOE)	Input	Purple	-	Absolute encoder 1 control data enable pin
48	ENCIFDO08_ABS08 (ABS1_DO)	Input	Gray	-	Absolute encoder 1 control data pin
49	ENCIFDI08_ABS08 (ABS1_DI)	Output	White	-	Absolute encoder 1 detection data pin
50	GND_A	GND	Black	✓	MPU I/O GND pin

Table 4-3 CN_VM terminal

No	Pin name	I/O	Function
1	GND	GND	Motor GND pin
2	+24V_P	Power supply	Motor power supply pin (DC24V input)

Table 4-4 CN_MOT terminal

No	Pin name	I/O	Function
1	U	I/O	U-phase motor pin
2	V	I/O	V-phase motor pin
3	W	I/O	W-phase motor pin
4	GND	GND	Motor GND pin (frame GND)

Table 4-5 CN_ENC_ABS0 terminal

No	Pin name	I/O	Function
1	VDD1	Power supply	Absolute encoder power supply pin (+3.3V/+5.0V output)
2	GND	GND	Motor GND pin
3	D0+	I/O	Data pin
4	D0-	I/O	$\overline{\text{Data}}$ pin
5	C0+	Output	Clock pin
6	C0-	Output	$\overline{\text{Clock}}$ pin

Table 4-6 CN_ENC_ABS1 terminal

No	Pin name	I/O	Function
1	VDD1	Power supply	Absolute encoder power supply pin (+3.3V/+5.0V output)
2	GND	Power supply	Motor GND pin
3	D1+	I/O	Data pin
4	D1-	I/O	$\overline{\text{Data}}$ pin
5	C1+	Output	Clock pin
6	C1-	Output	$\overline{\text{Clock}}$ pin

Table 4-7 CN_ENC_INC terminal

No	Pin name	I/O	Function
1	VDD	Power supply	Incremental encoder power supply pin (+3.3V/+5.0V output)
2	GND	GND	Motor GND pin
3	A+	Input	A-phase pin
4	A-	Input	$\overline{\text{A}}$-phase pin
5	B+	Input	B-phase pin
6	B-	Input	$\overline{\text{B}}$-phase pin
7	Z+	Input	Z-phase pin
8	Z-	Input	$\overline{\text{Z}}$-phase pin

4.1.5 Jumper Settings

Table 4-8 and Figure 4-4 show the default settings and functions of the jumpers from JP7 to JP11.

Table 4-8 Settings of jumpers on Inverter Board

| Jumper	Factory settings	Function
JP7, JP8, JP9	1-2pin short	Incremental encoder input selection 1-2pin short: RX485 RX Receiver (differential input) 2-3pin short: 5V Tolerant Buffer
JP10	2-3pin short	Absolute encoder I/O power supply selection 1-2pin short: +3.3V 2-3pin short: +5.0V
JP11	2-3pin short	Incremental encoder I/O power supply selection 1-2pin short: +3.3V 2-3pin short: +5.0V
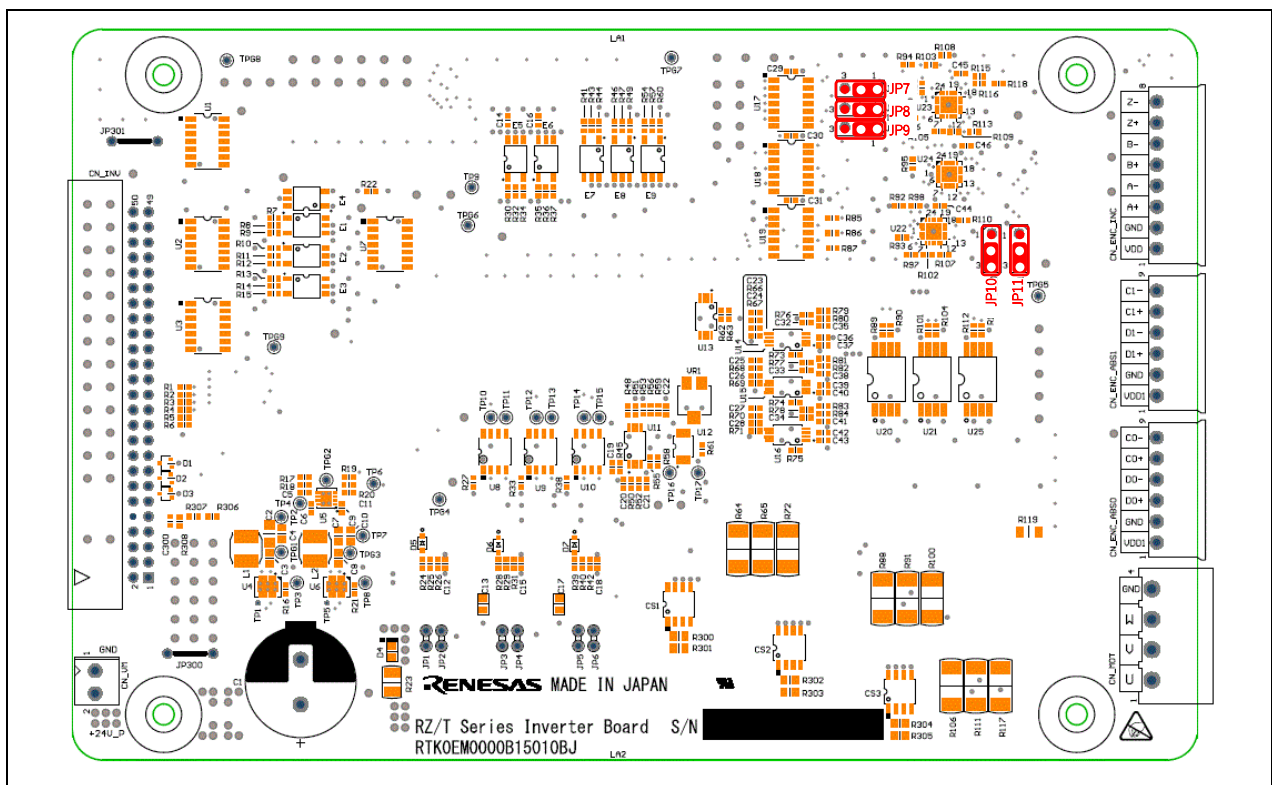
Figure 4-4 Jumper settings on Inverter Board

4.2 Motor

RZ/T Series Inverter Board Kit includes a motor manufactured by TAMAGAWA SEIKI Co., Ltd.
Table 4-9 lists the specifications of TSM3101N2001E020.
For the detailed specification of the motor, contact TAMAGAWA SEIKI Co., Ltd.

Table 4-9 TSM3101N2001E020 specifications

Item	Specification
Product name	TBL-I IV
Product number	TSM3101N2001E020
Manufacturer	TAMAGAWA SEIKI Co., Ltd
Motor form	P.M. 10 poles 3Φ Y connect
Sensor	Absolute encoder type
Voltage used	Motor voltage: DC24V Sensor I/O voltage: DC5.0V
External view	 Note: The actual product may differ from this photo.
Rated output	30 W
Rated torque	0.095 N·m
Stoll torque	0.095 N·m
Rated rotation speed	3000 rpm
Max rotation speed	6000 rpm
Rotor inertia	0.023×10^{-4} kg·m^2
Rated armature current of E.D.C.M.[1]	3.5 A (rms)
Stoll armature current of E.D.C.M. [1]	2.9 A (rms)
No-load armature current of E.D.C.M. [1]	0.6 A (rms)
Peak armature current of E.D.C.M. [1]	10.6 A (rms)
Torque constant of E.D.C.M. [1]	0.033 N·m/A (±10%)
Voltage constant of E.D.C.M. [1]	3.5×10^{-3} v/(r/min)
Armature resistance of E.D.C.M. [1]	1.9 Ω (±10%)
Armature inductance of E.D.C.M. [1]	2.0 mH (±30%)
Electrical time constant	1.1 ms

*1: E.D.C.M is Equivalent DC Motor

5. Hardware Setup

5.1 Motor Connection

When using the motor in Kit, attach the connector for motor to CN_MOT terminal and the connector for absolute encoder to CN_ENC_ABS0 terminal.

Note that motor manufacturer's default connectors are attached to the motor in Kit when shipped. Exchange the connectors referring to 5.1.1 and 5.1.2. To use a motor prepared by users, similar processing is also required.

When using an incremental encoder or absolute encoder 1, the terminal is required to be implemented.
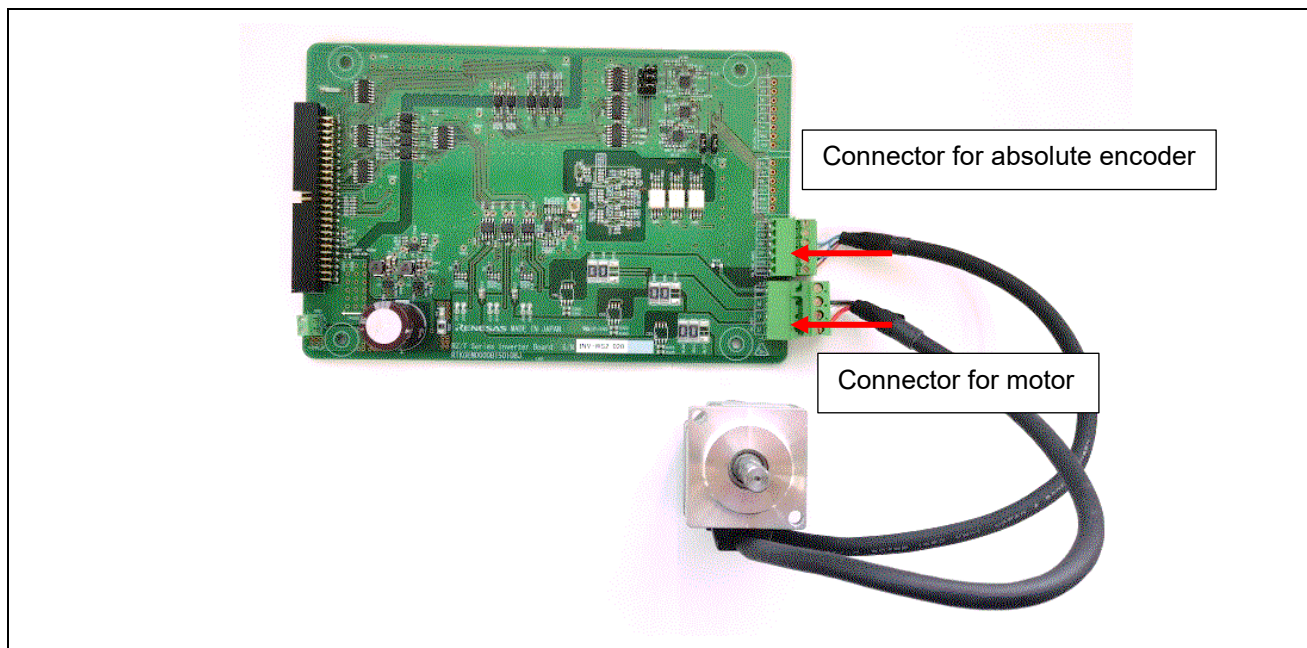

Figure 5-1 Connection of Inverter Board and motor

5.1.1 Connector for Motor

Process the connector as shown in Figure 5-2. If connecting to other motors, process the connector similarly.

① Motor manufacturer's default connectors are attached to the motor in Kit when shipped. This connector is not used in this product.

② Detach the cable and connector with a tool such as a pair of nippers, remove the sheath from the end of the red, white, and black cables, then connect them to U, V, and W of the connector for motor, respectively. In this product, connection of the green cable (FG) is not required. Protect it with insulation tape etc. to prevent short circuit with other wiring.

③ Tighten the screws of the connector for motor.

① When shipped

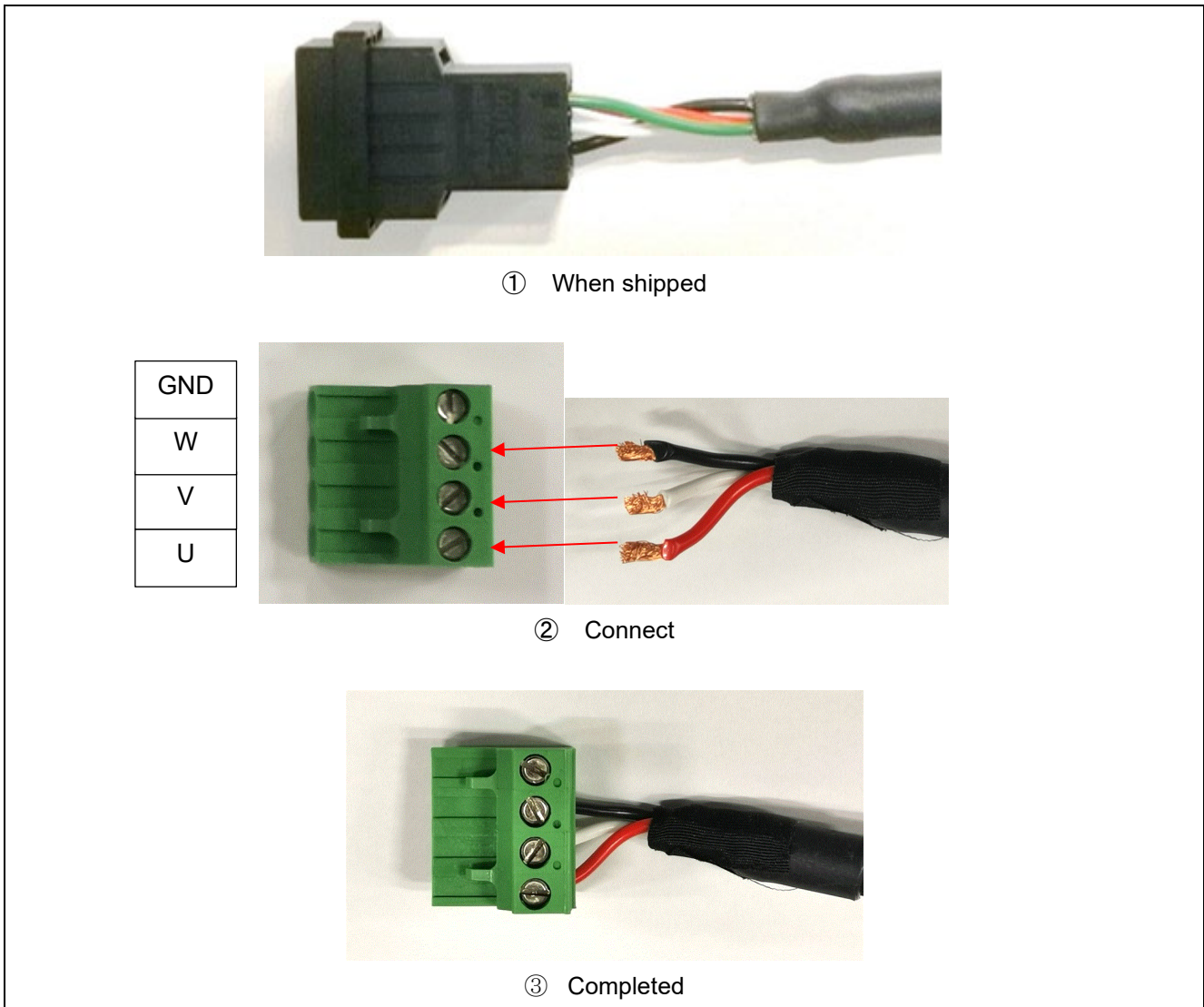| GND |
| --- |
| W |
| V |
| U |

② Connect

③ Completed

Figure 5-2 Motor cable processing

5.1.2 Connector for Encoder

When connecting the motor in Kit to Inverter Board, the connector should be processed before connecting. Process it as shown in Figure 5-3. When connecting other motors, process the connector similarly.

① When shipped, default connectors are attached to the motor in Kit, which are unnecessary for Inverter Board. These connectors are not used in this product.

② Detach the cable and connector with a tool such as a pair of nippers, remove the sheath from the end of the red, black, blue, and blue/brown cables, then connect them to the connector for absolute encoder, VDD1, GND, D0+, and D0-, respectively. In this product, connection of the brown (VB), brown/black (Sub GND), and thick black (SHIELD) is not required. Protect them with insulation tape etc. to prevent short circuit with other wiring.

③ Tighten the screws of the connector for absolute encoder.

① When shipped

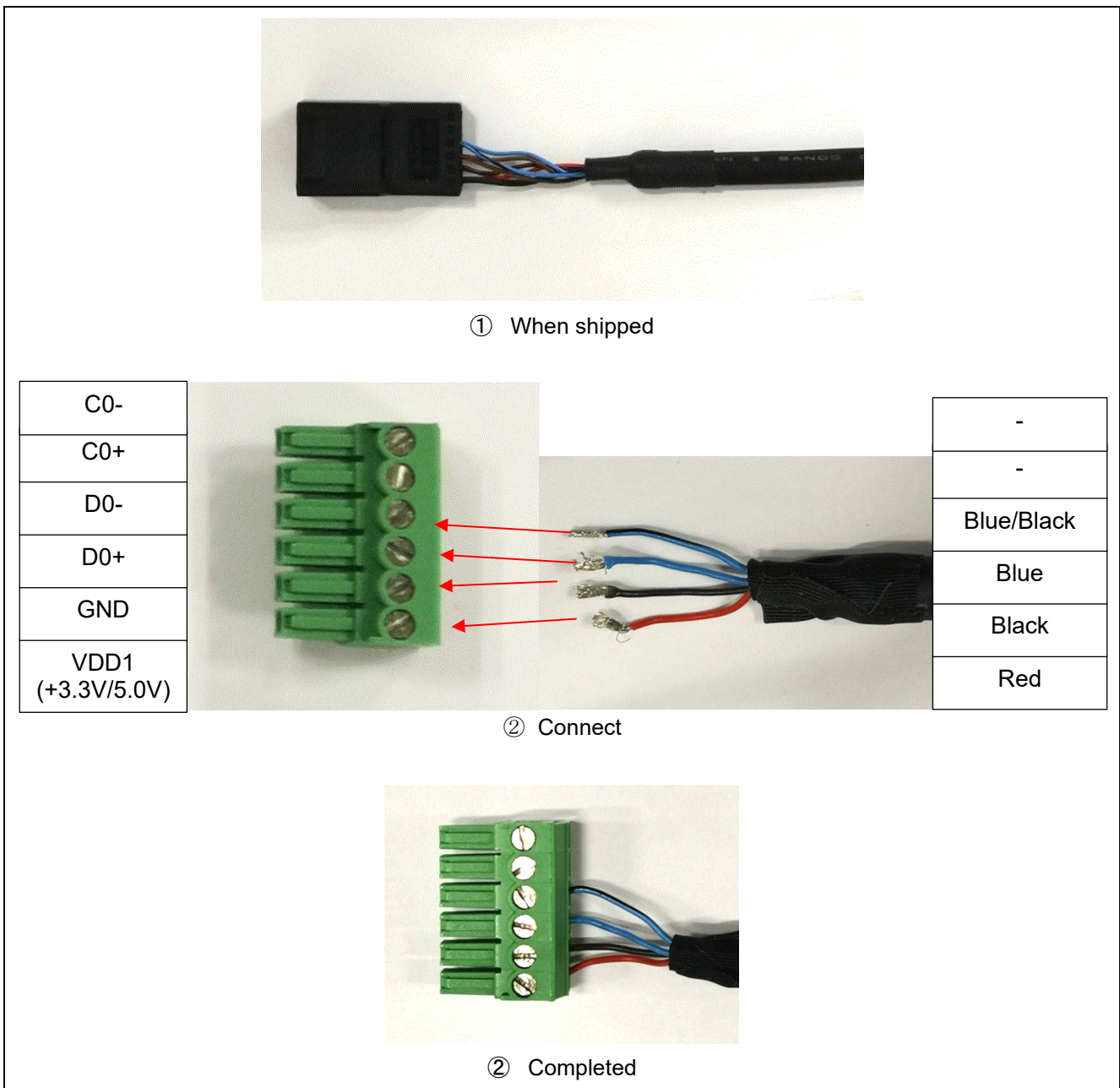| C0-	
C0+	-
D0-	Blue/Black
D0+	Blue
GND	Black
VDD1 (+3.3V/5.0V)	Red

② Connect

② Completed

Figure 5-3 Absolute encoder cable processing

5.2   MPU Evaluation Board Connection

Using the attached 50-pin flat cable allows Inverter Board to be connected to the MPU Evaluation Board.
Table 4-2 describes the pin functions of the 50-pin flat cable. Refer to the manual of each MPU Evaluation Board and Application Note, and attach QI contacts to the corresponding pins. The configuration of the attached 50-pin flat cable is assumed to be used with the motor in Kit. When using an absolute encoder 1 or incremental encoder, additional QI contacts should be attached.
For motor power supply, supply DC24V from CN_VM.
When using an incremental encoder or absolute encoder 1, each terminal is required to be implemented.

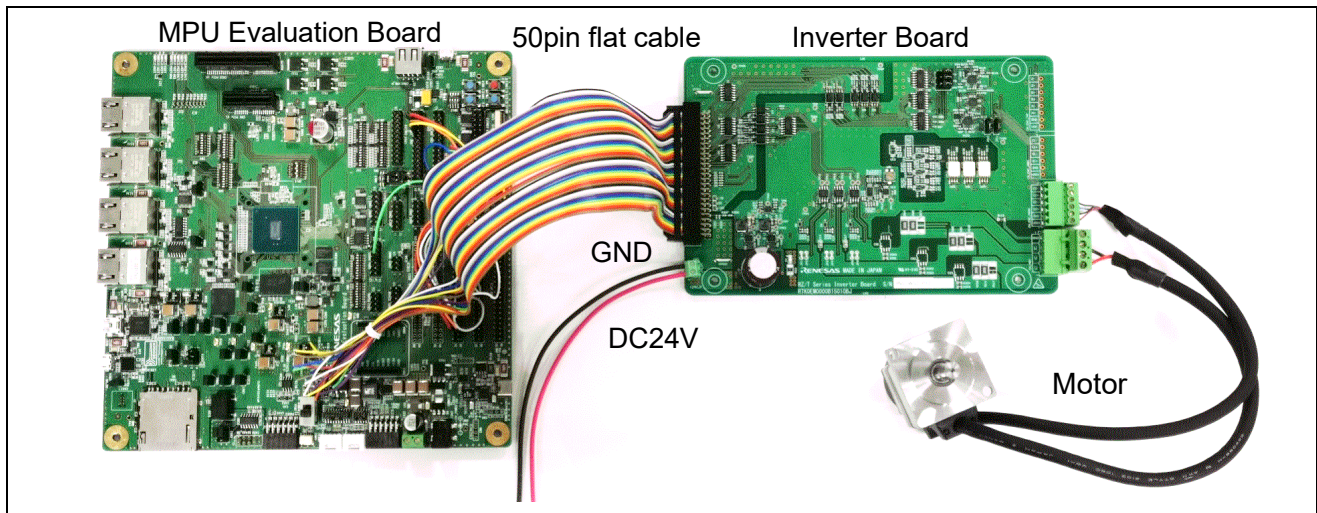
Figure 5-4 Connection of Inverter Board and MPU Evaluation Board

5.3   Bus Board Connection

Using Bus Board that supports Inverter Board allows multiple Inverter Boards to be easily connected to the MPU Evaluation Board. For the detailed connection, refer to the manual of Bus Board and Application Note. If using Bus Board, it is not required to connect motor power supply to CN_VM, since motor power supply can be applied from the INV_CON terminal.
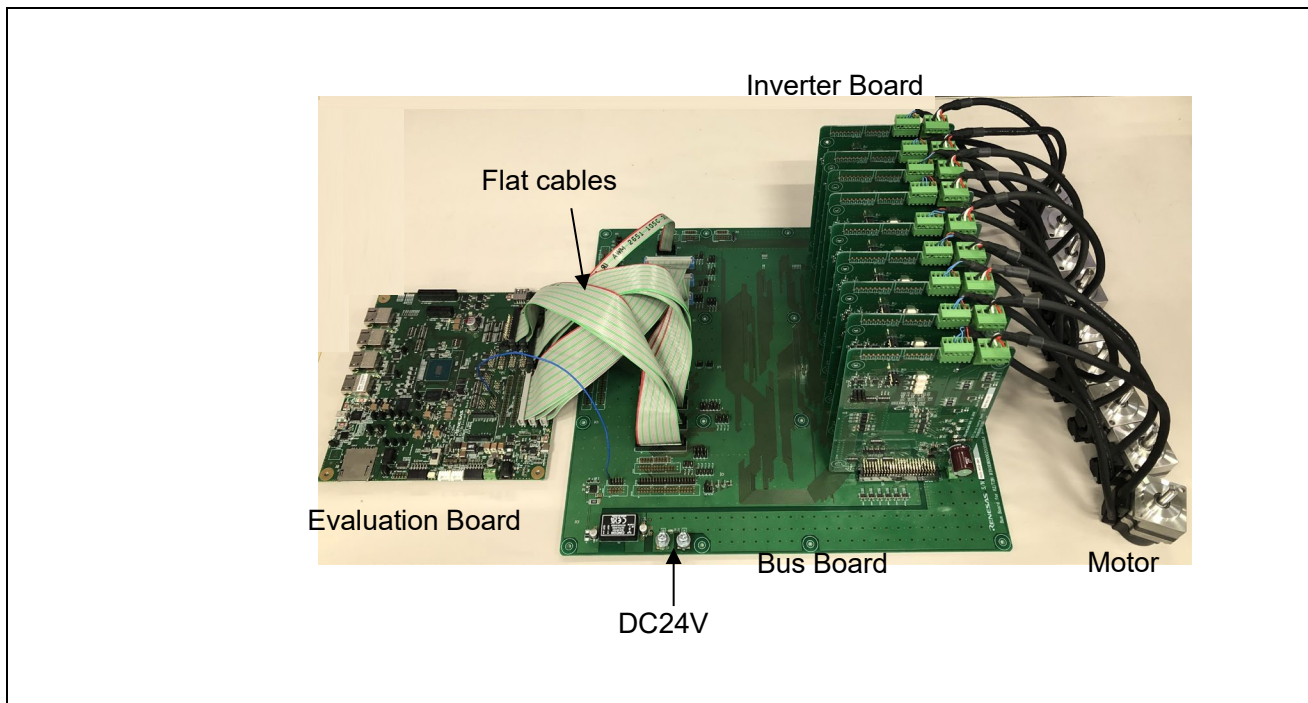

Figure 5-5 Connection of Inverter Boards and MPU Evaluation Board with Bus Board

6.　Functions

This section describes the functions of Inverter Board.

6.1　Power Supply

6.1.1　Power System

In Inverter Board, there are four kinds of power supply voltages (24V, 12V, 5V, 3.3V).

・+24V is supplied externally with GND pin referenced as motor power supply.

・+12V is generated from +24V as gate driver power supply.

・For 5V, there are +5V that is generated from +24V with GND pin referenced, and +5V_U, +5V_V, and +5V_W that are generated from +12V with each motor pin (U, V, W) referenced as Delta Sigma Modulator power supply for phase current sense.

The power supply for Delta Sigma Modulator is referenced to the motor pin voltage, and power is supplied when potential differences between each of U, V, and W and +12V are caused by motor drive. Note that when the motor is stopped, power supplying is not guaranteed, and accurate values may not be obtained.

・For 3.3V, there are +3.3V that is generated from +5V with GND pin referenced and VCC33_A that is supplied externally as power supply for MPU I/O with GND_A pin referenced.

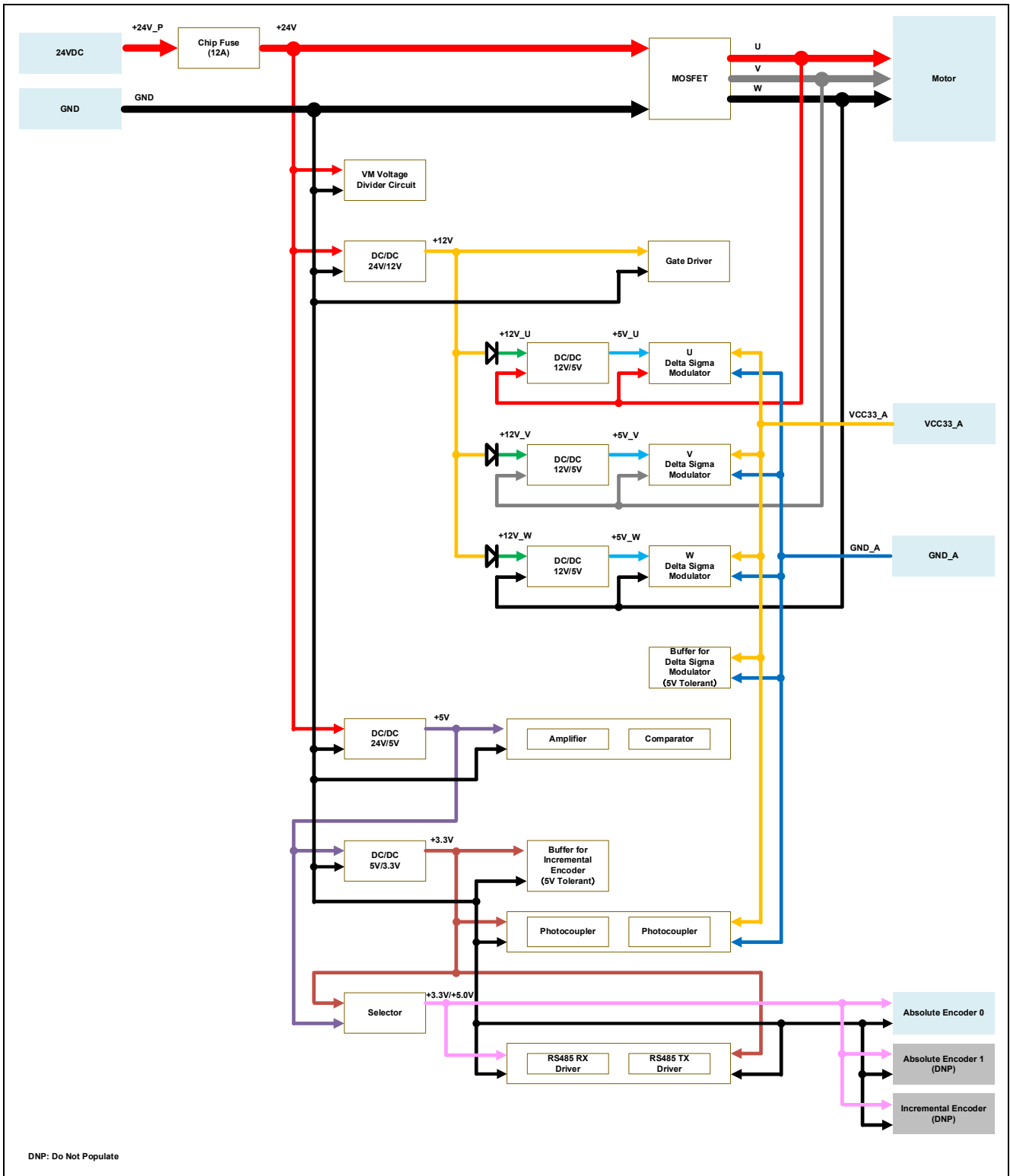Figure 6-1 shows the power system.

Figure 6-1 Inverter Board power system

6.1.2 Motor Power Supply Voltage Measurement Circuit

This is a voltage-dividing circuit for checking that the correct power supply voltage (VM) is supplied to MOSFET.
It divides the voltage supplied to +24V_P and outputs it with GND pin referenced.
When the voltage of +24V_P is 24V, a voltage of about 1.057V is output.
When measuring this circuit with the MPU ADC, the GND pin and GND_A pin should be common.

$$\mathrm{VM\_DIV[V]} = \frac{470[\Omega]}{5100[\Omega] \ + \ 5100[\Omega] \ + \ 470[\Omega]} \times \mathrm{VM[V]} \quad (1)$$
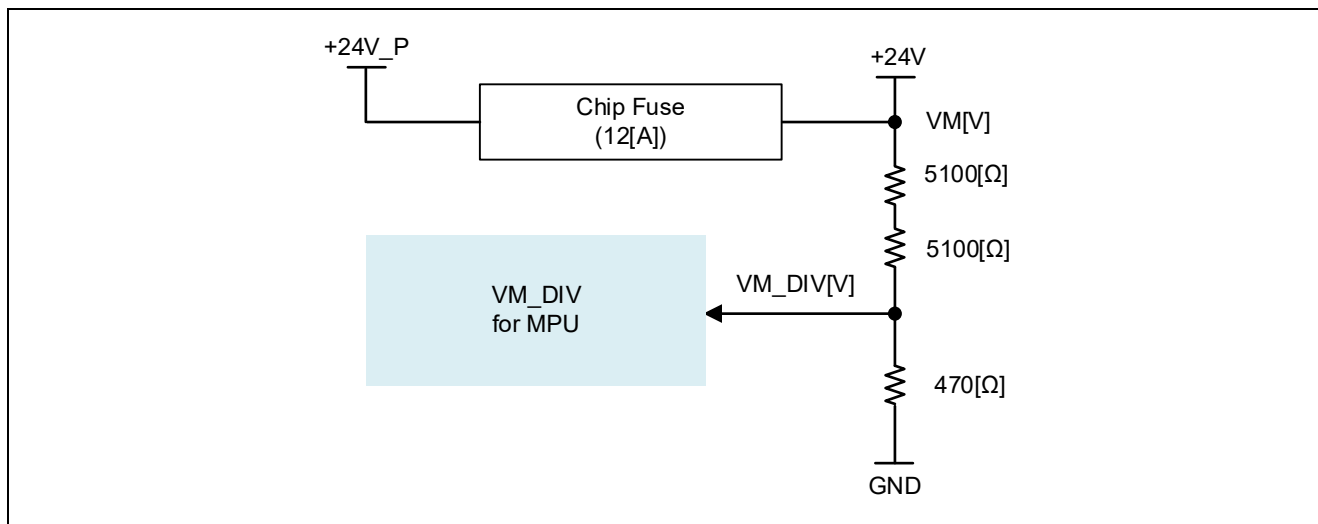

Figure 6-2 Motor power supply voltage measurement circuit

6.2   Inverter Control Circuit

The Inverter Board control circuit is a circuit that controls the motor with six Power MOSFETs.

In this product, the PWM signals (UP, UN, VP, VN, WP, WN) that are input from the MPU go through photocouplers and gate drivers and drive the POWER MOSFET gates.
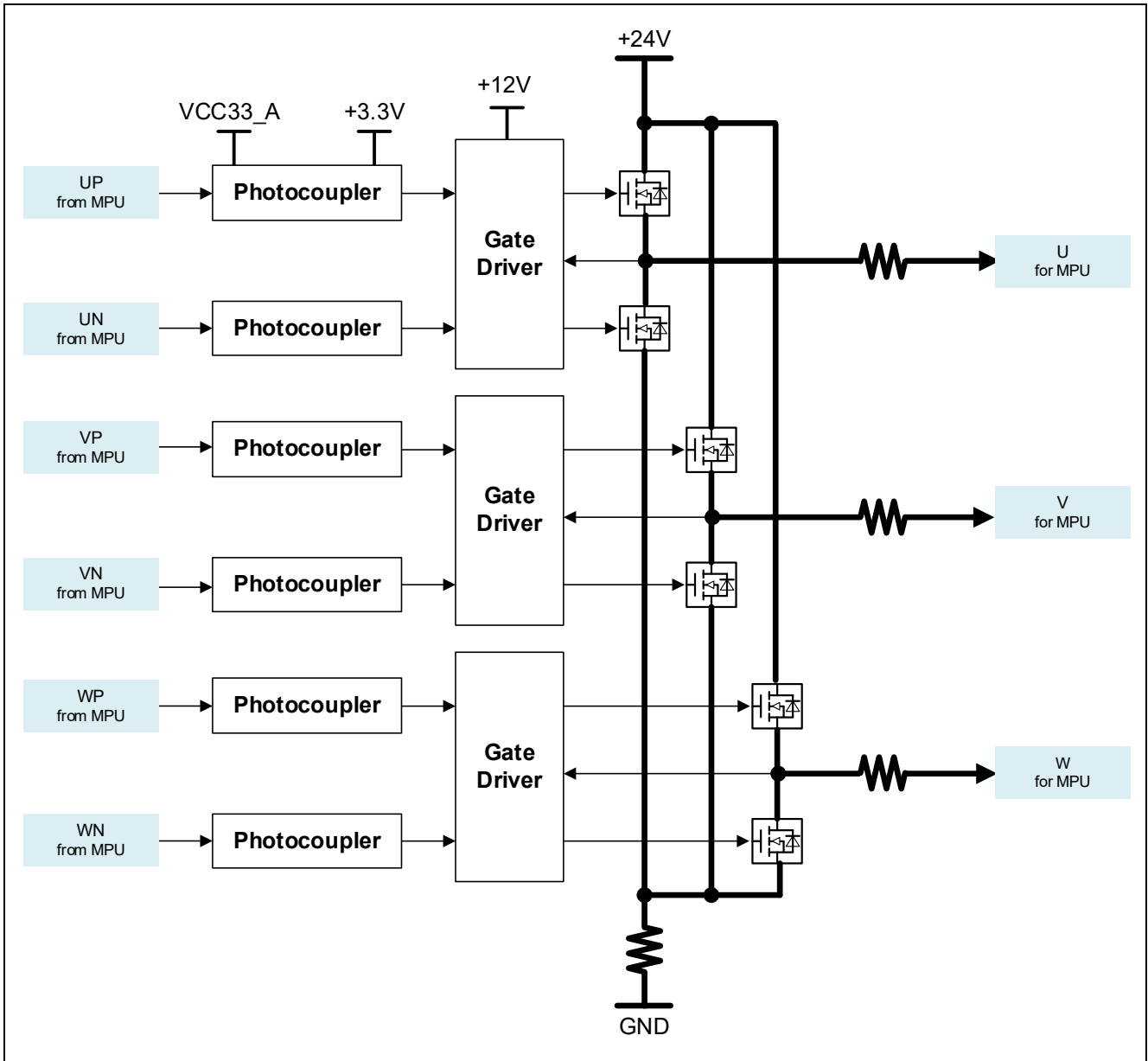It supports 3-shunt phase current sense and overcurrent detection for the GND pin.

Figure 6-3 Inverter control circuit

6.3 Phase Current Detection Circuit

6.3.1 Delta Sigma Modulator

By using Delta Sigma Modulator with a photocoupler on Inverter Board, the current flowing at each motor pin (U, V, W) can be detected. When the current flows to the motor side, it is positive current, and when the current flows to the inverter circuit side, it is negative current.

As the GNP pin of Delta Sigma Modulator is connected to each motor pin (U, V, W), the GND of the regulator that supplies power is each motor pin (U, V, W), and power is supplied to the regulator only when the motor is in motion. Therefore, this function may not be available when the motor is stopped.

$$I\_x[A] = \frac{((VIN + [V]) - (VIN - [V]))}{(0.016[\Omega] / 2)} \quad (2)$$

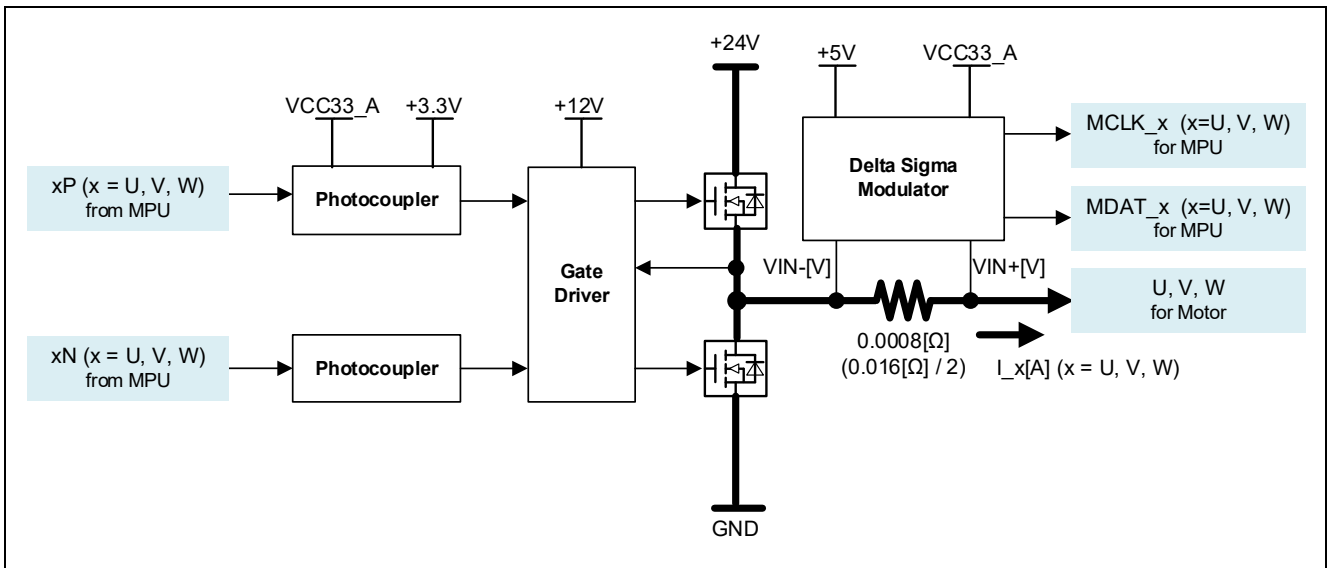
Figure 6-4 Phase current detection circuit (Delta Sigma Modulator)

6.3.2 Overcurrent Detection Circuit

This is a circuit that measures the current flowing from the Inverter Board control circuit to the GND and detects overcurrent.

If overcurrent is not detected, OC_DET is HIGH, and if overcurrent is detected, it changes to LOW.

As OC_DET is not latched, it returns to HIGH when the overcurrent detection is released by motor stop etc.

The threshold for overcurrent detection can be changed from 0A (left end) to ±25A (right end) with the variable resistor (VR1).

However, a chip fuse (12A) is provided in the power supply circuit of Inverter Board. When overcurrent continues on the board due to MOSFET failure etc., the chip fuse is blown regardless of OC_DET detection, and the power supply to Inverter Board is shut down. The overcurrent detection formula is shown below.

$$|IDC[A]| > \left(\frac{(VR1[\Omega] + 10000[\Omega]) \times 5[V]}{(10000[\Omega] + 10000[\Omega])} - 2.5[V] \right) / (0.010[\Omega] \times 10) \quad (3)$$

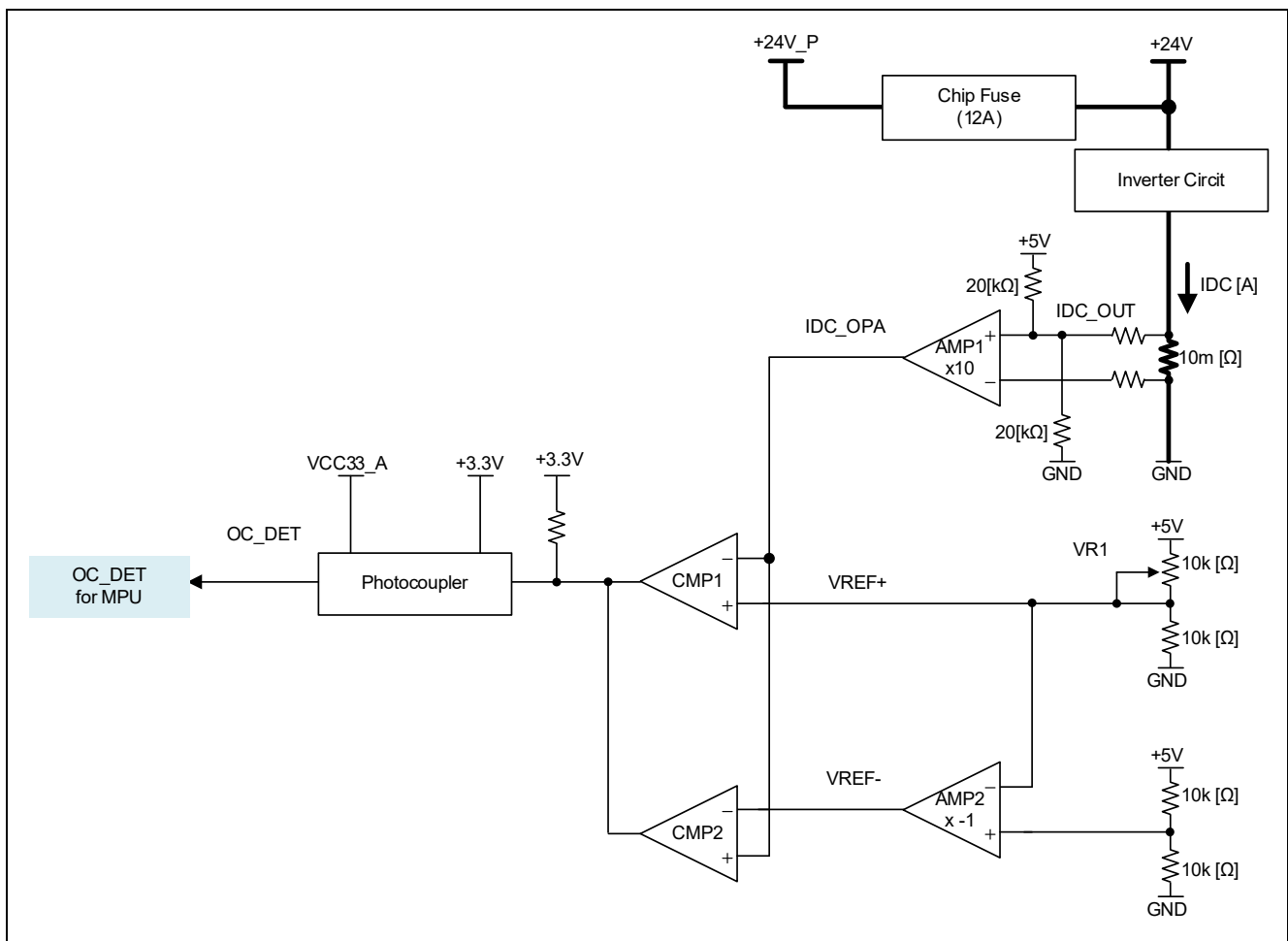$$0 < VR1 < 10000[\Omega] \quad (4)$$

Figure 6-5 Overcurrent detection circuit

6.4   Encoder

Inverter Board supports three channels of encoder I/O. When shipped, the connectors for absolute encoder 1 and incremental encoder are not implemented. Users should implement them for use.

6.4.1   Absolute Encoder

Inverter Board is equipped with two channels of absolute encoder terminals.
Inputs and outputs to the absolute encoder are each via a differential interface IC (RS485 RX/TX Driver).
I/O power supply voltage for absolute encoder can be selected from +3.3V or +5.0V.
When shipped, only the connector for absolute encoder 0 is implemented. As the connector for absolute encoder 1 is not implemented, users should implement it to use this function.
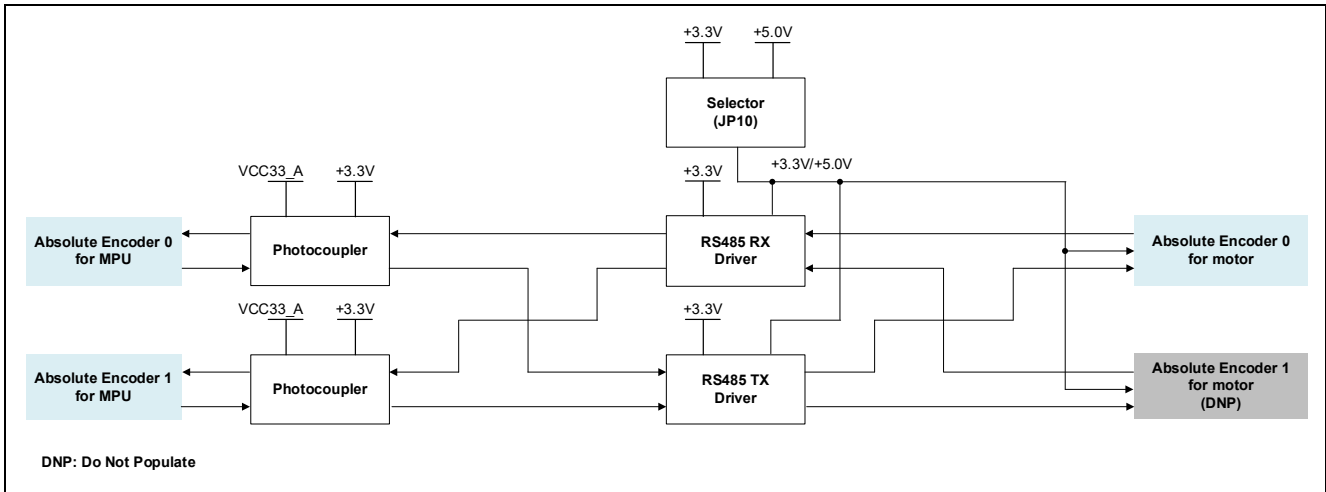

Figure 6-6 Absolute encoder control circuit

6.4.2   Incremental Encoder

Incremental encoder input can be selected from two channels, single-end input (use Buffer) or differential input (use RS485 RX Driver). The I/O power supply voltage of incremental encoder can be selected from +3.3V or +5.0V as well. Select one depending on the specification of the motor in use.
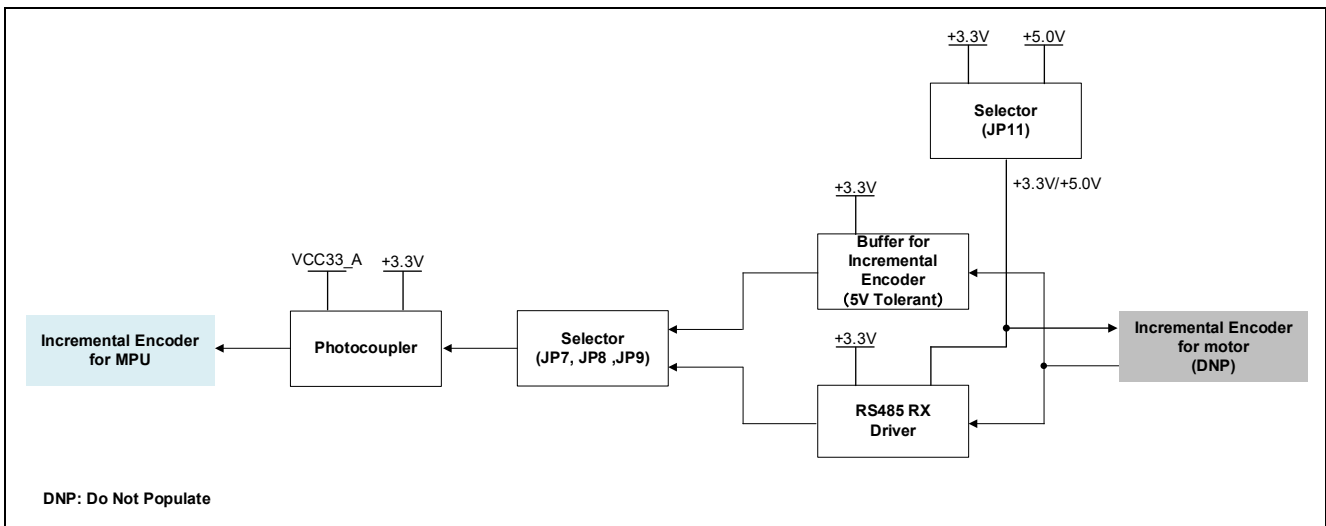Users should implement the connector to use this terminal.

Figure 6-7 Incremental encoder control circuit

7. Information on Regulations

This product complies with the following directive.
- EMC Directive   : 2014/30/EU (EN61326-1:2021)
  EMI   : Class A
  EMS   : Industrial Electromagnetic Environment

In this product, the following components have been used for EMC test.
  RZ/T Series Inverter Board (RTK0EM0000B15010BJ) x 9
  Motor (TSM3101N2001E020, TAMAGAWA SEIKI Co., Ltd) x 9
  RZ/T2H Evaluation Board Kit (RTK9RZT2H0S00000BJ)
  Bus Board for RZ/T2H (RTK0EM0000Z03000BJ)

Measures for compliance with regulations:

1. Ferrite Core (Manufacturer: SEIWA, Product No.: E04SR200935A, 1-turn)
   Attach two cores to the motor cable of the first axis.
   Attach one core to each of the motor cables of the second through ninth axis.
   Attach one core to the encoder cable of the first axis.
2. Ferrite Core (Manufacturer: TDK, Product No.: ZCAT2035-0930, 1-turn)
   Attach one core to each of the motor cables of the second through ninth axis.
   Attach one core to each of the encoder cables of the second through ninth axis.
3. Ferrite Core (Manufacturer: TDK, Product No.: ZCAT6819-5230D, 1-turn)
   Attach two cores to the 30-pin flat cable connecting between CN18 on RZ/T2H Evaluation Board and CN18A on Bus Board
   Attach two cores to the 30-pin flat cable connecting between CN21 on RZ/T2H Evaluation Board and CN21A on Bus Board.
   Attach two cores to the 30-pin flat cable connecting between CN22 on RZ/T2H Evaluation Board and CN22A on Bus Board.
   Attach one core to the 36-pin flat cable connecting between CN24 on RZ/T2H Evaluation Board and CN24A on Bus Board.
   Attach one core to the 36-pin flat cable connecting between CN25 on RZ/T2H Evaluation Board and CN25A on Bus Board.
   Attach one core to the 36-pin flat cable connecting between CN26 on RZ/T2H Evaluation Board and CN26A on Bus Board.
4. Ferrite Core (Manufacturer: TDK, Product No.: ZCAT4625-3430D, 1-turn)
   Attach one core to the 30-pin flat cable connecting between CN2 on RZ/T2H Evaluation Board and CN2A on Bus Board.
   Attach one core to the 30-pin flat cable connecting between CN3 on RZ/T2H Evaluation Board and CN3A on Bus Board
5. Ferrite Core (Manufacturer: KGS, Product No.: GTFC-25-15-12, 3-turn)
   Attach one core to the 10-pin flat cable connecting between CN19 on RZ/T2H Evaluation Board and CN19A on Bus Board
6. Ferrite Core (Manufacturer: SEIWA, Product No.: E04SR301334, 1-turn)
   Attach one core to the 10-pin flat cable connecting between CN19 on RZ/T2H Evaluation Board and CN19A on Bus Board.
7. Ferrite Core (Manufacturer: TDK, Product No.: ZCAT3035-1330, 1-turn)
   Attach one core to the 10-pin flat cable connecting between CN19 on RZ/T2H Evaluation Board and CN19A on Bus Board.
8. Ferrite Core (Manufacturer: SEIWA, Product No.: E04SR401938, 8-turn)
   Attach one core to the 15V AC adaptor of RZ/T2H Evaluation Board.
9. Ferrite Core (Manufacturer: KGS, Product No.: KRFC-9, 3-turn)
   Attach one core to the 15V AC adaptor of RZ/T2H Evaluation Board
10. Ferrite Core (Manufacturer: SEIWA, Product No.: E04SR301334, 4-turn)
    Attach one core to the DC24V power supply cable.
11. Ferrite Core (Manufacturer: TDK, Product No.: ZCAT1518-0730, 2-turn)
    Attach one core to the DC24V power supply cable.
12. Ferrite Core (Manufacturer: KGS, Product No.: KRFC-10, 2-turn)
    Attach one core to the DC24V power supply cable.

8. Design and Manufacture Information

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

9. Website and Support

In order to learn, download tools and documents, apply technical support for RZ family MPU and its kit, visit the below website.
• RZ Product Information renesas.com/rz
• Renesas Support renesas.com/support

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Nov.15.2024	-	First Edition

RZ/T Series Inverter Board/Kit
User's Manual

RENESAS

Renesas Electronics Corporation