Millennium Series
PC/104 Motion Controllers

User's Manual

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Related Documents

Navigator Motion Processor User's Guide (MC2000UG)

How to set up and use all members of the Navigator Motion Processor family.

Navigator Motion Processor Programmer's Reference (MC2000PR)

Descriptions of all Navigator Motion Processor commands, with coding syntax and examples, listed alphabetically for quick reference.

Content

1 PC/104 Board Installation

In addition to the PC/104 card, the Millennium motion controller includes storage media (CD) with the C-MotionPlus software library and device drivers. C-MotionPlus is a full-featured C/C++ language library, which simplifies the development of motion applications for the Navigator chipsets.

1.1 Installation Sequence

For a normal installation of the Millennium controller, you will need to configure the 3mc-0x-xx board for the PC system and motor hardware that you will connect it to. Configuration of the 3mc-0x-xx board is described in detail in the section below entitled "Preparing the board for installation"

Next you will need to connect your system's motors, encoders, amplifiers and sensors as desired to operate your motion hardware. A description of the connections that are made for the various Navigator chipsets is found in the "3mc-0x-xx Connections Summary" sections [1.5 – 1.9].

The final step to finish the installation is to perform a functional test of the finished system. This is described in the section entitled "First time system verification".

Once all of the above has been accomplished installation is complete. You can now exercise your motion system.

1.2 Components List

The Millennium controller set contains the following components:

1) Millennium Controller PC/104 board
2) Storage media with:
    - C-MotionPlus library (static and DLL)
    - Device drivers
    - Millennium Series PC/104 Motion Controller – User's Manual
    - Navigator Motion Processor User's Guide (pdf format file)
    - Navigator Motion Processor Programmers Reference (pdf format file)
3) Documentation:
    Millennium Series PC/104 Motion Controller – User's Manual

If any of these components are missing, please contact Cito Systems directly, or your Cito Systems representative.

1.3 Required Hardware

To install the Millennium series PC/104 motion board, you will need the following hardware:

1) PC/104 platform: the minimum platform consists of an Intel (or compatible) processor, 80286 or better, 5MB of available disk space, CD-ROM drive. The recommended platform is an Intel (or compatible) processor, Pentium or better, 5MB of available disk space, 32MB of available RAM, and CD-ROM drive. The operating system may be Windows95/98/Me/NT/2000/XP/CE or Linux. An asynchronous serial communications port is optional for both the minimum and recommended platforms.
2) 1 to 4 pulse and direction, PWM, or analog-input amplifiers. The type of amplifier depends on the controller's chipset type.
3) 1 to 4 step motors or servo motors. These motors may or may not provide encoder position feedback signals depending on the type of chipset being used.
4) Additional connectors, as required to connect the 3mc-0x-xx PC board to the amplifiers and the servo motors. Dual male 50-pin header-type connectors will be needed to interface to the 3mc-0x-xx board's signal cable, part number CAB-100_2x50.

1.4 Preparing the Board for Installation

The board provides the following user-settable hardware options:

Option	Set using	Default
PC/104 bus I/O Address	switch bank S1, 1-4	340 (hex)
PC/104 bus IRQ #	switch bank S1, 5-8	IRQ disabled
Host interface mode	jumper JP7	PC/104 bus

Table 1-1. PC/104 motion controller board default settings.

The host interface mode jumpers will not need to be changed unless it is desired that the card be operated in serial mode. If operated in serial mode, a special adapter board is required.

The following diagram shows the location of the jumper JP7:

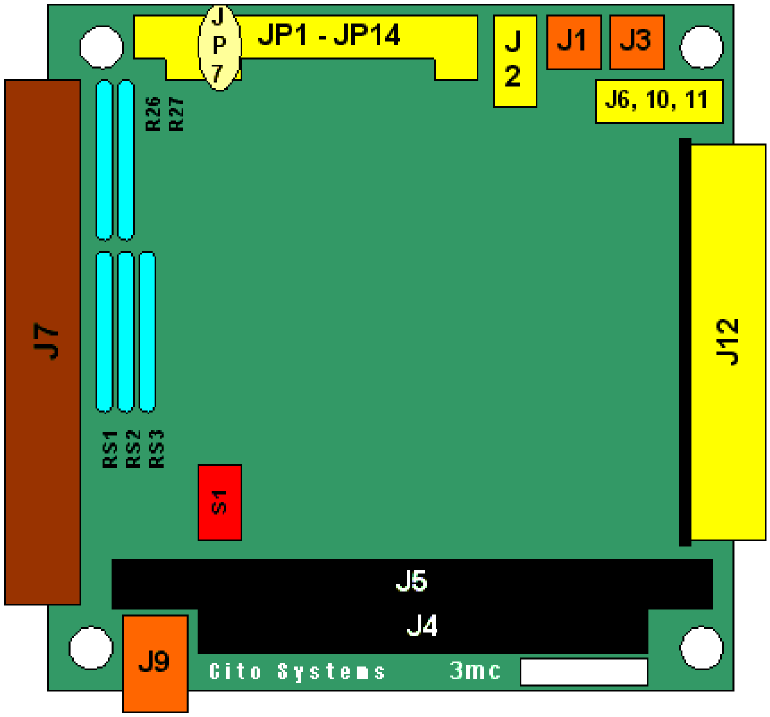


Figure 1-1. Settable jumpers and connectors

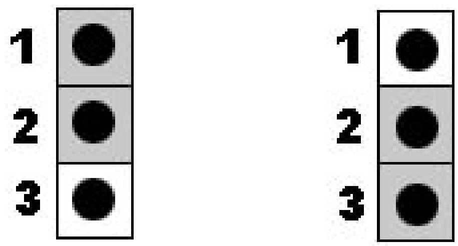
If you need to change the default setting values from the Table 1-1, or are not sure if they need to be changed, the following sections explain more about these settings.

1.4.1. Setting the Host I/O Mode

The PC/104 motion controller supports two different communication modes. This is shown in the following table:

Mode	Description
PC/104 mode	The motion processor accepts instructions and data as full 16-bit words, using the entire 16-bit data path
Serial port	The motion processor accepts instructions through an asynchronous serial port.

The figure below shows how the JP7 jumper should be installed to select the host mode. PC/104 mode is the default. Shading indicates the location of the jumper.



serial port **PC/104 parallel**

1.4.2. Setting the PC/104 bus I/O address

The PC/104 motion card occupies 16 consecutive I/O addresses on the PC/104 bus, starting at the "base address", and ending at the base address+F (hex). For example for the default base address, which is 340 (hex), the total used range of addresses is 340 (hex) – 34F (hex).

The I/O port base address should be chosen so that it doesn't conflict with any other devices using addresses in the range 300h-3FFh. Certain of these addresses are reserved for specific peripherals, as shown in the following table (not all will be present in a given system):

Port address	Device
300-377h	*available*
378-37Fh	LPT1
380-3Afh	*usually available*
3B0-3DFh	VGA
3E0-3E7h	*available*
3E8-3Efh	COM3
3F0-3F7h	Hard disk controller
3F8-3FFh	COM1

Switch block S1, switches 1 - 4 determine the PC/104 bus base address. In the table below switches, which should be on are indicated as such. A blank space in the table indicates the switch should be set off (or left).

Address	S1-1	S1-2	S1-3	S1-4
300h	on	on	on	on
310h		on	on	on
320h	on		on	on
330h			on	on

340h	on	on		on
350h		on		on
360h	on			on
370h				on
380h	on	on	on	
390h		on	on	
3A0h	on		on	
3B0h			on	
3C0h	on	on		
3D0h		on		
3E0h	on			
3F0h				

The default I/O port address is 340 hex (1-4: on, on, off, on)

For more detailed info on the I/O addresses used by the motion controller board, see Appendix A, "PC/104 Motion Controller Electrical Reference", section 5.1.3.6.

1.4.3. Setting the IRQ level

The PC/104 controller board allows the motion chipset's HostIntrpt signal (used by the chipset to signal special events) to generate a PC/104 interrupt that can be processed by interrupt handling routines in the PC/104-based control software. The specific interrupt (IRQ) that is generated can be programmed on the Millennium board using S1 switches #5-8. The PC interrupt is generated when the chipset's HostIntrpt signal transitions from high to low.

The table below shows the IRQs that are selectable and the associated S1 switch settings. If no IRQ generation is desired than the "IRQ disabled" option should be selected. A blank space in the table indicates the switch should be off (down).

IRQ #	**S1-5**	**S1-6**	**S1-7**	**S1-8**
3	on	on	on	on
5		on	on	on
7	on		on	on
10			on	on
11	on	on		on
IRQ disabled				

The default IRQ setting is "IRQ disabled"

1.5 3mc-0x-Bx Connections Summary

The following table summarizes the connections provided and expected by the Millennium PC/104 board when a MC2140 chipset is installed. Although the MC2140 supports up to four axes any number of axis between 1 and 4 may be connected.

Chipset:	MC2100 series
Maximum # of Axes:	4
Encoder Input Type:	Incremental encoder
Encoder Input Signals: (per axis)	A quadrature channel input B quadrature channel input Index pulse channel input
# motor output channels: (per axis)	1
Amplifier Output Signals (per axis, if PWM sign, magnitude used)	PWM Direction PWM magnitude
Amplifier Output Signals (per axis, if PWM 50/50 used)	PWM magnitude
Amplifier Output Signals (per axis, if analog output used)	Differential analog out (DAC output)
Other Control Signals: (per axis)	Home signal channel input Positive limit switch input Negative limit switch input Fault input AxisOut output
Miscellaneous Signals:	GND +5 V (for encoder power)

For a complete description of the PC/104 card connectors and interfacing requirements see Appendix A "PC/104 Motion Controller Electrical Reference".

1.6 3mc-0x-BLx Connections Summary

The following table summarizes the connections provided and expected by the Millennium PC/104 board when a MC2340 chipset is installed. Although the MC2340 supports up to four axes any number of axis between 1 and 4 may be connected.

Chipset:	MC2300 series
Maximum # of Axes:	4
Encoder Input Type:	Incremental encoder
Encoder Input Signals: (per axis)	A quadrature channel input B quadrature channel input Index pulse channel input

# motor output channels: (per axis)	2 or 3 depending on motor output selected and # phases
Amplifier Output Signals (per axis, if PWM 50/50 used)	PWM magnitude (phase A) PWM magnitude (phase B) PWM magnitude (phase C)
Amplifier Output Signals (per axis, if analog output used)	Analog out (phase A) Analog out (phase B)
Hall inputs:	Hall (phase A) Hall (phase B) Hall (phase C)
Other Control Signals: (per axis)	Home signal channel input Positive limit switch input Negative limit switch input Fault input AxisOut output
Miscellaneous Signals:	GND +5 V (for encoder power)

For a complete description of the PC/104 card connectors and interfacing requirements see Appendix A "PC/104 Motion Controller Electrical Reference".

1.7 3mc-0x-B/BLx Connections Summary

The following table summarizes the connections provided and expected by the Millennium PC/104 board when a MC2840 chipset is installed. Although the MC2840 supports up to four axes any number of axis between 1 and 4 may be connected. Since this chipset allows controlling a combination of brush and brushless servomotors, two pairs of each motor type can be used.

Chipset:	MC2800 series
Maximum # of Axes:	4
Encoder Input Type:	Incremental encoder
Encoder Input Signals: (per axis)	A quadrature channel input B quadrature channel input Index pulse channel input
# motor output channels: (per axis)	1, 2 or 3 depending on motor output selected and # phases
Amplifier Output Signals (per axis, if PWM sign, magnitude used)	PWM Direction PWM magnitude
Amplifier Output Signals (per axis, if PWM 50/50 used)	PWM magnitude (phase A) PWM magnitude (phase B) PWM magnitude (phase C)

Amplifier Output Signals for brush type motors (per axis, if analog output used)	Differential analog out (DAC output)
Amplifier Output Signals for brushless type motors (per axis, if analog output used)	Analog out (phase A) Analog out (phase B)
Hall inputs:	Hall (phase A) Hall (phase B) Hall (phase C)
Other Control Signals: (per axis)	Home signal channel input Positive limit switch input Negative limit switch input Fault input AxisOut output
Miscellaneous Signals:	GND +5 V (for encoder power)

For a complete description of the PC/104 card connectors and interfacing requirements see Appendix A "PC/104 Motion Controller Electrical Reference".

1.8 3mc-0x-MSx Connections Summary

The following table summarizes the connections provided and expected by the Millennium PC/104 board when a MC2440 chipset is installed. Although the MC2440 supports up to four axes any number of axis between 1 and 4 may be connected.

Chipset:	MC2400 series
Maximum # of Axes:	4
Encoder Input Type:	Incremental encoder
Encoder Input Signals: (per axis)	A quadrature channel input B quadrature channel input Index pulse channel input
# motor output channels: (per axis)	2 or 3 depending on motor output selected and # phases
Amplifier Output Signals (per axis, if PWM 50/50 used)	PWM magnitude (phase A) PWM magnitude (phase B) PWM magnitude (phase C)
Amplifier Output Signals (per axis, if analog output used)	Analog out (phase A) Analog out (phase B)

Other Control Signals: (per axis)	Home signal channel input Positive limit switch input Negative limit switch input Fault input AxisOut output
Miscellaneous Signals:	GND +5 V (for encoder power)

For a complete description of the PC/104 card connectors and interfacing requirements see Appendix A "PC/104 Motion Controller Electrical Reference".

1.9 3mc-0x-S Connections Summary

The following table summarizes the connections provided and expected by the Millennium PC/104 board when a MC2540 chipset is installed. Although the MC2540 supports up to four axes any number of axis between 1 and 4 may be connected.

Chipset:	MC2500 series
Maximum # of Axes:	4
Encoder Input Type:	Incremental encoder
Encoder Input Signals: (per axis)	A quadrature channel input B quadrature channel input Index pulse channel input
# motor output channels: (per axis)	1
Amplifier Output Signals: (per axis)	Pulse Direction
Other Control Signals: (per axis)	Home signal channel input Positive limit switch input Negative limit switch input Fault input AxisOut output
Miscellaneous Signals:	GND +5 V (for encoder power)

For a complete description of the PC/104 card connectors and interfacing requirements see Appendix A "PC/104 Motion Controller Electrical Reference".

1.10 Applying Power

Once you have connected the board to the desired number of external amplifiers and motor encoders, hardware installation is complete and the board is ready for operation.

Upon power up, the motion controller will be in a reset condition. In this condition no motor output will be applied until the chipset is initialized (see next section on software for details). Therefore, the motors should remain stationary. If the motors do move or jump, power down the board and check the amplifier and encoder connections. If anomalous behavior is still observed, call Cito Systems, or your local representative for assistance.

2 Software Installation

On the storage media (CD) provided with the Millennium series PC/104 motion controller there is a motion functions library called C-MotionPlus. This library contains functions that are commands for the motion processor installed in the controller. The user is responsible for writing a program to control motors motion and serving specific application. In the following sections [2.2.1. – 2.2.5] are samples of the functions to perform some basic moves.

The C-MotionPlus software library provided by Cito Systems supersedes the C-Motion supporting the Navigator motion processors. C-MotionPlus provides interfaces to the C functions as well as to the methods of C++ classes. It also has an interface to the TCL scripting language. Additionally, this library allows communicating with multiple cards on the bus at the time and invoking directly from a terminal window all the functions on a local computer or remote one via network or RS-232/RS-485 link. The library supports functions specific to Millennium series motion control boards.

It can be used in the Windows and Linux operating systems environment.

2.1 Using EasyMotion Console

EasyMotion is an application software package that can be purchased from Cito Systems for easy and fast setting of a motion system. It contains a set of tools that help and assist in configuring the motion card. One of the tools is a Motion Console that works as a terminal interface allowing direct calling of the C-MotionPlus library functions. This way, without writing a single line of code one can talk to the board and quickly verify the system.

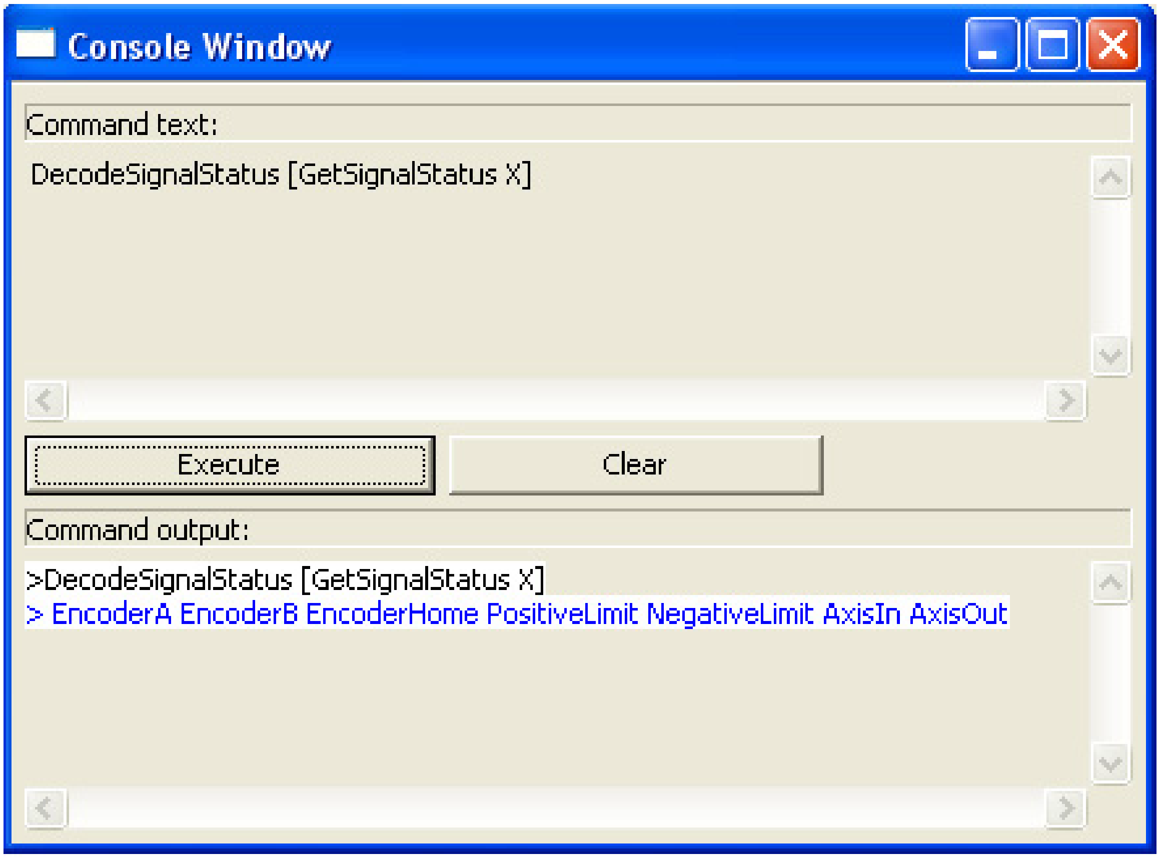


Figure 2-1. Motion Console - EasyMotion command interface

2.2 First Time System Verification

To verify that the Millennium board has been properly installed, it is useful to have each axis of the system perform a short move.

For the MC2100 parts to perform this simple sequence it is necessary to specify two items:

- the motor amplifier type (PWM sign/mag, PWM 50/50, or analog)
- the filter gains

For the MC2300 parts it is necessary to specify these two items as well as to initialize the motor commutation.

The following table summarizes this. Note that the step #'s reference specific steps, which are detailed in the next section.

Chipset	Step #	Operation
MC2100	1	Set amplifier type (PWM sign/mag, PWM 50/50, DAC)
	4	Set filter parameters
	5	Make a trajectory move

MC2300	1	Set amplifier type (PWM 50/50, DAC)
	2	Initialize commutation
	3	Check Commutation
	4	Set filter parameters
	5	Make a trajectory move

Only perform the setup step sequences indicated above for the chipset installed on your board.

To start verification use the following Navigator commands

SetActualPosition 0

Update

SetKp 25

Refer to the "Programmers Reference Manual" for a full list of commands.

It is assumed that you will check out each axis of your system one at a time. Then to check out other axes enter a new axis number and check that axis out entirely, etc.

2.2.1. Step #1 Set the Motor Amplifier Type

The card must be told what type of motor output mode to use, PWM sign/mag, PWM 50/50, or DAC. This can be set using the command SetOutputMode. Assuming the axis you want to exercise is #1, you would use the command "SetOutputMode" followed by the output mode: 0 for DAC, 1 for PWM sign/mag, and 2 for PWM 50/50. For example to specifiy the output mode as PWM 50/50 the following command would be used:

SetOutputMode 2

2.2.2. Step #2 Initialize Commutation

Note: This sections applies to MC2300 and MC2800 chipsets only.

For the motor to be controlled properly using the MC2300, the chipset must select and possibly initialize the commutation phasing. If you will be using Hall-based commutation then no initialization is necessary. Simply specify this to the chipset using the command:

SetCommutationMode 1

No other commands are necessary and you may proceed to step #3.

If you will be commutating using a sinusoidal technique you must initialize the commutation phasing. There are two ways this can be done. You will need to decide whether to initialize using Hall-based or algorithmic methods. See the Navigator User's Guide for more information on this.

Each of these two phase initialization methods requires a separate sequence, as follows (note that // indicates a comment and should not be typed in):

Hall-based initialization command sequence:

```
SetPhaseInitializeMode 1        // set phase initialize mode to 'Hall-based'
SetNumberPhases x               // where x is 2 or 3 depending on type of motor
InitPhase
```

Algorithmic-based initialization command sequence:

```
SetPhaseInitializeMode 0          // set phase initialize mode to 'algorithmic'
SetMotorMode 0          // places axis in open loop mode, required for algorithmic init.
SetNumberPhases x          // x is 2 or 3 depending on type of motor
SetPhaseCounts yyyy          // yyyy is # of encoder counts per elec. cycle
SetPhaseInitializeTime zzzz          // zzzz is # of chipset cycles to initialize for
SetMotorCommand wwww          // wwww is motor command.
InitPhase
```

To determine the values of x, yyyy, zzzz, and wwww you should refer to the Navigator User's Guide, "commutation" section.

If your system has one or more of the following conditions present then the above sequence will need to be expanded. To handle such systems you will need to use the SetSignalSense command as well as the SetPhasePrescale command. Call Cito Systems for assistance

1) One or more Hall signals must be inverted to commutate or initialize the commutation correctly

2) # of encoder counts per electrical cycle exceeds 32,767

2.2.3. Step #3 Check Commutation

Note: This sections applies to MC2300 and MC2800 chipsets only.

After phase initialization has been completed it is useful to check the smoothness of the motor rotation in open loop mode to verify that the motor phasing initialization and commutation is correct. To do this use the following command sequence:

```
SetMotorMode 0          // set axis for open loop operation
SetMotorCommand xxxx          // xxxx is the motor command from 0 to 32,767 to output
Update
```

The 'xxxx' value represents the fraction of the value 32,768 of total power that will be applied to the motor. For example, a value of 1,000 sends roughly 3% of the total power to the motor.

When the motor mode is set off, the motor is not under servo control. Beware that the motor may spin rapidly after a motor command value is applied. Use small values and increase slowly.

After this command sequence the motor should smoothly spin in one direction or the other. The motor command is a signed number and the sign controls the rotation direction. When a positive motor command is given the motor should rotate in the positive (increasing encoder counts) direction. If the motor spins roughly, in the wrong direction, or if it moves a short distance and then abruptly stops there may be a problem with the commutation. Check your wiring and re-test. Once the motor is spinning smoothly in both directions under open loop control re-enable closed-loop servo control by executing the following command:

SetMotorMode 1

2.2.4. Step #4 Set Filter Parameters

For motion to occur, some amount of feedback gain must be specified. Initially use just a proportional gain with a very low value between 1 and 25. Later you can add integral or derivative gains as well as feedforward gains if desired. The following sequence shows how to set the P, I, and D terms of the filter and how to 'update' them, making them active.

```
SetKp xxxx          // xxxx is the desired proportional gain
SetKd yyyy          // yyyy is the desired derivative gain
SetKi zzzz          // zzzz is the desired integral gain
Update              // make thee values active.
```

It is not necessary to specify all 3 gains. Just Kp, followed by an Update can be specified, just a Kd, etc...

Important note:

> When exercising the motor use extreme caution. It is the responsibility of the user to observe safety precautions at all times.

2.2.5. Step #5 Make a Trajectory Move

To test that the motor is being driven properly, set up and execute a small trapezoidal move. Specify a small distance of (for example) 5,000 counts, and a low velocity and acceleration of (for example) 10,000 counts/sample time, and 10 counts/sample time^2 respectively. With a cycle time of 400 µsec, these values correspond to roughly 381 counts/sec, and 954 counts/sec^2, respectively.

Whatever profile values you use, be sure that they are safe for your system.

Here is the command sequence to use:

```
SetProfileMode 0          // Sets current profile mode to trapezoidal
SetPosition xxxx          // xxxx is the desired destination position
SetVelocity yyyy          // yyyy is the desired maximum velocity
SetAcceleration zzzz      // zzzz is the desired acceleration
SetDeceleration wwww      // wwww is the desired deceleration
Update                    // execute the move
```

After entering this sequence of commands you should see the axis smoothly move for about 15 seconds (if the suggested values are used and the cycle time of the chipset is 400 µsec). If you do not see the axis moving, or if the axis jumps rapidly in one direction or the other, there may be a problem with the board or software settings. Re-check and review the board setup procedures, as well as the exerciser parameter settings.

If you are still having problems after re-checking your system call your Cito Systems representative.

3 Operation

3.1 Card overview

The PC/104 motion controller harnesses the power of a dedicated DSP motion processor, which calculates the servo filter algorithm, generates the trajectory profile and handles some I/Os. It works along with the ASIC chip that conditions encoder feedback signals, generates the PWM output and handles the parallel communication with the host. The motion processor incorporates an advanced PID filter with velocity and acceleration feedforward terms.

The DSP processor is supported by an on-board dual-port RAM. The DP RAM can be utilized as a data trace to capture on-the-fly various parameters or as a fast data exchange buffer between the board and the host.

The motion control card implements the open architecture concept that allows for an easy way to satisfy specific customer needs. Most of the applications, however, fit in the standard board design that features powerful set of I/Os. Besides dedicated opto-isolated I/Os for motion tasks, the board has a set of general purpose digital I/Os, the board has a set of general purpose digital I/Os. The TTL level outputs are paralleled with a driver that allows controlling power demanding peripheral devices. In addition, there is a set of analog inputs. Motor drives can be interfaced with differential signals enhancing immunity to electrical noise. The board has built-in features that make easy implementation of sophisticated safety and fault handling schemes. The design eliminates need for additional daughter boards, thus enabling extremely compact and versatile control systems integration.

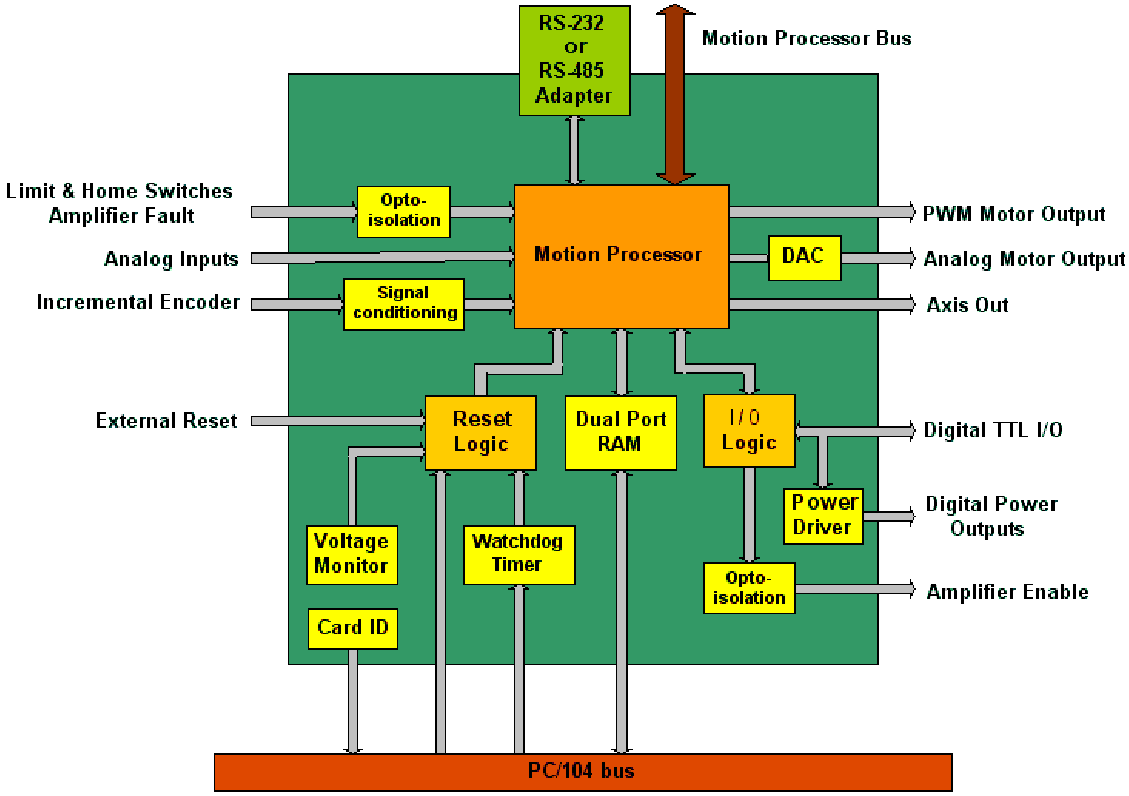


Figure 3-1. PC/104 motion controller block diagram

3.2 Dual-port RAM

To enhance the card performance, the dual-port RAM capability has been implemented for fast data exchange with the host. It allows direct data flow from and to the host, bypassing the card's motion processor. The DP RAM can be accessed through automatically incremented addressing (auto-incremental mode), which is faster than the non-incremental mode, in which the memory address has to be specified each time being accessed.

The dual port RAM can operate in 4 different modes, which are listed in the table below. They can be set through *CMSetMemoryMode()* command from the C-MotionPlus library. Writing and reading to the memory is done through respectively *CMWriteMemory()* and *CMReadMemory().*

Access operation	Parameter value
Non-incremental **writing and reading** to/from the memory	0
Auto-incremental, for only **reading** from the memory	1
Auto-incremental, for only **writing** to the memory	2
Auto-incremental, for **writing and reading** to/from the memory	3

3.3 Safety Features

The PC/104 motion card design accommodates a set of features that can be utilized in developing safety and fault handling schemes. In the event, external or internal erroneous conditions occur, the board settings could be brought to their default state. The most important purpose of these features is to insure the moving motors to a safe stop.

3.3.1. Hard Reset

The hard reset generates a signal that causes the board to go into an initial state as when it is powered up. The processor reinitializes itself bringing all settings to the default values and the card circuitry is set to its initial state. It means that motor command outputs are set to zero forcing the motors to a safe stop. The hard reset is executed by the C-MotionPlus command - *CMHardReset()*.

3.3.2. Soft Reset

The board can perform a soft reset command. The soft reset, executed by *PMDReset()* command from the C-MotionPlus library, changes all motion processor settings to their default values and does not affect other circuitry on the board like the general purpose I/Os, memory content and reset status monitor. This command sets motor output signals to zero thus bringing the motors to a safe stop.

For the motion processor default values refer to the “Programmer’s Reference Manual”.

3.3.3. External Reset

The card provides an input at the pin 43 of the J12 connector to interface the external reset signal, which can be generated by a switch or an electronic circuit. The reset is triggered by an active-low TTL compatible logic for a minimum duration of 1 ms. The reset input employs an internal pull-up resistor.

3.3.4. Under Voltage Monitor

An under voltage monitor circuit contributes to the overall system safety scheme. It detects power supply voltage drop below level of 4.625V and, should it happened, generates the hard reset signal to the processor. The reset causes the motor command outputs to be set to zero bringing the motors to a safe stop and all the board settings to the default values.

3.3.5. Watchdog Timer

The watchdog timer is a dedicated 4-bit write only register that serves system safety functionality. It generates the hard reset signal in the event of disrupted communication between the motion card and the host lasting more than the specified period of time. The reset causes the motor command outputs to be set to zero bringing the motors to a safe stop and all the board settings to the default values.

A dedicated C-MotionPlus library function *CMSetWatchdog()* enables the watchdog timer when it is called for the first time. The default state of the watchdog timer is *disabled*, thus long as no call to this function happens the watchdog remains inactive. A parameter to the function specifies the watchdog sleep phase, which falls in a range of 1-393 msec. Repeatable calling this function within the specified time period prevents the processor from being reset and keeps it in normal working condition. Once this period is exceeded and no function call happens, the reset event will occur

3.3.6. Reset Status Monitor

All the reset sources can be monitored via the reset status register. The *CMGetResetStatus()* command from the C-MotionPlus library reads the register's content. The below table list the encoding of the data returned by this command.

Reset source	Bits	Description
Reserved	0..7	Not used, may be 0 or 1
Soft reset	8	Set to 1 when Reset() command was executed
External reset	9	Set to 1 when external signal at J12 pin 43 was brought to low
Under voltage	10	Set to 1 when power supply voltage dropped below 4.625V
Watchdog	11	Set to 1 when watchdog time out occured
Hard reset	12	Set to 1 when HardReset command was executed
Reserved	13..15	Always set to 0

After the reset signal has been detected and its source identify from the reset status register through *CMGetResetStatus()* command, the content of the reset status register can be cleared. This way the register bits are refreshed to capture new reset conditions.

3.4 Card ID Number

Each card has its own identification number coded. To query the board for its ID number, the CM*GetCardID()* function from the C-MotionPlus library should used.

4 Connecting Hardware

This section explains how to connect external components to the Millennium PC/104 motion control card. It assists the motion system designers in integrating the card to their designs.

4.1 Motor Output Command Signals

The Millennium series controllers can control, depending on the card model, servo brush, servo brushless, stepper and micro-stepping motors. The following sections describe motor output command signals that control each motor type.

4.1.1. Analog Output Motor Command

For motor amplifiers that take an analog control signal and drive servo or microstepping motors, this group of motor command signals should be used. This output provides analog voltage in the –10V - +10V range and can used as the single-ended or differential analog signal in case of non-phased motion processor MC21xx.

The analog output mode of operation can be set ing *PMDSetOutputMode()* command from the C-MotionPlus library.

Section 5.2 *Appendix B. Outputs to Motor Amplifiers* in this manual describes in detail connections to motor amplifiers, depending on a motor type and its phase number.

4.1.2. PWM Output Motor Command

This set of motor command signals is being used to control servo or microstepping motors and very well suits purpose of simple structure motor amplifiers. The PWM (Pulse With Modulation) output can be configured as Sign/Magnitude or 50/50 mode using *PMDSetOutputMode()* command from the C-MotionPlus library.

Section 5.2 *Appendix B. Outputs to Motor Amplifiers* in this manual describes in detail connections to motor amplifiers, depending on a motor type and its phase number.

4.1.3. Pulse and Direction Output Motor Command

These motor command output signals are compatible with standard amplifies that drive stepper motors. The Pulse signal is a pulse train that controls motor velocity, while the Direction signal, which can be set as low or high, determines in which direction the motor rotates.

4.2 Incremental Encoder

The incremental encoder signals QuadA, QuadB and Index provide position feedback information to the motion processor. They are necessary to close the position loop in servo system applications for DC brush or DC brushless servomotors, continuously tracking motor shaft position. In case of stepper and microstepper motors they can be used as optional source of information to verify a motor shaft position at the move end to eventually compensate for lost steps.

The encoder signals can be configured as single-ended or differential. The single-ended configuration should be used in an electrical noise-free environment and short wire length up to 3m (10ft). It requires only one set of signals to be connected i.e. QuadA+, QuadB+ and Index+, the JP8-JP11 jumpers set to the position 2-3 and the RS1-RS3 resistor packs removed. The differential encoder configuration uses long line drivers and requires all encoder signals to be connected – QuadA+, QuadA-, QuadB+, QuadB-, Index+ and Index-, the JP8-JP11 jumpers installed at the position 1-2 and the RS1-RS3 resistor packs installed on the cards.

4.3 Parallel Feedback Devices

The PC/104 board is capable of handling feedback information from parallel devices, like absolute encoders and laser interferometers. Since these devices vary from one manufacturer to another, a dedicated adapter board has to be designed to interface to a specific device. Cito Systems provides design resources upon customer request.

4.4 Home and Limit Switches

The card has a group of dedicated input signals that interface to the motion processor. The Positive and Negative Limits are assigned to each axis to prevent motors from over running its travel limits. They can be programmed as active high or low. When the motion processor senses their active state, it abruptly stops further motor motion in that direction. The reverse motion is possible in order to deactivate the limit signal.

The Home signal is assigned to each axis and is dedicated to its homing function. It can be programmed as active high or low and is used in various homing schemes.

Check “The EasyMotion User’s Manual” and “The Navigator’s Processor User Guide” for a detail description of these signals functionality.

For board’s processor safety and noise immunity these signals are opto-isolated. See fig. 3.1 for the electrical interface to these signals.

In the environment, where electrical noise is not a concern and there is no external power supply available to power Home and Limit switches signals, opto-isolation can be defeated by connecting the board’s digital ground with the Opto ground. In order to that, jumpers JP12 and JP13 should be installed. These jumpers also defeat the Amp Fault signal opto-isolation.

4.5 Amplifier Enable Outputs

The Amp Enable1-4 signals provide opto-isolated digital output for each axis to enable motor amplifiers. They are controlled through *CMAmpEnable()*, a C-MotionPlus library function.

These signals, if not used for the amplifier enable function, can be used as general purpose digital outputs. To ensure boards reliability and noise immunity these signals are opto-coupler driven.

In the environment, where electrical noise is not a concern and there is no external power supply available to power Amp Enable signal, opto-isolation can be defeated by connecting the board’s digital ground with the Amp Enable signal ground. In order to that, jumpers JP16 and JP17 should be installed.

4.6 Amplifier Fault Inputs

The Amp Fault 1-4 signals provide opto-isolated digital inputs, one per axis, from motor amplifiers. This is a direct feedback to the motion card from the amps about their malfunction status. The current status of motor amps can be monitored using the *CMGetAmpFault()* function from the C-MotionPlus library.

If these inputs are not attached to the motor amplifiers they can be used as general purpose inputs. To ensure boards reliability and noise immunity these signals are opto-coupler driven.

In the environment, where electrical noise is not a concern and there is no external power supply available to power Amp Fault signal, opto-isolation can be defeated by connecting the board’s digital ground with the Opto ground. In order to that, jumpers JP12 and JP13 should be installed. These jumpers also defeat the Home and Limit switches signals opto-isolation.

4.7 Axis Out Signal

The Axis Out Signal lines, one per each axis, serve as an external monitoring signals of the Event Status, Activity Status or Signal Status registers bits. They can be used as trigger signals for external devices.

The status register and its monitored bit can be selected using *PMDSetAxisOutSource()* command from the C-MotionPlus library. For detail description of this function see "The Programer's Reference Manual".

4.8 General Purpose Digital I/Os

The board features 8 input and 8 output general purpose TTL level signals. They can be expanded up to 128 inputs or 128 outputs with an additional circuitry. The outputs are configured as totem poles and can interface to CMOS or bipolar external circuits being capable to source/sink up to 20 mA current.

4.8.1. High power digital I/Os

The 8 digital output signals are interfaced through opto-couplers to high power drivers providing control signals for devices that drive higher current at higher voltage than just the TTL devices are capable of. Since there is no need for additional interface driver boards, a highly compact control system can be assembled capable of controlling LEDs, lamps, relays or other devices requiring power control signals.

The high power signals can be configured as current sink or current source devices. When all 8 outputs are turned on, they can continuously provide up to 300 mA current at +24 V supply. Maximum driver rating allows for current not exceeding 500 mA at +50V, when outputs are working in a switching cycle mode. For specifics see technical notes of ULN2803 and UDN2982 devices.

Important note:

> **The power output drivers interface 8 TTL level digital outputs, what means that they have the same logic control. One cannot assume them as being additional signals to the 8 general purpose TTL outputs (see figs. 5.3 and 5.4.).**

4.9 Analog Inputs

The board features 8 analog inputs working in 0 – 5V range with 10-bit resolution. The analog-to-digital converters can be configured in 2 different reference voltage modes using the JP1-JP4 jumper set. When jumpers are installed, the board's internal supply voltage of 5V is enabled as the input to the reference voltage pins. Otherwise, the external voltage not exceeding 5V should be applied to the pins 33, 34, 35 and 36 of the J12 connector. Applying a smaller voltage range to the J12 – pins 33 & 34 than the supply voltage to pins 35 & 36 allows maximizing the measured voltage resolution. In addition to it, using highly stable external power source preserves accuracy and noise immunity of A/D conversion

To read an analog input value the *PMDReadAnalog()* command from the C-MotionPlus library should be used. This function returns 10 bit ADC reading shifted by 6 bits. In case, when 4.0V reference voltage range is applied, the following formula is used to determine analog voltage value:

Value[V] = ADC reading [counts] * 65, 472 / 4.0[V]

The ADCs are sampled every 400 μsec, when the MC2100 and MC2500 chipset series are used or every 600 μsec in case of the MC2300, MC2400 or MC2800.

Important note:

The external reference voltage should not exceed 5V otherwise the analog converters can be damaged.

4.10 The Synch Signal Connector for Multiple Chip Synchronization

When more than one board on the bus is used and precise timing synchronization between the motion processors is required to start or stop the motion, or to change profile parameters, then the J1 connector signal should be used. This signal becomes useful in case when more than 4 axes of motion are involved in synchronized motion.

The *SetSynchronizatinMode()* command from the C-MotionPlus library should be used to set the state of the Synch signal. See the "Programmer's Reference Manual" for the detail description of this command.

Note:

This function is supported by the Navigator MC21x3, MC23x3, MC24x3 and MC28x3 processors, only.

4.11 Serial Transceiver

The card is capable to communicate with the host using the PC/104 bus or an asynchronous serial communication port. When set up to operate with the PC/104 bus as the primary channel of communication, it is still possible to monitor card's parameters via the serial communication port. This setting does not allow executing active commands over the serial port, though and it is used only for diagnostic purposes. In case, when the board is set to use the serial port as the primary communication channel, the PC/104 bus becomes disabled and all the commands can be executed over the serial port.

To configure the card for the PC/104 bus communication mode, jumper JP7 should be set to position 2-3. For the serial port communication only, pins 1-2 of JP7 should be jumped.

The asynchronous serial communication can be performed following the RS-232 or RS-485 communication standards. Each of these interfaces requires a dedicated adapter available from Cito Systems. The adapter interfaces to J2 connectors and allows setting transmission parameters such as a baud rate, parity, stop bits and protocol.

The transmission parameters can be set with the *SetSerialPortMode()* command from the C-MotionPlus library or using micro-switches directly on the adapter board. The baud rate can range from 1200 to 416667 bauds at different combination of parity and stop bit settings. The point-to-point, multi-drop using address bit or multi-drop using idle line detection protocols are available. The default transmission parameter settings are: 9600 baud rate, no parity, one stop bit, and point to point mode.

For micro-switch hardware settings the user should refer to the “Serial Adapter Users Manual”.

5 Appendices

5.1 Appendix A. PC/104 Motion Controller Electrical Reference

5.1.1. PC/104 Motion Card Layout

Figure 5.1 shows the locations of the principal components of the Millennium controller board. The component side of the board is shown, with the PC/104 bus connector at the bottom. All component locations in this manual are referred to this orientation.

Jumpers JP1 – JP4 set analog input reference source
Jumpers JP5 & JP6 leave at the default factory setting
Jumper JP7 sets the Host I/O mode
Jumpers JP8 – JP11 set incremental encoder signal type
Jumpers JP12 & JP13 set committed I/O signals voltage supply source
Jumpers JP14 & JP15 set high power digital output configuration
Switch block S1 sets the card's base address and the IRQ level
Connectors J1 – J12 are described in the second part of this manual
Resistor packs RS1 – RS3 are set according to the type of encoder used
Resistor packs R26 & R27 are set according to external power supply voltage of opto-isolated committed I/O signals used

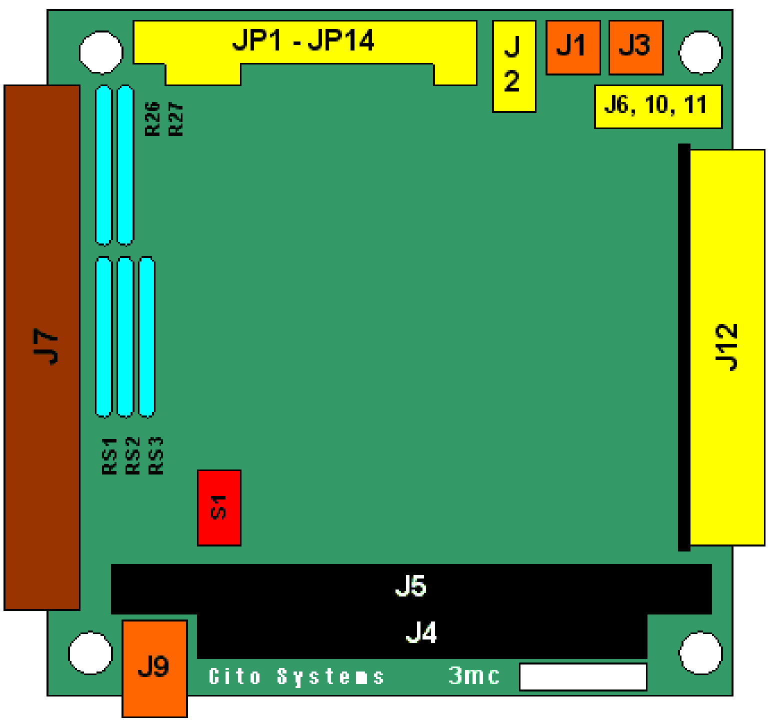


Figure 5-1. PC/104 motion controller connector layout

5.1.2. PC/104 Motion Card Connectors

This section describes the pinouts for the following cable connectors on the Millennium motion control card (Figure 5-1):

J1	2-pin chipset synchronization signal
J2	5-pin serial asynchronous communication port connector
J3	2-pin host interrupt signal
J6	internal use
J7	100-pin main connector containing encoder input, Hall input, Fault Input, Axis Out signals, Motor output signals, and limit switch inputs
J8	internal use
J9	4-pin +5V, -12V and +12V power supply
J10	internal use
J11	internal use
J12	44-pin miscellaneous I/O signals connector

5.1.2.1. Motion Processor Synchronization Signal Connector (J1)

Location: Along the upper edge, at the far right corner of the board, between J1 and J3.
This is a 2-pin header (0.1” spacing)

Pin number	Signal Name
1	Synch
2	GND

This connector provides signal for synchronizing motion processors on different boards.

5.1.2.2. Serial Communication Channel Connector (J2)

Location: Along the upper edge, at the far right corner of the board, next to the J1.
This is a 7-pin single row header (0.1” spacing).

Pin number	Signal Name
1	SrlXmt
2	SrlRcv
3	Synch
4	RDSSN
5	V_{cc}
6	GND
7	N/C

Interface connector for serial link communication adapters.

5.1.2.3. Host Interrupt Signal Connector (J3)

Location: Along the upper edge, at the far right corner of the board, next to J1.
This is a 2-pin header (0.1” spacing)

Pin number	Signal Name
1	Host interrupt
2	GND

This connector provides the interrupt signal to the outside world.

5.1.2.4. Motion Peripherals Connector (J7)

Location: On the left edge of the board.
This is a 100-pin high-density connector (2x50, 0.05” spacing). The cable assembly that can be purchased from Cito Systems, consists of two 36” flat ribbon cables terminating together at one end in the matching 100-pin connector. At the other end, each ribbon terminates in a 50-pin header (2x25, 0.1” spacing). The ribbons are labeled **Hdr1** and **Hdr2**. Pins 1-50 on Hdr1 connect to pins 1-50 of J7. Pins 1-50 of Hdr2 connect to pins 51-100 of J7.

Header 1 *(to J7 pins 1-50)*				**Header 2** *(to J7 pins 51-100)*			
First row		*Second row*		*Third row*		*Fourth row*	
Pin	**Signal Name**	**Pin**	**Signal Name**	**Pin**	**Signal Name**	**Pin**	**Signal Name**
1	QuadA1+	26	QuadA2+	1	QuadA3+	26	QuadA4+
2	QuadA1-	27	QuadA2-	2	QuadA3-	27	QuadA4-
3	QuadB1+	28	QuadB2+	3	QuadB3+	28	QuadB4+
4	QuadB1-	29	QuadB2-	4	QuadB3-	29	QuadB4-
5	Index1+	30	Index2+	5	Index3+	30	Index4+
6	Index1-	31	Index2-	6	Index3-	31	Index4-
7	V_{cc} (encoder)	32	V_{cc} (encoder)	7	V_{cc} (encoder)	32	V_{cc} (encoder)
8	GND (encoder)	33	GND (encoder)	8	GND (encoder)	33	GND (encoder)
9	Hall1A	34	Hall2A	9	Hall3A	34	Hall4A
10	Hall1B	35	Hall2B	10	Hall3B	35	Hall4B
11	Hall1C	36	Hall2C	11	Hall3C	36	Hall4C
12	GND (Hall)	37	GND (Hall)	12	GND (Hall)	37	GND (Hall)
13	PosLim1	38	PosLim2	13	PosLim3	38	PosLim4
14	NegLim1	39	NegLim2	14	NegLim3	39	NegLim4
15	Home1	40	Home2	15	Home3	40	Home4
16	Fault1	41	Fault 2	16	Fault 3	41	Fault 4
17	AxisOut1	42	AxisOut2	17	AxisOut3	42	AxisOut4
18	PWMMagA1	43	PWMMagA2	18	PWMMagA3	43	PWMMagA4

19	PWMMagB1	44	PWMMagB2	19	PWMMagB3	44	PWMMagB4
20	PWMMagC1	45	PWMMagC2	20	PWMMagC3	45	PWMMagC4
21	PWMsign1	46	PWMsign2	21	PWMsign3	46	PWMsign4
22	DACV1*	47	DACV2*	22	DACV3*	47	DACV4*
23	/DACV1*	48	/DACV2*	23	/DACV3*	48	/DACV4*
24	GND (DAC)	49	GND (DAC)	24	GND (DAC)	49	GND (DAC)
25	Opto VSS	50	Opto GND	25	Opto VSS	50	Opto GND

*DACV*n* and /DACV*n*, are mapped to two analog output signals for axis *n*. For non-phased chipset products (for example MC2401) this is an analog differential control output.

Note 1.

For MC2500 chipset series (stepper motor controllers) signals PWMMagA are used as Pulse and PWMMagC are used as Direction. The remaining motor signals are not connected.

5.1.2.5. External Power Supply Connector (J9)

Location: Along the lower edge, at the far left corner of the board.

This is a 6-pin single row right-angle header (0.1" spacing).

Pin number	Signal Name
1	+VS
2	Power GND
3	+5 V
4	GND
5	-12V
6	+12V

This connector harnesses external power supply source signals in case, when the power is not available through PC/104 bus.

+VS is a supply voltage that can range from +5 to +50 VDC and allowing do derive max. 500 mA current from a single high power digital output.

5.1.2.6. Miscellaneous I/O Signal Connector (J12)

Location: On the right edge of the board.

This is a 44-pin right angle header (2x22, 0.1" spacing).

Pin number	Signal Name	Pin number	Signal Name
1	PrlIn 0	23	PrlPwrOut 6
2	PrlIn 1	24	PrlPwrOut 7
3	PrlIn 2	25	Analog Input 1

4	PrlIn 3	26	Analog Input 2
5	PrlIn 4	27	Analog Input 3
6	PrlIn 5	28	Analog Input 4
7	PrlIn 6	29	Analog Input 5
8	PrlIn 7	30	Analog Input 6
9	PrlOut 0	31	Analog Input 7
10	PrlOut 1	32	Analog Input 8
11	PrlOut 2	33	AnalogRefHigh
12	PrlOut 3	34	AnalogRefLow
13	PrlOut 4	35	AnalogVcc
14	PrlOut 5	36	AnalogGND
15	PrlOut 6	37	Amp Enable 1
16	PrlOut 7	38	Amp Enable 2
17	PrlPwrOut 0	39	Amp Enable 3
18	PrlPwrOut 1	40	Amp Enable 4
19	PrlPwrOut 2	41	Amp Enable +V
20	PrlPwrOut 3	42	Amp Enable GND
21	PrlPwrOut 4	43	External Reset
22	PrlPwrOut 5	44	HSTRDY (internal use)

Note 2.

PrlPwrOut *n* output signals overlap digital output TTL-level signals PrlOut *n*. They can be used to control relays, solenoids, lamps, LED, etc. They can deliver up to 300 mA continuous current when all of the outputs are ON at +24V. Otherwise, up to max 500 mA at +50V, depending on the switching cycle.

Note 3.

PrlOut *n* output signals are overlapped by high power output signals PrlPwrOut. They can be used when high power logic signals are not desirable to be used e.g. interfacing to CMOS or TTL logic.

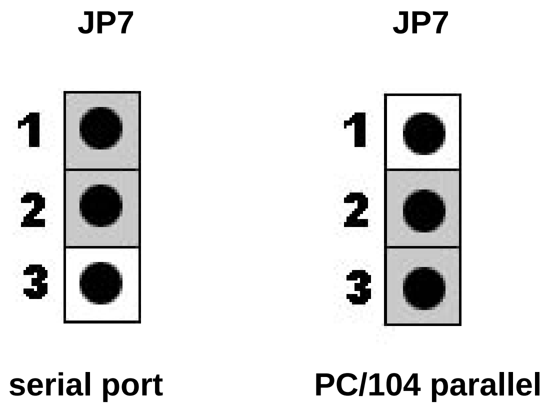
5.1.3. PC/104 Motion Controller Configuration Jumpers and Switch Block Settings

The PC/104 motion control board employs a set of jumpers and a block of microswitches for some hardware configuration. The jumper bank is located along the upper edge of the board, while the switch block in its lower part, close to the bus connectors J4 and J5. This section describes settings of the jumpers and the switch block for possible hardware configurations.

5.1.3.1. Setting the Host I/O Mode – JP7

The PC/104 motion controller supports two different communication modes.

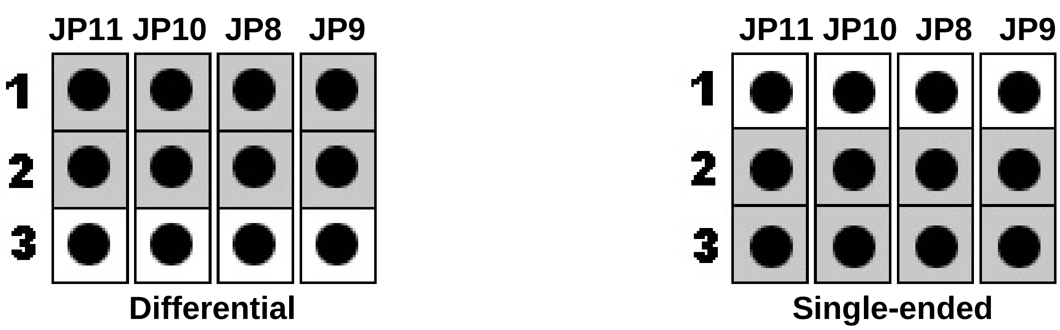
The figure below shows how the JP7 jumper should be installed to select the host mode. PC/104 mode is the default. Shading indicates the location of the jumper.



The default Host I/O mode setting is "PC/104 bus"

5.1.3.2. Setting the Incremental Encoders Input Signal – JP8 - JP11

The Millennium series controllers support differential or single-end incremental encoder outputs. The figure below shows how JP8 – JP11 jumpers should be installed to select the encoder output signal.



The default incremental encoder output signal setting is "Differential"

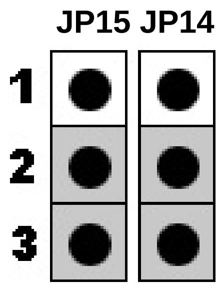
5.1.3.3. Setting the Committed I/O Signal Voltage Supply Source – JP12 & JP13

The PC/104 motion controllers use opto-isolation on the HOME, LIM"-", LIM"+" and FAULT dedicated input signals. For applications that do not demand opto-isolation the internal +5VDC supply voltage can be used, otherwise an external power supply voltage has to be applied. If the board internal supply voltage is used, the jumpers JP12 & JP13 should be installed, otherwise they must be removed.

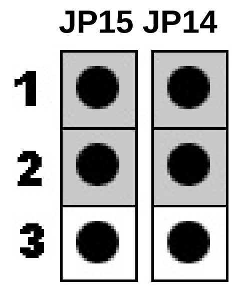
The default committed I/O signal voltage supply source setting is "Internal"

5.1.3.4. Setting the High Power Digital Output – JP14 & JP15

The PC/104 motion board provides high voltage high current digital signals on the J12 connector. These output signals can work either as current sink with ULN2803 or current source with UDN2982. It is up to customer order, what type of output driver should be installed. The figure below shows how JP14 & JP15 jumpers should be installed to select the digital output configuration.



Current source
UDN2982



Current sink
ULN2803

The default high power digital output signal setting is "current source"

5.1.3.5. Setting the Analog Input Voltage Reference Source – JP1 – JP4

The PC/104 motion controller supports analog input signals on the J12 connector. The reference voltage is provided internally as +5 VDC or can be supplied from an external source. If the board internal reference source is used, the jumpers JP1, JP2, JP3 & JP4 should be installed, otherwise they must be removed.

The default analog input voltage reference source setting is "Internal"

Note:
Jumpers JP5 & JP6 should follow the factory setting – JP5 installed on 1&2 and JP6 removed.

5.1.3.6. Setting the Base Address and the IRQ Level – S1

DIP switch block S1

Switch block S1 is oriented vertically on the controller board; "ON" is the position to the right.

S1 switches 1-4: base I/O address

Address	S1-1	S1-2	S1-3	S1-4
300h	■	■	■	■
310h	□	■	■	■
320h	■	□	■	■
330h	□	□	■	■
340h	■	■	□	■

350h	□	■	□	■
360h	■	□	□	■
370h	□	□	□	■
380h	■	■	■	□
390h	□	■	■	□
3A0h	■	□	■	□
3B0h	□	□	■	□
3C0h	■	■	□	□
3D0h	□	■	□	□
3E0h	■	□	□	□
3F0h	□	□	□	□

S1 switches 5-8: IRQ

IRQ	**S1-5**	**S1-6**	**S1-7**	**S1-8**
3	□	□	□	■
5	■	□	□	■
7	□	■	□	■
10	■	■	□	■
11	□	□	■	■
12	■	□	■	■
14	□	■	■	■
15	■	■	■	■
IRQ disabled	–	–	–	□

5.2 Appendix B. Outputs to Motor Amplifiers

The controller board supports three types of output to the motor amplifiers:

DAC — Analog signals from the on-board D/A converters

PWM 50/50 — Pulse-width modulated square-wave signals with a 50% duty cycle

PWM sign-magnitude — Pulse-width modulated signals with definable duty cycle and direction

These outputs should be connected from the designated J7 pins to the appropriate amplifier inputs, as shown in the following tables. The names of the inputs pins may vary among amplifiers; common names are shown.

5.2.1. Brushed Servo Motors (MC2100 series)

			J7 connection (Header-pin)			
	Signal name	**Amplifier input**	**Axis 1**	**Axis 2**	**Axis 3**	**Axis 4**
DAC	DACA*n*	Ref+ or V+	Hdr1-22	Hdr1-47	Hdr2-22	Hdr2-47
	/DACA*n*	Ref- or V-	Hdr1-23	Hdr1-48	Hdr2-23	Hdr2-48
	GND*n*	Ref- or Gnd	Hdr1-24	Hdr1-49	Hdr2-24	Hdr2-49

PWM sign-magnitude	PWMMagA*n* PWMSignA*n*	PWM magnitude PWM direction	Hdr1-18 Hdr1-21	Hdr1-43 Hdr1-46	Hdr2-18 Hdr2-21	Hdr2-43 Hdr2-46

5.2.2. Brushless Servo Motors (MC2300 series)

			J7 connection (Header-pin)			
	Signal name	**Amplifier input**	**Axis 1**	**Axis 2**	**Axis 3**	**Axis 4**
DAC	DACA*n* DACB*n* GND*n*	Ref1+ or V1+ Ref2+ or V2+ Ref- or Gnd	Hdr1-22 Hdr1-23 Hdr1-24	Hdr1-47 Hdr1-48 Hdr1-49	Hdr2-22 Hdr2-23 Hdr2-24	Hdr2-47 Hdr2-48 Hdr2-49
PWM 50/50	PWMMagA*n* PWMMagB*n* PWMMagC*n*	PWM phase 1 PWM phase 2 PWM phase 3	Hdr1-18 Hdr1-19 Hdr1-20	Hdr1-43 Hdr1-44 Hdr1-45	Hdr2-18 Hdr2-19 Hdr2-20	Hdr2-43 Hdr2-44 Hdr2-45

5.2.3. Brush and Brushless Servo Motors (MC2800 series)

			J7 connection (Header-pin)			
	Signal name	**Amplifier input**	**Axis 1**	**Axis 2**	**Axis 3**	**Axis 4**
DAC	DACA*n* DACB**n* GND*n*	Ref1+ or V1+ Ref2+ or V2+ Ref- or Gnd	Hdr1-22 Hdr1-23 Hdr1-24	Hdr1-47 Hdr1-48 Hdr1-49	Hdr2-22 Hdr2-23 Hdr2-24	Hdr2-47 Hdr2-48 Hdr2-49
PWM 50/50	PWMMagA*n* PWMMagB**n* PWMMagC**n*	PWM phase 1 PWM phase 2 PWM phase 3	Hdr1-18 Hdr1-19 Hdr1-20	Hdr1-43 Hdr1-44 Hdr1-45	Hdr2-18 Hdr2-19 Hdr2-20	Hdr2-43 Hdr2-44 Hdr2-45

Note:
* - depends on user axes designation

5.2.4. Microstepping Motors (MC2400 series)

			J7 connection (Header-pin)			
	Signal name	**Amplifier input**	**Axis 1**	**Axis 2**	**Axis 3**	**Axis 4**
DAC	DACA*n* DACB*n* GND*n*	Ref1+ or V1+ Ref2+ or V2+ Ref- or Gnd	Hdr1-22 Hdr1-23 Hdr1-24	Hdr1-47 Hdr1-48 Hdr1-49	Hdr2-22 Hdr2-23 Hdr2-24	Hdr2-47 Hdr2-48 Hdr2-49
PWM 50/50	PWMMagA*n* PWMMagB*n* PWMMagC*n*	PWM phase 1 PWM phase 2 PWM phase 3	Hdr1-18 Hdr1-19 Hdr1-20	Hdr1-43 Hdr1-44 Hdr1-45	Hdr2-18 Hdr2-19 Hdr2-20	Hdr2-43 Hdr2-44 Hdr2-45

5.2.5. Stepper Motors (MC2500 series)

	Signal name	Amplifier input	*J7 connection (Header-pin)* Axis 1	Axis 2	Axis 3	Axis 4
Pulse/Direction	Pulse*n* Direction*n*	Pulse train Direction signal	Hdr1-18 Hdr1-20	Hdr1-43 Hdr1-45	Hdr2-18 Hdr2-20	Hdr2-43 Hdr2-45

5.3 Appendix C. Encoder Inputs

Resistor packs RS1 – RS3.

The three resistor packs are at the left edge of the controller board, next to the 100-pin connector J7. When using differential encoders, leave these packs in place. When using single-ended encoders, remove all three packs. Encoder connections are listed in the below table.

Encoder connections on J7

	Axis 1	Axis 2	Axis 3	Axis 4
A	Hdr1-1	Hdr1-26	Hdr1-51	Hdr1-76
~A	Hdr1-2	Hdr1-27	Hdr1-52	Hdr1-77
B	Hdr1-3	Hdr1-28	Hdr1-53	Hdr1-78
~B	Hdr1-4	Hdr1-29	Hdr1-54	Hdr1-79
Index	Hdr1-5	Hdr1-30	Hdr1-55	Hdr1-80
~Index	Hdr1-6	Hdr1-31	Hdr1-56	Hdr1-81
V_{CC}	Hdr1-7	Hdr1-32	Hdr1-57	Hdr1-82
GND	Hdr1-8	Hdr1-33	Hdr1-58	Hdr1-83

5.4 Appendix D. Opto-isolated Committed Inputs

Resistor packs R26 & R27.

The three resistor packs are at the left end of the controller board, next to the 100-pin connector J7. When using opto-isolation of committed input signals – the fault, home and limit switches powered by an external power supply appropriate values need to be installed. The table below shows the resistor packs values corresponding to different external power supply voltage levels applied.

External supply voltage (+VS)	Resistor value
5V	330 Ω

12-15V	1.2kΩ
24V	2.2 kΩ
48V	4.7kΩ

The default factory setting is 2.2kOhm for +24V external supply voltage.

5.5 Appendix E. PC/104 Motion Controller Signal Connections

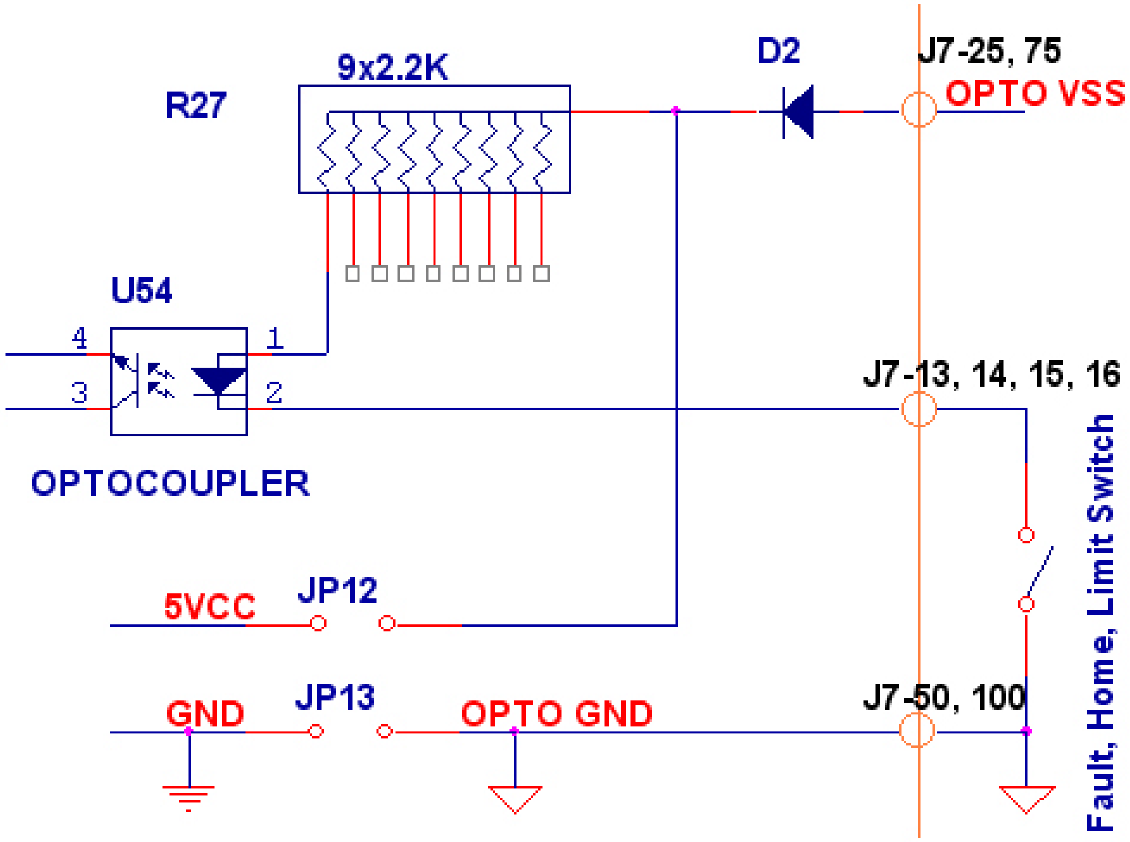


Fig. 5-2. Connecting dedicated inputs of limit and home switches to the controller.

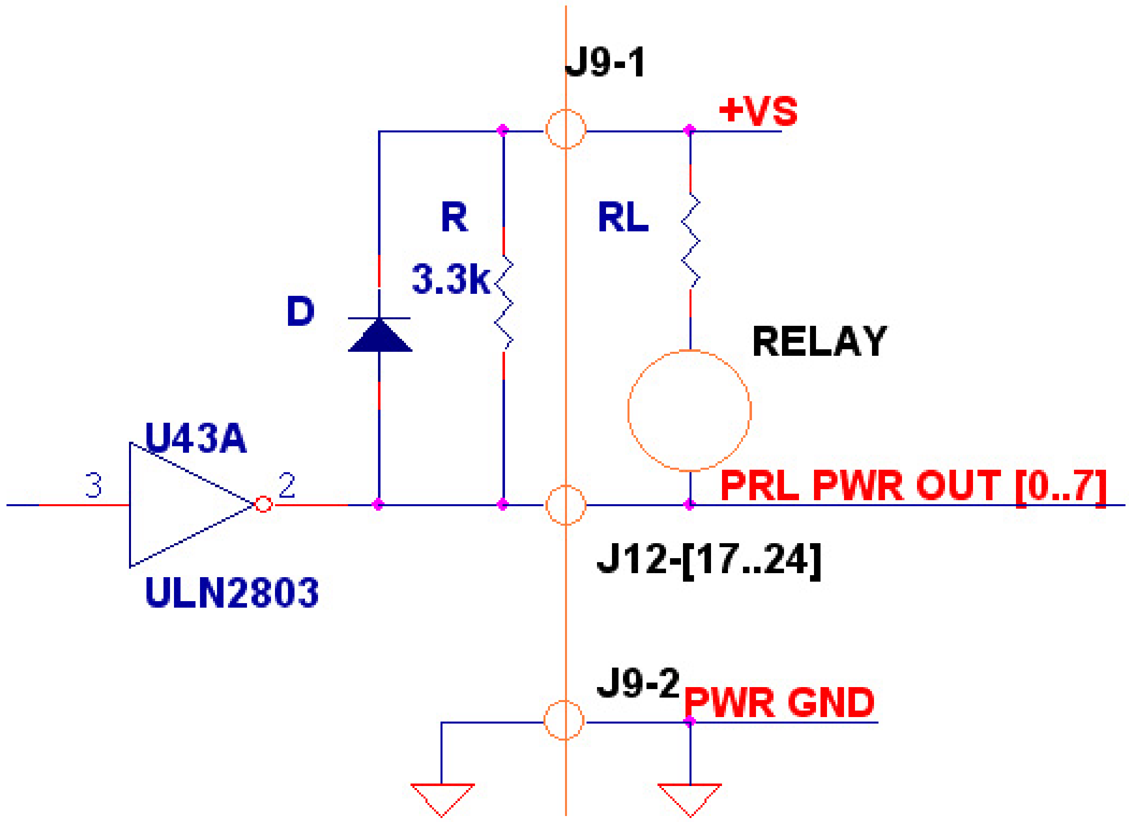


Fig 5-3. Connecting outputs in a version of ULN2803 through ULN2824 high current sinking driver – J12 connector.

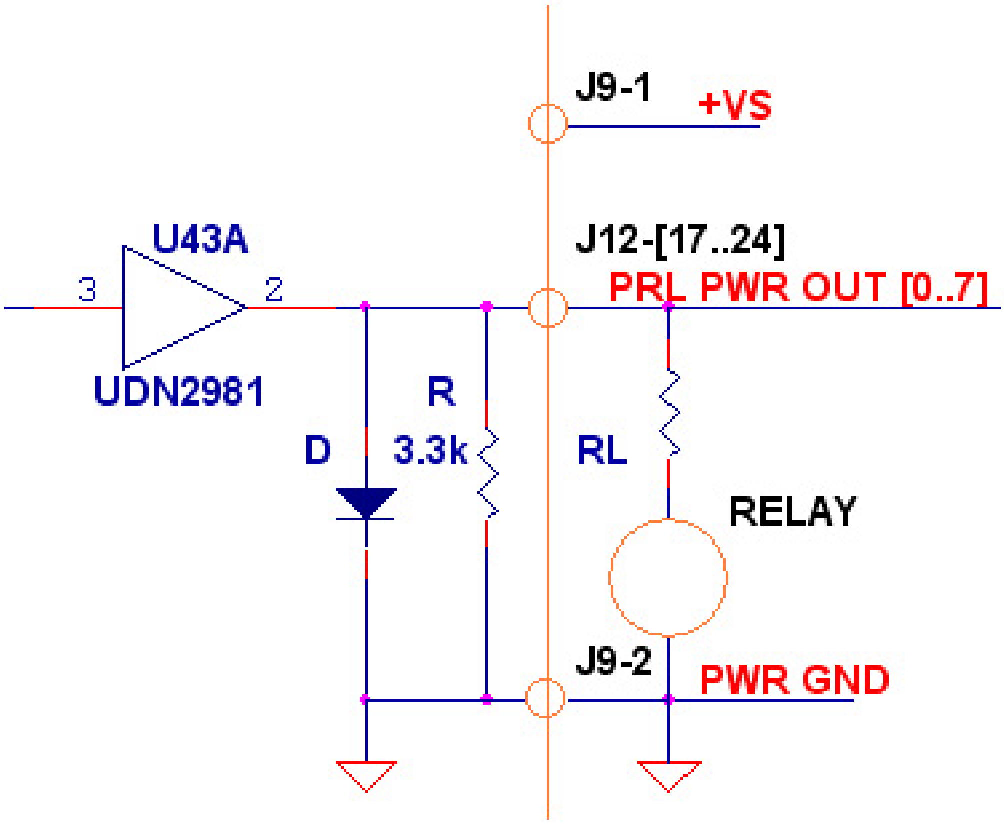


Fig 5-4. Connecting outputs in a version of UDN2981 through UDN2984 high current sourcing driver – J12 connector.

5.6 Appendix F. PC/104 Motion Controller Hardware Information

Environmental and Electrical Ratings

Dimensions	3.945” x 3.775” (100.2 mm x 95.9 mm), PC/104 Adapter
Storage Temperature	-40 °C to 125 °C
Operating Temperature	0 °C to 70 °C*
Power Consumption	1A @ 5V; 83mA @ 12V
Supply Voltage limits	-0.3V to +7.0V
Supply Voltage operating range	4.75V to 5.25V
High power digital output supply voltage range	5.0V to 50.0V
Max. current derived from high power digital I/O	500 mA with variable cycle, 300 mA constant
Analog Output range	-10.0V to 10.0V
Analog Input range	0.0V to 5.0V