CONTEC

CPI Series

Reference Manual

Raspberry Pi Expansion Card
Analog Output Board 16bit DAC Channel Isolation

CPI-AO-1602LC

CONTENTS

CONTEC CO., LTD.

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Table of Contents

Introduction

This section provides necessary information of the product such as the outline, bundled items and manuals before actual use.

1.Related Manuals

The manuals related to the product are listed below.

Read them as necessary along with this document.

◆ Must Read the Followings.

Name	Purpose	Contents	How to get
Product Guide	Must read this after opening the package.	This lists the product configuration and describes the precautions.	Included in the package (Printed matter)
Reference Manual (This Document)	Read when connecting to the Raspberry Pi.	This describes the hardware aspects such as functions and settings.	Download from the Contec website (PDF)

◆ Download Manuals

Download the manuals accordingly from the following URL.

Download   https://www.contec.com/download/

2.About the Product

This product is an expansion card that adds an analog output interface to the Raspberry Pi.

It has analog outputs with 16-bit resolution of inter-channel isolation.

Voltage output 2ch and current output 2ch are switchable with one card.

3.Features

■ Analog outputs with inter-channel isolation

Analog voltage output and analog current output with inter-channel isolation are equipped.
Inter-channel isolation prevents interference between channels, therefore, the product can be used even when the ground levels of the device connected to each channel are different.

■ Supportable for various voltage output ranges and current output types

With the CPSN-AO-1602LC, the output ranges of ±10V, ±5V, 0 to +10V, 0 to +5V, and 0 to +20mA can be switched by software command.

■ No external power is required for current outputs

The CPSN-AO-1602LC has the built-in power for current outputs, therefore, requires no external power supply.

■ Relay for controlling outputs

With the relay in the product, unstable output voltage/current, which often occurs when the CPU Unit is powered on, can be avoided.
Since outputs from all the channels are performed through the relay, damages or errors of the connected devices can be prevented.

■ Connectivity for up to 8 cards

Connect up to 8 expansion cards of the same series. Use the Board ID setting switch on the main body to identify connected expansion cards.
* The Board ID setting switch cannot be set to 4 when using the CPI-RAS.

■ Adaptable to a wide range of temperature between -20 and +60°C

The product is capable of operating in the temperature between -20 and + 60°C. It can be installed in the various environments.

■ No electrolytic capacitor

Without an electrolytic capacitor, which has a limited life, we are creating the product with a longer life.

■ Linux compatible driver software

Using the analog I/O driver API-AIO(LNX) makes it possible to create applications of Linux.

4.Product Configuration List

The product consists of the items listed below.

Check, with the following list, that your package is complete.

If you discover damaged or missing items, contact your retailer.
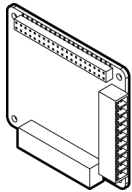
Product...1

10-pin Connector...1
(Attached to the product)
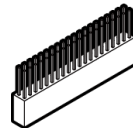
40-pin Pin-header...1
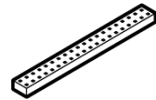
Plastic spacer
for CPU card...1
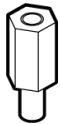
Hexagonal spacers...4
(Height 12.5mm)

Three-point Sems Screw...4

Nuts...4
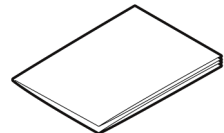
Product Guide
& Warranty
Certificate...1
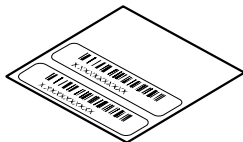
Serial Number Label...1

5.Support Software

You can use CONTEC support software according to your purpose and development environment.

For more details on the supported OS, applicable languages, or to download the latest version of software, visit the CONTEC Web site.

Name	Contents	How to get
Driver software API-AIO(LNX)	This is the Linux version driver software provided in API function formats. The software includes various sample programs such as gcc (C, C++) and Python programs.	Download from the CONTEC website

Download the files from the following URL.

Download   https://www.contec.com/download/

Reference for installation

Information	Reference to
API-AIO(LNX) Online Help	Contains API-AIO(LNX) installation and API function information.

Online Help   https://help.contec.com/pc-helper/api-tool-lnx/aio/jp/caio.htm

6.Optional Products

Optional product items are as follows:

Acquire them as required.

Product Name	Model type	Description
RAS card	CPI-RAS	RAS/RTC function, 8 to 28 VDC input function expansion
DIN RAIL ADAPTER	CPI-DIN01	

Visit the Contec website for the latest optional products.

Website   https://www.contec.com/

Safety Precautions

Understand the following definitions and precautions to use the product safely.
Never fail to read them before using the product.

1. Safety Information

This document provides safety information using the following symbols to prevent accidents resulting in injury or death and the destruction of equipment and resources.

Understand the meanings of these labels to operate the equipment safely.

⚠DANGER	Signal word used to indicate an imminently hazardous situation which, if not avoided, will result in death or serious injury.
⚠WARNING	Signal word used to indicate a potentially hazardous situation which, if not avoided, could result in death or serious injury.
⚠CAUTION	Signal word used to indicate a potentially hazardous situation which, if not avoided, could result in minor or moderate injury.

2.Handling Precautions

⚠ DANGER

- Do not use the product in locations exposed to a flammable or corrosive gas. It may cause explosion, fire, electrical shock, or malfunction.
- Be sure to connect the product to the stipulated power supply voltage. Connecting to a different voltage might cause a fire or electrical shock.
- This product is not intended for use in aerospace, space, nuclear power, medical equipment, or other applications that require a very high level of reliability. Do not use the product in such applications.
- If using this product in applications where safety is critical such as in railways, automotive, or disaster prevention or security systems, please contact your retailer.

⚠ CAUTION

- Be certain the following requirements are satisfied when using the product.
  - Indoor use
  - Altitude up to 5000m
  - Applicable POLLUTION DEGREE 2

  When using the product at high altitudes, refer to the relational expression below to find an appropriate ambient temperature. The heat dissipation decreases due to air pressure drop and could lead to damages or a shorter product life.
  - Ambient temperature = 60[°C] - 0.005 x altitude [m]

    An Example)
    The product is used at 3000 meters
    60°C - (0.005 x 3000m) = 45°C (Ambient temperature)
- Do not use this product in extremely humid or dusty locations. It is extremely dangerous to use this product with its interior penetrated by water or any other fluid or conductive dust. If this product must be used in such an environment, install it on a dust-proof control panel, for example.
- There are switches on this product that need to be set in advance.
  Be sure to check this product before installing it on the Raspberry Pi.
- Only set the switches on this product to the specified settings.
  Otherwise, this product may malfunction, overheat, or cause a failure.
- Make sure that Raspberry Pi can supply ample power to all the expansion cards installed. Insufficiently energized products could malfunction, overheat, or cause a failure.
- When transporting the product, take suitable measures to avoid applying shock or vibration directly to the product.
  This product conforms to JIS Z0200: 1999 and JIS Z0232: 2004.

- Do not use or store the product in a hot or cold place where the temperature exceeds the specified range, or in a place that is subject to severe temperature changes. Otherwise, the product may malfunction, overheat, cause a failure or breakage.
- Do not use this product in the vicinity of devices that generate strong magnetic force or noise. Otherwise, the product may malfunction, overheat, cause a failure or breakage.
- Do not use or store this product in the presence of chemicals.
- Be sure to unplug the Raspberry Pi cable from the connector and leave the product LED unlit when connecting this product and connecting/disconnecting each connector and cable.
- CONTEC reserves the right to refuse to service a product modified by the user.
- When connecting cables, first check the shapes of connectors (such as USB connectors), and then insert them in the correct orientation. After they are connected, do not put too much load on the connected part. Doing so may result in poor contact or damage to this product and the connected part.
- Do not touch terminals of the product with your hands in operation. Otherwise, this product may malfunction, overheat, or cause a failure. If the terminals are touched by someone's hands, clean the terminals with industrial alcohol.
- The specification of this product is subject to change without notice for enhancement and quality improvement. Even when using this product continuously, be sure to read the manual of CONTEC's website and understand the contents.
- If you want to use in places where the influence of the overcurrent or overvoltage is, please select appropriate surge protection device for all of the route (Power line etc).
- The product is an open-type device (a device designed to be housed inside other equipment) and must always be mounted inside a mechanical enclosure having enough strength.
- Do not strike or bend this product. Otherwise, this product may malfunction, overheat, cause a failure or breakage.
- When disposing this product, please comply with the municipal regulations and ordinances.
- Regardless of the foregoing statements, CONTEC is not liable for any damages whatsoever (Including damages for loss of business profits) arising out of the use or inability to use this CONTEC product or the information contained herein.

1. FCC PART15 Subpart B Class A Notice

NOTE

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment.

This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC WARNING

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

2. CE EMC Directive Class A Notice

EN55032Class A Notice
Warning:
 Operation of this equipment in a residential environment could cause radio interference.

Product Nomenclature and Function

This section describes product component names and their functions, pin assignment of each connector.

1.Nomenclature of Product Components

Component names of the product are shown in the figure below.
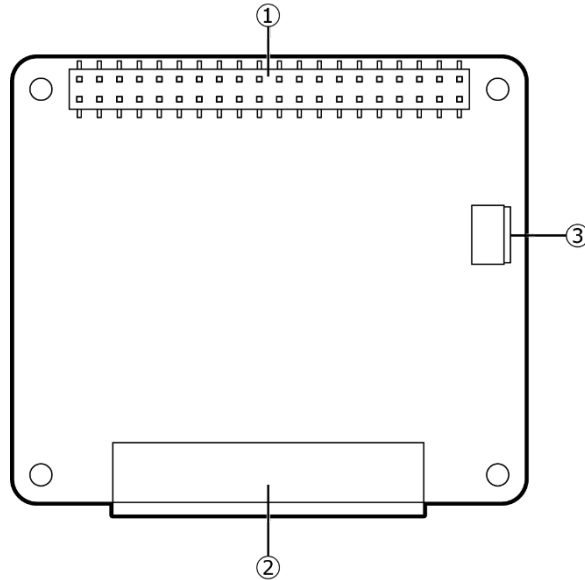
No.	Name	Function
1	GPIO 40 pin connector	This connector is used to connect to a Raspberry Pi or an expansion card.
2	Interface connector	This is a connector for analog output. Use the 10-pin connector included in the package.
3	Board ID setting switch	This setting switch is used to identify I2C communication expansion cards. The switch is used to change the I2C address.

2.Description of Product Components

Components such as connectors, switches are described.

1. GPIO 40 pin connector

This connector is used to connect to a Raspberry Pi or an expansion card.
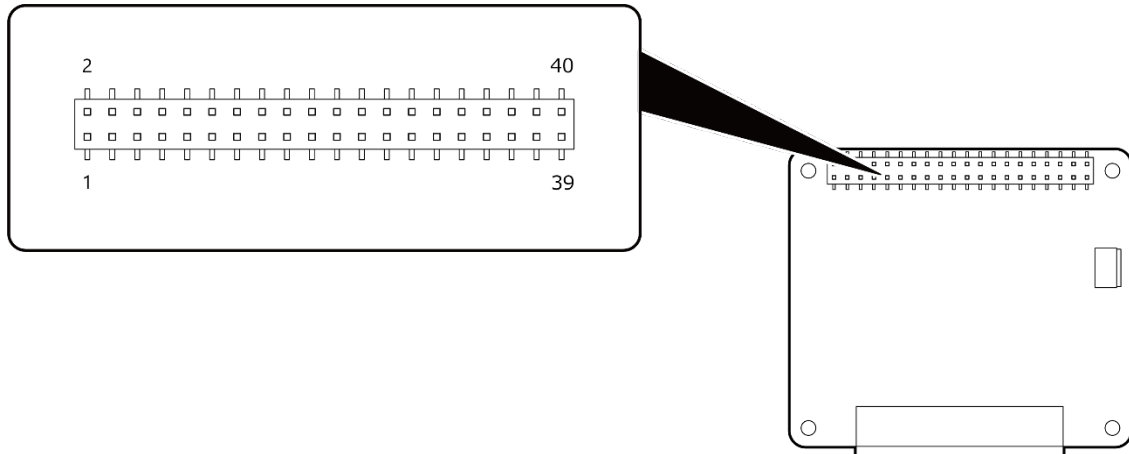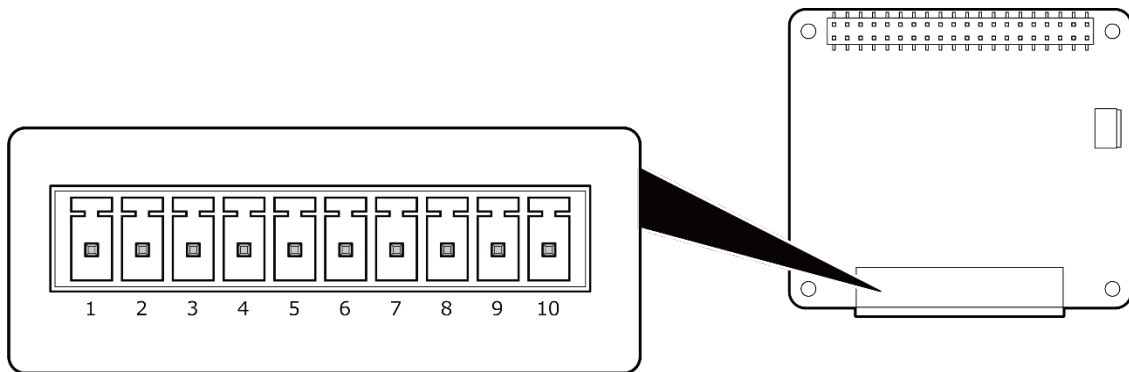
Pin Assignment

Pin No.	Signal Name	Description	Pin No.	Signal Name	Description
1	3.3V Power	3.3V power supply	2	5V Power	5V power supply
3	GPIO 2(I2C1 SDA)	I2C1 SDA	4	5V Power	5V power supply
5	GPIO 3(I2C1 SCL)	I2C1 SCL	6	Ground	GND
7	GPIO 4(GPCLK0)	(Don't use)	8	GPIO 14(UART TX)	(Don't use)
9	Ground	GND	10	GPIO 15(UART RX)	(Don't use)
11	GPIO 17	(Don't use)	12	GPIO 18(PCM CLK)	(Don't use)
13	GPIO 27	(Don't use)	14	Ground	GND
15	GPIO 22	(Don't use)	16	GPIO 23	(Don't use)
17	3.3V Power	3.3V power supply	18	GPIO 24	(Don't use)
19	GPIO 10(SPI0 MOSI)	(Don't use)	20	Ground	GND
21	GPIO 9(SPI0 MISO)	(Don't use)	22	GPIO 25	(Don't use)
23	GPIO 11(SPI0 SCLK)	(Don't use)	24	GPIO 8(SPI0 CE0)	(Don't use)
25	Ground	GND	26	GPIO 7(SPI0 CE1)	(Don't use)
27	GPIO 0(EEPROM SDA)	I2C0 SDA	28	GPIO 1(EEPROM SCL)	I2C0 SCL
29	GPIO 5	(Don't use)	30	Ground	GND
31	GPIO 6	(Don't use)	32	GPIO 12(PWM0)	(Don't use)
33	GPIO 13(PWM1)	(Don't use)	34	Ground	GND
35	GPIO 19(PCM FS)	(Don't use)	36	GPIO 16	(Don't use)
37	GPIO 26	(Don't use)	38	GPIO 20(PCM DIN)	(Don't use)
39	Ground	GND	40	GPIO 21(PCM DOUT)	(Don't use)

2. Interface connector

This connector is used for analog output. It uses the included 10-pin connector.

Connector type: DEGSON 15EDGKD-3.81-10P-13-00A(H)
            PHOENIX CONTACT FK-MCP 1.5/10-ST-3.81 (or equivalent)

Pin Assignment

Pin No.	Signal Name	Description
1	AGND1	Analog ground signals. The numbers correspond to channel numbers.
2	N.C.	No connection to this pin.
3	AGND1	Analog ground signals. The numbers correspond to channel numbers.
4	AO1	Analog output signals. The numbers correspond to channel numbers.
5	N.C.	No connection to this pin.
6	AGND0	Analog ground signals. The numbers correspond to channel numbers.
7	N.C.	No connection to this pin.
8	AGND0	Analog ground signals. The numbers correspond to channel numbers.
9	AO0	Analog output signals. The numbers correspond to channel numbers.
10	N.C.	No connection to this pin.

3. Board ID setting switch

This setting switch is used to identify I2C communication expansion cards.

The Board ID setting switch can be used to switch I2C addresses.

The following table shows the switch settings and the corresponding I2C addresses.
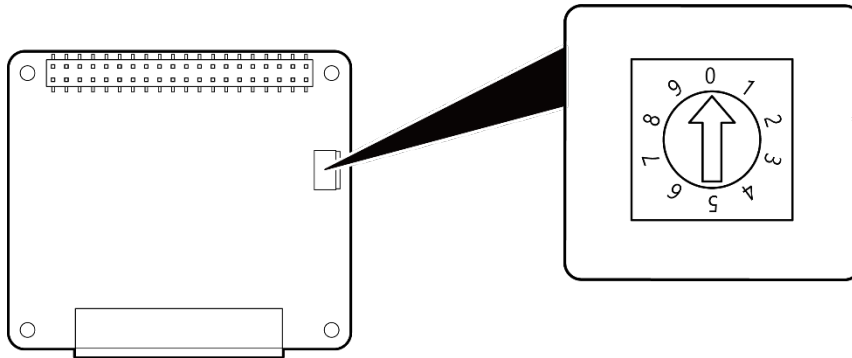
Switch settings and the corresponding I2C addresses

Setting the Board ID	Extended I/O (I2C1) I2C address	EEPROM(I2C0) I2C address
0	0x28 (Factory setting)	0x50 (Factory setting)
1	0x29	0x51
2	0x2A	0x52
3	0x2B	0x53
4 *	0x2C	0x54
5	0x2D	0x55
6	0x2E	0x56
7	0x2F	0x57
8	Do not use this setting.	
9		

* The Board ID setting switch cannot be set to 4 when using the CPI-RAS because the I2C address (0x2C) with this setting will overlap with the I2C address of the CPI-RAS.

Setup

This section describes how to set up this product.

1.What is Setup?

Setup means a series of steps to take before the product can be used.

The provided explanations are based on an operating environment with Raspberry Pi OS installed on a Raspberry Pi device.

Perform the operations described in the steps in this chapter (outlined below) to prepare expansion cards.

Step 1   Raspberry Pi Setting (page23)

Step 2   Expansion Card Setting (page24)

Step 3   Connecting an Expansion Card (page25)

Step 4   Setting up the Driver software (page28)

If Setup fails to be performed properly, see the **"Setup Troubleshooting(page31)"** section at the end of this chapter.
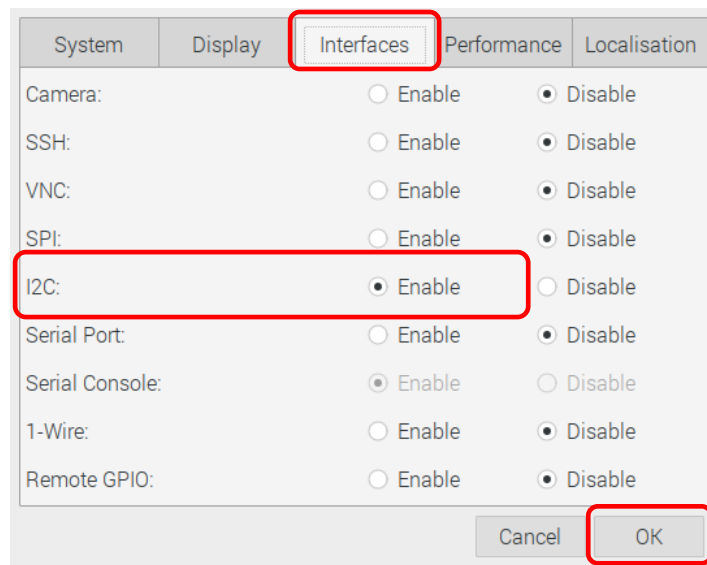
2.Raspberry Pi Setting

This section describes how to enable I2C (Inter-Integrated Circuit) communication.

1 Turn on the Raspberry Pi.

2 Click the Raspberry Pi icon on the display and under "Preference" select "Raspberry Pi Configuration".
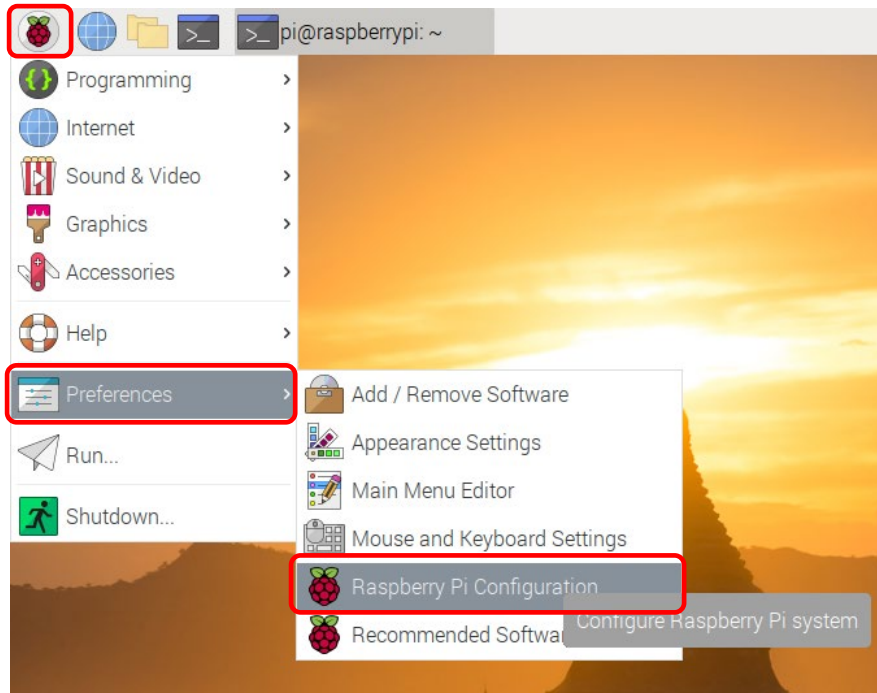
3 Select "Interfaces" in the displayed dialog, and under "I2C" select "Enable". Click "OK" and then reboot the device.
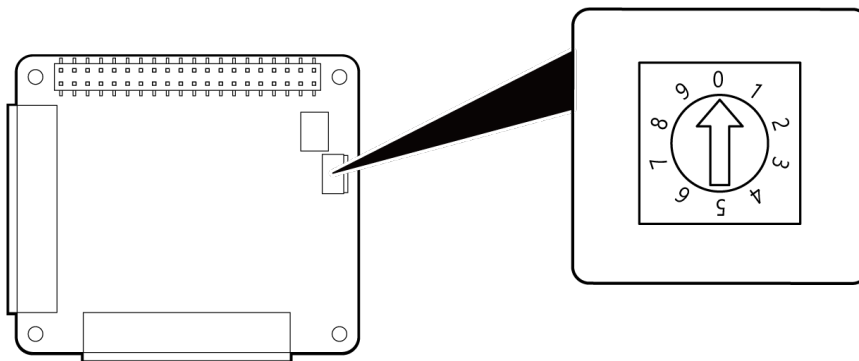
3.Expansion Card Setting

This section describes how to configure the settings required for connecting an expansion card.

1. Board ID setting switch

When connecting two or more cards of the same model to the Raspberry Pi, set the Board ID to distinguish between the cards. Set each card to a different value. For details on setting the Board ID, see **"Board ID setting switch" (page 20)**.

The Board ID can be set to any number between 0 and 7 for distinguishing between up to 8 cards.

Use the factory default setting (Board ID = 0) when connecting only one card.

* The Board ID setting switch cannot be set to 4 when using the CPI-RAS.

4.Connecting an Expansion Card

This section describes how to install/remove an expansion card.

1. Installing the Expansion Card

1 Before connecting this product, shut down the system and disconnect the Raspberry Pi power cable from the connector.

2 Insert the included 40-pin pin header from the back of the product.
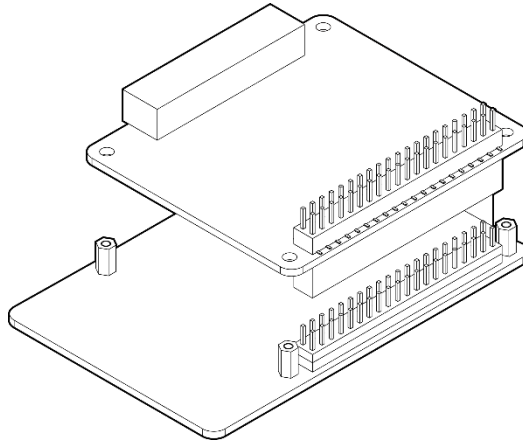Insert the pins vertically taking care to prevent them from bending.
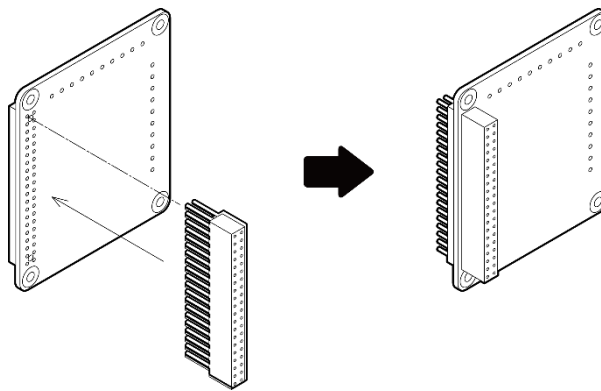
**3** Attach the four hexagonal spacers and nuts included with the Raspberry Pi.
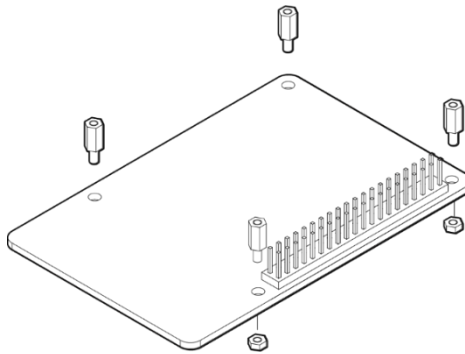
4 Attach the included plastic spacer for CPU card onto the Raspberry Pi GPIO 40-pin connector.
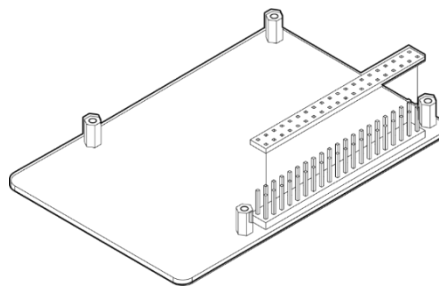
5 Connect the Raspberry Pi GPIO 40-pin connector to the product.
Insert the pins vertically taking care to prevent them from bending.
The spacing between the cards is 12.5 mm (not including component height). If a heat sink is attached to the CPU card, make sure it does not come into contact with the expansion card.

6 Attach the included three-point SEMS screws in the four locations.
If connecting additional expansion cards, also attach the included hexagonal spacers.
If stacking additional expansion cards on top, the plastic spacer for CPU card does not need to be attached.
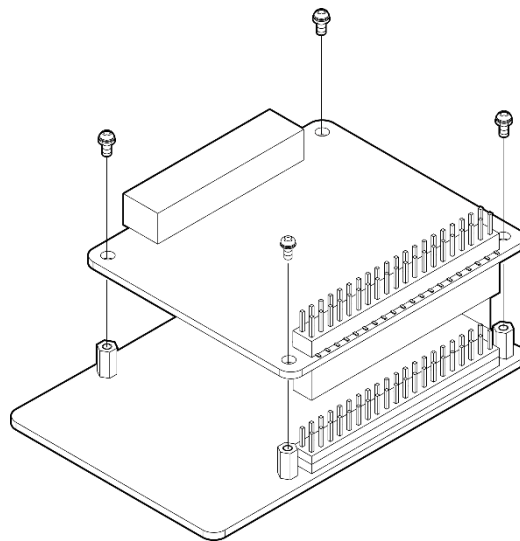
⚠ CAUTION

Be sure to disconnect the Raspberry Pi cable from the connector before attaching or removing an expansion card.

2. Removing an Expansion Card

1 Perform the procedure found under **"Connecting an Expansion Card" (page25)** in reverse to remove an expansion card. The 40-pin pin header is connected very securely. Insert and remove the connector pins vertically taking care to prevent them from bending.
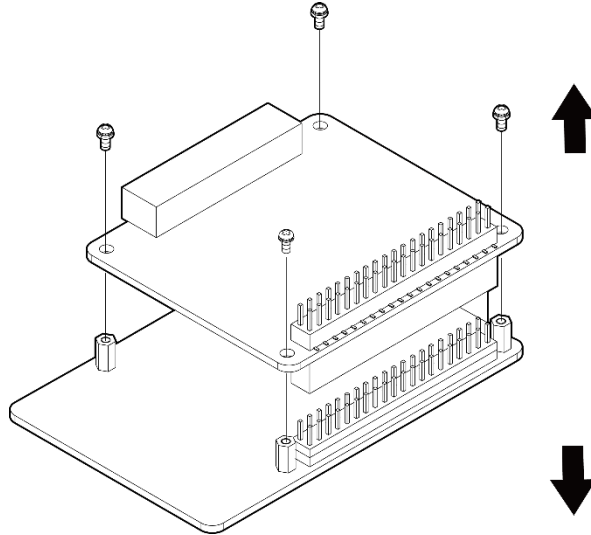
5.Setting up the driver software

Refer to the API-AIO(LNX) online help for more detailed instructions.

1. Driver Software Installation

Linux kernel headers are required for compiling the modules.

Install the kernel headers before proceeding.

Root privileges are required to install the software.
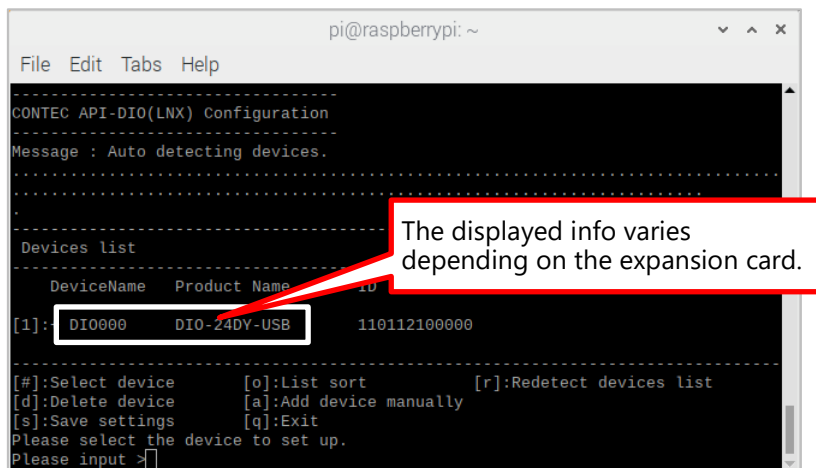
1 Install the product on the Raspberry Pi and then turn on the Raspberry Pi.

2 Download the API-AIO(LNX) software from the CONTEC website.

3 Extract the downloaded file to the destination OS.
cd (Directory of downloaded files)
tar xvfz caioXXX.tgz
* XXX is the driver version.

4 Execute the following commands in Terminal to install.
cd /(Expanded directory)/contec/caio
make
　 ....
sudo make install

2. Configuring the initial settings of the driver software

Configure the I2C device settings and initial settings of the driver software.

Root privileges are required to configure the initial settings.

1 Configure the I2C device settings.
Edit /boot/config.txt and add "dtparam=i2c_vc=on".

2 Restart the Raspberry Pi.
If no expansion card is connected, turn off the power, connect the expansion card, and then restart. For details on how to connect an expansion card, see "Connecting an Expansion Card".

3 Execute the following commands in Terminal.
cd /(Expanded directory)/contec/caio
cd config
sudo ./config

4 The following config screen will be displayed in Terminal. Select "s" and press Enter to save the settings.

```
                          pi@raspberrypi: ~              ∨  ∧  ✕

 File  Edit  Tabs  Help
 --------------------------------
 CONTEC API-DIO(LNX) Configuration
 --------------------------------
 Message : Auto detecting devices.
 ..............................................
 ..............................................
 .
 ---------------------------------------
  Devices list             The displayed info varies
                           depending on the expansion card.
    DeviceName   Product Name      ID

 [1]:  DIO000     DIO-24DY-USB      110112100000

 --------------------------------------------------------------
 [#]:Select device      [o]:List sort        [r]:Redetect devices list
 [d]:Delete device      [a]:Add device manually
 [s]:Save settings      [q]:Exit
 Please select the device to set up.
 Please input >
```

5 After saving the config screen, execute the following commands to complete configuration of the initial settings.
sudo ./contec_aio_start.sh

3. Uninstalling the driver software

Execute the uninstall shell script to uninstall the driver software.

Root privileges are required to uninstall the software.

1 Execute the following commands in Terminal to uninstall.
cd /(Expanded directory)/contec/caio
sudo ./caio_uninstall.sh

···················

6.Setup Troubleshooting

1. Examples and Solution

◆ If the expansion card is not recognized

- Check whether the Board IDs have been duplicated.
- Check whether I2C is enabled.
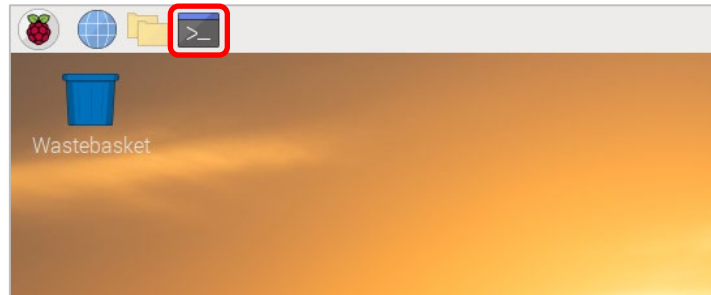- Check whether the expansion card is connected correctly.

◆ If your problem cannot be resolved

Contact your retailer.
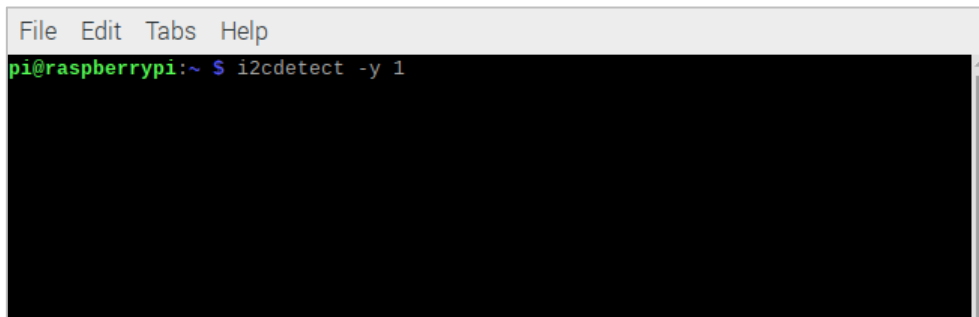
7.Checking the Expansion Card Connection

This section describes how to check whether an expansion card is connecting correctly.

1 Restart the Raspberry Pi OS while the Raspberry Pi and the expansion card are connected. Click the LXTerminal icon on the desktop.
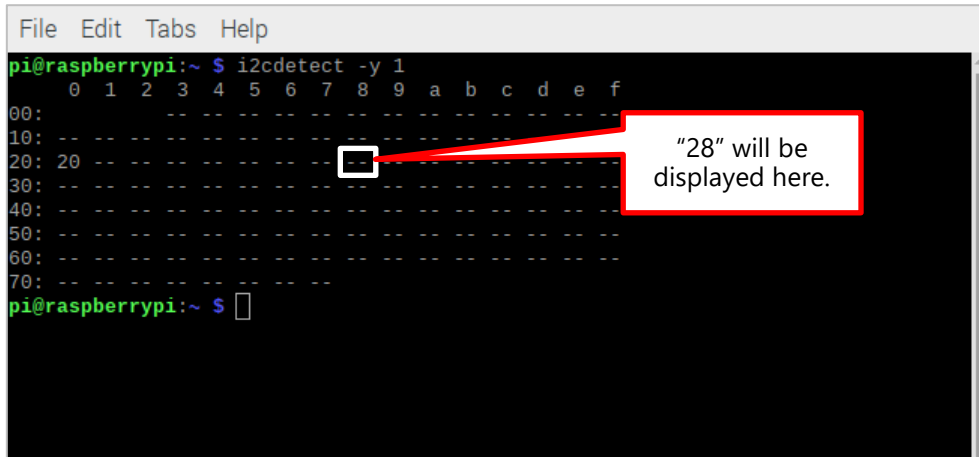

2 Check the expansion I/O port (I2C1) connection on the expansion card.
Enter the following command in the terminal window and press [Enter] on the keyboard to execute.
i2cdetect -y 1

3 The set I2C address will be displayed if the expansion card is connected to the Raspberry Pi.
When Board ID = 0 (factory default setting), the I2C address will be "28".

(CPI-DIO-0808L screen with Board ID = 0: "20")

If the expansion I/O port (I2C1) I2C address set with the Board ID setting switch is displayed, the expansion I/O port is connected properly.

4 Check the EEPROM port (I2C0) connection on the expansion card.
Enter the following command in the terminal window and press ¥[Enter] on the keyboard to execute.
i2cdetect -y 0

5 The set I2C address will be displayed if the expansion card is connected to the Raspberry Pi. When Board ID = 0 (factory default setting), the I2C address will be "50".
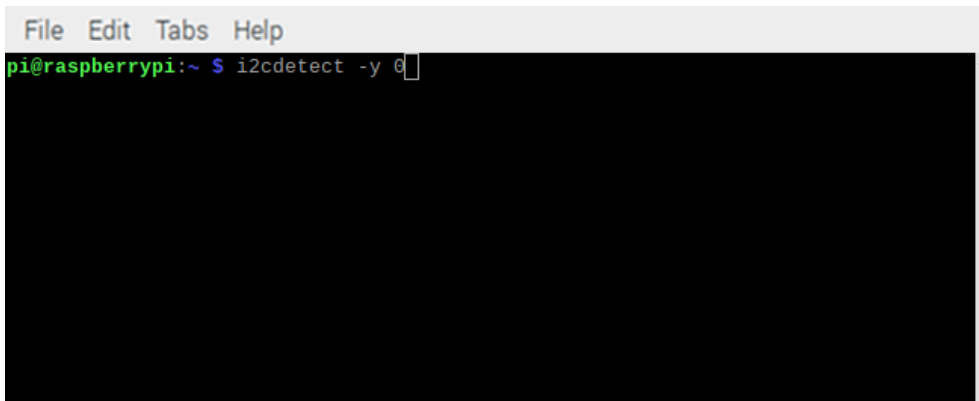

(If Board ID = 0, "50" will be displayed on the screen.)

If the EEPROM port (I2C0) I2C address set with the Board ID setting switch is displayed, the EEPROM port is connected properly.
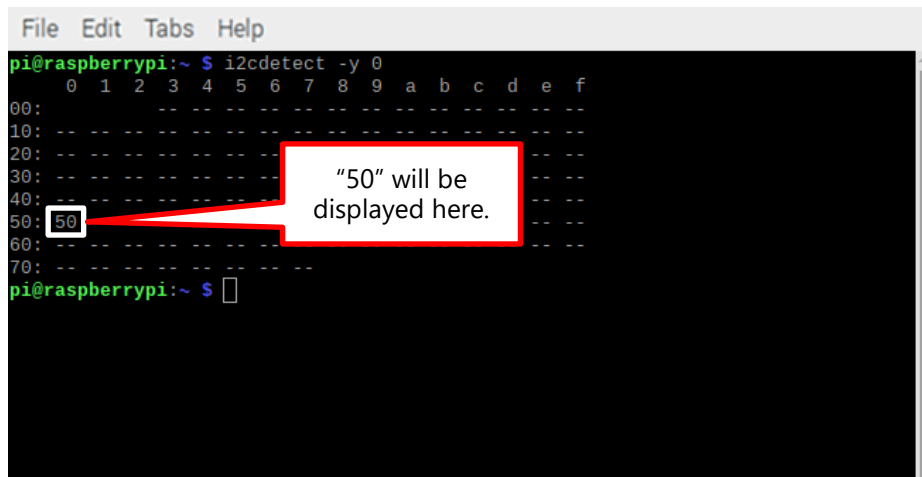
Installation and connection

This section describes how to install the product and connecting external devices to the product.

1.Install the Product

1. Installation Conditions

◆ Installation Orientation

When installing the product horizontally, check whether heat dissipation is sufficient before installation.

When connecting multiple expansion cards, also screw the cards into a fixture with sufficient strength on both sides.

Horizontal installation

Vertical installation
(Vertically placed)

Vertical installation
(Horizontally placed)
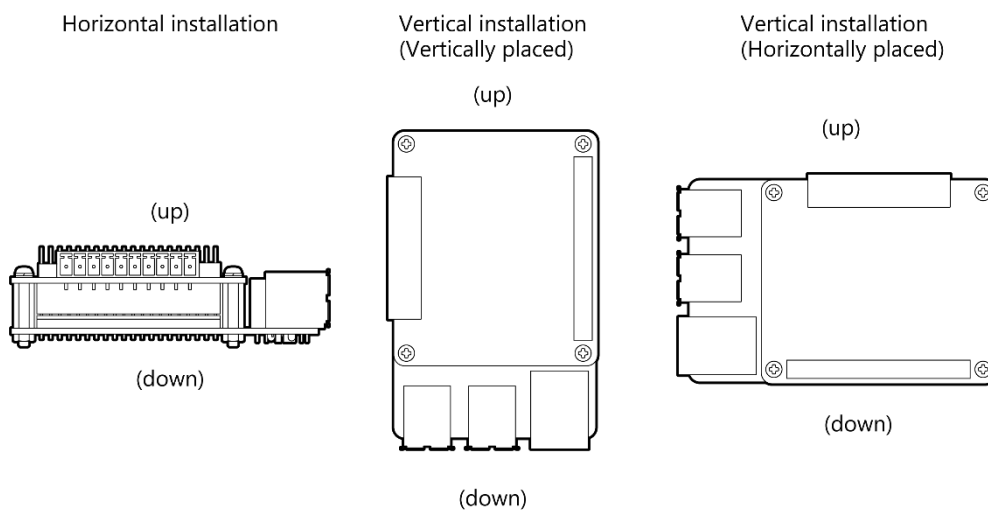
Make sure to gain proper space between the product and devices that generate heat or exhaust air so that the ambient temperature stays in the range specified in the environment requirement.

◆ Ambient Temperature

When connecting one expansion card to the Raspberry Pi, the ambient operating temperature of the product is the temperature measured at multiple points located 50 mm around the product.

During the operation, adjust the air current to make certain that the temperatures measured in the points stay within the specified temperature. (-20 - +60 °C)

* The ambient operating temperature of the Raspberry Pi and this product combined is the lower operating temperature between the Raspberry Pi and this product.
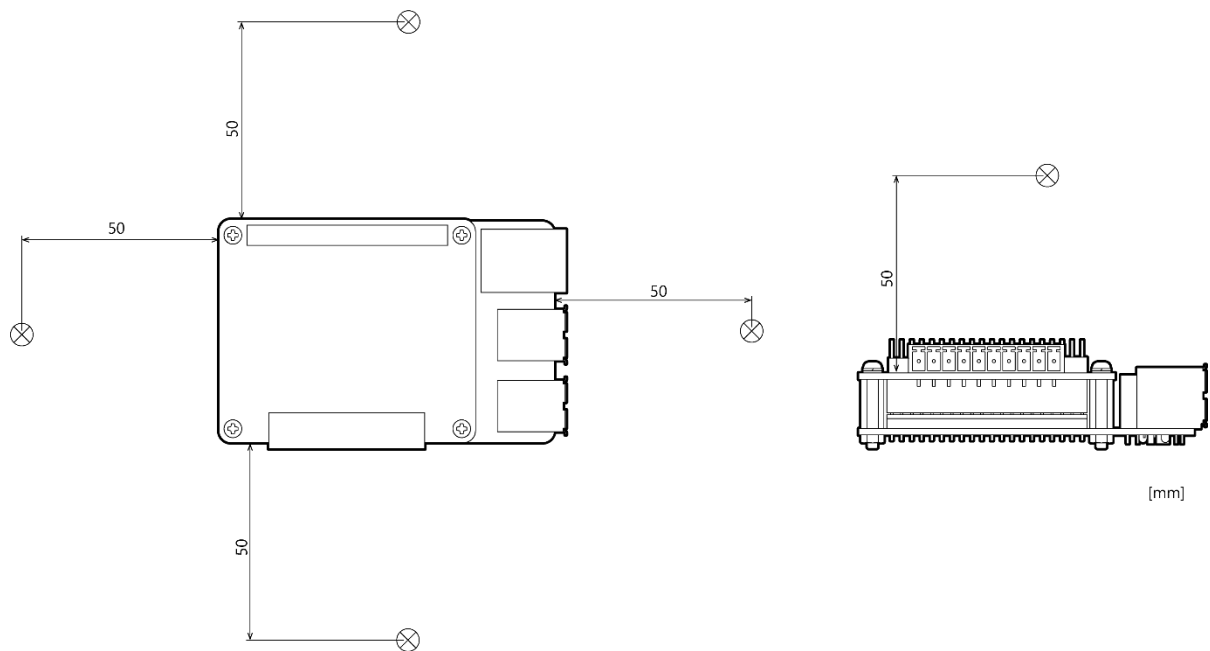
When connecting multiple expansion cards, adjust the airflow so that the temperature at the measurement point between the cards (as shown below) is within the ambient operating temperature (-20 to +60°C).

Temperature measurement point when adding cards

Horizontal installation

Vertical installation
(Vertically placed)

Vertical installation
(Horizontally placed)
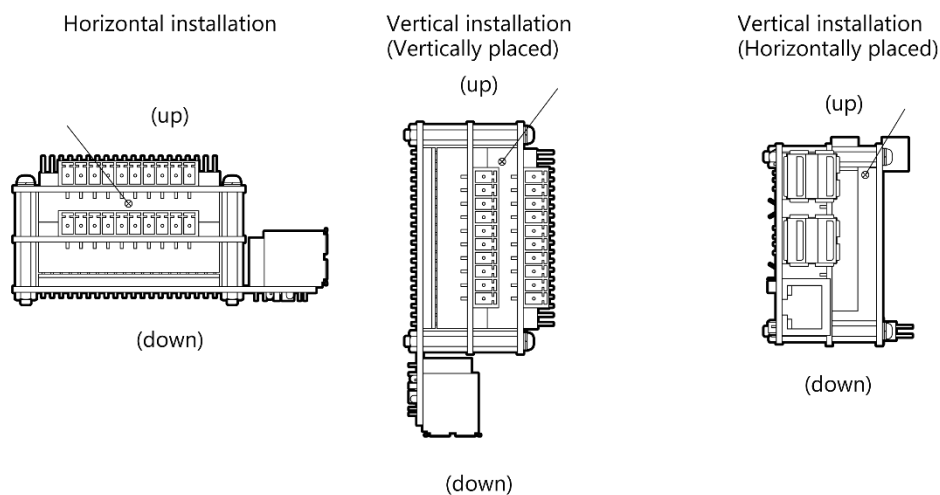
⚠ CAUTION

- The product is an open-type device (a device designed to be housed inside other equipment) and must always be mounted inside a mechanical enclosure having enough strength.
- Note that although the ambient temperature is within the specified range, an operational malfunction may occur if there is other device generating high heat; the radiation will influence the product to increase its temperature.
- Do not install this product into the fully-sealed space except the case in which the internal temperature is adjustable by equipment such as air conditioner. Long-term usage might increase the temperature of the product and lead to malfunctions or other troubles.
- When using the product in a high temperature environment, its life time will be shortened. Perform the forced air cooling to counteract.

2.Connecting to an External Device

1. Connecting an Interface Connector

When connecting the product to an external device, use the included connector.

When wiring the connector, strip off 8 mm ± 0.5 mm of the wire's covering, and then insert this stripped part into the connector's opening.

While pushing the orange part in the center of the connector with a precision screwdriver or a similar tool, insert the cable into the round connection hole. After that, release the pushed part to fix the cable in place.

You can also insert cables without pushing on the orange part of the connector by using a ferrule terminal.

10-pin connector

8±0.5mm
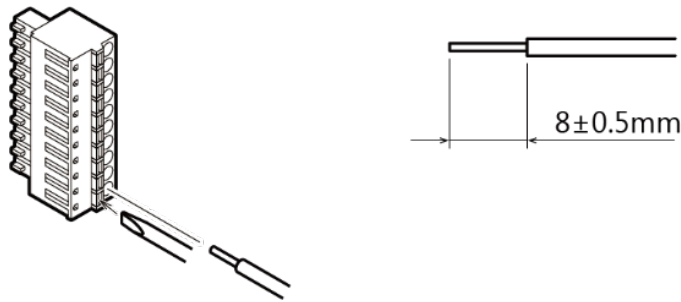
⚠ CAUTION

- Removing the connector plug by grasping the cable can break the wire. Always grasp the interface connector to remove it.
- Do not set or remove the interface connector when the power is on or during the communication.

2.   Connecting Cable

◆ Analog Output Cable

Use the analog output cable described below.

Cable	Use copper wires that withstand the temperature of 75 °C and higher.
Applicable wire	AWG28 - 16

*Refer to **"Interface connector"** in the **page19** for details of the analog input connector and pin assignment.

◆ Analog Output Circuit

Output methods of analog signals are voltage outputs and current outputs. This section describes the example connections of each output method using a flat cable, a coaxial cable, and a shielded cable.

◆ Voltage Output

[Connection using a flat cable]

The example below uses a flat cable to connect the product to an external device.

For each analog output channel, connect the input of external device and ground on one-to-one basis.
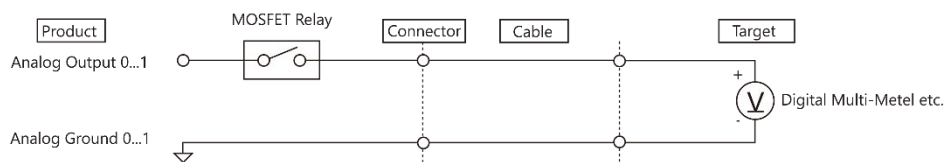
[Connection using a twisted cable]

The example below uses a twisted cable to connect the product to an external device.

Use this type of cable if the external device is located at a distance from the product. For each analog output channel, connect the input of the external device and ground on one-to-one basis.

[Connection using a coaxial cable]

The example below uses a coaxial cable to connect the product to an external device.

Use this type of cable if the external device is located at a distance from the product.

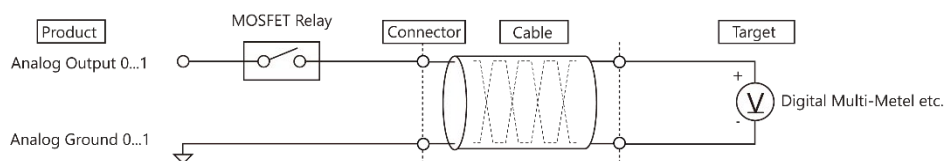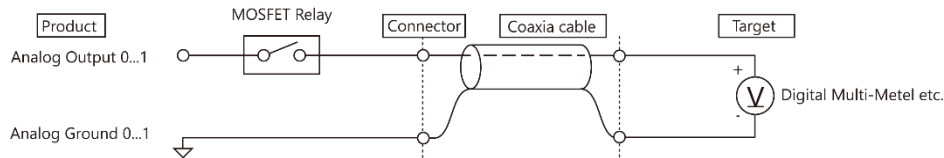For each analog output channel, connect the core wires to the input of the external device and connect the shielding to ground

[Connection using a two-conductor twisted shield cable]

The example below uses a two-conductor twisted shield cable to connect the product to an external device. Use this type of cable if the external device is located at a distance from the product or if the connection requires higher noise immunity. For each analog output channel, connect the core wires to the input of the external device and to ground, connect the shielding to earth.
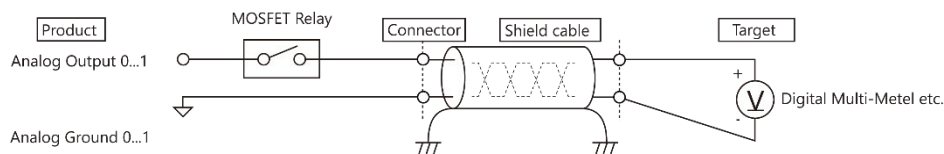
⚠ CAUTION

- Do not short-circuit voltage output signals and analog ground, as it may cause failure on the product.
- Do not connect voltage output signals to any other analog output, either on the product or on an external device, as it may cause failure on the product.
- To avoid any malfunction or damages, the connector plug should not be attached or detached when the power for the product or the external device is on.
- In situations where the connecting cable is subject to the effects of noise, the accurate voltage outputs can fail. The connecting cable should be installed away from any source of noise.
- The maximum current capacity for a voltage output signal is ±5mA. To avoid any malfunction, do not connect an external device that generates a load exceeding this range.
- In situations where the connecting cable is excessively long, the accurate voltage outputs can fail. The connection cable should therefore be within 1.5 meters.

◆ Current Output

[Connection using a flat cable]

The example below uses a flat cable to connect the product to an external device.

For each analog output channel, connect the positive side and the negative side of the external device on one-to-one basis.

[Connection using a twisted cable]

The example below uses a twisted cable to connect the product to an external device.

Use this type of cable if the external device is located at a distance from the product.

For each analog output channel, connect the positive side and the negative side of the external device on one-to-one basis.

[Connection using a two-conductor twisted shield cable]

The example below uses a two-conductor twisted shield cable to connect the product to an external device. Use this type of cable if the external device is located at a distance from the product or if the connection requires higher noise immunity. For each analog output channel, connect the core wires to the external device and connect the shielding to ground.
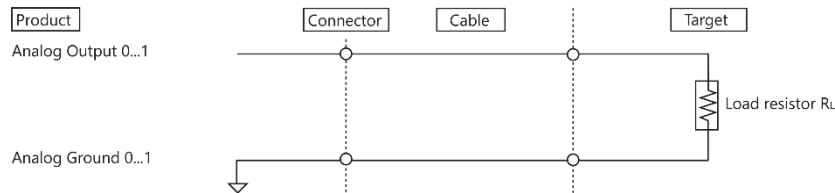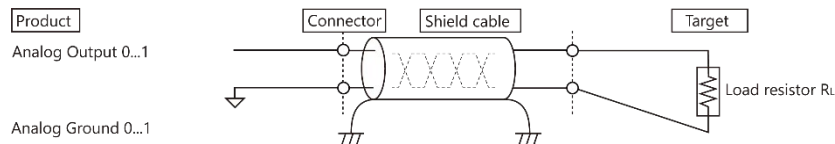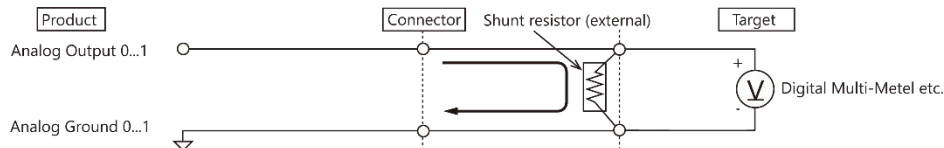
◆ A connection example when current outputting with an external device.

[Connection with an external device of voltage inputs]

The current can be converted to voltage by connecting a shunt resistor to the external device for connecting with an external device of voltage inputs.

0-20mA can be converted to 0 - 5V when a 250Ω shunt resistor is used.

[Connection with more than one external device of current inputs]

When connecting with more than one external device of current inputs, the external devices can be connected in series. However, some external devices are unable to be connected for the following reasons.

- The total input impedance of the input device exceeds the maximum load resistance (600Ω) of this product.
- There is no potential difference (common) between the negative side of the input pin on the external device and the negative side of the power supply.
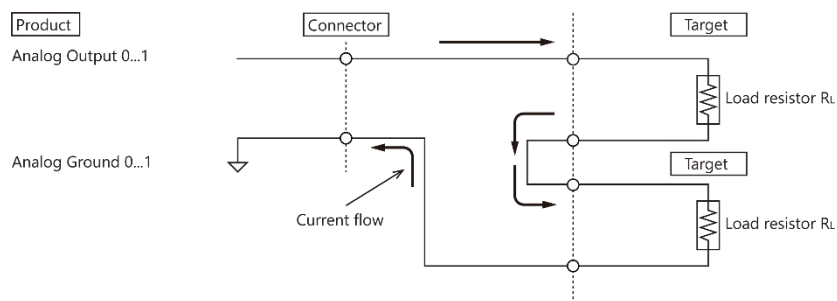
[Connection to an external device of current inputs with low input impedance]

This product is designed to operate with input impedance of between 100Ω and 600Ω. However, if the input impedance is low, the output accuracy might be affected by temperature, therefore it is recommended to use the product at 250Ω or higher.

When connecting to the device with 50Ω or 100Ω, for instance, make a dummy resistor connection and make the total of input impedance to be 250Ω to 600Ω.
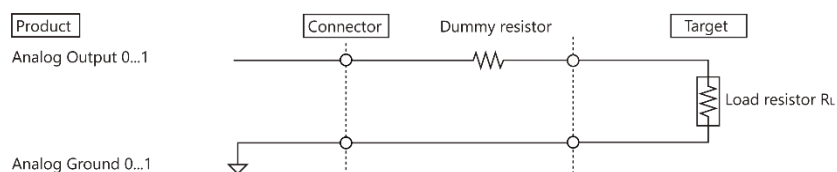
⚠ **CAUTION**

- Do not connect current output signals to any other analog output, either on the product or on an external device, as it may cause failure on the product.
- In situations where the connecting cable is subject to the effects of noise, the accurate current output can fail. The connecting cable should be installed away from any source of noise.
- To avoid any malfunction or damages, the connector plug should not be attached or detached when the power for the product or the external device is on.

About Software

This section describes analog I/O driver for Linux developed by CONTEC.

1.About Driver Software

1. Analog Output Driver for Linux

API-AIO(LNX) is the Linux-version analog I/O driver for controlling the product with API functions. Use this software as necessary.

The driver software "API-AIO(LNX)" contains the functions that provide the following features:

- Analog input or output through arbitrary channels
- The setting parameters for the analog I/O card can be saved as default values, enabling operation without configuring the parameters.

Moreover, Sample programs are individually offered for the basic application.

For details, refer to the online help file.
The online help contains application development function references and other information.
Refer to the online help tutorial for basic usage information.

Function

This section describes the features achieved by combining hardware and driver functions.

1.Analog Output Function

1. Simple Analog Output

When an analog output start command is executed by software, output data is set for one or more channels, DA conversion is performed, and then the analog output operation is terminated.

Analog output from a specified one channel

Analog output operating — Operation stop

Analog output start command

0ch

Conversion start — Analog output finalized

0ch analog output change

Settling time

The output voltage at 0ch is updated as illustrated above.

Analog outputs from multiple channels (Multiple channel outputs are updated simultaneously.)

Analog output operating — Operation stop

Analo

2ch
1ch
0ch

Conversion start — Analog output finalized

2ch analog output change

1ch analog output change

0ch analog output change

Settling time

The output voltage from 0 to 2ch is updated as illustrated above.

*   The analog output is finalized after the settling time after conversion is started.
    The conversion speed is determined by the settling time per channel.

Simple analog output assumes the following conditions and settings.

◆ Resolution

"Resolution" signifies the number of bits used by an analog output device to represent analog signals. The higher the resolution, the more finely the voltage range is segmented, allowing the device to convert to analog value more precisely.

A device with a resolution of 12bit divides the range width into 4096 segments.

When the device covers the range of 0 - 10V, the minimum unit of converted voltages is

$10 \div 4096 \approx 2.44mV$.

If the device has a resolution of 16bit, it is $10 \div 65536 \approx 0.153mV$ instead.

Low-resolution board   High-resolution board
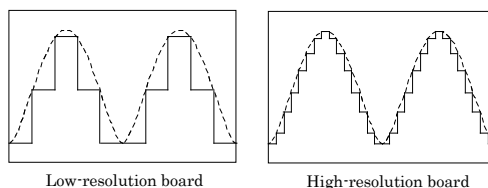
◆ Range

"Range" means the range of voltages (current) at which analog output can be performed.

The output range can be selected by setting the output signal type (voltage and current) and the upper and lower output signals.

◆ Output data

The following equation represents the relationship between output data and voltage.

Output data = ((voltage – Min. range value) x Resolution) ☐ (Max. range value – Min. range value)

The value of resolution for the 12bit device is 4096; that for the 16bit device is 65536.

The table below shows the relationship between output data and voltage in the ±10-V range.

Voltage	Conversion data (12bit)
+9.995V	4095
:	:
0.005V	2049
0V	2048
-0.005V	2047
:	:
-10.000V	0

Voltage	Conversion data (16bit)
+9.99970V	65535
:	:
0.00030V	32769
0V	32768
-0.00030V	32767
:	:
-10.000V	0

Ex.:   When 3V is output at a resolution of 12bit in the ± 10-V range

Output data   = (3 - (-10)) x 4096 ÷ (10 - (-10))

= 2662.4 *

*   The value that can be set as output data at this time is an integer.
Select "2662" or "2663" as the output data.

The analog signal corresponding to the output data contains an error as follows:

- Output data "2662" converted to: 2.9980 V

- Output data "2663" converted to: 3.0029 V

This error is a consequential error occurring when output data is obtained from an expected analog value.

◆ Channel

"Channel" represents each point of analog output.

For individual channel numbers, see "Connector Pin Assignment" in "**Interface connector(page19)**".

You can specify an arbitrary number of points of analog output by setting the channels by means of software.

Appendix

This section lists the specifications and the physical dimensions of the product, and the details of model name.

1.Specifications

1. Specifications

Function Specifications

Item		Description
Analog Output	Output type	Inter-channel isolation Voltage Current Outputs
	Output range	±10V, ±5V, 0 - +10V, 0 - +5V, 0 - +20mA (Set by software command)
	Maximum output current	±5mA(For voltage output)
	Load resistor	100 - 600Ω(For current output)
	Voltage output impedance	10Ωmax.
	Output channel	2ch
	Resolution	16-bit
	Non-Linearity error *1	For voltage : ±20LSB(25°C, 1-99%FS, no load) For current : ±20LSB(25°C, 1-99%FS, with 250Ω)
	Settling time *2	Voltage : 30μsec (no load) Current : 10μsec (with 250Ω)
	Data buffer	-
	Isolation	Bus / Inter-channel isolation
	Voltage resistance	500VAC
	Cable Length	For voltage : 1.5 meters approx. (vary depending on the wiring environment) For current : 50 meters approx. (vary depending on the wiring environment)
Bus specification		I2C bus (I2C1)
Max. module count for connection		Maximum of 8cards *3
Connector		2 pieces 3.81mm pitch 10-pin terminal
Applicable wire		AWG28 - 16
Electricity consumption		5VDC 400mA 3.3VDC 1mA
Physical dimensions (mm)		65.0(W) x 56.5(D) (No protrusions) Spacer height : 12.5mm
Weight		50g

*1 The non-linearity error means an error of approximately 0.18% occurs over the maximum range at -20°C and 60°C ambient temperature.

*2 Settling time is from when data is set in DAC IC until the change of the analog value stops.

*3 The Board ID setting switch cannot be set to 4 when using the CPI-RAS.

Installation Environment Requirements

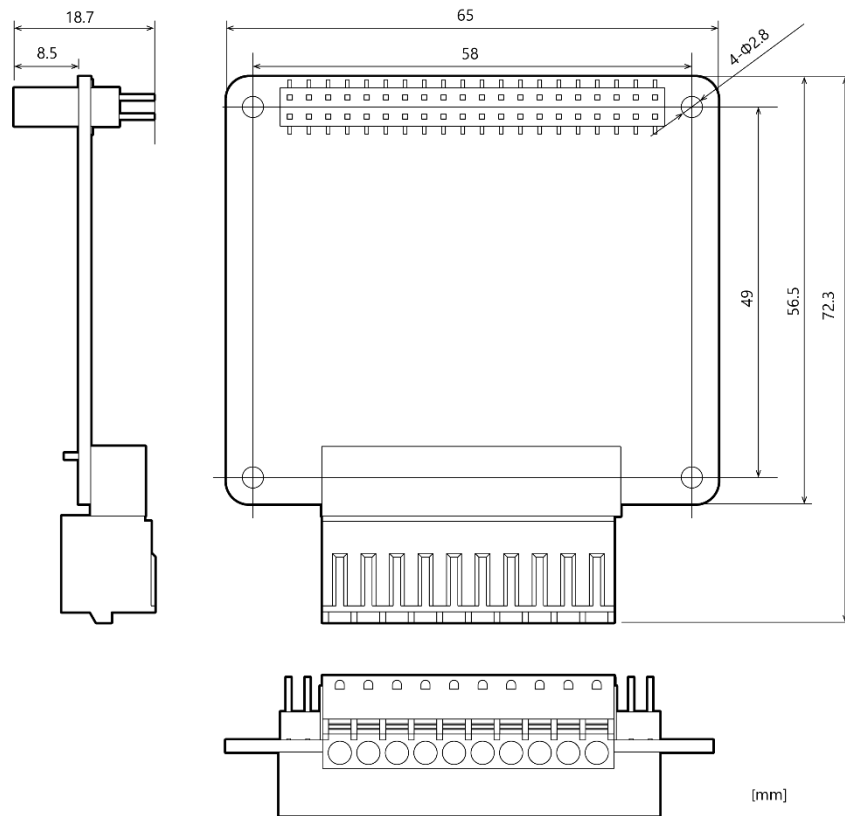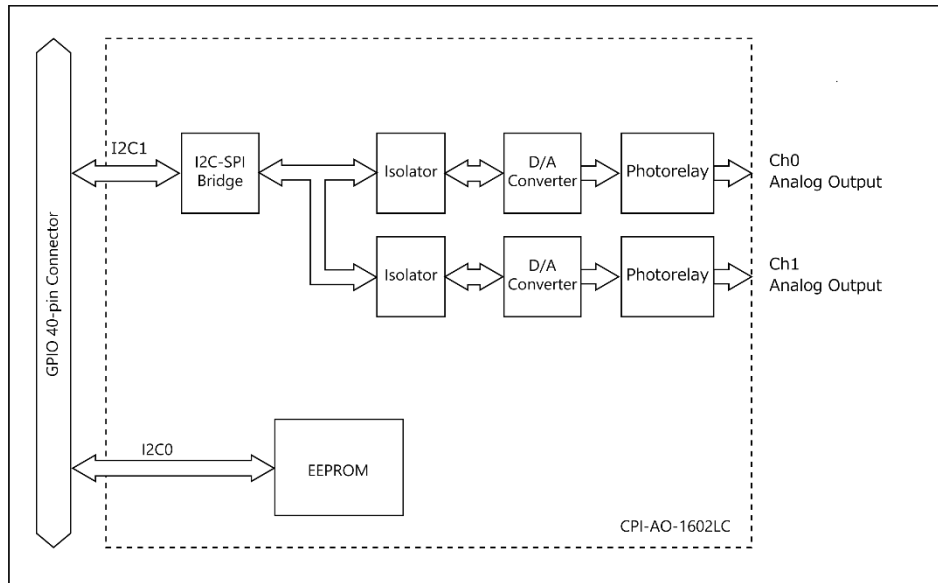| Item		Description
Operating Temperature		-20 - +60°C
Storage Temperature		-20 - +60°C
Humidity		10 - 90%RH (No condensation)
Floating dust particles		Not to be excessive
Corrosive gases		None
Line-noise resistance *1	Line noise	Signal Line /±1kV (IEC61000-4-4 Level 3, EN61000-4-4 Level 3)
	Static electricity resistance	Indirect discharge /±4kV (IEC61000-4-2 Level 2, EN61000-4-2 Level 2)
Vibration resistance	Sweep resistance	10 - 57Hz/semi-amplitude vibration 0.15mm, 57 - 150Hz/2.0G 40minutes each in X, Y, and Z directions (JIS C60068-2-6-compliant, IEC60068-2-6-compliant)
Shock resistance		15G half-sine shock for 11ms in X, Y, and Z directions (JIS C 60068-2-27 -compliant, IEC 60068-2-27 -compliant)
Standard		VCCI Class A, FCC Class A, CE Marking (EMC Directive Class A, RoHS Directive)

*1 When using the CPI-RAS.
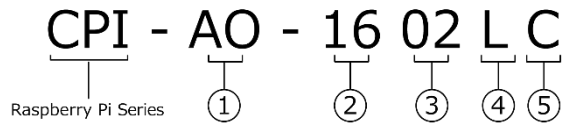
2.Physical Dimensions

Main body only

17.3

8.5

65

58

49

56.5

[mm]
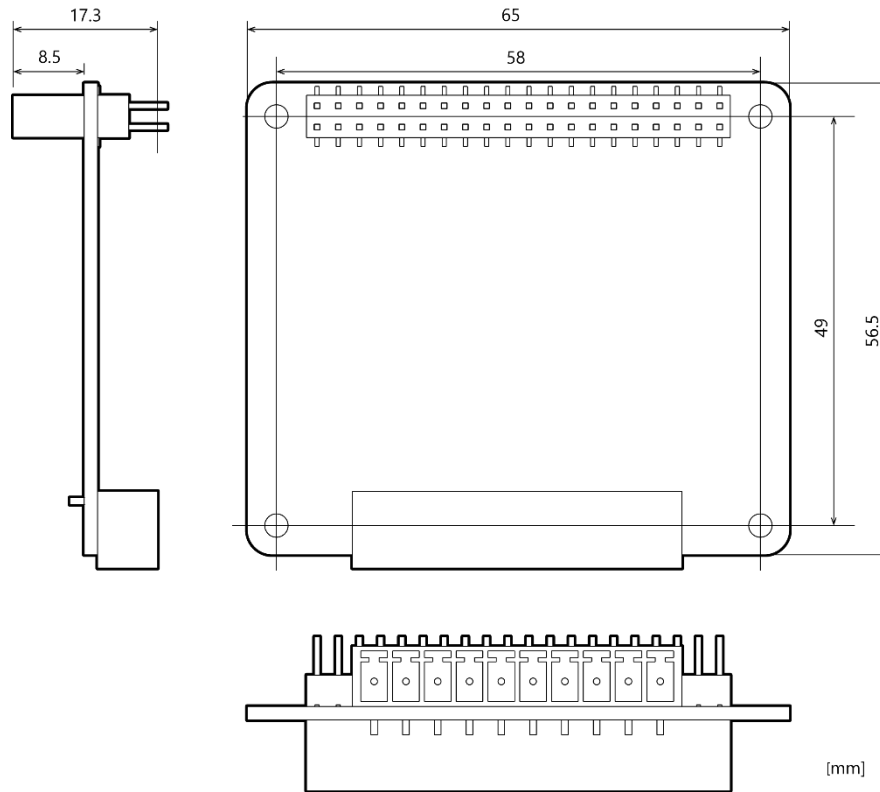
With connector attached

[mm]

3.Circuit Block Diagram

4.The Details of Model Name

Details of the model name are described below.

CPI - AO - 16 02 L C

Raspberry Pi Series ① ② ③ ④⑤

No.	Item		Description
1	Interface	**AO**	Analog Output
2	Resolution	**16**	16-bit
3	Channel	**02**	2 Channels
4	Model Type	**L**	Low-Cost Model
5	Isolation	**C**	Channel Isolation

Customer Support and Inquiry

CONTEC provides the following support services for you to use CONTEC products more efficiently and comfortably.

1.Services

CONTEC offers the useful information including product manuals that can be downloaded through the Contec website.

Download

https://www.contec.com/download/

You can download updated driver software, firmware, and differential manuals in several languages. Membership registration (myCONTEC) is required to use the services.

Revision History

MONTH YEAR	Summary of Changes
November 2021	The First Edition