# Raspberry Pi Expansion Card
## Analog Output Board 16bit DAC Channel Isolation
# CPI-AO-1602LC

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.

* Specifications, color and design of the products are subject to change without notice.
*The contents in this document are subject to change without notice.
*Visit the CONTEC website to check the latest details in the document.
*The information in the data sheets is as of October, 2021.

## 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℃**
The product is capable of operating in the temperature between -20 and + 60℃. 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.

## Specifications

### Function specification

| 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℃, 1-99%FS, no load)<br>For current : ±20LSB(25℃, 1-99%FS, with 250Ω) |
| | Settling time *2 | Voltage : 30μsec (no load)<br>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)<br>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<br>3.3VDC 1mA |
| Physical dimensions (mm) | | 65.0(W) x 56.5(D) (No protrusions)<br>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℃ and 60℃ 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.

## List of Option

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

*        Information about the option products, see the Contec's website.

## Installation Environment Requirements

| Item | | Description |
|------|------|------|
| Operating Temperature | | -20 - +60℃ |
| Storage Temperature | | -20 - +60℃ |
| 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.

## Packing List

Product [CPI-AO-1602LC] ...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

## 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.    https://www.contec.com/download/
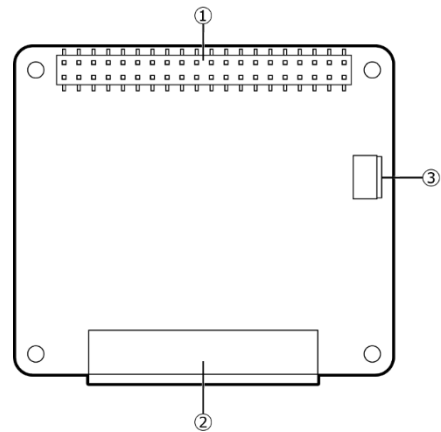
## Physical Dimensions

**Main body only**

[mm]
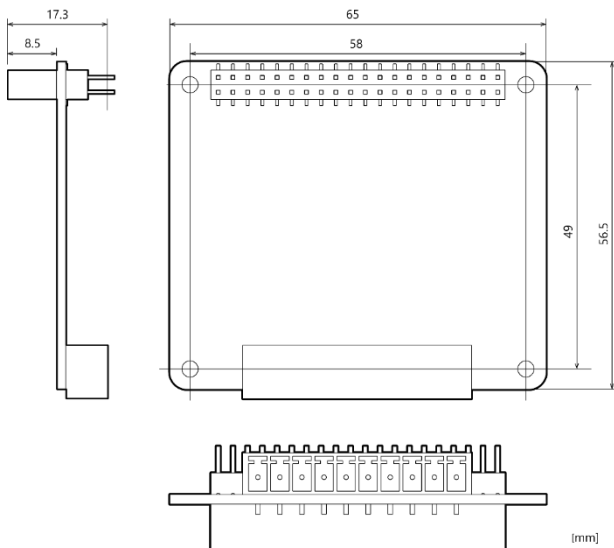
## With connector attached

[mm]
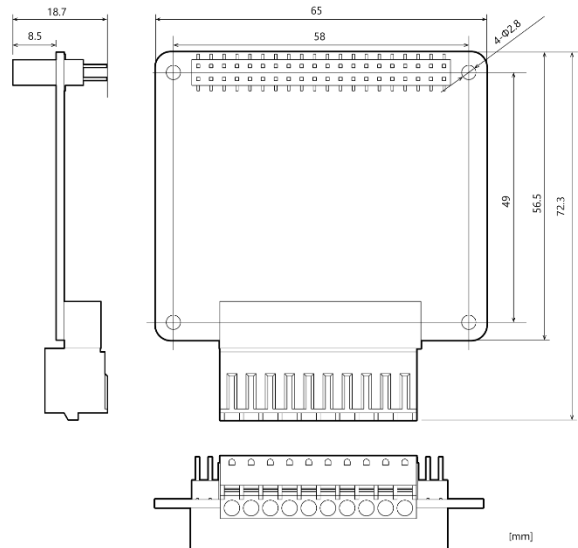
## Component Name

| 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. |

## Connection to external devicese

### GPIO 40 pin connector
This connector is used to connect to a Raspberry Pi or an expansion card.
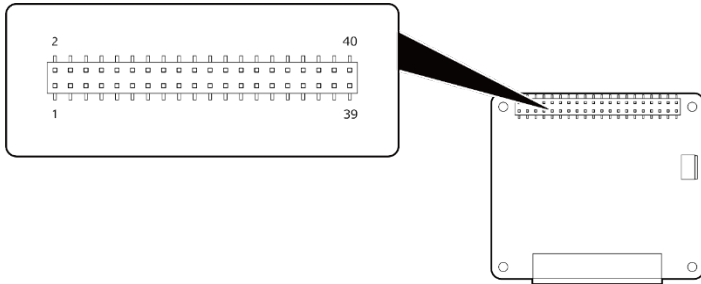
### Pin Assignment

| 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) |

### 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)
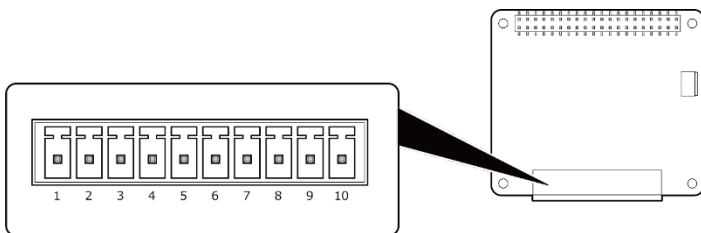
### Pin Assignment

| 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. |

### 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.
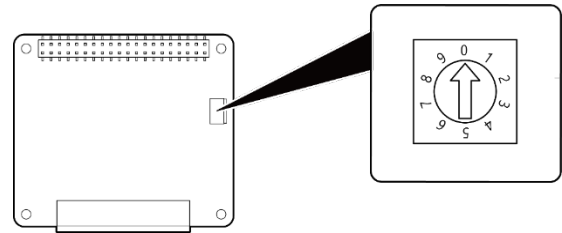
### Switch settings and the corresponding I2C addresses

| 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.

## Voltage Output

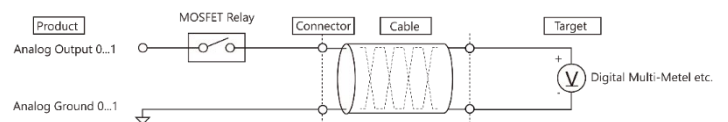### [Connection using a flat cable]
The example below uses a flat cable to connect the product to an external device. For each analog output channel, connect the input of external device and ground on one-to-one basis.
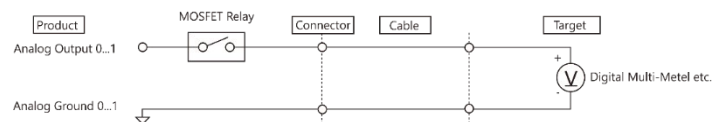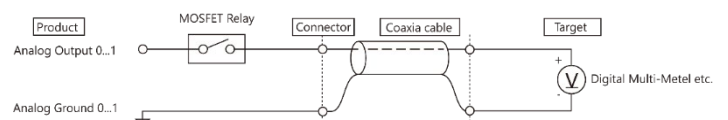
### [Connection using a twisted cable]
The example below uses a twisted cable to connect the product to an external device.
Use this type of cable if the external device is located at a distance from the product. For each analog output channel, connect the input of the external device and ground on one-to-one 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.
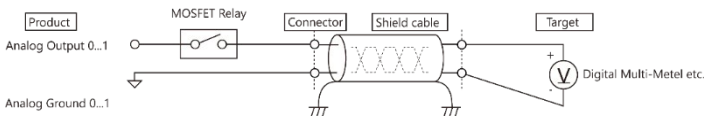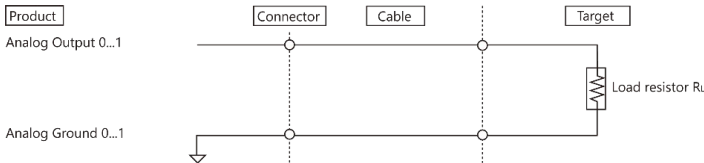


## CAUTION

- 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.
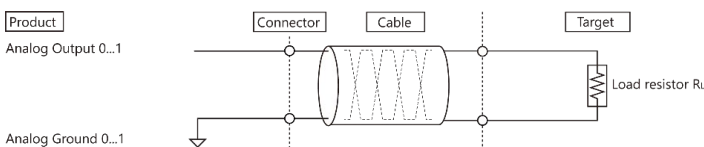
# Current Output

## [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.
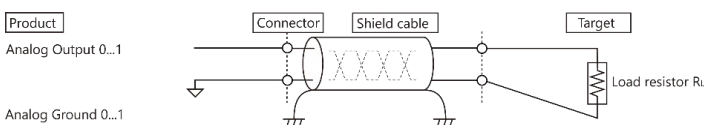


# A connection example when current outputting with an external device.

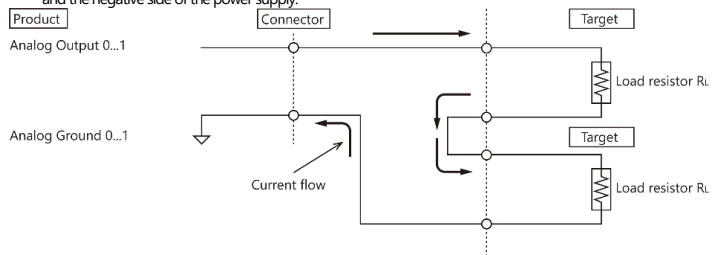## [Connection with an external device of voltage inputs]

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.
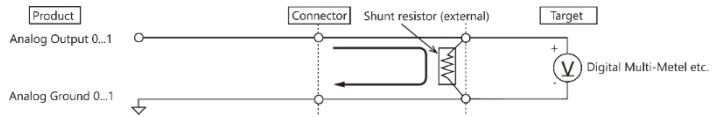


## [Connection with more than one external device of current inputs]

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.
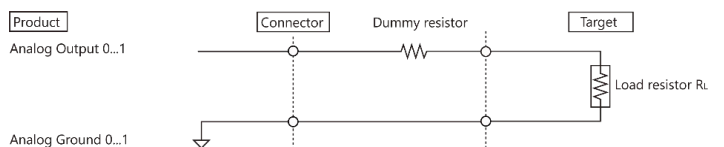


## CAUTION

- 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.

# Block Diagram