

PC-HELPER

High-Resolution Analog  
I/O Board for PCI Express Low Profile

**AIO-160802L-LPE**

High-Resolution Analog  
Input Board for PCI Express Low Profile

**AI-1616L-LPE**

High-Resolution Analog  
Output Board for PCI Express Low Profile

**AO-1604L-LPE**

User's Guide

CONTEC CO., LTD.

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# Check Your Package

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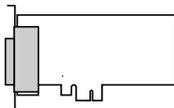
Thank you for purchasing the CONTEC product.

The product consists of the items listed below.

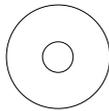
Check, with the following list, that your package is complete. If you discover damaged or missing items, contact your retailer.

## Product Configuration List

- Board (One of the following) ...1  
[AIO-160802L-LPE, AI-1616L-LPE or AO-1604L-LPE]
  - First step guide ...1
  - Disk \*1 [API-PAC(W32)] ...1
  - Standard size bracket ...1
  - Warranty Certificate ...1
  - Serial Number Label ...1
- \*1 The bundled disk contains the driver software and User's Guide (this guide)



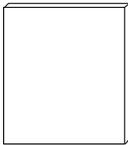
Board



Disk  
[API-PAC(W32)]



Standard size  
bracket



First step guide



Warranty Certificate



Serial Number Label

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# Copyright

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# Trademarks

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# 1. Before Using the Product

## About the Product

This product is a multi-function, PCI Express bus-compliant interface board that incorporates high-precision 16-bit analog inputs, high-precision 16-bit analog outputs, digital inputs/outputs (LVTTTL level each 4ch), and a counter (32-bit, 1ch) function.

This product supports a Low Profile size slot and, if replaced with the supplied bracket, supports a standard size slot, too.

You can use the driver library (API-PAC(W32)) supplied with the board to write Windows application programs in any programming language (such as Visual Basic, Visual C++, etc.) that supports the calling of Win32 API functions.

It can also collect data easily without a program when the data logger software [C-LOGGER] stored on the bundled disk is used.

With plug-ins for the dedicated libraries, the board also supports MATLAB and LabVIEW.

## Features

### Multi-function

High-precision analog I/O can be implemented in a compact system. The series consists of three different models from which you can select the best model to suit your application.

The < AIO-160802L-LPE > contains the analog input (16bit, 8ch), analog output (16bit, 2ch).

The < AI-1616L-LPE > contains the analog input (16bit, 16ch).

The < AO-1604L-LPE > contains the analog output (16bit, 4ch).

All three models include digital inputs and outputs (4 each, LVTTTL level) and a counter (32-bit 1ch).

Analog I/O can be synchronized with an internal timer or external clock.

Analog I/O can both be performed at fixed time intervals or synchronized with an external signal.

Buffer memory available for background processing independent of software

The boards include buffer memory (1K Word each for analog input and output) which can be used in either FIFO or ring format. This allows analog I/O to be performed independently of the operating state of the PC or software.

### Software-based calibration function

Calibration of analog input/output can be all performed by software. Apart from the adjustment information prepared before shipment, additional adjustment information can be stored according to the use environment.

### Filter function for easy connection of external signals

The digital input signals, counter input signals, and the external control signals for analog I/O incorporate a digital filter to prevent problems such as chattering.

Support for both of Low Profile and standard size slots

Support for both of Low Profile and standard size slots (interchangeable with a bundled bracket).

Supported to the data logger software [C-LOGGER] (Analog input only)

Supporting the data logger software [C-LOGGER] that enables the graph display of recorded signal data, file saving, and dynamic transfer to the spreadsheet software program "Excel".

Plug-ins for the dedicated libraries, the board also supports MATLAB and LabVIEW.

We offer a dedicated library [ML-DAQ], which allows you to use this product on MATLAB by The MathWorks as well as another dedicated library [VI-DAQ], which allows you to use the product on LabVIEW.

These dedicated libraries are available, free of charge (downloadable), on our web site.

## Support Software

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

### Windows version of analog I/O driver **API-AIO(WDM)**

[Stored on the bundled disk driver library API-PAC(W32)]

The API-AIO(WDM) is the Windows version driver library software that provides products in the form of Win32 API functions (DLL). Various sample programs such as Visual Basic and Visual C++, etc and diagnostic program

\*Useful for checking operation is provided.

For more details on the supported OS, applicable language and new information, please visit the CONTEC's Web site.

### Linux version of analog I/O driver **API-AIO(LNX)**

[Stored on the bundled disk driver library API-PAC(W32)]

The API-AIO(LNX) is the Linux version driver software which provides device drivers (modules) by shared library and kernel version. Various sample programs of gcc are provided.

For more details on the supported OS, applicable language and new information, please visit the CONTEC's Web site.

### Data Logger Software **C-LOGGER**

[Stored on the bundled disk driver library API-PAC(W32)]

C-LOGGER is a data logger software program compatible with our analog I/O products. This program enables the graph display of recorded signal data, zoom observation, file saving, and dynamic transfer to the spreadsheet software "Excel". No troublesome programming is required.

For more details on the supported OS, applicable language and new information, please visit the CONTEC's Web site.

### Data Acquisition library for MATLAB **ML-DAQ**

(Available for downloading (free of charge) from the CONTEC web site.)

This is the library software which allows you to use our analog I/O device products on MATLAB by the MathWorks. Each function is offered in accordance with the interface which is integrated in MATLAB's Data Acquisition Toolbox.

For more details on the supported OS, applicable language and new information, please visit the CONTEC's Web site.

Data acquisition VI library for LabVIEW **VI-DAQ**  
 (Available for downloading (free of charge) from the CONTEC web site.)

This is a VI library to use in National Instruments LabVIEW.

VI-DAQ is created with a function form similar to that of LabVIEW's Data Acquisition VI, allowing you to use various devices without complicated settings.

For more details on the library and download of VI-DAQ, please visit the CONTEC's Web site.

## Cable & Connector (Option)

Shield Cable with Two 50-Pin Mini-Ribbon Connector	: PCB50PS-0.5P (0.5m)
	: PCB50PS-1.5P (1.5m)
Shield Cable with One 50-Pin Mini-Ribbon Connector	: PCA50PS-0.5P (0.5m)
	: PCA50PS-1.5P (1.5m)

## Accessories (Option)

Screw Terminal Unit(M3 terminal block, 50 points)	: EPD-50A *1
Buffer Amplifier Box for Analog Input Boards (8ch type)	: ATBA-8L *1*2*3*4
Buffer Amplifier Box for Analog Input Boards (16ch type)	: ATBA-16L *1*2*3
BNC Connector Screw Terminal Unit	: ATP-8L *1*5

\*1 PCB50PS-0.5P or PCB50PS-1.5P optional cable is required separately.

\*2 Only AIO-160802L-LPE, AI-1616L-LPE can be used.

\*3 An external power supply is necessary (optional AC adaptor POA200-20 prepared.)

\*4 As for the AI-1616L-LPE, capable of using the analog input of up to 8ch.

\*5 Capable of using the analog input of up to 8ch, and analog output of up to 2ch.

\* Check the CONTEC's Web site for more information on these options.

## Customer Support

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

### Web Site

<https://www.contec.com/>

Latest product information

CONTEC provides up-to-date information on products.

CONTEC also provides product manuals and various technical documents in the PDF.

Free download

You can download updated driver software and differential files as well as sample programs available in several languages.

Note! For product information

Contact your retailer if you have any technical question about a CONTEC product or need its price, delivery time, or estimate information.

## Limited Three-Years Warranty

CONTEC products are warranted by CONTEC CO., LTD. to be free from defects in material and workmanship for up to three years from the date of purchase by the original purchaser.

Repair will be free of charge only when this device is returned freight prepaid with a copy of the original invoice and a Return Merchandise Authorization to the distributor or the CONTEC group office, from which it was purchased.

This warranty is not applicable for scratches or normal wear, but only for the electronic circuitry and original products. The warranty is not applicable if the device has been tampered with or damaged through abuse, mistreatment, neglect, or unreasonable use, or if the original invoice is not included, in which case repairs will be considered beyond the warranty policy.

## How to Obtain Service

For replacement or repair, return the device freight prepaid, with a copy of the original invoice. Please obtain a Return Merchandise Authorization number (RMA) from the CONTEC group office where you purchased before returning any product.

\* No product will be accepted by CONTEC group without the RMA number.

## Liability

The obligation of the warrantor is solely to repair or replace the product. In no event will the warrantor be liable for any incidental or consequential damages due to such defect or consequences that arise from inexperienced usage, misuse, or malfunction of this device.

# Safety Precautions

Understand the following definitions and precautions to use the product safely.

## 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	DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.
⚠ WARNING	WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
⚠ CAUTION	CAUTION indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury or in property damage.

## Handling Precautions

### DANGER

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Do not use the product where it is exposed to flammable or corrosive gas. Doing so may result in an explosion, fire, electric shock, or failure.

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### CAUTION

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- There are switches and jumpers on the product that need to be set in advance.  
Be sure to check these before installing the expansion slot.
  - Only set the switches and jumpers on the product to the specified settings.  
Otherwise, the product may malfunction, overheat, or cause a failure.
  - Do not strike or bend the product.  
Otherwise, the product may malfunction, overheat, cause a failure or breakage.
  - Do not touch the product's metal plated terminals (edge connector) with your hands.  
Otherwise, the product may malfunction, overheat, or cause a failure.  
If the terminals are touched by someone's hands, clean the terminals with industrial alcohol.
  - Do not plug or unplug the cables which are connected to the board while the PC or expansion unit is still turned on.  
Otherwise, the board may malfunction, overheat, or cause a failure.  
Be sure that the personal computer power is turned off.
  - Make sure that your PC or extension unit can supply ample power to all the products installed.  
Insufficiently energized products could malfunction, overheat, or cause a failure.
  - The specifications of this product are subject to change without notice for enhancement and quality improvement.  
Even when using the product continuously, be sure to read the manual and understand the contents.
  - Do not modify the product. CONTEC will bear no responsibility for any problems, etc., resulting from modifying this product.
  - 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.
  - Regarding "CE EMC Directive Notice".  
Please connect the Interface Connector with a shielded cable to meet the mentioned standard above.
-

## Environment

Use this product in the following environment. If used in an unauthorized environment, the product may overheat, malfunction, or cause a failure.

Operating temperature

0 - 50°C

Operating humidity

10 - 90%RH (No condensation)

Corrosive gases

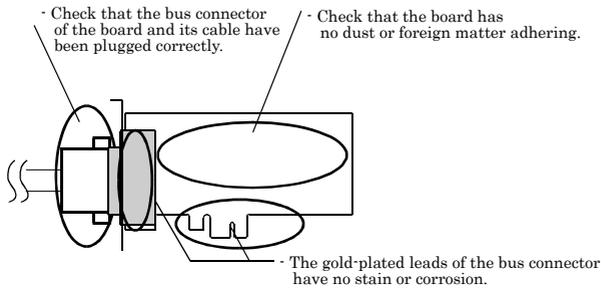
None

Floating dust particles

Not to be excessive

## Inspection

Inspect the product periodically as follows to use it safely.



## Storage

When storing this product, keep it in its original packing form.

- (1) Put the product in the storage bag.
- (2) Wrap it in the packing material and then put it in the box.
- (3) Store the package at room temperature at a place free from direct sunlight, moisture, shock, vibration, magnetism, and static electricity.

## Disposal

When disposing of the product, follow the disposal procedures stipulated under the relevant laws and municipal ordinances.



## 2. Setup

This chapter explains how to set up the product.

### What is Setup?

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

Different steps are required for software and hardware.

The setup procedure varies with the OS and applications used.

### Using the product under Windows

#### Using the Driver Library API-PAC(W32)

This section describes the setup procedure to be performed before you can start developing application programs for the product using the bundled disk “Driver Library API-PAC(W32)”.

Taking the following steps sets up the software and hardware. You can use the diagnosis program later to check whether the software and hardware function normally.

**Step 1 Installing the Software**

**Step 2 Setting the Hardware**

**Step 3 Installing the Hardware**

**Step 4 Initializing the Software**

**Step 5 Checking Operations with the Diagnosis Program**

If Setup fails to be performed normally, see the “Setup Troubleshooting” section at the end of this chapter.

### Using the product under Windows

#### Using Software Other than the Driver Library API-PAC(W32)

For setting up software other than API-PAC(W32), refer to the manual for that software. See also the following parts of this manual as required.

**This chapter Step 2 Setting the Hardware**

**This chapter Step 3 Installing the Hardware**

**Chapter 3 External Connection**

**Chapter 6 About Hardware**

## Using the Product under an OS Other than Windows

For using the product under Linux, see the following parts of this manual.

**This chapter Step 2 Setting the Hardware**

**Chapter 3 External Connection**

**Chapter 5 About Software**

**Chapter 6 About Hardware**

For using the product under an OS other than Windows and Linux, see the following parts of this manual.

**This chapter Step 2 Setting the Hardware**

**Chapter 3 External Connection**

**Chapter 6 About Hardware**

---

## Step 1 Installing the Software

This section describes how to install the Driver libraries.

**Before installing the hardware on the PC, install the driver library from the bundled disk provided with the product.**

The following description assumes the operating system as Windows XP. Although some user interfaces are different depending on the OS used, the basic procedure is the same.

### Which Driver to Use

CONTEC has two analog I/O drivers: “API-AIO(WDM)” and “API-AIO(98/PC)”

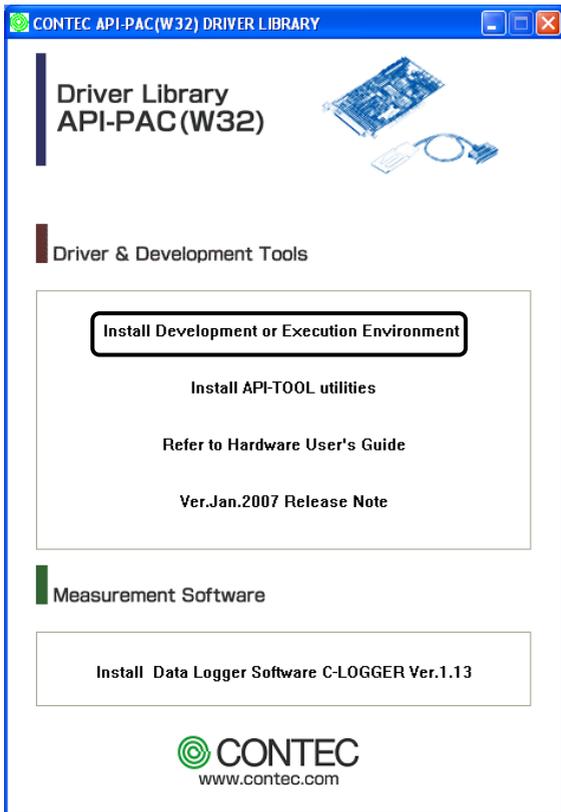
API-AIO(WDM) is a new driver for analog I/O under Windows.

This driver was developed to be easier to use and to provide additional functions above those provided by the previous API-AIO(98/PC) driver.

Please use the API-AIO(WDM) with this product. API-AIO(98/PC) is not supported.

## Starting the Install Program

- (1) Load the bundled disk [API-PAC(W32)] on your PC.
- (2) The API-PAC(W32) Installer window appears automatically.  
If the panel does not appear, run (drive letter):\AUTORUN.exe.
- (3) Click on the [Install Development or Execution Environment] button.



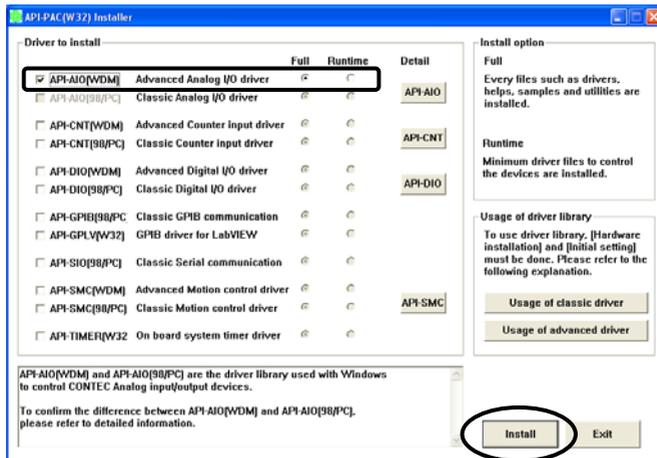
### CAUTION

Before installing the software in Windows Vista, XP, XP, Server 2003, 2000, log in as a user with administrator privileges.

---

Selecting API-AIO(WDM)

- (1) The following dialog box appears to select “Driver to install” and “Install option”, “Usage of driver library”.
- (2) Select the "Advanced Analog I/O driver".
- (3) Click on the [Install] button.



- \* Clicking the [Details] button displays detailed information about API-AIO(WDM) and API-AIO(98/PC).

Run the installation

- (1) Complete the installation by following the instructions on the screen.
- (2) The Readme file appears when the installation is complete.

**You have now finished installing the software.**

## Step 2 Setting the Hardware

This section describes how to set the product and plug it on your PC.

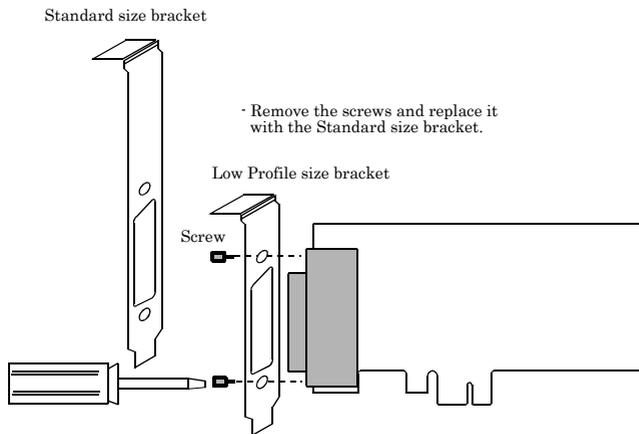
The product has some switches to be preset.

Check the on- product switches before plugging the product into an extension slot.

The product can be set up even with the factory defaults untouched. You can change product settings later.

### Replacing the Bracket

This product is shipped with a Low Profile size bracket mounted. To plug the product into a standard size slot, replace the bracket with the bundled standard size bracket. The replacing method is as follows :



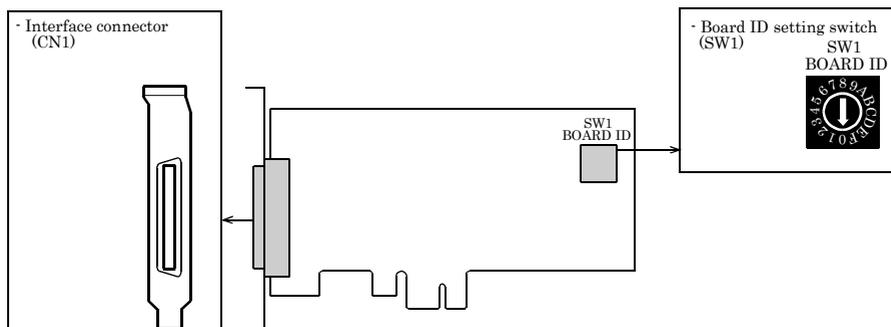
Use a flathead screwdriver or hexagonal spanner to undo and tighten the screws.

**Figure 2.1. Replacing the Bracket**

## Parts of the Product and Factory Defaults

Figure 2.1 shows the names of each part of the product.

The switch settings shown in the figure are the factory default settings.



**Figure 2.2. Part Names**

## Setting the Product ID

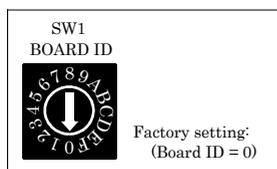
If you install two or more products on one personal computer, assign a different ID value to each of the products to distinguish them.

The product IDs can be set from 0 to Fh to identify up to sixteen products.

If only one product is used, the original factory setting (Product ID = 0) should be used.

### Setting Procedure

To set the product ID, use the rotary switch on the product. Turn the SW1 knob to set the product ID as shown below.



**Figure 2.3. Product ID Settings (SW1)**

## Plugging the Product

- (1) Before plugging the product, shut down the system, unplug the power code of your PC.
- (2) Remove the cover from the PC so that the product can be mounted.
- (3) Plug the product into an extension slot.
- (4) Attach the product bracket to the PC.
- (5) Put the cover back into place.



---

### **⚠ CAUTION**

- Do not touch the product's metal plated terminals (edge connector) with your hands. Otherwise, the product may malfunction, overheat, or cause a failure. If the terminals are touched by someone's hands, clean the terminals with industrial alcohol.
  - Do not install or remove the product to or from the slot while the computer's power is turned on. Otherwise, the product may malfunction, overheat, or cause a failure. Doing so could cause trouble. Be sure that the personal computer or the I/O expansion unit power is turned off.
  - Make sure that your PC or expansion unit can supply ample power to all the products installed. Insufficiently energized products could malfunction, overheat, or cause a failure.
-

## Step 3 Installing the Hardware

Windows needs to detect the I/O address and interrupt used by the product. This is called hardware installation.

When using more than one product, install the products one at a time and do not install the next product until setup is complete for the previous product.

### Turning on the PC

Turn on the power to your PC.



#### CAUTION

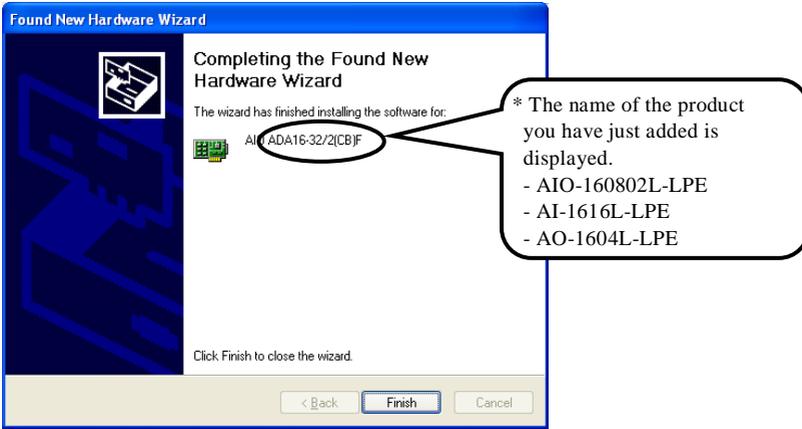
- The product cannot be properly installed unless the resources (I/O addresses and interrupt level) for the product can be allocated. Before attempting to install the product, first determine what PC resources are free to use.
- The resources used by each product do not depend on the location of the PCI bus slot or the product itself. If you remove two or more products that have already been installed and then remount one of them on the computer, it is unknown that which one of the sets of resources previously assigned to the two products is assigned to the remounted product. In this case, you must check the resource settings.

### Using the API-AIO(WDM)

- (1) The “Found New Hardware Wizard” will be started.  
Select “Install from a list or specific location[Advanced]”, then click on the [Next] button.



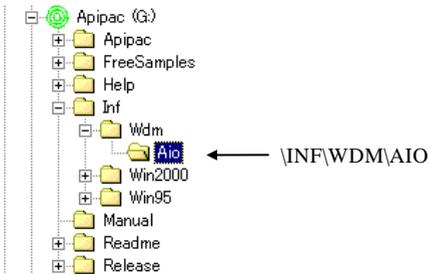
(2) Specify that folder on the bundled disk which contains the setup information file (INF) to register the product.



Source folder

The setup information file (INF) is contained in the following folder on the bundled disk.

\INF\WDM\AIO



**You have now finished installing the software.**

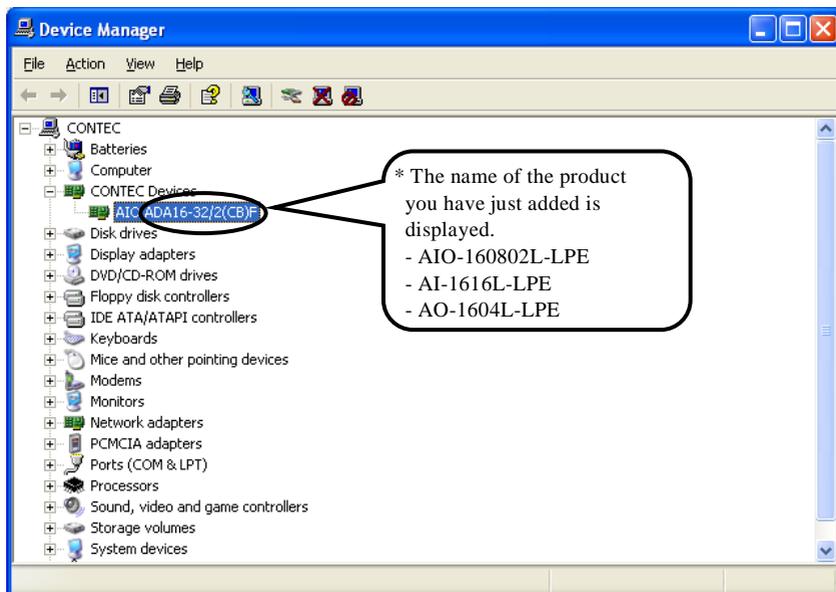
## Step4 Initializing the Software

The driver library requires the initial setting to recognize the execution environment. It is called the initialization of the Driver library.

Setting the device name

- (1) Run Device Manager. From [My Computer] - [Control Panel], select [System] and then select the [Device Manager] tab.

(You can also open Device Manager by right clicking on My Computer and selecting Properties.)

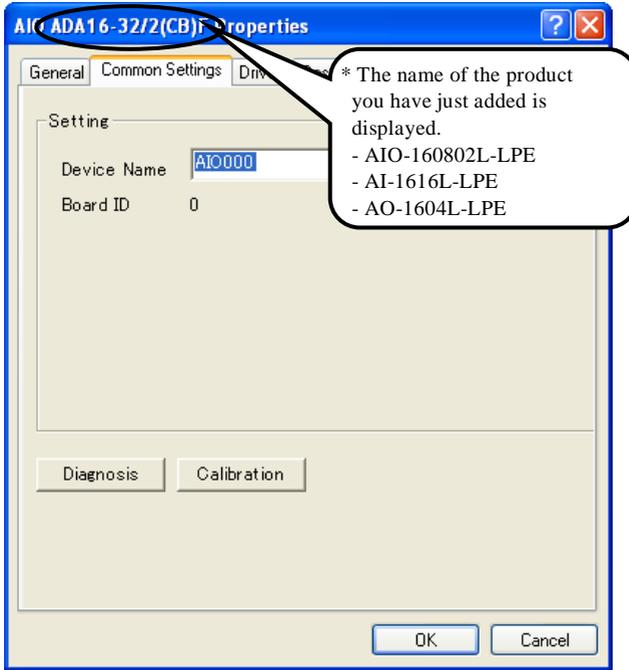


- (2) The installed hardware appears under the CONTEC Devices node. Open the CONTEC Devices node and select the device you want to setup (the device name should appear highlighted). Click [Properties].

(3) The property page for the device opens.

Enter the device name in the common settings tab page and then click [OK].

The device name you set here is used later when programming.



\* The initial device name that appears is a default value. You can use this default name if you wish.

\* Make sure that you do not use the same name for more than one device.

**You have now finished installing the initial setting of Software.**

## Step 5 Checking Operations with the Diagnosis Program

Use the diagnosis program to check that the product and driver software work normally, thereby you can confirm that they have been set up correctly.

### What is the Diagnosis Program?

The diagnosis program diagnoses the states of the product and driver software.

It can also be used as a simple checker when an external device is actually connected.

Using the “Diagnosis Report” feature reports the driver settings, the presence or absence of the product, I/O status, and interrupt status.

### Check Method

To check the analog I/O data, connect to an external signal source.

The figure below shows an example of checking by connecting to an external signal.

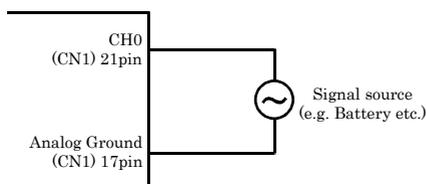
The analog input example illustrated below is an example of using analog input channel 0 on the AIO-160802L-LPE or AI-1616L-LPE. The analog output example illustrated below is an example of using analog output channel 0 on the AIO-160802L-LPE or AO-1604L-LPE.

Connection diagram

#### < Analog Input >

- Single-Ended Input

Interface connector



#### CAUTION

Input data remains indeterminate when no input pin is connected. The input pin for the channel not connected to the signal source must be connected to the analog ground.

For details, see “Chapter 3 External Connection”.

#### < Analog Output >

Interface connector

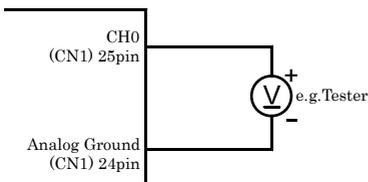
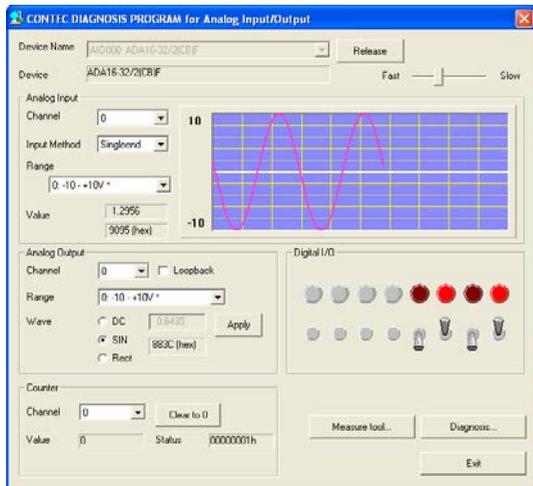
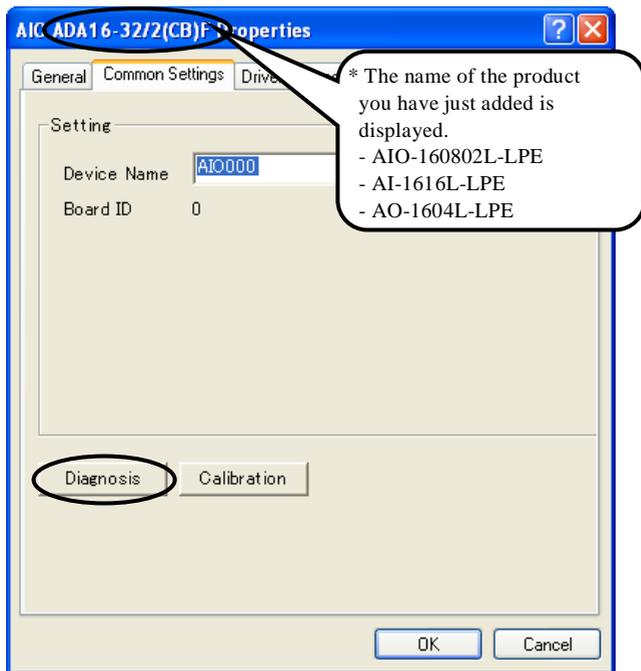


Figure 2.4. Connection diagram

## Using the Diagnosis Program

### Starting the Diagnosis Program

Click the [Diagnosis] button on the device property page to start the diagnosis program.



### Analog input

Select the input channel, input type, and input range from the lists.

Input data is plotted on a graph.

\* This function is available only to the AIO-160802L-LPE and AI-1616L-LPE.

### Analog output

You can select the desired output channel and output range from the lists.

You can set the output data to DC (constant voltage), sine wave, or square wave.

\* This function is available only to the AIO-160802L-LPE and AO-1604L-LPE.

### Digital I/O

The upper row of circular lamps indicates the digital input states. Red indicates the bit is ON and brown indicates OFF.

Clicking the lower row of switches turns the digital output bits ON or OFF.

### Counter input

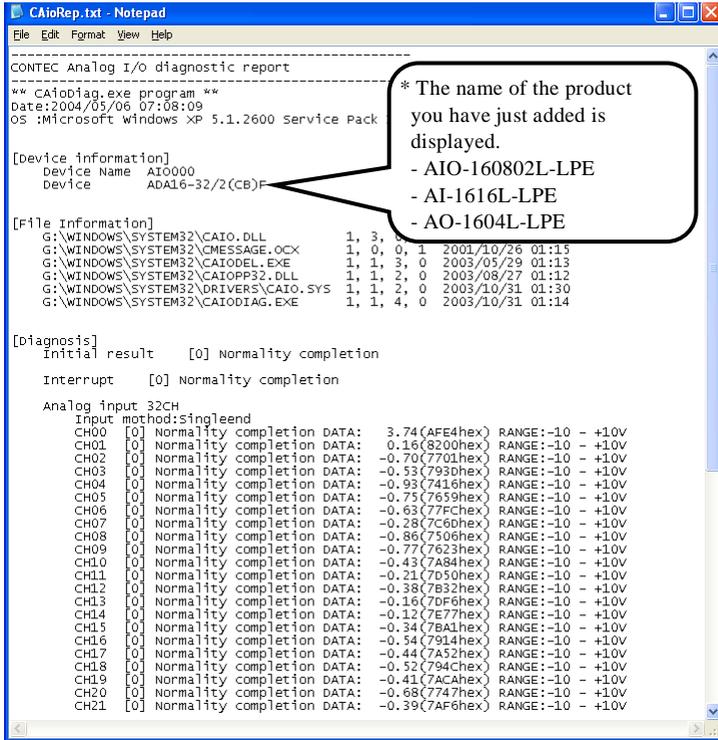
Selecting a counter channel displays the count value and state of that counter channel.

Clicking the zero clear button resets the count to zero.

Diagnosis Report

(1) The diagnosis report saves detailed data, including the device settings and settings for each channel, to a text file and displays the file for you to view.

Clicking [Diagnosis Report] prompts you to specify where to save the report text file.



(2) The diagnosis report contains the following data.

- Version of OS
- Device Information
- File Information
- Initialization, interrupts, current input or output state for each channel

---

# Setup Troubleshooting

## Symptoms and Actions

Data input or output does not operate correctly

- Run the diagnosis program to check that the device is registered and whether any initialization errors have occurred.
- Is there a problem with the device settings, wiring, or similar? Check the I/O range setting. Also, the input data will be undefined if the wiring terminals are not connected. Ensure that the channels you are using are correctly connected. Connect unused channels to analog ground.
- For voltage input, check by connecting a battery or similar if you do not have any other suitable signal source. Also check that connecting to analog ground reads correctly as 0V.

The product works with the Diagnosis Program but not with an application.

The Diagnosis Program is coded with API-TOOL functions. As long as the product operates with the Diagnosis Program, it is to operate with other applications as well. In such cases, review your program while paying attention to the following points:

- Check the return values of the API functions.
- Refer to the source code for the sample programs.

The OS won't normally get started or detect the device.

Refer to the "Troubleshooting" section of API-AIO(WDM) HELP.

## If your problem cannot be resolved

Contact your retailer.



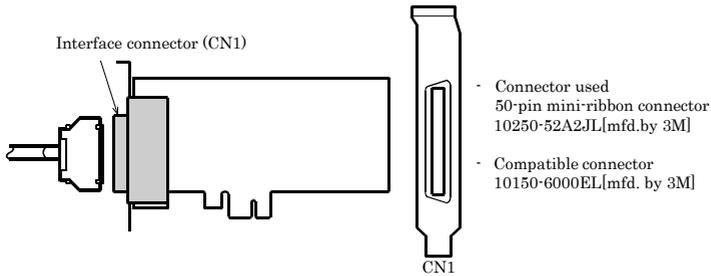
## 3. External Connection

This chapter describes the interface connectors on the product and the external I/O circuits. Check the information available here when connecting an external device.

### How to connect the connectors

#### Connector shape

The on-product interface connector (CN1) is used when connecting this product and the external devices.



\* Please refer to chapter 1 for more information on the supported cable and accessories.

**Figure 3.1. Interface Connector Shape**

## Connector Pin Assignment

Pin Assignments of AIO-160802L-LPE Interface Connector (CN1)

Non Connect	N.C.	50	25	-- AO 00	Analog Output 00
Analog Ground ( for AO )	AGND	49	24	-- AGND	Analog Ground ( for AO )
Non Connect	N.C.	48	23	-- AO 01	Analog Output 01
Analog Ground ( for AO )	AGND	47	22	-- AGND	Analog Ground ( for AO )
Analog Input 04	AI 04	46	21	-- AI 00	Analog Input 00
Non Connect	N.C.	45	20	-- N.C.	Non Connect
Analog Input 05	AI 05	44	19	-- AI 01	Analog Input 01
Non Connect	N.C.	43	18	-- N.C.	Non Connect
Analog Ground ( for AI )	AGND	42	17	-- AGND	Analog Ground ( for AI )
Analog Ground ( for AI )	AGND	41	16	-- AGND	Analog Ground ( for AI )
Analog Input 06	AI 06	40	15	-- AI 02	Analog Input 02
Non Connect	N.C.	39	14	-- N.C.	Non Connect
Analog Input 07	AI 07	38	13	-- AI 03	Analog Input 03
Non Connect	N.C.	37	12	-- N.C.	Non Connect
AO External Start Trigger Input	AO START	36	11	-- AI START	AI External Start Trigger Input
AO External Stop Trigger Input	AO STOP	35	10	-- AI STOP	AI External Stop Trigger Input
AO External Sampling Clock Input	AO EXCLK	34	9	-- AI EXCLK	AI External Sampling Clock Input
Digital Ground	DGND	33	8	-- DGND	Digital Ground
Digital Output 00	DO 00	32	7	-- DI 00	Digital Input 00
Digital Output 01	DO 01	31	6	-- DI 01	Digital Input 01
Digital Output 02	DO 02	30	5	-- DI 02	Digital Input 02
Digital Output 03	DO 03	29	4	-- DI 03	Digital Input 03
Digital Ground	DGND	28	3	-- DGND	Digital Ground
Counter UP Clock Input	CNT UPCLK	27	2	-- CNT GATE	Counter Gate Control Input
Reserved	Reserved	26	1	-- CNT OUT	Counter Output

Analog Input00 - Analog Input07	Analog input signal. The numbers correspond to channel numbers.
Analog Output00 - Analog Output01	Analog output signal. The numbers correspond to channel numbers.
Analog Ground	Common analog ground for analog I/O signals.
AI External Start Trigger Input	External trigger input for starting analog input sampling.
AI External Stop Trigger Input	External trigger input for stopping analog input sampling.
AI External Sampling Clock Input	External sampling clock input for analog input.
AO External Start Trigger Input	External trigger input for starting analog output sampling.
AO External Stop Trigger Input	External trigger input for stopping analog output sampling.
AO External Sampling Clock Input	External sampling clock input for analog output.
Digital Input00 - Digital Input03	Digital input signal.
Digital Output00 - Digital Output03	Digital output signal.
Counter Gate Control Input	Gate control input signal for counter.
Counter Up Clock Input	Count-up clock input signal for counter.
Counter Output	Counter output signal.
Digital Ground	Common digital ground for digital I/O signals, external trigger inputs, external sampling clock inputs, and counter I/O signals.
Reserved	Reserved pin.
N.C.	No connection to this pin.

Figure 3.2. Pin Assignments of Interface Connector (CN1) < AIO-160802L-LPE >

 CAUTION

---

- Do not connect any of the outputs and power outputs to the analog or digital ground. Neither connect outputs to each other. Doing either can result in a fault.
  - If analog and digital ground are shorted together, noise on the digital signals may affect the analog signals. Accordingly, analog and digital ground should be separated.
  - Leave "Reserved" pins unconnected. Connecting these pins may cause a fault in the product.
-

## Pin Assignments of AI-1616L-LPE Interface Connector (CN1)

Non Connect	N.C.	50	25	- N.C.	Non Connect
Reserved	Reserved	49	24	- Reserved	Reserved
Non Connect	N.C.	48	23	- N.C.	Non Connect
Reserved	Reserved	47	22	- Reserved	Reserved
Analog Input 04	AI 04	46	21	- AI 00	Analog Input 00
Analog Input 12	AI 12	45	20	- AI 08	Analog Input 08
Analog Input 05	AI 05	44	19	- AI 01	Analog Input 01
Analog Input 13	AI 13	43	18	- AI 09	Analog Input 09
Analog Ground ( for AI )	AGND	42	17	- AGND	Analog Ground ( for AI )
Analog Ground ( for AI )	AGND	41	16	- AGND	Analog Ground ( for AI )
Analog Input 06	AI 06	40	15	- AI 02	Analog Input 02
Analog Input 14	AI 14	39	14	- AI 10	Analog Input 10
Analog Input 07	AI 07	38	13	- AI 03	Analog Input 03
Analog Input 15	AI 15	37	12	- AI 11	Analog Input 11
Non Connect	N.C.	36	11	- AI START	AI External Start Trigger Input
Non Connect	N.C.	35	10	- AI STOP	AI External Stop Trigger Input
Non Connect	N.C.	34	9	- AI EXCLK	AI External Sampling Clock Input
Digital Ground	DGND	33	8	- DGND	Digital Ground
Digital Output 00	DO 00	32	7	- DI 00	Digital Input 00
Digital Output 01	DO 01	31	6	- DI 01	Digital Input 01
Digital Output 02	DO 02	30	5	- DI 02	Digital Input 02
Digital Output 03	DO 03	29	4	- DI 03	Digital Input 03
Digital Ground	DGND	28	3	- DGND	Digital Ground
Counter UP Clock Input	CNT UPCLK	27	2	- CNT GATE	Counter Gate Control Input
Reserved	Reserved	26	1	- CNT OUT	Counter Output

Analog Input00 - Analog Input15	Analog input signal. The numbers correspond to channel numbers.
Analog Ground	Analog ground.
AI External Start Trigger Input	External trigger input for starting analog input sampling.
AI External Stop Trigger Input	External trigger input for stopping analog input sampling.
AI External Sampling Clock Input	External sampling clock input for analog input.
Digital Input00 - Digital Input03	Digital input signal.
Digital Output00 - Digital Output03	Digital output signal.
Counter Gate Control Input	Gate control input signal for counter.
Counter Up Clock Input	Count-up clock input signal for counter.
Counter Output	Counter output signal.
Digital Ground	Common digital ground for digital I/O signals, external trigger inputs, external sampling clock inputs, and counter I/O signals.
Reserved	Reserved pin.
N.C.	No connection to this pin.

Figure 3.3. Pin Assignments of Interface Connector (CN1) &lt; AI-1616L-LPE &gt;

### CAUTION

- Do not connect any of the outputs and power outputs to the analog or digital ground. Neither connect outputs to each other. Doing either can result in a fault.
- If analog and digital ground are shorted together, noise on the digital signals may affect the analog signals. Accordingly, analog and digital ground should be separated.
- Leave "Reserved" pins unconnected. Connecting these pins may cause a fault in the product.

## Pin Assignments of AO-1604L-LPE Interface Connector (CN1)

Analog Output 02	AO 02	50	25	- AO 00	Analog Output 00
Analog Ground ( for AO )	AGND	49	24	- AGND	Analog Ground ( for AO )
Analog Output 03	AO 03	48	23	- AO 01	Analog Output 01
Analog Ground ( for AO )	AGND	47	22	- AGND	Analog Ground ( for AO )
Non Connect	N.C.	46	21	- N.C.	Non Connect
Non Connect	N.C.	45	20	- N.C.	Non Connect
Non Connect	N.C.	44	19	- N.C.	Non Connect
Non Connect	N.C.	43	18	- N.C.	Non Connect
Reserved	Reserved	42	17	- Reserved	Reserved
Reserved	Reserved	41	16	- Reserved	Reserved
Non Connect	N.C.	40	15	- N.C.	Non Connect
Non Connect	N.C.	39	14	- N.C.	Non Connect
Non Connect	N.C.	38	13	- N.C.	Non Connect
Non Connect	N.C.	37	12	- N.C.	Non Connect
AO External Start Trigger Input	AO START	36	11	- N.C.	Non Connect
AO External Stop Trigger Input	AO STOP	35	10	- N.C.	Non Connect
AO External Sampling Clock Input	AO EXCLK	34	9	- N.C.	Non Connect
Digital Ground	DGND	33	8	- DGND	Digital Ground
Digital Output 00	DO 00	32	7	- DI 00	Digital Input 00
Digital Output 01	DO 01	31	6	- DI 01	Digital Input 01
Digital Output 02	DO 02	30	5	- DI 02	Digital Input 02
Digital Output 03	DO 03	29	4	- DI 03	Digital Input 03
Digital Ground	DGND	28	3	- DGND	Digital Ground
Counter UP Clock Input	CNT UPCLK	27	2	- CNT GATE	Counter Gate Control Input
Reserved	Reserved	26	1	- CNT OUT	Counter Output

Analog Output00 - Analog Output03	Analog output signal. The numbers correspond to channel numbers.
Analog Ground	Analog ground.
AO External Start Trigger Input	External trigger input for starting analog output sampling.
AO External Stop Trigger Input	External trigger input for stopping analog output sampling.
AO External Sampling Clock Input	External sampling clock input for analog output.
Digital Input00 - Digital Input03	Digital input signal.
Digital Output00 - Digital Output03	Digital output signal.
Counter Gate Control Input	Gate control input signal for counter.
Counter Up Clock Input	Count-up clock input signal for counter.
Counter Output	Counter output signal.
Digital Ground	Common digital ground for digital I/O signals, external trigger inputs, external sampling clock inputs, and counter I/O signals.
Reserved	Reserved pin.
N.C.	No connection to this pin.

Figure 3.4. Pin Assignments of Interface Connector (CN1) &lt; AO-1604L-LPE &gt;

**CAUTION**

- Do not connect any of the outputs and power outputs to the analog or digital ground. Neither connect outputs to each other. Doing either can result in a fault.
- If analog and digital ground are shorted together, noise on the digital signals may affect the analog signals. Accordingly, analog and digital ground should be separated.
- Leave "Reserved" pins unconnected. Connecting these pins may cause a fault in the product.

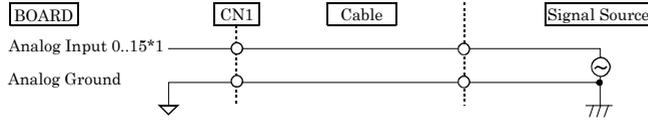
## Analog Input Signal Connection

Analog signal input types are divided into single-ended input and differential input. This product uses single-ended input fixed. The following examples show how to connect analog input signals using a flat cable and a shielded cable.

### Single-ended Input

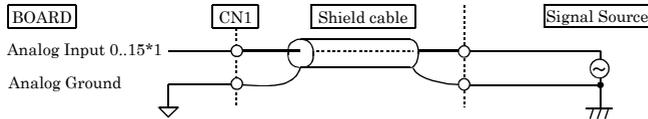
The following figure shows an example of flat cable connection.

Connect separate signal and ground wires for each analog input channel on CN1.



**Figure 3.5. Single-ended Input Connection (Flat Cable)**

The following figure shows an example of shield cable connection. Use shielded cable if the distance between the signal source and product is long or if you want to provide better protection from noise. For each analog input channel on CN1, connect the core wire to the signal line and connect the shielding to ground.



**Figure 3.6. Single-ended Input Connection (Shield Cable)**

\*1 The number of channels depends on each product.

The AIO-160802L-LPE has eight channels; the AI-1616L-LPE has 16 channels;  
the AO-1604L-LPE has no channel.

### ⚠ CAUTION

- If the signal source contains over 1MHz signals, the signal may effect the cross-talk noise between channels.
- If the product and the signal source receive noise or the distance between the product and the signal source is too long, data may not be input properly.
- An input analog signal should not exceed the maximum input voltage (relate to the product analog ground). If it exceeds the maximum voltage, the product may be damaged.
- Connect all the unused analog input channels to analog ground.
- The signal connected to an input pin may fluctuate after switching of the multiplexer. If this occurs, shorten the cable between the signal source and the analog input pin or insert a high-speed amplifier as a buffer between the two to reduce the fluctuation.

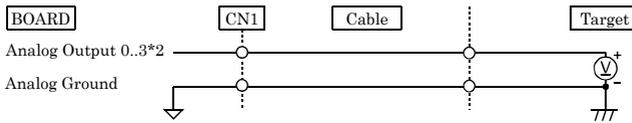
- An input pin may fail to obtain input data normally when the signal source connected to the pin has high impedance. If this is the case, change the signal source to one with lower output impedance or insert a high-speed amplifier buffer between the signal source and the analog input pin to reduce the effect.

## Analog Output Signal Connection

This section shows how to connect the analog output signal by using a flat cable or a shielded cable.

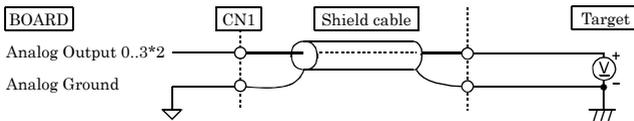
The following figure shows an example of flat cable connection.

Connect the signal source and ground to the CN1 analog output.



**Figure 3.7. Analog Output Connection (Flat Cable)**

The following figure shows an example of shield cable connection. Use shielded cable if the distance between the signal source and product is long or if you want to provide better protection from noise. For each analog input channel on CN1, connect the core wire to the signal line and connect the shielding to ground.



**Figure 3.8. Analog Output Connection (Shield Cable)**

\*2 The number of channels depends on each product.

The AIO-160802L-LPE has two channels; the AI-1616L-LPE has no channel;  
the AO-1604L-LPE has four channels.



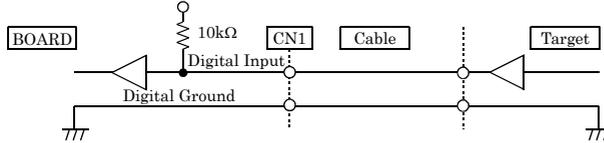
### CAUTION

- If the product or the connected wire receives noise, or the distance between the product and the target is long, data may not be outputted properly.
- For analog output signal, the current capacity is  $\pm 3\text{mA}$  (Max.). Check the specification of the connected device before connecting the product.
- Do not short the analog output signal to analog ground, digital ground, and/or power line. Doing so may damage the product.
- Do not connect an analog output signal to any other analog output, either on the product or on an external device, as this may cause a fault on the product.

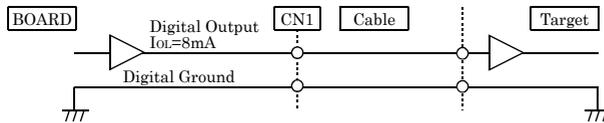
# Digital I/O signals, Counter signals and Control signals Connection

The following sections show examples of how to connect digital I/O signals, counter I/O signals, and other control I/O signals (external trigger input signals, sampling clock input signals, etc.).

All the digital I/O signals and control signals are LVTTTL level signals.



**Figure 3.9. Digital Input Connection**



**Figure 3.10. Digital Output Connection**

About the counter input control signal

Counter Gate Control Input (refer to the chapter 3 Connector Pin Assignment) acts as an input that validate or invalidate the input of an external clock for the counter. This function enables the control of an external clock input for the counter. The external clock for the counter is effective when input is "High", and invalid when input is "Low". If unconnected, it is a pull-up in the board (card) and remains "High". Therefore the external clock for the counter is effective when the counter gate control input is not connected.

## ⚠ CAUTION

Do not short the output signals to analog ground, digital ground, and/or power line. Doing so may damage the product.

### Reference

For the operation timings for control signal input, see "Control Signal Timings" in Chapter 6 "Hardware".

## 4. Functions

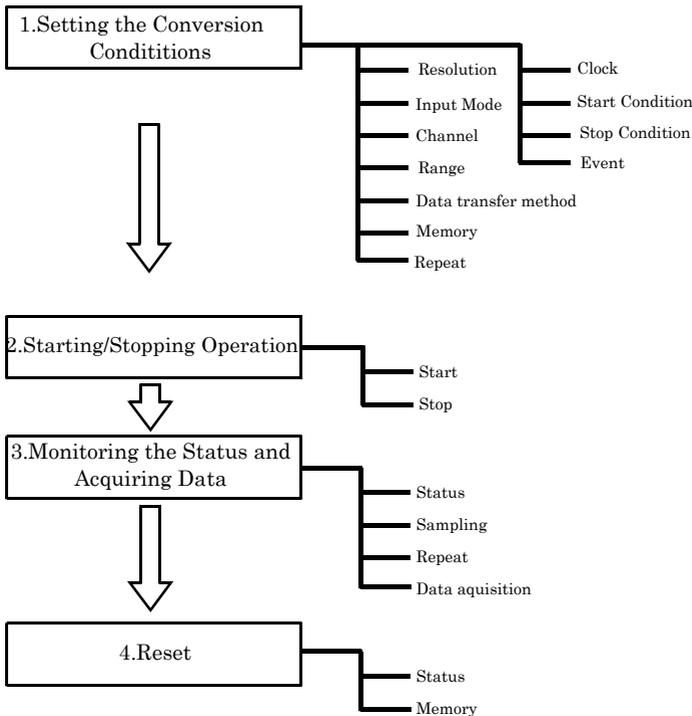
This chapter describes the different functions that can be implemented using the hardware and driver together. Unless stated otherwise, the driver is assumed to be API-AIO(WDM).

### Analog Input Function

The product converts analog signals to digital data according to the resolution and stores it in memory.

You can set a variety of conditions for analog input, including the input channel, sampling period, and sampling start/stop conditions.

Analog input processes are classified as follows:



\* This function is available to the AIO-160802L-LPE and AI-1616L-LPE.

## 1. Setting the Conversion Conditions

First, set the conditions for executing analog input.

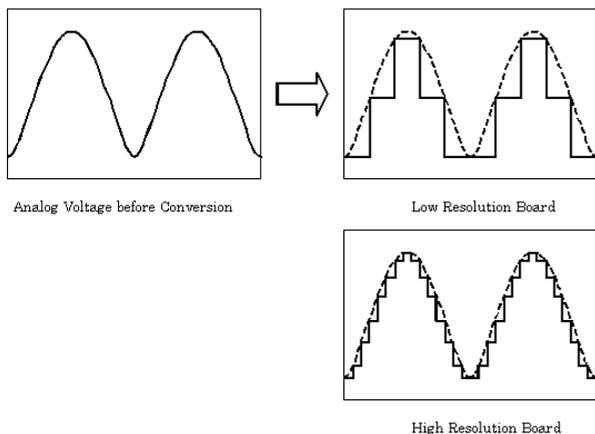
### Resolution

”Resolution” signifies the number of bits used by an analog input device to represent analog signals. The higher the resolution, the more finely the voltage range is segmented, allowing the device to convert analog values to digital equivalents more precisely.

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

When the device covers the range of 0 – 10V, the minimum unit of converted voltages is  $10 \div 4096 \approx 2.44\text{mV}$ .

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



- |                 |                                  |
|-----------------|----------------------------------|
| AIO-160802L-LPE | : The resolution is 16-bit.      |
| AI-1616L-LPE    | : The resolution is 16-bit.      |
| AO-1604L-LPE    | : The function is not available. |

### Input Mode

”Input Mode” indicates the method of connecting analog input signals.

The input modes available are single-ended input and differential input.

The single-ended input mode is suitable for the environment in which the potential difference between the signal source and ground and noise components can be ignored. For the environment in which they cannot be ignored, the differential input mode is suitable. The number of channels available in differential input mode is half that in single-ended input mode.

Software setup of the input mode is not required as this product uses the single-ended input mode fixed.

### Channel

”Channel” represents each point of analog input.

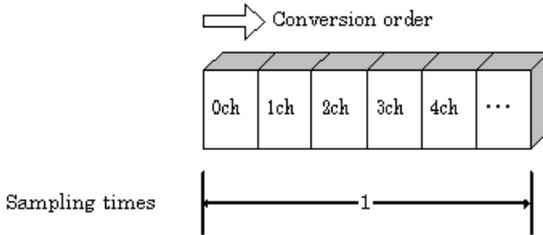
For individual channel numbers, see “Using the On-product Connectors” to “Connector Pin Assignment” in Chapter 3 “External Connection”.

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

### Channel conversion order

Normally, when performing conversion for more than one channel at each sampling, conversion is performed consecutively starting from channel 0.

Software setup is not required as this product uses a fixed channel conversion priority.



### Range

"Range" means the range of voltages at which analog input can be performed.

Software setup of the range is not required as this product uses a fixed range of voltages.

AIO-160802L-LPE :  $\pm 10\text{V}$

AI-1616L-LPE :  $\pm 10\text{V}$

AO-1604L-LPE : The function is not available.

Data transfer method

A device buffer mode is available, which uses the device's or driver's conversion data storage memory.

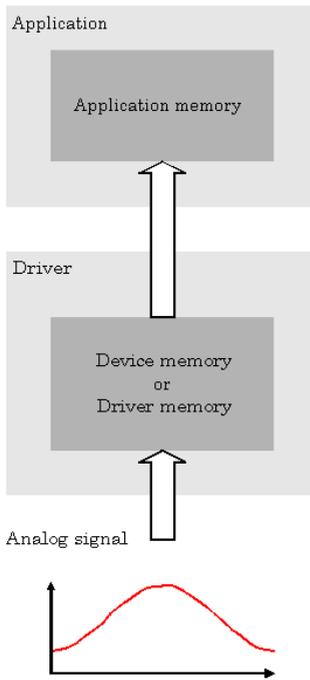
- Device buffer mode

When conversion starts, data is saved in the device buffer (memory on the device itself or in the driver).

The device buffer can operate as FIFO or ring memory.

The application calls an API function at an appropriate timing and fetches the conversion data from the device buffer.

The device buffer mode provides function that allows the number of items of conversion data using the number of sampling times as a unit to obtain the number of items of conversion data directly from the voltage.



**Device buffer mode**

## Memory format

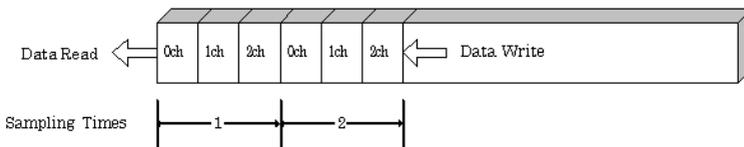
This product uses device buffer transfer mode; it does not require software setup of the memory format.

### Device buffer mode

#### - FIFO format

In the FIFO (First In First Out) format, input data items are read from memory in the same order in which they were written to the memory. Input data items are fed out of the memory sequentially, where the oldest one is always read from the memory. The status monitor and application notification functions are provided, which check and report the state in which the memory has stored a fixed amount of data or in which the memory has become full.

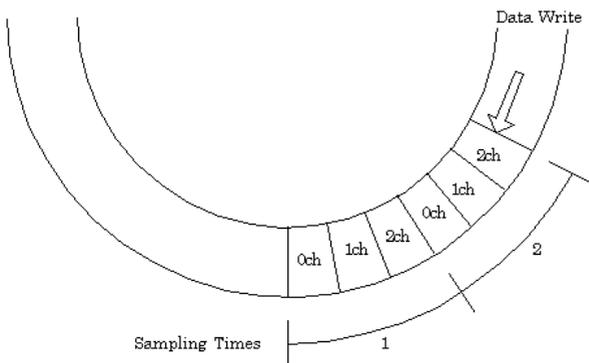
The FIFO memory is used to obtain all input data from analog input in a short or infinite period of time.



#### - RING format

In the ring format, the memory contains storage areas arranged in a ring. Input data items are written to the memory sequentially. When it stores data exceeding the limit, it overwrites the area storing the previous item of input data. The status monitor and application notification functions are provided, which check and report the state in which data has been written to certain areas of memory.

The ring memory is used to obtain data where conversion has stopped due to some event, usually without obtaining data in the normal state.

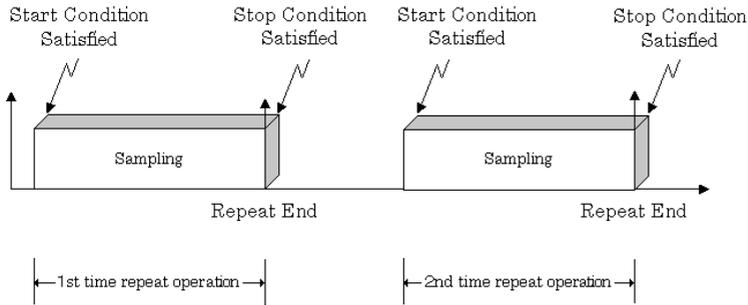


### Repeat

”Repeat” indicates the number of repetitions of sampling to be executed, from when the sampling start condition is satisfied until the end of sampling, including delayed sampling.

The number of repetitions is set by means of software, for which conversion is repeated. You can set an infinite number of repetitions, in which case the conversion is terminated by the software abort command.

Input data items are stored to the memory sequentially. The repetition state can be subject to status monitoring and application notification.



### Clock

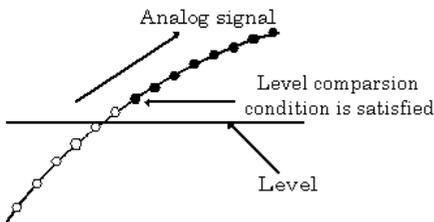
The sampling clock controls the sampling frequency. You can select either the internal sampling clock, external sampling clock.

- Internal sampling clock  
The clock signal from the on- product clock generator is used.
- External sampling clock  
The edge of the digital signal input from an external device is used for the sampling clock.

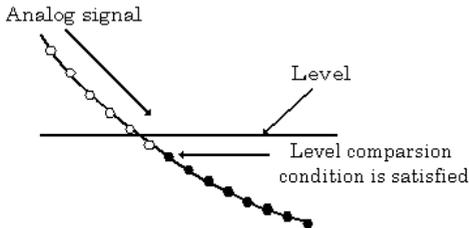
### Start Condition

The condition for controlling the start of sampling can be selected from among software, input data comparison, an external trigger. The conditions for controlling the start and stop of sampling are completely independent of each other; they can be set separately.

- Software  
The product starts sampling and storing input data to memory immediately after the operation start command is issued.
- Input data comparison  
When the operation start command is issued, the product compares the analog signal input through a specified channel to the value of the preset comparison level. If the analog signal satisfies the condition, the product starts storing input data.  
Level comparison conditions are set as two conditions: level and direction.



The above sketch shows that the level comparison condition is satisfied in the rising direction. The start condition is satisfied when the analog signal at the specified channel passes the comparison level in the rising direction. Input data items are stored to memory, starting with those at solid dots.



The above sketch shows that the level comparison condition is satisfied in the falling direction. The start condition is satisfied when the analog signal at the specified channel passes the comparison level in the falling direction. Input data items are stored to memory, starting with those at solid dots.

If you set the level comparison directions to both directions, the start condition is satisfied when the analog signal passes the level both in the rising and falling directions.

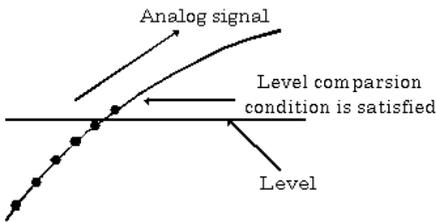
- External trigger  
The product starts waiting for an external control signal as soon as the operation start command is output.  
Sampling and data transfer to memory start when the specified edge (rising edge or falling edge) is input from the external control signal.

Stop condition

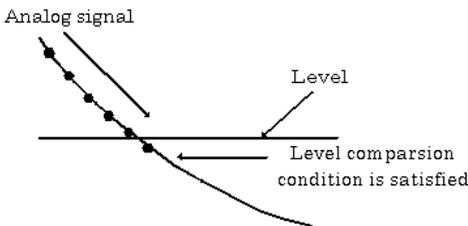
The condition for controlling the stop of sampling can be selected from among the last sampling count, input data comparison, an external trigger, and software abort.

The product stops sampling whenever an error occurs irrespective of the stop condition setting.

- Last sampling count  
The product stops sampling after storing input data to memory for the specified number of times of sampling.
- Input data comparison  
Once the product has started sampling, it compares the analog signal input through a specified channel to the value of the preset comparison level. If the analog signal satisfies the condition, the product stops sampling.  
Level comparison conditions are set as two conditions: level and direction.



The above sketch shows that the level comparison condition is satisfied in the rising direction. The stop condition is satisfied when the analog signal at the specified channel passes the comparison level in the rising direction. Input data items are stored to memory, ending until those at solid dots.



The above sketch shows that the level comparison condition is satisfied in the falling direction. The stop condition is satisfied when the analog signal at the specified channel passes the comparison level in the falling direction. Input data items are stored to memory, ending until those at solid dots

If you set the level comparison directions to both directions, the start condition is satisfied when the analog signal passes the level both in the rising and falling directions.

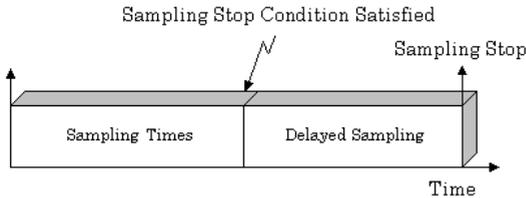
- External trigger  
The product starts waiting for an external control signal after the specified number of samples have been performed. Sampling stops when the specified edge (rising edge or falling edge) is input from the external control signal.

## Delay

Delayed sampling is performed after the sampling stop condition is satisfied.

When a sampling stop condition other than the software abort command is satisfied, the product performs sampling for the specified number of times of delayed sampling to store input data to memory.

If you set the number of times of delayed sampling to 0, the product stops sampling the moment the sampling stop condition is satisfied.



## Event

“Event” works as a function for reporting the occurrence of a certain product state to the application. The following events can be used in combination depending on the specifications and purpose of the application.

- “AD conversion start condition satisfied” event  
This event occurs when the AD conversion start condition is satisfied. The event is nullified when the conversion start condition is “software”.
- “Repeat end” event  
This event occurs whenever a repetition is completed.
- “End of device operation” event  
This event occurs when the entire operation including repetitions is completed.
- “Stored specified sampling times” event  
This event occurs when sampling has been performed for the number of times set by software. This event can only be used in device buffer mode.
- Overflow event  
This event occurs at an attempt to store input data with the memory full.
- Sampling clock error event  
This event occurs when conversion stops as an error occurs due to a sampling clock period that is too short.
- AD conversion error event  
This event occurs when conversion stops due to an AD conversion error.

## 2. Starting/Stopping Operation

Sampling is started by the software command.

Once started, sampling can be stopped by the software command at any timing.

### 3. Monitoring the Status and Acquiring Data

Software commands are used to monitor the operation status of the device and to acquire input data from memory. Status monitoring and data acquisition can be performed even during sampling.

#### Status

The current state of the device can be checked by obtaining the device status.

The following types of device status are available:

- Device operating  
The “device operating” status remains ON, after the execution of the sampling start command until the product completes conversion, aborts operation due to an error, or stops sampling in response to the command.
- Waiting for start trigger  
This status remains ON, after the product starts sampling until the start trigger is input, if the conversion start condition is an external trigger or level comparison. The status is set to OFF when the input trigger is input to start conversion.  
The status is set to ON whenever the product enters the conversion start wait status even when repeated operation has been set.
- Specified sampling data stored  
This status is set to ON when input data stored in memory has reached the amount corresponding to the preset number of times of sampling.  
If the memory format is FIFO, the status is set to OFF when the amount of input data in the memory falls below the value corresponding to the preset number of times of sampling as data is acquired.  
Once the status is set to ON when the memory format is ring, it remains ON until it is reset.
- Overflow  
An overflow error occurs when an attempt is made to store input data to memory while it has been full of input data.  
When the memory format is FIFO, the product stops conversion.  
When the memory format is ring, the product continues conversion while overwriting existing data with new one.
- Sampling clock error  
This error occurs when the sampling clock period is too short.
- AD conversion error  
If the “device operating” status remains ON (without terminating conversion) for an extended period of time, the driver regards that state as an operation error and sets this status to ON. This error stops sampling.

#### Sampling

The number of sampled items of input data stored in memory can be obtained by the software command. This command can only be used in device buffer mode.

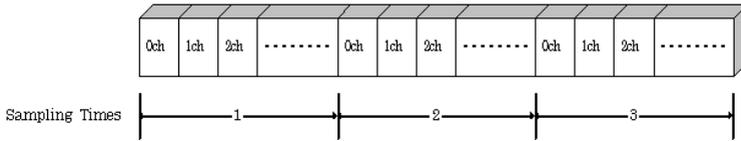
#### Repeat

The current repeat count can be obtained by the software command.

## Data acquisition

When using the device buffer, the conversion data stored in memory can be retrieved using a software command.

The figure below shows the correspondence between the sampling count and the conversion channel for the conversion data stored in memory.



Input data is acquired differently depending on the memory format used.

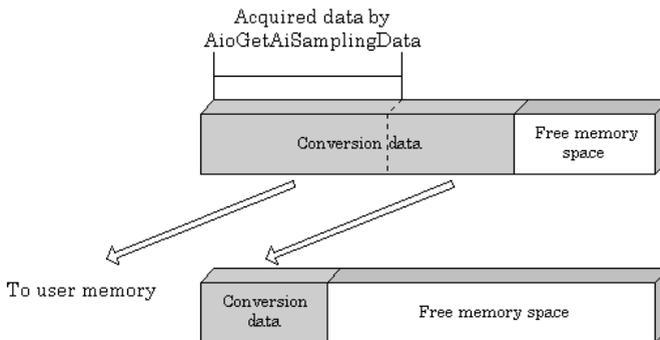
### - Data acquisition in FIFO format

When FIFO memory is used, the oldest data is always read first.

The following sketch shows an image of data acquisition in FIFO format.

When data is acquired from the memory, the free memory space increases by that data size. When data is acquired next, the oldest one of the existing data items is taken from the memory in the same way.

The FIFO memory deletes data once that data is acquired.



- Data acquisition in ring format

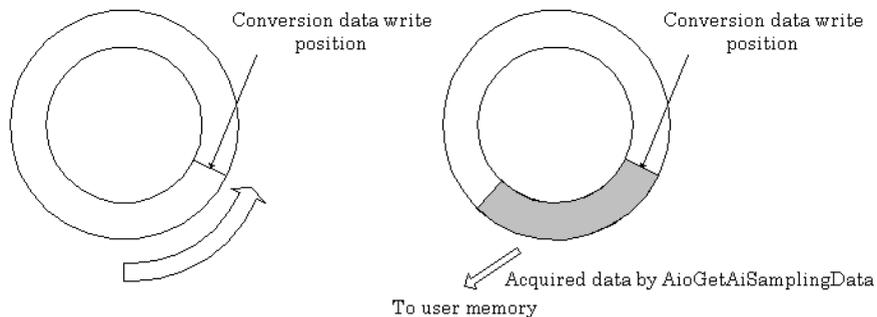
When ring memory is used, data is read always with respect to the current input data write position.

The following sketch shows an image of data acquisition in ring format.

The sampling count obtained is always the number of times of sampling for up to the latest data (shaded portion below).

The larger the number of samples taken, the older the data item acquired first.

As the ring memory retains data even after that data is acquired, you can fetch the same data any number of times.



### Input data

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

Voltage = Input data x (Max. range value - Min. range value) / Resolution + Min. range value

The value of resolution for the 16-bit device is 65536.

The table below shows the relationship between input data and voltage in the  $\pm 10V$  range.

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

Ex.: When input data 49152 is input at a resolution of 16-bit in the  $\pm 10V$  range

$$\begin{aligned} \text{Voltage} &= 49152 \times (10 - (-10)) \div 65536 + (-10) \\ &= 5.0 \end{aligned}$$

## 4.Reset

Various states can be reset by executing the following reset commands:

### Status

This command resets the sampling clock error status and AD conversion error status.

### Memory

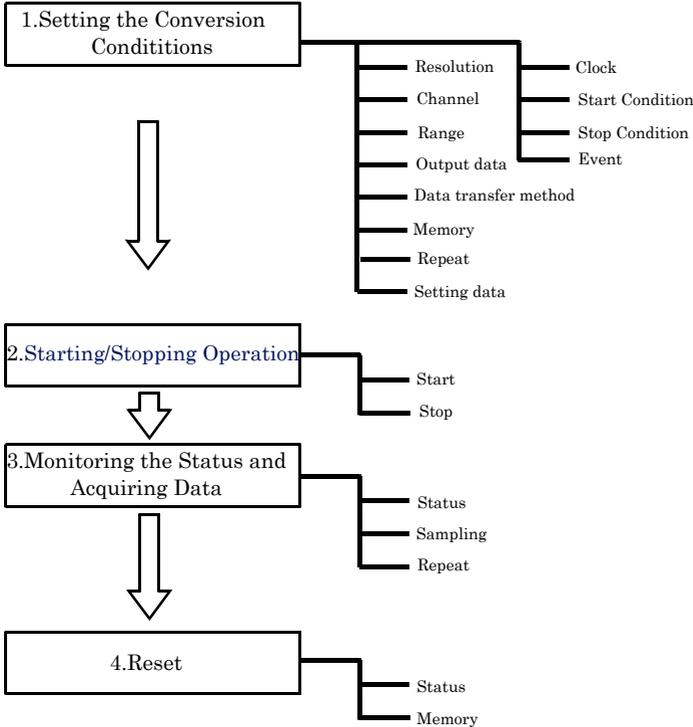
This can only be used when the transfer mode is set to device buffer mode.

This command resets the following memory related states.

- Resets the conversion data in memory.
- Resets the repeat count to 0.
- Resets the sampling count to 0 when a stop trigger is input.
- Resets the buffer overflow status.
- Resets the status information for the specified data save count.

# Analog Output Function

The product converts digital data to analog signals according to the resolution. You can set a variety of conditions for analog output, including the output channel, sampling period, and sampling start/stop conditions. Analog output processes are classified as follows:



\* This function is available to the AIO-160802L-LPE and AO-1604L-LPE.

## 1. Setting the Conversion Conditions

First, set the conditions for executing analog output.

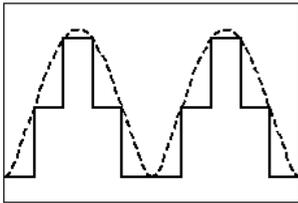
### Resolution

"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 digital values to analog equivalents more precisely.

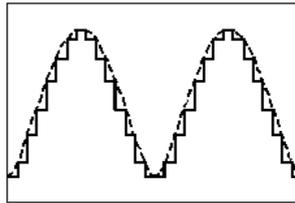
A device with a resolution of 12-bit divides the range width into 4096 segments.

When the device covers the range of 0 - 10V, the minimum unit of converted voltages is  $10 \div 4096 \approx 2.44\text{mV}$ .

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



Low Resolution Board



High Resolution Board

AIO-160802L-LPE : The resolution is 16-bit.  
 AI-1616L-LPE : The function is not available.  
 AO-1604L-LPE : The resolution is 16-bit.

### Channel

"Channel" represents each point of analog output.

For individual channel numbers, see "How to connect the connectors" to "Connector Pin Assignment" in Chapter 3 "External Connection".

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

### Range

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

Software setup of the range is not required as this product uses a fixed range of voltages.

AIO-160802L-LPE :  $\pm 10\text{V}$   
 AI-1616L-LPE : The function is not available.  
 AO-1604L-LPE :  $\pm 10\text{V}$

## Output data

Output data = ((Voltage - Min. range value) x Resolution) / (Max. range value - Min. range value)

The value of resolution for the 16-bit device is 65536.

The table below shows the relationship between output data and voltage in the  $\pm 10\text{V}$  range.

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

Ex.: When 3V is output at a resolution of 16-bit in the  $\pm 10\text{V}$  range

$$\begin{aligned}\text{Output data} &= (3 - (-10)) \times 65536 \div (10 - (-10)) \\ &= 42598.4^*\end{aligned}$$

\* The value that can be set as output data at this time is an integer. Select "42598" or "42599" as the output data.

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

- Output data "42598" converted to: 2.9998 V

- Output data "42599" converted to: 3.0001 V

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

### Data transfer method

A device buffer mode is available, which uses the device's or driver's conversion data storage memory.

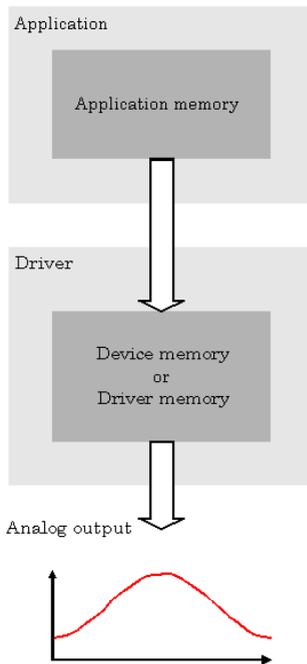
#### - Device buffer mode

The application output data is first stored in the device buffer (memory on the device itself or in the driver).

When conversion starts, the device starts outputting the output data.

The device buffer can operate as FIFO or RING memory.

The device buffer mode provides a function that allows the number of items of conversion data using the number of sampling times as a unit to set the number of items of conversion data directly using the voltage.



**Device buffer mode**

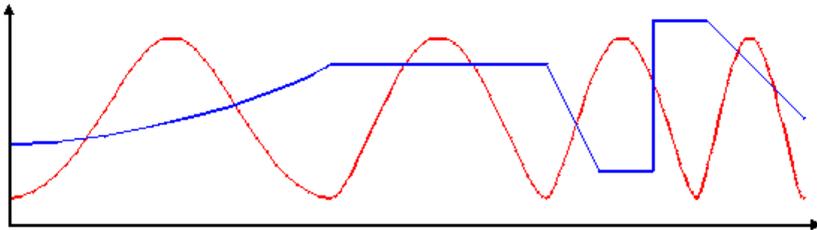
Memory format

This product uses device buffer transfer mode; it does not require software setup of the memory format.

**Device buffer mode**

- FIFO format

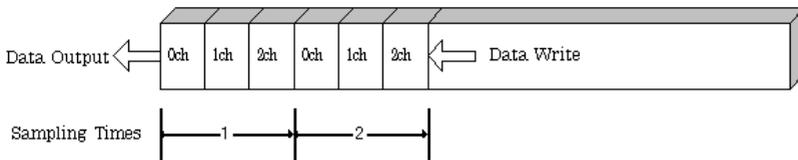
Use FIFO format if you wish to output a continuous arbitrary analog output like that shown below.



When using FIFO format, writing of conversion data to memory is always performed from after the most recent data and DA conversion is performed on the oldest data in memory.

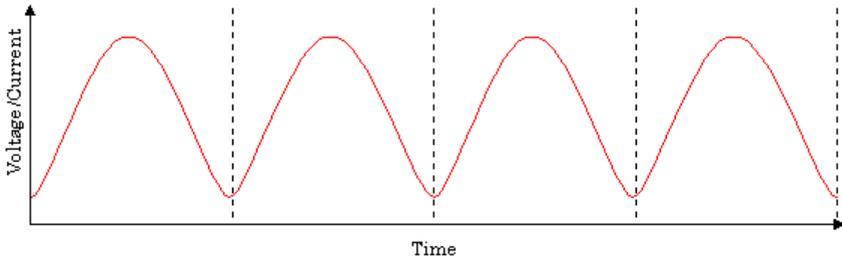
You can write to memory during analog output operation.

An error occurs if the volume of data exceeds the memory size. However, this error does not stop analog output if it is in progress.



- Ring format

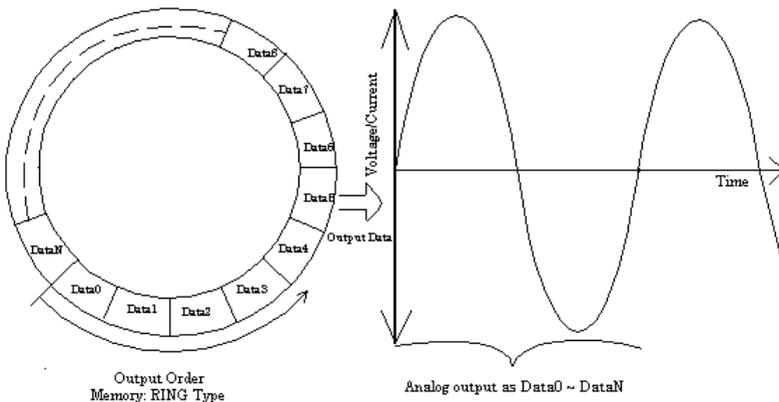
Use ring format if you wish to output a repeated pattern like that shown below.



When using ring format, write the data for one complete cycle of the output waveform before starting operation.

You cannot write to the memory during its operation of analog output.

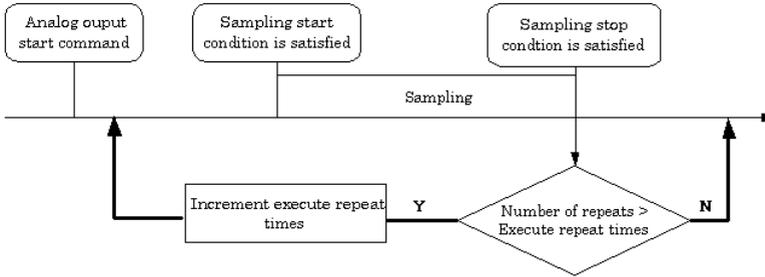
DA conversion data is output continuously in the sequence in which the ring format data is stored.



- \* Although the figure shows a single analog output channel, output from multiple channels is also possible.

Repeat

You can specify a repeat count to perform sampling for a specified number of times.



Memory must be set to ring format if a number of repetitions is to be specified.

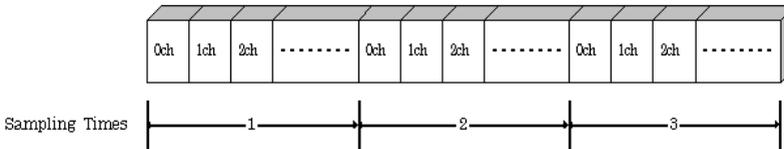
(The number of repetitions cannot be specified for FIFO memory format.)

The number of repetitions is set by software and sampling is repeated for the specified number of times. You can also specify that operation continue indefinitely. If set to repeat indefinitely, analog output operation is stopped by outputting an analog output stop command by software.

Setting data

Use a software command to save the data in memory.

The figure below shows the relationship between the conversion data stored in memory and the sampling count and conversion channels.

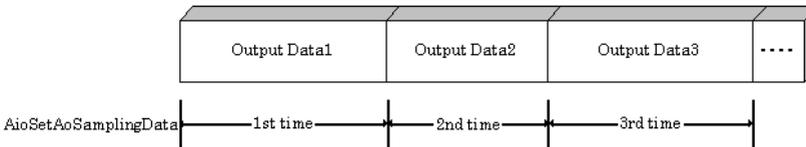


The procedure for setting the conversion data is different depending on the memory format being used.

- Procedure for FIFO format

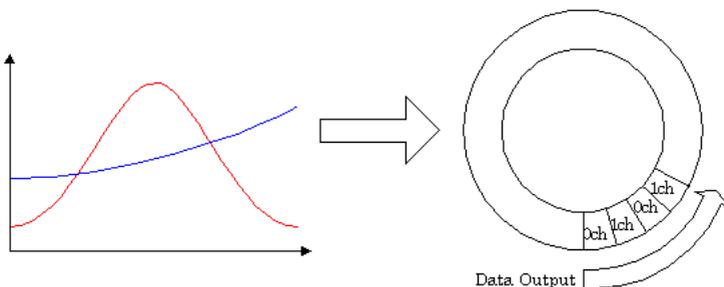
When using FIFO format, setting data to memory is always performed from the most recent data.

New data can be added during conversion.



- Procedure for RING format

When using ring format, a ring memory area large enough for the data to be set is reserved. Data cannot be modified during DA conversion.



### Clock

The sampling clock controls the sampling frequency. You can select either the internal sampling clock, or external sampling clock. The sampling clock is selected by means of software.

- Internal sampling clock

The clock signal from the on-product clock generator is used.

- External sampling clock

The edge of the digital signal input from an external device is used for the sampling clock.

### Start Condition

The condition for controlling the start of sampling can be selected from among software, external trigger. The conditions for controlling the start and stop of sampling are completely independent of each other; they can be set separately.

- Software

The product starts sampling and storing input data to memory immediately after the operation start command is issued.

- External trigger

The product starts waiting for an external control signal as soon as the operation start command is output.

Sampling and data transfer from memory start when the specified edge (rising edge or falling edge) is input from the external control signal.

### Stop Condition

The condition for controlling the stop of sampling can be selected from among the last sampling count, an external trigger, and software abort.

The product stops sampling whenever an error occurs irrespective of the stop condition setting.

- Last sampling count

The product stops sampling after storing input data to memory for the specified number of times of sampling.

- External trigger

The product starts waiting for an external control signal after the specified number of samples have been performed. Sampling stops when the specified edge (rising edge or falling edge) is input from the external control signal.

- Software

Sampling continues indefinitely in this mode. Sampling only stops in response to a software command or an error.

### Event

“Event” works as a function for reporting the occurrence of a certain product state to the application. The following events can be used in combination depending on the specifications and purpose of the application.

- “DA conversion start condition satisfied” event  
This event occurs when the DA conversion start condition is satisfied. The event is nullified when the conversion start condition is “software”.
- “Repeat end” event  
This even occurs whenever a repetition is completed.
- “End of device operation” event  
This event occurs when the entire operation including repetitions is completed.
- “Specified number of output samples complete” event  
This event occurs when the number of output samples specified by software have been completed. This event is used when the device buffer mode is used for data transfer.
- Specified number of transfers event  
This event occurs each time a specified number of samples (set by software) has been completed. When FIFO format is used, the event occurs when the remaining number of samples falls below a specified level. The event occurs repeatedly as long as this condition is satisfied. When ring memory format is used, the event occurs when the number of samples output from memory reaches a specified value. The event occurs for the specified number of repetitions. This event is used when the user buffer mode is used for data transfer.
- Sampling clock error event  
This event occurs when conversion stops as an error occurs due to a sampling clock period that is too short.
- DA conversion error event  
This event occurs when conversion stops due to an DA conversion error.

## 2. Starting/Stopping Operation

Analog output operation is started by a software command (the analog output start command). Similarly, you can stop analog output at any time using a software command (the analog output stop command).

### 3. Monitoring the Status and Acquiring Data

You can use a software command to check the status of analog output operation and of the output data stored in memory.

#### Status

The current state of the device can be checked by obtaining the device status.

The following types of device status are available:

- Device operating  
The “device operating” status remains ON, after the execution of the sampling start command until the product completes conversion, aborts operation due to an error, or stops sampling in response to the command.
- Waiting for start trigger  
This status remains ON, after the product starts sampling until the start trigger is input, if the conversion start condition is an external trigger or can vent controller output. The status is set to OFF when the input trigger is input to start conversion.  
The status is set to ON whenever the product enters the conversion start wait status even when repeated operation has been set.
- Specified number of data outputs  
This status turns ON when the output data set in memory has reached a predefined number of samples.
- Sampling clock error  
This error occurs when the sampling clock period is too short.
- DA conversion error  
If the “device operating” status remains ON (without terminating conversion) for an extended period of time, the driver regards that state as an operation error and sets this status to ON. This error stops sampling.

#### Sampling

The number of sampled items of output data transferred from in memory can be obtained by the software command.

This command can only be used in device buffer mode.

### 4.Reset

Various states can be reset by executing the following reset commands:

#### Status

This command resets the sampling clock error status and AD conversion error status.

#### Memory

This can only be used when the transfer mode is set to device buffer mode.

This command resets the following memory related states.

- Resets the conversion data in memory.
- Resets the repeat count to 0.
- Resets the sampling count to 0 when a stop trigger is input.
- Resets the status information for the specified data save count.

# Counter Function

## 1. Setting the Operating Conditions

This specifies the conditions for counter operation.

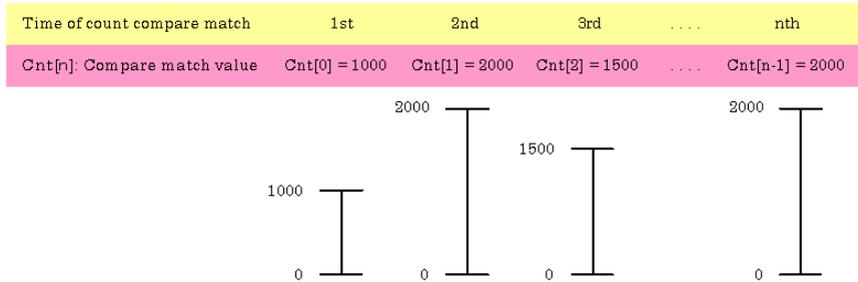
### Operating conditions

The basic operation of the counter is to count an external input signal.

The counter includes a function to detect a count match and perform a specified operation when the current count value reaches a preset count value.

### Compare count values

The compare count load function automatically loads the next compare count value when a count match occurs.



The figure above shows an example of using the compare count load function.

After the counter starts, the first count match occurs when the count reaches 1000.

When the count reaches 1000, the counter value at which the second compare count match is to occur (2000) is set.

This continues with the next value from the array being set each time a count match occurs.

After the final value from the array is loaded, operation can start again from the beginning of the array.

Alternatively, loading can be halted (in which case, the compare count value remains at 2000).

### Digital filter Input signal

The external clock can be used as the counter input signal.

### Digital filter

A digital filter can be used on external input bits.

The filter time can be set to "don't use", 1µs by software.

## Event

The event function notifies the application when something occurs on the device. The following events can be used as required.

- Compare count match event  
This event is triggered when a compare match occurs on the counter.
- Count overrun event  
This event is triggered when a counter overrun occurs.
- Counter operation error  
This event is triggered when a counter operation error causes the counter to stop.

## 2. Starting/Stopping Operation

Starting and stopping the counter are performed using software commands. Once the counter has started, it can be stopped at any time by a software command.

## 3. Monitoring the Status and Acquiring Data

Software commands can be used to monitor the device operating status and read counter data. Status monitoring and data acquisition can both be performed while the counter is running.

### Status

The current state of the device can be checked by obtaining the device status. The following types of device status are available:

- Counter operating  
The device operating status is ON from the time the operation start command is executed until operation stops due to a stop command or error.
- Compare count match  
The compare count match status turns ON when a count match occurs after the counter is started. The status is turned OFF by the status reset command.
- Overrun  
The overrun status turns ON if another count match occurs when the compare count match status is already ON. The status is turned OFF by the status reset command. Even if the overrun status turns ON, this does not stop the counter.
- Counter operation error  
Execution of driver processing may not be able to keep up if multiple count match events occur within a short time period.  
In this case, the counter operation error status turns ON and counter operation stops.

### Data acquisition

The current count value can be read using a software command.

## 4.Reset

Various states can be reset by executing the following reset commands:

### Counter reset

Resets the counter. This restores the counter to its state after power on.

### Status

Resets the compare count match status and overrun status.

# Digital Input Function

## Input bit

Individual digital input points are called input bits.

When the number of input points of a device is 4, the bits are determined as bit 0 - bit 3.

Bit 3	Bit 2	Bit 1	Bit 0
-------	-------	-------	-------

## Input in Bits

The state 1 (ON) or 0 (OFF) of each input bit can be obtained by specifying the bit.

## Input in Bytes

Individual input bits can be input in byte units.

When the number of input points of the device is 4, the individual input bits are arranged as shown below and the byte data to be input is a value between 0 and 15 depending on the states of the bits.

EX. Input of bit 3 (OFF), bit 2 (ON), bit 1 (OFF), bit 0 (ON)

Byte data = 05(5H)

Bit 3	Bit 2	Bit 1	Bit 0
0(OFF)	1(ON)	0(OFF)	1(ON)

## Digital filter

A digital filter can be used on the input bits.

The filter time can be set to "don't use", 1 $\mu$ s by software.

# Digital Output Function

## Output bit

Individual digital output points are called output bits.

When the number of output points of a device is 4, the bits are determined as bit 0 - bit 3.

Bit 3	Bit 2	Bit 1	Bit 0
-------	-------	-------	-------

## Output in Bits

The state of each output bit can be changed to ON or OFF by specifying the bit and setting it to 1 or 0.

## Output in Bytes

Individual output bits can be output in byte units.

When the number of output points of the device is 4, the individual output bits are arranged as shown below and byte data to be output is a value between 0 and 15.

Ex. Output of bit 3 (ON), bit 2 (OFF), bit 1 (ON), bit 0 (OFF)

Byte data = 10(AH)

Bit 3	Bit 2	Bit 1	Bit 0
1(ON)	0(OFF)	1(ON)	0(OFF)

## 5. About Software

### Bundled disk Directory Structure

```

\
├─ Autorun.exe           Installer Main Window
├─ Readmej.html         Version information on each API-TOOL (Japanese)
├─ Readmeu.html         Version information on each API-TOOL (English)
├─ .
├─ ── APIPAC            Each installer
│   └─ ── AIO
│       └─ ── DISK1
│           └─ ── DISK2
│               └─ ── .....
│                   └─ ── DISKN
│                       └─ ── AioWdm
│                           └─ ── CNT
│                               └─ ── DIO
│                                   └─ ── .....
│                                       .
│                                       .
│                                       .
├─ ── HELP             HELP file
│   └─ ── Aio
│       └─ ── Cnt
│           └─ ── .....
│               .
│               .
│               .
├─ ── INF              Each INF file for OS
│   └─ ── WDM
│       └─ ── Win2000
│           └─ ── Win95
│               .
│               .
│               .
├─ ── linux           Linux driver file
│   └─ ── cnt
│       └─ ── dio
│           └─ ── .....
│               .
│               .
│               .
├─ ── Readme          Readme file for each driver
│   .
│   .
│   .
├─ ── Release         Driver file on each API-TOOL
│   └─ ── API_NT      (For creation of a user-specific install program)
│       └─ ── API_W95
│           .
│           .
│           .
├─ ── UsersGuide     Hardware User's Guide(PDF files)

```

# About Software for Windows

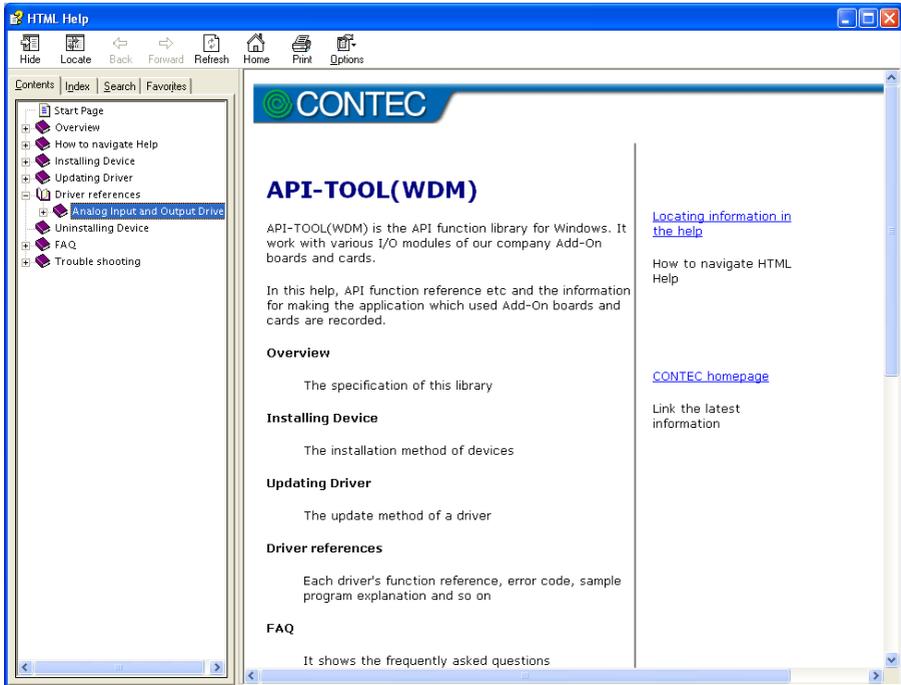
The bundled disk “Driver library API-PAC(W32)” contains the functions that provide the following features:

- Analog input or output through arbitrary channels
- Analog input at arbitrary intervals using the internal or external sampling clock
- Simultaneous monitoring of the termination of analog input sampling, buffer memory usage, and interrupt events such as occurrences of errors
- Driver option check using a demo driver even without the product installed

For details, refer to the help file. The help file provides various items of information such as “Function Reference”, “Sample Programs”, “Tutorial”, “FAQs” and “Troubleshooting”. Use them for program development and troubleshooting.

## Accessing the Help File

- (1) Click on the [Start] button on the Windows taskbar.
- (2) From the Start Menu, select “Programs” - “CONTEC API-PAC(W32)” - “AIOWDM” - “API-AIO(WDM) HELP” to display help information.

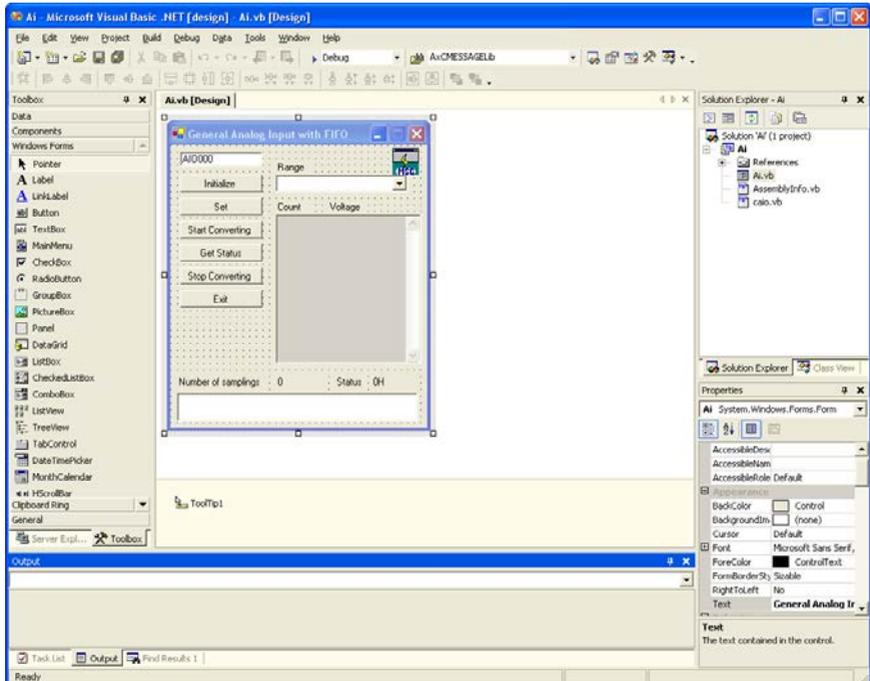


## Using Sample Programs

Sample programs are provided for each of the basic operations. You can use these to check the operation of the product and as a reference when writing your own programs.

To use the sample programs, specify the device name in the property page for the program.

The sample programs are stored in \Program Files\CONTEC\API-PAC(W32)\AIOWDM\Samples.



### Running a Sample Program

- (1) Click on the [Start] button on the Windows taskbar.
- (2) From the Start Menu, select “Programs” – “CONTEC API-PAC(W32)” – “AIOWDM” – “SAMPLE...”.
- (3) A sample program is invoked.

## Sample Programs - Examples

### Analog input

#### Simple sample program

- SingleAi            Perform single analog input from specified channel
- MultiAi            Perform single analog input from multiple channels

#### Device buffer

- Ai                    Perform standard analog input using a FIFO buffer
- AiPoll              Perform standard analog input by polling
- AiEx                Perform analog input for multiple channels using a FIFO buffer
- AiLong             Perform long-duration analog input using a FIFO buffer
- AiExt               Perform analog input using an external clock
- AiTrg               Perform analog input using an external trigger to start and stop operation
- AiLevel1           Use a level trigger to start analog input
- AiLevel2           Use a level trigger to stop analog input
- Ai2                  Perform standard analog input using more than one device
- AiCall              Perform analog input using a callback routine

### Analog output

#### Simple sample program

- SingleAo            Perform single analog output from specified channel
- MultiAo            Perform single analog output from multiple channels

#### Device buffer

- Ao                    Perform standard analog output using a FIFO buffer
- AoPoll              Perform standard analog output by polling
- AoEx                Perform analog output for multiple channels using a FIFO buffer
- AoLong             Perform long-duration analog output using a FIFO buffer
- AoExt               Perform analog output using an external clock
- AoRing              Perform continuous analog output using a ring buffer
- AoTrg               Perform analog output using an external trigger to start and stop operation
- Ao2                  Perform standard analog output using more than one device
- AoCall              Perform analog output using a callback routine

### Digital input/output

- DioBit              Perform digital I/O using bit values
- DioByte             Perform digital I/O using byte values

### Counter/Timer

- Counter                    General purpose counter
- Interval                   Interval timer
- Watch                     Stopwatch timer

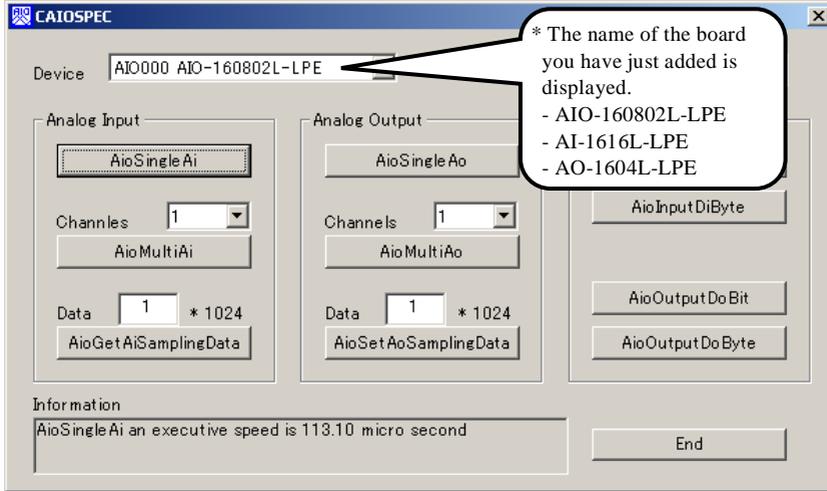
Others

- Convert                    Data conversion

## Usage of Utility Program

### Program for Measurement of Function Execution Speed

The execution time of some main functions can be measured in a function execution speed measurement program. To use a function execution speed measurement program, click the [execution time measurement] button in the diagnostic program.



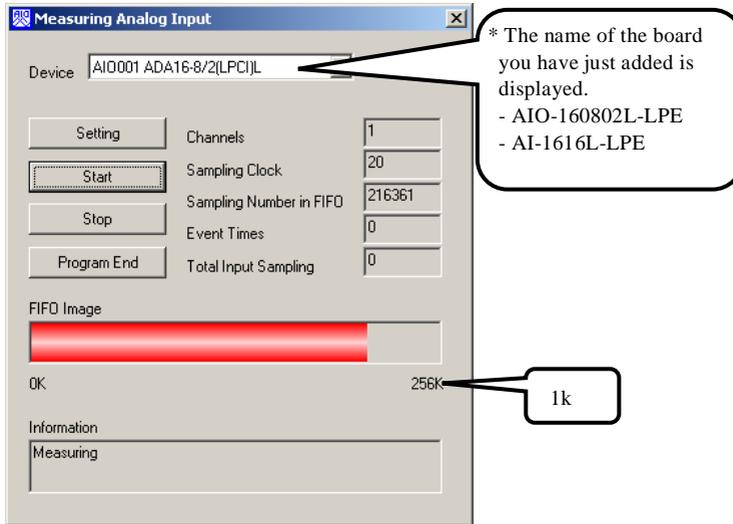
### Procedure

- (1) Chose the measure device from device list.
- (2) Click the button written with the function name to measure the execution speed of the function. Please choose from a list the number of channels used for conversion in function AioMultiAi and AioMultiAo. Input the transmission data size in function AioGetAiSamplingData and AioSetAoSamplingData. The transmission data is set by unit of kByte.
- (3) End the application with an [end] button.

## Analog Input Measurement Tool

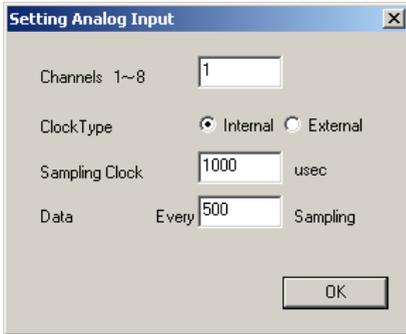
It is an analog input measurement utility to carry out infinity sample in the FIFO memory. Once the conversion data of memory accumulates to a certain quantity, the event occurs and data of the memory is acquired. Data in the FIFO memory can be confirmed visually.

The number of channels used, the internal/external clock, the conversion speed, and the sampling frequency at which an event generates can be set. Since the notification of a sampling clock error event is sent, please make use of it for the conversion spec measurement under various conversion conditions.



## Procedure

- (1) Chose the device name of the device to be used from the upper left combo box, and click the setting button.
- (2) The conversion conditions are set on the screen of the analog input setting.  
Once an input is done at the sampling frequency specified as data taking-in sampling, an event occurs and data will be acquired. Click the OK button to finish setting the conditions, and returns to former screen.



- (3) Start the measurement with measurement start button. The various states during the conversion are displayed.

The number of the samplings in FIFO is :

It is conversion data taken in the memory. This can be visually checked in a "memory image".

Event generation sampling frequency :

When the number of input sampling in FIFO reaches this frequency, the event generates.

Total input sampling frequency :

It is the total number of samplings for application in the memory.

Measurement may stop by the following errors.

Sampling clock error :

It means that the conversion speed is too fast and the driver processing is not in time when converting at the internal clock.

The cycle of the clock is too fast when converting it at the external clock. Moreover, the cause by noise etc. is also concerned.

Buffer overflow :

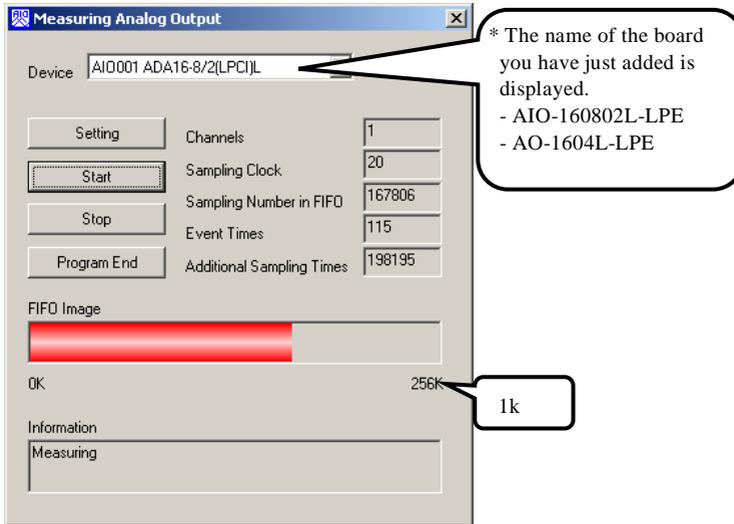
The memory overflows since the conversion speed is too fast compared with the one at which data is inputted.

- (4) Click the "stop" button, and measurement stops.

## Analog Output Measurement Tool

It is an analog output measurement utility to carry out infinity sample in the FIFO memory. Once the conversion data of memory accumulates to a certain quantity, the event occurs and new output data is added. Data in the FIFO memory can be confirmed visually.

The number of channels used, the internal/external clock, the conversion speed, the sampling frequency at which an event generates and number of the samplings to be added can be set. Since the notification of a sampling clock error event is sent, please make use of it for the conversion spec measurement under various conversion conditions.



### ⚠ CAUTION

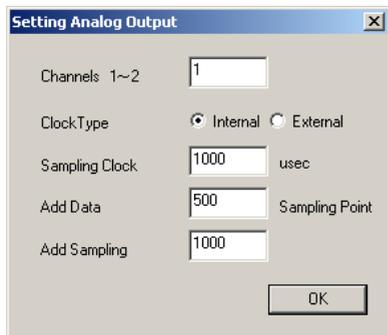
This program is made with Visual Basic. Therefore, it is not possible to execute it as it is in the environment in which Visual Basic is not installed. The program can be used by executing the following setup below the folder that installs the API-AIO(WDM).

AIOWDM\Utility\AoSpec\setup.exe

## Procedure

- (1) Chose the device name of the device to be used from the upper left combo box, and click the setting button.
- (2) The conversion conditions are set on the screen of the setting analog output.

Once an output is done at the sampling frequency specified as data setting sampling frequency, an event occurs and data will be added. Click the OK button to finish setting the conditions, and returns to former screen.



- (3) Start the measurement with measurement start button. The various states during the conversion are displayed.

The number of the samplings in FIFO is :

It is conversion data set in the memory. This can be visually checked in a "memory image".

Event generation sampling frequency :

When the number of unoutput sampling in FIFO reaches this frequency, the event generates.

Adding sampling frequency :

It is the number of samplings of output data to be added during the event.

Measurement may stop by the following errors.

Sampling clock error :

It means that the conversion speed is too fast and the driver processing is not in time when converting at the internal clock.

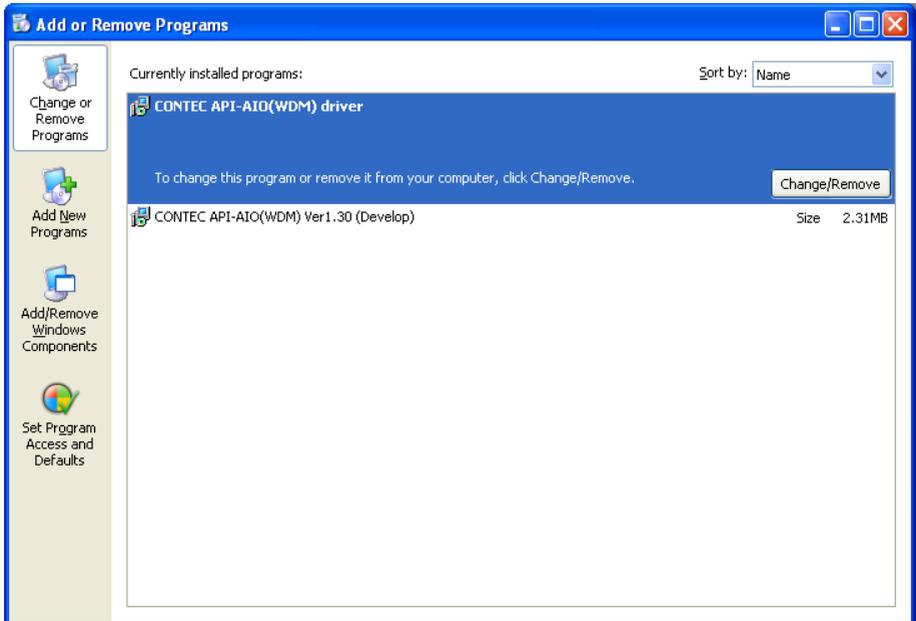
The cycle of the clock is too fast when converting it at the external clock. Moreover, the cause by noise etc. is also concerned.

- (4) Click the "stop" button, and measurement stops.

## Uninstalling the Driver Libraries

To uninstall API-PAC(W32), follow the procedure below.

- (1) Click on the [Start] button on the Windows taskbar. From the Start Menu, select “Settings” - “Control Panel”.
- (2) Double-click on “Add or Remove Programs” in the Control Panel.
- (3) Select "CONTEC API-AIO(WDM) driver" and "CONTEC API-AIO(WDM) VerX.XX (Development environment)" from the list of applications. Click the [Change or Remove Programs] button. Proceed with uninstalling by following the instructions that appear on the screen.



# About Software for Linux

The Linux version of analog I/O function driver, API-AIO(LNX), provides functions that execute the following features:

- The analog input/output of a specified channel can be done.
- It is possible to operate as a set parameter to the analog input/output product is preserved by the default value, and the setting of the parameter doesn't exist.

For details, refer to the help file. The help file provides various items of information such as “Function Reference”, “Sample Programs”, and “FAQs”. Use them for program development and troubleshooting.

## Driver Software Install Procedure

The Linux version for analog I/O driver, API-AIO(LNX), is supplied as a compressed file /linux/aio/caioXXX.tgz on the bundled disk. (Note: XXX represents the driver version.)

Mount the bundled disk as shown below, copy the file to an arbitrary directory, and decompress the file to install the driver.

For details on using the driver, refer to readme.txt and the help file in HTML format extracted by installation.

To install the driver, log in as a superuser.

Decompression and setup procedure

```
# cd
# mount /dev/cdrom /mnt/cdrom           Mount the bundled disk.
# cp /mnt/cdrom/linux/aio/caioXXX.tgz ./ Copy the compressed file.
# tar xvfz caioXXX.tgz                 Decompress the compressed
file.
.....
# cd contec/caio
# make                                 Compile the file.
.....
# make install                         Install.
.....
# cd config
# ./config                             Set up the product to be
used.
..... Set as follows.....
# ./contec_aio_start.sh                 Start the driver.
# cd
```

## Accessing the Help File

- (1) Invoke a web browser in your X-Window environment.
- (2) In the browser, open apitool.htm in the contec/caio/help directory.

## Using Sample Programs

Sample programs have been prepared for specific basic applications.

Sample programs for each language are contained in the contec/caio/samples directory. For compiling them, refer to the manual for the desired language.

## Uninstalling the driver

To uninstall the driver, use the uninstall shell script contained in the contec/caio directory. For details, check the contents of the script.



## 6. About Hardware

This chapter provides hardware specifications and hardware-related supplementary information.

### **For detailed technical information**

For further detailed technical information (“Technical Reference” including the information such as an I/O map, configuration register, etc.), visit the Contec's web site to call for it.

# Hardware specification

AIO-160802L-LPE

**Table 6.1. Specification < AIO-160802L-LPE > < 1 / 2 >**

Item	Specification
Analog input	
Isolated specification	Un-Isolated
Input type	Single-Ended Input
Number of input channels	8ch
Input range	Bipolar $\pm 10V$
Absolute max. input voltage	$\pm 20V$
Input impedance	1M $\Omega$ or more
Resolution	16bit
Non-Linearity error *1 *2	$\pm 5LSB$
Conversion speed	10 $\mu$ sec/ch*3 [100KSPS]*4
Buffer memory	1k Word
Conversion start trigger	Software / external trigger
Conversion stop trigger	Number of sampling times / external trigger/software
External start signal	LVTTL level (Rising or falling edge can be selected by software) Digital filter (1 $\mu$ sec can be selected by software)
External stop signal	LVTTL level (Rising or falling edge can be selected by software) Digital filter (1 $\mu$ sec can be selected by software)
External clock signal	LVTTL level (Rising or falling edge can be selected by software)
Analog output	
Isolated specification	Un-Isolated
Number of output channels	2ch
Output range	Bipolar $\pm 10V$
Output current ability	$\pm 3mA$
Output impedance	1 $\Omega$ or more
Resolution	16bit
Non-Linearity error *1	$\pm 5LSB$
Conversion speed	10 $\mu$ sec [100KSPS]*4
Buffer memory	1k Word
Conversion start trigger	Software / external trigger
Conversion stop trigger	Number of sampling times / external trigger/software
External start signal	LVTTL level (Rising or falling edge can be selected by software) Digital filter (1 $\mu$ sec can be selected by software)
External stop signal	LVTTL level (Rising or falling edge can be selected by software) Digital filter (1 $\mu$ sec can be selected by software)
External clock signal	LVTTL level (Rising or falling edge can be selected by software)

**Table 6.1. Specification < AIO-160802L-LPE > < 2 / 2 >**

Item	Specification
Digital I/O	
Number of input channels	Un-Isolated input 4ch (TTL level positive logic)
Number of output channels	Un-Isolated output 4ch (TTL level positive logic)
Counter	
Number of channels	1ch
Counting system	Up count
Max. count	FFFFFFFFh (Binary data,32bit)
Number of external inputs	2 LVTTTL level (Gate/Up)/ch Gate (High level), Up (Rising edge)
Number of external outputs	1 LVTTTL level, Count match output (positive logic, pulse output)
Response frequency	10MHz (Max.)
Common section	
I/O address	64 ports
Interruption level	Errors and various factors, One interrupt request line as INTA
Used Connector	10250-52A2JL[3M] or equivalent to it
Power consumption	3.3VDC 400mA 12VDC 200mA
Operating condition	0 - 50°C, 10 - 90%RH (No condensation)
Bus specification	PCI Express Base Specification Rev. 1.0a x1
External dimension (mm)	121.69 (L) x 67.90 (H)
Weight	60g

\*1: The non-linearity error means an error of approximately 0.1% occurs over the maximum range at 0°C and 50°C ambient temperature.

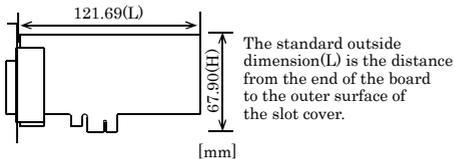
\*2: At the time of the source use of a signal which built in the high-speed operational amplifier.

\*3: The required time is indicated in the analog to digital translation of one channel. When AD of two or more channels is converted, time of the a few minutes of the channel is necessary.

Conversion time = Number of conversion channelsx10μsec

\*4: SPS = Samplings Per Second. The number of data that can be converted in one second is shown.

#### Product Dimensions



## AI-1616L-LPE

**Table 6.2. Specification < AI-1616L-LPE >**

Item	Specification
Analog input	
Isolated specification	Un-Isolated
Input type	Single-Ended Input
Number of input channels	16ch
Input range	Bipolar $\pm 10V$
Absolute max. input voltage	$\pm 20V$
Input impedance	1M $\Omega$ or more
Resolution	16bit
Non-Linearity error *1 *2	$\pm 5LSB$
Conversion speed	10 $\mu$ sec/ch*3 [100KSPS]*4
Buffer memory	1k Word
Conversion start trigger	Software / external trigger
Conversion stop trigger	Number of sampling times / external trigger/software
External start signal	LVTTL level (Rising or falling edge can be selected by software) Digital filter (1 $\mu$ sec can be selected by software)
External stop signal	LVTTL level (Rising or falling edge can be selected by software) Digital filter (1 $\mu$ sec can be selected by software)
External clock signal	LVTTL level (Rising or falling edge can be selected by software)
Digital I/O	
Number of input channels	Un-Isolated input 4ch (TTL level positive logic)
Number of output channels	Un-Isolated output 4ch (TTL level positive logic)
Counter	
Number of channels	1ch
Counting system	Up count
Max. count	FFFFFFFFh (Binary data, 32bit)
Number of external inputs	2 LVTTL level (Gate/Up)/ch Gate (High level), Up (Rising edge)
Number of external outputs	1 LVTTL level, Count match output (positive logic, pulse output)
Response frequency	10MHz (Max.)
Common section	
I/O address	64 ports
Interruption level	Errors and various factors. One interrupt request line as INTA
Used Connector	10250-52A2JL[3M] or equivalent to it
Power consumption	3.3VDC 400mA 12VDC 120mA
Operating condition	0 - 50°C, 10 - 90%RH (No condensation)
Bus specification	PCI Express Base Specification Rev. 1.0a x1
External dimension (mm)	121.69 (L) x 67.90 (H)
Weight	60g

\*1: The non-linearity error means an error of approximately 0.1% occurs over the maximum range at 0°C and 50°C ambient temperature.

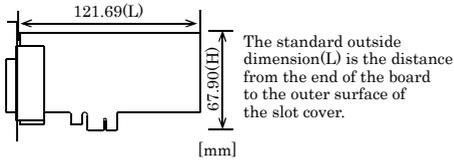
\*2: At the time of the source use of a signal which built in the high-speed operational amplifier.

\*3: The required time is indicated in the analog to digital translation of one channel. When AD of two or more channels is converted, time of the a few minutes of the channel is necessary.

Conversion time = Number of conversion channels x 10 $\mu$ sec

\*4: SPS = Samplings Per Second. The number of data that can be converted in one second is shown.

## Product Dimensions



AO-1604L-LPE

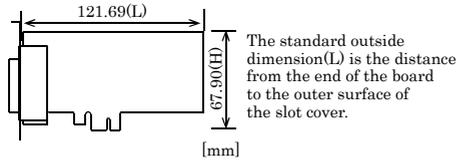
**Table 6.3. Specification < AO-1604L-LPE >**

Item	Specification
<b>Analog output</b>	
Isolated specification	Un-Isolated
Number of output channels	4ch
Output range	Bipolar $\pm 10V$
Absolute max. output voltage	$\pm 3mA$
Output impedance	$1\Omega$ or less
Resolution	16bit
Non-Linearity error *1	$\pm 5LSB$
Conversion speed	$10\mu sec [100KSPS]*2$
Buffer memory	1k Word
Conversion start trigger	Software / external trigger
Conversion stop trigger	Number of sampling times / external trigger/software
External start signal	LVTTTL level (Rising or falling edge can be selected by software) Digital filter ( $1\mu sec$ can be selected by software)
External stop signal	LVTTTL level (Rising or falling edge can be selected by software) Digital filter ( $1\mu sec$ can be selected by software)
External clock signal	LVTTTL level (Rising or falling edge can be selected by software)
<b>Digital I/O</b>	
Number of input channels	Un-Isolated input 4ch (TTL level positive logic)
Number of output channels	Un-Isolated output 4ch (TTL level positive logic)
<b>Counter</b>	
Number of channels	1ch
Counting system	Up count
Max. count	FFFFFFFFh (Binary data, 32bit)
Number of external inputs	2 LVTTTL level (Gate/Up)/ch Gate (High level), Up (Rising edge)
Number of external outputs	1 LVTTTL level, Count match output (positive logic, pulse output)
Response frequency	10MHz (Max.)
<b>Common section</b>	
I/O address	64 ports
Interruption level	Errors and various factors, One interrupt request line as INTA
Used Connector	10250-52A2JL[3M] or equivalent to it
Power consumption	3.3VDC 400mA 12VDC 250mA
Operating condition	0 - 50°C, 10 - 90%RH (No condensation)
Bus specification	PCI Express Base Specification Rev. 1.0a x1
External dimension (mm)	121.69 (L) x 67.90 (H)
Weight	60g

\*1: The non-linearity error means an error of approximately 0.1% occurs over the maximum range at 0°C and 50°C ambient temperature.

\*2: SPS = Samplings Per Second. The number of data that can be converted in one second is shown.

Product Dimensions



# Block Diagram

Figure 6.1 is a circuit block diagram of this product.

AIO-160802L-LPE

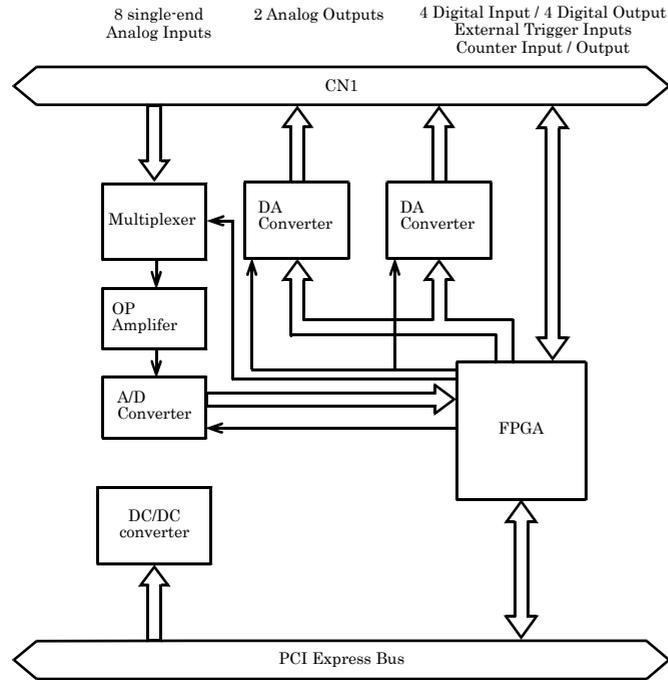
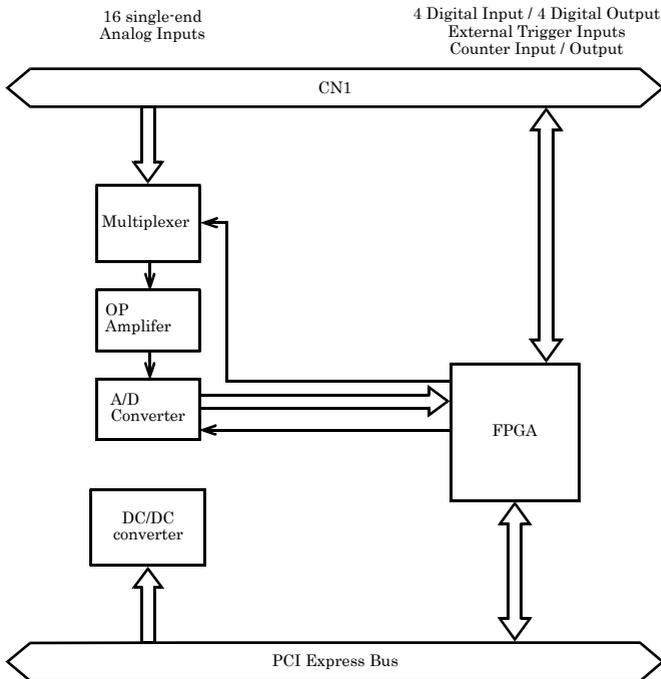


Figure 6.1. Block Diagram < AIO-160802L-LPE >

## AI-1616L-LPE

**Figure 6.2. Block Diagram < AI-1616L-LPE >**

AO-1604L-LPE

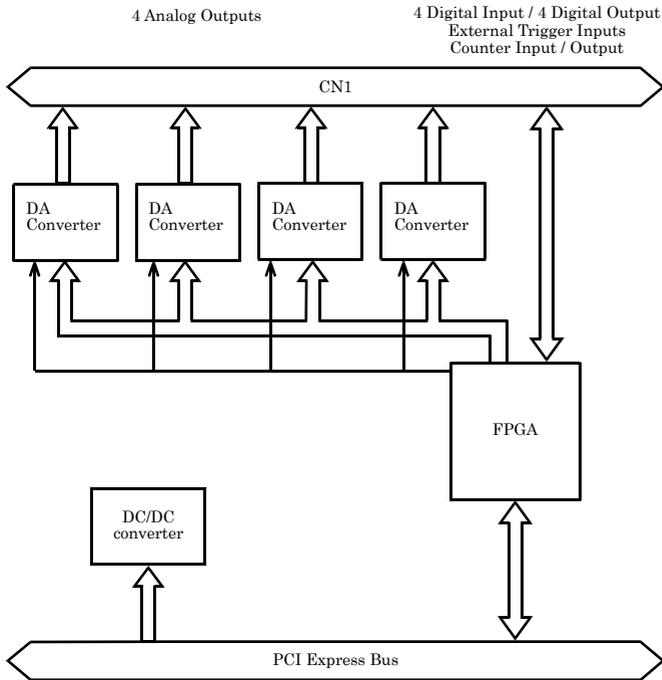
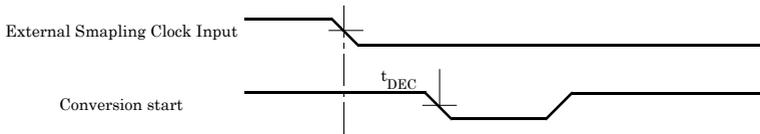


Figure 6.3. Block Diagram < AO-1604L-LPE >

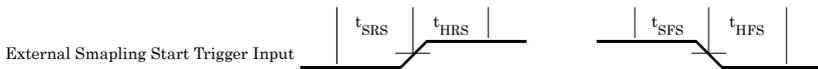
# Control Signal Timings

## Control Signal Timings for Analog Input

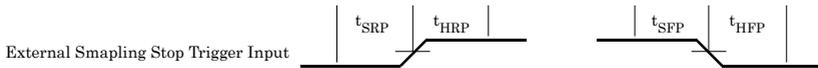
Figures 6.4, 6.5, 6.6, and Table 6.4 show the control signal timings for the analog input function.



**Figure 6.4. Timing Chart of External Smampling Clock**



**Figure 6.5. Timing Chart of Smampling Start Control Signal**



**Figure 6.6. Timing Chart of Smampling Stop Control Signal**

**Table 6.4. Control Signal Timings**

Parameter	Symbol	Time	Unit
Delay time from external sampling clock to first A/D start pulse	$t_{DEC}$	100	nsec
Set up time of sampling start (Rising edge)	$t_{SRS}$	100	nsec
Hold time of sampling start (Rising edge)	$t_{HRS}$	100	nsec
Set up time of sampling start (Falling edge)	$t_{SFS}$	100	nsec
Hold time of sampling start (Falling edge)	$t_{HFS}$	100	nsec
Set up time of sampling stop (Rising edge)	$t_{SRP}$	100	nsec
Hold time of sampling stop (Rising edge)	$t_{HRP}$	100	nsec
Set up time of sampling stop (Falling edge)	$t_{SFP}$	100	nsec
Hold time of sampling stop (Falling edge)	$t_{HFP}$	100	nsec

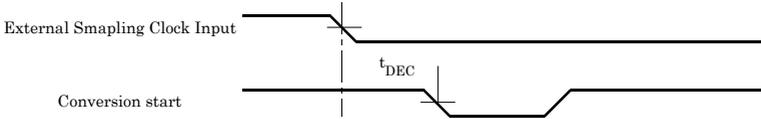


### CAUTION

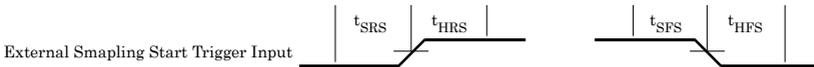
The times listed in Table 6.4 are for standard operating conditions.

## Control Signal Timings for Analog Output

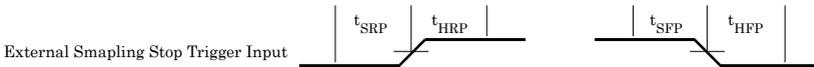
Figures 6.7, 6.8, 6.9 and Table 6.5 show the control signal timings for the analog input function.



**Figure 6.7. Timing Chart of External Sampling Clock (Analog output)**



**Figure 6.8. Timing Chart of Sampling Start Control Signal**



**Figure 6.9. Timing Chart of Sampling Stop Control Signal**

**Table 6.5. Control Signal Timings**

Parameter	Symbol	Time	Unit
Delay from external sampling clock to actual start	t <sub>DEC</sub>	100	nsec
Settling time	t <sub>WS</sub>	10000	nsec
Set up time of sampling start (Rising edge)	t <sub>SRS</sub>	100	nsec
Hold time of sampling start (Rising edge)	t <sub>HRS</sub>	100	nsec
Set up time of sampling start (Falling edge)	t <sub>SFS</sub>	100	nsec
Hold time of sampling start (Falling edge)	t <sub>HFS</sub>	100	nsec
Set up time of sampling stop (Rising edge)	t <sub>SRP</sub>	100	nsec
Hold time of sampling stop (Rising edge)	t <sub>HRP</sub>	100	nsec
Set up time of sampling stop (Falling edge)	t <sub>SFP</sub>	100	nsec
Hold time of sampling stop (Falling edge)	t <sub>HFP</sub>	100	nsec

### ⚠ CAUTION

The times listed in Table 6.5 are for standard operating conditions.

## Control Signal Timings for Counter

Figures 6.10, 6.11 and Table 6.6 show the control signal timings for the counter I/O function.



**Figure 6.10. Timing Chart of Counter Input Signal**



**Figure 6.11. Timing Chart of Counter Output Signal (Pulse output)**

**Table 6.6. Control Signal Timings**

Parameter	Symbol	Time	Unit
Set up time of counter input (Rising edge)	t <sub>src</sub>	100	nsec
Hold time of sampling start (Rising edge)	t <sub>hrc</sub>	100	nsec
Pulse width of counter output signal	t <sub>psc</sub>	1000	nsec

### ⚠ CAUTION

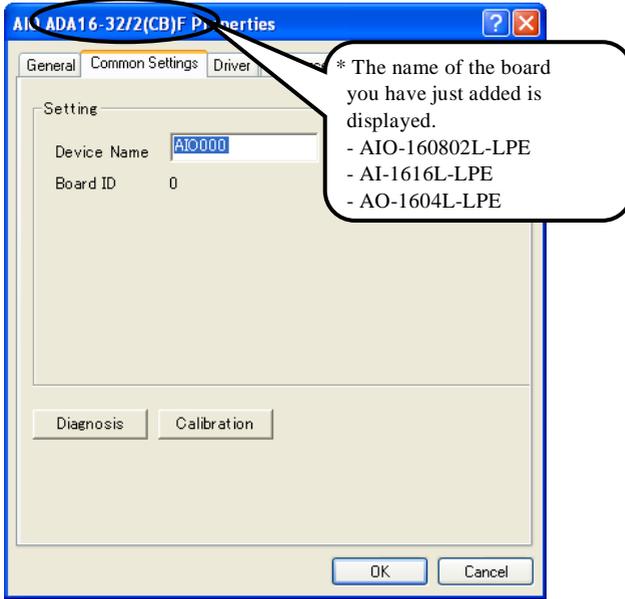
The times listed in Table 6.6 are for standard operating conditions.

# About Calibration

Although this product is calibrated before shipping, you can use the calibration program to calibrate analog input and output yourself.

Starting the calibration program

Click the [Calibration] button on the property page for the device to start the calibration program.



Proceed with connecting the calibration equipment and performing the calibration in accordance with the instructions displayed by the calibration program.

## Analog input calibration

Analog input calibration requires a reference voltage generator.

As the analog input has 16-bit resolution, use a reference voltage generator with a precision of at least 5 digits after the decimal point.

Calibrate one channel only for each range that you use.

## Analog output calibration

Analog output calibration requires a digital multimeter.

As the analog output has 16-bit resolution, use a multimeter with a precision of at least 5 digits after the decimal point.

Calibrate each channel separately for each range that you use.

## Factory setting

You can use the calibration program to restore the factory calibration settings.

If for some reason you are unable to achieve the rated accuracy, please contact your retailer.



# AIO-160802L-LPE AI-1616L-LPE AO-1604L-LPE User's Guide

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