

RL78/G1F Motor Driver Board GB01

R12UT0012EJ0100
Rev.1.00
20.10.2020

User's Manual

For Your Safety




Be sure to read this manual before using the RL78/G1F Motor Driver Board GB01 (P13130-D1-003) (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).
- The manual for the product, and specification (the documents) are the tool that was developed for the function and performance evaluation of Renesas Electronics semiconductor device (Renesas Electronics device) mounted on the product, and not guarantee the same quality, function and performance.
- By purchasing the product or downloading the documents from Renesas Electronics website, the support services provided from Renesas Electronics is not guaranteed.
- All information contained in this manual represents information on products at the time of publication of this manual. Please note that the product data, specification, sales offices, contents of website, address, etc., are subject to change by Renesas Electronics Corporation without notice due to product improvements or other reasons. Please confirm the latest information on Renesas Electronics website.



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.

	<p>General Prohibition The indicated action is prohibited.</p>		<p>Example: Do Not Touch! Touching the specified location could result in injury.</p>
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Marks indicating that an action is prohibited.






	<p>General Caution Indicates a general need for caution that is not specified.</p>		<p>Example: Caution – Hot! Indicates the possibility of injury due to high temperature.</p>
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Marks directing that the specified action is required.







	<p>General Instruction The specified action is required.</p>		<p>Example: Turn Off (Disconnect) Power Supply! Instructs the user to turn off (disconnect) the power supply to the product.</p>
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Warnings Regarding Use of the Product

■ Danger Items

 Danger	
  	<ul style="list-style-type: none"> 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.
	<p>Do Not Connect Load to Motor!</p> <ul style="list-style-type: none"> This could cause fire, burns, or injury.

Warning Items

 Warning	
	<p>Caution – Rotating Parts!</p> <ul style="list-style-type: none"> • The system includes a motor. Touching the rotating shaft could cause high-temperature burns or injury.
	<p>Always insert plugs, connectors, and cables securely, and confirm that they are fully inserted.</p> <ul style="list-style-type: none"> • Incomplete connections could cause fire, burns, electric shock, or injury.
	<p>Use the power supply apparatus specified in the manual.</p> <ul style="list-style-type: none"> • Failure to do so could cause fire, burns, electric shock, injury, or malfunction.
	<p>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.</p> <ul style="list-style-type: none"> • Failure to do so could cause fire, burns, electric shock, or malfunction. • This will protect the system against damage due to lightning.
	<p>Use a mechanism (switch, outlet, etc.) located within reach to turn off (disconnect) the power supply.</p> <ul style="list-style-type: none"> • In case of emergency, it may be necessary to cut off the power supply quickly.
	<p>Turn off the power supply immediately if you notice abnormal odor, smoke, abnormal sound, or overheating.</p> <ul style="list-style-type: none"> • Continuing to use the system in an abnormal condition could cause fire, burns, or electric shock.
	<p>Do Not Disassemble, Modify, or Repair!</p> <ul style="list-style-type: none"> • Failure to do so could cause fire, burns, electric shock, injury, or malfunction.
	<p>Do not use the product for any purpose other than initial evaluation of motor control in a testing room or lab.</p> <p>Do not integrate the product or any part of it into other equipment.</p> <p>Do not insert or remove cables or connectors when the product is powered on.</p> <ul style="list-style-type: none"> • 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	
	<p>Caution – Hot!</p> <ul style="list-style-type: none"> • The motor gets hot. Touching it could cause high-temperature burns.
	<p>Follow the procedure specified in the manual when powering the system on or off.</p> <ul style="list-style-type: none"> • Failure to do so could cause overheating or malfunction.

Summary

The RL78/G1F Motor Driver Board GB01 (P13130-D1-003) is a motor control evaluation board. Be sure to connect a communication board when using the Renesas Motor Workbench (RMW). The customer needs to prepare an E1 emulator and the power supply for using this product. This user's manual describes the proper handling of the product.

Target Device

RL78/G1F microcontroller

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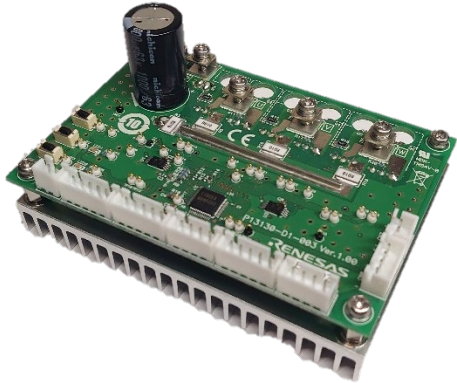
1. Overview

This user's manual describes the RL78/G1F Motor Driver Board BG01, a control evaluation board that drives a permanent magnet synchronous motor using the RL78/G1F microcontroller. The features of the evaluation board are shown below.

- (1) Supports the motor control microcontroller RL78/G1F.
- (2) Supports permanent magnet synchronous motors.
- (3) Can detect 3-shunt current and 1-shunt current.
- (4) Supports the input voltage of 12V to 50V.
- (5) Output peak current: 30A
- (6) Supports various sensor inputs (such as encoder and hall sensors), serial communications, and I2C communications.

2. Hardware Overview

Table 2.1 Specifications of 78/G1F Motor Driver Board GB01 (P13130-D1-003)

Item	Specification	
Operating input voltage	12V to 50V	
Maximum output current	30A (peak current for each phase)	
Driving monitor	3-phase permanent magnet synchronous motor	
Current detection method	Detects current using a shunt resistor for 3-phase and DC link.	
DC bus voltage detection	Detects using a resistance divider circuit.	
3-phase output voltage detection	Detects using a resistance divider circuit.	
PWM logic	Positive for both upper and lower arms.	
Overcurrent detection	Available by specifying the RL78/G1F MCU setting (PWMOPA) (No detection circuit is provided.)	
Dead time	1 μ s or more	
Switch	Three tact switches (including one switch for CPU reset)	
LEDs	2	
Connectors	<ul style="list-style-type: none"> • Emulator connector (with conversion cable): CN3 • I2C communication connector: CN6 • Two serial communication connectors: CN4 and CN8 • ABZ encoder signal input connector: CN2 • Hall sensor signal input connector: CN5 • Two analog signal input connectors: CN1 and CN7 	
Exterior view		
Heat dissipation	Natural air cooling by a heat sink	
MCU	Product No.	R5F11BGAEAFB
	CPU max. operating frequency	32MHz
	Bit count	16 bits
	Package/Pin count	LFQFP/48 pins
	ROM	64 KB
	RAM	5.5 KB
Operating temperature	Room temperature	
Operating humidity	No condensation	

3. Hardware Configuration

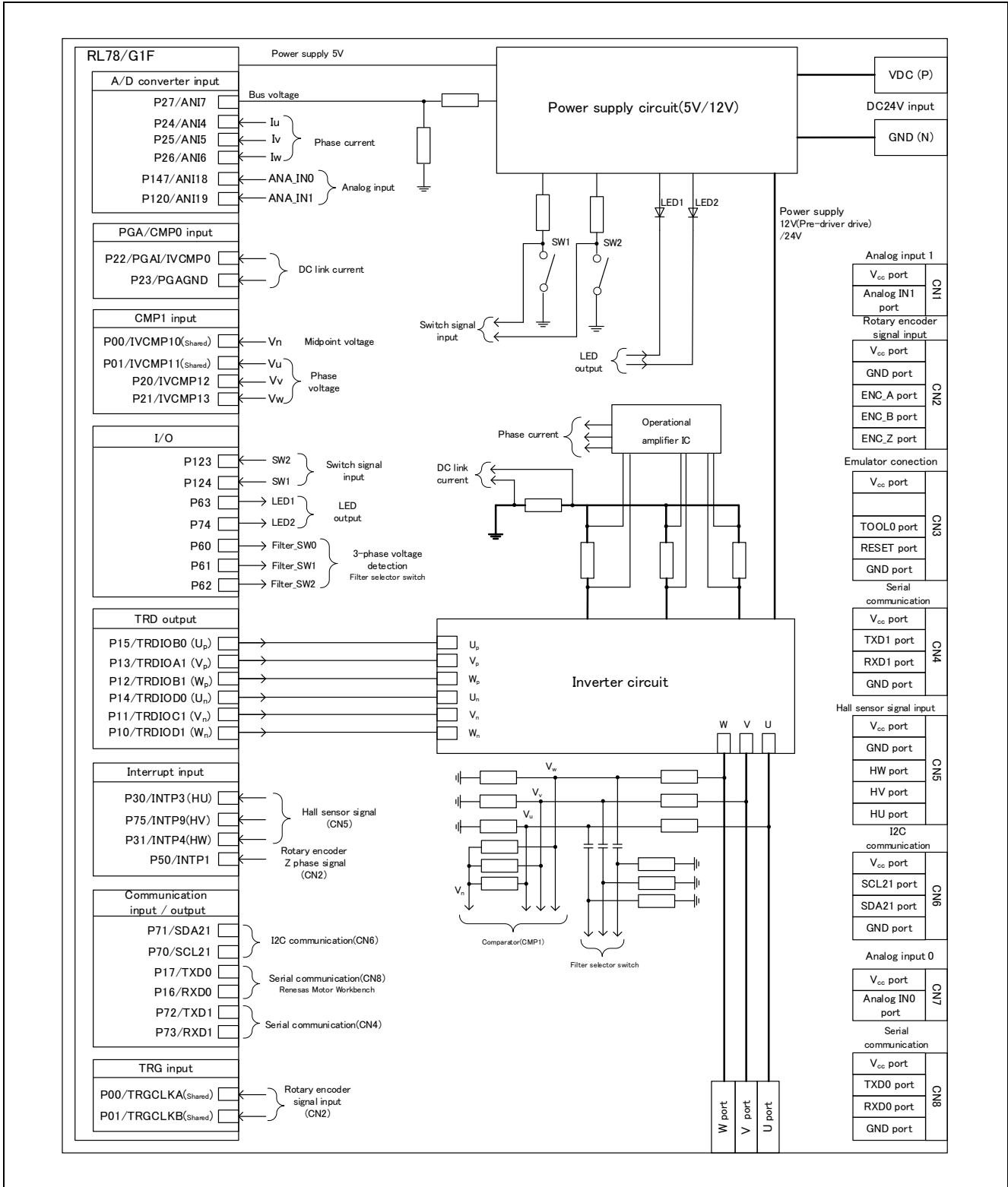


Figure 3-1 Hardware Configuration

4. Layout

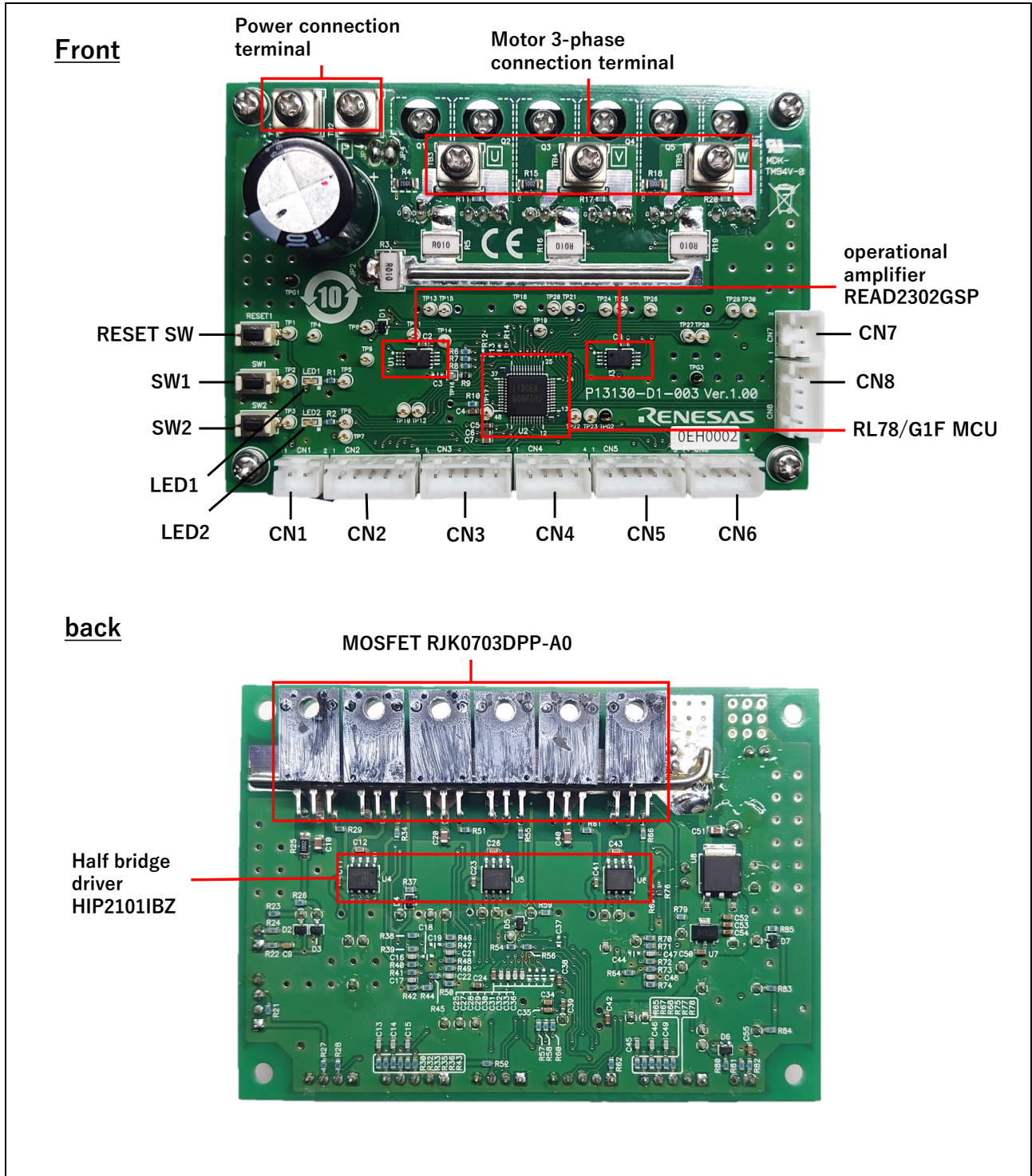


Figure 4-1 Layout

5. User Interface Specifications

Table 5.1 lists the user interface parts on this system.

Table 5.1 User Interface

Item	Interface Parts	Function
SW1	Tact switch	Can be defined by user
SW2	Tact switch	Can be defined by user
RESET	Tact switch (RESET1)	System reset
LED1	Yellow-green LEDs	Can be defined by user
LED2	Yellow-green LEDs	Can be defined by user

Table 5.2 lists the connector interface pins on this system.

Table 5.2 Connector Interface

Item	Pin Count	Function
CN1	2	Analog input
CN2	5	ABZ encoder signal input
CN3	5	Emulator connection (with conversion board)
CN4	4	Serial communications (SCI1)
CN5	5	Hall sensor signal input
CN6	4	I2C communications
CN7	2	Analog input
CN8	4	Serial communications (SCI0) with Renesas Motor Workbench

6. Alternate Function Pins

The RL78/G1F demo board switches the pin function using the 0-Ω resistors on the board circuit.

Table 6.1 Pin Function Switching

Port No.	Short-Circuited Resistor	Selected Pin Function	Function
P00	R9	ANI17/IVCMP10	Middle-point voltage detection
	R12	TRGCLKA	Encoder A phase
P01	R14	ANI16/IVCMP11	U-phase voltage detection
	R13	TRGCLKB	Encoder B phase

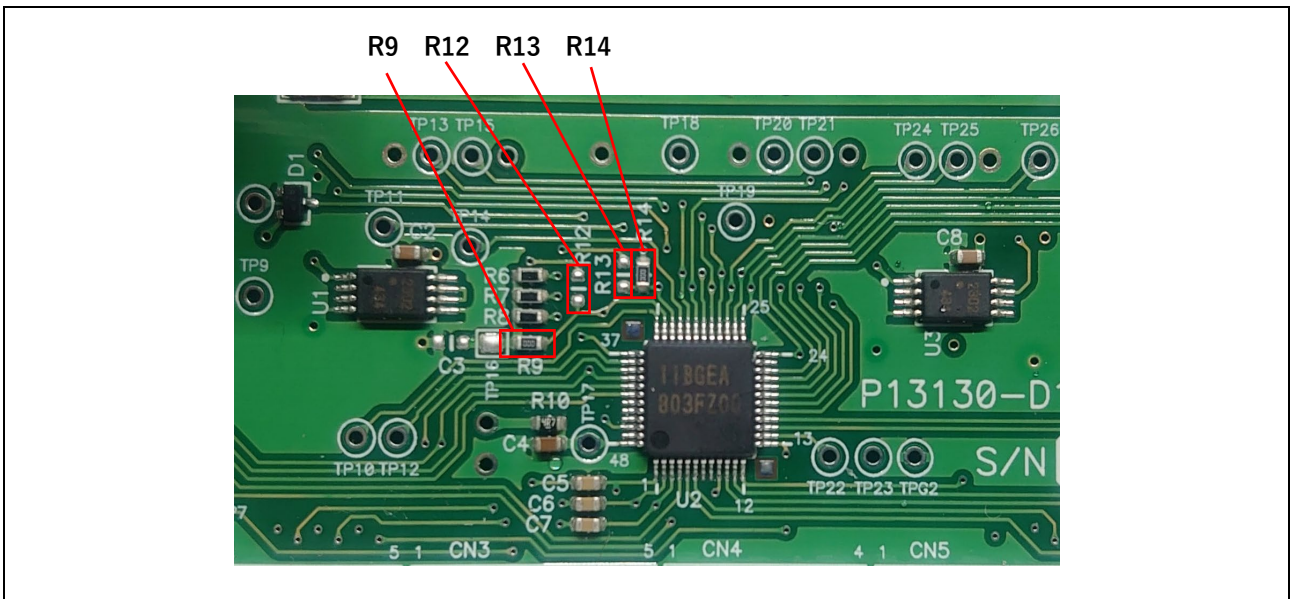


Figure 6-1 Short-Circuited Resistors on Board for Switching Pin Function

7. Sample Connection For Use

You need to prepare the cables for connecting the motor, power supply, and board. If you use the motor control development support tool “Renesas Motor Workbench”, you may use the communication board (RTK0EMX6B0Z00000BJ) or a third-party board (microcontroller waveform display tool “ICS++ (In Circuit Scope plus)”, manufactured by Desk Top Laboratories Inc.).

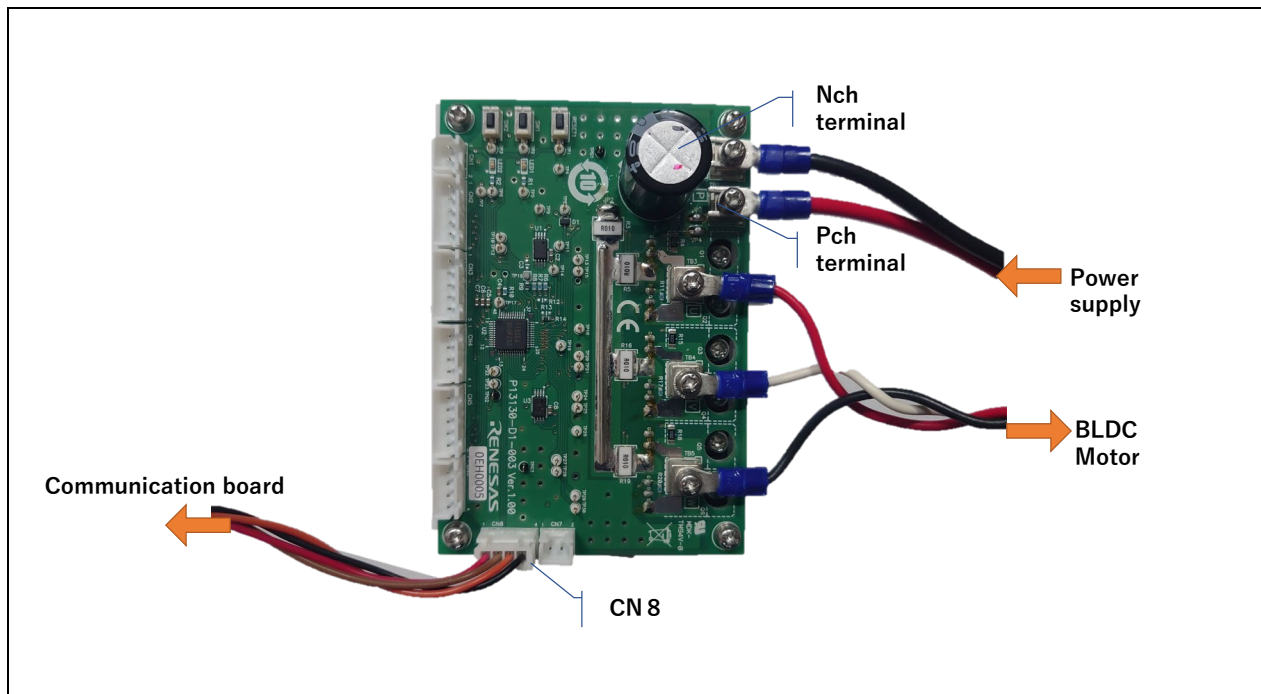


Figure 7-1 Sample Board Connection

8. Circuit Function

8.1 Inverter Control Circuit

The inverter control circuit control the motor using six Power MOS-FETs. The Power MOS-FETs use the 6-phase timer outputs from the microcontroller via the predriver IC.

The inverter control circuit inputs the DC line voltage, U-phase voltage, V-phase voltage, W-phase voltage, and shunt current to the A/D pins of the microcontroller. The analog values of each voltage and shunt current can thus be measured. See sections 8.2 and 8.3 for details about how to detect the current and voltage, respectively. The inverter control circuit also has a function to detect the overcurrent from the U-phase, V-phase, and W-phase shunt current.

Figure 8-1 shows a schematic diagram of the inverter control circuit. Note that the inputs to the A/D pins may actually pass through a voltage divider or an offset device. See the circuit diagram for details.

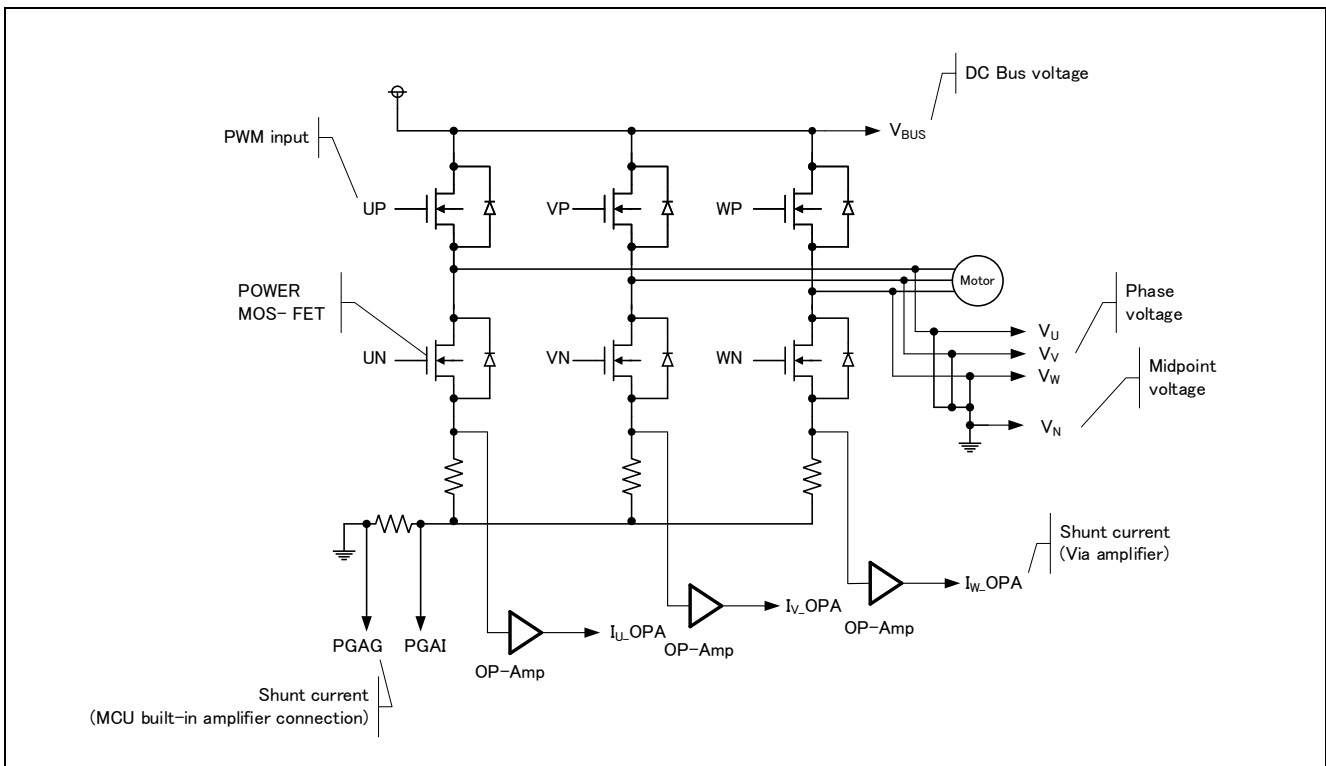


Figure 8-1 Schematic Diagram of Inverter Control Circuit

8.2 Current Detection Circuit

The current detection circuit is integrated to measure the U-phase, V-phase, and W-phase current. The current detection circuit is configured by mounting a shunt resistor for the U-phase, V-phase, and W-phase. The voltage drop generated when the current passes through the shunt resistor is amplified by the operational amplifier and then input to the microcontroller. The equation (1) below shows the relationship between the current I_{in} running through the shunt resistor and the voltage V_{out} input to the microcontroller.

$$V_{out}[V] = I_{in}[A] \times R_s[\Omega] \times 5 + 2.5 \quad (1)$$

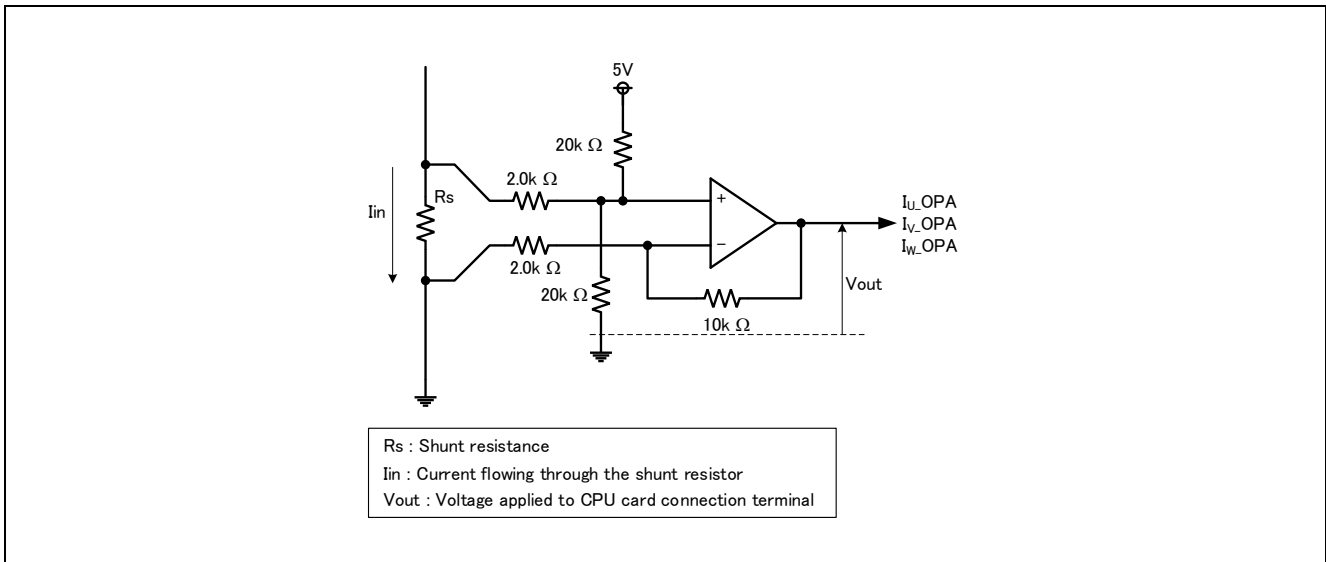


Figure 8-2 Schematic Diagram of Current Detection Circuit

Also, a DC link shunt resistor is mounted for 1-shunt current detection, which enables detection of the overcurrent by using the RL78/G1F internal PGA and current detection comparator.

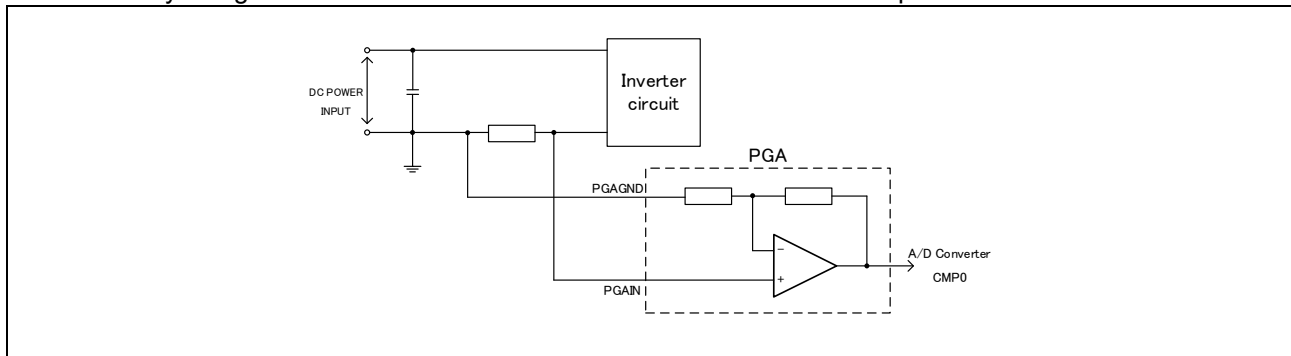


Figure 8-3 Connection of PGA and Inverter Control Circuit

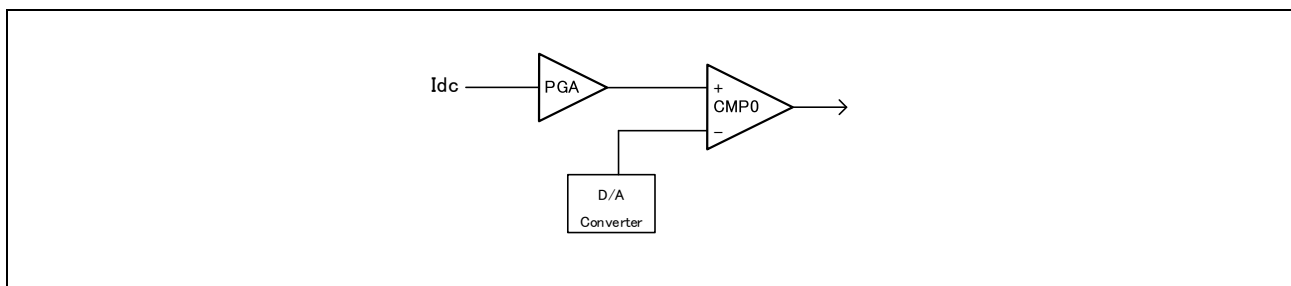


Figure 8-4 Overcurrent Detection Using Internal PGA and CMP0

8.3 Output Voltage Detection Circuit

The inverter board integrates a circuit used to input the bus line voltage and 3-phase output voltage (U-phase, V-phase, and W-phase) to the A/D pins of the microcontroller via a resistance voltage divider. The equation (2) below shows the relationship between the 3-phase output voltage, bus line voltage, and detection voltage.

$$V_{out}[V] = \frac{470}{10 \times 10^3 + 470} \times V_{in}[V] \quad (2)$$

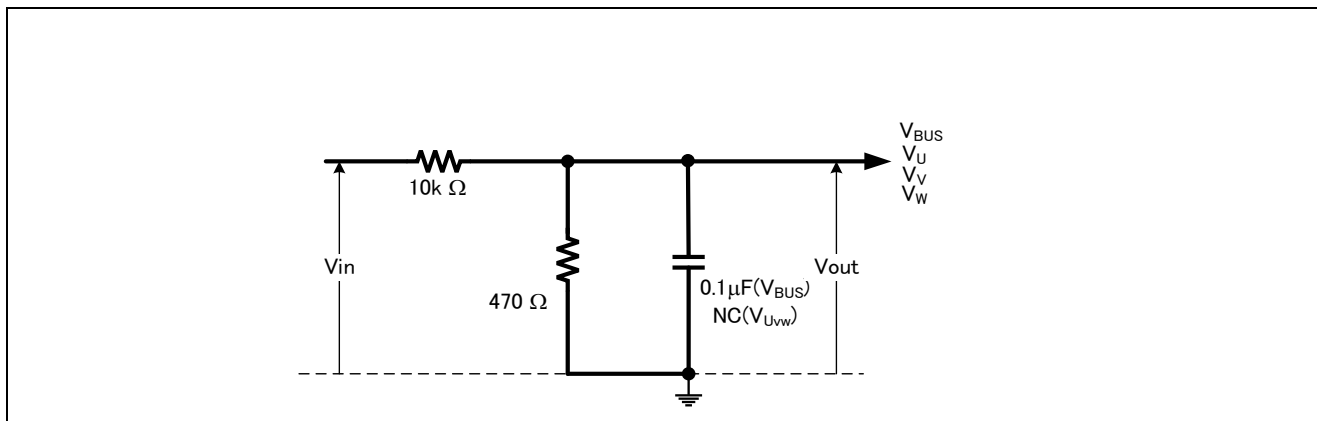


Figure 8-5 Schematic Diagram of Output Voltage Detection Circuit

8.4 Voltage Generation Circuit

This board generates the voltage of 12V and 5V from the main power supply (24V).

Table 8.1 Voltage Generation Circuit

Item	Input Voltage (Typ.) [V]	Output Voltage (Typ.) [V]	Output Current (Max.) [A]	Used for:
12V generation	24	12	0.06	<ul style="list-style-type: none"> • 5V generation • Gate driver IC
5V generation	12	5	0.1	Power supply for MCU

8.5 3-Phase Voltage Detection Filter Switching Circuit

This board integrates a circuit used to switch the filter constant for 3-phase voltage detection. When the signal level of the corresponding pin is changed, C of the ERC filter is switched, and the filter constant can thus be changed.

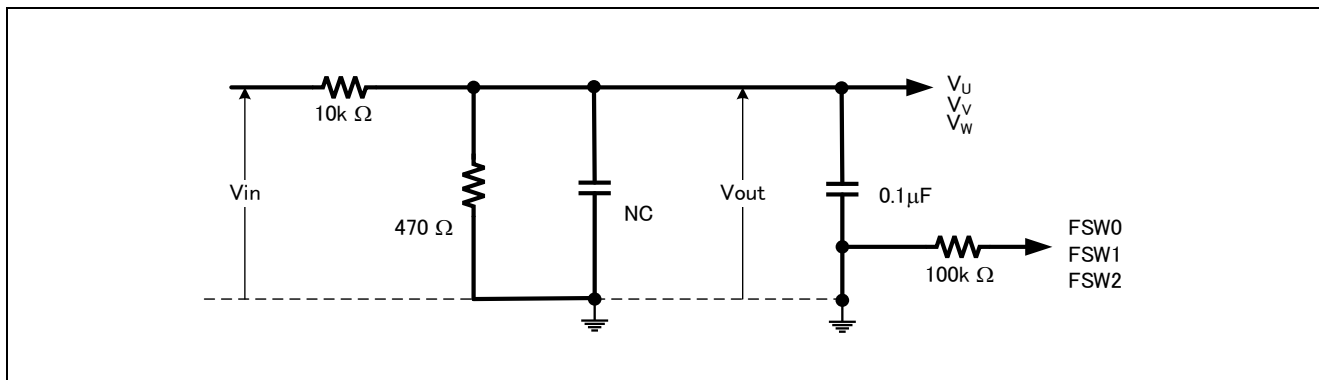


Figure 8-6 Schematic Diagram of 3-Phase Voltage Detection Filter Switching Circuit

Table 8.2 3-Phase Voltage Detection Filter Switching Circuit

FWS No.	Pin Signal Level	Filter Circuit State	Connected RL78/G1F Pin
FSW0	High	NC	P60
	Low	0.1μF	
FSW1	High	NC	P61
	Low	0.1μF	
FSW2	High	NC	P62
	Low	0.1μF	

8.6 LEDs

This board integrates two LEDs. The user can control the LEDs from the microcontroller.

Table 8.3 LEDs

LED No.	Pin Signal Level	LED State	Connected RL78/G1F Pin
LED1	High	Off	P63
	Low	On	
LED2	High	Off	P74
	Low	On	

8.7 Tact Switch

This board integrates two tact switches: SW1 and SW2. The user can define the behavior of them.

Table 8.4 Tact Switch

SW No.	Pin Signal Level	Switch Setting	Connected RL78/G1F Pin
SW1	High	Off	P124
	Low	On	
SW2	High	Off	P123
	Low	On	

8.8 Analog Signal Input Connector

This board integrates connectors for inputting analog signals. **Table 8.5** lists the pin assignment for each connector.

Table 8.5 Pin Assignment of Analog Signal Input Connectors (CN1/CN7)

Connector No.	Pin No.	Pin Function	Connected RL78/G1F Pin
CN1 Analog In1	1	5V	VCC
	2	Analog input	P147/ANI18
CN7 Analog In0	1	5V	VCC
	2	Analog input	P120/ANI19

When using these connectors, be sure to connect them to the compatible connector shown in **Table 8.6** below.

Table 8.6 Compatible Connector

Part	Part No.	Manufacturer
Connector	XHP-2	J.S.T. Mfg. Co. Ltd.

Table 8.7 Analog Signal Input Voltage Range

Item	Specification
Input voltage range [V]	0 to AVCC

8.9 Serial Communication Connector

This board integrates connectors for serial communication connection. Table 8.8 lists the pin assignment for each connector.

Table 8.8 Pin Assignment of Serial Communication Connectors (CN4/CN8)

Connector No.	Pin No.	Pin Function	Connected RL78/G1F Pin
CN4 UART0	1	5V	VCC
	2	Transmission	P17/TXD0
	3	Reception	P16/RXD0
	4	GND	VSS
CN8 UART1	1	5V	VCC
	2	Transmission	P72/TXD1
	3	Reception	P73/RXD1
	4	GND	VSS

When using these connectors, be sure to connect them to the compatible connector shown in **Table 8.9** below.

Table 8.9 Compatible Connector

Part	Part No.	Manufacturer
Connector	XHP-4	J.S.T. Mfg. Co. Ltd.

8.10 I2C Communication Connector

This board integrates a connector for I2C communication connection. **Table 8.10** lists the pin assignment for the connector.

Table 8.10 Pin Assignment of I2C Communication Connector (CN6)

Connector No.	Pin No.	Pin Function	Connected RL78/G1F Pin
CN6 I2C	1	5V	VCC
	2	SCL	P71/SDA21
	3	SDA	P70/SCL21
	4	GND	VSS

When using this connector, be sure to connect it to the compatible connector shown in **Table 8.11** below.

Table 8.11 Compatible Connector

Part	Part No.	Manufacturer
Connector	XHP-4	J.S.T. Mfg. Co. Ltd.

8.11 Hall Sensor Signal Input Connector

This board integrates a connector for Hall sensor signal input. This connector enables to input the Hall sensor signal from the supplied motor. The Hall sensor signal is pulled up to 5 V and then passed through an RC filter before being input to the board. **Table 8.12** lists the pin assignment of the Hall sensor signal input connector.

Table 8.12 Pin Assignment of Hall Sensor Signal Input Connector (CN5)

Pin No.	Pin Function	Connected RL78/G1F Pin
1	5V	VCC
2	GND	VSS
3	HU	P30/INTP3
4	HV	P75/INTP9
5	HW	P31/INTP4

When using this connector, be sure to connect it to the compatible connector shown in **Table 8.13** below.

Table 8.13 Compatible Connector

Part	Part No.	Manufacturer
Connector	XHP-5	J.S.T. Mfg. Co. Ltd.

8.12 Encoder Signal Input Connector

The encoder signal input function can input the encoder signals from the target motor. The encoder signal is pulled up to 5 V and passed through an RC filter before being input to the microcontroller. **Table 8.14** lists the pin assignment of the encoder signal input connector.

Table 8.14 Pin Assignment of Encoder Signal Input Connector (CN2)

Pin No.	Pin Function	Connected RL78/G1F Pin
1	5V	VCC
2	GND	VSS
3	A-phase	P00/TRDCLKA
4	B-phase	P01/TRDCLKB
5	Z-phase	P50/INTP1

When using this connector, be sure to connect it to the compatible connector shown in **Table 8.15** below.

Table 8.15 Compatible Connector

Part	Part No.	Manufacturer
Connector	XHP-5	J.S.T. Mfg. Co. Ltd.

8.13 Emulator Connector

When the board is connected with an emulator via the emulator connector, it is possible to write data from the emulator. **Table 8.14** lists the pin assignment of the emulator connector.

Table 8.16 Pin Assignment of Emulator Connector (CN3)

Pin No.	Pin Function	Connected RL78/G1F Pin
1	5V	VCC
2	NC	NC
3	Debugger data Input/output	P40/TOOL0
4	System reset input	P125/RESET
5	GND	VSS

When using this connector, be sure to connect it to the compatible connector shown in **Table 8.15** below.

Table 8.17 Compatible Connector

Part	Part No.	Manufacturer
Connector	XHP-5	J.S.T. Mfg. Co. Ltd.

When the conversion board (P014012-1-005) is used, the signals input via the emulator connector can be converted for connection.



Figure 8-7 Conversion Boards (P014012-1-005)

Figure 8-8 shows a schematic diagram of the conversion board circuit.

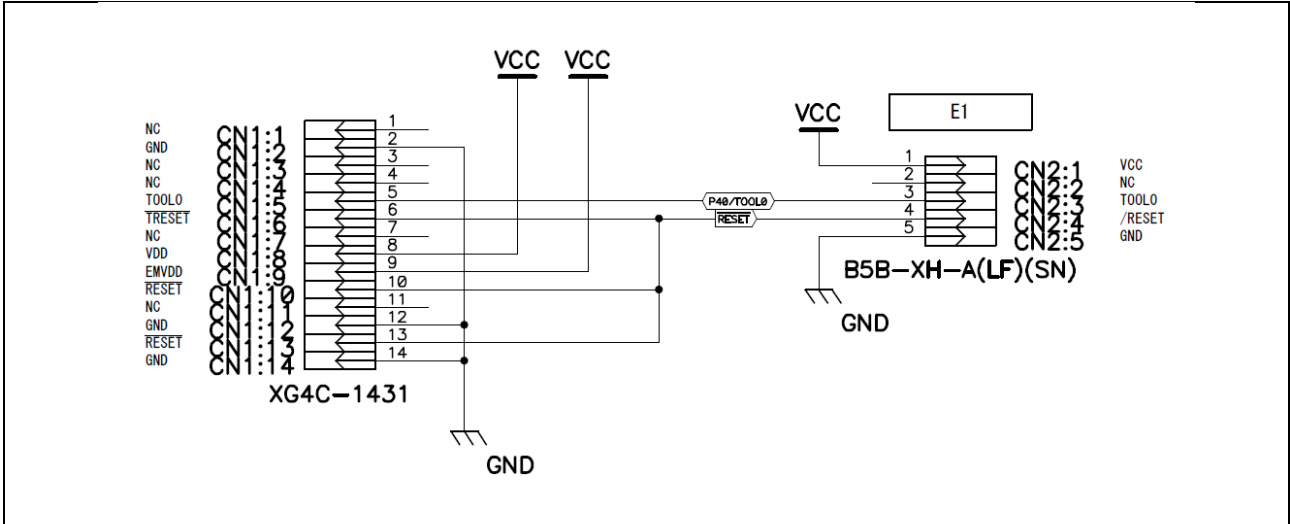


Figure 8-8 Schematic Diagram of Conversion Board Circuit

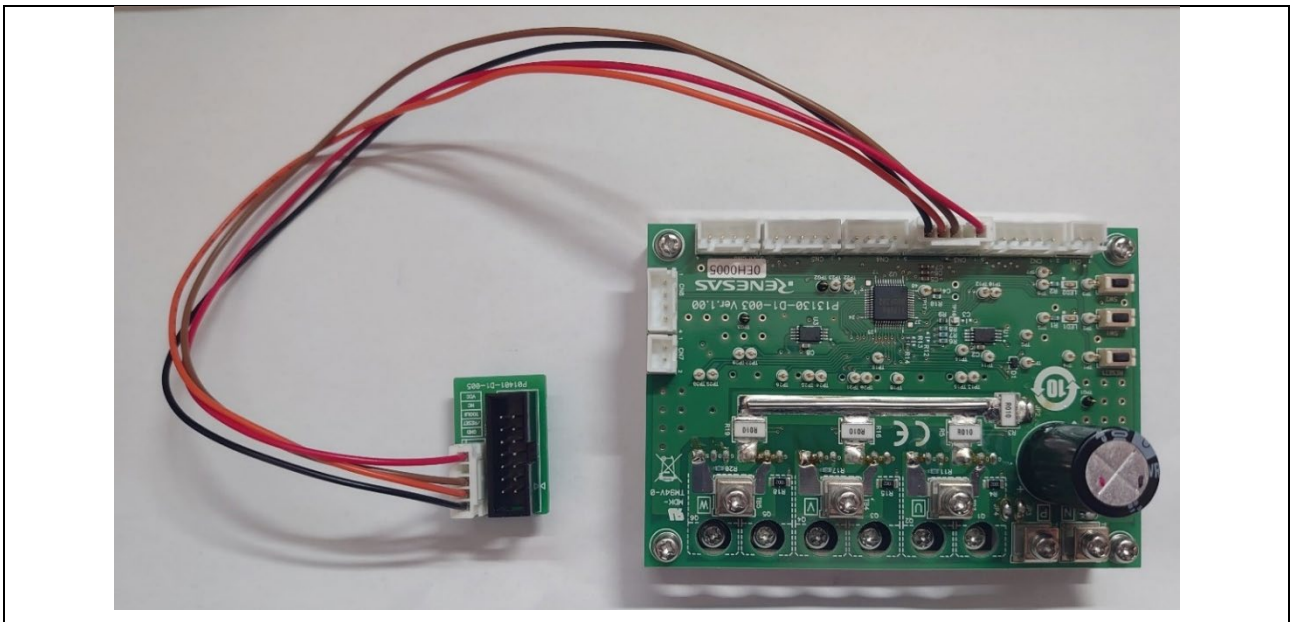


Figure 8-9 Connection with Inverter Board

8.14 Reset Circuit

This board integrates a reset circuit for resetting the microcontroller at power-on reset and external reset. To apply an external reset to the microcontroller, press the tact switch (RESET1).

9. List of RL78/G1F Pin Functions

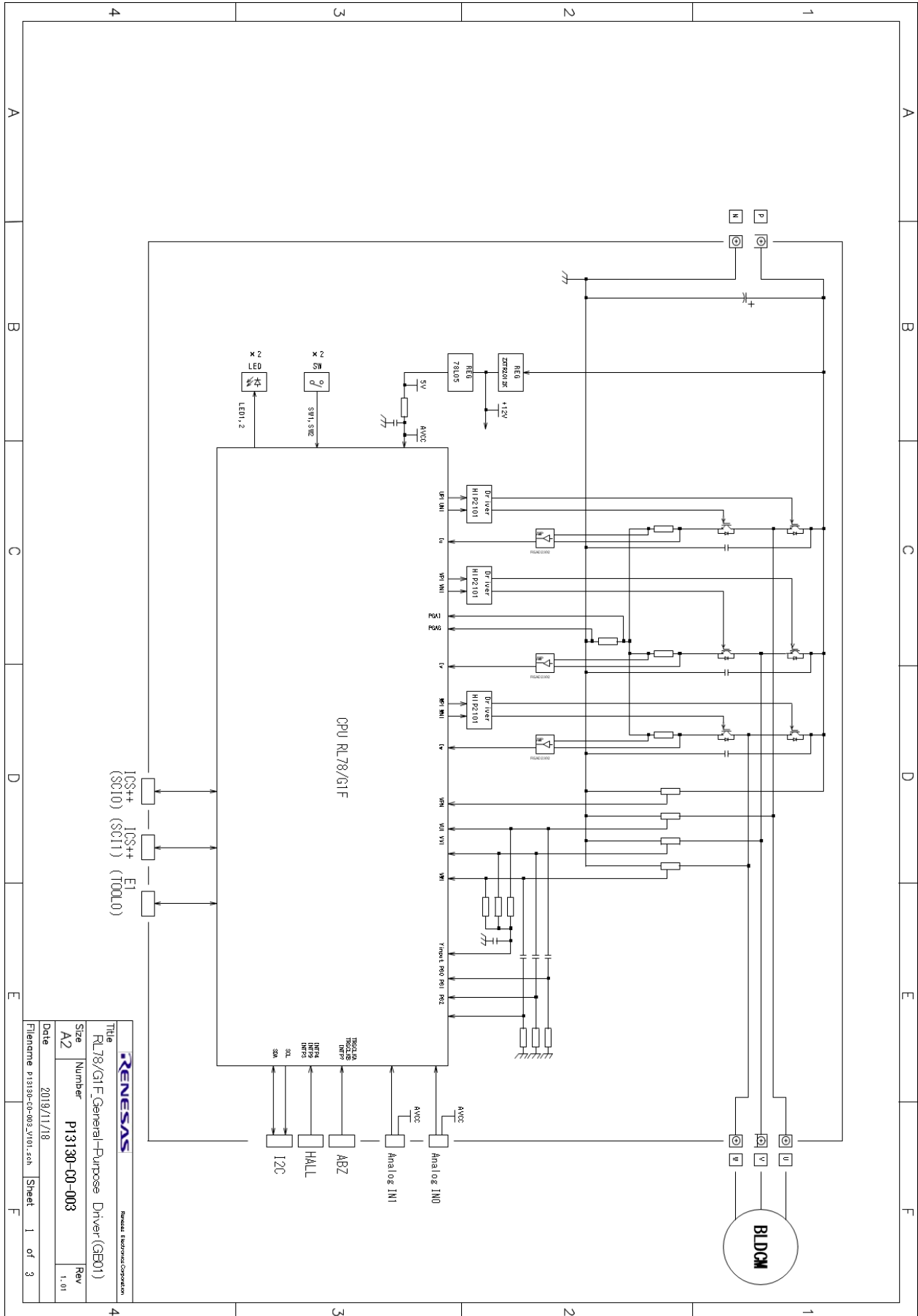
Table 9.1 List of RL78/G1F Pin Functions (1/2)

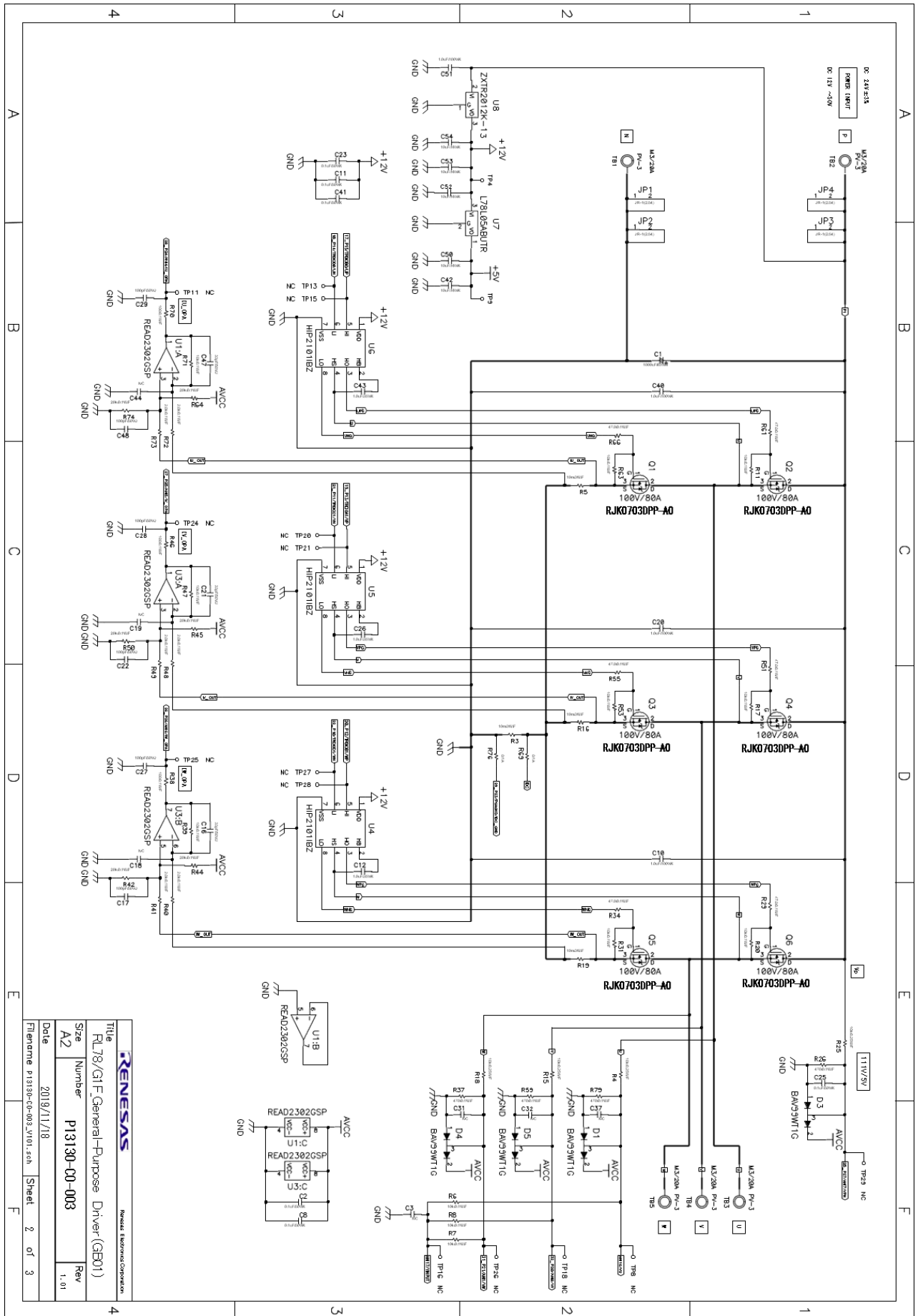
Pin No.	R5F11BGAEAFB Pin Name	Function
1	P60	U-phase voltage detection filter switch
2	P61	V-phase voltage detection filter switch
3	P62	W-phase voltage detection filter switch
4	P63	LED1 on/off control
5	P31/INTP4	Hall sensor input (HW)
6	P75/INTP9	Hall sensor input (HV)
7	P74	LED2 on/off control
8	P72/TXD1	Serial communication
9	P73/RXD1	Serial communication
10	P71/SDA21	I2C communication
11	P70/SCL21	I2C communication
12	P30/INTP3	Hall sensor input (HU)
13	P50/INTP1	Encoder Z-phase input
14	P51	-
15	P17/TXD0	Serial communication (SCI0)
16	P16/RXD0	Serial communication (SCI0)
17	P15/TRDIOB0	PWM output (U_p)
18	P14/TRDIOD0	PWM output (U_n)
19	P13/TRDIOA1	PWM output (V_p)
20	P12/TRDIOB1	PWM output (W_p)
21	P11/TRDIOC1	PWM output (V_n)
22	P10/TRDIOD1	PWM output (W_n)
23	P146	-
24	P147/ANI18	Analog input
25	P27/ANI7	Inverter bus line voltage measurement
26	P26/ANI6	W-phase current measurement
27	P25/ANI5	V-phase current measurement
28	P24/ANI4	U-phase current measurement
29	P23/PGAGND	DC link current detection GND
30	P22/PGA/IVCMP0	DC link current detection (A/D, PGA, CMP)
31	P21/IVCMP13	W-phase voltage measurement (CMP1)
32	P20/IVCMP12	V-phase voltage measurement (CMP1)
33	P130	-
34	P01/IVCMP11/TRDCLKB	U-phase voltage measurement (CMP1)/ Encoder B-phase input (pin shared)
35	P00/IVCMP10/ TRDCLKA	3-phase middle-point voltage measurement (CMP1)/ Encoder A-phase input (pin shared)
36	P140	-
37	P120/ANI19	Analog input
38	P41	-
39	P40/TOOL0	Debugger data Input/output
40	P125/RESET	System reset input
41	P124	Tact switch (SW1)
42	P123	Tact switch (SW2)
43	P137	GND
44	P122	GND
45	P121	GND

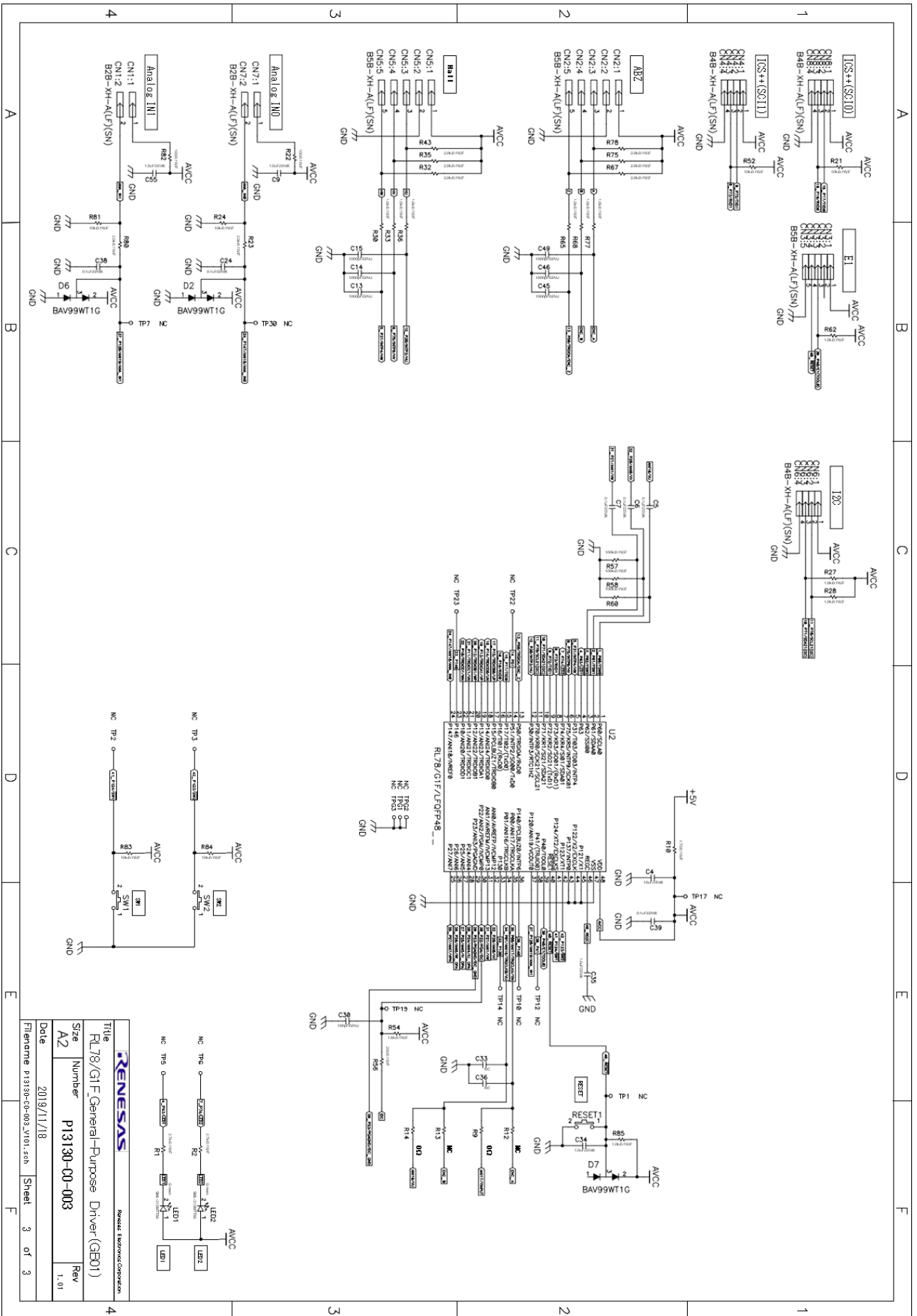
Table 9.2 List of RL78/G1F Pin Functions (2/2)

Pin No.	R5F11BGAEAFB Pin Name	Function
46	REGC	Connection of capacitor for stabilizing output from regulator for internal operation
47	VSS	Ground potential for pins
48	VDD	Positive power supply for pins

10. Schematics







11. BOM

Table 11-1 BOM [1/5]

No.	Name of articles	Model	Specification	Part number	Name of maker
1	CONN HEADER VERT 2POS 2.5MM	B2B-XH-A(LF)(SN)	2POS 2.5MM	CN1	JST Sales America Inc
2	CONN HEADER VERT 2POS 2.5MM	B2B-XH-A(LF)(SN)	"	CN7	JST Sales America Inc
3	CONN HEADER XH TOP 4POS 2.5MM	B4B-XH-A(LF)(SN)	4POS 2.5MM	CN4	JST Sales America Inc
4	CONN HEADER XH TOP 4POS 2.5MM	B4B-XH-A(LF)(SN)	"	CN6	JST Sales America Inc
5	CONN HEADER XH TOP 4POS 2.5MM	B4B-XH-A(LF)(SN)	"	CN8	JST Sales America Inc
6	CONN HEADER XH TOP 5POS 2.5MM	B5B-XH-A(LF)(SN)	5POS 2.5MM	CN2	JST Sales America Inc
7	CONN HEADER XH TOP 5POS 2.5MM	B5B-XH-A(LF)(SN)	"	CN3	JST Sales America Inc
8	CONN HEADER XH TOP 5POS 2.5MM	B5B-XH-A(LF)(SN)	"	CN5	JST Sales America Inc
9	DIODE ARRAY GP 100V 215MA SC70-3	BAV99WT1G	SC-70/SOT-323	D1	ON Semiconductor
10	DIODE ARRAY GP 100V 215MA SC70-3	BAV99WT1G	"	D2	ON Semiconductor
11	DIODE ARRAY GP 100V 215MA SC70-3	BAV99WT1G	"	D3	ON Semiconductor
12	DIODE ARRAY GP 100V 215MA SC70-3	BAV99WT1G	"	D4	ON Semiconductor
13	DIODE ARRAY GP 100V 215MA SC70-3	BAV99WT1G	"	D5	ON Semiconductor
14	DIODE ARRAY GP 100V 215MA SC70-3	BAV99WT1G	"	D6	ON Semiconductor
15	DIODE ARRAY GP 100V 215MA SC70-3	BAV99WT1G	"	D7	ON Semiconductor
16	CAP CER 10UF 16V X5R 0603	GRM188R61C106KAALD	C1608/10uF/16V/K	C4	Murata
17	CAP CER 10UF 16V X5R 0603	GRM188R61C106KAALD	"	C42	Murata
18	CAP CER 10UF 16V X5R 0603	GRM188R61C106KAALD	"	C50	Murata
19	CAP CER 10UF 16V X5R 0603	GRM188R61C106KAALD	"	C52	Murata
20	CAP CER 10UF 16V X5R 0603	GRM188R61C106KAALD	"	C53	Murata
21	CAP CER 10UF 16V X5R 0603	GRM188R61C106KAALD	"	C54	Murata
22	CAP CER C1608_50V_10%	GCM188L81H104K	C1608/0.1uF/25V/K	C5	MURATA
23	CAP CER C1608_50V_10%	GCM188L81H104K	"	C6	MURATA
24	CAP CER C1608_50V_10%	GCM188L81H104K	"	C7	MURATA
25	CAP CER 1UF 35V X6S 0603	GRT188C8YA105KE13D	C1608/1.0uF/35V/K	C9	Murata
26	CAP CER 1UF 35V X6S 0603	GRT188C8YA105KE13D	"	C12	Murata
27	CAP CER 1UF 35V X6S 0603	GRT188C8YA105KE13D	"	C26	Murata
28	CAP CER 1UF 35V X6S 0603	GRT188C8YA105KE13D	"	C34	Murata
29	CAP CER 1UF 35V X6S 0603	GRT188C8YA105KE13D	"	C35	Murata
30	CAP CER 1UF 35V X6S 0603	GRT188C8YA105KE13D	"	C43	Murata
31	CAP CER 1UF 35V X6S 0603	GRT188C8YA105KE13D	"	C55	Murata
32	CAP CER C1608_50V_5%	GRM1882C1H101J	C1608/100pF/50V/J	C17	MURATA
33	CAP CER C1608_50V_5%	GRM1882C1H101J	"	C22	MURATA
34	CAP CER C1608_50V_5%	GRM1882C1H101J	"	C27	MURATA
35	CAP CER C1608_50V_5%	GRM1882C1H101J	"	C28	MURATA
36	CAP CER C1608_50V_5%	GRM1882C1H101J	"	C29	MURATA
37	CAP CER C1608_50V_5%	GRM1882C1H101J	"	C30	MURATA
38	CAP CER C1608_50V_5%	GRM1882C1H101J	"	C48	MURATA
39	CAP CER C1608_50V_5%	GRM1882C1H102J	C1608/1000pF/50V/J	C13	MURATA
40	CAP CER C1608_50V_5%	GRM1882C1H102J	"	C14	MURATA
41	CAP CER C1608_50V_5%	GRM1882C1H102J	"	C15	MURATA
42	CAP CER C1608_50V_5%	GRM1882C1H102J	"	C45	MURATA
43	CAP CER C1608_50V_5%	GRM1882C1H102J	"	C46	MURATA
44	CAP CER C1608_50V_5%	GRM1882C1H102J	"	C49	MURATA
45	CAP CER C1608_50V_10%	GCM188L81H104K	C1608/0.1uF/50V/K	C2	MURATA

Table 11-2 BOM [2/5]

No.	Name of articles	Model	Specification	Part number	Name of maker
46	CAP CER C1608_50V_10%	GCM188L81H104K	C1608/0.1uF/50V/K	C8	MURATA
47	CAP CER C1608_50V_10%	GCM188L81H104K	"	C11	MURATA
48	CAP CER C1608_50V_10%	GCM188L81H104K	"	C23	MURATA
49	CAP CER C1608_50V_10%	GCM188L81H104K	"	C24	MURATA
50	CAP CER C1608_50V_10%	GCM188L81H104K	"	C25	MURATA
51	CAP CER C1608_50V_10%	GCM188L81H104K	"	C38	MURATA
52	CAP CER C1608_50V_10%	GCM188L81H104K	"	C39	MURATA
53	CAP CER C1608_50V_10%	GCM188L81H104K	"	C41	MURATA
54	CAP CER C1608_50V_5%	GRM1882C1H330J	C1608/33pF/50V/J	C16	MURATA
55	CAP CER C1608_50V_5%	GRM1882C1H330J	"	C21	MURATA
56	CAP CER C1608_50V_5%	GRM1882C1H330J	"	C47	MURATA
57	CAP CER NC	*****	C1608/NC	C3	*****
58	CAP CER NC	*****	"	C18	*****
59	CAP CER NC	*****	"	C19	*****
60	CAP CER NC	*****	"	C31	*****
61	CAP CER NC	*****	"	C32	*****
62	CAP CER NC	*****	"	C33	*****
63	CAP CER NC	*****	"	C36	*****
64	CAP CER NC	*****	"	C37	*****
65	CAP CER NC	*****	"	C44	*****
66	CAP CER 1UF 100V X7S 0805	CGA4J3X7S2A105K125AB	C2125/1.0uF/100V/K	C10	TDK Corporation
67	CAP CER 1UF 100V X7S 0805	CGA4J3X7S2A105K125AB	"	C20	TDK Corporation
68	CAP CER 1UF 100V X7S 0805	CGA4J3X7S2A105K125AB	"	C40	TDK Corporation
69	CAP CER 1UF 100V X7S 0805	CGA4J3X7S2A105K125AB	"	C51	TDK Corporation
70	SWITCH LT TOUCH 6X3.5 240GF SMD	EVQ-5PN04K	6*3.56H4.3	RESET1	Panasonic - ECG
71	SWITCH LT TOUCH 6X3.5 240GF SMD	EVQ-5PN04K	"	SW1	Panasonic - ECG
72	SWITCH LT TOUCH 6X3.5 240GF SMD	EVQ-5PN04K	"	SW2	Panasonic - ECG
73	IC GATE DRVR HALF-BRIDGE 8SOIC	HIP2101BZ	EPSOIC8	U4	Renesas
74	IC GATE DRVR HALF-BRIDGE 8SOIC	HIP2101BZ	"	U5	Renesas
75	IC GATE DRVR HALF-BRIDGE 8SOIC	HIP2101BZ	"	U6	Renesas
76	PC TEST POINT TIN SMD	HK-4-S	1.0*1.2	TP16	MAC8
77	Jumper wire (2.54mm)	JR-1	2POS 2.54MM	JP1	MAC8
78	Jumper wire (2.54mm)	JR-1	"	JP2	MAC8
79	Jumper wire (2.54mm)	JR-1	"	JP3	MAC8
80	Jumper wire (2.54mm)	JR-1	"	JP4	MAC8
81	RES 0.01 OHM 3W 2512 WIDE	KRL6432E-M-R010-F-T1	R3264/10m/3W/F	R3	Susumu
82	RES 0.01 OHM 3W 2512 WIDE	KRL6432E-M-R010-F-T1	"	R5	Susumu
83	RES 0.01 OHM 3W 2512 WIDE	KRL6432E-M-R010-F-T1	"	R16	Susumu
84	RES 0.01 OHM 3W 2512 WIDE	KRL6432E-M-R010-F-T1	"	R19	Susumu
85	IC REGULATOR POS 5V SOT-89	L78L05ABUTR	TO-243AA/SOT-89-3	U7	STMicroelectronics
86	TEST POINT PC MINI 0.8D BLACK	LC-33-G BLACK	BLACK	TPG1	MAC8
87	TEST POINT PC MINI 0.8D BLACK	LC-33-G BLACK	"	TPG2	MAC8
88	TEST POINT PC MINI 0.8D BLACK	LC-33-G BLACK	"	TPG3	MAC8
89	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	WHITE	TP1	MAC8
90	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP2	MAC8

Table 11-3 BOM [3/5]

No.	Name of articles	Model	Specification	Part number	Name of maker
91	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	WHITE	TP3	MAC8
92	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP4	MAC8
93	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP5	MAC8
94	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP6	MAC8
95	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP7	MAC8
96	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP8	MAC8
97	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP9	MAC8
98	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP10	MAC8
99	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP11	MAC8
100	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP12	MAC8
101	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP13	MAC8
102	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP14	MAC8
103	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP15	MAC8
104	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP17	MAC8
105	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP18	MAC8
106	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP19	MAC8
107	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP20	MAC8
108	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP21	MAC8
109	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP22	MAC8
110	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP23	MAC8
111	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP24	MAC8
112	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP25	MAC8
113	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP26	MAC8
114	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP27	MAC8
115	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP28	MAC8
116	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP29	MAC8
117	TEST POINT PC MINI 0.8D WHITE	LC-33-G WHITE	"	TP30	MAC8
118	Power supply terminal for surface mounting	PV-3	7*7*H5	TB1	MAC8
119	Power supply terminal for surface mounting	PV-3	"	TB2	MAC8
120	Power supply terminal for surface mounting	PV-3	"	TB3	MAC8
121	Power supply terminal for surface mounting	PV-3	"	TB4	MAC8
122	Power supply terminal for surface mounting	PV-3	"	TB5	MAC8
123	RES NC		R1608/NC	R12	
124	RES NC		R1608/NC	R13	
125	RES SMD R1608_0/1A	RK73Z1JTDD	R1608/0/1A	R69	KOA
126	RES SMD R1608_0/1A	RK73Z1JTDD	"	R76	KOA
127	RES SMD R1608_0.1W_1%	RK73H1JTDD4R70F	R1608/4.70/0.1W/F	R10	KOA
128	RES SMD R1608_0.1W_1%	RK73H1JTDD47R0F	R1608/47.0/0.1W/F	R29	KOA
129	RES SMD R1608_0.1W_1%	RK73H1JTDD47R0F	"	R34	KOA
130	RES SMD R1608_0.1W_1%	RK73H1JTDD47R0F	"	R51	KOA
131	RES SMD R1608_0.1W_1%	RK73H1JTDD47R0F	"	R55	KOA
132	RES SMD R1608_0.1W_1%	RK73H1JTDD47R0F	"	R61	KOA
133	RES SMD R1608_0.1W_1%	RK73H1JTDD47R0F	"	R66	KOA
134	RES SMD R1608_0.1W_1%	RK73H1JTDD1000F	R1608/100/0.1W/F	R22	KOA

Table 11-4 BOM [4/5]

No.	Name of articles	Model	Specification	Part number	Name of maker
135	RES SMD R1608_0.1W_1%	RK73H1JTTD1000F	R1608/100/0.1W/F	R38	KOA
136	RES SMD R1608_0.1W_1%	RK73H1JTTD1000F	"	R46	KOA
137	RES SMD R1608_0.1W_1%	RK73H1JTTD1000F	"	R70	KOA
138	RES SMD R1608_0.1W_1%	RK73H1JTTD1000F	"	R82	KOA
139	RES SMD R1608_0.1W_1%	RK73H1JTTD1001F	R1608/1.0k/0.1W/F	R27	KOA
140	RES SMD R1608_0.1W_1%	RK73H1JTTD1001F	"	R28	KOA
141	RES SMD R1608_0.1W_1%	RK73H1JTTD1001F	"	R30	KOA
142	RES SMD R1608_0.1W_1%	RK73H1JTTD1001F	"	R33	KOA
143	RES SMD R1608_0.1W_1%	RK73H1JTTD1001F	"	R36	KOA
144	RES SMD R1608_0.1W_1%	RK73H1JTTD1001F	"	R62	KOA
145	RES SMD R1608_0.1W_1%	RK73H1JTTD1001F	"	R65	KOA
146	RES SMD R1608_0.1W_1%	RK73H1JTTD1001F	"	R68	KOA
147	RES SMD R1608_0.1W_1%	RK73H1JTTD1001F	"	R77	KOA
148	RES SMD R1608_0.1W_1%	RK73H1JTTD1001F	"	R85	KOA
149	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	R1608/10k/0.1W/F	R6	KOA
150	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	"	R7	KOA
151	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	"	R8	KOA
152	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	"	R11	KOA
153	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	"	R17	KOA
154	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	"	R20	KOA
155	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	"	R21	KOA
156	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	"	R24	KOA
157	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	"	R31	KOA
158	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	"	R39	KOA
159	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	"	R47	KOA
160	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	"	R52	KOA
161	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	"	R53	KOA
162	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	"	R63	KOA
163	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	"	R71	KOA
164	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	"	R81	KOA
165	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	"	R83	KOA
166	RES SMD R1608_0.1W_1%	RK73H1JTTD1002F	"	R84	KOA
167	RES SMD R1608_0.1W_1%	RK73H1JTTD1003F	R1608/100k/0.1W/F	R57	KOA
168	RES SMD R1608_0.1W_1%	RK73H1JTTD1003F	"	R58	KOA
169	RES SMD R1608_0.1W_1%	RK73H1JTTD1003F	"	R60	KOA
170	RES SMD R1608_0.1W_1%	RK73H1JTTD1801F	R1608/1.8k/0.1W/F	R54	KOA
171	RES SMD R1608_0.1W_1%	RK73H1JTTD2000F	R1608/200/0.1W/F	R56	KOA
172	RES SMD R1608_0.1W_1%	RK73H1JTTD2001F	R1608/2.0k/0.1W/F	R23	KOA
173	RES SMD R1608_0.1W_1%	RK73H1JTTD2001F	"	R32	KOA
174	RES SMD R1608_0.1W_1%	RK73H1JTTD2001F	"	R35	KOA
175	RES SMD R1608_0.1W_1%	RK73H1JTTD2001F	"	R40	KOA
176	RES SMD R1608_0.1W_1%	RK73H1JTTD2001F	"	R41	KOA
177	RES SMD R1608_0.1W_1%	RK73H1JTTD2001F	"	R43	KOA
178	RES SMD R1608_0.1W_1%	RK73H1JTTD2001F	"	R48	KOA

Table 11-5 BOM [5/5]

No.	Name of articles	Model	Specification	Part number	Name of maker
179	RES SMD R1608_0.1W_1%	RK73H1JTTD2001F	R1608/2.0k/0.1W/F	R49	KOA
180	RES SMD R1608_0.1W_1%	RK73H1JTTD2001F	"	R67	KOA
181	RES SMD R1608_0.1W_1%	RK73H1JTTD2001F	"	R72	KOA
182	RES SMD R1608_0.1W_1%	RK73H1JTTD2001F	"	R73	KOA
183	RES SMD R1608_0.1W_1%	RK73H1JTTD2001F	"	R75	KOA
184	RES SMD R1608_0.1W_1%	RK73H1JTTD2001F	"	R78	KOA
185	RES SMD R1608_0.1W_1%	RK73H1JTTD2001F	"	R80	KOA
186	RES SMD R1608_0.1W_1%	RK73H1JTTD2002F	R1608/20k/0.1W/F	R42	KOA
187	RES SMD R1608_0.1W_1%	RK73H1JTTD2002F	"	R44	KOA
188	RES SMD R1608_0.1W_1%	RK73H1JTTD2002F	"	R45	KOA
189	RES SMD R1608_0.1W_1%	RK73H1JTTD2002F	"	R50	KOA
190	RES SMD R1608_0.1W_1%	RK73H1JTTD2002F	"	R64	KOA
191	RES SMD R1608_0.1W_1%	RK73H1JTTD2002F	"	R74	KOA
192	RES SMD R1608_0.1W_1%	RK73H1JTTD2701F	R1608/2.7k/0.1W/F	R1	KOA
193	RES SMD R1608_0.1W_1%	RK73H1JTTD2701F	"	R2	KOA
194	RES SMD R1608_0.1W_1%	RK73H1JTTD4700F	R1608/470/0.1W/F	R26	KOA
195	RES SMD R1608_0.1W_1%	RK73H1JTTD4700F	"	R37	KOA
196	RES SMD R1608_0.1W_1%	RK73H1JTTD4700F	"	R59	KOA
197	RES SMD R1608_0.1W_1%	RK73H1JTTD4700F	"	R79	KOA
198	RES SMD R1608_0/1A	RK73Z1JTTD	R1608/0/1A	R9	KOA
199	RES SMD R1608_0/1A	RK73Z1JTTD	R1608/0/1A	R14	KOA
200	RES SMD 10K OHM 1% 1/4W 1206	RCG120610K0FKEA	R3216/10k/0.25W/F	R4	Vishay
201	RES SMD 10K OHM 1% 1/4W 1206	RCG120610K0FKEA	"	R15	Vishay
202	RES SMD 10K OHM 1% 1/4W 1206	RCG120610K0FKEA	"	R18	Vishay
203	RES SMD 10K OHM 1% 1/4W 1206	RCG120610K0FKEA	"	R25	Vishay
204	MSIG CMOS DUAL OPAMP HI-SPEED TS	READ2302GSP#GC3	TSSOP8	U1	Renesas
205	MSIG CMOS DUAL OPAMP HI-SPEED TS	READ2302GSP#GC3	"	U3	Renesas
206	MOSFET N-CH 75V 70A TO-220FPA	RJK0703DPP-A0	TO-220FPA	Q1	RENESAS
207	MOSFET N-CH 75V 70A TO-220FPA	RJK0703DPP-A0	"	Q2	RENESAS
208	MOSFET N-CH 75V 70A TO-220FPA	RJK0703DPP-A0	"	Q3	RENESAS
209	MOSFET N-CH 75V 70A TO-220FPA	RJK0703DPP-A0	"	Q4	RENESAS
210	MOSFET N-CH 75V 70A TO-220FPA	RJK0703DPP-A0	"	Q5	RENESAS
211	MOSFET N-CH 75V 70A TO-220FPA	RJK0703DPP-A0	"	Q6	RENESAS
212	IC MCU 16BIT 64KB FLASH 48LQFP	R5F11BGAFB#30	48-LQFP (7x7)	U2	Renesas
213	LED 570NM GREEN WTR CLR 0603 SMD	SML-310MTT86	D1608/GREEN	LED1	Rohm Semiconductor
214	LED 570NM GREEN WTR CLR 0603 SMD	SML-310MTT86	"	LED2	Rohm Semiconductor
215	CAP ALUM 1000UF 20% 63V RADIAL	UVR1J102MHD	FAI16_H27	C1	Nichicon
216	IC REG LINEAR 12V 60MA TO252-3	ZXTR2012K-13	TO-252-3	U8	Diodes

12. Caution Items

Caution items related to use of the product are as follows.

- The product includes some unused pins that have not been processed. Be sure to process the unused pins according to the intended use.

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	20/10/2020	—	First edition issued

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

2. Processing at power-on

The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.

3. Input of signal during power-off state

Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

4. Handling of unused pins

Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.

5. Clock signals

After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.

6. Voltage application waveform at input pin

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).

7. Prohibition of access to reserved addresses

Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

8. Differences between products

Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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