Acknowledgments

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CE notification

The PCM-3712, developed by ADVANTECH CO., LTD., has passed the CE test for environmental specifications when shielded cables are used for external wiring. We recommend the use of shielded cables. This kind of cable is available from Advantech. Please contact your local supplier for ordering information.

On-line Technical Support

For technical support and service, please visit our support website at:
http://www.advantech.com/support

Note

Concerning environmental protection, we would like to reduce the paper used for this user' s manual. Starting the page of *Appendix C*, please find the PDF file of the CD-ROM.

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Contents

Chapter 1

General Information

1.1 Introduction

The PCM-3712 is a PC/104 module which is primary intended to PC embedded application in industrial environment. It contains two analog output channels which can be independently configured for voltage or current output. Each channel is individually user selectable to any of the following ranges: 0 to 10 V, 0 to 5 V, -2.5 V to +2.5 V, -5 V to +5 V, -10 V to +10 V or 4 to 20 mA current loop and is protected from shorts to grounds. At power on, channels configured for voltage output are set to 0 V and channels configured for current output are set to 4 mA.

There is a 12-bit D/A converter, for each channel, with maximum 33 KHz throughputs. Typical applications of PCM-3712 include frequency generation control, direct control value positioning, wave form generation and utilizing a variable voltage output. The module can also be used for analog control in process or laboratory applications where material transfer rate, fluid flow, power consumption, motor speed, temperature levels, etc., are to be controlled. A 10-pin male connector or 9-pin D type connector is provided for easy interfacing to PCM-3712 output.

1.2 Features

- 2 channel analog output
- 0 to 5 V, 0 to 10 V, ±2.5 V, ±5 V, ±10 V and 4 to 20 mA output range
- 12-bit resolution
- High speed
- Single power (+5 V) operation
- Output cut off at power on

Note

For detailed specifications of the PCM-3712, please refer to *Appendix A, Specifications.*

1.3 Applications

- Frequency generation
- Positioning control
- Wave form generation
- Speed control
- Power consumption control
- Fluid flow control
- Programmable attenuator

1.4 Installation Guide

Before you install your PCM-3712 module, please make sure you have the following necessary components:

PCM-3712 module

PCM-3712 User's Manual

Driver software Advantech DLL drivers(included in the companion CD-ROM)

Wiring board ADAM-3909 (option)

Computer Personal computer or workstation with a PC/104 bus slot (running Windows 2000/95/98/ ME/NT/XP)

Some other optional components are also available for enhanced operation:

Application software ActiveDAQ, GeniDAQ or other third-party software packages

After you get the necessary components and maybe some of the accessories for enhanced operation of your Analog Output module, you can then begin the Installation procedures. Figure 1-1 on the next page provides a concise flow chart to give users a broad picture of the software and hardware installation procedures:

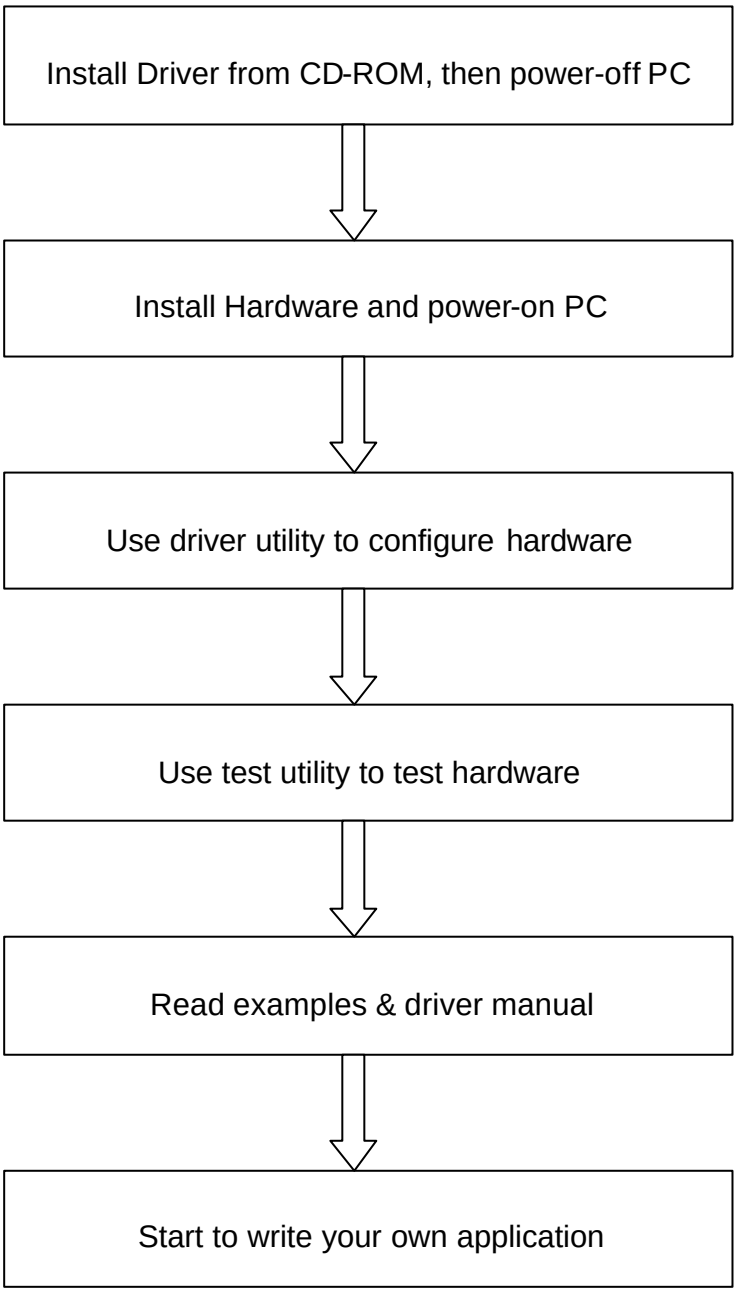


Fig. 1-1 Installation Flow Chart

1.5 Software Overview

Advantech offers a rich set of DLL drivers, third-party driver support and application software to help fully exploit the functions of your PCM-3712 module:

Device Drivers (on the companion CD-ROM)
LabVIEW driver
Advantech ActiveDAQ
Advantech GeniDAQ

Programming choices for DA&C modules: You may use Advantech application software such as Advantech Device Drivers. On the other hand, advanced users are allowed another option for register-level programming, although not recommended due to its laborious and time-consuming nature.

Device Drivers

The Advantech Device Drivers software is included on the companion CD-ROM at no extra charge. It also comes with all the Advantech DA&C modules. Advantech's Device Drivers features a complete I/O function library to help boost your application performance. The Advantech Device Drivers for Windows 2000/95/98/ME/NT/XP works seamlessly with development tools such as Visual C++, Visual Basic, Inprise C++ Builder and Inprise Delphi.

Register-level Programming

Register-level programming is available for experienced programmers who find it necessary to write code directly at the level of the device register. Since register-level programming requires much effort and time, we recommend that you use the Advantech Device Drivers instead. However, if register-level programming is indispensable, you should refer to the relevant information in *Appendix C, Register Structure and Format,* or to the example codes included on the companion CD-ROM.

1.6 Device Driver Programming Roadmap

This section will provide you a roadmap to demonstrate how to build an application from scratch using Advantech Device Drivers with your favorite development tools such as Visual C++, Visual Basic, Delphi and C++ Builder. The step-by-step instructions on how to build your own applications using each development tool will be given in the *Device Drivers Manual.* Moreover, a rich set of example source code is also given for your reference.

Programming Tools

Programmers can develop application programs with their favorite development tools:

- **Visual C++**
- **Visual Basic**
- **Delphi**
- **C++ Builder**

For instructions on how to begin programming works in each development tool, Advantech offers a *Tutorial* Chapter in the *Device Drivers Manual* for your reference. Please refer to the corresponding sections in this chapter on the *Device Drivers Manual* to begin your programming efforts. You can also look at the example source code provided for each programming tool, since they can get you very well oriented.

The *Device Drivers Manual* can be found on the companion CD-ROM. Alternatively, if you have already installed the Device Drivers on your system, The *Device Drivers Manual* can be readily accessed through the ***Start*** button:

Start/Program Files/Advantech Automation/Device Manger/Device Driver's Manual

The example source code could be found under the corresponding installation folder such as the default installation path:
\Program Files\Advantech\ADSAPI\Examples

Programming with Device Drivers Function Library

Advantech Device Drivers offer a rich function library that can be utilized in various application programs. This function library consists of numerous APIs that support many development tools, such as Visual C++, Visual Basic, Delphi and C++ Builder.

According to their specific functions or services, those APIs can be categorized into several function groups:

- **Device Functions Group**
- **Analog Output Function Group**
- **Port I/O Functions Group**

For the usage and parameters of each function, please refer to the *Function Overview* chapter in the *Device Drivers Manual*.

Troubleshooting Device Drivers Error

Driver functions will return a status code when they are called to perform a certain task for the application. When a function returns a code that is not zero, it means the function has failed to perform its designated function. To troubleshoot the Device Drivers error, you can pass the error code to **DRV_GetErrorMessage** function to return the error message. Alternatively, you can refer to the *Device Drivers Error Codes* Appendix in the *Device Drivers Manual* for a detailed listing of Error Codes, Error IDs and the Error Messages.

1.7 Accessories

Advantech offers a complete set of accessory products to support the PCM-3712 module. These accessories include:

Wiring Boards

ADAM-3909 9-pin wiring terminal for DIN-rail mounting

Chapter 2

Installation

This chapter gives users a package item checklist, proper instructions for unpacking and step-by-step procedures for both driver and module installation.

2.1 Unpacking

After receiving your PCM-3712 package, please inspect its contents first. The package should contain the following items:

☑ PCM-3712 module
☑ Companion CD-ROM (Device Drivers included)

The PCM-3712 module harbors certain electronic components vulnerable to *electrostatic discharge* (ESD). ESD can easily damage the integrated circuits and certain components if preventive measures are ignored.

Before removing the module from the antistatic plastic bag, you should take the following precautions to ward off possible ESD damage:

- Touch the metal part of your computer chassis with your hand to discharge the static electricity accumulated on your body. Alternatively, one can also use a grounding strap.
- Touch the anti-static bag to a metal part of your computer chassis before opening the bag.
- Take hold of the module only by the metal bracket when removing it out of the bag.

After taking out the module, you should first:

- Inspect the module for any possible signs of external damage (loose or damaged components, etc.). If the module is visibly damaged, please notify our service department or our local sales representative immediately. Do not install a damaged module into your system.

Also, pay extra caution to the following aspects to ensure proper installation:

- Avoid physical contact with materials that could hold static electricity such as plastic, vinyl and Styrofoam.
- Whenever you handle the module, grasp it only by its edges. DO NOT TOUCH the exposed metal pins of the connector or the electronic components.

Note

Keep the anti-static bag for future use. You might need the original bag to store the module if you have to remove the module from PC or transport it elsewhere.

2.2 Driver Installation

We recommend you to install the driver before you install the PCM-3712 module into your system, since this will guarantee a smooth installation process.

The Advantech Device Drivers Setup program for the PCM-3712 module is included in the companion CD-ROM that is shipped with your DA&C module package. Please follow the steps below to install the driver software:

Step 1: Insert the companion CD-ROM into your CD-ROM drive.

Step 2: The Setup program will be launched automatically if you have the autoplay function enabled on your system. When the Setup Program is launched, you will see the following Setup Screen.

Note

If the autoplay function is not enabled on your computer, use Windows Explorer or Windows ***Run*** command to execute AUTORUN.EXE on the companion CD-ROM.

Fig. 2-1 Setup Screen of Advantech Automation Software

Step 3: Select the *Individual Drivers* option.

Step 4: Select the specific device then just follow the installation instructions step by step to complete your device driver installation and setup.

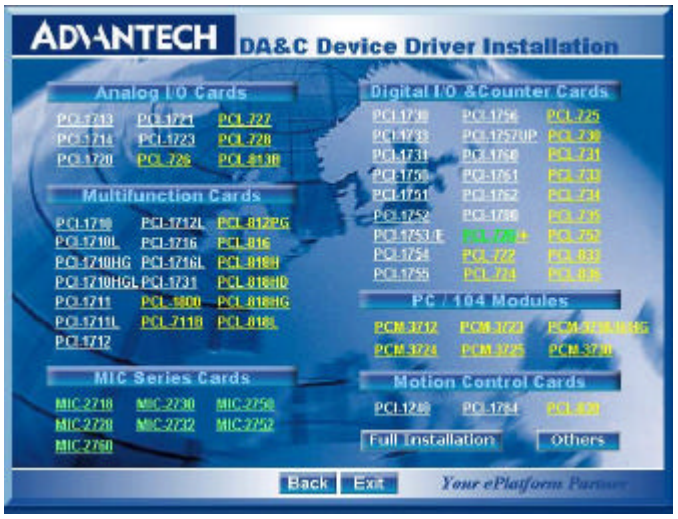


Fig. 2-2 Different options for Driver Setup

For further information on driver-related issues, an online version of the *Device Driver's Manual* is available by accessing the following path:

Start/Program Files/Advantech Automation/Device Manger/Device Driver's Manual

2.3 Hardware Installation

Note

Make sure you have installed the driver first before you install the module (please refer to *2.2 Driver Installation*)

After the Device Drivers installation is completed, you can then install the PCM-3712 module into any PC/104 socket on your computer. However, it is suggested that you refer to the computer user's manual or related documentation if you have any doubt. Please follow the steps below to install the module onto your system.

Step 1: Turn off your computer and unplug the power cord and cables. Turn off your computer before installing or removing any components on the computer.

Step 2: Remove the cover of your computer.

Step 3: Touch the metal part on the surface of your computer to neutralize the static electricity that might be on your body.

Step 4: Insert the PCM-3712 module into the PC/104 socket. Hold the module only by its edges and carefully align it with the slot. Insert the module firmly into place. Use of excessive force must be avoided; otherwise, the module might be damaged.

Step 5: Connect appropriate accessories (9-pin cable, wiring terminals, etc. if necessary) to the PC/104 module.

Step 6: Replace the cover of your computer chassis. Re-connect the cables you removed in step 2.

Step 7: Plug in the power cord and turn on the computer.

After your module is properly installed on your system, you can now configure your device using the *Advantech Device Manager* Program that has itself already been installed on your system during driver setup. A complete device installation procedure should include *device setup*, *configuration* and *testing*. The following sections will guide you through the Setup, Configuration and Testing of your device.

2.4 Device Setup & Configuration

The *Advantech Device Manager* program is a utility that allows you to set up, configure and test your device, and later stores your settings on the system registry. These settings will be used when you call the APIs of Advantech Device Drivers.

Setting Up the Device

Step 1: To install the I/O device for your module, you must first run the *Device Installation* program (by accessing ***Start/Program Files/ Advantech Automation/ Advantech Device Manager).***

Step 2: You can then view the device(s) already installed on your system (if any) on the *Installed Devices* list box. Since you have not installed any device yet, you might see a blank list such as the one below (Fig. 2-3).

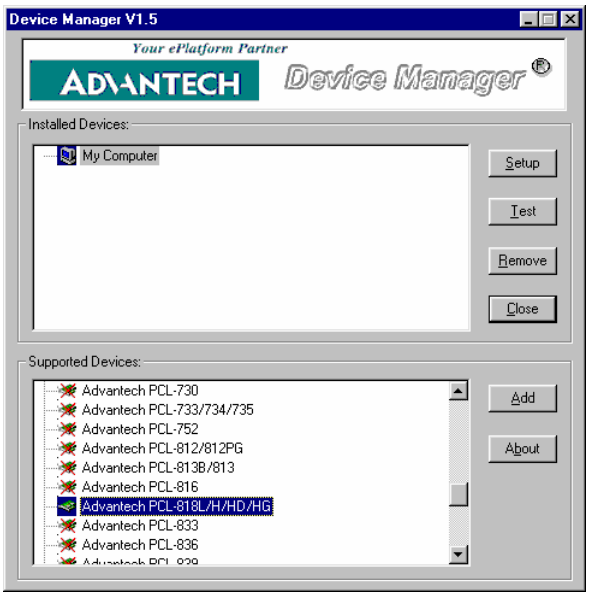


Fig. 2-3 The Device Manager dialog box

Step 3: Scroll down the *List of Devices* box to find the device that you wish to install, and then click the ***Add…*** button. You will see a *Device Setting* dialog box such as the one in Fig. 2-4.

Further information about device configuration of PCM-3712; please refer to the Device Driver's Manual.

Start/Program Files/Advantech Automation/Device Manger/Device Driver's Manual

Chapter 3

Signal Connections

3.1 Overview

Maintaining signal connections is one of the most important factors in ensuring that your application system is sending and receiving data correctly. A good signal connection can avoid unnecessary and costly damage to your PC and other hardware devices. This chapter provides useful information about how to connect input and output signals to the PCM-3712 via the I/O connector.

3.2 Switch and Jumper Settings

In setting the module configuration, a base address switch and some jumpers are used. Refer to the following figure to help locating these components.

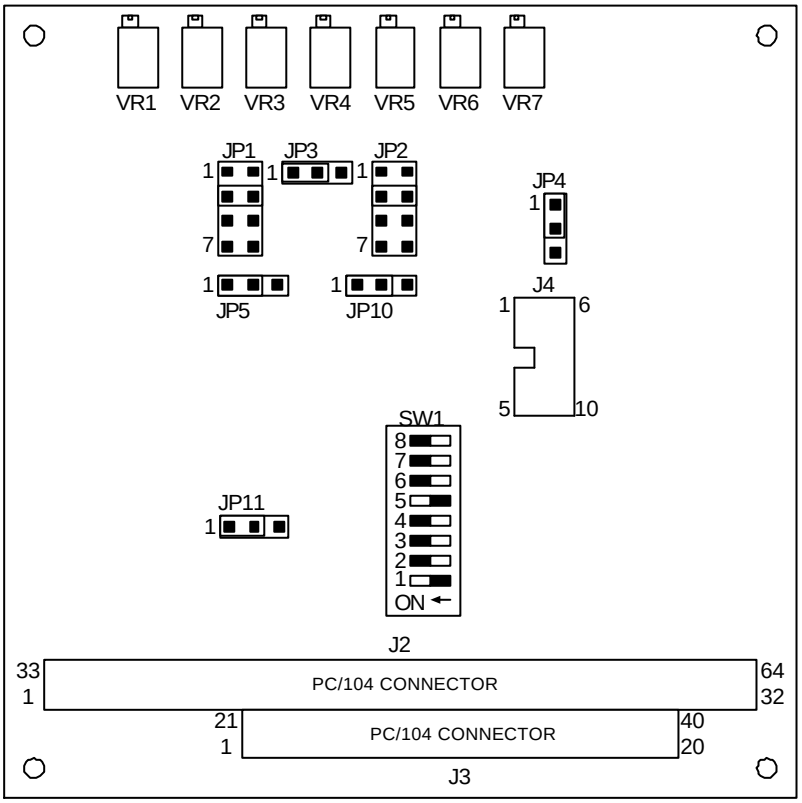


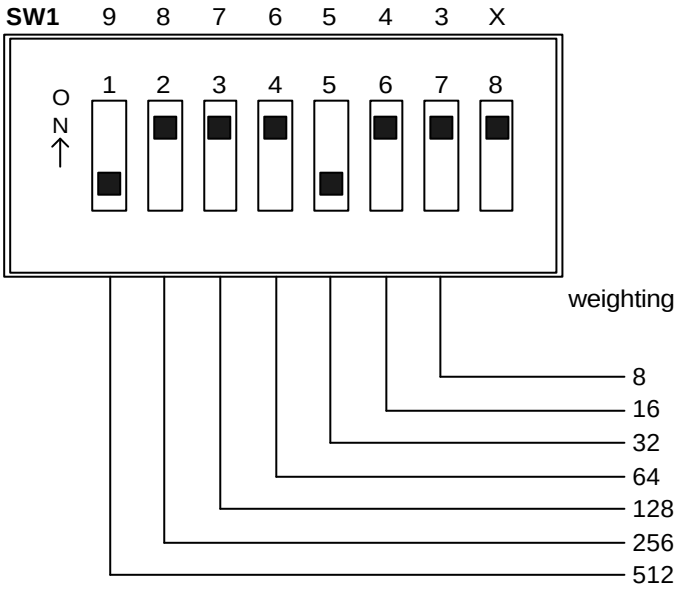
Fig. 3-1 Card connector, jumper and switch locations

Base I/O Port Address

The PCM-3712 module occupies 8 consecutive locations in I/O address space. If more than module is to be installed to the embedded system, each module must be given its own distinct I/O address or base address. No more than one module may use the same base address. The I/O port base address is selected via a 8-position DIP switch (SW1). In factory, the PCM-3712 base address is set for 220 (Hex).

To set to appropriate base address, switch the individual switches into the ON or OFF position. The following figure shows DIP SWITCH default setting, 220 (hex), where switches 1 and 5 are moved to the OFF position while leaving all other switches in the ON position. A table for DIP SWITCH setting is given in the following page.

Base Address Switch Setting



X : Not used.

Base Address = 512 + 32 = 544 (Decimal)

= 220 (Hexadecimal)

Cable I/O addresses, FIFO disabled (SW1)								
Range (Hex)	**Switch position**							
	1	2	3	4	5	6	7	8
200-207	○	●	●	●	●	●	●	×
208-20F	○	●	●	●	●	●	○	×
210-217	○	●	●	●	●	○	●	×
218-21F	○	●	●	●	●	○	○	×
*220-227	○	●	●	●	○	●	●	×
• • •								
3F0-3F7	○	○	○	○	○	○	●	×
3F8-3FF	○	○	○	○	○	○	○	×

○=Off ●=On *=default ×=don't care

Note

Switches 1-8 control the PC bus address lines as follows:

Switch	1	2	3	4	5	6	7	8
Line	A9	A8	A7	A6	A5	A4	A3	×

Asynchronous/Synchronous Selection

The PCM-3712 module can be configured for asynchronous or synchronous mode by means of jumper JP11. The following table gives the configuration for jumper JP11. In factory, the PCM-3712 module is set to asynchronous mode.

Names of Switches	Function description	
JP11		Asynchronous
		Synchronous

Table 3-1: Summary of switch JP11 settings

Analog Output Setting

Each channel of the PCM-3712 module can be independently configured for bipolar (±10 V, ±5 V, ±2.5 V, $\pm V_{REF}$), unipolar (0 – 10V, 0 – 5V, 0 – V_{REF}) or 4 – 20 mA current output. The V_{REF} is a external reference voltage which is input to the module through connector JP4. Jumpers JP1, JP3 and JP5 are used for channel 1' s analog output setting. While jumpers JP2, JP4 and JP10 are used for channel 2' s analog output setting. The jumper configurations are given in the following table.

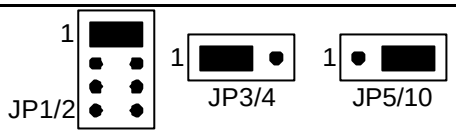
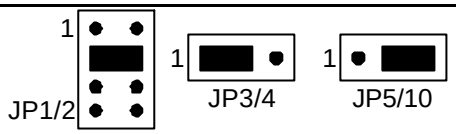
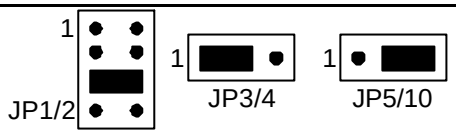
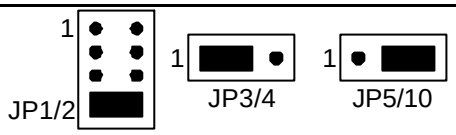
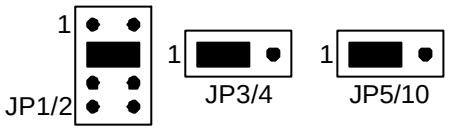
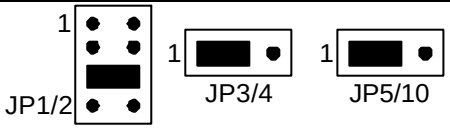
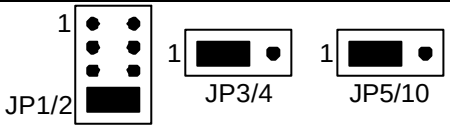
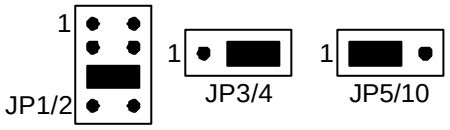
Mode	Range	Configuration	Jumper	Channel
Bipolar	±10V		JP1, JP3, JP5	1
			JP2, JP4, JP10	2
	±5V		JP1, JP3, JP5	1
			JP2, JP4, JP10	2
	±2.5V		JP1, JP3, JP5	1
			JP2, JP4, JP10	2
	±VREF1		JP1, JP3, JP5	1
			JP2, JP4, JP10	2
Unipolar	0 – 10V	 (Factory default setting)	JP1, JP3, JP5	1
			JP2, JP4, JP10	2
	0 – 5V		JP1, JP3, JP5	1
			JP2, JP4, JP10	2
	0 - VREF1		JP1, JP3, JP5	1
			JP2, JP4, JP10	2
	4 – 20mA		JP1, JP3, JP5	1
			JP2, JP4, JP10	2

Table 3-2: Summary of switch JP1/2/3/4/5/10 settings

3.3 Connector Pin Assignments

Pin Assignment

All PCM-3712 input and output signals are built in a 10-pin male connector labeled J4 whose pin assignments and description are shown below. A cable connector, that converts the 10-pin male connector to 9-pin D-type connector, is also given to user along with the PCM-3712 module.

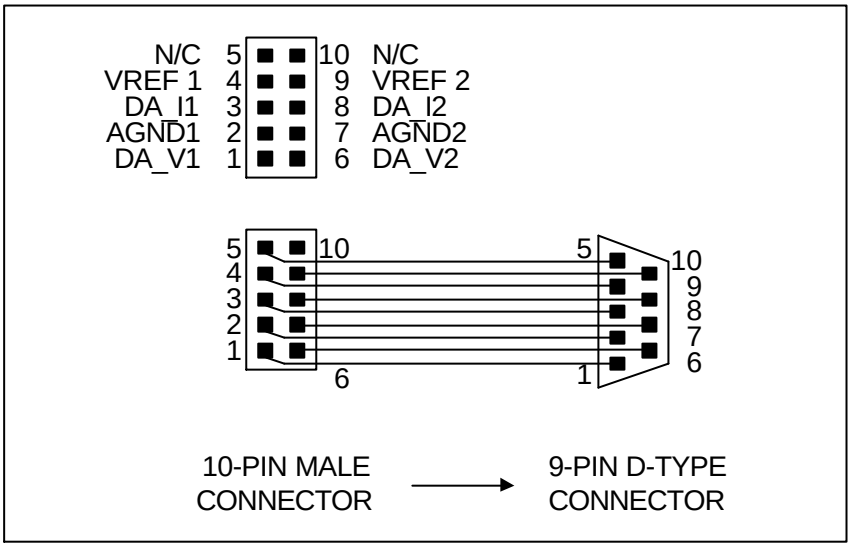


Fig. 3-2 Pin-header connector wiring diagram

I/O Connector Signal Description

Pin No.	Pin Name	Description
1	DA_V1	Voltage output channel 1.
2	AGND1	Analog ground for channel 1.
3	DA_I1	Current output channel 1.
4	VREF1	External reference voltage input for channel 1.
5, 10	N/C	No connect.
6	DA_V2	Voltage output channel 2.
7	AGND2	Analog ground for channel 2.
8	DA_I2	Current output channel 2.
9	VREF2	External reference voltage input for channel 2.

Table 3-3 I/O Connector Signal Descriptions

There are four kinds of reference voltage inputs can be set to input to the D/A converter. The reference voltages are +10V, +5V, +2.5V, and external reference voltage where the jumpers used are JP1 through JP4 and JP6 through JP9, refer to the ***Jumper Setting*** section.

Whatever reference voltage is selected, the D/A output channel is from 0V to the reference voltage (V_{REF}) for unipolar mode and from $-V_{REF}$ to $+V_{REF}$ for bipolar mode. The V_{REF} can be DC or AC voltage. In this way, the D/A output becomes a programmable attenuator. The equation for calculating the D/A output is as follows:

1. Voltage output for unipolar (DA_V1 or DA_V2)

$$V_{UNI} = 2 \times V_{REF} \times \frac{code}{4096}$$

2. Voltage output for bipolar (DA_V1 or DA_V2)

$$V_{BIP} = V_{REF} \times \frac{code - 2048}{2048}$$

3. 4 –20mA constant current output (DA_I1 or DA_I2)

$$I = 16mA \times \frac{code}{4096} + 4mA$$

where code is the data written to the D/A low/high byte register, its range is 0 – 4095.

Analog output connection

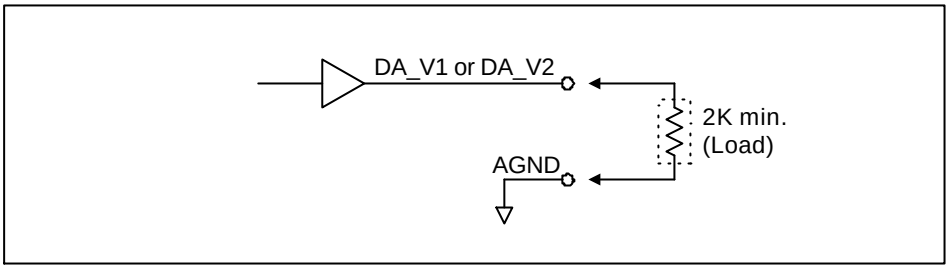


Fig. 3-3 Voltage output connection

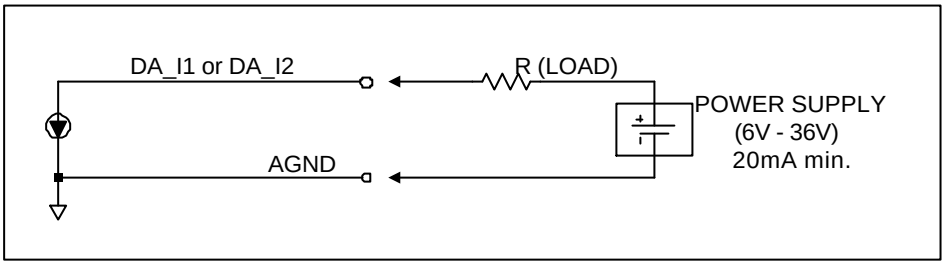


Fig. 3-4 Current loop output connection

Analog output System

Analog outputs are usually used to generate a programmable level signal for yielding a loop control system. The analog output ranges are 0 – 5 V, 0 – 10V, ±2.5 V, ±5 V, ±10 V, 4 – 20 mA. They can be employed to control DC power supply, frequency converter or to drive chart recorders. Normally analog output merely provides little power (voltage output is typical no more than 5mA), additional power amplifier or current boosters are required when large load is used.

D/A Converter with Double-Buffer

A digital-to-analog (D/A) converter affords an analog output proportional to the digital data on the input. Most converters are 8-, 12- or even 16- bit, with correspondingly higher resolution. Cost rises rapidly with resolution. Since the analog output change might need to be programmed twice (resolution more than 8-bit, needs two byte for one data), SPIKES or GLITCHES are usually engendered to result in control application instability. The PCM-3712 module uses 12-bit D/A

converter, consider the change from 1FF (Hex) to 200 (Hex) where a 1 LSB step raises. When the high byte is programmed prior to the low byte, a spike occurs. Similarly, when the low byte is programmed prior to the high byte, a glitch occurs.

Double-buffer technique is used at PCM-3712 module to diminish glitches and spikes. When programming the D/A channels, the low byte should be written first then the high byte. The 12-but buffer will keep the result not to be sent to the output until the high byte is written.

Asynchronous/Synchronous Mode

The PCM-3712 supports asynchronous and synchronous modes where the modes enable user to update the D/A channels individually or simultaneously. The 12-bit input data is split into low and high byte. Sequentially write the low byte then the high byte to the data registers, refer to ***Appendix C Register Format and Description***. Further descriptions for these modes are given later in this section. Programming examples, in asynchronous and synchronous modes, are provided in ***Appendix C.9 Programming***.

- Asynchronous mode

  For each channel, the D/A converter latch and output the new data as soon as all 12 bits of the new data are written to the D/A.

- Synchronous mode

  In synchronous mode, the outputs at the two D/A channels can be simultaneously updated due to a control command written to the synchronous transfer control register. That is the data written to the D/As has no effect on the output value until the module is commanded to change it.

3.4 Field Wiring Considerations

When you use the PCM-3712 to acquire data from outside, noises in the environment might significantly affect the accuracy of your measurements if due cautions are not taken. The following measures will be helpful to reduce possible interference running signal wires between signal sources and the PCM-3712.

- The signal cables must be kept away from strong electromagnetic sources such as power lines, large electric motors, circuit breakers or welding machines, since they may cause strong electromagnetic interference. Keep the analog signal cables away from any video monitor, since it can significantly affect a data acquisition system.

- If the cable travels through an area with significant electromagnetic interference, you should adopt individually shielded, twisted-pair wires as the analog input cable. This type of cable has its signal wires twisted together and shielded with a metal mesh. The metal mesh should only be connected to one point at the signal source ground.

- Avoid running the signal cables through any conduit that might have power lines in it.

- If you have to place your signal cable parallel to a power line that has a high voltage or high current running through it, try to keep a safe distance between them. Alternatively, you can place the signal cable at a right angle to the power line to minimize the undesirable effect.

- The signals transmitted on the cable will be directly affected by the quality of the cable.

APPENDIX

A

Specifications

A.1 Analog Input

Channels	2 channel		
FIFO Size	1K samples		
Output Voltage Range	Unipolar	0 ~ 5V, 0 ~ 10V	
	Bipolar	±2.5V, ±5V, ±10V	
Output Current Range	4 – 20mA	Voltage Output Current Range	±5mA
Source Impedance	0.1Ω max, 0.02Ω typ.		
Accuracy	Resolution	12 bits	
	Nonlinearity	± 1 LSB	
	Differential Nonlinearity	±1 LSB	
	System Accuracy	±0.025% FSR (Voltage Out) ±0.05% FSR (Current Out)	
Thermal Characteristic	Zero Drift	±10uV/°C	
	Gain Drift	±20 ppm of FSR/°C	
Power Requirements	+ 5V	700Ma max.	
	Loop Supply Range	6 ~ 40 V_{DC}	
Dynamic Performance	Setting Time to LSB	10V step: 33 μs 5V step: 16μs	
	Slew Rate	0.3V/μs typ. (Voltage) 1.2mA/μs (Current)	
	DAC Throughput for Single channel	33KHz	

General

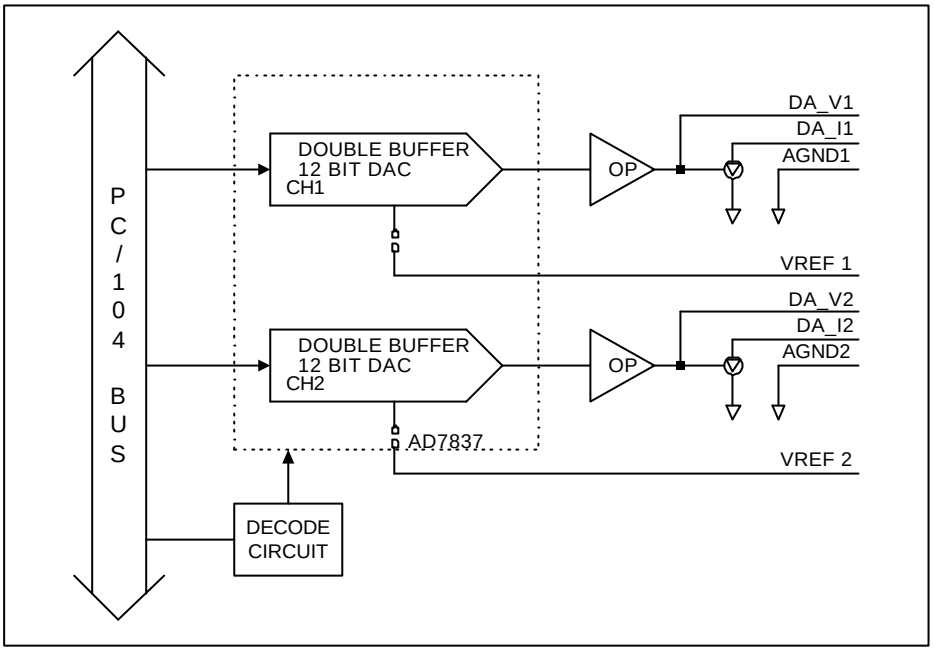
I/O Connector Type	10-pin male connector or 9-pin D-type connector	
Dimensions	95 mm x 90 mm	
Weight	200g	
Temperature	Operation	0°C to 60°C (32°F~140°F)
	Storage	-25°C to 85°C (-13°F~185°F)
Relative Humidity	5~95%RH non-condensing	
Certification	CE certified	

APPENDIX

B

Block Diagram

B.1 Block Diagram



APPENDIX C

Register Format and Description

C.1 Overview

The PCM-3712 is delivered with an easy-to-use 32-bit DLL driver for user programming under the Windows 2000/95/98/NT/ME/XP operating system. We advise users to program the PCM-3712 using the 32-bit DLL driver provided by Advantech to avoid the complexity of low-level programming by register.

The most important consideration in programming the PCM-3712 the register level is to understand the function of the module's registers. The information in the following sections is provided only for users who would like to do their own low-level programming.

C.2 I/O Port Address Map

The PCM-3712 requires 8 consecutive addresses in the PC's I/O space. The address of each register is specified as an offset from the module's base address. For example, BASE+0 is the module's base address and BASE+6 is the base address plus six bytes.

The table C-1 shows the function of each register of the PCM-3712 or driver and its address relative to the module's base address.

Base Addr. +HEX		7	6	5	4	3	2	1	0
00H	W	Low byte of D/A channel 0							
		D7	D6	D5	D4	D3	D2	D1	D0
01H	W	High byte of D/A channel 0							
		X	X	X	X	D11	D10	D9	D8
02H	W	Low byte of D/A channel 1							
		D7	D6	D5	D4	D3	D2	D1	D0
03H	W	High byte of D/A channel 1							
		X	X	X	X	D11	D10	D9	D8
04H	W	Synchronous transfer control							
		X	X	X	X	X	X	X	X
05H	W	Output control							
		ZD	X	X	X	X	X	X	X

Table C-1 PCM-3712 register format (Part 1)

C.3 Low byte of D/A channel 0 — Base + 00H

This is the D/A channel 0' s low byte data register. Write the low byte of the split digital input data to this register.

Write	Low byte of D/A channel 0							
Bit #	7	6	5	4	3	2	1	0
BASE + 00H	D7	D6	D5	D4	D3	D2	D1	D0

Table C-2 Register for Low byte of D/A channel 0

D7 ~ D0 A/D channel number from which the data is derived

D0 the least significant bit (LSB) of the channels

D7 the most significant bit (MSB)

C.4 High byte of D/A channel 0 — Base + 01H

This is the D/A channel 0' s high byte register. After writing the low byte to base +0, write the high byte of the split digital input data to this register. When the module is configured for asynchronous mode, the output value changed as soon as the high byte data is written to this high byte register.

Write	High byte of D/A channel 0							
Bit #	7	6	5	4	3	2	1	0
BASE + 01H	X	X	X	X	D11	D10	D9	D8

Table C-3 Register for High byte of D/A channel 0

D11 ~ D8 A/D channel number from which the data is derived

D8 the least significant bit (LSB) of the channels

D11 the most significant bit (MSB)

C.5 Low byte of D/A channel 1 — Base + 02H

This is the D/A channel 1's low byte data register. Write the low byte of the split digital input data to this register.

Write	Low byte of D/A channel 1							
Bit #	7	6	5	4	3	2	1	0
BASE + 02H	D7	D6	D5	D4	D3	D2	D1	D0

Table C-4 Register for low byte of D/A channel 0

D7 ~ D0 A/D range control

D0 the least significant bit (LSB) of the A/D range

D7 the most significant bit (MSB)

C.6 High byte of D/A channel 1 — Base + 03H

This is the D/A channel 1's high byte register. After writing the low byte to base +2, write the high byte of the split digital input data to this register. When the module is configured for asynchronous mode, the output value changed as soon as the high byte data is written to this high byte register.

Write	High byte of D/A channel 1							
Bit #	7	6	5	4	3	2	1	0
BASE + 03H	X	X	X	X	D11	D10	D9	D8

Table C-5 Register for high byte of D/A channel 1

D11 ~ D8 A/D channel number from which the data is derived

D8 the least significant bit (LSB) of the channels

D11 the most significant bit (MSB)

C.7 Synchronous transfer control — Base + 04H

When the PCM-3712 module is configured for asynchronous mode, any writing to this register (Base + 04H) means the module is commanded to update both D/A's output value.

Write	Synchronous Transfer Control							
Bit #	7	6	5	4	3	2	1	0
BASE + 04H	X	X	X	X	X	X	X	X

Table C-6 Register for synchronous transfer control

C.8 Output Control — Base + 05H

At power on, all voltage output at the D/As are zero and if the module is configured for current output, the output is 4mA. So before starting to program the module, user is recommended to enable an output control bit by setting bit ZD at base + 05H.

Write	Output Control							
Bit #	7	6	5	4	3	2	1	0
BASE + 05H	ZD	X	X	X	X	X	X	X

Table C-7 Register for output control

ZD = 0, output is disabled

ZD = 1, output is enabled

C.9 Programming

The PCM-3712 module consists of two 12-bit D/A channels. The D/A data registers (can only be written to) are in standard low/high byte sequence. The double-buffered D/A's are not updated until the second (high) byte is written. This mechanism ensures a single step transition on the analog output of the A/D.

Example 1

The following BASIC program shows how to generate a sine wave output in asynchronous mode. Properly configure the D/A output channel 1 for bipolar mode, ±10V range and asynchronous mode.

```
10  CLS
20  PORT% = &h220              ' REM Set base address
30  OUT PORT% +5, &H80         ' REM Enable output
40  FOR I = 0 TO 359           ' REM A cycle
50  X! = I * π/180             ' REM Convert to radian
60  Y% = SIN (X!) * 4095       ' REM Get sin value
70  YH% = Y%/256               ' REM Get high byte
80  YL% = Y% MOD 256           ' REM Get low byte
90  OUT PORT%, YL%             ' REM Output low byte
100 OUT PORT%+1, YH%           ' REM Output high byte
110 NEXT I
120 OUT PORT% +5, &H0          ' REM Disable output
130 END
```

Example 2

The following BASIC program shows how to generate sine and cosine wave outputs at both D/As simultaneously. Both D/A channels must be set to bipolar mode, ±10V range and synchronous mode.

```
10  CLS
20  PORT% = &H220                 ‘ REM Set base address
30  OUT PORT% +5, &H80            ‘ REM Enable output
40  FOR I = 0 TO 359              ‘ REM A cycle
50  X! = I * π/180                ‘ REM Convert to radian
60  Y% = SIN (X!) * 4095          ‘ REM Get sin value
70  YH% = Y%/256                  ‘ REM Get high byte
80  YL% = Y% MOD 256              ‘ REM Get low byte
90  OUT PORT%, YL%                ‘ REM Output low byte
100 OUT PORT%+1, YH%              ‘ REM Output high byte
110 Y% = COS (X!)* 4095           ‘ REM Get cos value
120 YH% = Y%/256                  ‘ REM Get high byte
130 YL% = Y% MOD 256              ‘ REM Get low byte
140 OUT PORT% +2, YL%             ‘ REM Output low byte
150 OUT PORT% +3, YH%             ‘ REM Output high byte
160 OUT PORT% %4, 0               ‘ REM Synchronous latch and
                                  output
170 NEXT I
180 OUT PORT% +5, &H0             ‘ REM Disable output
190 END
```

APPENDIX

D

Calibration

D.1 Calibration

The PCM-3712 D/A calibration can be separated into three parts:

- **Reference voltage adjustment**
- **Analog output channel offset adjustment**
- **4mA current adjustment**

The above three calibrations are dependent on each other. To do the calibration for AX10415 module, you need a 4½ (or better) DMM, a current meter and a 250Ω resistor. Refer to the Location Diagram section for help locating the trim resistors used during calibration

Reference Voltage Adjustment

There are 2.5V, 5V and 10V reference voltages. Three trim resistors (VRs) are dedicated for the reference voltages calibration. At factory, these reference voltages have been precisely adjusted, unless you can make sure the reference voltages are drifted, or else never change the VRs.

2.5V Reference Voltage Adjustment Procedure

User a 4½ DMM. Connect its positive probe to jumper JP1 pin 5 and negative probe to pin 2 at connector J4. Adjust VR3 until the DMM reads 2.5000V.

5V Reference Voltage Adjustment Procedure

Use a 4½ DMM. Connect its positive probe to jumper JP1 pin 3 and negative probe to pin 2 at connector J4. Adjust VR2 until the DMM reads 5.0000V.

10V Reference Voltage Adjustment Procedure

Use a 4½ DMM. Connect its positive probe to jumper JP1 pin 1 and negative probe to pin 2 at connector J4. Adjust VR1 until the DMM reads 10.000V.

Analog output Channel Offset Adjustment

This section gives null offset adjustment of the onboard OP amplifier. The procedure is as follows:

1. Make sure all the reference voltages have been precisely adjusted.
2. Configure both D/As for ±5V voltage output range.
3. Connect a 4½ DMM to DA_V1 and AGND1 pins at connector J4.
4. Turn power on and set D/A channel 1's code to 800 (Hex) by writing to the AX10415's data registers (base address +0 and base address +1), refer to ***Appendix C*** section.
5. Adjust VR4 until DMM reads zero voltage.
6. Repeat steps 3 through 5 for D/A channel 2 offset adjustment, where the trim resistor used in VR5, the 4½ DMM is connected to DA/V2 and AGND2 pins at connector J4 and the code is written to base address +2 and base address +3.

Current Sink Adjustment

The current output adjustment procedure is as follows:

1. Configure both analog output channels for 4 – 20 mA current output range.
2. Connect a 250 Ω resistor in series with a current meter to DA_I1 and AGND1 pins at connector J4.
3. Set analog output channel 1's code to 0 by writing to PCM-3712's data registers (base address +0 and base address +1).
4. Trim VR7 until the current meter reads 4.0000 mA.
5. Repeat step 2 through 4 for analog output channel 2 current sink adjustment, where the trim resistor used is VR6, the pins are DA_I2 and AGND2 pins at connector J4, and the code is written to base address +2 and base address +3.