AX10415

2 Channel

Analog Output Module

User's Manual

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- Do not remove boards or integrated circuits from their anti-static packaging until you are ready to install them.
- Before handling a board or integrated circuit, touch an unpainted portion of the system unit chassis for a few seconds. This helps to discharge any static electricity on your body.
- Wear a wrist grounding strap, available from most electronic component stores, when handling boards and components.

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The AX10415 is packed in an anti-static bag. The board has components that are easily damaged by static electricity. Do not remove the anti-static wrapping until proper precautions have been taken. Safety instructions in front of this User's Manual describe anti-static precautions and procedures.

Inventory and Inspection

After unpacking the board, place it on a raised surface and carefully inspect the board for any damage that might have occurred during shipment. Ground the board and exercise extreme care to prevent damage to the board from static electricity.

Integrated circuits will sometimes come out of their sockets during shipment. Examine all integrated circuits, particularly the BIOS, processor and keyboard controller chip to ensure that they are firmly seated.

The AX10415/AX10415-16 2 Channel Analog Output Module package includes the following:

- **AX10415/AX10415-16 board**
- **HD-D 10P/9P**
- **Screw 3mm (x4)**
- **Bronze stick 6mm (x4)**
- **AS59099 DAC Driver CD**

Make sure that all of the items listed above are present.

What To Do If There Is A Problem

If there are damaged or missing parts, contact your supplier and/or dealer immediately. Do not attempt to apply power to the board if there is damage to any of its components.

Table of Contents

Chapter 1
General Description

Introduction

The AX10415 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 10V, 0 to 5V, -2.5V to +2.5V, -5V to +5V, -10V to +10V or 4 to 20mA current loop and is protected from shorts to grounds. At power on, channels configured for voltage output are set to 0V and channels configured for current output are set to 4mA.

There is a 12-bit D/A converter, for each channel, with maximum 33KHz throughput. Typical applications of AX10415 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 AX10415 output.

Application

- Frequency generation (V to F)
- Positioning control
- Wave form generation
- Speed control
- Power consumption control
- Fluid flow control
- Programmable attenuator

Features

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

Specification

Analog Output

- **Number of Channels :** *2*
- **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 :** *±/ LSB*
- **System Accuracy :** *±0.025% FSR (Voltage Out)*
  ±0.05% FSR (Current Out)

Dynamic Performance

- **Setting Time to | LSB :**
  - 10V step : *33us*
  - 5V step : *16us*
- **Slew Rate :** *0.3V/us typ. (Voltage)*
  1.2mA/us (Current)
- **DAC Throughput for Single Channel :** *33KHz*

Thermal Characteristic

- **Zero Drift :** *±10uV/^{o}C*
- **Gain Drift :** *±20ppm of FSR/^{o}C*

Power Requirements

- **+5V :** *700mA max.*
- **Loop Supply Range :** *6 – 40VDC*

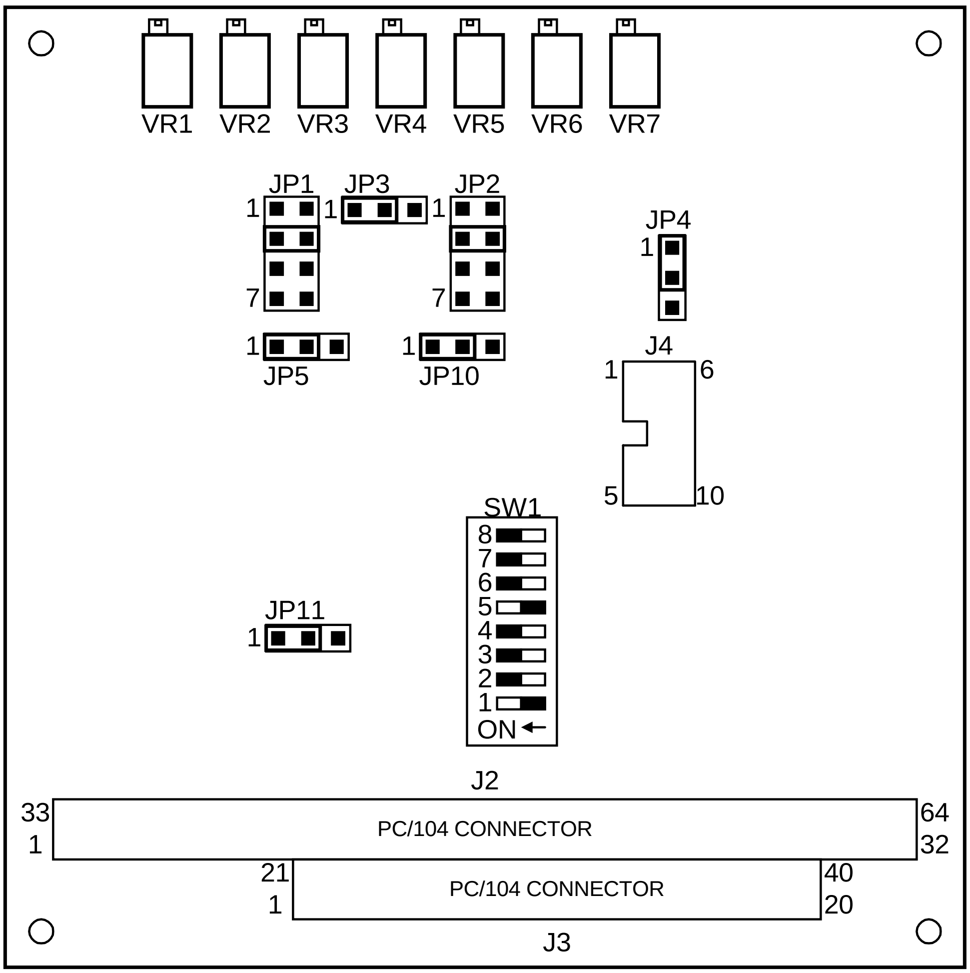
Physical/Environmental

- **I/O Connector :** *10-pin male connector or 9-pin D-type connector*
- **Dimension :** *95mm X 90mm*
- **Weight :** *200g*
- **Operating Temperature Range :** *0^oC to 60^oC*
- **Storage Temperature Range :** *-25^oC to 85^oC*
- **Relative Humidity :** *0 to 90%, non-condensing*

Chapter 2
Module Configuration and Installation

Location Diagram

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

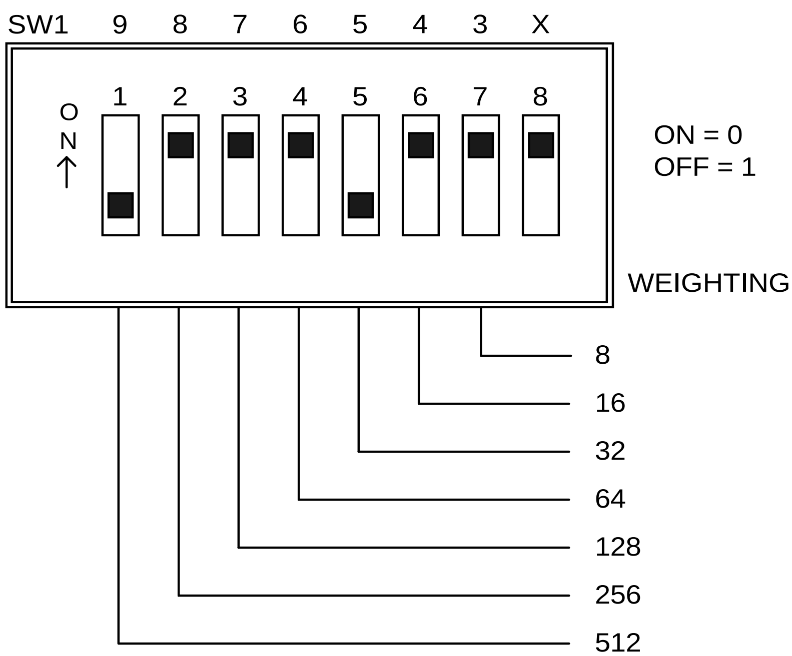


Base I/O Port Address

The AX10415 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). It would be better if you check with ***Appendix A PC I/O Port Mapping*** to avoid conflicting with other installed devices. In factory, the AX10415 base address is set for 220 (Hex) or 544 (Dec).

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



Each switch represents one address weight. The desired base address is determined by adding the weight of the switches. The base address calculation is as follows:

Base Address = 512 + 32 = 544 (Decimal)
= 220 (Hexadecimal)

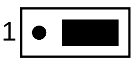
I/O Port Range	**DIP Switch Position**							
Hexadecimal	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
	A9	**A8**	**A7**	**A6**	**A5**	**A4**	**A3**	**X**
200 – 207	1	0	0	0	0	0	0	X
208 – 20F	1	0	0	0	0	0	1	X
210 – 217	1	0	0	0	0	1	0	X
218 – 21F	1	0	0	0	0	1	1	X
* 220 - 227	1	0	0	0	1	0	0	X
.	.		.				.	
.	.		.				.	
3F0 – 3F7	1	1	1	1	1	1	0	X
3F8 – 3FF	1	1	1	1	1	1	1	X

NOTE *0 = ON, 1 = OFF,*
(*) : Factory default setting

Jumper Setting

Asynchronous/Synchronous Selection

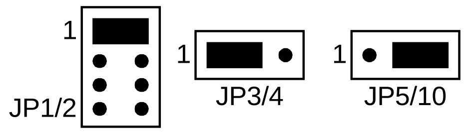
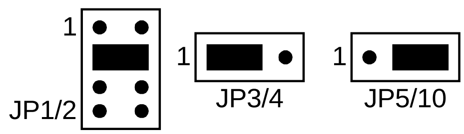
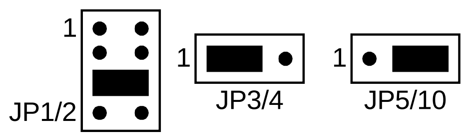
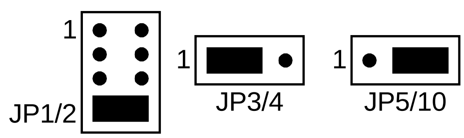
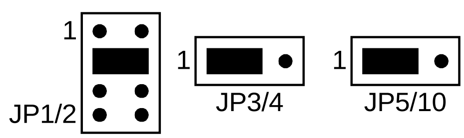
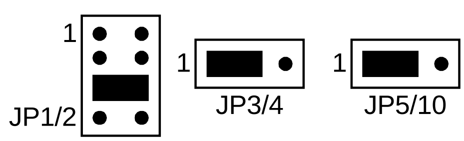
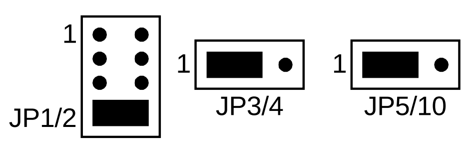
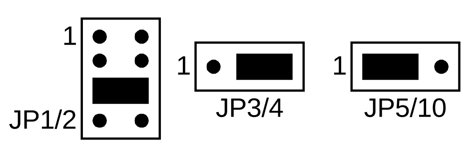
The AX10415 module can be configured for asynchronous or synchronous mode by means of jumper JP11. The following table gives the configuration for jumper JP11. In factory, the AX10415 module is jumpered to asynchronous mode.

Jumper	**Configuration**	**Mode**
JP11	1 	Asynchronous
JP11	1 	Synchronous

Analog Output Setting

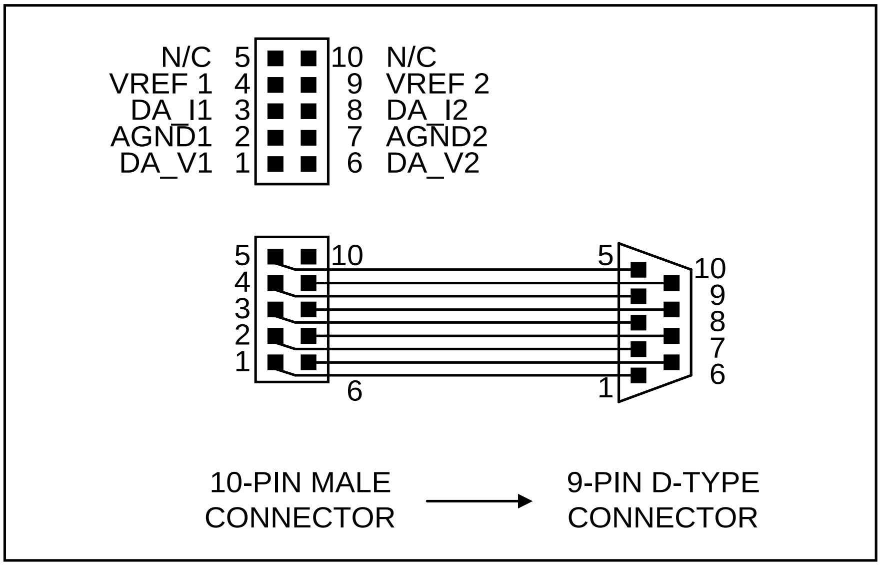
Each channel of the AX10415 module can be independently configured for bipolar (±10V, ±5V, ±2.5V, ±VREF), unipolar (0 – 10V, 0 – 5V, 0 – VREF) or 4 – 20mA current output. The VREF is a external reference voltage which is input to the module through connector JP4.

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

Connector Pin Assignments

All AX10415 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 AX10415 module.



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.

Module Installation

The AX10415 PC/104 module is shipped with protective electrostatic cover. When unpacking, touching the module electro-statically shielded packaging with the metal frame of your computer to discharge the accumulated static electricity prior to touching the module.

Following description summarizes the procedures for installing the AX10415:

WARNING *Turn off the PC and all accessories connected to the PC whenever installing or removing any peripheral board including the AX10415 module.*

The installation procedures are as follows:

1. Turn off the system power.
2. Unplug all power cords.
3. Remove the case cover if necessary.
4. Remove the top module if it is a non-stackthrough module.
5. Put the AX10415 module in line with the top present module as described in ***Appendix C PC/104 Mechanical Specifications***.
6. Install four spacer and fasten them if necessary.
7. Connect cable if necessary(J4).
8. Crush between the modules until inside distance is SPACER's height (0.6"). Restore all the screws.
9. Repeat step 6 until all modules are set into position.
10. Restore the case cover and connect all the necessary cables.
11. Turn on the system power.

Chapter 3
Register Format and Description

AX10415 Address Map

The AX10415 is programmable through the hardware registers. By writing to these registers, the two D/A converter outputs can be accessed. AX10415 uses 8 consecutive address in I/O space as follows (R = Read, W = Write, BASE = Base Address) :

Location	Function Description	Type
Base +0	Low byte – D/A channel 1	W
Base +1	High byte – D/A channel 1	W
Base +2	Low byte – D/A channel 2	W
Base +3	High byte – D/A channel 2	W
Base +4	Synchronous transfer control	W
Base +5	Output control	W
Base +6	Reserved	X
Base +7	Reserved	X

AX10415 Register Description

The output value at the two AX10415 D/A channels may be individually or simultaneously updated. To write all 12 bits of the data to D/A, the digital data must first be split into low byte and high byte data. Sequentially, the low byte data is written to low byte register and the high byte data is written to high byte register. In asynchronous mode, the output at individual D/A channel is changed as soon as the associated high byte of the new data is written. In synchronous mode, although the low and high byte of the new data have been written to the two D/As the outputs are not updated until the module receives a control command written to the synchronous transfer control registers. For detailed information, refer to the following registers format and descriptions. Simple example program in ***Chapter 5 Programming*** shows you how to program these registers.

- **Low Byte Register – D/A Channel 1 (Base +0, W)**

Base	7	6	5	4	3	2	1	0
+0	D7	D6	D5	D4	D3	D2	D1	D0

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.

- **High Byte Register – D/A Channel 1 (Base +1, W)**

Base	7	6	5	4	3	2	1	0
+1	X	X	X	X	D11	D10	D9	D8

This is the D/A channel 1'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.

- **Low Byte Register – D/A Channel 2 (Base +2, W)**

Base	7	6	5	4	3	2	1	0
+2	D7	D6	D5	D4	D3	D2	D1	D0

This is the D/A channel 2's low byte data register. Write the low byte of the split digital input data to this register.

- **High Byte Register – D/A Channel 2 (Base +3, W)**

Base	7	6	5	4	3	2	1	0
+3	X	X	X	X	D11	D10	D9	D8

This is the D/A channel 2'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.

- **Synchronous Transfer Control (Base +4, W)**

Base	7	6	5	4	3	2	1	0
+4	X	X	X	X	X	X	X	X

When the AX10415 module is configured for asynchronous mode, any writing to this register (base +4) means the module is commanded to update both D/A's output value.

■ Output Control (Base +5, W)

Base	7	6	5	4	3	2	1	0
+5	**ZD**	X	X	X	X	X	X	X

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 +5.

ZD = 0, output is disabled

ZD = 1, output is enabled

Chapter 4
Functional Description

D/A Output Calculation

There are four kinds of reference voltage inputs can be jumpered 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 (VREF) for unipolar mode and from –VREF to +VREF for bipolar mode. The VREF 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)**

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

2. **Voltage output for bipolar (DA_V1 or DA_V2)**

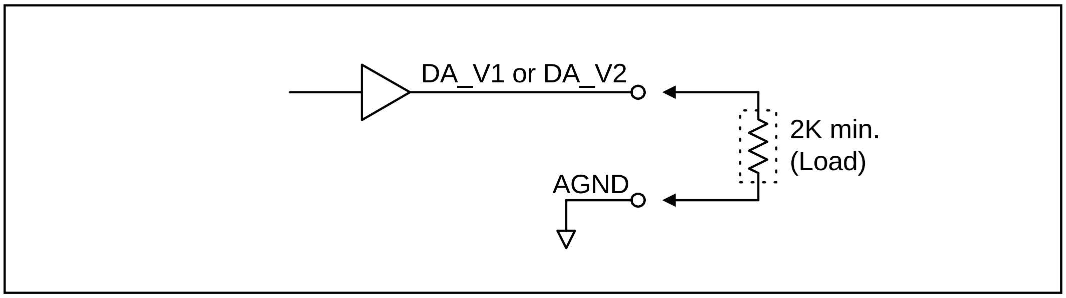
$$V_{BIP} = VREF \times \frac{code - 2048}{2048}$$

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

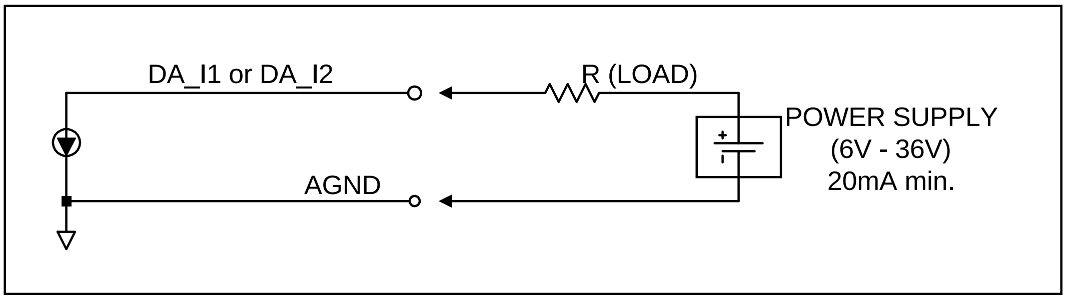
$$I = 16mA \times \frac{code}{4096} + 4mA$$

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

Output Connections



Voltage Output Connection



Current Loop Configuration 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- 5V, 0 – 10V, ±2.5V, ±5V, ±10V, 4 – 20mA. 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 AX10415 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 AX10415 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 AX10415 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 ***Chapter 3 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 ***Chapter 5 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.

Chapter 5
Programming

The AX10415 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.

Programming 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
```

Programming 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
```

Chapter 6
Calibration

The AX10415 D/A calibration can be separated into three parts:

- **Reference voltage adjustment**
- **D/A 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 4│ (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 4│ 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 4│ 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 4│ 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.

D/A 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 4| 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 ***AX10415 Register Description*** 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 4| 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

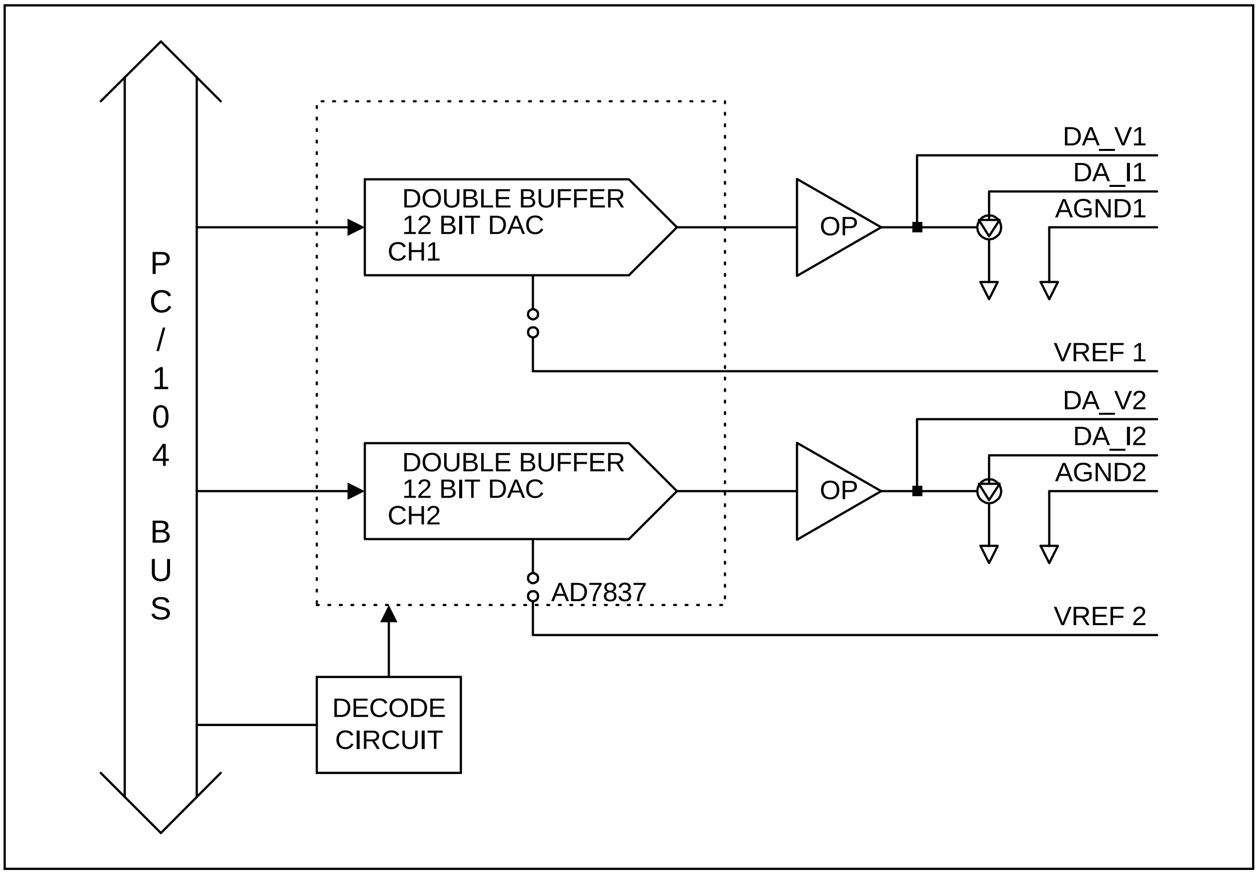
The current output adjustment procedure is as follows:

1. Configure both D/As for 4 – 20mA current output range.
2. Connect a 250Ω resistor in series with a current meter to DA_I1 and AGND1 pins at connector J4.
3. Set D/A channel 1's code to 0 by writing to AX10415's data registers (base address +0 and base address +1).
4. Trim VR7 until the current meter reads 4.0000mA.
5. Repeat step 2 through 4 for D/A 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.

Appendix A
PC I/O Port Mapping

I/O Port Address Range	Function
000 – 1FF	PC reserved
200 – 20F	Game controller (Joystick)
278 – 27F	Second parallel printer port (LPT2)
2E1	GPIB controller
2F8 – 2FF	Second serial port (COM2)
320 – 32F	Fixed disk (XT)
378 – 37F	Primary parallel printer port (LPT1)
380 – 38F	SDLC communication port
3B0 – 3BF	Monochrome adapter/printer
3C0 – 3CF	EGA, reserved
3D0 – 3DF	Color/graphics adapter
3F0 – 3F7	Floppy disk controller
3F8 – 3FF	Primary serial port (COM1)

Appendix B
Block Diagram



Appendix C
PC/104 Mechanical Specifications

PC/104 General Description

While the PC and PC/AT architectures have become extremely popular in both general purpose (desktop) and dedicated (non-desktop) applications, its use in embedded microcomputer applications has been limited due to the large size of standard PC and PC/AT motherboards and expansion cards. PC/104 module can be of two bus types, 8 bit and 16 bit, which correspond to the PC and PC/AT buses, respecitvely.

Besides bus option, there are stackthrough and non-stackthrough difference. The stackthrough version provides a self-stacking PC bus. It can be placed any where in a multi-module stack. The non-stackthrough version offers minimum thickness, by omitting bus stackthrough pins. It must be positioned at one end of a stack.

For convenience, the AX10415 is equipped with stackthrough version only.

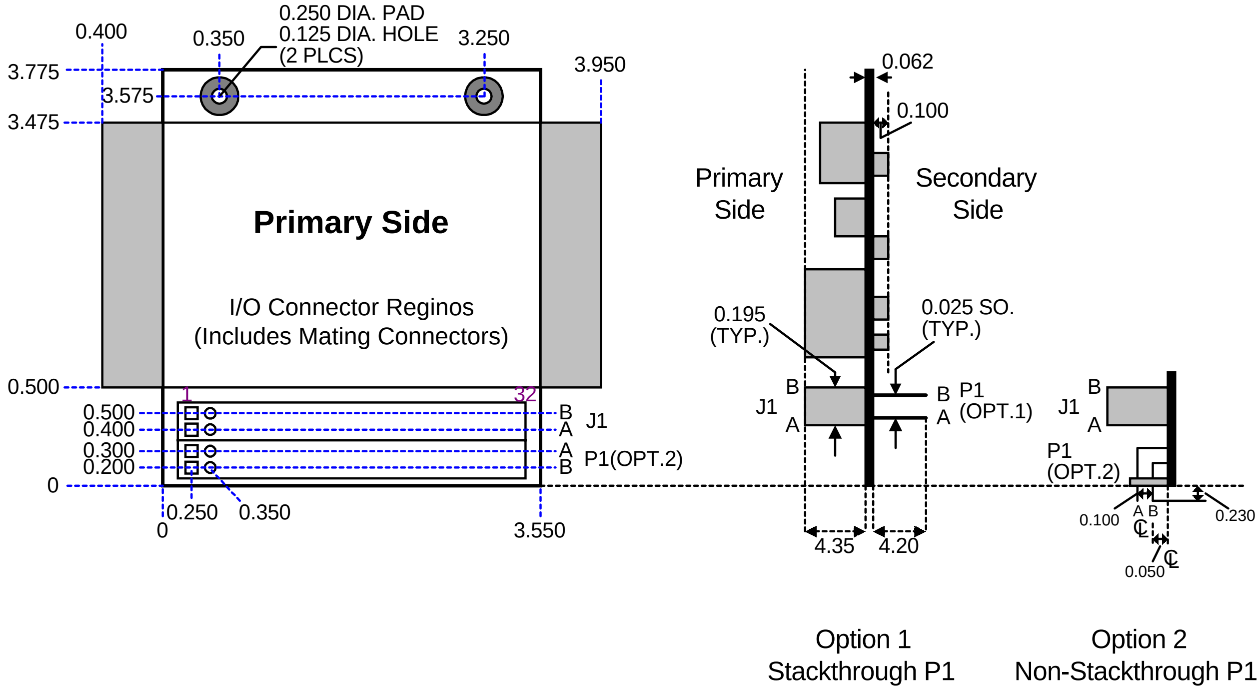
NOTE *For safety, you are suggested to cut bus stackthrough pins of the last module on condition; that you are sure you won't add/plug any module to the module stack in the future.*

The following sections provide the mechanical and electrical specifications for a compact version of the PC/AT bus, optimized for the unique requirements of embedded systems applications. The specification is herein referred to as "PC/104". Based on the 104 signal contacts on the two bus connectors (64 pins on J2 plus 40 pins on J3).

Module Dimensions

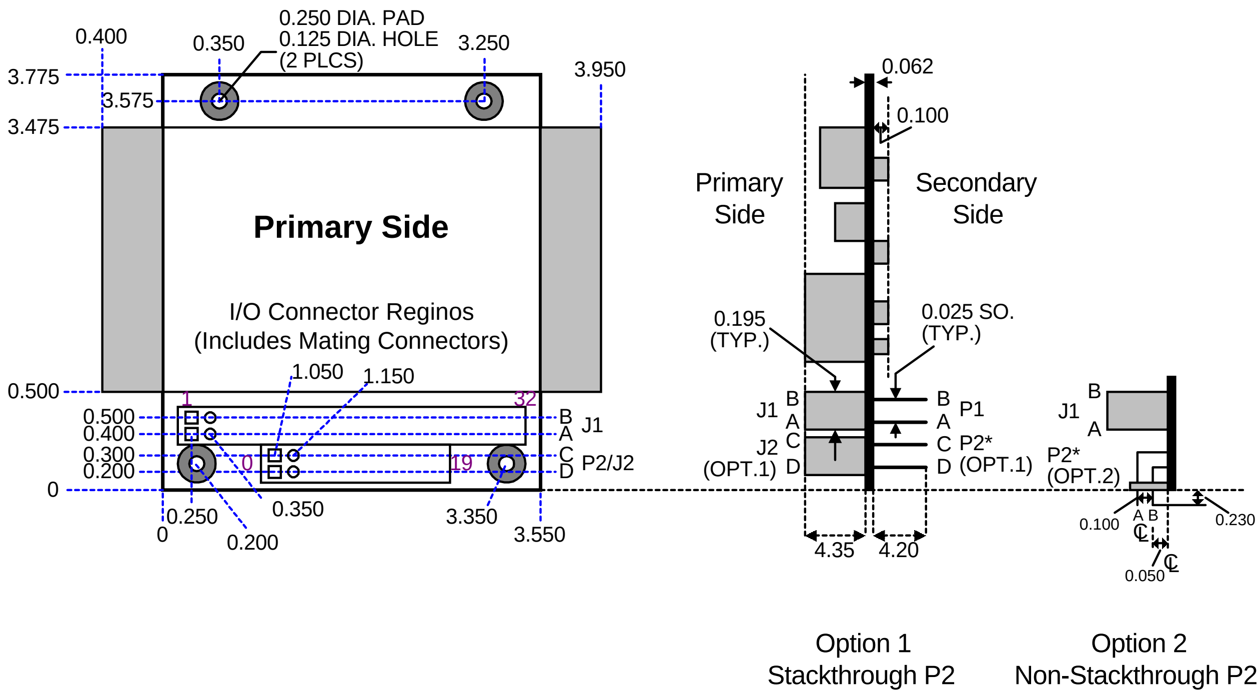
PC/104 modules can be of two bus types, 8-bit and 16-bit. These correspond to the PC and PC/AT buses, respectively.

■ PC/104 8-Bit Module Dimensions



NOTE *Dimensions are in inches ±0.05.*

■ PC/104 16-Bit Module Dimensions



NOTE *Dimensions are in inches ±0.05.*

■ Typical Module Stack

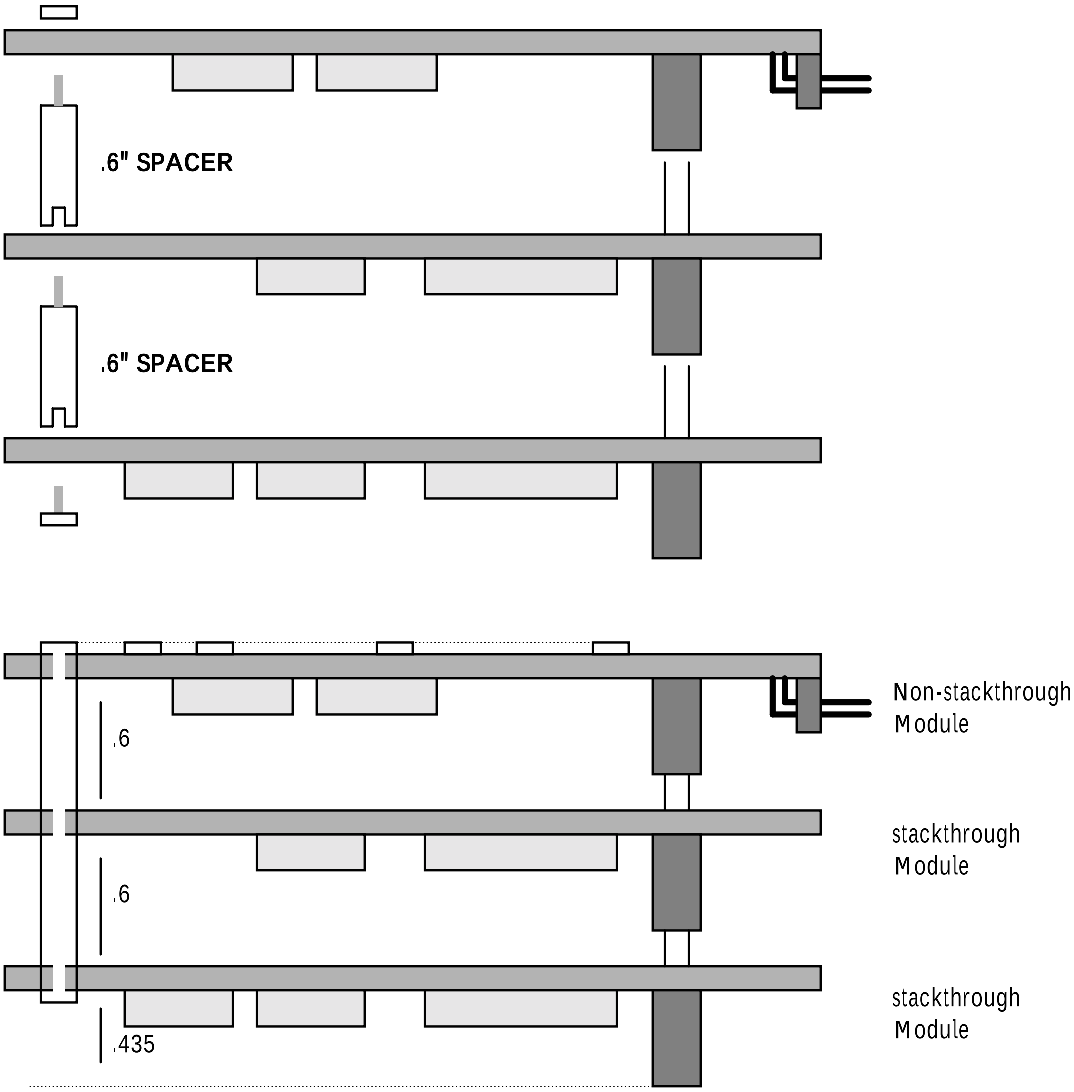


Figure 1 Typical Module Stack