Renesas Solution Starter Kit
Motor Control Evaluation System
-Motor Control IC : RAJ306010－
User's Manual

General purpose Motor control IC

Renesas Electronics
www.renesas.com

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(Rev.3.0-1 November 2016)

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. 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 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. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2. Processing at Power-on

   The state of the product is undefined at the moment 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 moment 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 moment 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 moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses Access to reserved addresses is prohibited.
   The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals

   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has 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. Moreover, 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.

5. Differences between Products

   Before changing from one product to another, i.e. to a product with a different part number, confirm that the change will not lead to problems.

   The characteristics of Microprocessing unit or Microcontroller unit products in the same group but having a different part number may differ in terms of the 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.

For Your Safety

Do not fail to read this manual before using the RAJ306010 Renesas Solution Starter Kit
(RTK0EML2C0S01020BJ) (this product).

- Follow the indications in this manual when using the product.
- Keep this manual near the product so you can refer to it whenever necessary.
- Transfer or sale of the product to third parties is prohibited without written approval.
- The purchaser or importer of the product is responsible for ensuring compliance with local regulations. In addition, the customer is responsible for ensuring that the product is handled correctly and safely, in accordance with the laws of the customer's country (region).
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Meaning of Notations

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

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

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

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

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

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

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

- Marks indicating that an action is prohibited.

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

- Marks indicating that an action is prohibited.

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

- Marks directing that the specified action is required.

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

■ Danger Items

<div align="center">

⚠ **Danger**

</div>

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

■Warning Items

<div align="center">

⚠ **Warning**

</div>

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

■ Caution Items

	⚠ **Caution**	
⚠	Caution – Hot! ● The motor gets hot. Touching it could cause high-temperature burns.	
❗	Follow the procedure specified in the manual when powering the system on or off. ● Failure to do so could cause overheating or malfunction.	
⚠	Caution – Static Electricity ● Use the antistatic band. Failure to do so could cause malfunction or unstable motion.	

How to Use This Manual

Readers   This manual is intended for user engineers who wish to understand the functions of the RL78/G1F and design and develop application systems and programs for these devices. The target products are as follows.

- 64-pin: RAJ3060xx (xx = 01,10)

Purpose   This manual is intended to give users an understanding of the functions described in the **Organization** below.

Organization   The RAJ306000 series manual is separated into three parts: this manual, RL78/G1F hardware Manual and the software edition. This manual explains the function unique to RAJ306000 series. For detailed usage of the RL78/G1F microcomputer, refer to the RL78 / G1F User's Manual Hardware(R01UH0516E) and "Technical Update" on RL78/G1F. (common to the RL78 family).

RAJ306000 Series User's Manual Hardware (This Manual)	RL78/G1F User's Manual Hardware	RL78 Family User's Manual Software

About RAJ36000

- Pin functions
- Internal block functions
- Pre-Driver function
- How to use RL78/G1F

About RL78/G1F

- Pin functions
- Internal block functions
- Interrupts
- Other on-chip peripheral functions
- Electrical specifications

- CPU functions
- Instruction set
- Explanation of each instruction

How to Read This Manual

It is assumed that the readers of this manual have general knowledge of electrical engineering, logic circuits, and microcontrollers.

•To gain a general understanding of functions:

→ Read this manual in the order of the **CONTENTS**. The mark "<R>" shows major revised points.   The revised points can be easily searched by copying an "<R>" in the PDF file and specifying it in the "Find what:" field.

•How to interpret the register format:

•To know details of the RL78/G1F Microcontroller instructions:

→ Refer to the separate document **RL78 Family User's Manual Software(R01US0015E).**

Conventions

Data significance: Higher digits on the left and lower digits on the right

Active low representations: $\overline{\times\times\times}$ (overscore over pin and signal name)

Note: Footnote for item marked with Note in the text

Caution: Information requiring particular attention

Remark: Supplementary information

Numerical representations: Binary   ·· $\times\times\times\times$ or $\times\times\times\times$B

Decimal   ·· $\times\times\times\times$

Hexadecimal.. $\times\times\times\times$Hor 0x$\times\times\times\times$

Related Documents

The related documents indicated in this publication may include preliminary

versions.   However, preliminary versions are not marked as such.

Documents Related to Devices

Document Name	Document No.
RAJ306000 Series User's Manual Hardware	R18UZ0066E
RL78/G1F User's Manual Hardware	R01UH0516E
RL78 Family User's Manual Software	R01US0015E
Data sheet RAJ306001, RAJ306010 (General-Purpose Motor Control IC)	R18DS0034E

Documents Related to Flash Memory Programming (User's Manual)

Document Name	Document No.
PG-FP5 Flash Memory Programmer	-
RL78, 78K, V850, RX100, RX200, RX600 (Except RX64x), R8C, SH	R20UT2923E
Common	R20UT2922E
Setup Manual	R20UT0930E

Caution The related documents listed above are subject to change without notice.   Be sure to use the latest version of each document when designing. Other Documents

Document Name	Document No.
Renesas Microcontrollers RL78 Family	R01CP0003E
Semiconductor Package Mount Manual	R50ZZ0003E
Semiconductor Reliability Handbook	R51ZZ0001E

Caution The related documents listed above are subject to change without notice.   Be sure to use the latest version of each document when designing.

Caution: This product uses SuperFlash® technology licensed from Silicon Storage Technology, Inc.

Renesas Solution Starter Kit

Motor Control Evaluation System - Motor Control IC: RAJ306010

This product is a kit for evaluating motor system using RAJ306010. It consists of a board with RAJ306010 mounted, a small 24V motor, and a connecting cable.

Contents

1. Overview

1.1 Abstract

This product is a kit for evaluating motor system using RAJ306010. It consists of a board with RAJ306010 mounted, a small 24V motor, and a connecting cable.

RAJ306010 is initially equipped with a sample code for 120° conduction control using a Hall IC, and a basic evaluation of motor control can be performed simply by connecting a 24V DC power supply and the attached motor. In addition, it is possible to connect and evaluate a motor and MOSFET prepared by user.

Related Documents:

The related documentation and sample code of the RAJ306010 RSSK can be downloaded from our motor solution website.

Motor Solution Website:

https://www.renesas.com/us/en/application/home-building/motor-control-solutions:

- RAJ306010 RSSK: R18UZ0078EJ
- RAJ306010 Evaluation Board Schematic: R18TU0001EJ
- RAJ306010 Evaluation Board BOM LIST: R18TU0002EJ
- RAJ306010 Evaluation Board PWB Pattern Drawing: R18TU0003EJ

RAJ306010 Product Information Website:

https://www.renesas.com/us/en/products/power-power-management/motor-control-ics/raj306010-general-purpose-motor-control-ic

Package Contents

Item	RAJ306010 Evaluation Board (RTK0EML2C0D05020BJ)	Number
Board	RAJ306010 Evaluation Board	1
Motor	TG-55L-KA 24V	1
Connection Cable	TG-55L-KA 24V Cable	1
Paper material	Renesas Solution Starter Kit Motor Control Evaluation System - Motor Control IC: RAJ306010 - Information	1
	Caution regarding the Renesas Solution Starter Kit Motor Control Evaluation System - Motor Control IC: RAJ306010 - (RTK0EML2C0S01020BJ)	1

Equipment to prepare for

Item	Model name (Specification)
Power supply	Use the attached motor: 24V/2A
Emulator	Emulator corresponding to the RL78 (E2, E2Lite, E20, E1, etc.) Note.1
USB cable	USB mini-B type Note.2
Motor (optional)	Connecting a motor other than the attached motor.
Shunt resistor (optional)	When connecting a motor prepared by the user, change the shunt resistance according to the characteristics of the motor.

Note.1 The emulator, E2, E2Lite, etc., is necessary to rewrite the firmware.

Note.2 USB cable for connecting with PC is necessary to use ICS.

1.2 Feature

1. **Easy to start the motor control evaluation with RAJ306010.**
   Since reference firmware has already been written on the RAJ306010, by connecting the attached small motor to the board and supplying power, evaluation can be start immediately.

2. **High expandability and operability by small board (about B6 size: 148mm * 125mm).**
   The board is small and easy to operate, but, since switches, potentiometers, LEDs and thermistors are mounted, their functions can be used by using the user program.

3. **Connectable to the external MOSFET board.**
   By setting the switching pin, it is possible to select mounted MOSFET and external MOSFET.

4. **Various sample codes for the basic motor drive.**
   Sample code of basic control required for BLDC Motor control can be downloaded from the website

   - Hall IC 120° conduction control
   - Hall IC 120° energization speed control
   - Hall IC 120° conduction control
   - Hall IC 120° energization speed control

   RAJ306010 Sample code download web-site:
   https://www.renesas.com/us/en/products/power-power-management/motor-control-ics/raj306010-general-purpose-motor-control-ic
   Refer to "4.2 Emulator connection" for the devices and procedures required to rewrite the firmware.

5. **Support Desktop Lab ICS tool. (ICS: PC tool for waveform display)**
   ICS is a tool for monitoring and changing global variables in operation from a PC. Note.2
   Refer to Desktop Lab's website for detail features and operation methods.

   Desk Top Laboratories Inc. URL: http://www.desktoplab.co.jp/download.html

   Note.1 The attached motor does not support encoder vector control. When evaluating encoder vector control, prepare the motor corresponding to the encoder control by the user.

   Note.2 When using ICS, the general-purpose UART function cannot be used.

2.   Specification Overview

2.1   Specification list

Table 2-1. RAJ306010 RSSK specification list

Item	Specification
Board model name	RTK0EML2C0D05020BJ
Power supply	VM power supply range: DC6V-42V Use a stable power supply such as a regulated power supply or a battery. (Use attached motor: DC24V/2A power supply)
Operation temperature	Room temperature
Operation humidity	Non-condensation
MOSFET	TPH2R506PL,L1Q [TOSHIBA] 60V 160A
Sensor	Hall IC, Encoder
Connector	■ External MOSFET connector (CN_INV) [Note.2] ■ Emulator connector (CN_E1) ■ Hall sensor signal input connector (CN_HALL) [Note.2] ■ Encoder signal input connector (CN_ENC) [Note.2] ■ Analog general-purpose input/output connector [Note.1, Note.2] ■ Digital general-purpose input/output connector [Note.1, Note.2] ■ I2C communication connector (CN_I2C) [Note 1, Note.2] ■ SPI communication connector (CN_SPI) [Note.1, Note.2] ■ UARTcommunication connector (CN_UART) [Note.1, Note.2] ■ External volume connector (CN_VOL) [Note 1]
Switch/Potentiometer	■ Toggle switch × 1 ■ Push switch × 1 ■ Potentiometer ×1
LED	User control LED × 6 Power supply indication LED× 1
Wave viewer tool	Support Desktop Lab ICS tool. The latest tool can be received from the Desk Top lab's website. ICS occupies the resources of UART1 and DTC. Therefore, when using ICS, P02(TxD1) and P03(RxD1) cannot be used for other functions.

Note.1 Since the terminal is not mounted, please mount it at the time of use.
Note.2 There is a through hole for monitoring.

2.2　Board

2.2.1.　Main parts and terminals

The main parts and terminals of the board are as follows:
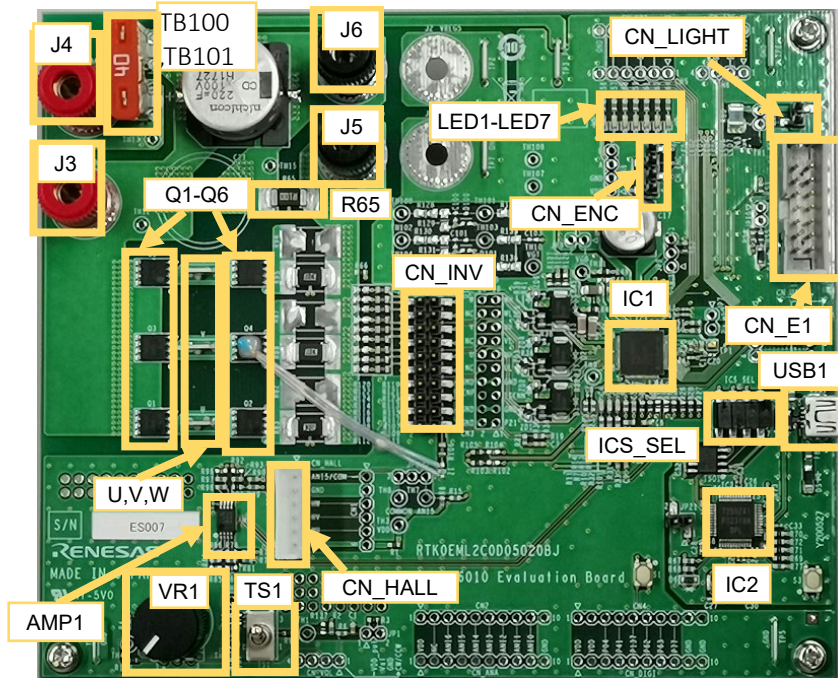
Figure 2-1. Main parts and terminals

Table 2-2. Main parts list

Parts number	Item
IC1	RAJ306010GNP (for motor control)
IC2	RX231 (for ICS communication control)
AMP1	Phase current detection amplifier (U-Phase, W-Phase)
CN_E1	Emulator connector
CN_ENC	Encoder signal input connector
CN_HALL	HALL IC signal input connector
CN_INV	External MOSFET connector
CN_LIGHT	High brightness LED connector
ICS_SEL	ICS connection select terminal
J3	VM connection terminal for external MOSFET
J4	VM connection terminal
J5	GND connection terminal for external MOSFET
J6	GND connection terminal
JP4, JP5	Power supply current detection resistor selection terminal
JP11	Thermistor for MOSFET connection selection terminal
JP12-JP20	MOSFET connection selection terminal
LED1-LED7	LED
Q1-Q6	MOSFETs (TPH2R506PL)
R65	Shunt resistor (Power supply current detection)
TS1	Toggle switch
USB1	USB connector for ICS connection
U, V, W	Motor driving output terminal
VR1	Potentiometer
TB100,TB101	Fuse (Fuse holder)
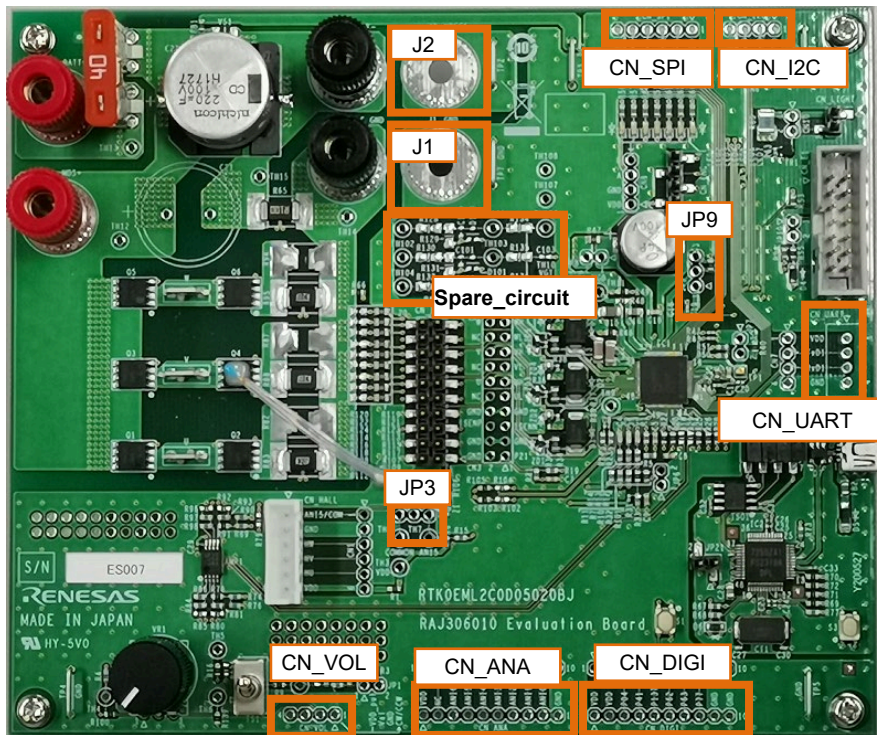
Figure 2-2. Main parts and terminal (Non-mounted)

Table 2-3. Main parts list (Non-mounted)

Parts number	Item
CN_ANA	Analog general-purpose input/output connector
CN_DIGI	Digital general-purpose input/output connector
CN_I2C	I2C communication connector
CN_SPI	SPI communication connector
CN_UART	UART communication connector
CN_VOL	External volume connector
J1	GND connection terminal
J2	5V Power supply connection terminal (When using internal 5V regulator of RAJ306010, No need for external 5V power supply)
JP2	Power supply selection terminal for HALL-IC
JP3	COMMON/Thermistor selection terminal
JP9	5V regulator selection terminal
Spare_circuit	Spare circuit

2.2.2. Block diagram

The board is initially written with a program that performs basic operations of 120° conduction control. its functional block diagram is shown in Figure 2-3.

Also, the board has extended functions such as communication terminals and LED terminals. A block diagram of all the functions is shown in Figure 2-4.
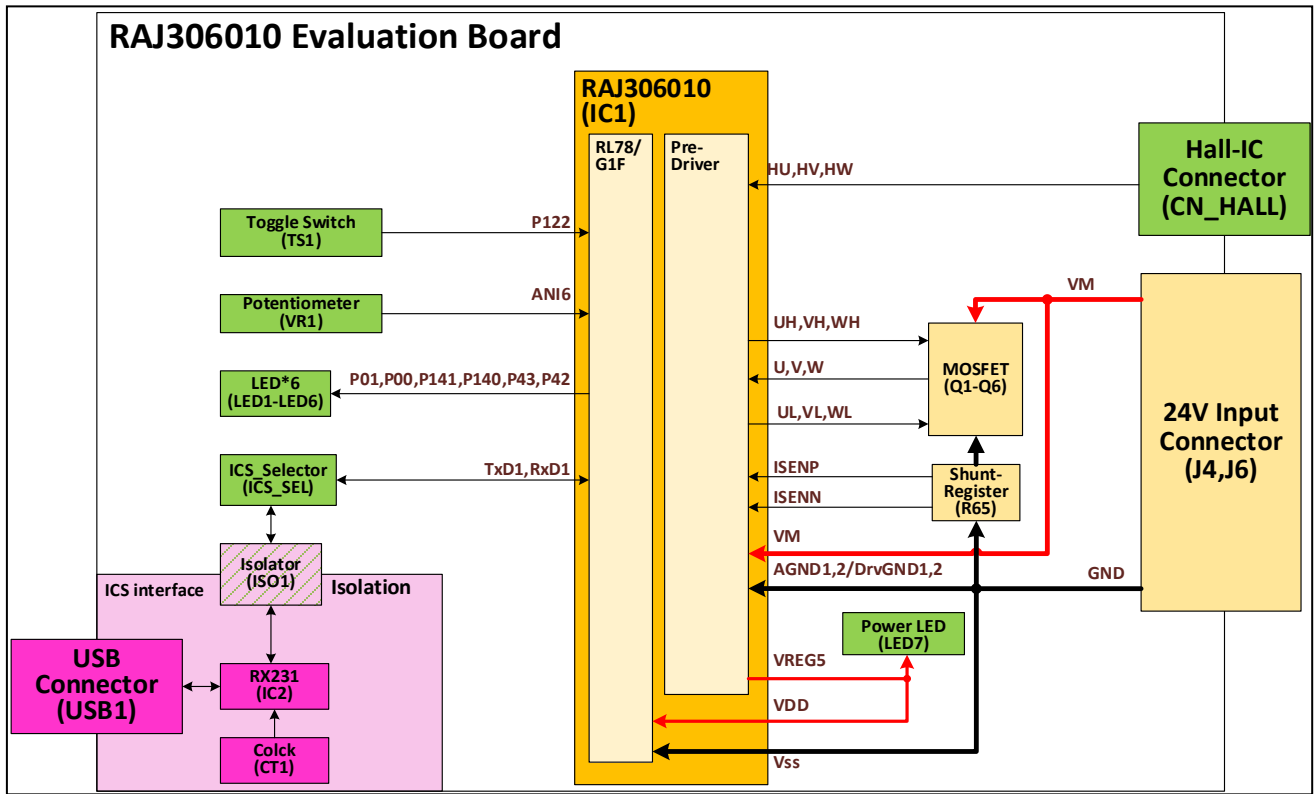
Figure 2-3. Outline functional block diagram
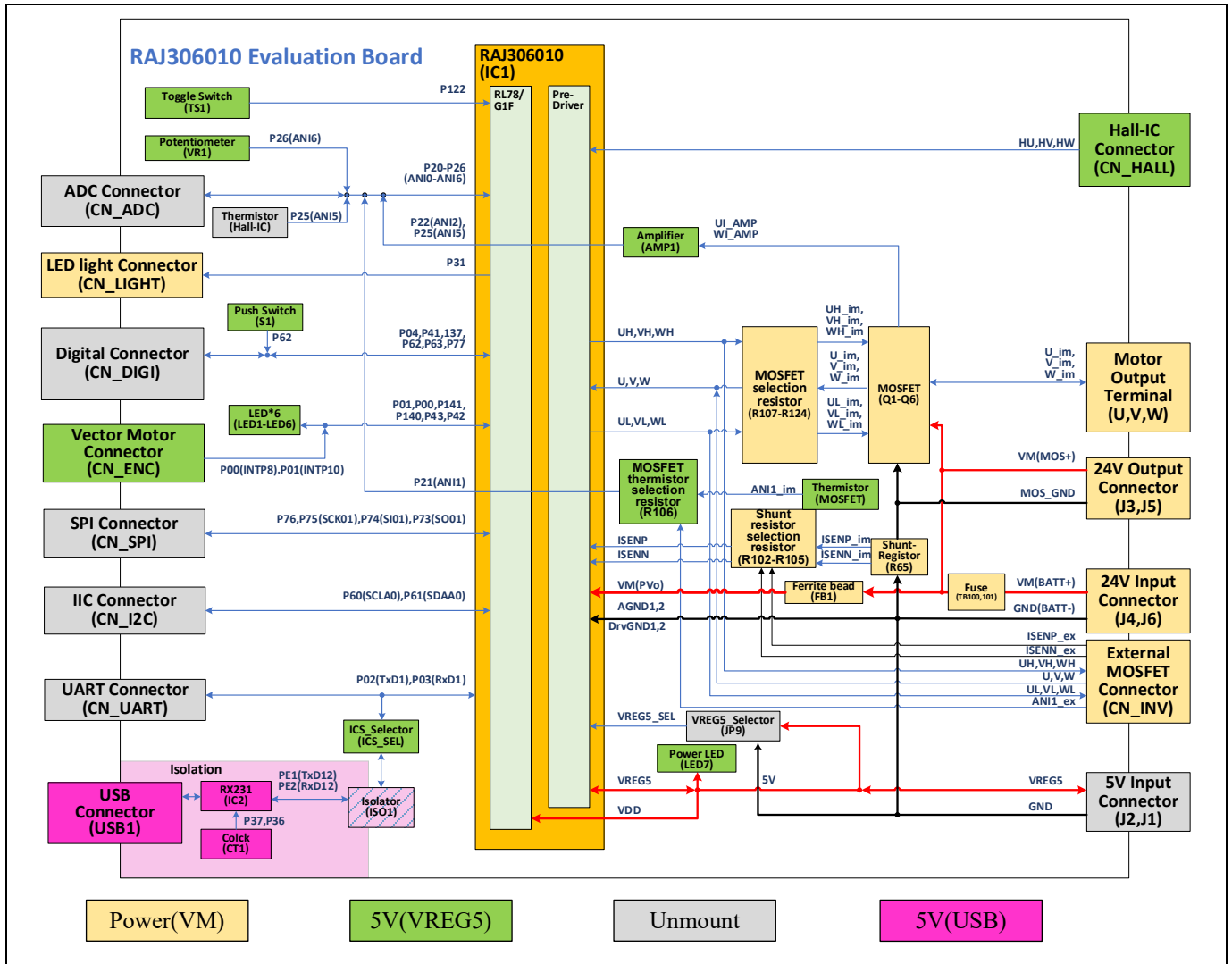
Figure 2-4. RAJ306010 Board Block diagram

2.2.3. Motor [TG-55L-KA 24V(TSUKASA ELECTRIC CO.,LTD)]

Refer to TSUKASA ELECTRIC website for the latest specifications.

Table 2-4. TG-55L-KA 24V Motor specification

Rated Voltage (V)	24
Rated Speed (rpm)	2650
No-Load Speed (rpm)	3900
Rated Current (mA)	420
No-Load Current (mA)	85
Torque (mN·m)	19.6

2.2.4. Cable for motor connection

This cable is used to connect the board and the evaluation motor.

1. Motor terminal

2. W terminal (Blue)

3. V terminal (White)

4. U terminal (Orange)

5. HALL-IC connector
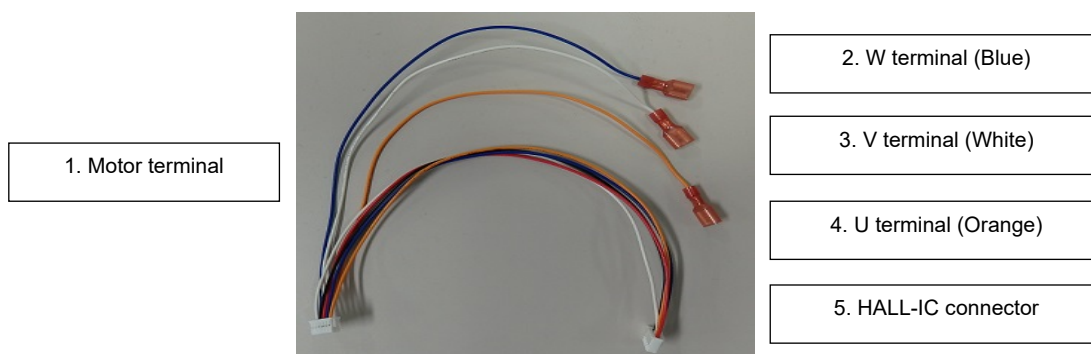
Table 2-5. Motor cable terminal parts

Parts number Item	Product name	Maker
1	PHDR-12VS	J.S.T
2,3,4,	TMEDN 630809-FA	NICHIFU
5	XHP-6	J.S.T

2.3   Information

2.3.1.   European Union regulatory notices

This product complies with the following EU Directives.

(These directives are only valid in the European Union.)

CE Certifications:

- · Electromagnetic Compatibility (EMC) Directive 2014/30/EU

EN61326-1 : 2013 Class A

WARNING: This is a Class A product. This equipment can cause radio frequency noise when used in

the residential area. In such cases, the user/operator of the equipment may be required

to take appropriate countermeasures under his responsibility.

- Information for traceability
- Authorized representative

   Name: Renesas Electronics Corporation

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

- Manufacturer

   Product name: Renesas Solution Starter Kit

      Motor Control Evaluation System -Motor Control IC : RAJ306010 –

      Type name: RTK0EML2C0S01020BJ

   Environmental Compliance and Certifications:

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

3. How to use

3.1 Quick start (Use the mounted MOSFET and attached motor)

3.1.1. Confirmation items before operation

1. Check the following 0Ω jumper settings.

   - MOSFET selection resistors (R107-R124): Mounted right side

   - MOSFET thermistor selection resistor (R106): Mounted

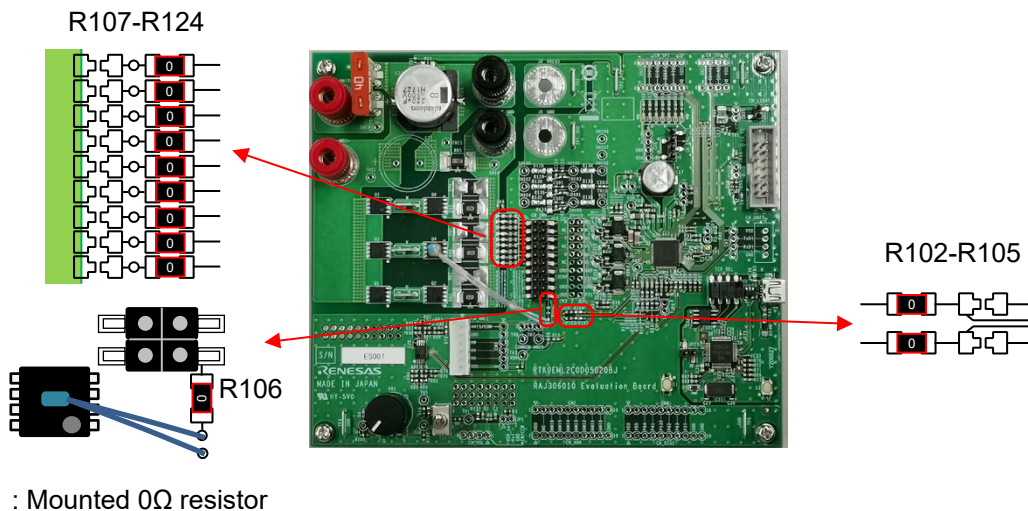   - Shunt resistor selection resistors (R102-R105): Mounted left side

0 : Mounted 0Ω resistor

Figure 3-1. Terminal setting to select connection (Use the MOSFET on board)

2. Check the following connection and settings.

- Turn potentiometer VR1 counterclockwise to the end so that the motor does not rotate at the power on.
- Connect the board and motor with motor connection cable
- Connect VM input terminal (J4) to positive side of power supply, GND input terminal (J6) to GND.
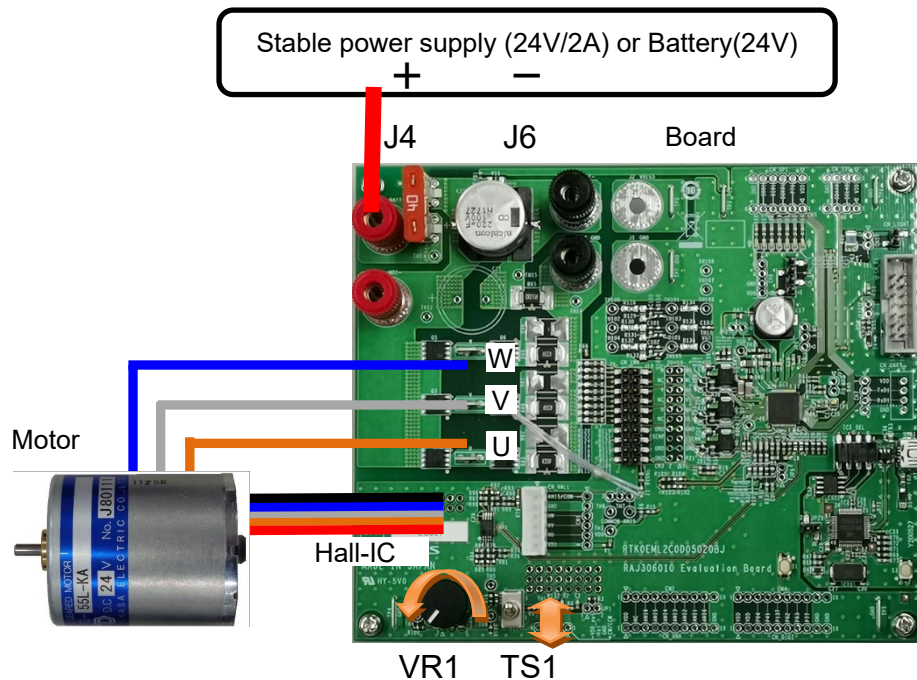
Figure 3-2. Connection of Motor and power line (Use the MOSFET on board)

3. Operation

Start the power supply, select the direction of rotation with the toggle switch (TS1), and turning the potentiometer (VR1) clockwise starts the motor to rotate. To reverse the rotation direction of the motor, turn VR1 counterclockwise, and after confirming that the motor has stopped, reverse the TS1 switch. Operating the TS1 while the motor is rotating may generate an unintended current, which may damage the IC. Therefore, switch TS1 after confirming that the motor has completely stopped.

The specifications of the sample code written initially are shown below. For details, refer to the application note of "Hall IC 120 Degree Conduction Control" on website.

ATTENTION!

Countermeasures for offensive odor, smoke, abnormal noise, heat generation, etc.

If any abnormality (such as offensive odor, abnormal noise, heat, smoke) occurs, immediately stop the power supply and stop the motor. Please change the fuse rating according to the motor drive application.

Table 3-1. the initial firmware specification

Contents	Specification
Rotate Speed	1200-3900[rpm]
Control method	Hall sensor 120° conduction control
VR1	Clockwise: Rotation start → acceleration Counterclockwise: Deceleration → Stop rotation
TS1	Top (1-2 short): Rotate clockwise Bottom (2-3 shorts): Turn counterclockwise
LED1	Off: Normal operation On: Error detected
LED2	Off: the motor stops On: the motor is rotating
LED3	Off:1500[rpm] or under On:1500[rpm] or over
LED4	Off:3000[rpm] or under On:3000[rpm] or over
LED5	Off: Normal On: Error detect
LED6	Off: Normal On: Error detect
LED7	Off: 5V power supply stopped On: 5V power supply in progress

3.1.2.   Error release method

When an error occurs, LED1, LED5 and LED6 will light up depending on the content and the motor stop. The error condition is released by turning VR1 counterclockwise to the end. Also, the contents of the error can be confirmed by connecting ICS and monitoring the corresponding global variable.

3.1.3.   End of operation

Stop the motor by turning VR1 counterclockwise to the end. After confirming that the motor has stopped, turn off the power.

4. Function

4.1 Power supply

The board operates by supplying a single power supply of 6V to 42V to the J4 (VM input pin) and J6 (GND input pin) pins. And, the 5V built-in regulator of RAJ306010 operates to supply 5V to the peripheral circuits and VDD.[Note.1]

When using any motor, refer to "4.3.4" and supply the voltage according to the motor within the operating range of RAJ306010. (When using the motor included in this kit, supply 24V.) In addition, fuses are mounted on TB100 and TB101 of this board. Replace the fuse capacity according to the motor current to be controlled.

When using external MOSFET and shunt resistor mounted on this board, refer to "4.3.5 When using an external MOSFET board" and connect the external MOSFET board power and GND to J3 and J5.

This board is equipped with J1/J2 to supply external 5V power without using RAJ306010's built-in regulator. For details, refer to "4.16 5V Power Supply Selection Function".

Note.1 When using the attached motor, apply 24V ± 10% to J3 (VM connection terminal) and J6 (GND connection terminal).

4.2 Emulator connection

To rewrite or debug the firmware of RAJ306010, use an emulator compatible with RL78 manufactured by Renesas Electronics. Connect the emulator to the emulator connector (CN_E1).The pin assignment of the Emulator connector is shown below. This pin assignment is compatible with the cable that comes with the Renesas emulator.[Note.2]

Table 4-1. Emulator connector (CN4) pin assignment

Terminal No.	Terminal function	RAJ306010 terminal	Terminal No.	Terminal function	RAJ306010 terminal
1	NC	-	2	GND	VSS
3	NC	-	4	NC	-
5	TOOL0	TOOL0	6	RESET_IN	RESET
7	NC	-	8	VDD	VDD
9	EMVDD	VDD	10	RESET_OUT	RESET
11	NC	-	12	GND	VSS
13	RESET_OUT	RESET	14	GND	VSS

Note.2   For more information about emulators, please refer to the manual of each emulator.

4.2.1. Update firmware by using CS+

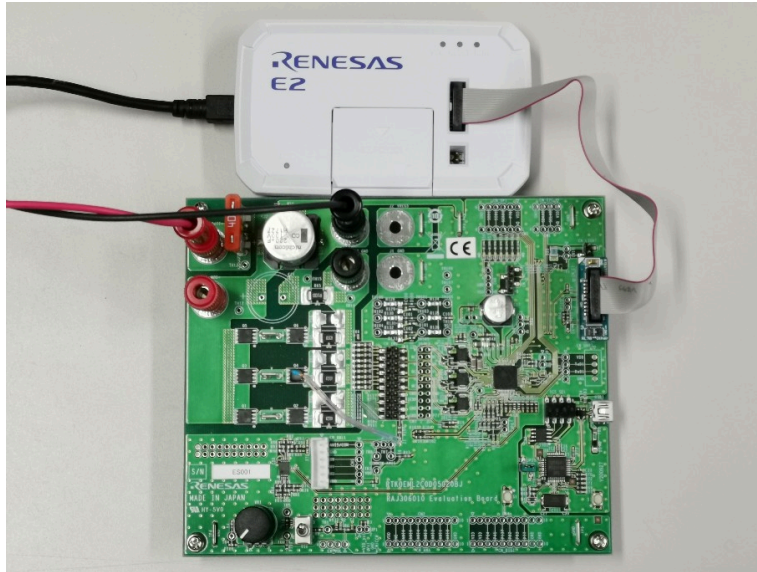1. Connect PC, emulator and board.

Figure 4-1. E2 emulator connection

2. Supply power to the VM terminal select the download method from debug tab of CS+ tool.

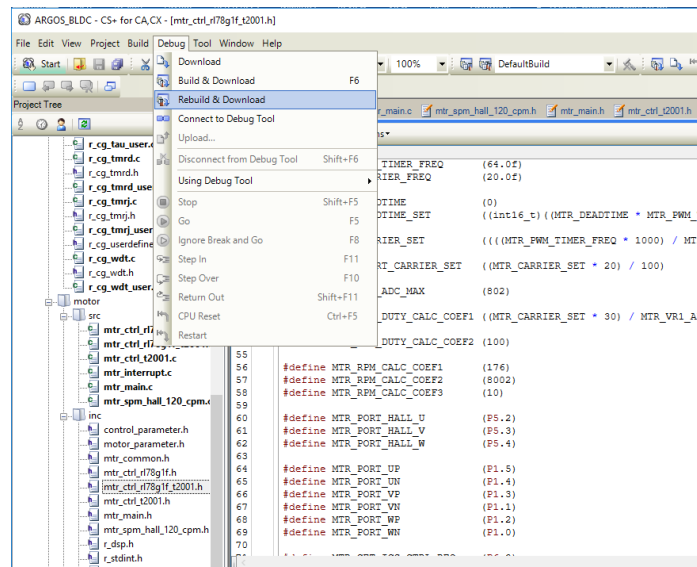Recommended download method: Download to rebuild & debug tool. [Note1]

Figure 4-2. Firmware download

Note.1 This document is confirmed using CS + for CA, CX V4.00.01.

4.3   Motor driving circuit

On the board, a MOSFET, a shunt resistor, and a thermistor for MOSFET are mounted as motor driving circuit. Also, it is possible to connect an external motor drive circuit to CN_INV (external MOSFET connector). In order to switch the motor drive circuit, it is necessary to set by 0Ω resistor.

The following shows the function switching specification by jumper pins and the information of CN_INV connector.

Table 4-2. Driving circuit selection by 0Ω resistor

Function selection	Terminal No.	Resistor mounting	RAJ306010 function
Power supply current measurement	R102-R105	Right side	ISENP/ISENN terminal on CN_INV terminal is selected
		Left side (default setting)	Shunt resistor (R65) on board is selected
Thermistor for MOSFET[Note.1]	R106	Mounted (default setting)	Thermistor on the board is selected
		Unmount	Connection of CN_INV terminal to P21 is selected
MOSFET	R107-R124	Left side (default setting)	Onboard MOFET is selected [Note2]
		Right side	External MOSFET (Onboard MOSFET is unselected)

Note.1 The operation of the thermistor for MOSFET is not supported by the initial firmware. When using the thermistor, please add to the firmware by user.

Note.2 Even if the on-board MOSFET is selected, the connection of the MOSFET pin of CN_INV is valid. When driving an on-board MOSFET, DO NOT connect an external MOSFET to the CN_INV connector.
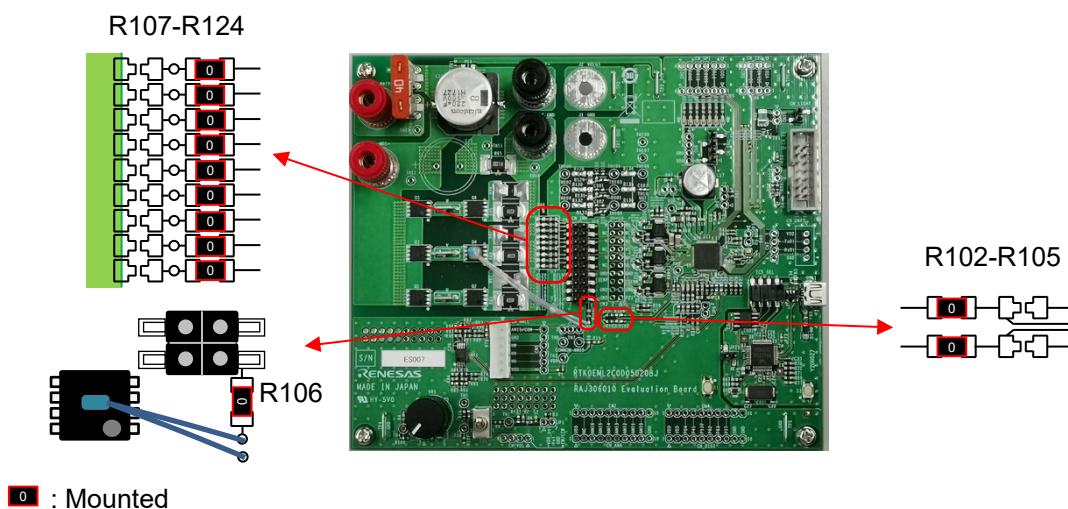

: Mounted

Figure 4-3. Motor drive circuit function selection resistor (factory default)

Table 4-3. Pin assign of External MOSFET connector (CN_INV)

Connector	Pin No.	Silk screen (Terminal function)	RAJ306010 Pin
CN_INV	1	P21 (for thermistor analog input)	P21/ANI11
	2	GND (for thermistor GND)	VSS
	3	GND (for guard shield of ISENP/ISENN)	VSS
	4	GND (for guard shield of ISENP/ISENN)	VSS
	5	ISENP	ISENP
	6	ISENN	ISENN
	7	GND (for guard shield of ISENP/ISENN)	VSS
	8	GND (for guard shield of ISENP/ISENN)	VSS
	9	UL	ULOUT
	10	NC	NC
	11	UH	UHOUT
	12	U	U
	13	VL	VLOUT
	14	NC	NC
	15	VH	VHOUT
	16	V	V
	17	WL	WLOUT
	18	NC	NC
	19	WH	WHOUT
	20	W	W

Table 4-4. CN_INV connector

Header part number	Product name	Product Maker	Specification	Product maker
CN_INV	TSM-110-01-L-DV	SAMTEC	2.54 Pitch female connector	-

4.3.1. MOSFET

This board has an internal MOSFET for evaluation. However, it is also possible to connect an external MOSFET board prepared by the user. The MOSFET is selected by switching the implementation of the MOSFET connection selection resistors (R107-R124).

By default, the 0Ω resistors are mounted on the right side of the MOSFET connection selection resistors (R107-R124), and the MOSFET on this board is enabled. In this configuration, the connection of external MOSFETs to CN_INV is prohibited.

When using external MOSFETs, remove the right-side resistors and mount it on the left side land. By mounting on the left side, the gate and source of the mounted MOSFETs on this board are changed to MOS_GND level to prevent through-hole breakdown due to voltage instability.

Note: Depending on the motor and control method, the power supply voltage may exceed the withstand voltage of the MOSFET. In this case, depending on the specification of the motor, please replace the MOSFETs or connect an external MOSFETs, or use an external MOSFETs.

4.3.2. Shunt resistor

Using the shunt current sense amplifier built in the RAJ306010, the power supply current is detected, and overcurrent protection is performed by measuring the voltage difference between the two ends of the shunt resistor connected to the ISENP/ISENN pin. A shunt resistor (R65: 100mΩ) is mounted on this board between the MOS_GND pin (J5) and the GND input pin (J6). By default, the left side is selected by the Shunt resistor selection resistors (R102-R105), so the shunt resistor (R65) on the board is enabled.

The external shunt resistor can be used via the MOSFET connection connector (CN_INV) by changing to the right side of the shunt resistor selector. However, external shunt resistors tend to be more susceptible to noise and other effects, so using an on-board shunt resistor (R65) is recommended. When using an external shunt resistor, please pay careful attention to the wiring path and length.

4.3.3. MOFET thermistor (Option)

The thermistor(Z1) is mounted to measure MOSFET temperature. By default, the on-board thermistor (Z1) is available by mounted 0Ω register of the MOSFET thermistor selection resistor(R106) and the on-board thermistor (Z1) is connected to P21 (ANI1). [Note1]

When using an external thermistor, it can be used by removing the 0Ω resistor mounted on the R106 and connecting a thermistor between P21 (1Pin) and GND (2Pin) of CN_INV.

The following shows the calculation formula of the thermistor resistor value and a calculation example of the relationship between the temperature of the MOSFET thermistor (Z1) used on the board and the input voltage of ANI1. Figure 4-4 shows how to get the resistance of the thermistor mounted on the board at a specific temperature T and how to get the ADC conversion result from the resistance. Determine the threshold value from here.

Figure 4-5 shows an example calculation of the relationship between the temperature of the MOSFET thermistor (Z1) used in this board and the input voltage of ANI1.

Table 4-5 shows examples of actual measurements.

This data is just an example and does not guarantee the performance.

Note 1 The MOSFET thermistor is optional and is not used in the initial firmware. When using a MOSFET thermistor, please add to the firmware by the user.

$$R_{TH} = R_0 * \exp^{\left\{B\left(\frac{1}{T}-\frac{1}{T_0}\right)\right\}}$$

$$ADCR = \frac{R_{TH} + 65536}{(R_0 + R_{TH})} + 32$$

ADCR: RL78 10-bit ADC conversion result register (10 bits, top-justified)
$R_{TH}[\Omega]$: Thermistor resistance at T
$R_0[\Omega]$: Reference resistance at T_0
B[K]: B constant (3350-3399K)
T[K]: Thermistor temperature (t°C + 273°C)
T_0[K]: Reference temperature (25°C + 273°C)

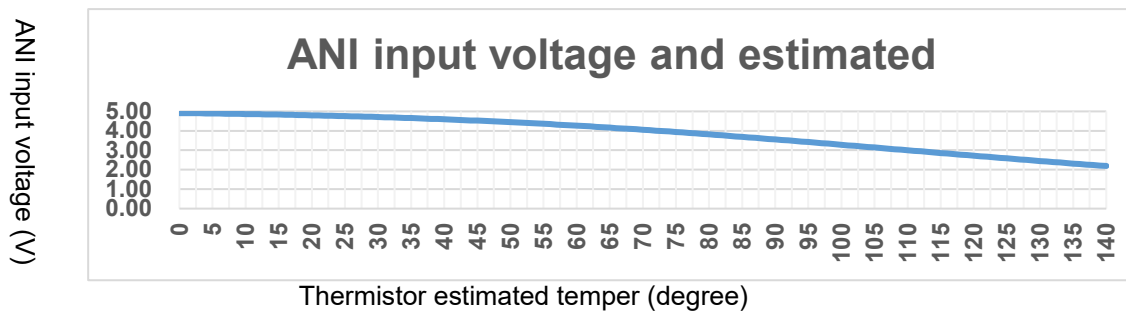**Figure 4-4. Formula for calculating the thermistor resistor**

Figure 4-5. Thermistor (Z1) temperature and ANI1 input voltage

Table 4-5. Thermistor Temperature Data for MOSFETs (Reference)

Ambient Temperature	0°C	25°C	50°C	75°C	100°C	125°C
ANI1 voltage calculation evaluation	4.91V	4.76V	4.44V	3.94V	3.28V	2.58V
ANI1 actual voltage	4.91V	4.75V	4.42V	3.89V	3.21V	2.50V
ADCR value calculation evaluation	0xFBC0	0xF340	0xE380	0xC940	0xA880	0x83C0
ADCR register actual value	0xFB80	0xF340	0xE680	0xC780	0xA440	0x8080

4.3.4.   Connect User's MOTOR (Not attached motor)

The board and initial firmware are set according to the attached motor. When using a user's motor, it is necessary to adjust setting parameters such as drive current and lead angle setting and so on. Also, change the hardware and software settings. [Note.1]

Below are the parts that need to be changed.

- Shunt resistor(R65) -- change according to the amount of power supply current (initial value 100mΩ)
- Phase current detection resistors(R83,R88,R95)
  - Modified to fit the amount of phase current of the motor (Initial 200mΩ)
- Phase current detection bleeder resistors (R82,R87,R94)
  - Adjusting the current flowing to the phase current detection resistors

Also, when connecting a motor with encoder, change the following settings.

- AMP1 activation resistor (R79, R80, R85 R92, R96, R18, R29) -- short (initial: not installed)
- LED1, LED2 current limiting resistors (R56, R57) -- Remove (initially: 3.3kΩ resistor mounting) [Note.2]
- Hall IC thermistor activation resistor (R20) -- Remove

Note.1 In the worst case, damage may occur depending on the motor specifications and drive conditions. If necessary, change the multiplier of the protection resistor or diode. Check the data sheet for details.

Note.2 LED1 and LED2 cannot be used when connecting an encoder to P00 and P01.
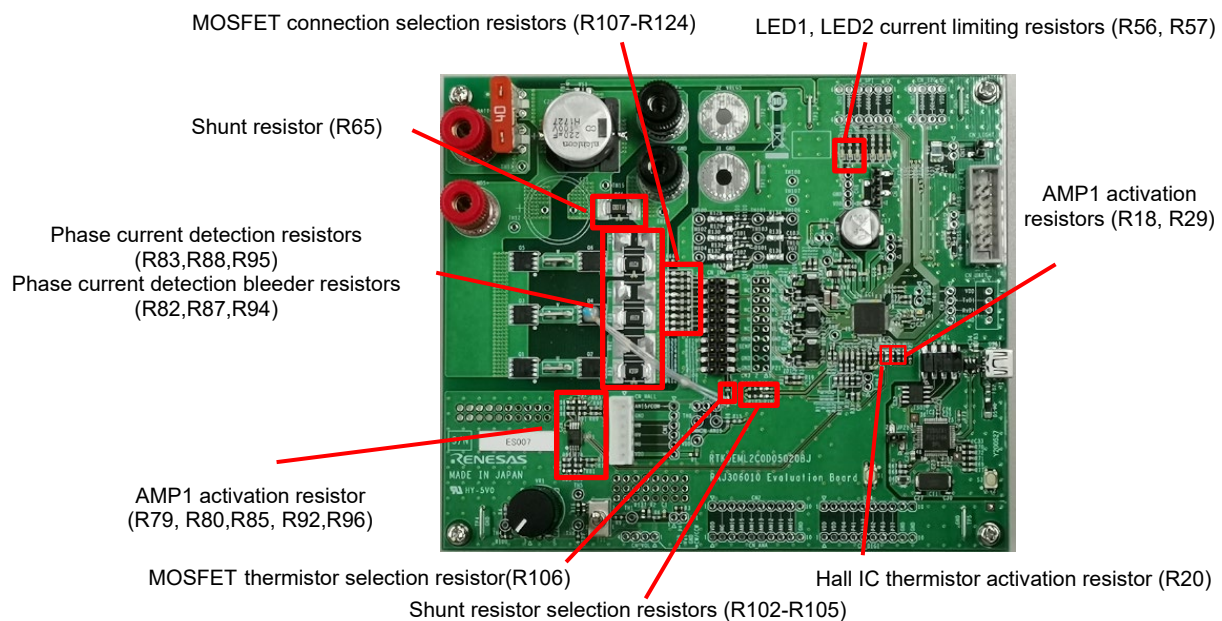

Figure 4-6. Parts change location (Connect User's motor)

Attention!

Renesas will not be liable for any damages such as board failure or injury resulting from the change. Please be safe to change and configure the board at your own risk.

4.3.5.   Use external MOSFET board

1.   0Ω jumper setting

- MOSFET connection selection resistors (R107-R124):Select left side (on-board MOSFET is off)

- MOSFET thermistor selection resistor(R106): Open (Thermistor connected to CN_INV is valid)

- Shunt resistor selection resistors (R102-R105): Select right side(on-board shunt resistor (R65) is valid)[Note1]
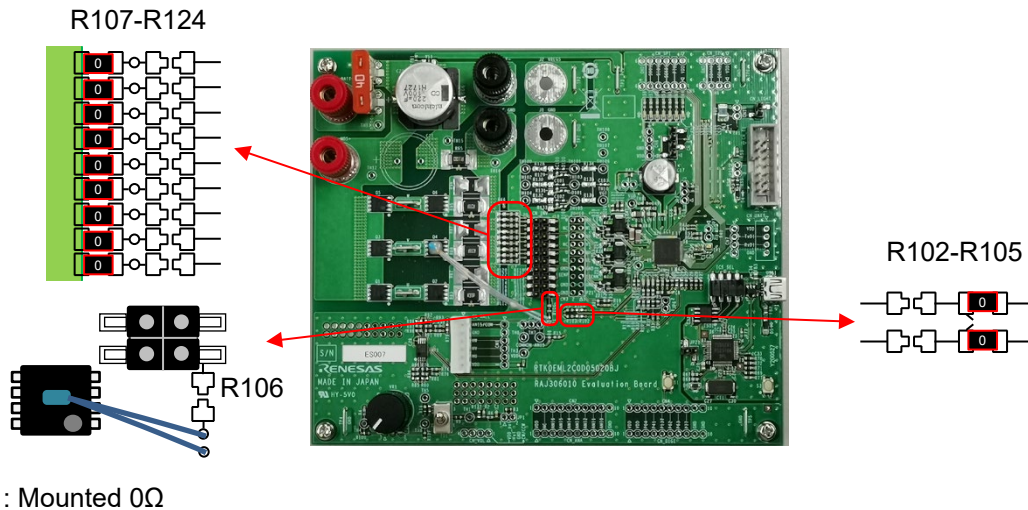

[0] : Mounted 0Ω

Figure 4-7. Connection selection pin setting (Use the external MOSFET)

Note 1: If external MOSFETs are used, it is recommended to use the on-board shunt resistor (R65). When using an external shunt resistor, note the wiring length, wiring path, noise, etc.

2. Board settings and connections

    Make the following settings and connections.

    ▪ Turn potentiometer VR1 counterclockwise to the end, so that the motor does not rotate when the power is turned on.

    ▪ When using a shunt resistor on this board, connect J3 (VM connection for external MOSFET) and J5 (GND connection for external MOSFET) to the power and GND terminal of the external MOSFET board.

    ▪ Connect the CN_INV connector on the board to the following terminal on the external MOSFET board. Note.1

        o   Gate drive signal terminal (UH, UL, VH, VL, WH, WL)

        o   Motor output terminal (U, V, W)

        o   Current detection signal terminal (ISENP / ISENN): When using a current detection resistor on the external board

        o   Thermistor connection terminal (P21/GND): When using a thermistor on an external MOSFET board

    ▪ Connect the external MOSFET board and motor

    ▪ Connect the CN_HALL connector of the board and the HALL terminal of the motor

    ▪ When using the included motor, connect 24V to the VM input terminal (J4) and connect the GND input terminal (J6) to GND.
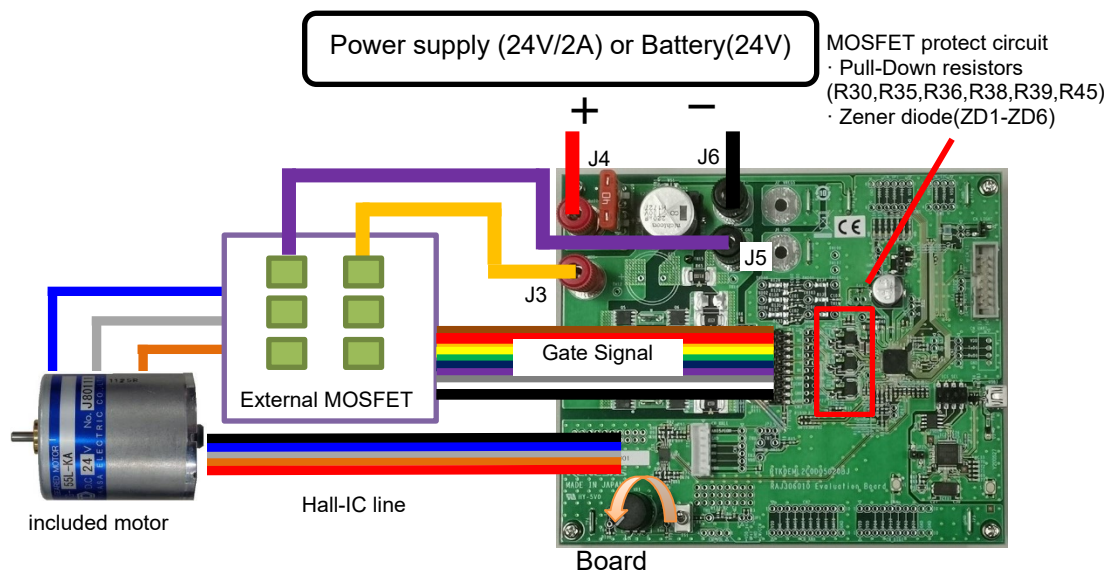

Figure 4-8. Use External MOSFET

Note.1 Please prepare the external MOSFET board by yourself.

Note.2 Each GND terminal of CN_INV is GND for thermistor and GND for shield of ISENP / ISENN wiring.If the GND of CN_INV is used for the GND for MOSFET, it may be damaged by the over current etc.

Note 3 When connecting a user-prepared motor, a supply voltage of up to 42 V is available to match the motor's operating voltage. Select MOSFETs with a withstand voltage that takes into account the amplitude of the supply voltage.

Attention!

Renesas will not be liable for any damages such as board failure or injury resulting from the change. Please be safe to change and configure the board at your own risk.

4.4   Potentiometer (VR1) & Toggle switch (TS1)

A potentiometer is mounted and connected to ANI6 for input indication of the amount of rotation. The resistance of the potentiometer is 20kΩ and is pulled up to 5V by a resistance of 5.6kΩ and has hysteresis.

A toggle switch is connected to P122 to input the direction of rotation.

The potentiometer and toggle switch mounted on the board can be disabled by removing the 0Ω resistor, allowing the user to implement user-prepared trigger switches or other devices on the CN_VOL.
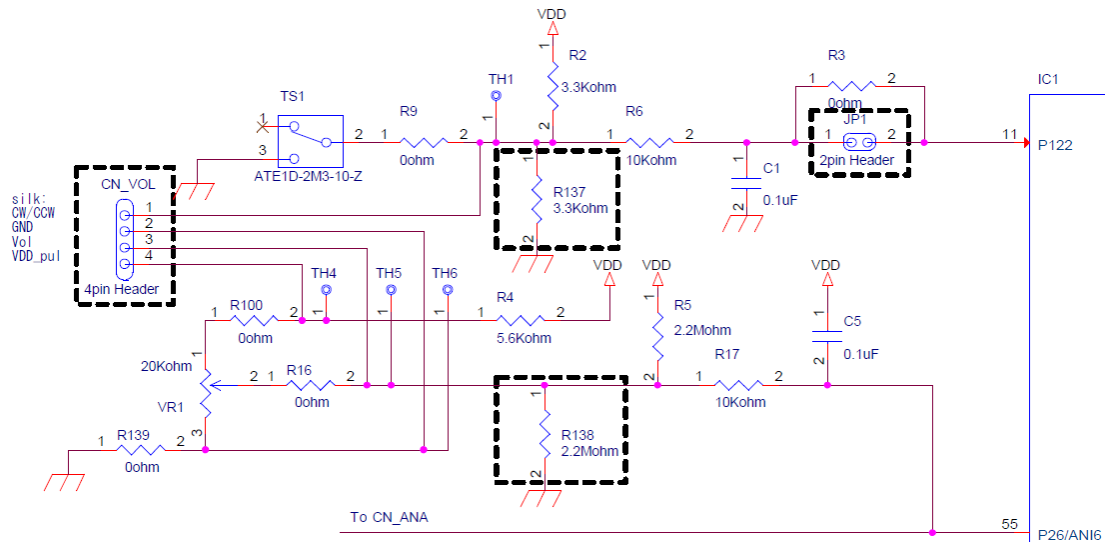

Figure 4-9. Potentiometer & Toggle switch circuit

Table 4-6. Connector for CN_VOL connection (CN UART,CN7) pin assignment

Connector	Terminal No.	Silk screen(Terminal function)	RAJ306010 terminal
CN_VOL	1	CW/CCW(Connect to CW/CCW switch)	P122(Pull-up 3.3kΩ)
	2	GND	Vss
	3	Vol(Connect to potentiometer)	P26/ANI6(Pull-up 2.2MΩ)
	4	VDD_Pul	V_{DD}(Pull-up 5.6kΩ)

4.5　UART terminal

For UART communication, a through hole for CN_UART connector and check through hole (CN7) are mounted on the board. When using UART communication, remove the jumper pin of ICS connection selection terminal (ICS_SEL).

In the initial firmware, UART communication is set to use the ICS function.

▪ Communication method: UART start-stop synchronization function

▪ Communication rate: Up to 1Mbps

Table 4-7. UART connector (CN_UART, CN7) pin assignment

Connector	Terminal No.	Silk screen(Terminal function)	RAJ306010 terminal
CN_UART CN7	1	5V	V_{DD}
	2	TxD1(RAJ306010 UART Send)	P02/TxD1
	3	RxD1(RAJ306010 UART Receive)	P03/RxD1
	4	GND	V_{SS}

4.6　SPI Terminal

For SPI communication, a through hole for CN_SPI connector and check through hole (CN5) are mounted on the board. The initial firmware does not use SPI terminal.

▪ Communication method: CSI

▪ Communication rate: up to 1 Mbps.

Table 4-8. SPI connector (CN_SPI, CN5) pin assignment

Terminal	Terminal No.	Silk screen(Terminal function)	RAJ306010 terminal
CN_SPI CN5	1	VDD	V_{DD}
	2	P76(CS input / output)	P76/INTP11[Note.1]
	3	SCK01(SCLK)	P75/SCK01
	4	SI01(MISO)	P74/SI01
	5	SO01(MOSI)	P73/SO01
	6	GND	V_{SS}

Note.1 When using P76 as CS (Chip Select) of SPI slave, set PIOR07 to "0" and assign INTP11 to P77.

4.7 I2C terminal

For I2C communication, a through hole for CN_I2C connector and check through hole (CN6) are mounted on the board. The initial firmware does not use I2C terminal.

- Communication method: Normal mode, Fast mode, Fast mode plus
- Communication rate: up to 1 Mbps.

Table 4-9. I2C connector (CN_I2C, CN6) pin assignment

Terminal	Terminal No.	Silk(Terminal function)	RAJ306010 terminal
CN_I2C CN6	1	VDD(5V)	VDD
	2	SCLA0(SCL)	P60/SCLA0(Pull up 1K by VDD)
	3	SDAA0(SDA)	P61/SDAA0(Pull up 1K by VDD)
	4	GND	GND

4.8 Digital general purpose I/O terminal

For general purpose I/O terminal, a through hole for CN_DIGI connector and check through hole (CN4) are mounted on the board. Two power supplies and two GNDs and seven digital ports are connected to the CN_DIGI connector.

The pin assignment of CN_DIGI is shown below.

The initial firmware does not use as digital general purpose input/output terminals.

Table 4-10. Digital general purpose I/O terminal connector (CN_DIGI, CN4) pin assignment

Terminal	Terminal No.	Silk screen(Terminal function)	RAJ306010 terminal
CN_DIGI CN4	1	VDD(5V)	V_{DD}
	2	VDD(5V)	V_{DD}
	3	P04	P04
	4	P41	P41
	5	P137	P137
	6	P62(Push Switch)	P62
	7	P63	P63
	8	P77	P77
	9	GND	V_{SS}
	10	GND	V_{SS}

4.9   Analog general purpose I/O terminal

For AD converter input and general purpose digital port terminal, a through hole for CN_ANA connector and check through hole (CN2) are mounted on the board. The pin assignment of CN_ANA is shown below.

Terminal No.5 and Terminal No.9 can be used as general purpose terminals, but check the circuit diagram for other terminals and disable the multi function such as thermistor.

Table 4-11. Analog general purpose input / output connector (CN_ANA, CN2) pin assignment

Terminal	Terminal No.	Silk screen(Terminal function)	RAJ306010 terminal
CN_ANA CN2	1	VDD(5V)	V_{DD}
	2	NC	NC
	3	ANI16(Potentiometer)	P26/ANI16
	4	ANI15(Thermistor for HALL-IC/Wiamp Input)	P25/ANI15
	5	ANI14	P24/ANI14
	6	ANI13(VM voltage detection)	P23/ANI13
	7	ANI12(Uiamp Input)	P22/ANI12
	8	ANI11(Thermistor for MOSFET)	P21/ANI11
	9	ANI10	P20/ANI10
	10	GND	V_{SS}

4.10 HALL IC input terminal

CN_HALL connector and through-hole for checking (CN1) are provided for Hall IC signal input.

When the motor has a thermistor terminal or a COMMON terminal, terminal No.1 of CN_HALL can be used to select either input by setting JP3. Pins No.3-No.5 are used to input Hall IC signals. The input Hall signals are input to the RAJ306010 via a pull-up with 5V and an RC filter. Please refer to the circuit diagram for the filter constants. In case of sensor-less control (when input from Hall IC is not used), BEMF output can be output from terminal No.3. when BEMF output is used, if peripheral circuit is attached, it will interfere with input to ANI7 (IC internal connection), so filter adjustment is required. When stopping BEMF output by software setting, it is not necessary to set the filter constant. For details, please refer to the RAJ306000 Series User's Manual Hardware Edition (R18UZ0066EJ).

Power supply (VDD:5V) for Hall IC can be supplied from pin No.6.

Table 4-12. Hall IC connector (CN-HALL, CN1) pin assignment

Terminal	Terminal No.	Silk screen(Terminal function)	RAJ306010 terminal
CN_HALL CN1	1	ANI5(Thermistor) /COM(COMMON)	JP3 select (initial setting: unselected) 1-2: ANI5 2-3: COMMON
	2	GND	V_{SS}
	3	HW(Hall sensor input/BEMF output)	HW
	4	HV(Hall sensor input)	HV
	5	HU(Hall sensor input)	HU
	6	VDD(5V:Bias for Hall sensor)	VDD

Table 4-13. CN_HALL connector

Header	Product name	Product Maker	Connector	Product maker
CN_HALL	B6B-XH-A	JST	XHP-P	JST

4.11   Encoder signal input

A CN_ENC connector and a check through hole (CN8) are mounted for encoder signal input.[Note1]

When performing operations such as vector control, input the motor encoder signal from this connector to the RAJ306010. Both VCC and VDD are 5V(same voltage). The pin assignment of CN_ENC connector are shown below.

Note.1 : When using the CN_ENC connecter, remove R56 and R57. LED1 and LED2 can not be used.

Table 4-14. Encoder signal input connector (CN_ENC, CN8) pin assignment

Connector	Terminal No.	Silk screen(Terminal function)	RAJ306010 terminal
CN_ENC CN8	1	VDD(5V)	V_{DD}
	2	GND	V_{SS}
	3	A(A Phase signal from encoder)	P00/TRGCLKA
	4	B(B Phase signal from encoder)	P01/TRGCLKB

Table 4-15. CN_ENC Connector

Header	Product Name	Product Maker	RAJ306010 terminal	Connector
CN_ENC	TSM-104-01-L-SV	SAMTEC	2.54pitch connector	-
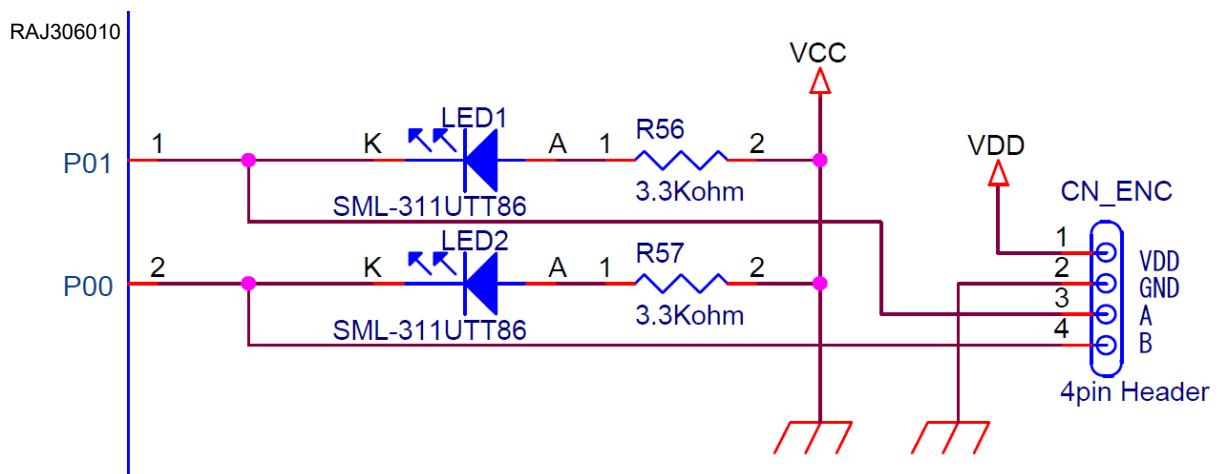
When connecting encoder, remove R56 and R57

Figure 4-10. Encoder terminal

4.12 Phase current detection Amplifier

Amplifiers are mounted on the U and W phases to detect the current that drives the motor on the board. In the initial state, this amplifier is invalid. If this amplifier is required, such as encoder vector control, mount the following resistors and disconnect the resistors.

Mount

▪ R80, R85, R92, R96, R79, R29, and R18

Remove

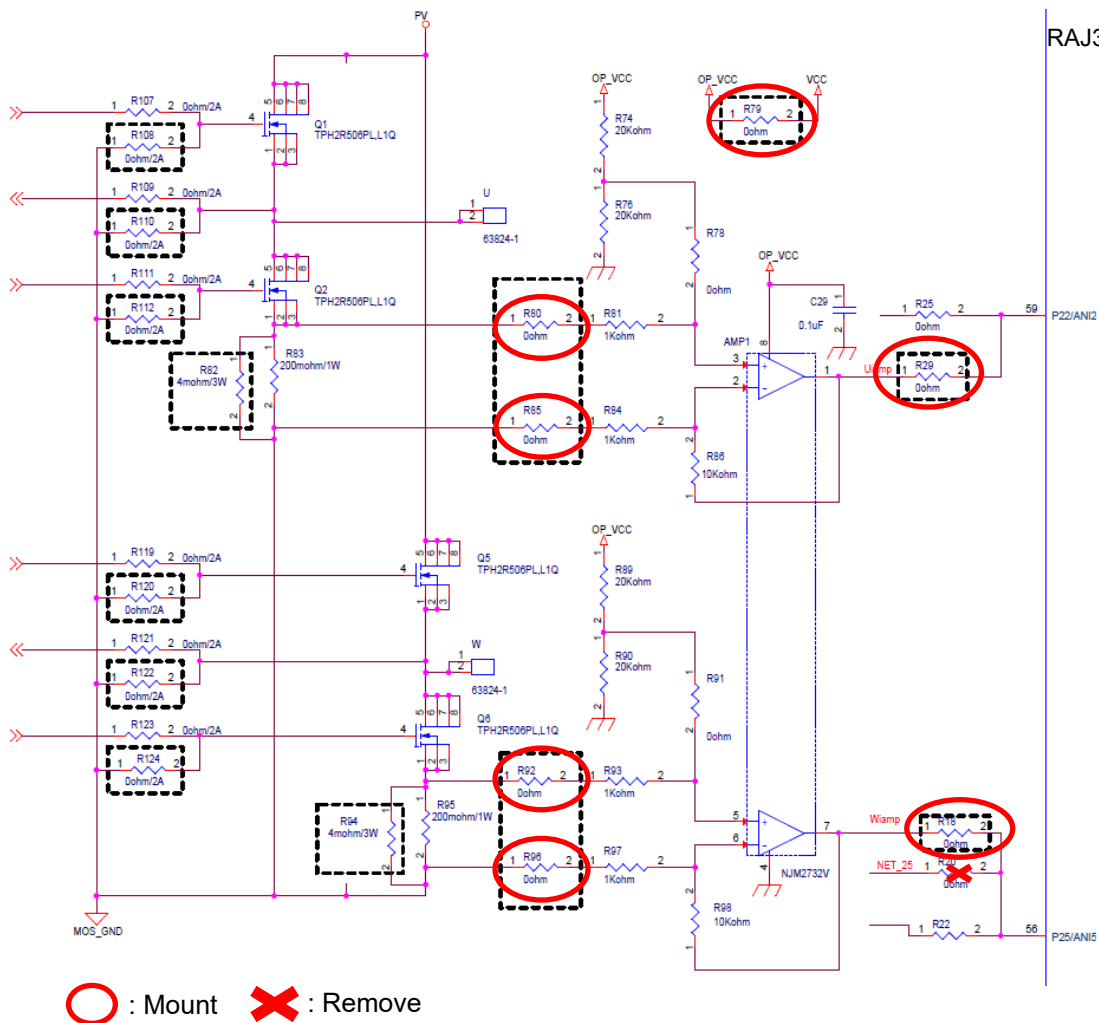▪ R20(Thermistor connection resistor for HALL-IC)

Figure 4-11. Phase current detection amplifier

4.13 LED

Seven LEDs are mounted for program debugging and system operation confirmation. Lights when the terminal level is low and turns off when the terminal level is high. The pin assignments corresponding to the LEDs are shown below.

Table 4-16. Pin Assignment of LED Connection

Silk screen(Terminal function)	RAJ306010 terminal	LED off	LED on
LED1	P01	High level	Low level
LED2	P00	High level	Low level
LED3	P141	High level	Low level
LED4	P140	High level	Low level
LED5	P43	High level	Low level
LED6	P42	High level	Low level
LED7 Note.1	5V Power supply	No power supply	With power supply

4.14 High Brightness LED terminal

This product has connector CN_LIGHT corresponding to large current drive such as LED light and the through hole CN10 for checking. Please note that the voltage of this terminal is VM level.

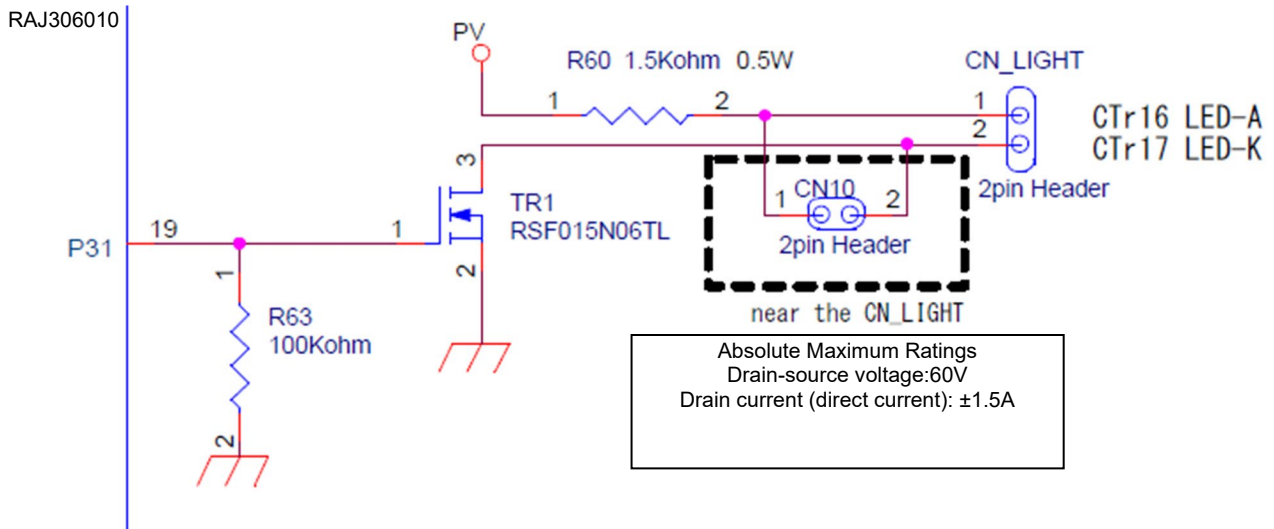Note : The initial firmware does not use high current terminals

Figure 4-12. High Brightness LED circuit

Table 4-17. Pin assign of High Brightness LED connector (CN_LIGHT,CN10)

Connector	Terminal No.	Silk(function)	RAJ306010 terminal
CN_LIGHT CN10	1	PV(anode)	VM (Pull-up by R60)
	2	TR1(cathode)	TR1 (P31: Low output: OFF, High output: ON)

4.15 Power supply current check terminal

For measuring the current of RAJ306010, through holes for VM current measurement (JP8: not mounted) and through holes for VDD current measurement (JP9) are mounted on the board. When using these terminals, remove the 0Ω resistor (for VM: R47, for VDD: R40) that has been short-circuited, and add a wire for current measurement.

4.16 5V power supply selection function

The 5V power supply (internal regulator supply/external supply) is selected using JP9[note.1] In addition, since JP9 is not mounted, when supplying 5V from the outside, need to mount a connector.

The initial setting is to connect 2-3 with R52 (0Ω resistor), and the built-in regulator is enabled.

When supplying 5V from the outside, remove R52, connect JP9 1-2, and input the power supply from J2 (5V), J1 (GND).

Table 4-18. 5V power supply selection terminal (JP9) pin assignment

Connector	Terminal No.	Function
JP9	1-2	External 5V supply
	2-3	Internal 5V regulator (Initial selected: fixed by 0Ω resistor)

4.17 Spare_circuit

This circuit is a spare circuit. Therefore, no components are mounted, and VDD_in/VSS_in are independent from other circuits. Please use it by connecting it to peripheral circuits as needed.

In this board, TPH2R506PL,L1Q MOSFETs are mounted to support applications that require high torque, but ringing tends to appear in the BEMF waveform when used with the included motor. For this reason, when using this kit to perform sensor-less control experiments, it is recommended to implement a snubber circuit in this circuit if necessary.
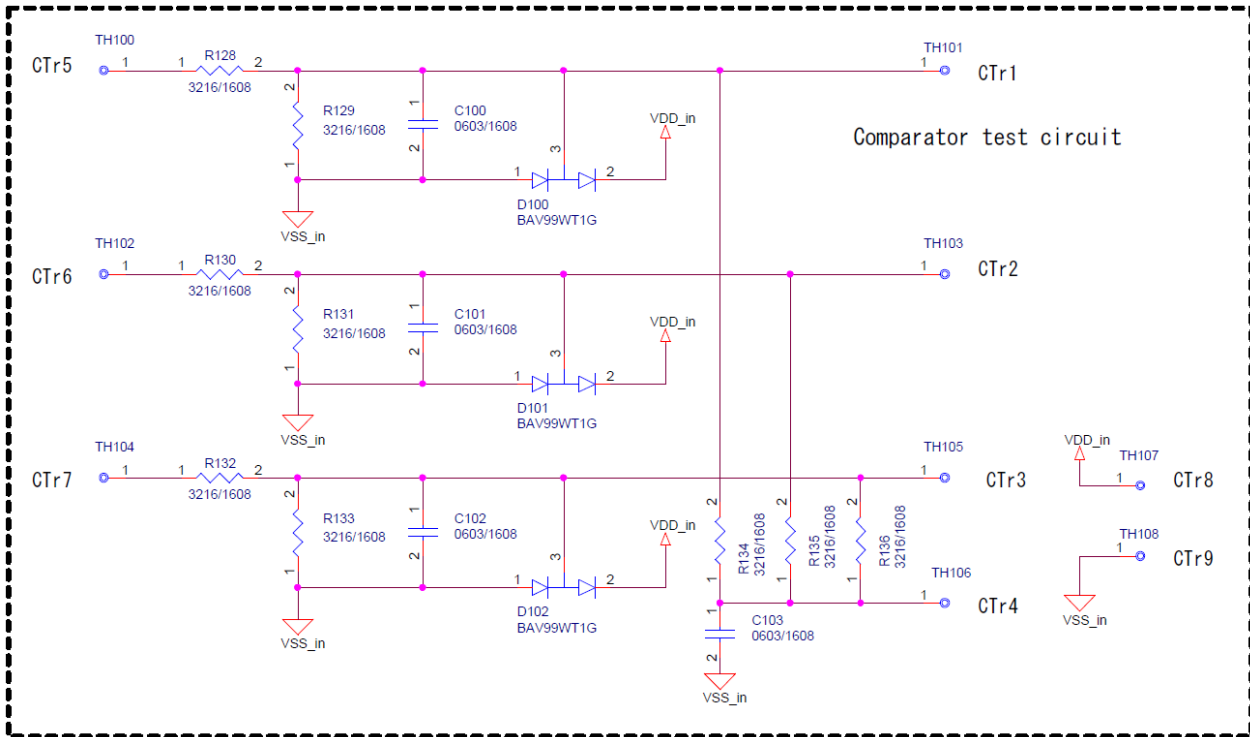
Figure 4-13. Spare_circuit

4.18 ICS (Wave viewer tool) Host function

The board is equipped with an evaluation version of the ICS host function. Install ICS on Windows PC, connect PC and board with USB cable, monitor and change global variables from PC, and display graphs (With this product, up to 16 channels can be monitored and changed, and up to 4 channels can be displayed for graph display.)

When using ICS, it is necessary to set a jumper pin in ICS_SEL.

ICS uses the UART function. Therefore, UART can not be used as a general-purpose function at the same time.

In order to incorporate the ICS function into the user program, it is necessary to incorporate the library.

ICS Programs and libraries for Windows are available from the download page of Desktop Lab Co., Ltd. website.

Please set the ICS referring to the following.

Reference :

Desktop Lab Co., Ltd. URL: http://www.desktoplab.co.jp/download.html

- ICS Program for Windows : "ICS tool software for W1003 or Inverter kit for CQ publishing"
  =>"ICS PC soft Download"
- ICS Library : "ICS++ V3.xx library and Manuals download"->"RL78G1F(RAJ306000)"
- ICS Library programing method: "ICS++ RL78 Lib for CS+/EWRL manual V3.7x download"

This tool or library is a sample and is free or unsupported. In addition, Renesas can not be held responsible for any problems such as damage caused by incorporating or using this tool.

If you wish to use ICS in your user system, please consider purchasing the ICS / ICS ++ product version. The product version of ICS/ICS++ is sold by Desktop Lab Co., Ltd.

5.   RAJ306010

5.1   Feature

RAJ306010 is a SIP built in RL78/G1F and Pre-Driver. The main features are described below.

For details, refer to the data sheet and Hardware Manual.

- RL78/G1F (R5F11BLEGFB)
  - Flash ROM: 64KB
  - Data Flash: 4KB
  - RAM 5.5KB
- Three-phase DC Brushless motor control
  - Support Hall IC type/ Hall Sensor-less type
  - The self-align dead time adjustment function
  - Gate driver current adjustment function
- Operation voltage: 6V to 30V
- 5V regulator Built-in
- Direct drive of N-channel MOSFET for motor drive
- Gate drive current for MOSFET is up to 500mA (peak)
- Built-in bootstrap circuit with double boosting function to drive MOSFET securely
- Drive mode selection (PWM control/ commutation control)
- Safety function
  - Equipped with a safety standard IEC60730 compliant MCU (RL78 / G1F)
  - Fever detection (TSD)
  - Over current detection (CS amplifier, 5V regulator)
  - Abnormal voltage drop detection (VM, charge pump)
  - Abnormal voltage rise detection (5V regulator, charge pump)
  - Motor lock detection
- Support Hall IC control
  - Input threshold voltage changeable
  - Hysteresis voltage level selection
- Built-in measurement circuits
  - VM voltage
  - Chip temperature (Pre-Driver)
  - Motor current
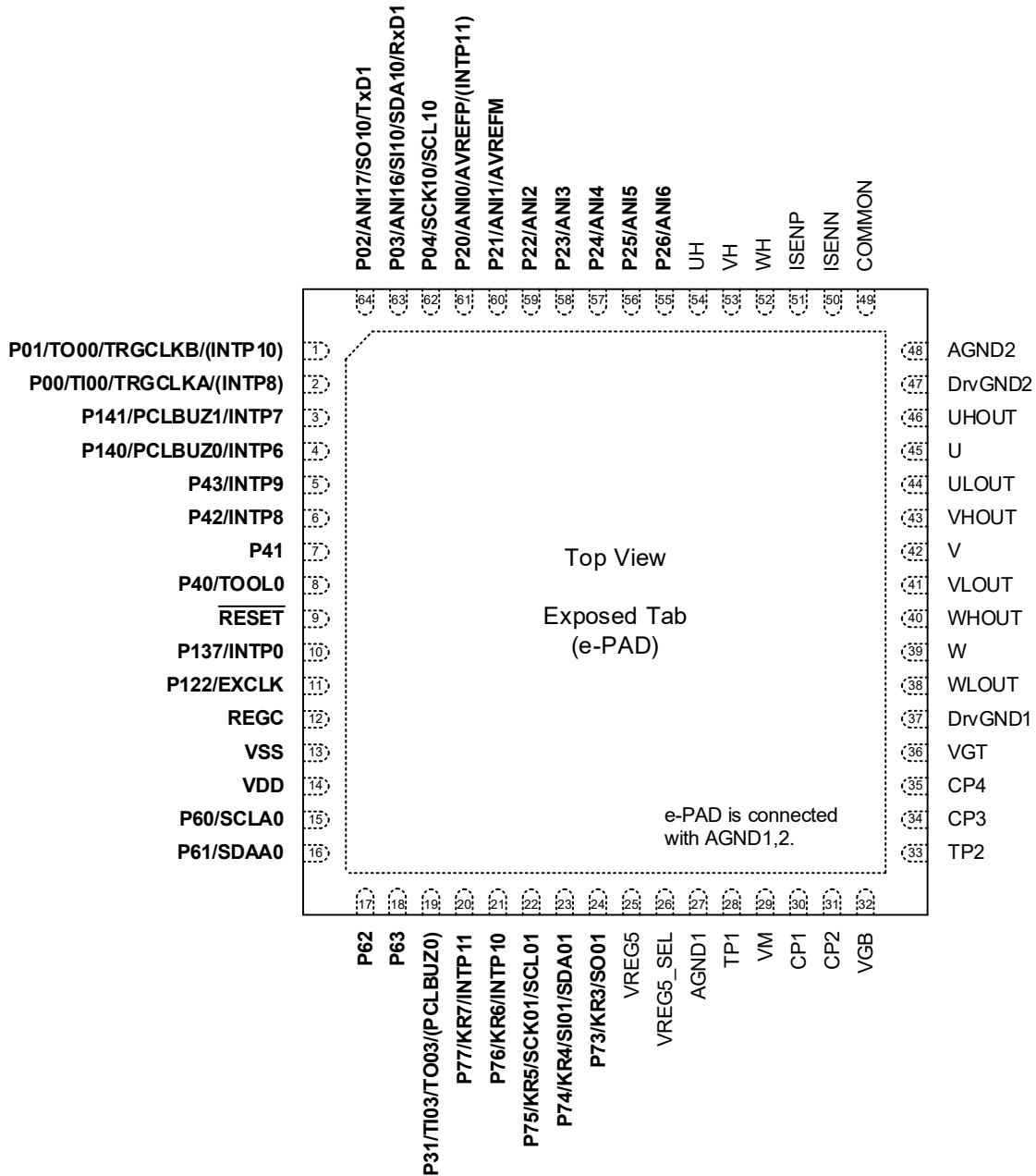 - Back electromotive force

5.2 RAJ306010 Pin assignment

Figure 5-1. RAJ306010 Pin assignment

Note:
Bold text : RL78 pins
Normal-face font : Pre-driver pins

5.2.1.   RAJ306010 Pin function list

Table 5-1. RAJ306010 Pin function list (1/3)

Pin No.	RAJ306010 Pin function	Connector/TP/Function	Note
1	P01/TO00/TRGCLKB/(INTP10)	LED1/CN_ENC-3 Pin CN8-3 Pin	When using CN_ENC, disconnect R56 resistor.
2	P00/TI00/TRGCLKA/TRJO0/(INTP8)	LED2/CN_ENC-4 Pin CN8-4 Pin	When using CN_ENC, disconnect R57 resistor.
3	P141/PCLBUZ1/INTP7	LED3	
4	P140/PCLBUZ0/INTP6	LED4	
5	P43/INTP9	LED5	
6	P42/INTP8	LED6	
7	P41	CN_DIGI-4 Pin/CN4-4 Pin	
8	P40/TOOL0	CN_E1	Connect to CN_E1 only
9	RESET	CN_E1	Connect to CN_E1 only
10	P137/INTP0	CN_DIGI-5 Pin/CN4-5 Pin	Pull-up to VDD
11	P122/EXCLK	TS1(CW/CCW)	
12	REGC	-	Regulator output
13	VSS	GND	GND
14	VDD	VDD	VDD
15	P60/SCLA0	CN_I2C-2 Pin/CN6-2 Pin	
16	P61/SDAA0	CN_I2C-3 Pin/CN6-3 Pin	
17	P62	CN_DIGI-6 Pin/CN4-6 Pin	
18	P63	CN_DIGI-7 Pin/CN4-7 Pin	
19	P31/TI03/TO03/(PCLBUZ0)/VCOUT1	CN_LIGHT-2 Pin/CN10-2 Pin	
20	P77/KR7/INTP11	CN_DIGI-8 Pin/CN4-8 Pin	
21	P76/KR6/INTP10	CN_SPI-2 Pin/ CN5-2 Pin	
22	P75/KR5/SCK01/SCL01	CN_SPI-3 Pin/ CN5-3 Pin	
23	P74/KR4/SI01/SDA01	CN_SPI-4 Pin/ CN5-4 Pin	
24	P73/KR3/SO01	CN_SPI-5 Pin/ CN5-5 Pin	

Table 5-2. . RAJ306010 Pin function list (2/3)

25	VREG5	VDD	
26	VREG5_SEL	JP9	5V input/output selection
27	AGND1	GND	
28	TP1	GND	Connect to GND with 0Ω resistor.
29	VM	VM	
30	CP1	-	Capacitor connection terminal for charge pump
31	CP2	-	Capacitor connection terminal for charge pump
32	VGB	TH11	
33	TP2	GND	Connect to GND with 0Ω resistor.
34	CP3	-	Capacitor connection terminal for charge pump
35	CP4	-	Capacitor connection terminal for charge pump
36	VGT	TH10	
37	DrvGND1	GND	
38	WLOUT	CN_INV-17 Pin/ CN3-17 Pin	
39	W	CN_INV-20 Pin/ CN3-20 Pin	
40	WHOUT	CN_INV-19 Pin/ CN3-19 Pin	
41	VLOUT	CN_INV-13 Pin/ CN3-13 Pin	
42	V	CN_INV-16 Pin/ CN3-16 Pin	
43	VHOUT	CN_INV-15 Pin/ CN3-15 Pin	
44	ULOUT	CN_INV-9 Pin/ CN3-9 Pin	
45	U	CN_INV-12 Pin/ CN3-12 Pin	
46	UHOUT	CN_INV-11 Pin/ CN3-11 Pin	
47	DrvGND2	GND	
48	AGND2	GND	

Table 5-3. RAJ306010 Pin function list (3/3)

Pin No,	RAJ306010 Pin function	Connector/TP/Function	Note
49	COMMON	CN-HALL-1 Pin/ CN1-1 Pin	Function selection by JP3
50	ISENN	CN_INV-5 Pin/ CN3-5 Pin	
51	ISENP	CN_INV-6 Pin/ CN3-6 Pin	
52	WH	CN-HALL-3 Pin/ CN1-3 Pin	
53	VH	CN-HALL-4 Pin/ CN1-4 Pin	
54	UH	CN-HALL-5 Pin/ CN1-5 Pin	
55	P26/ANI6	VR1/ANI6-3 Pin/ CN2-3 Pin	
56	P25/ANI5	CN-HALL-1 Pin/ CN1-1 Pin ANI6-2 Pin/ CN2-2 Pin	Function selection by JP3
57	P24/ANI4	ANI6-3 Pin/ CN2-3 Pin	
58	P23/ANI3/ANO1/PGAGND	ANI6-4 Pin/ CN2-4 Pin	
59	P22/ANI2/ANO0/PGAI/IVCMP0	ANI6-5 Pin/ CN2-5 Pin	
60	P21/ANI1/AVREFM/IVCMP13	ANI6-6 Pin/ CN2-6 Pin	
61	P20/ANI0/AVREFP/IVCMP12	ANI6-7 Pin/ CN2-7 Pin	
62	P04/SCK10/SCL10	CN_DIGI-3 Pin/ CN4-3 Pin	
63	P03/ANI16/SI10/SDA10/RxD1/IVCMP11	CN_UART-3 Pin/ CN7-3 Pin	
64	P02/ANI17/SO10/TxD1/IVCMP10	CN_UART-2 Pin/ CN7-2 Pin	

Note. Unused general-purpose pins of RAJ306010 have unimplemented pins such as pull-up and pull-down resistors on the board for functional expansion. After confirming the recommended pin settings described in the circuit diagram of this board and the user's manual hardware of the RAJ306010, process correctly with the user program or hardware.

Rev.	Date	Description	
		Page	**Summary**
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