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USER'S MANUAL

INTELLIGENT MOTOR CONTROLLERS

For PCI bus

PCIx FAMILY

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1. GENERAL DESCRIPTION

1.1. INTRODUCTION

The Pro-Dex, Inc.,Oregon Micro Systems' PCIx family of PCI products comply with the PCI Local Bus specification (revision 2.2) for a "short-card". The PCIx controller can manage up to four axes of stepper or servo motion control while incorporating other signals; i.e. limits, sensors, I/O, etc. into the system. It can manage coordinated or independent motion of each or all of the axes simultaneously. With high level functionality, such as circular and linear interpolation, multi-tasking, custom profiling, etc., the PCIx can satisfy most any motion control application. See Appendix C Specifications for specific PCIx Family Models.

The PCIx communicates as a slave only device and functions as a motion coprocessor. It utilizes a 32-bit microprocessor and patented, proprietary technology to control the trajectory profile, acceleration, velocity, deceleration and direction of selected axes. In response to commands from the host computer, the PCIx controller will calculate the optimum velocity profile to reach the desired destination in the minimum time while conforming to the programmed acceleration and velocity parameters. In addition the PCIx can provide motion control information such as axis position, the state of overtravel limits and Done interrupts.

The stepper control of the PCIx produces a 50% duty cycle square wave step pulse at velocities of 0 to 1,044,000 pulses per second and an acceleration of 0 to 8,000,000 pulses per second, per second. The servo control utilizes a 16-bit DAC and outputs either +/- 10V or 0 to +10V. The encoder feedback control can be used as feedback for the servo PID, position maintenance for the stepper axes or as strictly a position feedback of any axes. The encoder input supports either differential or single ended quadrature TTL signals at a rate of up to 4MHz and counts at a 4 times resolution. This means a 1000 line encoder will produce 4000 counts per revolution in the PCIx controller.

The PCIx command set employs an ASCII character syntax. Using virtually any programming language, simple ASCII command strings are sent to the PCIx through the PCI bus. A typical motion requirement of 1,000,000 counts at 400,000 counts/sec and an acceleration of 500,000 counts/sec/sec the following string would be sent from the host computer to the PCIx:

VL400000;
AC500000;
MR1000000;
GO;

For additional command programming examples see Section 5 Command Structure

1.2. SYSTEM OVERVIEW

The PCIx is physically a standard PCI module with plug and play capability. The PCIx communication interface is accessed through the bus.

The PCIx utilizes the Motorola 68332 32-bit microcontroller and FPGA technology for extensive logic integration and flexibility. The firmware, which resides in Flash Memory, can be upgraded through the communication interface without having to remove the controller from the system. All input signals to the PCIx are buffered through differential or opto-coupled components and are located on connector J2. The PCIx utilizes the +5VDC supplied by the Host computer through the PCI bus for the logic control and the servo models utilize the additional +/- 12V supply for the analog control.

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The PCIx supports four I/O address registers that provide near real-time information. The data communication is performed by sending and receiving strings of data (ASCII characters) through the data port register. The status register provides handshaking information for writing to the data register as well as some status information including error conditions, motion complete, etc. The PCIx can generate an interrupt to the PCI host and the conditions that cause interrupt can be individually selected by writing to the control register.

More details on each of the communication interfaces as well as the functionality of the controller are included in the following chapters.

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2. GETTING STARTED

2.1. PREPARE FOR INSTALLATION

The installation of the PCIx board is straight forward: With power OFF to the computer, insert the card in a PCI slot of the computer. Power up the computer and install the device driver.

NOTE: The PCIx board may not work well if it is assigned to a shared IRQ in the host system. If this is the case, disable the shared IRQ in the host system's BIOS before installing the PCIx.

Though the PCIx is a very low power device, there should be ventilation, including forced air, around the circuit board. The PCIx will get all of its power from the PCI bus.

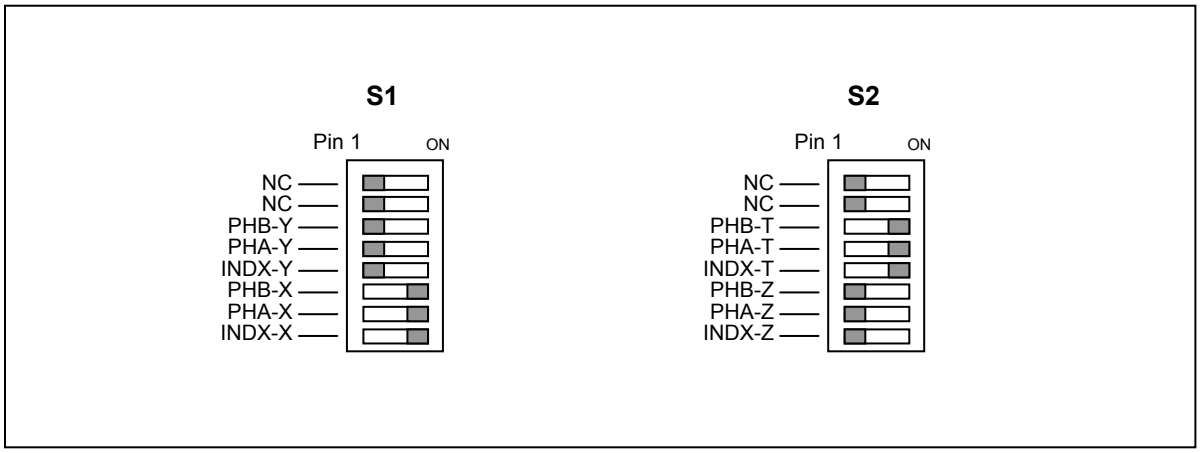
2.2. TO PREPARE FOR INSTALLATION

If you plan on changing any of the factory default jumper or switch settings this should be done before installing the PCIx in the computer. The I/O Bit Direction switch and Board Number Select jumper must be set BEFORE power up.

If the PCIx is to be installed with other PCIx boards, the Board Number Select jumper must be set to a different value on each board. The Board Number Select jumper is located near the top center of the PCIx board and is labeled JP6. Set the first PCIx to identification number 1, the second PCIx to 2, and so forth, according to Table 2-1 Possible Board Number Select Settings (JP6). See Section 2.3 INSTALL THE PCIx INTO A PCI SYSTEM for further installation instructions. For instruction on configuring stepper motors for use with the PCIx see Section 2.5 CONNECT TO STEPPER MOTOR SYSTEM. For instruction on configuring servo motors with the PCIx, see Section 2.6 CONNECT AND CHECKOUT THE SERVO SYSTEM.

Switches S1 and S2 are used for encoder biasing when using single ended encoders. For differential encoders, leave these switches in the OFF position (factory default). When using single ended encoders on an axis, put the appropriate switch positions for Phase A-, Phase B- and Index- of that axis in the ON position. See figure 2-1 Definition of Encoder Biasing Switches.

FIGURE 2-1 DEFINITION OF ENCODER BIASING SWITCHES



Note: In Figure 2-1 switches S1 and S2 are configured for differential encoder inputs for the Y and Z axes and single ended encoder inputs for the X and T axes.

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Switch S3 is used to determine I/O bit direction. The factory default setting (Figure 2-4 PCIx Jumpers/Switches) sets I/O bits 0-3 as inputs and bits 4-7 as outputs. A switch in the ON position sets the associated I/O bit as an output. A switch in the OFF position sets the associated I/O bit as an input. See S3 Switch Definition.

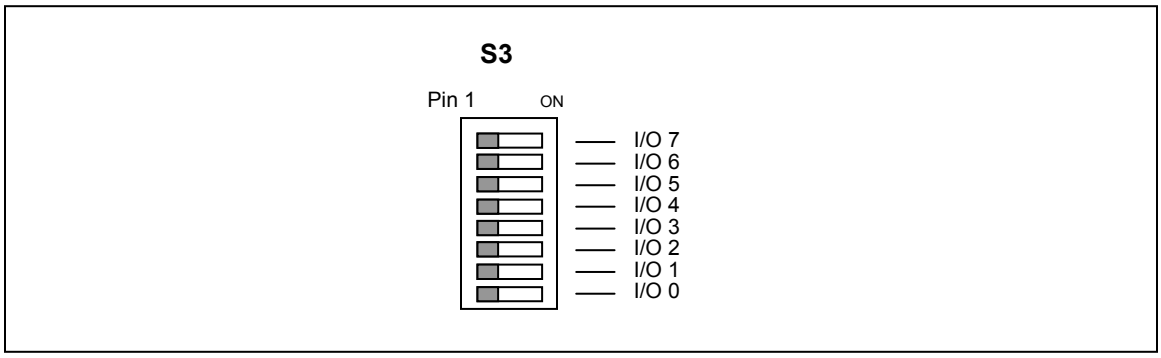


FIGURE 2-2 S3 SWITCH DEFINITION

Note: In Figure 2-2 switch S3 is configured for I/O bits 0-7 as inputs.

Jumper J3 is used to route the appropriate I/O bit to the output connector J2. The factory default setting routes the input bits 0-3 and the output bits 4-7 to J2. See Figure 2-3 J3 Pin Definition.

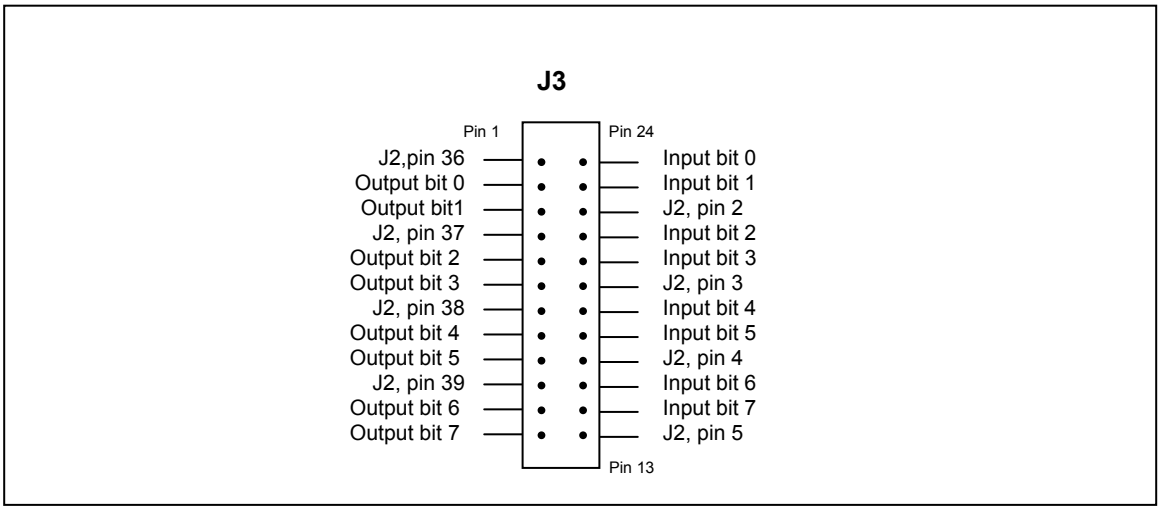


FIGURE 2-3 J3 PIN DEFINITION

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For example, if you set all I/O bits as inputs, J3 would be configured as follows:

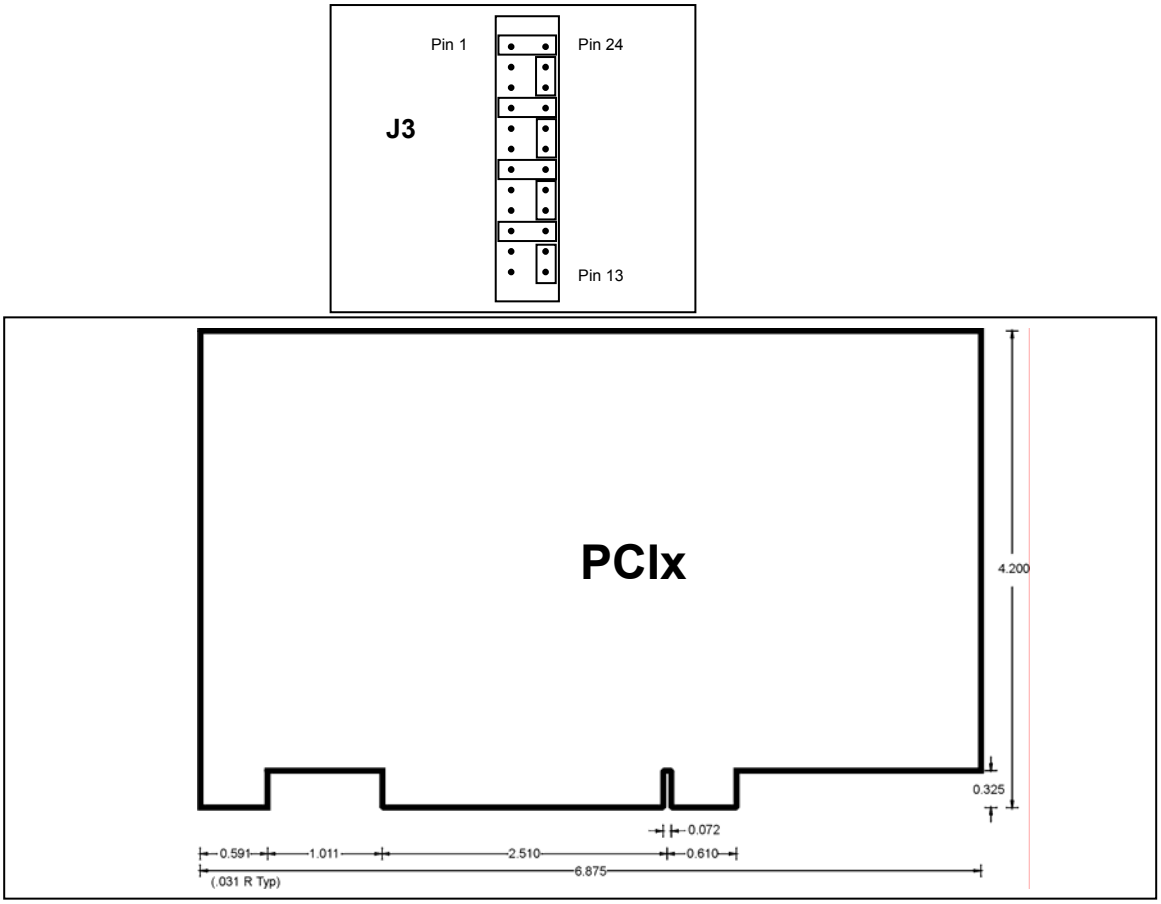


FIGURE 2-4 PCIX Diagram

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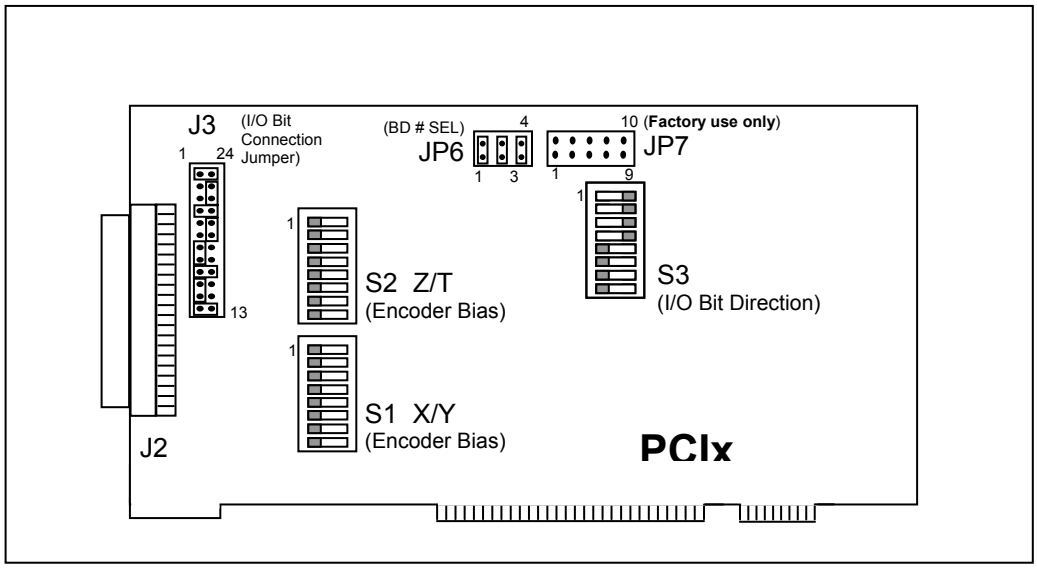


FIGURE 2-5 PCIx JUMPERS/SWITCHES (Factory default shown)

Figure 2-5 illustrates the locations of the jumpers and switches on the PCIx.

TABLE 2-1 POSSIBLE BOARD NUMBER SELECT SETTINGS (JP6)

Board ID#	Jumper 1 / 2 / 3 Setting
1*	On / On / On
2	Off / On / On
3	On / Off / On
4	Off / Off / On

* Factory Default

Up to four PCIx boards may be installed in the same computer. Note that Jumper 3 in the Board Number Select (JP6) must be ON at all times.

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2.3. INSTALL THE PCIx INTO A PCI SYSTEM

- Turn off power to the PCI computer, and disconnect its power cord from the wall socket. Remove the cover of the computer to gain access to the PCI Bus.
- On the PCIx board, use factory default jumper settings or configure all switches and jumpers as needed. (Configurable switches are: S1, S2 and S3. Configurable jumpers are: J3 and JP6).
- Align the PCIx in the PCI slot of the computer and insert the PCIx fully into the slot (non-master slot.)
- Double check the board to ensure it is properly seated in the connector.
- Use a screw to fix the bracket on the PCIx to the computer's chassis.
- Replace the power cord, and turn on the computer.
- Allow the computer to boot up.

Caution

Establish communication with the controller board **before** wiring external components to the board (i.e. drivers and motors).

DO NOT make wiring connections to the controller board with power applied to the board.

2.4. SOFTWARE INSTALLATION

Pro-Dex, Inc., Oregon Micro Systems provides drivers for Windows NT/XP/2000 and Windows 95/98/ME, for Linux support-refer to Linux support package on our website (http://www.pro-dex.com), for other operating systems please contact Pro-Dex, Inc., Oregon Micro Systems, refer to Appendix B.

For Windows NT/XP/2000

After installing the PCIx in the chassis, apply power to the host PC and insert the software support disk or CD-ROM supplied by Pro-Dex, Inc., Oregon Micro Systems, or downloaded from the Pro-Dex, Inc., Oregon Micro Systems website. Follow the installation instructions found in README.TXT in the root directory of the disk.

To begin communicating with the PCIx, run PCICOMM.EXE from the installation disk. You can begin interactively sending commands and receiving responses immediately if all has been properly installed. If the Board Number select jumper is set to something other than 1, run the communication program with the switch /c:#, where # is the Board Number. For example if Board Number = 2 then type "PCICOMM /C:2".

Type WY and observe the response from the PCIx. You should receive a reply similar to “PCIX-400 ver 1.26 S/N 000000, Oregon Micro Systems” from the PCIx. If you receive nothing, double

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check that the PCIx is fully seated in the chassis and the device drivers are installed properly. For technical support, refer to Appendix B of this manual for contact information.

For Windows 95/98/ME

After Installing the PCIx in the chassis, apply power to the host PC. The system will request a driver for the device. Insert the software support disk from Pro-Dex, Inc., Oregon Micro Systems and follow the instructions in Windows for adding a new hardware device.

To begin communicating with the PCIx, run PCICOMM.EXE from the installation disk. You can begin interactively sending commands and receiving responses immediately if all has been properly installed. If the Board Number select jumper is set to something other than 1, run the communication program with the switch /c:#, where # is the Board Number. For example, if Board Number = 2 then type "PCICOMM /C:2".

Type WY and observe the response from the PCIx. You should receive a reply similar to “PCIX-400 ver 1.26 S/N 000000, Oregon Micro Systems” from the PCIx. If you receive nothing, double check that the PCIx is fully seated in the chassis and the device drivers are installed properly. For technical support, refer to Appendix B of this manual for contact information.

2.5. CONNECT TO STEPPER MOTOR SYSTEM

The PCIx control signals are located on the J2 connector. This section will explain how to connect a stepper motor driver to the controller board.

Begin this procedure with an Pro-Dex, Inc., Oregon Micro Systems controller board installed in your system. Be sure that communication to the board has been established. This can be checked by issuing a WY command to the board and verifying that the board responds with its model type and revision level (i.e. PCIX-400 ver 1.26 S/N 000000, Oregon Micro Systems).

NOTE: Reference Section 2.4 Software Installation for software installation instructions.

Once communication has been established with the controller, shut down the system and turn power off to the controller board.

Connect the motor phase signals from the motor to the stepper driver output signals. Use the motor and stepper driver manufacturer’s manuals for instructions.

Now, connect the controller signals from J2 on the PCIx SCSI connector to the stepper driver. Short cable lengths and shielded cables are recommended for improved signal integrity and reduction in signal noise.

If you are using the IO68-M, connect the IO68-M to the PCIx using a shielded cable with 68-pin connectors. From the terminal block on the IO68-M connect wires to your motor drivers and system I/O.

Attach the STEP outputs from the controller to the STEP inputs on the stepper driver. Do the same for DIR signals.

Next, connect an external power supply (that is OFF) to the stepper driver. Again, refer to the manufacturer’s manual for instructions. (Note that power supply requirements differ from driver to driver.)

Once all wire connections have been made, power can be restored to your system. It is recommended that you bring the controller board up first (so it is in a known state), and then apply power to the stepper driver.

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Refer to Figure 2-6 for an example wiring diagram of Pro-Dex, Inc., Oregon Micro Systems' PCIx-004 connected to a stepper driver.

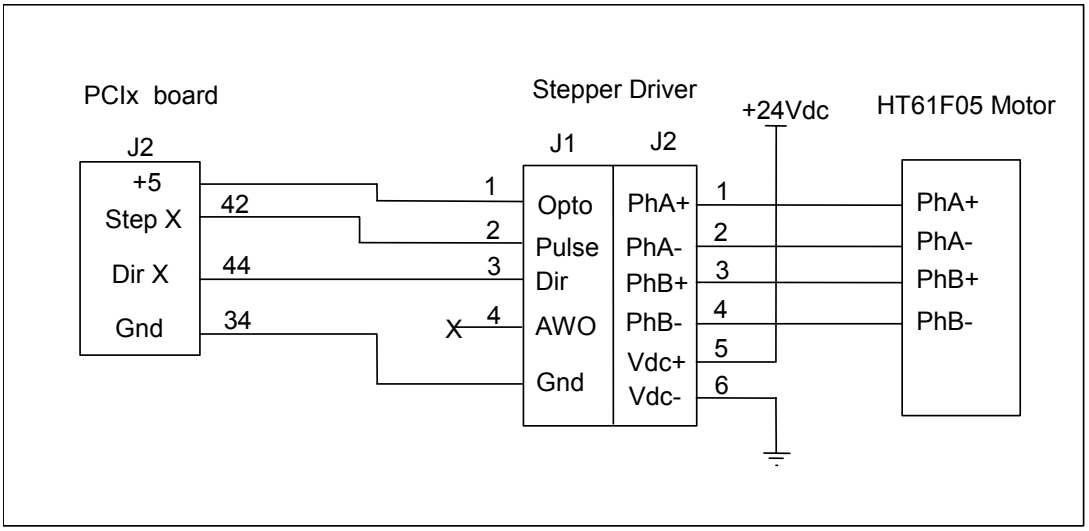


FIGURE 2-6 EXAMPLE WIRING DIAGRAM OF PCIX CONTROLLER

2.6. CONNECT AND CHECKOUT THE SERVO SYSTEM

Servo systems tend not to respond gracefully to connection errors. You can reduce the chance of making connection errors by following this step-by-step procedure:

Caution

The servo motor may jump or spin at a very high velocity during connection and configuration. The motor should be restrained via fastening to the physical system or by some other means before beginning this procedure. Keep hands and clothing clear of the motor and any mechanical assemblies while performing this procedure.

2.6.1. CONNECT AND CONFIGURE THE MOTOR/AMPLIFIER

1. Connect and configure your amplifier per the manufacturer's instructions for "Torque" or "Open-Loop" mode.

2. With the motor and amplifier power turned off, connect the PCIx to the amplifier.

3. Balance your motor:

   a. Using a voltage meter, verify that the command signal from the PCIx is less than 500mV. If it is not, send the command "DZ0;" to the PCIx and recheck the voltage. If

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the voltage is still too high, contact Pro-Dex, Inc., Oregon Micro Systems' Technical Support department for guidance.

b. Turn on power to the amplifier and then to the motor.

c. Adjust the balance setting of your amplifier (if equipped) until the motor stops moving.

d. If the motor continues to revolve or your amplifier has no balance adjustment:

i) Send the command "DZ100;" to the PCIx.

ii) If the motor spins faster, reduce the command parameter and resend the command, e.g. "DZ50;".

iii) If the motor spins slower but does not stop, increase the command parameter and resend the command, e.g. "DZ150;".

iv) Continue adjusting and resending the DZ command until the motor comes to rest. Write down the final DZ value for later reference as your "zero" setting.

4. Maximize your system's usage of the PCIx's DAC:

a. Connect the servo encoder to the PCIx.

b. Set the signal/command gain of your amplifier to its minimum setting.

c. Send the "DZ3277;" command to the PCIx and observe the velocity of the motor. The output of PCIx will be near 1VDC.

d. If the motor does not move at all, your amplifier does not work well at a low velocity. In this case, adjust the signal/command gain of the amplifier to approximately 20% of maximum or until the motor begins to move.

e. Using a frequency meter, measure the pulse rate of Phase A of the encoder. The frequency measured is ¼ of the actual pulse rate.

f. Adjust the signal/command gain of the amplifier until the pulse rate of Phase A (4 is approximately 10% of your desired peak operational velocity. If the pulse rate is already greater than 10% of peak, your amplifier is not designed for low velocity motion and you will likely have some difficulty tuning your motors.

g. Send the "DZ-3277;" command to the PCIx and recheck the velocity. You may need to readjust your amplifier. If so, do not reduce the signal/command gain – only increase the setting as needed. Increasing the gain will not impair the forward peak velocity but reduction will.

h. Send the DZ command with the "zero" value noted at the end of step 3d (iv) to the PCIx. Send the same value using the KO command, e.g. "KO-175;".

5. Verify the direction of your servo encoder:

a. Send the "LP0; DZ2000;" command to the PCIx.

b. Send the "RE" command to the PCIx and observe the response.

c. If the response is positive, no further action need be taken; go to step 6.

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d. If the response is negative, your encoder must be reversed.

i) If your encoder produces a differential signal, swap Phase B with Phase B-not and repeat from step (a.) above.

ii) If your encoder produces a single-ended (or TTL) signal, swap Phase A with Phase B and repeat from step (a.) above.

e. If the RE response is still negative, contact Pro-Dex, Inc., Oregon Micro Systems, Technical Support for assistance.

6. Repeat from step 1 for the other servo axes.

7. Remember to set DZ and KO for each axis at every power-up unless you store the values in Flash (See AP command).

NOTE: Most encoder problems are caused by lack of power or incorrect connections. If the encoder position changes by only 1 count, this is an indication that one of the phases is not connected.

Do not proceed until you perform all the steps in this procedure, ensure that the outputs of the PCIx are as described and ensure that the encoder is operating correctly

2.7. TUNE THE SYSTEM

2.7.1. INTRODUCTION

The following is an introduction to tuning a servo motor and the basics of the process. Tuning a servo system is the process of balancing three primary gain values P, I and D in order to achieve optimum system performance.

In a closed loop system, an error signal is derived, amplified, then supplied to the motor to correct any error. Clearly, if a system is to compensate for infinitely small errors, the gain of the amplifier needs to be infinite. Real world amplifiers do not possess infinite gain; therefore, there is some minimal error which cannot be corrected.

The three primary gain values used in servo systems are P (proportional), I (integral) and D (derivative). The "P" term is used as a straight gain factor to get the system response "in the ballpark." The "I" term defines how quickly the system will respond to change. The "D" term determines the system's stability. This term defines how quickly the system settles at its desired position without oscillating.

The effects of these parameters can be seen when looking at the system’s response to a step change at the input. The shape of the step response falls into one of three categories: under damped, critically damped or over damped. Over damped systems are slow to reach their final value and produce little or no oscillation. Critically damped systems reach final value quickly, without overshoot. Under damped systems reach final value quickly, but have various degrees of “ringing”, or oscillation, that decay to zero over time. Ideally, a system should be critically damped, allowing for the fastest response time with the least amount of oscillation.

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2.7.2. MANUAL TUNING

In most all motion control applications the optimum tuning of the servo system is achieved through a manual tuning process. Auto-tuning algorithms typically can only get the system parameters close and require manual steps to fine tune the parameters. An empirical trial and error approach will be discussed first.

There are some system parameters that need to be defined before attempting to tune a motor. The encoder resolution, counts per revolution, is one element to be determined. Another is the system's maximum velocity. Note that a motor should never exceed 90% of the motor's top rpm. If the system requirement is for a velocity higher than 90% of the motors top rpm, then another motor with higher rpm capability is to be used.

The system's maximum acceleration is determined several different ways. The best method is to determine the system time constant, which includes "hitting" or "bumping" the motor under system load and measure the time from 0 rpm to maximum rpm and divide this value by 5. The maximum acceleration is either 2.5 times this value, or is based on the system requirements for handling the load as defined in the operating specifications of the system. This value is always lower than the calculated value and if this acceleration value is not high enough then a different motor/amplifier with more power or bandwidth should be utilized.

The PCIx can control either current mode or voltage mode amplifiers. The servo update rate of the PCIx is 488μs for four axes. High "Following Error" can be compensated for using the feedforward coefficients explained later in this section. There are some general formulas that have been developed to determine acceptable following error for both current and velocity mode systems:

Current mode "Following Error" for KP = (3°/360°) × (counts per revolution)

Voltage mode "Following Error" for KP = (90°/360°) × (counts per revolution)

It is obvious that the voltage mode allows for much greater following errors than the current mode. This value is the following error when the motor is at peak velocity and will be used when determining the proportional gain (KP).

The "Following Error" for the integral term (KI) or long-term gain value will follow the guidelines below:

Current Mode following error for KI = 0 counts

Voltage Mode following error for KI = 80° of 360° (expressed in motor counts)

While still in open-loop mode, hold off (HF), use the DZ command to zero the motor. This variable is used to provide a constant output that will compensate for any torque offset from the load. So, when the system should be stationary, the necessary voltage will be sent to the amplifier to cause the motor to maintain position. With the correct DZ value, the motor should successfully maintain a zero position.

KO is the offset coefficient used while in closed-loop mode, hold on (HN). KO is essentially the same as DZ, but used for closed-loop operation. Once you have determined the correct value for DZ, this same value should be used for the KO variable before beginning to tune the PID filter.

The values for DZ and KO range from –32640 to 32640.

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Set the known values for velocity, acceleration and the move distance for a trapezoidal profile with at least a 20% flat spot at peak velocity. Formula:

Profile distance = ((peak velocity)^2/(2×acceleration))×2.4

Example: ((50,000)^2/(2×500,000))×2.4 = 6,000

Execute the move by sending the move commands to the PCIx.

Example:
```
MR6000;
GO;
```

Adjust the KP term while repeating step 3 until the following error at the flat spot of the profile is acceptable. If the motor becomes unstable prior to obtaining the optimum KP term than increase the KD term until the motor stabilizes.

Example:
```
LP0;
KP3;
HN;
MR6000;
GO;
LP0;
KP10;
HN;
MR6000;
GO;
LP0;
KP25;
HN;
MR6000;
GO;
LP0;
KD100;
HN;
LP0;
KP35;
HN;
MRMR6000;
GO;
LP0;
KD125;
HN;
```

The values in the above example are totally arbitrary and may vary drastically with different systems. The LP0 command is used to set the position error to 0.

The values for KP range from 0 to 249.99.

Once the KP term has been obtained, then continue executing the motion while raising the KI term until the long-term following error is acceptable. This error can be measured at the two knees of the motion profile. By increasing the KI term, the response time of your system will increase. The motion profile should have a steeper slope as KI increases.

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However, as KI increases the system can also become unstable. When the instability becomes unacceptable, increase the KD parameter. This will increase the dampening on the system's motion profile (therefore reducing oscillation, or "ringing".) Continue adjusting the KI and KD terms until the proper response time is obtained.

The values for KI range from 0 to 249.99.

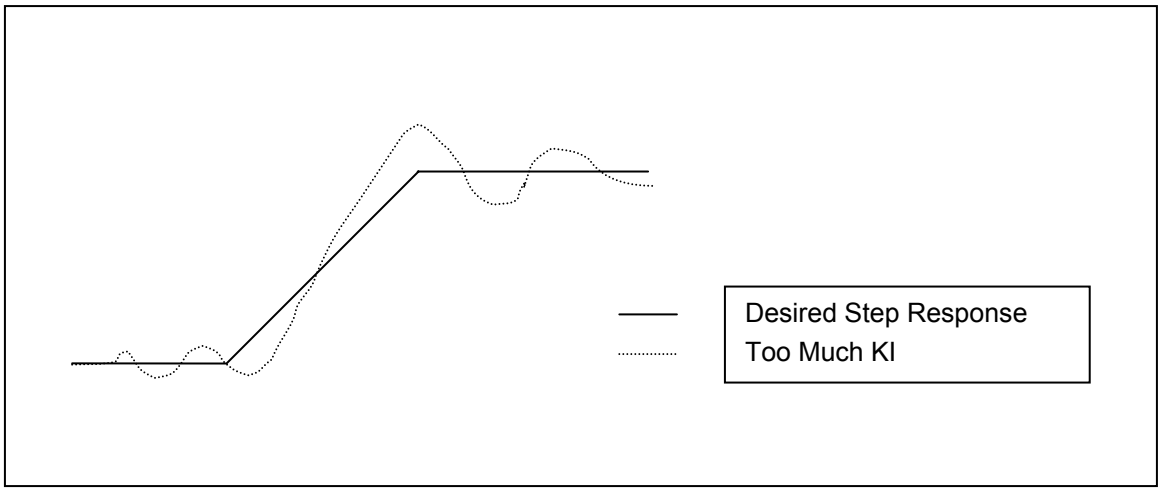


FIGURE 2-7

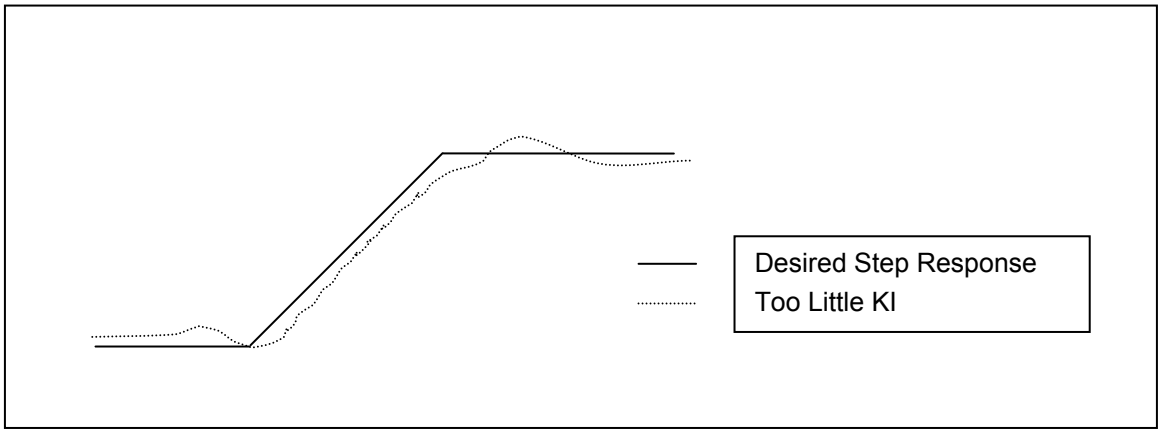


FIGURE 2-8

If you are getting too much "ringing" in the motion profile, then increase KD to help dampen the system's response. If, instead, the system is over-damped and is reaching the final velocity too slowly, then reduce the KD parameter. Optimally, the system's motion profile should show the motor reaching the desired velocity as quickly as possible without overshoot and oscillation ("ringing").

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The values for KD range from 0 to 249.99.

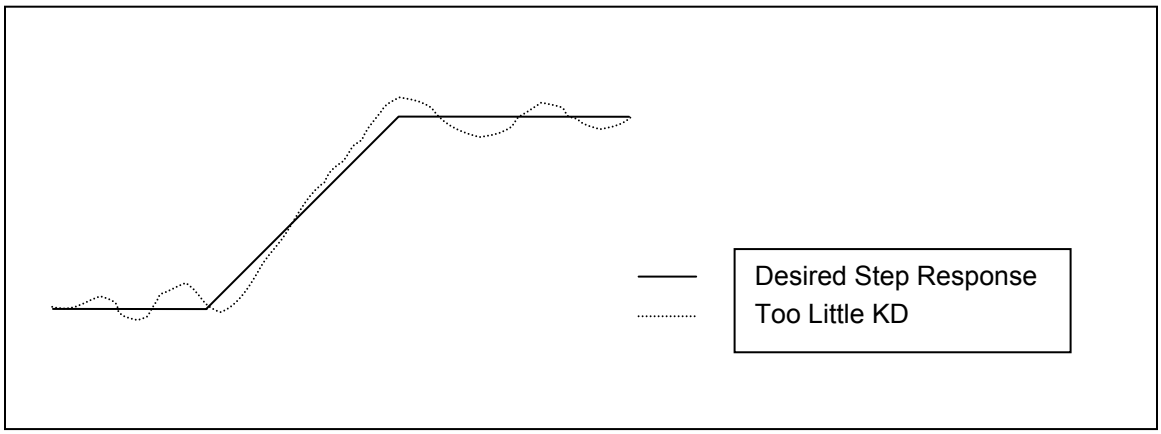


FIGURE 2-9

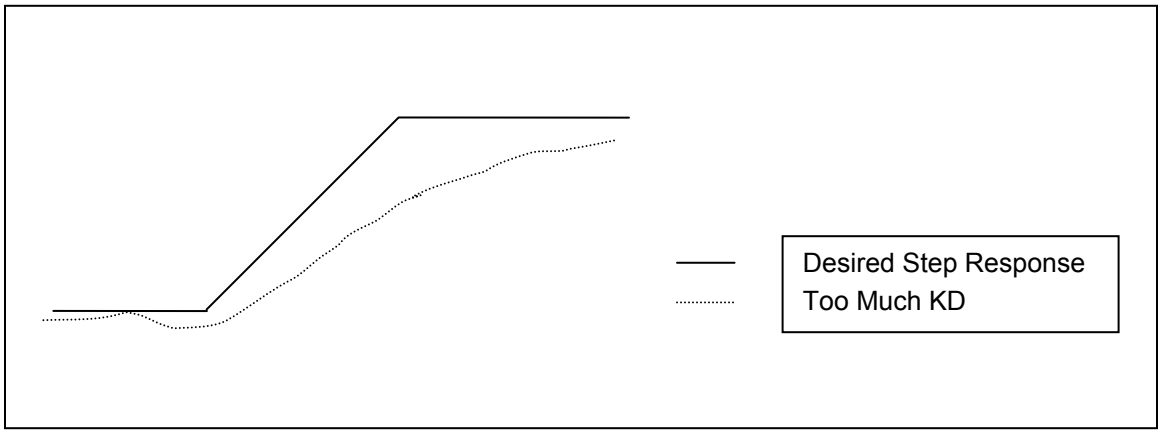


FIGURE 2-10

KP, KI, and KD are the primary parameters of concern when tuning a servo system. Once the optimum values for these variables have been determined, then you can adjust some of the secondary parameters that will help fine tune your system's performance. These other variables are described in the subsequent steps.

The KV variable is used when tuning velocity controlled servos (voltage mode servo amplifiers.) This is the velocity feedforward coefficient. KV determines how closely the system follows the desired constant velocity portion of the motion profile. By increasing this term, the "Following Error" of the system's response can be minimized. However, too large of a value may result in unstable behavior after command velocity changes.

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The values for KV range from 0 to 249.99.

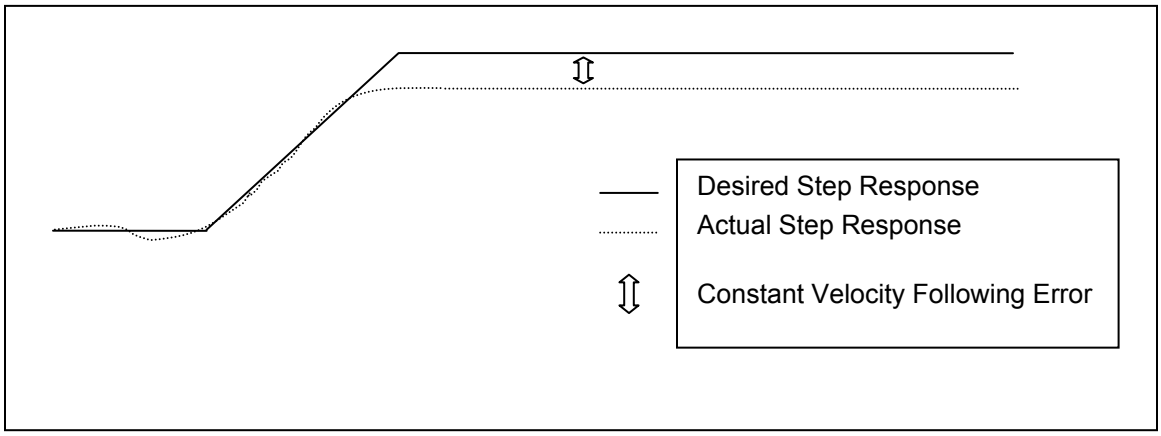


FIGURE 2-11

The KA variable is used when tuning torque controlled servos (current mode servo amplifiers.) This is the acceleration feedforward coefficient. Systems with high inertial loads may require additional torque during acceleration or deceleration to achieve optimum performance. KA determines how closely the system follows the desired acceleration and deceleration portions of the motion profile. Increasing this term reduces the following error occurring during acceleration and deceleration of the system. Although, if KA is too large, instability may occur.

The values for KA range from 0 to 249.99.

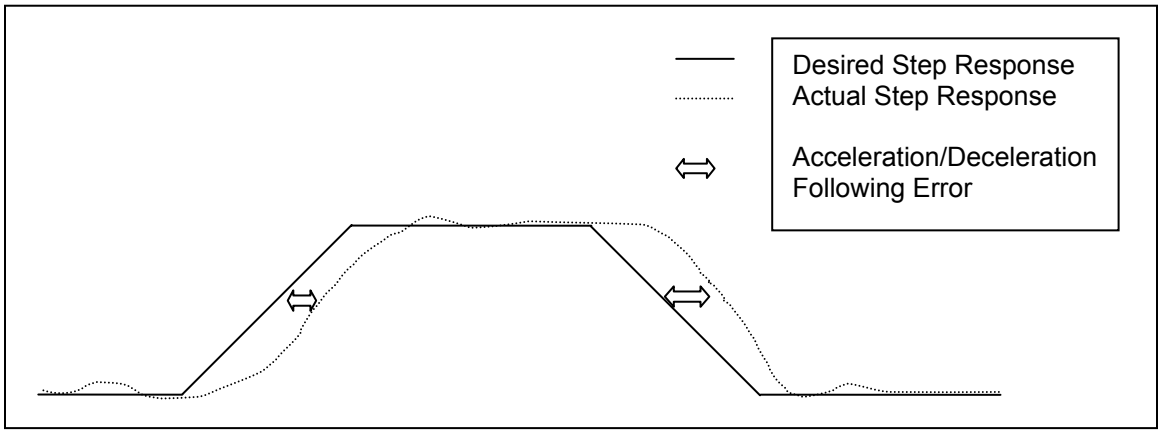


FIGURE 2-12

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The block diagram below describes the feedback loop that is taking place in the servo system:

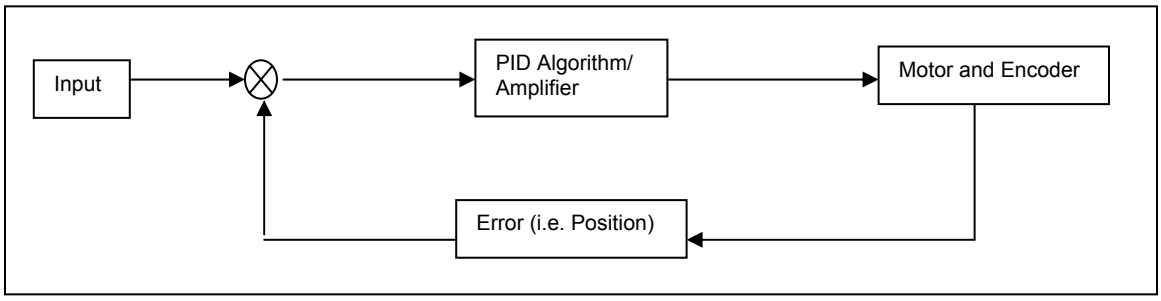


FIGURE 2-13 FEEDBACK LOOP

You may want to save the values for KP, KI, KD, etc., for future reference. These values can be saved in the board's flash memory, so they can be accessed easily on reset or power-up. The command AP will store your current parameter assignments, such as KP, KI, KD, etc., into flash memory. These saved parameters will then be used as the power up default set of values. Refer to page 5-43 for more detailed information regarding how to use the commands to save and load parameter sets from flash memory.

To verify that your motor is tuned properly after you have completed the first 10 steps perform the following test to test the holding torque: Send LP0;HN; commands and check the shaft of the motor to make sure it is stiff. If there is play in the motor shaft when you turn it then you may have to re-adjust your PID filter.

Once you are satisfied with the static holding torque you could check for position error. Send the command "AC100000;VL5000;MR64000;GO". With a 2000 line encoder this move would be equivalent to 8 revolutions of the motor. After the move is complete check the position error by sending the RE and RP commands for the specific axis you are moving. Compare the difference in the two responses. If they are the same then you are on the right track, if the error is greater than 32768 than the controller will disable the PID so that you don't have a runaway motor and major changes to the PID parameters may be required. For minor differences in the encoder and the position reading you can fine-tune your PID filter according to the earlier steps.

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2.8. SETTING THE USER DEFAULT CONFIGURATION

There are several parameters that can be defined by the user as default. These parameter values can supersede the factory default values and be stored in flash memory for power-up configuration. Most of these parameters consist of axis specific values; i.e. velocity, acceleration, limit switch logic sense, etc.

The PCIx comes from the factory with default values for all parameters. For instance, the default value for the velocity of all axes is 100,000 counts per second. (A count is equivalent to a step pulse or one count of an encoder.) In a typical application, when the system is powered up, the main host computer would initialize all of the peripherals, such as the PCIx, sending to each of the axes the peak velocity. When the User Definable Default Parameter value is defined for the velocity then the initialization of the system can skip initializing the velocities of the defined axes. This feature can greatly simplify the software and initialization process.

Once the values for all of the associated parameters are defined; i.e. velocity, acceleration, PID values, etc. then the "AP" Archive Parameters command is executed to place the values into Flash Memory. From this point forward these defined values will be used after reset or power-up. The individual parameters can be over-written at anytime by using the associated command; i.e. VL#, AC#, etc. To restore the factory defaults the command "RF" Restore Factory defaults is executed. To restore the User Defined Default Parameters the command "RD" Restore Defaults is executed.

The following is a list of parameters that can be defined as part of the User Definable Power-Up Default Parameters.

FACTORY DEFAULT SETTINGS	
Axis direction bit output state is normal(DBN)	Encoder/Motor ratio disabled (ER1,1)
Over travel limits are active low(LL)	Encoder slip detection tolerance is 1 (ES1)
Limit enabled (LN)	Position maintenance deadband is zero (HS0)
Home inputs are active low(HL)	Position maintenance velocity is zero (HV0)
Soft limits are disabled(SF)	Position maintenance hold gain is one (HG1)
Acceleration is 2000000 (AC2000000)	Servo DAC mode is bipolar (BI)
Use linear acceleration ramps(LA)	PID proportional gain is 10.0 (KP10.0)
Early deceleration factor is zero	PID derivative gain is 160.0 (KD160.0)
Velocity is 200000 (VL200000)	PID integral gain is 1.0 (KI1.0)
Base Velocities zero(VB0)	PID acceleration feedforward is zero (KA0)
User units are off(UF)	PID velocity feedforward is zero (KV0)
Auxiliary output bits settle times are zero(SE0)	PID offset coefficient is zero (KO0)
Auxiliary output bits power control is disabled(AN)	PID friction coefficient is zero (KF0)
Auxiliary output bit power up states are high(ADH)	PID upper bound limit coefficient is 10.0 (KB10.0)
Backlash compensation (BL0)	PID integration sum upper limit is 200 (KU200)
Software over travel limits are disabled (TL0,0;)	Servo voltage inversion state is disabled (SVN)
Encoder slip detection is off (ES1)	

2.9. POWER SUPPLY REQUIREMENTS

The PCIx Motion Controller Card plugs into the PCI Bus. The PCIx is designed to fit into a standard short card PCI slot, and draws 1.2 Amps from the +5 Volt Power Supply of the PC. For servo models only +12V at 0.1 amp and -12V at 0.1 amp are also taken from the PC.

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3. COMMUNICATION INTERFACE

3.1. INTRODUCTION

The PCIx is 100% compatible with standard PC's and complies with the PCI standards. The PCIx can be considered a motion coprocessor in the PCI computer where it can execute the motion process independent of the PCI CPU or continue to be interactive. The PCI interface of the PCIx has four consecutive 16 bit I/O registers available for control of interrupts, status of interrupt requests, data transfer as well as done flags. The PCIx can generate interrupts for several different conditions and these are covered in detail in the following sections.

3.2. PCI INTERFACE

The PCI interface to the controller consists of four 16 bit memory mapped I/O registers and 8K bytes (4K words) of dual port RAM.

After the host system BIOS has executed its PCI resource allocation functions the controller's PCI configuration registers will contain the following information:

PCI Register Offset (HEX)	Register Contents (32 bits)
0x000:	The Device ID and Vendor ID. (9050 1065) This register identifies the vendor that supplies the PCI bridge chip.
0x018:	The base address of the controller's dual port RAM.
0x020:	The base address of the controller's memory mapped I/O registers.
0x02C:	The controller's Subsystem ID and Subsystem Vendor ID. (0001 160C) This register identifies the PCI card as an Oregon Micro System controller.
0x03C:	Bits 0 through 3 contain the controller's IRQ assignment.

The dual port RAM is used to pass data from the controller to the host computer. The 16 bit word, at offset zero in the dual port RAM, contains a binary image of the controller's configuration dip switches. Bits 0 thru 2 contain the controller number selection. The remainder of the RAM is used to pass velocity profile and servo tuning information to the host.

The I/O registers are mapped into the host memory space with offsets from the base address as follows:

Address Offset	Register Function
0	Interrupt Control
2	Status
4	Done flags
6	Data

Note bits 8 through 15 of these I/O registers are reserved for future expansion.

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3.3. PCI COMMUNICATION THEORY

The process for communicating to the PCIx through the PCI bus at its simplest form consists of the data register and the status register of the PCIx. Reference Figure 3-1 Data Communication Flow Chart for a flow chart of the communication sequence.

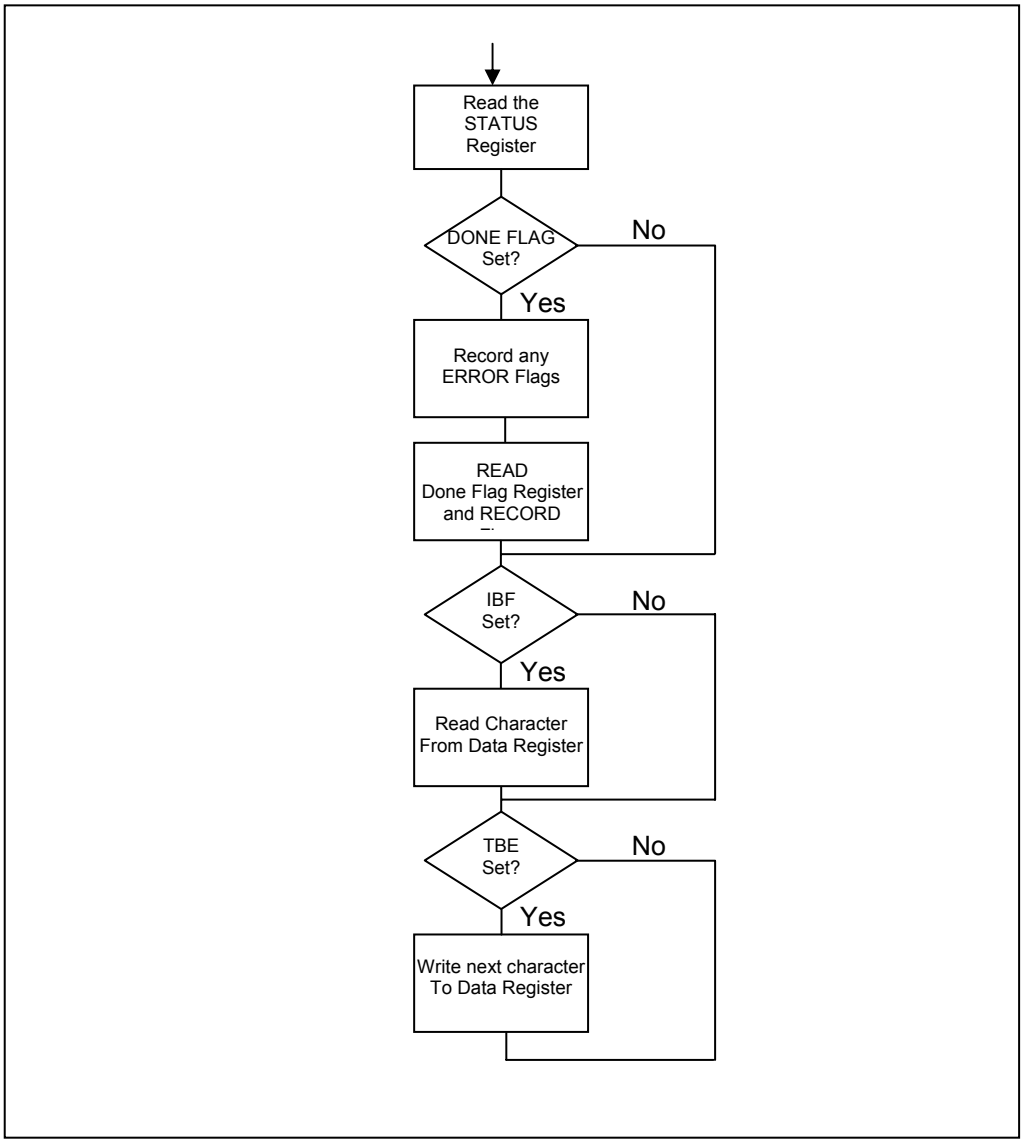


FIGURE 3-1 DATA COMMUNICATION FLOW CHART

The PCIx Master (host) first reads the status register. The information provided in the low order 8 bits informs the host whether the PCIx is ready to receive a character and if there are any characters in the data register to be read by the host. The other information provided in the status registers is not a function of the communication at this point. It is required that the TBE_S bit of the status register is set high before the host can write a character to the data register. The TBE_S bit will go low until the PCIx reads the character from the data register. The host can either wait for an interrupt generated by a high TBE_S or poll the status register to determine when it can send another character.

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When the PCIx sends a character the IBF_S bit will go high. This generates an interrupt to the host. At this point the host would read the data register. This will cause the IBF_S bit to go low until the PCIx sends another character.

3.4. PCI ADDRESS SELECTION

The PCIx is operated as a memory mapped device and occupies a block of 8 bytes of memory addresses. Refer to Table 3-1 Done Flag Register Selection, Table 3-2 Control Register Description, Table 3-3 Status Register Description.

3.5. USING INTERRUPTS

Full interrupt capability is provided by the PCIx in accordance with the PCI specification, but not required. Interrupts provided are: input buffer full (IBF), transmit buffer empty (TBE), overtravel fault (limit), command error and operation complete (done).

3.6. DATA REGISTER

The data register is the data communication port between the PCIx and the PCI Master CPU (host). All data is passed between the PCI Master and the PCIx through this register. The register is full duplex; i.e. it passes data in both directions. This allows for faster processing of the data between the host and the PCIx.

3.7. DONE FLAG REGISTER

The done flag register is a PCI Master read only register of the PCIx. Each bit of this register identifies the done status of each of the axes of the PCIx. It is a 16-bit register where the low 4-bits are used for the four axes of the PCIx. When requested by command, the PCIx will set the appropriate bits of the done flag register to indicate when a process is complete on the associated axes. The host can then read the register at any time to determine the done status of any axes. The register is cleared at the completion of the host read or by the execution of the RA or RI commands. The detail definition of the register is shown in Table 3-1 Done Flag Register Selection.

TABLE 3-1 DONE FLAG REGISTER SELECTION

DONE STATUS REGISTER DESCRIPTION	
BIT	**DESCRIPTION**
0	Done Status of X Axis
1	Done Status of Y Axis
2	Done Status of Z Axis
3	Done Status of T Axis

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3.8. INTERRUPT CONTROL REGISTER

This is a host read/write register that provides different interrupt sources from the PCIx to be individually enabled or disabled. This may be performed at any time by a write to the associated bit of the register. The register may be read back at anytime to verify or determine the state of the interrupts. Reference Table 3-2 Control Register Description for a detailed definition of the control register.

NOTE: A PCIx Interrupt Service Routine (ISR) should clear the IRQ_E bit on entry and set the IRQ_E bit just before it exits.

TABLE 3-2 CONTROL REGISTER DESCRIPTION

BIT	NAME	CONTROL DESCRIPTION
7	IRQ_E	Interrupt enable bit. This bit must be on to enable any interrupts.
6	TBE_E	Transmit buffer empty interrupt enable bit. This bit should be checked before writing to the data register to avoid sending a character when the interrupt has been disabled.
5	IBF_E	Input buffer full interrupt enable bit.
4	DON_E	Done or error status interrupt enable bit.
3	Unused	
2	Unused	
1	Unused	
0	Unused	

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3.9. STATUS REGISTER

This register is a PCI Master (host) read only register that provides status information to the host. This status is independent of the enable status of the interrupt, allowing the board to operate in a polled mode if desired. In an interrupt mode the host would read this register upon receiving an interrupt. The information provided in this register can define the source of the interrupt. The functionality of this and the other registers is consistent with other Pro-Dex, Inc., Oregon Micro Systems products. Future expansions to these registers may be performed to enhance the controllers capabilities. See Table 3-3 Status Register Description for details on the status register.

TABLE 3-3 STATUS REGISTER DESCRIPTION

BIT	NAME	STATUS DESCRIPTION
7	IRQ_S	Interrupt request status.
6	TBE_S	Transmit buffer empty status. This high true bit indicates a character may be written to the transmit buffer.
5	IBF_S	Input buffer full status. This high true bit indicates a character is available in the input buffer
4	DON_S	Done or error status. This high true bit indicates the command is complete; i.e. an ID command has been detected. If bits 0 through 3 are all false it indicates a command completion; i.e. an ID command has been executed. The error bits indicate one or more errors have been detected.
3	OVRT	Overtravel. An overtravel switch was true, indicating attempted travel out of bounds.
2	ENC_S	Encoder error. This bit flags a slip error on models with the encoder option if the interrupt on slip (IS) command has been issued.
1	INIT	Init flag. This bit indicates the PCIx is being reset or the 68332 microprocessor has not completed initialization. Host initialization routines should check this bit for a zero before proceeding.
0	CMD_S	Command error. An unrecognizable command has been detected or LS and LE commands are not in matched pairs.

In order to resolve the source of a done or error interrupt, the DON_S bit (bit 4) of the status register should be read first. This bit in the status register is automatically reset upon the termination of the read cycle. If the DON_S flag is true the error bits should be checked to determine if the interrupt was caused by an error condition. If no error condition is present, the done flag register should be read to determine which axis or axes are done. The Status Register and Done Flag Register clear when read.

The transmit buffer empty (TBE_S) bit of the status register is reset by a host write to the data register and the input buffer full (IBF_S) bit of the status register is reset by a host read of the data register.

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4. CONTROL SIGNAL INTERFACE

4.1. INTRODUCTION

The PCIx family of motion controllers are available in several configurations to manage combinations of servo and step motor systems. The PCI connector incorporates all the control signals of the PCIx. The PCIx controller meets the PCI specification fully and plugs directly into a PCI slot in a computer Motherboard.

4.2. GENERAL PURPOSE I/O, LIMIT AND HOME INPUTS

To facilitate system implementation, limit and home inputs are provided for each axis. Limits may be activated by mechanical switches using contact closures or other suitable active switches, such as a hall effect switch or opto-isolator that connects to ground.

If the motor travels beyond its allowable limits and trips the switch, the limit switch closure removes the excitation from the affected axis. You can select the limit switch active signal state with the LH and LL command on an axis by axis basis. The behavior of the limit functionality can be controlled with the System Control Commands. The PCIx accepts TTL level limit signal inputs.

The home switch provides a means to synchronize the motor controller with the load at some home, or reference, position. The home switch, when used with the software commands HM or HR, causes the motor to decelerate to a stop when the switch closes. On finding the home position, the position counters are initialized to the parameter supplied with the command. You can change the sense of the home switches to TRUE when open by use of the HH command (described on page 5-89).

The Home switch and general purpose I/O signals to the PCIx are optically isolated on the board. The PCIx expects TTL level signals for the inputs. To insure these inputs operate correctly, the switch input must be connected properly to the PCIx. Refer to Figure 4-2 Opto Isolated Input Wiring Diagram for a home switch wiring example. (The same connections shown in the diagram apply to a general purpose input bit.)

4.3. CONTROL OUTPUT

The PCIx is configured at the factory for control of servo motors, stepper motors or a combination of both. The servo output may be either unipolar analog (0/+10V) or bipolar analog (-10/+10 V). (See the UN and BI commands on page 5-181 and on page 5-47, respectively.)

Step pulse and direction outputs are open-collector TTL level signals which will wire directly into most driver inputs. If the motor drive is not naturally pulled high (to +5VDC) you may need to add a pull-up resistor (typically 1-2.2k Ohms) from the step/clock input to +5 VDC. Refer to Figure 4-1.

Auxiliary outputs are optically isolated. Each auxiliary output has a 2.2KΩ pull-up resistor on the PCIx board.

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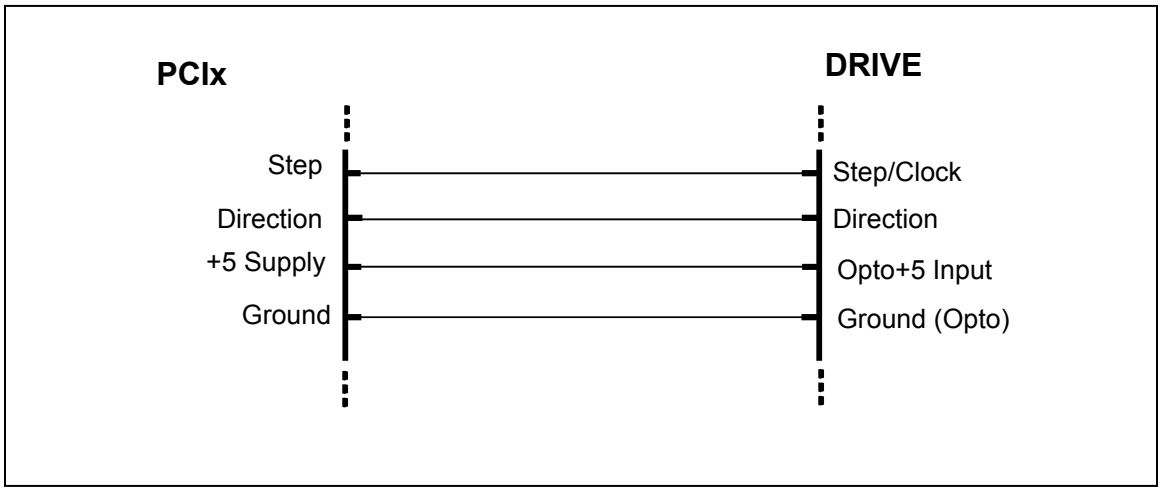


FIGURE 4-1 CONNECTION TO STEP DRIVES

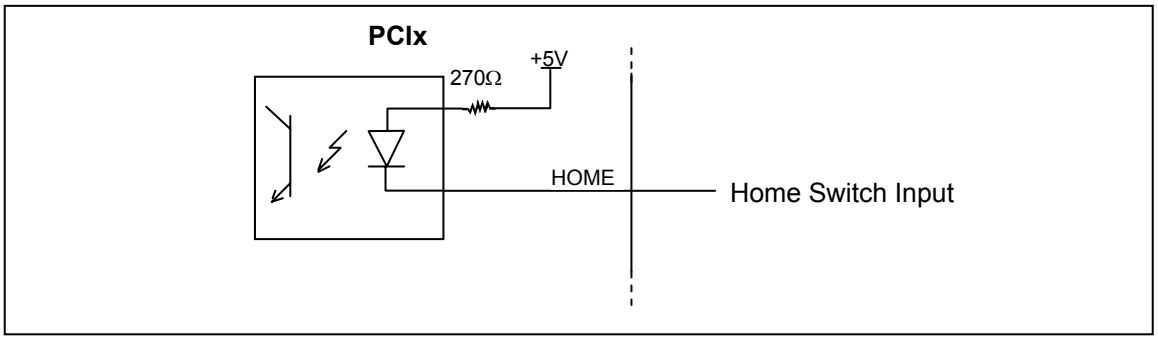


FIGURE 4-2 OPTO ISOLATED INPUT WIRING DIAGRAM

4.4. ENCODER FEEDBACK

Incremental encoder feedback is provided for all servo axes and is optional for the stepper axes. The PCIx encoder feedback accepts quadrature pulse inputs from high resolution encoders at rates up to 4 MHz (after quadrature detection.) The encoder monitors actual position through the encoder pulse train. On servo axes it continuously calculates the position error, amplifies it through the PID filter, and adjusts the output. The stepper axes can monitor the error and correct the position after the move is finished. The encoder input can also be used as an independent feedback source. All modes are capable of slip or stall detection and encoder tracking with electronic gearing. These options are selectable by the user through software commands.

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4.5. ENCODER SELECTION AND COMPATIBILITY

The PCIx is compatible with virtually any incremental encoder which provides quadrature outputs. Times four quadrature detection is used to increase resolution. This means that an encoder rated for 1000 counts (or lines) per revolution will result in 4000 counts. The inputs are compatible with encoders, which have single ended or differential TTL outputs. The PCIx inputs have built in hysteresis to minimize effects of noise pickup. The PCIx has differential line receivers to accommodate encoders with differential line driver outputs.

When single ended encoders are used the unused negative inputs; i.e. Phase A-, Phase B-, etc. must be biased at or near +1.5V. This is to be done using the appropriate switch settings on switches S1 and S2. Refer to Section 2.2 TO PREPARE FOR INSTALLATION.

4.6. HOME PROCEDURES

Two logical input functionalities are provided to synchronize the physical hardware with the PCIx controller; i.e. put the controlled motor in the home position.

The home switch input is a TTL level input signal that is optically isolated on the PCIx. A 270Ω current limiting resistor has been placed in line with the HOME signals on the PCIx. If additional current limiting is required, it should be done externally to the board. Contact Pro-Dex, Inc., Oregon Micro Systems for assistance with this.

The PCIx Home Switch Input can be used to physically home a mechanical stage. When this functionality is used the axis position counter will be reset to a select value when the switch is activated. At this point the PCIx can either ramp the axis to a stop or stop the axis immediately. The control of the direction of travel, the logic active state and the response to the active switch are controlled through commands.

The other homing method on the PCIx uses the Home Switch and the encoder signals to home a motor. When using the HE mode, homing logic is used with these input signals. The home position consists of the logical AND of the encoder index pulse, the home switch input (LOW true only) and a single quadrant from the encoder logic. The home enable pulse must be true for less than one revolution of the encoder thus allowing only one home for the complete travel of the stage. This home input cannot be inverted by the HH and HL commands while using HOME in the HE mode. The home logic expressed in Boolean terms is:

$$\text{HOME} = \text{PHASEA} \cdot \overline{\text{PHASEB}} \cdot \text{INDEX} \cdot \overline{\text{HOME SWITCH}}$$

It is necessary that the above quadrant occur within the index pulse as provided by the encoder for this logic to function properly. It may be necessary with some encoders to shift the phase of this quadrant by inverting one or both of the phases. Inverting one phase or swapping phase A for phase B will also reverse the direction. The encoder counter (read by an RE command) must increase for positive moves or the system will oscillate due to positive feedback.

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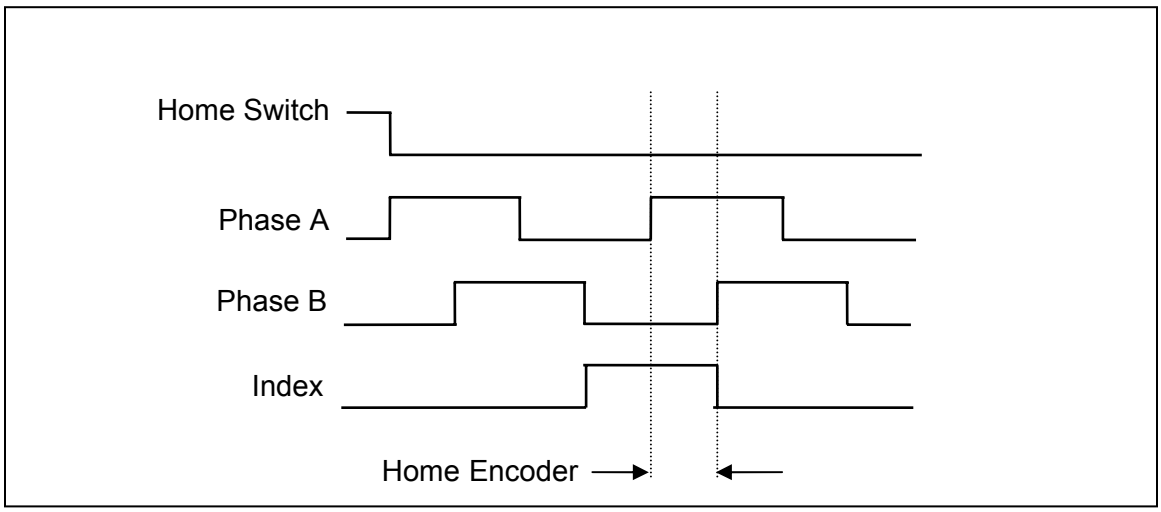
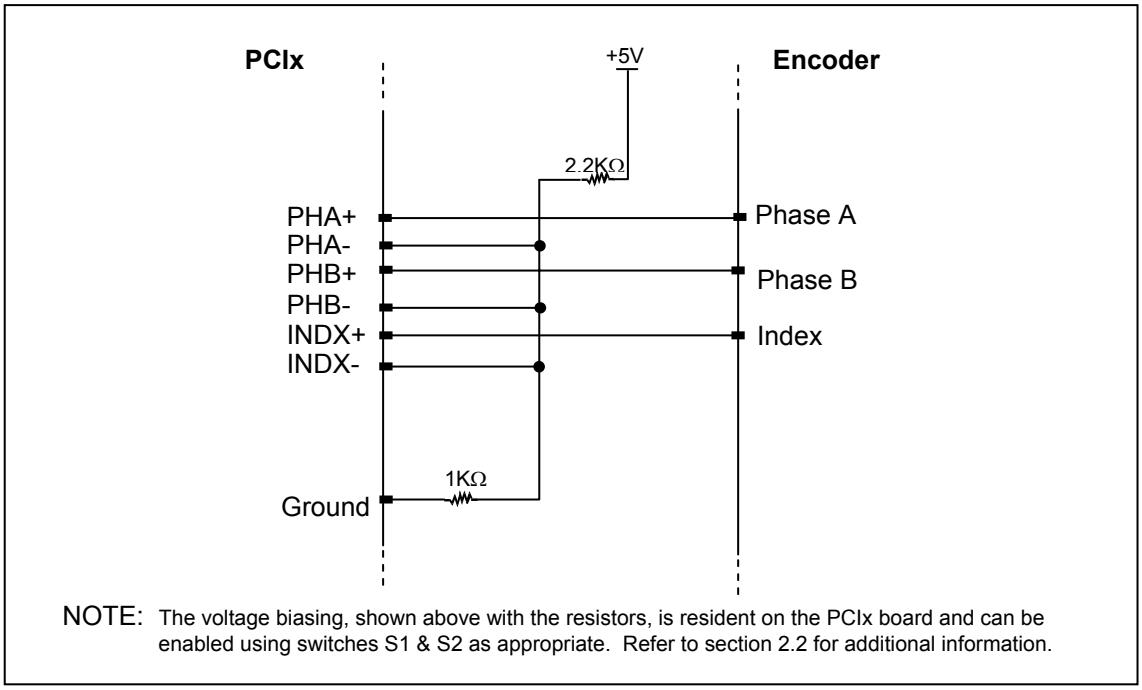


FIGURE 4-3 ENCODER HOMING STATE DETECTION



NOTE: The voltage biasing, shown above with the resistors, is resident on the PCIx board and can be enabled using switches S1 & S2 as appropriate. Refer to section 2.2 for additional information.

FIGURE 4-4 ENCODER WIRE DIAGRAM FOR SINGLE-ENDED INPUT SIGNALS

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TABLE 4-1 OUTPUT CONNECTOR PIN LIST (J2)

SIGNAL CONNECTOR (J2)			
Pin#	**Description**	**Pin#**	**Description**
1	Digital Ground	35	+5VDC
2	I/O-1	36	I/O-0
3	I/O-3	37	I/O-2
4	I/O-5	38	I/O-4
5	I/O-7	39	I/O-6
6	Digital Ground	40	+5VDC
7	X-Index +	41	X-Servo
8	X-Index -	42	X-Step
9	X-Phase A +	43	X-Auxiliary
10	X-Phase A -	44	X-Direction
11	X-Phase B +	45	X-Limit +
12	X-Phase B -	46	X-Limit -
13	Y-Servo	47	X-Home
14	Y-Index +	48	Y-Step
15	Y-Index -	49	Y-Auxiliary
16	Y-Phase A +	50	Y-Direction
17	Y-Phase A -	51	Y-Limit +
18	Y-Phase B +	52	Y-Limit -
19	Y-Phase B -	53	Y-Home
20	Analog Ground	54	+5VDC
21	Z-Index +	55	Z-Servo
22	Z-Index -	56	Z-Step
23	Z-Phase A +	57	Z-Auxiliary
24	Z-Phase A -	58	Z-Direction
25	Z-Phase B +	59	Z-Limit +
26	Z-Phase B -	60	Z-Limit -
27	T-Servo	61	Z-Home
28	T-Index +	62	T-Step
29	T-Index -	63	T-Auxiliary
30	T-Phase A +	64	T-Direction
31	T-Phase A -	65	T-Limit +
32	T-Phase B +	66	T-Limit -
33	T-Phase B -	67	T-Home
34	Digital Ground	68	+5VDC

4.7. IO68-M ADAPTER MODULE

The optional IO68-M is an adapter module designed to provide easy connection for each signal of the PCIx. It incorporates a three row terminal block and some on board filters for the limit inputs. A cable is available with the mating connector to fit the PCIx connector (J2). The +5VDC on the IO68-M is supplied by the PCIx and is protected by a resetable fuse on the PCIx.

This supply voltage is intended to be utilized with accessories used in conjunction with the PCIx such as sensors, motor driver modules, etc., and is specified to supply a maximum current of 0.5 amps for these purposes.

If the fuse detects an over current situation (such as an external short circuit), the supply will shut down. It can be re-activated by powering down the PCIx, ensuring the over current situation has been removed, and by powering the PCIx back up again after 3 seconds.

As the fuse is a semiconductor device, it never has to be replaced and requires no maintenance.

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4.8. EXPLANATION OF ADDITIONAL CIRCUITRY ON THE IO68-M

The IO68-M board is to be used in conjunction with the PCIx board. The IO68-M board contains low-pass filtering circuitry for the positive and negative limit signals. The default values for the RC constants are 100Ω and 1.0μF. With these RC constants used the average cutoff frequency is 21.5kHz in a worse case scenario where all other signals are left unterminated.

In addition to the above mentioned circuitry, there are also 2.2k pull-up resistors that have been added to the step output signals for each axis. These resistors have been added to the IO68-M to help reduce noise that may occur on the step output signals.

These resistors and capacitors are packaged as through hole devices. Should your particular application require different RC constants, these devices can be removed from the board and replaced with the appropriate components. When changing these components, use appropriate methods to desolder and solder the components to avoid causing damage to the board (i.e. lifting pads from the board.)

There are two switches on the IO68-M (S43 and S45) that are used in regards to biasing encoder signals. Since the PCIx board has on board switches for encoder signal biasing, the switches on the IO68-M are not needed. So, ALWAYS keep switches 1-6 on S43 & S45 of the IO68-M in the OFF position.

TABLE 4-2

IO68-M SWITCH (S43)

Switch Number	Signal Description
1	(Leave OFF)
2	(Leave OFF)
3	(Leave OFF)
4	(Leave OFF)
5	(Leave OFF)
6	(Leave OFF)
7	(Leave ON)
8	(Leave ON)

IO68-M SWITCH (S45)

Switch Number	Signal Description
1	(Leave OFF)
2	(Leave OFF)
3	(Leave OFF)
4	(Leave OFF)
5	(Leave OFF)
6	(Leave OFF)
7	(Leave OFF)
8	(Leave OFF)

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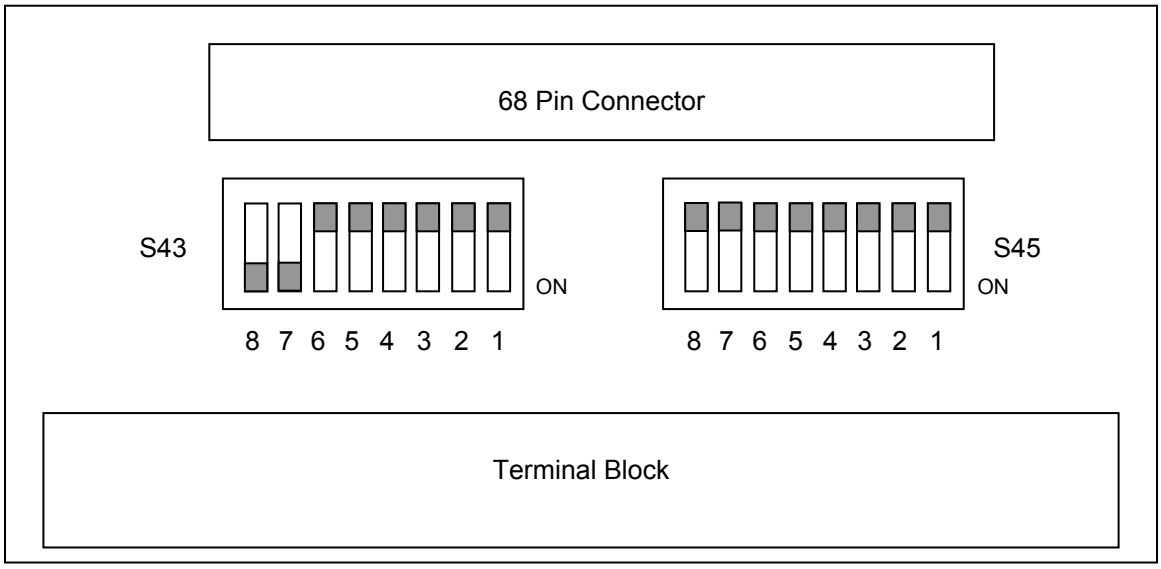


FIGURE 4-5 IO68-M DEFAULT SWITCH SETTING

Switches 7 & 8 of S43 & S45 are used to configure the IO68-M. When the IO68-M is used with the PCIx the switches should be set as shown in Figure 4-5. For the IO68-M, S43, pins 7 and 8 are to be ON, while S45, pins 7 and 8 are to be OFF.

All other signals on the IO68-M are straight through connections, with no additional circuitry added. Should you need filtering circuitry on any of these other signals, it would have to be added external to the IO68-M. Contact Pro-Dex, Inc., Oregon Micro Systems' technical support for further instruction.

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Table 4-3 shows the pin definitions on the IO68-M terminal block connector.

TABLE 4-3 IO68-M TERMINAL BLOCK PIN-OUT

Row 1	Description	Row 2	Description	Row 3	Description
1	X-Step	24	X-Direction	47	X-Auxiliary
2	X-Phase A+	25	X-Phase B+	48	X-Index +
3	X-Phase A-	26	X-Phase B-	49	X-Index -
4	X-Limit +	27	X-Limit-	50	X-Home
5	+5VDC	28	X-Servo	51	Digital Ground
6	Y-Step	29	Y-Direction	52	Y-Auxiliary
7	Y-Phase A+	30	Y-Phase B+	53	Y-Index +
8	Y-Phase A-	31	Y-Phase B-	54	Y-Index -
9	Y-Limit +	32	Y-Limit-	55	Y-Home
10	+5VDC	33	Y-Servo	56	Digital Ground
11	I/O-0	34	I/O-3	57	I/O-5
12	I/O-1	35	No Connect	58	I/O-6
13	I/O-2	36	I/O-4	59	I/O-7
14	+5VDC	37	Z-Servo	60	Analog Ground
15	Z-Step	38	Z-Direction	61	Z-Auxiliary
16	Z-Phase A+	39	Z-Phase B+	62	Z-Index +
17	Z-Phase A-	40	Z-Phase B-	63	Z-Index -
18	Z-Limit +	41	Z-Limit-	64	Z-Home
19	+5VDC	42	T-Servo	65	T-Auxiliary
20	T-Step	43	T-Direction	66	T-Index +
21	T-Phase A+	44	T-Phase B+	67	T-Index -
22	T-Phase A-	45	T-Phase B-	68	T-Home
23	T-Limit +	46	T-Limit-	69	Digital Ground

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5. COMMAND STRUCTURE

5.1. INTRODUCTION

An extensive command structure is built into the PCIx family of intelligent motor controllers. The commands consist of two or three ASCII characters and may be in upper or lower case. Some of the commands expect a numerical operand to follow. These commands are identified with a "#" after the command. The operand must be terminated by a space, carriage return, or semi-colon to indicate the end of the operand list. No terminator is required on the other commands, but it is strongly recommended it be included to improve readability. The operand must immediately follow the command with no space or separation character. The "#" indicates a signed integer input parameter or a signed fixed point number of the format "##.#" when user units are enabled. With user units enabled, distance, velocity, and acceleration parameters may be entered in units such as inches, revolutions, etc.

Most commands are usable in both single-axis and multi-axis modes. Those that require a numeric parameter in single-axis mode require multiple numeric parameters of the same type in multi-axis modes. For example, the MR (Move Relative) command takes a distance as a numeric parameter and is formatted as "MR#;" in single-axis modes. Multi-axis modes have a parameter position for each axis and must be formatted as "MR#,#,#,#;" in an 4-axis system. (Note: Use of commas "," between axes.) Any "#" parameter may be omitted for any axis which is not to be affected by the command and the command may be terminated prematurely with a semicolon. For example, to move only the Y and Z axes, enter the command as "MR,#,#;".

Some commands that are usable in both single-axis and multi-axis modes do not take a parameter in single-axis mode. These commands require numeric parameters in multi-axis modes, and the parameters indicate whether of not to take action for each axis. If a parameter exists for an axis, then the command affects that axis and if the parameter does not exist for that axis, then the command has no affect on that axis. For example, the single-axis format of LN (Limits On) is simply "LN" without any parameters of any kind. The multi-axis format of LN is "LNb,b,b,b;" for 4-axis systems where 'b' represents the parameter for the corresponding axis. Like other multi-axis commands, a 'b' parameter may be omitted if that axis is to remain unchanged and command may be prematurely terminated with a semicolon. Each 'b' position, if used, can be any numeric value. For example, to enable the Y and Z axes limit switches and leave the X and T axes unchanged, send the command "LN,1,100;". The 1 and 100 parameters could be any numeric value whatsoever, and the effect of the command would be the same. For example, the following commands are equivalent:

"LN,1,1;"
"LN,0,0;"
"LN,50,99;"

Synchronized moves may be made by entering the AA or AM command. These commands perform a context switch which allows entering motion commands in the format MRx#,y#,z#,t#;. Numbers are entered for each axis which is to be commanded to move. An axis may be skipped by entering a comma with no parameter. The command may be prematurely terminated with a ";" i.e. a move requiring only the X and Y axes would use the command MRx#,y#; followed by the GO command. Each axis programmed to move will start together upon executing the GO command. The PCIx can be switched back to the unsynchronized mode by entering the desired single axis command such as AX.

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The AM command is provided for complex applications where the host manages multiple motion processes by a multitasking operating system. This mode shares the same instructions as the AA mode, but allows starting a task while some other task involving one or more axes is active. For example, the X and Y axes could be doing linear interpolation while the Z axis is making an unrelated move simultaneously.

Constant velocity contouring provides another mode wherein the move parameters are predefined by entering AA (or AM) then CD#,#;. The PCIx will then calculate the move profile in advance and move at a constant velocity in the prescribed pattern. It can do linear interpolation on as many as 4 axes between the predefined points and it can do circular interpolation mixed with linear on any two axes.

5.2. QUEUES

The input characters are placed in a character buffer on input then removed and interpreted. The commands are then placed in separate command and argument queues for each axis. The command queues contain the commands, while the argument queues contain the operands for the commands. For example, in the string "AX; MR100; GO;" the X axis command queues would get "AX; MR; GO;" and the X axis argument queue would get "100". As they are executed the space is reclaimed allowing the host to pass commands ahead of the moves actually being processed. Most of the commands are placed in the appropriate command and argument queues for execution, while others are executed immediately allowing return of status information in a timely way rather than when encountered in the command stream. This information is provided in a table for each command which shows the queue requirements, if any, and indicates immediate in those cases where the command is not queued. The queue requirements shown in the tables are typical. Depending on the circumstances in which the command is issued, the actual queue requirement may vary slightly. The single axis cases are indicated by the mode reference indicating the appropriate axis. The synchronized mode is indicated by the mode identifier AA/AM. The contouring case is indicated by AA/CD for multiple axes in contour definition mode. The RQ command may be used to determine the actual queue space available at any time. The queues operate independently allowing each axis to perform separate processes concurrently. The synchronized modes (AA) insert special wait opcodes which allow the axes to be synchronized in this mode. When the commands are nested within loops, the queue space is not reclaimed until after the loop has been executed the programmed number of times. For loops larger than the queue space, the loop may never be completed since it cannot reclaim the queue space and cannot accept the loop terminator. Therefore, loops are effectively limited in size by the size of the command queue. The current axis command queue size for PCIx is 800. Note that if either queue is overrun the PCIx will stall and the communication link will be lost. There is just one contour queue on PCIx to handle all axes commands while in contour mode. The size of the contour queue is 7160.

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Some commands are valid only for stepper axes, others for stepper axes with encoder feedback, and still others for servo axes. Most are valid for all three types or some combination of types. A set of symbols to the right of each command identifies which motor types with which each command may be used. The symbols' meanings are as follows:

 Stepper motor without an encoder (open loop)

 Stepper motor with an encoder (closed loop)

 Servo motor

If a command is usable with one of these motor types, the symbol will appear in black. If the command is not usable with a motor type, that motor symbol will be displayed in gray

 This command is not usable with servo motors

 Indicates an example.

The following commands are available in firmware revision 1.29 and above.

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5.3. COMMAND SUMMARY

The following commands are included in the PCIx family of motor controllers. The '#' indicates a signed integer input parameter or a signed fixed point number of the format ##.# when user units are enabled. With User Units enabled, distances, velocity and acceleration parameters may be input in inches, revolutions, etc. Note that numeric parameters must be within the range of a 32-bit signed integer (2147483647 to -2147483648). For fixed point numeric parameters, the value without the decimal point must be within the range of a signed 32-bit integer. Entering parameter values outside the range of a signed 32-bit integer will cause a Command Error.

ALPHABETICAL COMMAND SUMMARY			
COMMAND	**PAGE**	Q = QUERY C=CMD	**COMMAND DESCRIPTION**
AA	5-31	C	All axes mode
?AB	5-32	Q	Report auxiliary bit state
AC	5-33	C	Acceleration
?AC	5-34	Q	Report AC command
?AD	5-34	Q	Report default auxiliary bit state
ADH	5-35	C	Set auxiliary default to high
ADL	5-35	C	Set auxiliary default to low
AF	5-36	C	Auxiliary off
AJ	5-37	C	Custom S-curve Definition
?AJ	5-40	Q	Report custom S-curve parameters
AM	5-41	C	Axes multitasking mode
AN	5-42	C	Auxiliary on
AP	5-43	C	Assign current parameter as power up defaults
?AQ	5-43	Q	Query current axis
AT	5-44	C	Axis T
AX	5-44	C	Axis X
AY	5-45	C	Axis Y
AZ	5-45	C	Axis Z
BC	5-46	C	Set backlash compensation
?BC	5-46	Q	Report backlash compensation
BH	5-47	C	Bit high
BI	5-47	C	Bipolar
BL	5-48	C	Bit low
BS	5-49	C	Bit set
BW	5-50	C	Wait for input to go low
BX	5-50	Q	Report I/O bit state in hex
CA	5-51	C	Clear axis done flag
CD	5-52	C	Contour define
CE	5-54	C	Contour end
CG	5-55	C	Contour execute while preventing MT parsing

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ALPHABETICAL COMMAND SUMMARY			
COMMAND	**PAGE**	Q = QUERY C=CMD	**COMMAND DESCRIPTION**
CK	5-56	C	Contour end and kill
CN	5-57	C	Cosine on
CR	5-58	C	Circular interpolation
CV	5-59	C	Contour velocity
CW	5-59	C	Clear while
CX	5-60	C	Contour execute
?DA	5-61	Q	Print a custom ramp
DAB	5-62	C	Define custom ramp breakpoint
DAE	5-62	C	End custom ramp definition
DAR	5-63	C	Begin custom ramp definition
?DB	5-64	Q	Report direction bit logic
DBI	5-65	C	Invert direction bit
DBN	5-66	C	Normalize direction bit
DC	5-67	C	Deceleration
?DC	5-67	Q	Report deceleration rate
?DE	5-68	Q	Report a custom ramp table entry
?DS	5-68	Q	Report the size of a custom ramp table
DZ	5-69	Q	Offset coefficient
EA	5-70	Q	Encoder status
EG	5-71	C	Electronic gearing
EG?	5-73	Q	Report electronic gearing command
EGF	5-73	C	Turn off electronic gearing
ER	5-74	C	Encoder ratio
?ER	5-75	Q	Report motor:encoder ratio
ES	5-76	C	Encoder slip tolerance
?ES	5-77	Q	Report encoder slip tolerance
ET	5-77	C	Encoder tracking
FL	5-78	C	Flush
FP	5-78	C	Force position
GD	5-79	C	Go and reset done
GN	5-81	C	Go and notify when done
GO	5-82	C	Go
GS	5-83	C	Go and monitor slip trigger
GU	5-84	C	Go asymmetrical
HD	5-85	C	Hold deadband
?HD	5-85	Q	Report position maintenance deadband
HE	5-86	C	Home encoder
HF	5-87	C	Hold off
HG	5-88	C	Hold gain

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ALPHABETICAL COMMAND SUMMARY			
COMMAND	**PAGE**	Q = QUERY C=CMD	**COMMAND DESCRIPTION**
?HG	5-88	Q	Report position maintenance gain
HH	5-89	C	Home high
HL	5-89	C	Home low
HM	5-90	C	Home
?HM	5-91	Q	Report home state selection
HN	5-92	C	Hold on
HR	5-93	C	Home reverse
HS	5-94	C	Home switch
?HS	5-94	Q	Report home switch true state selection
HV	5-95	C	Hold velocity
?HV	5-95	Q	Report position maintenance velocity
IC	5-96	C	Interrupt clear
ID	5-97	C	Interrupt when done
II	5-98	C	Interrupt independent
IN	5-99	C	Interrupt nearly done
IP	5-100	C	Interrupt when in position
IS	5-100	C	Interrupt on slip
JF	5-101	C	Jog fractional velocities
JG	5-102	C	Jog
KA	5-104	C	Acceleration feedforward
?KA	5-104	Q	Report acceleration feedforward
KB	5-105	C	PID upper bound limit coefficient
?KB	5-105	Q	Report axis PID upper bound limit
KD	5-106		Derivative gain coefficient
?KD	5-106	Q	Report PID derivative gain
KF	5-107	C	Set servo axis PID friction coefficient
?KF	5-107	Q	Report servo axis friction offset
KI	5-108	C	Integral gain coefficient
?KI	5-108	Q	Report PID integral gain
KL	5-109	C	Kill
KM	5-110	C	Home and kill
KO	5-111	C	Offset coefficient
?KO	5-111	Q	Report PID offset
KP	5-112	C	Proportional gain coefficient
?KP	5-112	Q	Report proportional gain
KR	5-113	C	Home reverse and kill
KS	5-114	C	Kill selected axes
KU	5-115	C	PID integration sum upper limit
?KU	5-115	Q	Report PID integration sum upper limit
KV	5-116	C	Velocity feedforward

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ALPHABETICAL COMMAND SUMMARY			
COMMAND	**PAGE**	Q = QUERY C=CMD	**COMMAND DESCRIPTION**
?KV	5-116	Q	Report velocity feedforward
LA	5-117	C	Linear ramp per axis
LE	5-118	C	Loop end
LF	5-119	C	Limits off
LH	5-120	C	Limits high
LL	5-121	C	Limits low
?LM	5-122	Q	Report limit switch selection
LN	5-123	C	Limits on
LO	5-124	C	Load motor position
LP	5-125	C	Load position
LS	5-126	C	Loop start
?LS	5-128	Q	Report limit active state
MA	5-129	C	Move absolute
MD	5-131	C	Temporary macro define
ML	5-132	C	Move linear
MM	5-133	C	Move minus
MO	5-133	C	Move one pulse
MP	5-134	C	Move positive
MR	5-135	C	Move relative
MT	5-136	C	Move to
MV	5-137	C	Move velocity
MX	5-139	C	Macro execute
NV	5-139	C	New contour velocity
PA	5-140	C	Power automatic
?PA	5-141	Q	Report power automatic state
PE	5-141	Q	Report encoder positions
PF	5-142	C	Parabolic off
PH	5-142	C	Power high
PL	5-143	C	Power low
PM	5-144	C	Print macro
?PM	5-144	Q	Report hold state
PN	5-145	C	Parabolic on
PP	5-146	Q	Report motor positions
PR	5-147	C	Parabolic ramp per axis
PT	5-148	C	Preserve a temporary macro
QA	5-149	Q	Query axis status
QI	5-149	Q	Query interrupt status
RA	5-150	Q	Report axis status
RB	5-151	Q	Report bit direction
RC	5-151	Q	Report acceleration

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ALPHABETICAL COMMAND SUMMARY			
COMMAND	**PAGE**	Q = QUERY C=CMD	**COMMAND DESCRIPTION**
RF	5-152	C	Restore factory default values
RD	5-153	C	Restore power-up default values
RE	5-153	Q	Report encoder position
RI	5-154	C	Report interrupt status
RL	5-154	Q	Report slip status
RM	5-155	Q	Remainder
RP	5-156	Q	Report position
RQ	5-157	Q	Report queue entries available
?RT	5-157	Q	Report ramp type
RU	5-158	Q	Report current position in user units
RV	5-158	Q	Report velocity
SA	5-159	C	Stop all
SC	5-160	C	Cosine ramp per axis
SD	5-161	C	Stop and reset done
SE	5-162	C	Settling time
?SE	5-162	Q	Report settling time
SF	5-163	C	Soft limit off
SI	5-164	C	Stop individual
?SK	5-165	Q	Report axis slip kill mode selection
SL	5-166	C	Soft limit on
?SL	5-166	Q	Report soft limit status
SO	5-167	C	Stop by ramping from distance
?SO	5-168	Q	Report analog output mode
SP	5-168	C	Stop at position
SR	5-169	C	Select custom ramp
SS	5-169	C	Selects custom S-curve profile
ST	5-170	C	Stop
?SV	5-170	Q	Report servo voltage inversion state
SVI	5-171	C	Invert servo voltage
SVN	5-171	C	Normalize servo voltage
SW	5-172	C	Sync wait
TF	5-174	C	Turn off slip kill mode
TL	5-175	C	Set software overtravel limits
?TL	5-176	Q	Report software overtravel limits
TM	5-177	C	Timed jog
TN	5-178	C	Turn on slip kill mode
TX	5-179	C	Track the X axis
UF	5-180	C	User units off
UN	5-181	C	Unipolar

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ALPHABETICAL COMMAND SUMMARY			
COMMAND	**PAGE**	Q = QUERY C=CMD	**COMMAND DESCRIPTION**
UU	5-182	C	User units
?UU	5-183	Q	Report axis user units
VB	5-184	C	Velocity base
?VB	5-185	Q	Report base velocity
VL	5-186	C	Velocity
?VL	5-187	Q	Report peak velocity setting
VS	5-188	C	Velocity streaming
WA	5-189	C	Wait for axes
WD	5-190	C	While end
WG	5-190	C	While flag
WH	5-191	C	While
WQ	5-193	C	Wait for queue to empty
WS	5-194	C	While sync
WT	5-195	C	Wait
WY	5-195	Q	Who are you

5.4. SYSTEM STATUS AND CONTROL COMMANDS

5.4.1. IDENTIFICATION COMMANDS

These commands allow the host to request the status of various move parameters, including the status of limit and home switches and/or allow control of various system parameters and operating modes to allow the user to optimize the response of the system for the application.

COMMAND	**PAGE**	Q = QUERY C=CMD	**COMMAND DESCRIPTION**
?AB	5-32	Q	Report auxiliary bit state
?AC	5-34	Q	Report AC command
?AD	5-34	Q	Set auxiliary default to high
?AJ	5-40	Q	Report custom S-curve parameters
?AQ	5-43	Q	Query current axis
?BC	5-46	Q	Report backlash compensation
?DA	5-61	Q	Print a custom ramp
?DB	5-64	Q	Report direction bit logic
?DC	5-67	Q	Report deceleration rate
?DE	5-68	Q	Report a custom ramp table entry
?ER	5-75	Q	Report motor:encoder ratio
?ES	5-77	Q	Report encoder slip tolerance
?HD	5-85	Q	Report position maintenance deadband
?HG	5-88	Q	Report position maintenance gain

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COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
?HM	5-91	Q	Report home state selection
?HS	5-94	Q	Report home switch true state selection
?HV	5-95	Q	Report position maintenance velocity
?KA	5-104	Q	Report acceleration feedforward
?KB	5-105	Q	Report axis PID upper Bound limit
?KD	5-106	Q	Report PID derivative gain
?KF	5-107	Q	Report servo axis friction offset
?KI	5-108	Q	Report PID integral gain
?KO	5-111	Q	Report PID offset
?KP	5-112	Q	Report proportional gain
?KU	5-115	Q	Report PID integration sum upper limit
?KV	5-116	Q	Report velocity feedforward
?LM	5-122	Q	Report limit switch selection
?LS	5-128	Q	Report limit active state
?PA	5-141	Q	Report power automatic state
?PM	5-144	Q	Report hold state
?RT	5-157	Q	Report ramp type
?SE	5-162	Q	Report settling time
?SK	5-165	Q	Report axis slip kill mode selection
?SL	5-166	Q	Report soft limit status
?SO	5-168	Q	Report analog output mode
?SV	5-170	Q	Report servo voltage invert state
?TL	5-176	Q	Report software overtravel limits
?UU	5-183	Q	Report axis user units
?VB	5-185	Q	Report base velocity
?VL	5-187	Q	Report peak velocity setting
WY	5-195	Q	Who are you

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5.4.2. POWER-UP DEFAULTS

The PCIx can store most user-settable parameters and reload them when the board powers-up or is reset. The following commands can be used to store these parameters, return the board to factory default, reload the stored parameters, and reset the board to reload the stored parameters. The following list of parameters can have their values saved to flash memory: AC, BI/UN, BRER, ES, HD, HG, HH/HL, HV, KA, KB. KD, KF, KI, KO, KP, KU, KV, LA/SC/PR/SS/AJ, LH/LL, LN/LF, PA0/PA1, SE, SF/SL, VB, VL, and UU

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
AP	5-43	C	Archive current parameters in back up archive
RF	5-152	C	Restore factory defaults
RD	5-153	C	Restore power-up default values

5.4.3. QUEUE SELECTION COMMANDS

The following commands set the context to direct the commands which follow to the appropriate axis. They remain in effect until superseded by another command of the same type, specifying a different axis.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
AA	5-31	C	All axes mode
AM	5-41	C	Axes multitasking mode
AT	5-44	C	Any following commands are for the T axis
AX	5-44	C	Any following commands are for the X axis (default on reset)
AY	5-45	C	Any following commands are for the Y axis
AZ	5-45	C	Any following commands are for the Z axis

5.4.4. QUEUE STATUS COMMANDS

Commands sent to the PCIx are either queued or immediate. As the type names imply, queued commands are stored in first-in-first-out buffers to be executed in the order they were sent while immediate commands are executed the moment they are received. There are several internal queues in the PCIx corresponding to the various axis and command modes and each of these queues has a limited amount of storage space. For example, the X axis command queue can hold 800 “units”. Each command requires some number of storage units. The amount of storage required is listed in a table with each command. The following commands provide control and monitoring capability for the queues.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
FL	5-78	C	Flush
RQ	5-157	Q	Report queue entries available

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5.4.5. USER UNIT COMMANDS

The following commands allow specification of move parameters in user defined units. In the UU mode, the controller will automatically convert all move parameters to these units once they have been initialized

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
UF	5-180	C	User units off
UU	5-182	C	User units, multiply acceleration, velocity and distance parameters by specified parameter
?UU	5-183	Q	Report axis user units

5.4.6. AXIS STATUS COMMANDS

The PCIx monitors the various inputs and conditions that can affect motor movement and system status. This information is frequently needed by host applications so that proper motion decisions can be made and appropriate actions taken. The following commands provide this status feedback to the host.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
EA	5-70	Q	Encoder status
QA	5-149	Q	Query axis status
QI	5-149	Q	Query interrupt status
RA	5-150	Q	Report axis status
RI	5-154	Q	Report interrupt status

5.4.7. MACROS

In applications that must perform frequent, repetitive tasks, macros can be used to minimize communication bandwidth consumption and speed up initial task execution. Macros are storage areas in the PCIx of which 5 are “temporary”; i.e. not saved at power-off, and 20 are “permanent”; i.e. stored in non-volatile flash RAM.

Macros can be edited, stored, read back to the host, and executed using the following commands.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
MD	5-131	C	Temporary macro define
MX	5-139	C	Macro execute
PM	5-144	C	Print macro
PT	5-148	C	Preserve a temporary macro

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5.5. I/O CONTROL COMMANDS

5.5.1. AUXILIARY CONTROL COMMANDS

Each axis of the PCIx has an associated auxiliary output line. Though this line can be used as a general purpose output, it also has a special purpose: Power-Automatic Mode. In power-automatic mode, the auxiliary line will invert at the beginning of every motion and return to normal at the end. The "normal" state of this line is user-controllable as is the amount of time to delay, allowing the motor to settle, before returning the line to normal at the end of a move. The following commands provide this control as well as feedback regarding the state and function of each auxiliary line.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
?AD	5-34	Q	Set auxiliary default to high
ADH	5-35	C	Set auxiliary default to high
ADL	5-35	C	Set auxiliary default to low
AN	5-42	C	Auxiliary on
PA	5-140	C	Power automatic
?PA	5-141	Q	Report power automatic state
PH	5-142	C	Power high
PL	5-143	C	Power low
SE	5-162	C	Settling time
?SE	5-162	Q	Report settling time

5.5.2. GENERAL PURPOSE I/O CONTROL

The PCIx has 16 configurable general purpose I/O bits. From the factory they are configured as 8 inputs and 8 outputs. The following commands can be used to set outputs high or low individually or as a group and to read inputs as a group.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
BH	5-47	C	Bit high
BL	5-48	C	Bit low
BS	5-49	C	Bit set
BX	5-50	Q	Report I/O bit state in hex
RB	5-151	Q	Report bit direction

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5.5.3. HOME CONTROL COMMANDS

System homing is an essential step in most systems. To accommodate a wide range of homing methods, the following commands provide the ability to set home inputs active high or low and to enable or disable encoder index signals as part of home detection.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
HE	5-86	C	Home encoder
HH	5-89	C	Home high
HL	5-89	C	Home low
HS	5-94	C	Home switch

5.5.4. LIMIT CONTROL COMMANDS

Limit conditions are treated as critical errors in the PCIx. When a limit is encountered, the axis involved will cease motion and flush any pending motion commands for that axis. However, since needs vary from application to application, the following commands will allow limit behavior customization to fit almost any system.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
LF	5-119	C	Limits off
LH	5-120	C	Limits high
LL	5-121	C	Limits low
?LM	5-122	Q	Report limit switch selection
LN	5-123	C	Limits on
?LS	5-128	Q	Report limit active state
SF	5-163	C	Soft limit off
SL	5-166	C	Soft limit on
?SL	5-166	Q	Report soft limit status
TL	5-175	C	Set software overtravel limits
?TL	5-176	Q	Report software overtravel limits

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5.6. SERVO CONTROL COMMANDS

The following commands are valid only for servo axes and should never be executed while the specific axis is in motion.

5.6.1. SERVO VOLTAGE CONTROL COMMANDS

Different servo amplifiers have different requirements for their control inputs. Some simply behave differently despite similar input requirements. To enable the use of a wide range of amplifiers, the PCIx will accept the following commands for use in configuring servo outputs.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
BI	5-47	C	Bipolar
KO	5-111	C	Offset coefficient
?KO	5-111	Q	Report PID offset
?SO	5-168	Q	Report analog output mode
?SV	5-170	Q	Report servo voltage invert state
SVI	5-171	C	Invert servo voltage
SVN	5-171	C	Normalize servo voltage
UN	5-181	C	Unipolar

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5.6.2. PID COMMANDS

The PCIx uses a PID filter for servo position maintenance. The following commands provide user-control over the filter parameters and feedback of the same. See section 2.5 Connect and Checkout the Servo System for more information regarding the use of these commands for tuning your servo motors.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
HF	5-87	C	Hold off
HN	5-92	C	Enable PID
KA	5-104	C	Acceleration feedforward
?KA	5-104	Q	Report acceleration feedforward
KB	5-105	C	PID upper bound limit coefficient
?KB	5-105	Q	Report axis PID upper bound limit
KD	5-106	C	Derivative gain coefficient
?KD	5-106	Q	Report PID derivative gain
KF	5-107	C	Set servo axis PID friction coefficient
?KF	5-107	Q	Report servo axis friction offset
KI	5-108	C	Integral gain coefficient
?KI	5-108	Q	Report PID integral gain
KP	5-112	C	Proportional gain coefficient
?KP	5-112	Q	Report proportional gain
KU	5-115	C	PID integration sum upper limit
?KU	5-115	Q	Report PID integration sum upper limit
KV	5-116	C	Velocity feedforward
?KV	5-116	Q	Report velocity feedforward
?PM	5-144	Q	Report hold state

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5.7. STEP ENCODER CONTROL COMMANDS

5.7.1. STEP ENCODER CONTROL COMMANDS

Stepper systems, like servo systems, use encoder for position feedback. However, stepper systems do not use PID filters due to operating constraints in the stepper motors themselves. Instead, the PCIx uses the following commands to perform position maintenance for stepper axes.

It is important to note that stepper motor position cannot be maintained over the course of a move but rather at the end of the move. Once the axis has initially stopped, the axis will begin moving again to correct for any error encountered during the course of the full move. This process will continue until the encoder position is within the dead band of the motor's target position.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
ER	5-74	C	Encoder ratio
?ER	5-75	Q	Report motor:encoder ratio
HD	5-85	C	Hold deadband
?HD	5-85	Q	Report position maintenance deadband
HG	5-88	C	Hold gain
?HG	5-88	Q	Report position maintenance gain
HV	5-95	C	Hold velocity
?HV	5-95	Q	Report position maintenance velocity

5.7.2. STEP ENCODER SLIP COMMANDS

In applications that require notification when a stepper motor slips beyond a given tolerance, the following commands will be of assistance. These commands do nothing to maintain position. Instead, they tell the PCIx to react to a slip condition by notifying the host or ceasing motion.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
ES	5-76	C	Encoder slip tolerance
?ES	5-77	Q	Report encoder slip tolerance
IS	5-100	C	Interrupt on slip
RL	5-154	Q	Report slip status
TF	5-174	C	Turn off slip kill mode
TN	5-178	C	Turn encoder slip kill on

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5.7.3. ENCODER SLAVE MODES

Encoder tracking modes connect a motor to an axis at a given ratio. For each turn of the encoder, the motor will move proportionately.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
ET	5-77	C	Encoder tracking, set encoder tracking mode
TX	5-179	C	Track the X axis

5.7.4. HOMING COMMANDS

Section 5.5.3 Home Control Commands details the commands available for customizing homing operations. The commands below initiate the physical homing process.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
HM	5-90	C	Home
?HM	5-91	Q	Report home state selection
HR	5-93	C	Home reverse, find home in reverse direction and initialize position counter
?HS	5-94	Q	Report home switch true state selection
KM	5-110	C	Home and kill
KR	5-113	C	Home reverse and kill

5.7.5. POSITION COUNTERS

Applications frequently need to know the actual positions of motors and encoders as opposed to the assumed positions the applications keep track of. The following commands are available for retrieving that information as well as forcibly setting those positions. This can be useful for setting “floating zero” positions.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
LO	5-124	C	Load motor position
LP	5-125	C	Load position
PE	5-141	Q	Report encoder positions
PP	5-146	Q	Report motor positions
RE	5-153	Q	Report encoder position
RM	5-155	Q	Remainder
RP	5-156	Q	Report position
RU	5-158	Q	Return current position in user units

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5.8. PROFILE CONTROL COMMANDS

5.8.1. VELOCITY COMMANDS

Part of configuring any system involves defining velocity limits. The commands below provide control over setting these limits and reporting them back to the host.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
RV	5-158	Q	Report velocity
VB	5-184	C	Velocity base
?VB	5-185	Q	Report base velocity
VL	5-186	C	Velocity
?VL	5-187	Q	Report peak velocity setting

5.8.2. ACCELERATION COMMANDS

Along with velocity limits, acceleration limits are also critical to most systems. The following commands allow customization of these parameters.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
AC	5-33	C	Acceleration
?AC	5-34	Q	Report AC command
DC	5-67	C	Deceleration
RC	5-151	Q	Report acceleration

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5.8.3. PROFILE COMMANDS

Often, the default linear acceleration profile is not optimum for a given system. To meet the needs of those systems, the PCIx has a number of commands that allow partial or even complete customization of the profile. The commands below allow the use of parabolic, cosine, and even custom ramps. See Section 5.8.4 Custom Profile Commands for commands to define custom ramps.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
AJ	5-37	C	Custom S-curve Definition
?AJ	5-40	Q	Report Custom S-curve Parameters
CN	5-57	C	Cosine on
LA	5-117	C	Linear ramp per axis
PF	5-142	C	Parabolic off
PN	5-145	C	Parabolic on
PR	5-147	C	Parabolic ramp per axis
?RT	5-157	Q	Report ramp type
SC	5-160	C	Cosine ramp per axis
SR	5-169	C	Select custom ramp
SS	5-169	C	Selects custom S-curve profile

5.8.4. CUSTOM PROFILE COMMANDS

When linear, parabolic, and cosine acceleration ramps are insufficient, custom ramps can be defined to meet virtually any profiling need. The following commands provide the capability to define a custom ramp. For even more control over the custom ramp's definition, it is recommended to use the S-curve commands. (See AJ, SS, ?AJ)

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
?DA	5-61	C	Print a custom ramp
DAB	5-62	C	Define custom ramp breakpoint
DAE	5-62	C	End custom ramp definition
DAR	5-63	C	Begin custom ramp definition
?DE	5-68	Q	Report a custom ramp table entry
?DS	5-68	Q	Report the size of a custom ramp table

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5.9. MOTION GENERATION COMMANDS

5.9.1. JOGGING COMMANDS

When an application requires a motor to move without stopping or, perhaps, to move until told to stop, the jogging commands that follow will be useful. These commands will start motion on an axis, ramping up to the specified jog velocity, and continue indefinitely, stopping only when told to stop, a limit is reached, or a timeout occurs.

The JG command is very useful when first setting up and testing a system because it generates a continuous stream of step pulse that can easily be tracked.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
JF	5-101	C	Jog fractional velocities
JG	5-102	C	Jog
MO	5-133	C	Move one pulse
TM	5-177	C	Timed jog

5.9.2. MOVE SPECIFICATION COMMANDS

The following commands define motions on one or more axes that terminate at specified positions. Full profiles are generated that guarantee position achievement either on a per axis basis or in a coordinated fashion.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
MA	5-129	C	Move absolute
ML	5-132	C	Move linear, move specified distance relative from current position
MR	5-135	C	Move relative
MT	5-136	C	Move to

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5.9.3. MOVE EXECUTION COMMANDS

The following commands initiate moves defined by commands in section 5.9.2 Move Specification Commands. A number of different commands are available, tailored to various application needs.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
GD	5-79	C	Go and reset done
GN	5-81	C	Go and notify when done
GO	5-82	C	Go
GS	5-83	C	Go and monitor slip trigger
GU	5-84	C	Go asymmetrical

5.9.4. MOVE TERMINATION COMMANDS

The following commands allow termination of move sequences in process. When things go wrong or a motion simply needs to be commanded to stop prematurely, the commands below will be useful. These commands can be used to stop motors gracefully or abruptly, depending on the needs of the application.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
KL	5-109	C	Kill
KS	5-114	C	Kill selected axes
SA	5-159	C	Stop all
SD	5-161	C	Stop and reset done
SI	5-164	C	Stop individual
SO	5-167	C	Stop by ramping from distance
ST	5-170	C	Stop

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5.9.5. MOVE COMPLETION NOTIFICATION COMMANDS

These commands allow the synchronization of moves with external events or multiple axis sequences. If an application needs to know when a move or series of commands has completed and fully processed, the following commands can be used to generate notifications. Commands are available to generate a simple notification or perform a somewhat more complex analysis to decide when and how to notify the host.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
CA	5-51	C	Clear axis done flag
IC	5-96	C	Interrupt clear
ID	5-97	C	Interrupt when done
II	5-98	C	Interrupt independent
IN	5-99	C	Interrupt nearly done
IP	5-100	C	Interrupt when in position

5.9.6. VELOCITY STAIR CASING COMMANDS

The following commands describe the velocity staircase mode. This mode is useful in applications requiring a change in velocity at a prescribed position without stopping. Similar to the jogging commands, velocity stair casing will move an axis at a specified velocity. The difference is that the next stair casing command in the queue will not be processed until a specified position is reached. Stair casing also allows the host to specify a position for the motor to stop, unlike the jogging commands.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
FP	5-78	C	Force position
MM	5-133	C	Move minus
MP	5-134	C	Move positive
MV	5-137	C	Move velocity
SP	5-168	C	Stop at position

5.9.7. VELOCITY STREAMING COMMANDS

Velocity streaming is a specialized form of velocity stair casing. Streaming simply produces specified velocities without ramping or other processing. In effect, streaming allows the host to put velocities directly into the PCIx's internal velocity registers for the X and Y axes.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
VS	5-188	C	Velocity streaming

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5.9.8. CONTOURING COMMANDS

The PCIx will attempt to generate any profile which it is asked to do. It is the responsibility of the host to be sure the acceleration required when generating a circle or any other change in direction is possible within the mechanical constraints of the system. All corners must be defined by arcs and tangents to those arcs, else the change in direction will be instantaneous and generate very large accelerations. The arc radius must be chosen so that the acceleration constraints of the system are met.

Constant velocity contouring is similar to a series of discrete move commands except that it allows multiple discrete moves to be executed in series, without stopping, maintaining a constant vector velocity among the involved axes. The commands below are those that are available in contouring mode.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
AF	5-36	C	Auxiliary off
AN	5-42	C	Auxiliary on
CE	5-54	C	Contour end
CD	5-52	C	Contour define
CG	5-55	C	Contour execute while preventing MT parsing
CK	5-56	C	Contour end and kill
CR	5-58	C	Circular interpolation
CV	5-59	C	Contour velocity
CX	5-60	C	Contour execute
MT	5-136	C	Move to
NV	5-139	C	New contour velocity

5.10. SYNCHRONIZATION COMMANDS

5.10.1. WAITING COMMANDS

The commands below provide several methods of command and move synchronization. By forcing the PCIx to wait a specified amount of time or wait until a set of axes has stopped moving before processing the next command in the queue, the host gains fine-grained control over the motion process.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
BW	5-50	C	Wait for input to go low
SW	5-172	C	Sync wait
WA	5-189	C	Wait for axes
WQ	5-193	C	Wait for queue to empty
WT	5-195	C	Wait

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5.11. LOOPING COMMANDS

5.11.1. LOOPING COMMANDS

Often, applications have need of the ability to repeat a sequence of commands until some event occurs. The commands in this section will allow looping over a given series of commands until a timeout or an I/O event such as a rising or falling edge occurs or simply to loop a specific number of times. It should be noted that only queued commands can be looped; immediate commands will be executed immediately and will not stay in the queue to be part of a loop.

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
CW	5-59	C	Clear while
LE	5-118	C	Loop end
LS	5-126	C	Loop start
WD	5-190	C	While end
WG	5-190	C	While flag
WH	5-191	C	While
WS	5-194	C	While sync

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5.12. SPECIAL COMMANDS

5.12.1. S-CURVE ACCELERATION

An S-curve acceleration profile is an alternative to the traditional trapezoidal profile. A trapezoidal profile has a constant rate of acceleration, or jerk, on both the acceleration and deceleration sides of the profile. S-curve provides a more controlled and efficient mode of operation for those situations that require optimal speed and smooth starting and stopping of motion. The S-curve acceleration is a means for softening the jerk, controlling shifting materials such as liquids, and to prevent overshoot of high inertial loads.

Functional Description: An S-curve acceleration profile is one that starts with increasing jerk, then transitions to constant jerk, then transitions to decreasing jerk until zero acceleration is reached at the desired velocity. When it is time to start decelerating, the S-curve profile starts increasing negative jerk and then transitions to constant negative jerk, and finally transitions to decreasing negative jerk until zero velocity is reached.

The S-curve profile is not truncated in moves that do not reach full velocity. This happens when the total distance of the move is less than the distance required to accelerate to full velocity plus the distance to decelerate from the full velocity to a stop. In this case, the controller calculates the entire profile and selects the velocity that will preserve selected S-curve profile, by limiting the velocity on short moves to a velocity that is sufficiently small to allow the entire profile to be preserved. Typical S-curve Acceleration Profile (Symmetrical)

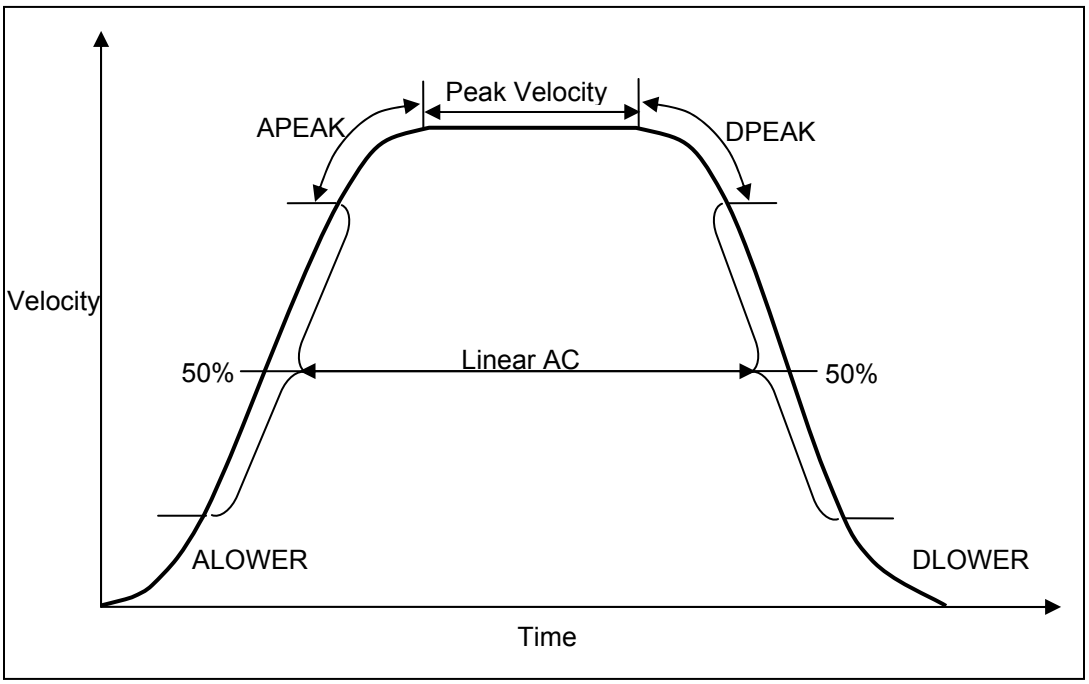


FIGURE 5-1 SYMMETRICAL S-CURVE

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5.12.2. BACKLASH COMPENSATION

Some motion systems require adjustments for backlash inherent in gearing systems when the direction of the drive motion is changed. This type of adjustment is particularly necessary when the gear train wears due to use and it may be necessary to adjust the number of steps compensated as the gear train ages.

The PCIx family of controllers includes the backlash compensation capability and is implemented for both stepper and servo axes. Note that the implementation is slightly different between the stepper and servos to accommodate the inherent differences.

The BC <step count> command is used to provide backlash compensation for an axis, and it can be saved as a parameter with the AP command. The command BC0; (zero) negates the backlash compensations for the selected axis.

5.12.3. STEPPER MOTOR AXIS

If the referenced axis controls a stepper motor, additional motor steps (specified by the number of steps in <step count> are generated), whenever a move command causes the motor to reverse direction to compensate for backlash. The backlash compensation count is output to the motor during the first motor update cycle following a direction change. This permits the compensation to be used with constant velocity contours. Note: it is assumed that the stepper motor is able to develop sufficient torque to accommodate this burst of motor steps. The backlash compensation for stepper motors is limited to a range of from 0 to 50 steps.



Example: For a stepper system, provide for 10 steps Backlash Compensation, i.e., cause the controller to output and additional 10 motor steps whenever a move causes the motor direction to be reversed.

Enter: AX;
BC10;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
BC#;	AX – AT	1
-	AA-AM	Not Valid
-	AA/CD	Not Valid

This command line will set the backlash compensation for the X-Axis to 10 steps adding 10 steps on a change of direction for the selected axis.

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5.12.4. SERVO MOTOR AXIS

If the referenced axis is a servo motor then offsetting the motor's position "set point" from the commanded position will compensate for backlash.

If the motor's "home position" has been set by moving in the positive direction, then the servo set point will automatically include the compensation for backlash in the positive direction. In this case the backlash compensation should be entered as a negative number of steps.

The backlash compensation for a servo motor occurs in the direction of the sign of the number in the BC command, and is limited to a range of from minus 50 to plus 50 encoder counts.



Example: Provide a 10 step backlash compensation for a servo motor on the X-Axis that has been homed in the positive direction.

Enter:
(1)
AX;
BC-10;
MA1000;
GO;
(2)
AX;
MA-1000;
GO;

Response: None

This would cause the controller to go to a position set point of 1000. Note the RP command would report the motor's commanded position of 1000. The RE command would report the motor's actual position of 1000.

However, in the second command you would be changing directions so that the motor will go 2010 steps, ending at -1000, and the encoder will read –1010.

Note: The recommended method of using the backlash compensation is to assign backlash compensation for each axis and archive the command, so that the compensation will occur automatically, for each appropriate axis, For example, AX;BC-10;AY;BC5;AZ;BC7; AP;

Related Commands: AP, ?BC

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
AJ	5-37	C	Custom S-curve Definition
?AJ	5-40	C	Report Custom S-curve Parameters
BC	5-46	C	Set Backlash Compensation
?BC	5-46	C	Report Backlash Compensation

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5.12.5. ELECTRONIC GEARING

COMMAND	PAGE	Q = QUERY C=CMD	COMMAND DESCRIPTION
EG	5-71	C	Electronic gearing
EG?	5-73	Q	Report electronic gearing command
EGF	5-73	C	Turn off electronic gearing

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5.13. COMMAND DESCRIPTIONS

AA ALL AXES MODE



The AA command performs a context switch to multi-axis mode. All commands entered after this one will be treated as "all axes" commands which must be formatted for multi-axis use rather than single-axis use. Each command will be executed in the order in which it is received. This is true even if the second command affects axes other than those affected by the first command. For example, if AA mode is entered followed by a move of the X axis and then a move of the Y axis, the Y axis move will not begin until the X axis move has completed.



Example: Perform an absolute move using the X and Y axes. When this move is complete, perform a relative move using the Y, Z, and T axes.

Enter:
```
AA
MA12000,14000;
GO;
MR,5000,1500,100000;
GO;
```

Response: None

NOTE: This command changes the axis mode immediately, but has axis queue requirements because it places synchronization entries in all axis queues.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
AA;	AX – AT	1
AA;	AA-AM	1
-	AA/CD	Not Valid

Related commands: AM, ?AQ, AT, AX, AY, AZ, CD

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?AB REPORT AUXILIARY BIT STATE

This command returns the bit state of the auxiliary bit of the current axis, (AN or AF).

Example: Determine if the X axis auxiliary bit is set on.

Enter: AX;
?AB

Response: an<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?AB	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: AF, AN, PA, ?SE, SE

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AC ACCELERATION



The AC command sets the acceleration/deceleration register to the operand which follows the command. The parameter must be greater than zero (zero is not valid) and less than 999,999,999, and the unit is in steps per second per second. All the following move commands for the axis being programmed will accelerate and decelerate at this rate until another AC command is entered. See the AP command, page **5-43** to preserve the AC settings as the power-up/reset values. The default value is 2,000,000.

RANGE: 1 ≤ AC ≤ 8,000,000



Example: In the single axis mode, set the Y axis acceleration to 200,000 counts per second per second.

Enter: AY;
AC200000;

Response: None



Example: In the AA mode, set the acceleration of the X axis to 200,000 and the Z axis to 50,000 and leave the other axes with their previous values.

Enter: AA ;
AC200000,,50000;

Response: None

QUEUE REQUIREMENTS			
FORMAT	**MODE**	**Axis Ramp Type**	**REQUIREMENTS**
AC#; or AC#,#,#,#;	AX-AT or AA-AM	Linear (LA or PF)	6
AC#; or AC#,#,#,#;	AX-AT or AA-AM	Short Parabolic (PN0; or PR0:)	8
AC#; or AC#,#,#,#	AX-AT or AA-AM	All other Parabolic Forms	15
AC#; or AC#,#,#,#;	AX-AT or AA-AM	Custom Ramps (SR)	3 + (No. of ramp segments +12)
AC#; or AC#,#,#,#;	AX-AT or AA-AM	S-curve (AJ)	69

Related commands: ?AC, DC, RC, VB, VL

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?AC REPORT AC COMMAND

This command will reply with the current acceleration value for the selected axis.

Example: Report the current AC value for this axis.

Enter: ?AC

Response: ac200000<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?AC	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: AC

?AD REPORT DEFAULT AUXILIARY BIT STATE

This command reports the power up default selection for the axis aux bit.

Example: Report the power up state of the Y axis auxiliary bit.

Enter: AY;
?AD

Response: adh<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?AD	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ADH, ADL

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ADH SET AUXILIARY DEFAULT TO HIGH

The ADH command sets the default power up or reset state of the auxiliary line for the current axis to high. This change is stored as a power up parameter in flash automatically and need not be stored via the AP command. Since this command writes to non-volatile memory it should be used only when necessary and not in repeatedly called functions.

NOTE: This command will also archive all other parameter values as power up defaults.

Example: Set the power up state of the Z axis auxiliary line to high.

Enter: AZ;
ADH;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
ADH;	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?AD, ADL

ADL SET AUXILIARY DEFAULT TO LOW

The ADL command sets the default power up or reset state of the auxiliary line for the current axis to low. This change is stored in nonvolatile memory automatically and need not be stored via the AP command. Since this command writes to non-volatile memory it should be used only when necessary and not in repeatedly called functions.

NOTE: This command will also archive all other parameter values as power up defaults.

Example: Set the power up state of the Y axis auxiliary line to low.

Enter: AY;
ADL;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
ADL	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?AD, ADH

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AF AUXILIARY OFF



The AF command turns off the selected auxiliary outputs. That is, it causes the signal to be driven low. The AF command may be used to change power level on driver modules so equipped or as a user specified output. Note that this command will turn power automatic (PA) mode off.

Example: Turn off the Y axis auxiliary output in the single axis mode.

Enter:
AY;
AF;

Response: None

Example: Turn off the X and Z axes auxiliary outputs when in the AA command mode. The Y axis is unchanged in this example.

Enter:
AA;
AF1,,1;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
AF;	AX – AT	1
AFb,b,b,b;	AA-AM	1
AFb,b,b,b;	AA/CD	2*

* When AF is used in a contour definition the aux bits of all axes included in that definition will be turned off when the contour is executed.

Related commands: ?AB, AN, BH, BL, BS, PA

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AJ CUSTOM S-CURVE DEFINITION 

The AJ command defines the ramp up and ramp down portions of the S-curve. It can accept from 2 to 7 parameters. The command parameters are as follows:

AJ#[,ALOWER][,APEAK][,ARADIUS][,DLOWER][,DPEAK][,DRADIUS]
Parameters in brackets [] are optional and if omitted will default to the values listed below.

specifies the S-curve profile number.
Range: 1≤ # ≤ number of axes on board

ALOWER specifies the flat portion of the lower half of the ramp up in a percentage.
Range: 0≤ ALOWER ≤ 1.0
Default value: 0.0

APEAK specifies the flat portion of the upper half of the ramp up in a percentage.
Range: 0≤ APEAK ≤1.0
Default value: alower

ARADIUS specifies the stretch factor in the curved portions of the ramp up.
Range: 1.0≤ ARADIUS ≤10.0
Default value: 1.0

DLOWER specifies the flat portion of the lower half of the ramp down in a percentage
Range: 0≤ DLOWER ≤1.0

DPEAK specifies the flat portion of the upper half of the ramp down in a percentage.
Range: 0≤DPEAK ≤1.0
Default value: DLOWER for ALOWER if DLOWER is not specified

DRADIUS specifies the stretch factor in the curved portions of the ramp down.
Range: 1.0≤ DRADIUS ≤10.0
Default value: 1.0

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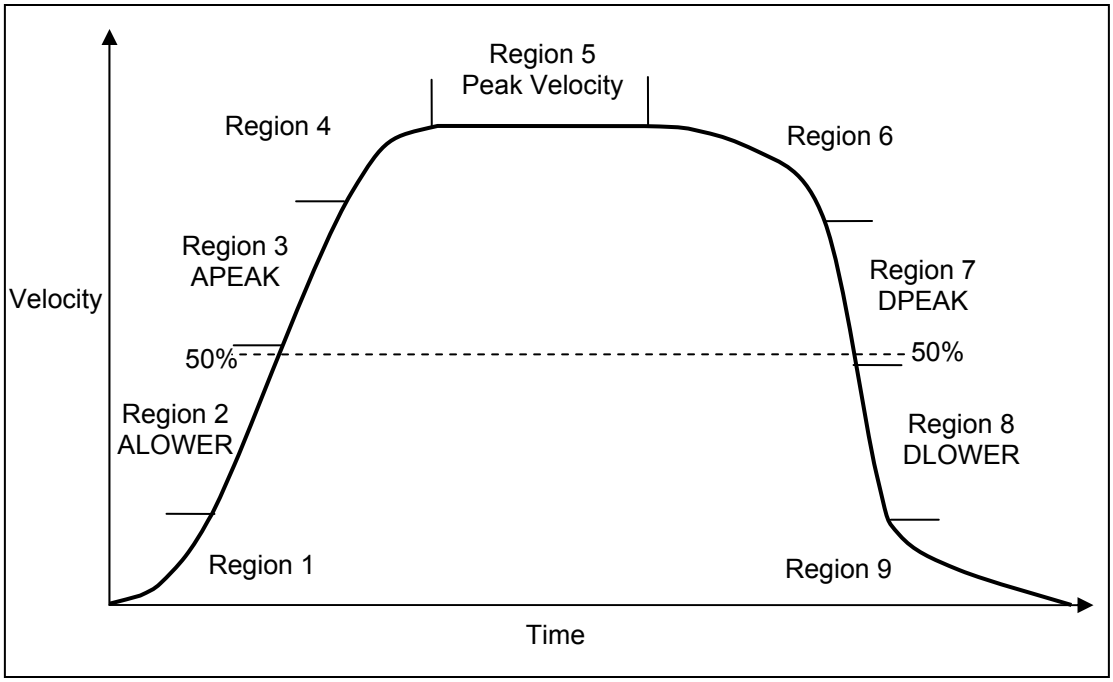


FIGURE 5-2

EXAMPLE OF A CUSTOM S-CURVE PROFILE WITH THE DEFINED REGIONS IDENTIFIED.

Region 1 = 1-ALOWER. It is the percentage of the lower half of the ramp up that S-curved.
Region 2 = ALOWER. It is the percentage of the lower half of the ramp up that is flat.
Region 3 = APEAK. It is the percentage of the upper half of the ramp up that is flat.
Region 4 = 1-APEAK. It is the percentage of the upper half of the ramp up that S-curved.
ARADIUS can "stretch" regions 1 and 4 in the time dimension.
Region 5 = Portion of profile running at maximum velocity.
Region 6 = 1-DPEAK. It is the percentage of the upper half of the ramp down that S-curved.
Region 7= DPEAK. It is the percentage of the upper half of the ramp down that is flat.
Region 8 = DLOWER. It is the percentage of the lower half of the ramp down that is flat.
Region 9 = 1-DLOWER. It is the percentage of the lower half of the ramp down that S-curved.
DRADIUS can "stretch" regions 6 and 9 in the time dimension. If the parameters are not given to define regions 6, 7, 8, and 9, they will be symmetrical with regions 4, 3, 2, and 1 respectively.

Example: Define a custom S-curve profile.

Enter: AX;
AJ1,0.5,0.5,1.0;
*Defines a profile where ramp down is symmetrical with ramp up.
AZ;
AJ2,0.1,0.1,1.0,0.8,0.8,1.0;
*Defines an asymmetrical S-curve profile.

Response: None.

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QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
AJ#,#,#,#,#,#,#;	AX-AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?AJ, ?RT, SS

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?AJ REPORT CUSTOM S-CURVE PARAMETERS



This command reports the parameters for a given custom S-curve profile.

Range: 1 ≤ Profile Number ≤ 4



Example: Report the parameters for custom S-curve profile number 5.

Enter: AX;
?AJ5;

Response: 5.0000000,0.50000000,0.50000000,1.00000000,0.10000000,0.10000000,
1.00000000<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?AJ#;	AX-AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: AJ, ?RT, SS

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AM AXES MULTITASKING MODE



The AM mode allows several tasks to be managed simultaneously. This command changes the mode of all future commands to multi-axis mode. In this mode, a task may be performing coordination motion on 2 axes, while a second task is performing unrelated but simultaneous motion on another axis. All commands sent in this mode must be formatted for multi-axis mode rather than single-axis mode.



Example: Perform a coordinated relative move on the X and Y axes, while moving the T axis as a separate move at the same time.

Enter:
```
AM;
ML2000,3000;
GO;
MA,,,10000;
GO;
```

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
AM;	AX – AT	Immediate
AM;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: AA, ?AQ, AT, AX, AY, AZ

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AN AUXILIARY ON



The AN command turns on the selected auxiliary output ports. That is, it allows the signal to be pulled high. This is the default mode for the auxiliary line at power up or reset. The AN command may be used to change power level on driver modules so equipped, trigger another board's input or as a user specified output.

A parameter must be supplied for the desired axes when used in the AA mode so that the other axes are not affected. No parameter is required in a single axis mode. Note this command will turn power automatic (PA) mode off.

Example: Turn on the Y axis auxiliary output in the single axis mode.

Enter:
```
AY;
AN;
```

Response: None.

Example: Turn on the X and Z axes auxiliary outputs when in the AA command mode. The Y axis is unchanged in this example.

Enter:
```
AA;
AN1,,1;
```

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
AN	AX – AT	1
ANb,b,b,b;	AA-AM	1
ANb,b,b,b;	AA/CD	2*

* When AN is used in a contour definition the aux bits of all axes included in that definition will be turned on when the contour is executed.

Related commands: ?AB, AF, BH, BL, BS, PA

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AP ASSIGN CURRENT PARAMETERS AT POWER-UP DEFAULTS

The AP command stores the current parameter set as the power-up default set of values. This is done by writing the current parameter set to flash memory. The following list of parameters will have their values saved to flash memory when this command is used: AC, BI/UN, BRER, ES, HD, HG, HH/HL, HV, KA, KB, KD, KF, KI, KO, KP, KU, KV, LA/SC/PR/SS/AJ, LH/LL, LN/LF, PA0/PA1, SE, SF/SL, VB, VL, and UU.

Note: This command should not be issued when an axis is in motion and it should be used sparingly because the flash memory has a limited number of write cycles.

Example: Save the current parameter set to be the power up default set of values.

Enter: AP;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
AP;	AX – AT	Immediate
AP;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: RD

?AQ QUERY CURRENT AXIS

The ?AQ command reports the mode that the current axis is in, i.e. AA mode, AM mode, etc.

Example: Determine what mode the X axis is in.

Enter: AX;
?AQ

Response: ax<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?AQ	AX – AT	Immediate
?AQ	AA-AM	Immediate
?AQ	AA/CD	Immediate

Related commands: AA, AM, AT, AX, AY, AZ

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AT AXIS T

The AT command directs all following commands to the T axis. Commands sent in this mode will be executed in the order in which they are received (subject to queued versus immediate execution) and are expected to be formatted for single-axis use.

Example: Move the T axis to absolute position -2468.

Enter:
AT;
MA-2468;
GO;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
AT;	AX – AT	Immediate
AT;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: AA, AM, ?AQ, AX, AY, AZ

AX AXIS X

The AX command directs all following commands to the X axis. This is the default mode at power up or reset. Commands sent in this mode will be executed in the order in which they are received (subject to queued versus immediate execution) and are expected to be formatted for single-axis use.

Example: Make the X axis step at a rate of 5,000 steps/second.

Enter:
AX;
JG5000;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
AX;	AX – AT	Immediate
AX;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: AA, AM, ?AQ, AT, AY, AZ

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AY AXIS Y



The AY command directs all following commands to the Y axis. Commands sent in this mode will be executed in the order in which they are received (subject to queued versus immediate execution) and are expected to be formatted for single-axis use.



Example: Examine the status of the Y axis.

Enter: AY;
RA

Response: PNNN<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
AY;	AX – AT	Immediate
AY;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: AA, AM, ?AQ, AT, AX, AZ

AZ AXIS Z



The AZ command directs all following commands to the Z axis. Commands sent in this mode will be executed in the order in which they are received (subject to queued versus immediate execution) and are expected to be formatted for single-axis use.



Example: Move the Z axis 2,000 steps at a rate of 500 steps per second.

Enter: AZ;
VL500;
MR2000;
GO;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
AZ;	AX – AT	Immediate
AZ;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: AA, AM, ?AQ, AT, AX, AY

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BC SET BACKLASH COMPENSATION



The BC command sets the backlash compensation factor for the currently active axis. This is a numeric value of the number of steps output when a direction reversal occurs.

The numeric parameter must be between 0 and 50 for stepper motors and between -50 and +50 for servo motors.

RANGE: 0 ≤ BACKLASH ≤ +50 STEPPERS

-50 ≤ BACKLASH ≤ +50 SERVOS



Example: Set backlash compensation factor of axis X to 12 counts

Enter: AX;
BC12;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
BC;	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: AN, AF, ?BC, BL, BS, BX

?BC REPORT BACK LASH COMPENSATION



The ?BC command reports the backlash compensation factor for the currently active axis. This is a numeric value of the number of steps added.



Example: Determine backlash compensation factor of axis X.

Enter: AX;
?BC

Response: bc23<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?BC	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: AF, AN, BC, BL, BS, BX

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BH BIT HIGH

The BH command turns the selected general purpose output off (i.e. logic high). The default state of general purpose outputs is off at power up or reset.

Note: Output bits should not be used as triggers for applying power to any device unless master power is applied separately and after the PCIx is fully configured. The states of the outputs are unpredictable during power-up and reset and can toggle several times before settling at a high level.

Range: 0 ≤ bit number ≤ 7

Example: Set general purpose bits 4 and 5 to high.

Enter:
BH4;
BH5;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
BH#;	AX – AT	2
BH#;	AA-AM	3
BH#;	AA/CD	2

Related commands: AF, AN, BL, BS, BX

BI BIPOLAR

The BI command sets the analog servo output of the current axis to bipolar. When bipolar is selected, a zero torque reference will result in a 0VDC output (+/- offset voltage). The analog output will range between +10VDC and -10VDC when bipolar is enabled. The BI command is valid only in the single axis mode and is the default mode at power up or reset.

Example: Set up servo axis X for bipolar operation.

Enter:
AX;
BI;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
BI;	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: DBI, DBN, ?SO, SVI, SVN, UN

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BL BIT LOW



The BL command turns the selected general purpose output line on (i.e. logic low). The default states of all output bits at power-up are logic high (off). The BS command can be used to set all outputs to a known state at once.

Note: Output bits should not be used as triggers for applying power to any device unless master power is applied separately and after the PCIx is fully configured. The states of the outputs are unpredictable during power-up and reset and can toggle several times before settling at a high level.

RANGE: 0 ≤ bit number ≤ 7



Example: Turn on output bits 4 and 5 after a move. Note that this is only valid for output bits; input bits cannot be modified.

Enter:
AX;
MA1000;
GO;
BL4;
BL5;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
BL#;	AX – AT	2
BL#;	AA-AM	3
BL#;	AA/CD	2

Related commands: AF, AN, BS, BX

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BS BIT SET



Set all of the output bits to a known state at the same time. This command will affect all output bits, setting their states to the specified bit mask nearly simultaneously. The mask must be in ASCII hex format where the least significant bit (bit 0) is on the right. To set a line low, the corresponding bit in the hex mask must be a 0. A one (1) in any bit position will set the corresponding bit high.

Note: Output bits should not be used as triggers for applying power to any device unless master power is applied separately and after the PCIx is fully configured. The states of the outputs are unpredictable during power-up and reset and can toggle several times before settling at a high level.

Range: 00 ≤ Hex number ≤ FF



Example: Assume I/O bit direction is set all outputs. Set output 0 high, 1-3 low, 4-6 high and 7 low (71 = (hex) 01110001)

Enter: BS71;

Response: None.

NOTE: Data written to input bits has no effect

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
BS#;	AX – AT	2
BS#;	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: AF, AN, BH, BL, BX

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BW WAIT FOR INPUT TO GO LOW

The BW command is just like the SW command except that it waits for the input line to reach a TTL low rather than a TTL high. Refer to the SW command for more detail.

RANGE: 0 ≤ Bit Number ≤ 7

Example: See the examples for the SW (see page **5-172**) command

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
BW#;	AX – AT	2
BW#;	AA-AM	4
-	AA/CD	Not Valid

Related commands: SW, WA, WT, WQ

BX REPORT I/O BIT STATE IN HEX

The BX command returns the states of the general purpose I/O bits in a hex_format. The rightmost character represents the least-significant-nibble (4 bits) and, if the nibble is rewritten as bits, the rightmost bit is the least-significant bit. An input set low will be represented as a binary 0 and a high as binary 1, similarly for an output.

Example: Assuming the default I/O bit direction = FF, bits 0-7 outputs.

Enter: BX

Response: 05<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
BX	AX – AT	Immediate
BX	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: BH, BL, BS

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CA CLEAR AXIS DONE FLAG



The CA command operates like the IC command, except it clears the done flag of the addressed axis only. In multi-axis modes, the CA command clears the flags of all selected axes. Unlike the IC command, CA will not clear other error flags in the status register such as slip and limit.



Example: After a multi-axis move, clear the Z axis done flag only.

Enter:
```
AA;
MR1000,2000,3000,4000;
GO;
ID;
AZ;
CA;
```

Response: None.



Example: After a multi-axis move, clear the Y and Z axis done flags only.

Enter:
```
AA;
MR1000,2000,3000,4000;
GO;
ID
CA,1,1;
```

Response: None.

NOTE: In AA or AM mode, a null value in the argument list specifies the done bit of that axis is not to be cleared.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
CA;	AX – AT	Immediate
CAb,b,b,b;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: GD, IC, ID, II, IN, IP

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CD CONTOUR DEFINE



The CD command enters contour definition mode and defines a constant velocity contour. The only way to exit this mode is to issue a CE or CK command. Commands following the CD command must be in multi-axis format and be commands valid in CD mode. All multi-axis commands entered in CD mode can address only those axes assigned in the CD command. No commands entered will be executed until a CX command is received which must be issued outside of CD mode.

The CD command takes up to four parameters. Each parameter specifies a starting point for each axis to be involved in the contour in absolute coordinates. If an axis is not to be involved in the contour, its parameter position should be skipped just as it would be in any other multi-axis command. Commands issued within CD mode must be formatted to include only those axes indicated in the CD command. Those that are not in the CD command simply do not exist in the formatting of commands entered in CD mode. For example, if a CD command is issued that uses the X, Y, and T axes (such as CD100,300,,400;), commands entered within CD mode will only consider the X, Y, and T axes. A MT command that moves X to 200, Y to 600, and T to 200 would take the form: MT200,600,200;. Note the lack of a placeholder comma for the Z axis.

Contours that will include circular interpolation (CR) must be defined for only 2 axes in the CD command. Contours involving more than 2 axes may not use the CR command. The size of the contour definition buffer for the PCIx is 7160 positions.

When the contour is executed, the PCIx will use the distance between the current position and the contour starting point to linearly ramp up each axis such that all involved axes reach a combined, vectored velocity equal to the value set with the CV command. If this distance is zero, no ramp will be generated resulting in an instantaneous jump to contour velocity. Most stepper systems cannot achieve this and servos will tend to oscillate wildly before settling down if at all. Care should be taken to allow sufficient ramping distance between the contour starting position and the current position when the CX command is issued.

Once the contour is completely executed, the PCIx will ramp the axes to a stop using the rate defined with the AC command. This ramp down will take each axis beyond the final point of the contour. Without manually calculating the ramp down distance for each axis, there is no way to force the contour to come to a complete stop at a predetermined point.

Example: The following demonstrates cutting a hole with a 1000 count radius using constant velocity contouring and circular interpolation. The contouring velocity is set to 1000 pulses per second. A contour is then defined beginning at coordinates 0,0 on the X and Y axes. The auxiliary output of the Z axis is turned on, which could turn on the cutting torch or laser starting the cut at the center of the circle. A half circle is cut from the center to the outside of the hole, positioning the cutting tool at the start of the desired hole. The hole is then cut, the torch turned off, the stage stopped and the definition is complete. The stage is then positioned and the hole cut with the CX command. The AN and AF commands must have commas for all axes since they can all be addressed from within the contour definition.

Enter:

```
AA;
CV1000;
CD0,0;
AN,,1;
CR5000,0,-3.1415926;
CR0,0,-6.2831853;
AF,,0;
```


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MT1000,-1000;
CE;
MT1000,0;
GO;
CX;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
-	AX – AT	Not Valid
CD#,#,#,#;	AA-AM	5 + number of axes in the contour
-	AA/CD	N/A

Related commands: AF, AN, BH, BL, CE, CK, CR, CV, CX, MT, NV,

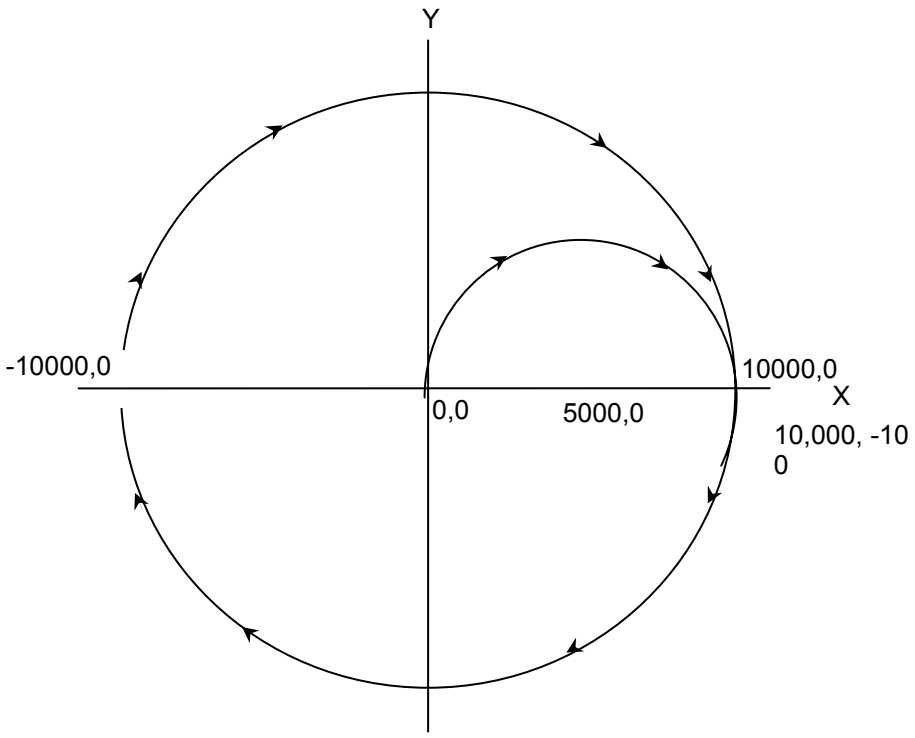


FIGURE 5-3

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CE CONTOUR END



The CE command marks the end of the contour sequence. It will terminate the CD mode and, when executed, ramp to a stop and exit to the AA command mode. The end of the contour should contain at least a short linear segment just prior to the CE command to initialize the parameters for the deceleration of the stage.



Example: (see CD command on page 5-52)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
-	AX – AT	Not Valid
-	AA-AM	Not Valid
CE;	AA/CD	2

Related commands: CD, CK

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CG CONTOUR EXECUTE WHILE PREVENTING MT PARSING



The CG command is a form of the CX command, use if CE is followed by a MT command. When CG is used to execute the contour, the following MT commands will be on hold until the contour execution is complete. After the contour has been executed, the MT commands that follow can be parsed.

CG is preferred over the CX when the MT commands are issued after a contour is executed. The CG command ensures that the MT command that follows starts from a known position. This makes for a more accurate calculation of the MT move.



Example: See page **5-52** (CD), Make sure that the hole is completely cut before executing the move to the new command position.

Enter:
```
AA;
CV1000;
CD0,0;
AN,,1;
CR5000,0,-3.1415926;
CR0,0,6.2831853;
AF,,0;
MT10000,-1000;
CE;
MT-10000,0;
GO;
CG;
```

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
-	AX – AT	Not Valid
CG;	AA-AM	9*
CG;	AA/CD	Not Valid

* If PA (power automatic) mode is selected add 2 to the command queue.
* If an aux bit settle time has been specified add 3 to the command queue.
* If the axis is stepper and encoder or servo add 1 to the command queue.
* Add the following queue requirements for the ramp types listed.

ADDITIONAL QUEUE REQUIREMENTS	
Axis Ramp Type	**Additional Requirements**
Linear (PF, LA)	8
Short Form Parabolic (PN0, PR0)	10
All other Parabolic forms (PN, PR)	26
Cosine (CN, SC)	26
Custom (SR)	6 + (2 x number of ramp segments)
S-curve (AJ)	113

Related commands: AF, AN, BH, BL, CD, CK, CR, CV, CX, MT, NV

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CK CONTOUR END AND KILL

The CK command will end the contour sequence, like the CE command, except there is no ramp down; i.e. motion will stop abruptly. It is used in place of the CE command.

NOTE: This command should be used with caution to prevent the stage from slipping or losing its correct position.

Example: Same scenario as CD command, but we want to end the contour with the minimum ramp down.

Enter:
```
AA;
CV1000;
CD0,0;
AN,,;
CR5000,0,-3.1415926;
CR0,0,-6.2831853;
AF,,0;
MT10000,-1000;
CK;
MT-1000,0;
GO;
CX;
```

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
-	AX – AT	Not Valid
-	AA-AM	Not Valid
CK;	AA/CD	2

Related commands: CD, CE

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CN COSINE ON



The CN command enables cosine velocity ramps; i.e. half sinusoid acceleration profiles, for all axes. The cosine profile is not truncated in moves cannot reach full velocity, but instead the velocity is reduced sufficiently to preserve the cosine profile. This command should not be given while an axis is in motion or the results may be unpredictable. This command affects all axes even if issued in the single axis mode. The PF command is used to return to linear motion profiles. See the AP command (see page **5-43**) to preserve the CN setting as the Power up/Reset ramp.



Example: Set the board to be in cosine mode.

Enter: CN;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
CN;	AX – AT	29
CN;	AA-AM	29
-	AA/CD	Not Valid

Related commands: LA, PF, PN, PR, ?RT, SC, SR

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CR CIRCULAR INTERPOLATION



The CR command defines a move in a circular pattern from the entry position. The first two parameters are the center of the circle in absolute units and the third parameter is the distance to move in radians. Positive radians equal counterclockwise movement. Negative radians equal clockwise movement. The radius of the circle is the linear distance between the current position and the first two parameters of the CR command.

The CR command generates a circle by breaking the circle into a series of linear segments. The number of segments will be equal to the total distance traveled divided by the contour velocity divided by the update rate. If finer resolution is required, the MT command may be used to produce smaller segments but the segments must be calculated by the user

RANGE:
Min Pos. Value ≤ Parameter 1 (First Coordinate for Center of Circle) ≤ Max Pos. Value
Min Pos. Value ≤ Parameter 2 (Second Coordinate for Center of Circle) ≤ Max Pos. Value

Note: The minimum and maximum position value depends on the settings used on PCIx, see the specifications for more detail.



Example: (see CD command on page 5-52)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
-	AX – AT	Not Valid
-	AA-AM	Not Valid
CR#,#,#;	AA/CD	8

Related commands: CD, MT

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CV CONTOUR VELOCITY

The CV command allows specification of a contouring velocity. It is executed from the AA mode before a contour definition. A contour defined by a CD command cannot be executed if followed by a CV command. Changing this parameter will make any previously defined contours invalid. The contour velocity defaults to 1000 at power up or reset. Use WQ between contour definitions to avoid having a CV associated with a second contour definition affect a prior contour still in motion. A CV cannot be issued between a CD and CE command. To change the contour velocity within a contour definition use the NV command.

RANGE: 1 ≤ CV ≤ 1,043,999

Example: (see CD command on page 5-52)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
-	AX – AT	Not Valid
CV#;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: CD, NV

CW CLEAR WHILE

The CW command breaks the WH loop upon execution of the remaining commands in the loop; i.e. the current execution of the loop is finished. The WH loop is always executed at least one time since the test for the flag is at the bottom.

Example: (see WH command page 5-191)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
CW;	AX – AT	Immediate
CW;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: WG, WH

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CX CONTOUR EXECUTE



The CX command will execute the previously defined contour sequence. The stage must be positioned such that it can accelerate to speed by the absolute position specified by the CD command it is executing and must be traveling in the proper direction. Once a contour is defined it may be executed at any time by executing a CX command until it is replaced by another contour definition. The CX command cannot be placed within a loop or while construct.



Example: (see CD command on page 5-52)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
-	AX – AT	Not Valid
CX;	AA-AM	8*
-	AA/CD	Not Valid

* If the axis is a stepper and encoder or servo add 1 to the command queue.
* If PA (power automatic) mode is active add 2 to the command queue.
* If an auxiliary output bit settle time has been specified add 3 to the command queue

ADDITIONAL QUEUE REQUIREMENTS	
AXIS RAMP TYPE	**ADDITIONAL REQUIREMENTS**
Short Form Parabolic (PN0, PR0)	4
All other Parabolic Forms (PN, PR)	18
Cosine (CN, SC)	18
Custom (SR)	6 + (2*number of ramp segments)
S-curve (AJ)	113

Related commands: CD, CE, CK, ID

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?DA PRINT A CUSTOM RAMP



This command will report the entries of a previously defined custom ramp table.

RANGE: 1 ≤ Ramp Table Numbers ≤ 4



Example: Print out custom ramp table #2

Enter: ?DA2;

Response: DAR2<LF>
DAB0.10000,0.20000<LF>
DAB0.90000,0.80000<LF>
DAB0.10000,1.00000<LF>
DAE<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?DA#;	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: DAB, DAE, DAR, ?DE, ?DS

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DAB DEFINE CUSTOM RAMP BREAKPOINT



The DAB command sets a breakpoint in a custom ramp table. This is the only command that should be used after DAR and before DAE. Each custom ramp may contain up to 25 breakpoints, each defined by a DAB command.

The DAB command takes two parameters; the first specifies the acceleration level that should be used to achieve the second parameter, velocity level. Both levels are expressed in terms of percentage in decimal format; i.e. 1.00 is 100%. At no time should a DAB command be entered in which the velocity parameter is less than the velocity parameter of the prior DAB. The PCIx will not flag this as a command error but the results of such a ramp will be unpredictable. Each DAB command sent should be equal to or greater than the DAB command that preceded it. It is the user's responsibility to make sure this command is used properly.

RANGE:
0.0 ≤ Parameter 1 ≤ 1.0
0.0 ≤ Parameter 2 ≤ 1.0

Example: See the DAR command (page **5-63**) for a complete example of a custom profile.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
DAB#,#;	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?DA, DAE, DAR, ?DE, ?DS, SR

DAE END CUSTOM RAMP DEFINITION



The DAE command terminates a custom ramp table definition initiated by the DAR command.

Example: See the DAR command (page **5-63**) for a complete custom ramp table definition.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
DAE;	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?DA, DAB, DAR, ?DE, ?DS, SR

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DAR BEGIN CUSTOM RAMP DEFINITION



The DAR command starts the definition of a custom ramp table. A parameter supplied with this command, from 1 to 8, specifies which ramp table to create. If a ramp table by that number has already been defined, it will be overwritten.

Once the DAR command has been issued, only the DAB and DAE commands will be valid. A series of ramp table breakpoints may be entered using the DAB command which define the profile breakpoints for this ramp table. Up to 25 breakpoints may be defined but a smaller number may be used. A ramp table containing no breakpoints is invalid and will result unpredictably if used.

RANGE: 1 ≤ DAR ≤ 4



Example: Create a ramp table definition resembling a jerk-limited linear profile.

```
Enter:  DAR3;          * Store as table #3
        DAB.1,.05;     * Ramp at 10% of AC until 5% of VL
        DAB.3,.1;      * Ramp at 30% of AC until 10% of VL
        DAB.9,.9;      * Ramp at 90% of AC until 90% of VL
        DAB.3,.95;     * Ramp at 30% of AC until 95% of VL
        DAB.1,1;       * Ramp at 10% of AC until 100% of VL
        DAE;           * End table definition

Response: None.
```

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
DAR#;	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?DA, DAB, DAE, ?DE, ?DS, SR

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?DB REPORT DIRECTION BIT LOGIC

The ?DB command reports the direction bit logic: inverted or normal. If the direction bit is low when moving positive, this command will return 'normal'. If the direction bit has been inverted, this command will return inverted.

Example: Report whether the direction bit for the T axis is low or high when making positive moves

Enter: AT;
?DB

Response: dbi<LF> (The inverted result indicates the T axis direction bit is high for positive moves)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?DB	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: DBI, DBN, ?SV

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DBI INVERT DIRECTION BIT



The DBI command inverts the logic of the direction control output of the addressed axis or axes. By default, the direction output of an axis is a TTL low when traveling in the positive direction and high when traveling negative. After using the DBI command, the direction bit will be high when traveling positive and low when traveling negative. This is useful for inverting the logical direction of a motor when the encoder counts opposite the motor direction. This command can be canceled using the DBN command. To make this the default at power up or reset, use the AP command.



Example: Set the direction outputs for axes Z and T to output high when traveling positive and low when traveling negative. Leaves X and Y as they are.

Enter:
```
AZ;
DBI;
AT;
DBI;
Or
AA;
DBI,,1,1;
```

Response: None.

Note: In AA or AM mode a null value in the argument list specifies that the sense of that direction bit is not to be changed.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
DBI;	AX – AT	1
DBIb,b,b,b;	AA-AM	1
-	AA/CD	Not Valid

Related commands: BI, ?DB, DBN, SVI, SVN, UN

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DBN NORMALIZE DIRECTION BIT



The DBN command normalizes the logic of the direction control output of the addressed axis or axes, returning their output logic to default; i.e. TTL low when traveling in the positive direction and high when traveling negative. This command negates the effect of the DBI command. To make this the default at power up or reset when DBI has already been made the default, use the AP command.

Example: Set the direction outputs for axes Z and T to default output logic; i.e. output high when traveling positive and low when traveling negative. Leave X and Y as they are.

Enter:
AZ;
DBN;
AT;
DBN;
Or
AA;
DBN,,1,1;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
DBN;	AX – AT	1
DBNb,b,b,b;	AA-AM	1
-	AA/CD	Not Valid

Related commands: BI, ?DB, DBI, SVI, SVN, UN

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DC DECELERATION

The DC command sets a deceleration rate overriding the AC parameter when the GU command is used to initiate a move. Only the GU command will use the DC value. The deceleration rate defaults to 200,000 and will take on whatever value is entered via the AC command. Therefore, the DC command must be reentered after using AC if a different deceleration rate is desired.

RANGE: 1 ≤ DC ≤ 8000000

Example: Send the Y axis on a 100,000 count move that accelerates at 100,000 counts per second per second up to 50,000 counts per second and decelerates at 20,000 counts per second per second.

Enter:
```
AY;
AC100000;
DC20000;
VL50000;
MR100000;
GU;
```

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
DC#;	AX – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: AC, ?DC, GU, RC, VB, VL

?DC REPORT DECELERATION RATE

The ?DC command reports the deceleration rate that will be used by the GU command.

RANGE= 1≤ DC ≤ 8000000

Example: Determine deceleration rate of none symmetric motion profiles of X axis.

Enter:
```
AX;
?DC
```

Response: dc20000<LF >

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?DC	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: AC, DC, GU

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?DE REPORT A CUSTOM RAMP TABLE ENTRY

The ?DE command will return a specific entry from a specific custom ramp table. The first parameter specifies the table to examine and the second parameter specifies the entry to return from the table.

RANGE:
1 ≤ Parameter1 ≤ 4
1 ≤ Parameter2 ≤ 25

Example: We can't remember what the 23rd breakpoint in table 4 was set to. Use the ?DE command to find out.

Enter: ?DE4,23;

Response: <LF> (there is no 23rd entry in table 4)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?DE#,#;	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?DA, DAB, DAE, DAR, ?DS

?DS REPORT THE SIZE OF A CUSTOM RAMP TABLE

The ?DS command returns the number of segments in the specified custom ramp table.

RANGE: 1 ≤ ?DS ≤ 4

Example: The 3rd custom ramp should be 17 breakpoints long. Make sure this is true.

Enter: ?DS3;

Response: ds17<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?DS#;	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?DA, DAB, DAE, DAR, ?DE, ?KO

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DZ DEFINE ZERO POSITION IN OPEN-LOOP MODE

The DZ command defines the offset coefficient needed to produce a zero voltage output or stationary position by the servo motor. This command is used in the open-loop mode with Hold Off (HF). This command can be used in combination with or in lieu of the balance adjustment on the servo amplifier. This is particularly useful with amplifiers that do not have a balance adjustment.

The factory default value is zero. Full-scale, the DZ command has a range of +/- 32,667 which corresponds directly to the 16-bit range of the DAC less a few counts as a buffer zone. Each increment/decrement of the DZ value will result in an approximate change in the output voltage of 0.0003 volts. See the AP Command on page 5-43 to preserve the DZ settings as the Power up/Reset values.

This command affects the offset only when in open-loop mode. The KO command is used to set the offset when the loop is closed. Typically, the value found that is satisfactory with the DZ command will also be used with the KO command. Since this is not always the case, DZ and KO are available to set differing offsets.

RANGE: -32,667 ≤ DZ ≤ 32,667

Example: Define the offset coefficient to be 250 (~ +76mV) for the X axis.

Enter: AX;
DZ250;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	REQUIREMENTS
DZ#;	AX–AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: HF, HN, KO,

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EA ENCODER STATUS

The EA command returns encoder status of the currently addressed axis or axes in the following format:

EA COMMAND RESPONSE DESCRIPTION		
CHAR	**SENT**	**DESCRIPTION**
1	E	Slip detection enabled
	D	Slip detection disabled
2	E	Position maintenance enabled
	D	Position maintenance disabled
3	S	Slip or stall detected (reset by execution of EA command)
	N	No slip or stall detected
4	P	Position Maintenance within deadband
	N	Position not within deadband
5	P	Encoder is at home condition
	N	Encoder is not at home
6	LF	Line feed

Example: Examine the status of the Y axis encoder.

Enter: AY;
EA

Response: DDNNN<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
EA	AX – AT	Immediate
EA	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: QA, QI, RA, RI

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EG ENGAGE ELECTRONIC GEARING



The electronic gearing engagement commands take the form of

EG<Master Axis><Gear ratio>;

Where:

<Master Axis> specifies the axis that the current axis is to follow and can reference the X, Y, Z or T axis. Note the current axis cannot be geared to itself or to an axis that has been geared to a master axis.

<Gear ratio> specifies a gearing ratio as the ratio of geared axis motion to master axis motion. The ratio can be entered in the following forms:

EG<*Master Axis*>; sets up gearing with a default gear ratio of 1 to 1.

For example: EGX; gears the current axis to the X axis using a ratio of 1 to1.

EG<*Master Axis*><Geared axis count>; sets up gearing with a ratio of <Geared axis count>:1.

For example: EGX2; gears the current axis to the X axis with a ratio of 2 to 1.

EG<*Master Axis*><Geared axis count>, <Master axis count>; sets up gearing with a ratio of Geared axis count>: <Master axis count>.

For example: EGX1,2; gears the current axis to the X axis with a gear ratio of 1 to 2.

Negative ratio values indicate that the current axis is to track the master axis in the opposite direction. The gear ratio must be such that (Gear Ratio *X the Master Axis' VL value) is at least 1 and less than the maximum controller step rate of 1,048,574 steps per second.

The commands specify that the current axis (geared axis) is to track the master axis velocity such that the current axis velocity = Ratio X Master Axis velocity.

Once a gearing engagement command is issued the geared axis will only respond to immediate commands until the gearing is cancelled. The EGF command addressed to the geared axis or over-travel on the geared axis will cancel electronic gearing. Note the following commands FL, KL, KS, SA, SD or SI flush the axis queue and will also cancel electronic gearing.



Example: Gear the Z axis to the X axis such that the Z axis velocity is always one half that of X.

Enter:
AZ;
EGX1,2;

Response: None

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Example: Gear the T axis to the Y axis such that the T axis velocity is always twice that of Y but in a direction that is opposite to Y.

Enter: AT;
EGY-2,1;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
EG#,#,#;	AX – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: EG?, EGF

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EG? REPORT ACTIVE ELECTRONIC GEARING COMMAND

The EG? command reports the currently active electronic gearing command for the current axis.

Example: Check the Y axis settings electronic gear ratio.

Enter: AY;
EG?

Response: =egx1,2 (Y axis is geared to the X with a gear ratio of 1:2)

Example: Check the Z axis settings electronic gear ratio.

Enter: AZ;
EG?

Response: =egf (Z axis is either not geared to another axis or it is the master axis in a electronic gearing relationship)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
EG?	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: EG, EGF

EGF TURN OFF ELECTRONIC GEARING

The **EGF** command turns off electronic gearing for the current axis.

Example: Turn off electronic gearing on the X axis

Enter: AX;
EGF;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
EGF;	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: EG, EG?

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ER ENCODER RATIO



The ER command allows specification of encoder:motor ratio for position maintenance mode. This command is not designed for use with servo motors. ER takes two arguments: encoder counts and motor counts. Both parameters must be integers. The ratio need not be per full revolution; reduce the fraction as far as possible and use those values.

The factory default ratio is 1:1. See the AP command (page **5-43**) to preserve the ER settings as the Power up/Reset values.

NOTE: That if an encoder ratio has been defined by the ER command, then the slip tolerance defined by the ES command is defined in encoder units and not in motor units.

Parameter 1 = Encoder Counts

Parameter 2 = Motor Counts



Example: You have an encoder connected to a stepper motor through a series of gears. When the motor steps 25,000 times, the encoder produces 10,000 counts. Set up an encoder ratio so hold mode will work correctly.

Enter: ER10000,25000;
or
ER2,5;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
ER#,#;	AX – AT	1
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?ER

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?ER REPORT MOTOR:ENCODER RATIO

The ?ER command reports the motor-to-encoder ratio as set with the ER command.



Example: Find out what the last ER command sent was.

Enter: ?ER

Response: er2.0<LF>
(The encoder produces 1 count for every 2 steps of the motor.)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?ER	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ER

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ES ENCODER SLIP TOLERANCE

The ES command parameter specifies the slip detection tolerance before slip or stall is flagged in the status register and in the RL command response. The encoder may get off target by as much as this value before the PCIx will consider the axis slipped. This mode must be turned on with an IS command and off with an HF command. The factory default value is 1. See AP command (see page **5-43**) to preserve the ES settings as the Power up/Reset values.

NOTE: If an encoder ratio is defined with the ER command, then the slip tolerance defined by the ES command is in encoder units and not in motor units.

NOTE: The GS command allows an open-loop stepper axis to perform a limited form of slip detection by using the home switch as a reference when executing a move command.

STEPPER RANGE: 0 < ES ≤ 65,535

Example: Your application can tolerate being up to 5 steps from the desired position before the controlling program should be notified of a slip condition.

Enter:
```
ES5;
IS;
```

Response: None.

Note: That if an encoder ratio has been defined by the ER command, then the slip tolerance defined by the ES command is defined in encoder units and not in motor units.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
ES#;	AX – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?ES, IS, RL, TF, TN

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?ES REPORT ENCODER SLIP TOLERANCE

The ?ES command reports the current value of the slip detect tolerance assigned to an axis.

Example: Report the current value for encoder slip detection tolerance

Enter: ?ES

Response: es15<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?ES	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ES

ET ENCODER TRACKING

The ET command turns on the encoder tracking mode. The axis will track its encoder input, thus allowing one axis to follow the activity of another or a thumbwheel for manual positioning or the movement of another device that produces a signal compatible to the encoder inputs. No acceleration or deceleration ramps are generated. The axis will duplicate the encoder input. The ER command allows the user to scale the motor's movements relative to the encoder. This command is intended to be used with stepper motors with encoders and not with servo motors.

Example: Set up the Y axis so it will follow its encoder input.

Enter: AY;
ET;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
ET;	AY – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ER, HF

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FL FLUSH

The FL command will flush an individual axis' queues. This command is similar in operation to the KL and ST commands except that current motion will remain unaffected by the FL command. All unexecuted commands remaining in the current axis queue will be flushed upon receipt of this command.

Example: Several motion commands have been sent to the X axis but a situation arose and now those commands must be cleared out. The currently executing motion must be allowed to complete to avoid damage to the product.

Enter: AX;
FL;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
FL;	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: KL, KS, SA, ST

FP FORCE POSITION

The FP command will flush the command queue and attempt to stop at the specified position. The axis will overshoot if there is insufficient distance left to stop at the programmed acceleration. This command should not be given to a servo axis while it is in motion; the results may be unpredictable. Force the axis to stop at a specified position.

Example: Force axis to stop at 25,000.

Enter: FP25000;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
FP#;	AX – AT	3*
-	AA-AM	Not Valid
-	AA/CD	Not Valid

* If PA (power automatic) mode is active add 1
* If an auxiliary output bit settle time has been specified add 3

Related commands: MM, MP, MV, SP

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GD GO AND RESET DONE



The GD command may be substituted for a GO command. It will reset the done flags and then initiate the move which has been previously programmed with such commands as MA, MR, MT, and ML just as the GO command does. In single axis mode, only the done flag for the selected axis will be reset.

In AA mode, all the done flags will be reset. In the AM mode, only the axes involved in the move will be reset. This allows the host to reset the interrupts on the axis involved in the next move without affecting other axes which may be still active. Note that this command is probably only useful in applications where commands are queued in advance since the interrupt may be reset before the host has the opportunity to service it if the GD command is waiting in the queue.

If this command is issued without having defined a move, the results are undefined. Issuing a GD command to execute an already-executed move also has undefined results. Only one GD command should be issued per defined move.



Example: In the single axis mode, move the Y axis 12345 counts in the negative direction and set the done flag when the move is completed. Then clear the done flag, move the motor 12345 counts in the positive direction, and set the done flag again when the move is completed.

Enter:
AY;
MR-12345;
GO;
ID;
MR12345;
GD;
ID;

Response: None.



Example: In AA mode, perform a linear absolute move with the X and Y axes to the position 10000,20000 and set the done flag when the move is completed. Then clear the done flag, perform a linear relative move on both axes moving the X axis 10000 steps in the negative direction and the Y axis 20000 steps in the negative direction, and set the flag once again.

Enter:
AA;
MT10000,20000;
GO;
ID;
ML-10000,-20000;
GD;
ID;

Response: None.

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QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
GD;	AX – AT	6*
GD;	AA-AM	8*
-	AA/CD	Not Valid

* If the axis is stepper and encoder or servo axis add 3 to the command queue.
* If PA (power automatic) mode is active add 2 to the command queue
* If an auxiliary output bit settle time has been specified add 3 to the command queue.

Related commands: MA, MR, MT, ML, GN, GO, GS, GU

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GN GO AND NOTIFY WHEN DONE

The GN command will initiate a move which has been previously programmed with such commands as MA, MR, MT, and ML and set the axis done flags when the move is complete. No operand is required with the GN command. If this command is issued without having defined a move, the results are undefined. Issuing a GN command to execute an already-executed move also has undefined results. Only one GN command should be issued per defined move.

Example: In the single axis mode, move the X axis to absolute position 12345.

Enter:
AX;
MA12345;
GN;

Response: None

Example: In the AA mode, move the X axis 2468 steps in the positive direction and the Y axis 2468 steps in the negative direction.

Enter:
AA;
MR2468,-2468;
GN;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
GN;	AX – AT	6*
GN;	AA-AM	7*
-	AA/CD	Not Valid

* If the axis is a stepper and encoder or servo axis add 3
* If PA (power automatic) mode is active add 2
* If an auxiliary output bit settle time has been specified add 3

Related commands: GD, GN, GS, GU, MA, ML, MR, MT

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GO GO



The GO command will initiate a move which has been previously programmed with such commands as MA, MR, MT, and ML. No operand is required with the GO command. If this command is issued without having defined a move, the results are undefined. Issuing a GO command to execute an already-executed move also has undefined results. Only one GO command should be issued per defined move.



Example: In the single axis mode, move the X axis to absolute position 12345.

Enter:
AX;
MA12345;
GO;

Response: None



Example: In the AA mode, move the X axis 2468 steps in the positive direction and the Y axis 2468 steps in the negative direction.

Enter:
AA;
MR2468,-2468;
GO;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
GO;	AX – AT	5*
GO;	AA-AM	7*
-	AA/CD	Not Valid

* If the axis is a stepper and encoder or servo axis add 3
* If PA (power automatic) mode is active add 2 to the command queue
* If an auxiliary output bit settle time has been specified add 3

Related commands: GD, GN, GS, GU, MA, ML, MR, MT

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GS GO AND MONITOR SLIP TRIGGER



The GS command works exactly like the GO command except that the home switch will be monitored during the motion. If the home switch becomes active the slip flag will be set for the axis. The host application can read the slip flag and see that the home switch was encountered during the move. This is useful in applications that register slip conditions by means other than encoder position verification; in fact, this command is not valid in controls with encoder feedback which includes servo motors.

If this command is issued without having defined a move, the results are undefined. Issuing a GD command to execute an already-executed move also has undefined results. Only one GD command should be issued per defined move.



Example: Move the X axis 50,000 counts in the positive direction. If the motor slips it will close a switch wired to the home input of the X axis. Monitor this switch during the move and set the slip flag for axis X if the switch becomes active.

Enter:
```
AX;
MR50000;
GS;
```

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
GS;	AX – AT	5*
-	AA-AM	Not Valid
-	AA/CD	Not Valid

* If PA (power automatic) mode is active add 2
* If an auxiliary output bit settle time has been specified add 3

Related commands: GD, GN, GO, GU, MA, MR

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GU GO ASYMMETRICAL



The GU command initiates a previously defined move using the AC value for acceleration and the DC value for deceleration. This command may be used with only one axis at a time; i.e. it is not valid with the ML and MT commands.

If this command is issued without having defined a move, the results are undefined. Issuing a GU command to execute an already-executed move also has undefined results. Only one GU command should be issued per defined move. GU is used only with linear acceleration ramps. Use S-curve command (see AJ, ?AJ, SS) for defining more complex asymmetrical motion profiles.



Example: Move the Y axis to position 1,500 using the current acceleration and velocity and a deceleration of 5,000 counts per second per second.

Enter:
```
AY;
DC5000;
MA1500;
GU;
```

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
GU;	AX – AT	3*
-	AA-AM	Not Valid
-	AA/CD	Not Valid

* If the axis is a stepper and encoder or servo axis add 3
* If PA (power automatic) mode is active add 2
* If an auxiliary output bit settle time has been specified add 3

Related commands: AC, DC, GD, GN, GO, GS, MA, MR

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HD HOLD DEADBAND

The HD command specifies deadband counts for position maintenance mode. If the encoder count is within this distance of target, it is considered in position and no further correction will be made. This parameter interacts with the HG and HV commands; i.e. a larger dead band will allow a larger gain parameter in many applications. This command is designed to work with stepper motor applications using encoders and is not designed for use with servo motors. The factory default value is zero. See the AP command to preserve the HD settings as the Power up/Reset values.

RANGE: 0 ≤ HD ≤ 64,000

Example: (see HN command page 5-92)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
HD#;	AX – AT	2
HD#,#,#,#;	AA-AM	2
-	AA/CD	Not Valid

Related commands: ?HD, HF, HG, HN, HV

?HD REPORT POSITION MAINTENANCE DEADBAND

The ?HD command reports the current setting of the HD command. This command will only work on stepper axes with encoders.

Example: Report the HD setting

Enter: ?HD

Response: hd5<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?HD	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: HD, ?HG, ?HV

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HE HOME ENCODER



The HE command enables encoder index, and phase A and B signals to be considered in addition to the home switch input when an HM or HR command is executed. This command does not execute the home motion which must be initiated with an HM, HR, KM, or KR command. Default home behavior (considering only the home switch for home commands) may be reestablished via the HS command. In the HE mode, home is defined as the logical AND of the encoder index, the external home enable and the encoder quadrant where channel A is positive and channel B is negative. The default home logic expressed in Boolean terms is:

home = phase_A * / phase_B * index * / home_switch

The HL and HH commands are not valid in this state.

.



Example: Set up the Y axis so it will use the encoder signals to recognize the home position.

Enter:
AY;
HE;
or
AA;
HE,1;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
HE	AX – AT	Immediate
HEb,b,b,b;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: HM, HR, HS, KM, KR

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HF HOLD OFF

The HF command disables position hold, stall detection and tracking modes, for stepper with an encoder axis. If the current axis is a servo, this command will open the loop and turn off the PID. If the current mode is multi-axis, all axes will go into open-loop mode. This is the default mode at power up or reset.



Example: Turn off encoder hold mode on the X axis.

Enter: AX;
HF;

Response: None

NOTE: In AA or AM mode, a null value in the argument list specifies feedback for that axis is not to be disabled.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
HF;	AX – AT	2
HF;	AA-AM	2
-	AA/CD	Not Valid

Related commands: HN, ?PM

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HG HOLD GAIN

The HG command allows the user to specify the position hold gain parameter. This gain parameter is multiplied by the position error in determining the velocity during correction. The velocity used will not exceed the value set with the hold velocity (HV) command. This command is designed to work with stepper motor applications using encoders and is not designed for use with servo motors. The parameter should be set experimentally by increasing it until the system is unstable then reducing it slightly below the threshold of stability. The factory default value is 1. See the AP command (page **5-43**) to preserve the HG settings as the Power up/Reset values.

RANGE: 1 ≤ HG ≤ 32,000

Example: (see HN command (page **5-92**)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
HG#;	AX – AT	2
HG#,#,#,#;	AA-AM	2
-	AA/CD	Not Valid

Related commands: HD, HF, ?HG, HN, HV

?HG REPORT POSITION MAINTENANCE GAIN

The ?HG command reports the current setting of the position maintenance hold gain constant for the current axis. This command works only with stepper with encoder axes.

Example: Position corrections seem slow. Check the setting of HG to be sure it is correct.

Enter: ?HG

Response: hg100<LF >

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?HG	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?HD, HG, ?HV

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HH HOME HIGH

The HH command sets the sense of the home switch on the current axis to active TTL high. This command allows TTL logic high to be treated as the “true” state for applications where this is more convenient. Once this command has been sent to the PCIx, active high homes can be made the power-up default by using the AP command; refer to the AP command for details. This command sets the home switch “true” state to TTL logic high for the HS mode of the home operation and it is not valid in HE mode..

Example: (see HL command on page 5-89)

Note: In AA or AM modes, a null argument in the parameter list specifies that axis home switch to be unchanged.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
HH;	AX – AT	1
HHb,b,b,b;	AA-AM	1
-	AA/CD	Not Valid

Related commands: HL, HM, HR, HS, KM, KR

HL HOME LOW

The HL command sets the sense of the home switch on the current axis to active TTL low. This is the power-up and reset default “true” state unless HH has been saved as a user power-up default (See the AP command.). This command sets the “true” state of a home input to a TTL logic low.

This command sets the home switch “true” state to TTL logic high for the HS mode of the home operation and it is not valid in HE mode..

Example: The stage is moved through home with the home switch set for active low at low speed to meet the less than 2048 steps per second requirement of the home command.

Enter:
```
AX;
VL2000;
HL;
HM0;
```

Response: None

Note: In AA or AM modes, a null argument in the parameter list specifies that axis home switch to be unchanged.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
HL;	AX – AT	1
HLb,b,b,b;	AA-AM	1
-	AA/CD	Not Valid

Related commands: HH, HM, HR, HS, KM, KR

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HM HOME

The HM command will cause the current axis or specified axes to move in the positive direction at the predefined velocity until the home is detected for each axis. The position counters will be initialized to the positions supplied as parameters.

How home is detected depends on whether the HS or HE modes has been selected. The default mode, HS, detects home based on an external home input only. The HE mode detects home based on the external home input and the encoder signals (Index, A and B).

The velocity should be less than the update rate to maintain accuracy of the home position loaded. A velocity set to less than or equal to the update rate will provide a homing accuracy of +/-0 counts. Every multiple of the update rate adds +/-1 count to the error range.

Each axis will, when home is detected, reset its position counter to the parameter specified in the HM command. Once the counter is reset, the axis will ramp to a stop at the rate specified previously via the AC command. This will result in the axis stopping beyond the home switch so care should be taken to ensure adequate stopping distance is available beyond the switches. The axis can be easily returned to the precise home position by using an MA command after the HM command.

If no parameter is specified in single axis modes, the HM command will use zero as a default value. Parameters must be specified in multi-axis modes to inform the PCIx which axes are to be homed.

Example: Find the physical home position of the X axis of the stage. The motor runs until the home switch input is activated and then initializes the position counter to the parameter supplied. Since the motor decelerates to a stop after reaching home, it is necessary to do an MA to the same position as specified in the home command if it is desired to physically position the device at home. The following commands will find home, initialize it to 1000 counts, and then return to home. In many cases it will not be necessary to return home, only find the position and synchronize the controller to it.

Enter:
```
AX;
VL1000;
HM1000;
MA1000;
GO;
```

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
HM#;	AX – AT	4*
HM#,#,#,#;	AA-AM	4*
-	AA/CD	Not Valid

* If the axis is a stepper and encoder or servo axis add 2 to the command queue
* If PA (power automatic) mode is active add 2 to the command queue.
* If an auxiliary output bit settle time has been specified add 3 to the command queue

Related commands: HE, HH, HL, HR, HS, KM, KR, LO, LP, RP

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?HM REPORT HOME STATE SELECTION



Reports homing mode selected for an axis. The possible responses are 'switch' for home switch (HS) mode and 'encoder' for home encoder (HE) mode.

Example: Report the homing mode assigned to the X axis.

Enter:
AX;
?HM

Response: hs<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?HM	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: HE, HH, HL, HM, HR, HS, KM, KR

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HN HOLD ON



For servo axes, the HN command closes the loop, enabling the PID. For servo axes, this mode is disabled when the HF command is entered, when the servo error becomes too large or a limit is encountered.

For stepper with encoder feedback axes, the HN command enables position correction after a move and activates the HD, HG and HV commands for stepper axes with encoders. For stepper axes with encoders, this mode will be canceled (as though via an HF command) if an CG, CX, HM, HR, MV, SO, SP command is entered, if a limit is encountered or the maximum allowable position error is executed.

Example: (Stepper)

The following commands could be used to set up the position correction mode on a stepper axis. This sequence sets up a move velocity of 100,000 steps per second and an acceleration of 500,000 steps per second per second. The position correction velocity is set for 50,000 steps per second, a dead band of 10 steps and correction gain of 2,000. The correction is then enabled. A 200,000 step move is performed, then that position is maintained within the 10 step dead band until commanded to a new position.

Enter:

```
AX;
VL100000;
AC500000;
HV50000;
HD10;
HG2000;
HN;
MR200000;
GO;
```

Response: None

Example: (Servo)

Close PID loop or X axis after having modified one of the PID parameters.

Enter:

```
AX;
HN;
```

Response: None

NOTE: In AA or AM mode, a null value in the argument list specifies that encoder feedback is not to be enabled for that axis.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
HN;	AX – AT	1*
HNb,b,b,b;	AA-AM	1*
-	AA/CD	Not Valid

* Values in table are for a stepper with encoder axis. For a servo axis the command queue requires 2.

Related commands: HF, HD, HG, HV, ?PM

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HR HOME REVERSE

The HR command will cause the current axis or specified axis to move in the negative direction at the predefined velocity, until the home is detected for each axis. When the home input is detected, the position and encoder counters are loaded with the parameter(s) supplied in the HR command. Then the axis is ramped to a stop. It behaves exactly like the HM command, except it travels in the reverse direction.

How home is detected depends on whether the HS or HE modes has been selected. The default mode, HS, detects home based on an external home input only. The HE mode detects home based on the external home input and the encoder signals (Index, A and B).

Example: In a long stage it may be awkward to travel the full distance to home at less than the update rate. The following will get close to home at higher speed, and then refine the position at lower speed in the reverse direction.

Enter:
```
AX;
VL100000;
HH;
HM;
VL1000;
HL;
HR;
```

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
HR#;	AX – AT	4*
HR#,#,#,#;	AA-AM	4*
-	AA/CD	Not Valid

* If the axis is a stepper and encoder or servo axis add 2 to the command queue.
* If PA (power automatic) mode is active add 2 to the command queue.
* If an auxiliary output bit settle time has been specified add 3 to the command queue

Related commands: HE, HH, HL, HM, HS, KM, KR, LO, LP

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HS HOME SWITCH

The HS command disables HE mode and returns the PCIx to the default home behavior. Default behavior defines a home state to be active when the home switch input is either low in default or HL mode or high when in HH mode. This mode can also be used with encoders which contain internal home logic by connecting their output to the PCIx home input for the appropriate axis. The active level of this input may be controlled by the HH and HL commands.

Example: Set up the Y axis so it will ignore the encoder signals and only use the home input to recognize the home position.

Enter:
AY;
HS;
or
AM;
HS,1;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
HS	AX – AT	Immediate
HSb,b,b,b;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: HE, HH, HL, HM, HR, KM, KR

?HS REPORT HOME SWITCH TRUE STATE SELECTION

The ?HS command reports if the true state of the home switch is set to be active high or low.

Example: Determine if true home switch selection of Z axis is high.

Enter:
AZ;
?HS

Response hh<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?HS	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: HE, HH, HL, HM, HS, KM, KR, LO, LP

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HV HOLD VELOCITY

The HV command specifies the maximum velocity to be used when correcting position error. The factory default setting is zero; some value must be set for position correction to occur at all. See the AP command to preserve the HV settings as the Power up/Reset values. This command is not designed for use with servo motors.

Hold gain (HG) will be used to scale the HV value based on the total error that must be corrected. In most cases the HV value will never be reached unless the position error is very wide or the HG value is set very high.

RANGE: 1 ≤ HV ≤ 1,039,999

Example: (see HN command, see page **5-92**)

NOTE: In AA or AM mode, a null value in the argument list specifies that the hold velocity parameter is not to be changed for that axis.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
HV#;	AX – AT	2
HV#,#,#,#;	AA-AM	2
-	AA/CD	Not Valid

Related commands: HD, HF, HG, HN, ?HV

?HV REPORT POSITION MAINTENANCE VELOCITY

The ?HV command reports the current setting of the position maintenance hold velocity limits for the current axis. This command works only with stepper + encoder axes.

Example: Check the peak correction velocity for the T axis

Enter: AT;
?HV

Response: hv20000<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?HV	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?HD, ?HG, HV

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IC INTERRUPT CLEAR



The IC command or the ASCII character Control-Y (hex 19) is used to clear the done and error flags in the status register and the done flag register on PCIx, otherwise the axis would always appear to be “done”. This command will be executed immediately and will usually be placed in the done and error handler interrupt service routine to clear the interrupt and the associated flags. The flags may be polled by an RA or RI command which will also reset the flags.

Note: That this command is not recommended in Windows environments using Pro-Dex, Inc., Oregon Micro Systems,-supplied device drivers and DLLs. The preferred method is to use the device driver and DLL to handle the reporting and clearing status flags.



Example: Clear the flags after an X axis move relative of 5000 steps was flagged as done when an ID executes.

Enter:
AX;
MR5000;
GO;
ID; (done flag set, wait until done interrupt received)
IC; (done flag cleared on PCIx)

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
IC;	AX – AT	Immediate
IC;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: CA, GD, ID, II, IN, IP

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ID INTERRUPT WHEN DONE



The ID command will set the done flag for the axis or axes to which the command was issued. An interrupt to the host will be generated if interrupts have been enabled in the PCIx. In Windows environments, this interrupt is captured by the device driver which will store the flags to pass on to the host application when requested.

This command allows the PCIx to signal the host when a string of commands has been completed. In AA mode, the done flag register bits will be set as each axis encounters the ID in its command stream, but the done flag in the status register will not be set until all axes have executed the ID command. In the AM mode, only the axes active in the most recent move will set their done flags.

Though move commands are most commonly used with the ID command, others may be used as well. The ID command may be sent to the PCIx to tell it to set done flags whenever the host application could benefit from knowing an event or series of commands has completed.



Example: Interrupt the host CPU after the execution of Move Absolute is finished. When the move is finished the ID command will be encountered in the command queue and will set the done flags.

Enter:
```
AX;
MA100000;
GO;
ID;
```

Response: None



Example: Wait until an input line becomes false then notify the host that this occurred.

Enter:
```
SW2;
ID;
```

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
ID;	AX – AT	1
ID;	AA-AM	1
ID;	AA/CD	1

Related commands: II, IN, IP, RA, RI

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II INTERRUPT INDEPENDENT



Like the ID command, the II command tells the PCIx to interrupt the host when each axis finishes a move. Unlike the ID command, only those axes which have been supplied parameters in the most recent move command will get their done flags set and cause interrupts.



Example: The following command sequence would cause interrupts when the Y and T axes finish. If they do not complete at the same time, two separate interrupts would be generated.

Enter:
```
AM;
MR,1000,,10000;
GO;
II;
```

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
-	AX – AT	Not Valid
II;	AA-AM	1
-	AA/CD	Not Valid

Related commands: ID, IN, IP

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IN INTERRUPT NEARLY DONE



The IN command allows the PCIx to interrupt the host when the axis or combination of axes is nearly complete. When used in an application involving probing a part after a move, the probes could start accelerating down while the stage is finishing its move, improving the overall system throughput. This command is valid in all modes. The IN command must be entered before the GO or GD command since it is executed before the move is complete. The test is only performed during deceleration. If the IN parameter is greater than the ramp down distance, the interrupt will be generated when the control starts decelerating.

When a multi-axes move is ised in AA/AM modes, IN specifies a separate near distance for each axis, but only a single interrupt occurs when all the axes in the move are within their respective distances specified by the IN command. Once an interrupt has occurred, the IN command must be re-issued in order to generate another interrupt.

RANGE:
-33,544,431 ≤ Parameter (Distance Before End of Move) ≤ 33,544,431



Example: The following sequence would interrupt the host once when the X axis is complete and the Z axis is within 10,000 counts of being complete. The Y axis completion would be ignored in this example.

Enter:
```
AA;
IN0,,10000;
MR100000,100000;
GO;
MR,,50000;
GO;
```
(X and Z interrupt occurs when Z is within 10000 steps of the Z destination.)

Response: None

NOTE: In AA or AM mode, a null value in the argument list specifies the position tolerance for nearly done is not to be set for that axis.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
IN#;	AX – AT	3
IN#,#,#,#;	AA-AM	3
-	AA/CD	Not Valid

Related commands: ID, II, IP

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IP INTERRUPT WHEN IN POSITION

The IP command operates like the ID command except the interrupt is deferred until the stage is within the specified step encoder dead band. If the position hold (HN) is not enabled for an axis, the command will behave like an ID command for that axis.

Example: Set the done flag when axis is within its dead band.

Enter:
```
AX;
HV1000;
HG100;
HD10;
HN;
MR1000;
GO;
IP;
```

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
IP;	AX – AT	1
IP;	AA-AM	1
-	AA/CD	Not Valid

Related commands: HN, ID, II, IN

IS INTERRUPT ON SLIP

The IS command enables the PCIx to interrupt the host on slip or stall detection if the appropriate bit has been set in the interrupt control register. Slip detection are disabled if a ER, ET, HF, HM, HR, JG, LP, or TM command is entered or if a limit is encountered. If a slip occurs, slip detection must be re-enabled. The factory default slip tolerance (ES) value is 1. This command is intended to be used with stepper motors and not servo motors.

Example: (see ES command on page 5-76)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
IS;	AX – AT	1
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ES, RL, TF, TN

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JF JOG FRACTIONAL VELOCITIES

The JF command will jog one or more axes at the velocities specified, like the JG command. The parameter may include a fractional part allowing better resolution at low speeds. The velocity set by this command will remain the default velocity until altered by a VL, JG or another JF command.

RANGE: -1,043,999.999 ≤ JF ≤ 1,043,999.995

Example: Jog the Y axis at 2 2/3 steps per second.

Enter: AY;
JF2.667;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
JF#;	AX – AT	4
JF#,#,#,#;	AA-AM	4
-	AA/CD	Not Valid

* If PA (power automatic) mode is active add 1 to the command queue
* If the axis is a stepper and encoder or servo axis add 1 to the command queue

Related commands: JG, SA, ST, TM

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JG JOG

The JG command is a velocity mode and will move one or more axes at the velocities supplied as parameters. The JG command will accelerate to the programmed velocity at the current AC rate and run until altered by an ST, SA, KL, HF (servo models), another JG command, or a limit switch is encountered while limits are enabled.

The jog velocity may be changed by following the command with another JG command of a different velocity. A change in direction between two JG commands will cause an axis to ramp to a stop then back up in the opposite direction.

This command modifies the move velocity parameter (VL) for the affected axis or axes. The JG command does not require any other command to start the motion.

RANGE: -1,043,999 ≤ JG ≤ 1,043,999

Example: Jog the motor at 100,000 counts per second then change to 35,000 counts per second when the second JG is entered, stay at that velocity for 5 seconds, then stop by decelerating to a stop. Next, jog the motor at 5,000 counts per second in the negative direction.

Enter:
```
JG100000;
JG35000;
WT5000;
ST;
JG-5000;
```

Response: None

Note: Output events waiting for completion of JG will begin when JG is up to its requested velocity. In this case, the motor will ramp from zero to 100,000, ramp back down to 35,000, flatten out at 35,000 for 5 seconds, then ramp to a stop, before moving in the negative direction at a velocity of 5,000.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
JG#;	AX – AT	4
JG#,#,#,#;	AA-AM	4
-	AA/CD	Not Valid

* If PA (power automatic) mode is active add 1 to the command queue
* If the axis is a stepper encoder or servo axis add 1 to the command queue
* If the profile move, just prior to this home command was either a MT or ML move then the axis acceleration and velocity values will be reset to the AC and VL values just prior to the execution of the home. This add to the queue requirements under the following conditions:

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Axis Ramp Type	Requirements
Linear (PF, LA)	8
Short Form Parabolic (PN0, PR0)	10
All other Parabolic forms (PN, PR)	26
Cosine (CN, SC)	26
Custom (SR)	6 + (2 x number of ramp segments)
S-curve (AJ)	113

Related commands: JF, SA, ST, TM

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KA ACCELERATION FEEDFORWARD

KA is the acceleration feedforward gain coefficient used in the PID filter calculations. The factory default value is zero. See the AP command to preserve the KA settings as the power up/reset values. The default value is 0.00

RANGE: 0.00 ≤ KA ≤ 32,767.00

Example: Define KA to be 2 on the T axis.

Enter: AT;
KA2;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
KA#;	AX – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: HF, HN, ?KA, KD, KI, KP, KV

?KA REPORT ACCELERATION FEEDFORWARD

The ?KA command reports the current setting of the acceleration feedforward constant (KA) for the current servo axis. Default value is 0.00

Example: Find out what the current KA value is for servo axis Y

Enter: AY;
?KA

Response: ka10.50<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?KA	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: KA, ?KV

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KB PID UPPER BOUND LIMIT COEFFICIENT

The KB command sets the servo axis PID output value upper bound limit from DAC. (This can be useful in debugging servo drives.) The default value is 0.00

RANGE: 0.0 ≤ KB ≤ 10.0

Example: Limit the servo output from DAC to 9 max on Y axis. This is approximately half of its normal range.

Enter: AY;
KB9;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
KB#;	AX – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?KB

?KB REPORT AXIS PID UPPER BOUND LIMIT

The ?KB command requests the value of the KB parameters for the upper bound limit to the DAC.

Example: Determine PID upper bound limit for X axis

Enter: AX;
?KB

Response: kb5.00<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?KB	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: DBI, DBN, ?SV

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KD DERIVATIVE GAIN COEFFICIENT

KD is the derivative gain coefficient used in the PID filter calculations. See Section 2 for more information regarding this parameter. The factory default value is 20.00. See the AP command to preserve the KD settings as the Power up/Reset values.

RANGE: 0.00 ≤ KD ≤ 32,767.00

Example: Set KD to 56 on the Z axis.

Enter: AZ;
KD56;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
KD#;	AX – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?KD, KI, KP, HF, HN

?KD REPORT PID DERIVATIVE GAIN

The ?KD command reports the current setting of the derivative gain coefficient (KD) in the PID of the current servo axis.

Example: Forgot to write down the Y axis KD setting which is working well. Report the setting so it can be recorded.

Enter: AY;
?KD

Response: kd5.12<LF >

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?KD	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: KD, ?KI, ?KP,

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KF SET SERVO AXIS PID FRICTION COEFFICIENT

The KF command sets the friction offset coefficient of a servo axis PID. This assists in the smooth start up motion of the X axis, and compensates for friction. The default value is 0.

Range: 0 ≤ KF ≤ 32,767

Example: Set the Y axis friction coefficient to 100.

Enter: AY;
KF100;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
KF#;	AX – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?KF

?KF REPORT SERVO AXIS FRICTION OFFSET

The ?KF command reports the value of the frictional offset coefficient.

Example: Verify Z axis friction offset coefficient is 12

Enter: AZ;
?KF

Response: kf12<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?KF	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: KD, ?KI, ?KP

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KI INTEGRAL GAIN COEFFICIENT

KI is the integral gain coefficient used in the PID filter calculations. See the AP command to preserve the KI settings as the power up/reset values. Default value is 0.04.

RANGE: 0.00 ≤ KI ≤ 32767.00

Example: Define KI to be 3.42 on the X axis.

Enter:
AX;
KI3.42;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
KI#;	AX – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: HF, HN, KD, ?KI, KP

?KI REPORT PID INTEGRAL GAIN

The ?KI command reports the current setting of the integral gain constant (KI) in the PID of the current servo axis.

Example: Report the setting of the KI coefficient on the Z axis

Enter:
AZ;
?KI

Response: ki1.00<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?KI	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?KD, KI, ?KP

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KL KILL

The KL command will flush the command queues and terminate pulse generation of all axes immediately. It is intended for emergency termination of any program and to reset the input queues to a known state.

Step motors may not stop immediately even though no more step pulses are delivered due to inertia of the motor and system load. This may result in slippage of the motor. Therefore, the position counter may not accurately reflect the true position of the motor following this command. All axes should be re-homed to return the position counters to a known state.

Due to the encoders used in servo systems, position will not be lost, so re-homing servo axes is unnecessary.

Example: Stop all previously defined movement and flush the queue of a partially entered incorrect move command (you wanted a negative move not a positive one), before GO is entered.

Enter:
```
AX;
MR5000; (oops!)
KL;
MR-5000;
GO;
```

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
KL;	AX – AT	1
KL;	AA-AM	1
-	AA/CD	Not Valid

* If PA (power automatic) mode is active add 1
* If an auxiliary output bit settle time has been specified add 3

Related commands: FL, KS, SA, SD, SI, SO, ST,

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KM HOME AND KILL



The KM command will move the current axis in the positive direction until home is detected and then kill motion immediately; i.e. without using a deceleration ramp. The position counter will not be reset or cleared. Due to motor and/or payload inertia, the motor may not stop immediately but slip some distance instead. This will result in inaccurate position counters. This command's primary purpose is to move an axis out of the way quickly or to get the axis near home rapidly to speed up the homing process.



Example: Move the Y axis in the positive direction to the home sensor and stop movement as quickly as possible.

Enter: AY;
KM;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
KM;	AX – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

* If PA (power automatic) mode is active add 2 to the command queue.
* If an auxiliary output bit settle time has been specified add 3 to the command queue

Related commands: HE, HH, HL, HM, HR, HS, KR, LO, LP

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KO OFFSET COEFFICIENT

The KO command defines the offset coefficient to cause the motor to remain stationary and compensate for additional torque on the motor from loading. The factory default value is zero. See the AP command to preserve the KO settings as the power up/reset values.

The factory default value is zero. Full-scale, the KO command has a range of +/-32,767 which corresponds directly to the 16-bit range of the DAC less a few counts as a buffer zone. Each increment/decrement of the KO value will result in an approximate change in the output voltage of 0.0003 volts.

RANGE: -32767 ≤ KO ≤ 32767

Example: Define the offset coefficient to be –2000 (~ -610mV) on the Y axis.

Enter: AY;
KO-2000;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
KO#;	AX – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: HF, HN, ?KO

?KO REPORT PID OFFSET

The ?KO command reports the voltage offset (KO) setting for the current servo axis.

Example: The open-loop offset is 218. Make sure the closed-loop offset is the same.

Enter: ?KO

Response: ko218<LF >

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?KO	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: KO

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KP PROPORTIONAL GAIN COEFFICIENT

KP is the proportional gain coefficient used in the PID filter calculations. See the AP command to preserve the KP settings as the power up/reset values. Default value is 10.00.

RANGE: 0.00 ≤ KP ≤ 32767.00

Example: Define KP to be 45.6 on the Z axis.

Enter: AZ;
KP45.6;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
KP#;	AX – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: HF, HN, KD, KI, ?KP

?KP REPORT PROPORTIONAL GAIN

The ?KP command reports the current setting of the proportional gain coefficient (KP) in the PID of the current servo axis.

Example: Find out what the X axis proportional gain is set to.

Enter: AX;
?KP

Response: kp10.00<LF >

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?KP	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?KD, ?KI, KP

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KR HOME REVERSE AND KILL



The KR command will find home by issuing a JG in reverse. When home is found, it will stop generating pulses immediately; i.e. no deceleration ramp will be generated. This command is identical to the KM command except that the direction of motion is reversed.



Example: Move the Y axis in a negative direction to the home sensor and stop movement as quickly as possible.

Enter: AY;
KR;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
KR#;	AX – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

* If PA (power automatic) mode is active add 2 to the command queue.
* If an auxiliary output bit settle time has been specified add 3 to the command queue

Related commands: HE, HH, HL, HM, HR, HS, KM, LO, LP

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KS KILL SELECTED AXES



This command performs the same operation as the KL (kill) command except that individual axes can be killed without affecting others. KS will flush only the selected axes' command queues rather than the entire board. Refer to the KL command for more details.



Example: The Y axis has hit a limit switch and is now executing commands that were waiting in the queue. This axis must be reset but the other axes must be allowed to continue operation.

Enter:
AY;
KS;
or
AA;
KS,1;

Response: None

NOTE: In AA or AM modes, null values in the argument list specify that motion on that axis is not to be killed.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
KS;	AX – AT	1*
KSb,b,b,b;	AA-AM	1*
-	AA/CD	Not Valid

* If PA (power automatic) mode is active add 1
* If an auxiliary output bit settle time has been specified add 3

Related commands: FL, KL, SA, SD, SI, SO, ST

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KU PID INTEGRATION SUM UPPER LIMIT

This command sets servo axis PID integration sum upper limit.

RANGE: 0 ≤ KU ≤ 32767

Example: Set the integration sum upper limit of X axis to 150

Enter: AX;
KU150;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
KU#;	AX – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?KU

?KU REPORT PID INTEGRATION SUM UPPER LIMIT

Report servo axis PID integration sum upper limit.

Example: Check to make sure the integration sum upper limit of X axis is less than 200.

Enter: AX;
?KU

Response: ku150<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?KU	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: HF, HN, KD, KP, KU

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KV VELOCITY FEEDFORWARD

KV is the velocity feedforward coefficient used in the PID filter calculations. The factory default value is zero. See the AP command to preserve the KV settings as the power up/reset values.

RANGE: 0.00 ≤ KV ≤ 32,767.00

Example: Set KV to 35.3 on the Y axis.

Enter: AY;
KV35.3;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
KV#;	AX – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: HF, HN, KA, KD, KI, KP, ?KV

?KV REPORT VELOCITY FEEDFORWARD

The ?KV command reports the current velocity feedforward coefficient (KV) of the current servo axis. Default value is 0.00

Example: Make sure the velocity feedforward setting of axis T is zero

Enter: AT;
?KV

Response: kv0.00<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?KV	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?KA, KV

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LA LINEAR RAMP PER AXIS



The LA command specifies that the linear acceleration ramp is to be used by the selected axes. This is the factory default for all axes. See the AP command to preserve the LA settings as the power up/reset values. This command is similar to the PF command but can be used to switch a single axis rather than all axes at once.



Example: Select a linear ramp for the X axis.

Enter: AX;
LA;

Response: None



Example: Select the linear ramp for the Y and T axes.

Enter: AA ;
LA,1,,1;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
LA;	AX – AT	11
LAb,b,b,b;	AA-AM	11
-	AA/CD	Not Valid

Related commands: CN, PF, PN, PR, ?RT, SC, SR

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LE LOOP END



The LE command terminates the most recent LS command. The axis will loop back and repeat the commands within the loop the number of times specified in the LS command. The loop will start repeating as soon as this command is issued.



Example: Perform a relative move on axis Z 5 times. After each Z move, wiggle the T axis 20 times.

Enter:
AZ;
LS5;
MR5000;
GO;
AT;
LS20;
MR50;
GO;
MR-50;
GO;
LE; (terminates the LS20; command)
AZ;
LE; (terminates the LS5; command)

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
LE;	AX – AT	2
LE;	AA-AM	2
-	AA/CD	Not Valid

Related commands: LS

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LF LIMITS OFF



The LF command disables the limit switches for the addressed axis or axes. This allows the stage to move beyond the limit switches and should be used with caution. The PCIx will still recognize that a limit switch has been closed if the stage runs into one and will report this information via the query commands (See the QA command). However, the limit switch closure will have no effect on motion; i.e. the axis will not be forced to stop as a result.

NOTE: In systems not designed to handle motion beyond the limit switch points, this can potentially cause damage to the system and/or persons operating the system. This command should be used with extreme caution.



Example: Set up a board to ignore the Y axis limit switches.

Enter:
AY;
LF;
or
AA;
LF,1;

Response: None

Note: In AA or AM modes, a null argument in the parameter list specifies that axis home switch to be affected.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
LF;	AX – AT	1
LFb,b,b,b;	AA-AM	1
-	AA/CD	Not Valid

Related commands: LH, LL, LN, SF SL

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LH LIMITS HIGH



The LH command sets the senses of the limit switches on the current axis to active high. The default "true" states of the limits are TTL logic low. This command allows TTL logic high to be treated as the "true" state for applications where this is more convenient. Through the execution of the AP command, limits can be made to default as active high on power-up or reset; see the AP command for details.



Example: Select the limit switch high true condition for the X axis.

Enter:
AX;
LH;

Response: None



Example: Select a high true limit condition for the Z and T axes.

Enter:
AA;
LH,,1,1;

Response: None

Note: In AA or AM modes, a null argument in the argument list specifies that axis is not to be affected.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
LH;	AX – AT	1
LHb,b,b,b;	AA-AM	1
-	AA/CD	Not Valid

Related commands: LF, LL, LN, ?LS, SF, SL, TL

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LL LIMITS LOW



The LL command specifies that over travel occurs when the limit input signal is low (active low). This is the factory default mode. See the AP command for information on how to preserve the LL settings as the power up/reset values.



Example: Select the limit switch low true condition for the X axis.

Enter: AX;
LL;

Response: None



Example: Select a low true limit condition for the Y and T axes.

Enter: AA;
LL,1,,1;

Response: None

Note: In AA or AM modes, a null argument in the argument list specifies that axis is not to be affected.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
LL;	AX – AT	1
LLb,b,b,b;	AA-AM	1
-	AA/CD	Not Valid

Related commands: LF, LH, LN, ?LS, SF, SL, TL

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?LM REPORT LIMIT SWITCH SELECTION



The ?LM command reports the limit detection enable mode of an axis.



Example: Query PCIx to learn if limit detection is enabled for the Z axis.

Enter: AZ;
?LM

Response: In<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?LM	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: LF, LN

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LN LIMITS ON



The LN command restores the operation of the limit switches for the addressed axis or axes. This is the default mode at power up or reset. With limit switches enabled, if the axis encounters a limit switch in the course of executing any motion, the axis will be instructed to stop and the host will be notified of the event. Limit conditions are treated as critical errors and should not be used as simple positioning inputs to the PCIx.



Example: Set up the Y and T axes to stop immediately when a limit switch is encountered.

Enter:
```
AA;
LN,1,,1;
or
AY;
LN;
AT;
LN;
```

Response: None

Note: In AA or AM modes, a null argument in the parameter list specifies that axis is not to be affected.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
LN;	AX – AT	1
LNb,b,b,b;	AA-AM	1
-	AA/CD	Not Valid

Related commands: LF, LH, LL, SF, SL

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LO LOAD MOTOR POSITION



The LO command sets the motor position independently of the encoder position unlike LP which sets both to the same supplied value. The LP command will override the LO command and reset the motor position. If the LP command is used and a different motor position value than the encoder position is desired, the LO command must be reentered. Any valid position within the allowable position range may be used.



Example: Set the motor position to 50,000 and the encoder position to 100,000 on the T axis

Enter:
AT;
LP100000;
LO50000;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
LO#;	AX – AT	2
LO#,#,#,#;	AA-AM	2
-	AA/CD	Not Valid

NOTE: For AA and AM modes, any value missing from the argument list specifies that axis is not to be affected.

Related commands: LP, RE, RM, RP, RU

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LP LOAD POSITION

The LP command will immediately load the number supplied as a parameter in the absolute position registers of the axis. In models with the encoder option, the parameter will be loaded into the encoder position register and the parameter times the encoder ratio will be loaded into the position counter. In single axis mode, if no parameter is supplied, the value of zero is used. In AA/AM modes, if no parameter is supplied for an axis, the position is left unchanged.

The LO command can be used after this command to set the motor position independently of the encoder position.

RANGE: -33,554,431 ≤ LP ≤ 33,554,431

Example: The following would load the X axis position register with 1000, and the Z axis position register with 2000.

Enter:
AA;
LP1000,,2000;

Response: None

Example: The following would load the Y axis position register with 20,000 and the encoder position register with 30,000 counts, in encoder models.

Enter:
AY;
ER3,2;
LP30000;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
LP#;	AX – AT	2*
LP#,#,#,#;	AA - AM	2*
-	AA/CD	Not Valid

* If the axis is a stepper and encoder or servo axis add 2

Related commands: LO, RE, RM, RP, RU

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LS LOOP START



The LS command sets the loop counter for the axis being programmed in the single axis mode and all axes in the AA mode. The command expects a loop counter operand following the command. The commands up to the LE loop terminator will be executed the number of times specified by the operand. Loops may be nested up to four levels deep on each axis. The parameter must be less than 32,767.

The first loop of commands will occur immediately as they are entered. The remaining loops will be executed after the loop terminator (LE) has been entered.

The axis mode (e.g. AX, AY, and AA) must be the same when entering and exiting the loop, otherwise the matching loop termination command will not be found by the board's command processor. The axis mode may be switched within the loop provided the board is in the same mode when the LE command is sent as when the LS command was sent.

If you want one axis to wait for another in the loop, you must be in the AA mode throughout the loop. If you are in the single axis mode in the loop, each axis' commands will go into their separate queues and execute independently of each other.

If, when entering a looping sequence of commands, the command queue is filled before the LE loop terminator is entered, the board will hang. This is because there is no space for the LE command. When programming a loop of more than four or five moves, the queue size should be examined with the RQ command to see if it is nearing zero.

RANGE: 1 ≤ LS ≤ 32,767

Example: Execute a 100,000 count relative move on the Z axis 5 times.

Enter:
```
AZ;
LS5;
MR100000;
GO;
LE;
```

Response: None

NOTE: The first move will occur immediately after entering the GO command. The remaining 4 moves will be executed after the loop terminator LE has been entered.

Example: Execute a 100,000 count move relative on the X axis together with a 100 count move on the T axis, followed by a move absolute to 100 counts on the X axis and 200 counts on the T axis, four times.

Enter:
```
AA;
LS4;
MR100000,,,100;
GO;
MA100,,,200;
GO;
LE;
```

Response: None

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QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
LS#;	AX – AT	2
LS#;	AA-AM	2
-	AA/CD	Not Valid

Related commands: LE, WH, WS

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?LS REPORT LIMIT ACTIVE STATE

The ?LS command reports the active state of the limits for the current axis. The LL and LH commands are used to set this value.

Example: Find out whether the Y axis limits are active high or active low.

Enter: AY;
?LS

Response: ll<LF> or lh<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?LS	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: LH, LL

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MA MOVE ABSOLUTE



The MA command will set up one or more axes to move to the absolute positions supplied as parameters. In AA mode, an axis may remain stationary by entering a comma but omitting the parameter. The move is actually initiated by a GO or GD command.

In AA mode all axes begin their move at the same time. Each axis will use its predefined acceleration and velocity values to move to the new absolute position. Each axis may or may not get to the destination at the same time because each axis utilizes individual velocities and accelerations. The MT command will ensure all axes reach their target positions simultaneously.



Example: In the single axis mode, move the X axis to absolute position 100,000 counts with the previously entered acceleration and velocity parameters.

Enter:
```
AX;
MA100000;
GO;
```

Response: None



Example: In the AA mode, move the Y axis to absolute position 10,000 counts and the T axis to absolute position 1,000 counts. The other axes will remain in their current positions.

Enter:
```
AA;
MA,10000,,1000;
GO;
```

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
MA#;	AX – AT	2*
MA#,#,#,#	AA-AM	4*
-	AA/CD	Not Valid

* If the axis is a stepper encoder or servo axis add 2 to the command.
* If the axis is using the cosine acceleration ramp, and velocity needs to be adjusted so the profile is not truncated, add 11 to the command queue.
* If the axis is using the S-curve acceleration ramp, and velocity needs to be adjusted so the profile is not truncated, add 44 to the command queue.
* If the acceleration and velocity values need to be reset to their AC and VL values because the last move just prior to this move was either a MT or ML move, add the following queue requirements:

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Axis Ramp Type	Requirements
Linear (PF, LA)	8
Short Form Parabolic (PN0, PR0)	4
All other Parabolic forms (PN, PR)	18
Cosine (CN, SC)	18
Custom (SR)	6 + (2 x number of ramp segments)
S-curve (AJ)	113

Related commands: GD, GN, GO, GS, GU, ML, MR, MT

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MD TEMPORARY MACRO DEFINE

MD is used to begin defining a temporary macro. A macro can contain up to 250 characters. Macros 0 through 4 are temporary and they will be erased when the controller is reset or power is turned off. Macros 5 through 24 are stored in non-volatile memory and will be preserved when the controller is reset or powered off. This command cannot be used to define a macro directly into numbers 5 through 24. They must be defined with this command and then moved into the non-volatile space with the PT command.

Enter the macro number immediately after the MD command. The macro number must be between 0 and 4. Next enter the command string, which is made up of up to 250 ASCII characters. After entering the command string for the macro, enter a control Z to end the macro definition. The control Z may be ASCII value 26 or the string "^Z" (carat, shift 6 on a US keyboard, followed by a Z.)

Be careful not to exceed 250 ASCII characters or the size of the axis queue when working with macros.

RANGE: 0 ≤ MD ≤ 4

Example: Define macro 2 to set velocities to 20000 on all axes of a two axes board.

Enter:
```
MD2;
AA;
VL20000,20000;
^Z
```

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
MD#;	AX – AT	Immediate
MD#;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: MX, PM

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ML MOVE LINEAR



The ML command uses linear interpolation to perform a straight line relative move. Input parameters are relative distances for each axis involved in the move. The ML command should be followed by a GO or GD to start the axes together. The velocity and acceleration parameters are scaled to allow the axes to move and finish together. All axes are scaled to the axis with the longest move time (the master axis). At the end of the move, all involved velocities and accelerations will be restored to their pre-move values.



Example: In the AA mode, move the Y, Z and T axes 10000, 100 and 1000 counts respectively with all axes starting and finishing together. The other axes remain in their previous positions.

Enter:
```
AA;
ML,10000,100,1000;
GO;
```

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
-	AX – AT	Not Valid
ML#,#,#,#;	AA-AM	4*
-	AA/CD	Not Valid

* If this is the master axis for this move and its acceleration and velocity values need to be reset to their original AC and VL values, because a previous move altered them, add the following queue requirements:

If this is not the master axis, then the acceleration and velocity values will be modified, and the following queue requirements will be added:

Axis Ramp Type	Requirements
Linear (PF, LA)	6
Short Form Parabolic (PN0, PR0)	6
All other Parabolic forms (PN, PR)	20
Cosine (CN, SC)	20
Custom (SR)	6 + (2 x number of ramp segments)
S-curve (AJ)	113

* If the axis is using the cosine acceleration ramp, and velocity needs to be adjusted so the profile is not truncated, add 11 to the command queue:

* If the axis is using the S-curve acceleration ramp, and velocity needs to be adjusted so the profile is not truncated, add 44 to the command queue.

Related commands: GD, GN, GO, MA, MR, MT

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MM MOVE MINUS



The MM command sets the direction logic to move in the negative direction. The direction output for the current axis will change (if necessary) to reflect the new direction. All non-direction-specific move commands will now move in the negative direction.

Example: Set the direction line to move in the negative direction on the Y axis.

Enter:
AY;
MM;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
MM;	AX – AT	1
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: FP, MO, MP, MV, SP

MO MOVE ONE PULSE



The MO command will output one count in the current direction (do not use the GO command). The direction may be reversed directly by use of the MM or MP command or indirectly via a move such as JG or MR. This command generates the output signal in one sample interval and thus eliminates the latency of generating a ramp with an MR1; GO command sequence.

Example: Move the Z axis one pulse in the negative direction.

Enter:
AZ;
MM;
MO;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
MO;	AX – AT	1
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: MM, MP

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MP MOVE POSITIVE



The MP command sets the direction logic to move in the positive direction. The direction output for the current axis will change (if necessary) to reflect the new direction. All subsequent non-direction-specific motion commands will now move in the positive direction.



Example: (see MV command page 5-137)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
MP;	AX – AT	1
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: FP, MM, MO, MV, SP

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MR MOVE RELATIVE



The MR command will set up one or more axes to move relative from their current positions at the time the move is executed. In the AA mode, an axis may remain stationary by entering a comma but omitting the parameter. The move is actually initiated by a GO or GD command.

In AA mode all axes will start at the same time. Each axis will use its predefined acceleration and velocity values to move to the new position. Each axis may, or may not, get to the destination at the same time, because each axis utilizes individual velocities and accelerations. To ensure all axes reach their destinations simultaneously use the ML command.



Example: In the single axis mode, move the X axis 2468 steps in the negative direction.

Enter:
AX;
MR-2468;
GO;

Response: None



Example: In the AA mode, move the X axis 12345 steps in the positive direction and the Y axis 6789 steps in the positive direction. Both axes will start at the same time.

Enter:
AA;
MR12345,6789;
GO;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
MR#;	AX – AT	2*
MR#,#,#,#;	AA-AM	2*
-	AA/CD	Not Valid

* If the axis is a stepper encoder or servo axis add 1 to both the command.

* If the axis is using the cosine acceleration ramp, and velocity needs to be adjusted so the profile is not truncated, add 11 to the command queue.

* If the axis is using the S-curve acceleration ramp, and velocity needs to be adjusted so the profile is not truncated, add 44 to the command queue.

* If the acceleration and velocity values need to be reset to their AC and VL values because the last move just prior to this move was either a MT or ML move, add the following queue requirements:

Axis Ramp Type	Requirements
Linear (PF, LA)	8
Short Form Parabolic (PN0, PR0)	10
All other Parabolic forms (PN, PR)	26
Cosine (CN, SC)	26
Custom (SR)	6 + (2 x number of ramp segments)
S-curve (AJ)	113

Related commands: GD, GN, GO, GS, GU, MA, ML, MT

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MT MOVE TO



The MT command uses linear interpolation to move two or more axes to the specified absolute positions. The syntax is similar to the ML command. This command is invalid if loops are being used due to the overhead involved. The command will become valid again after executing an ST or KL command. When used in the contour definition mode, only the axes being used in the contour must be provided for in the MT syntax. A GO or GD command initiates the move.

The axis that will reach its destination first (the master axis) is used as a gauge to modify the acceleration and velocity values of the other axes. This is done to ensure all involved axes arrive at their targets simultaneously. At the end of the move, any velocity or acceleration value that was modified is restored to its pre-move value.



Example: In the AA mode, move the X, Y and T axes to absolute positions 1000, 10000 and 100 counts, respectively, with each starting and finishing together. The unused axis remains in its previous position.

Enter:
```
AA;
MT1000,10000,,100;
GO;
```

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
-	AX – AT	Not Valid
MT#,#,#,#;	AA-AM	4*
MT#,#,#,#;	AA/CD	6 + (number of axes included in contour definition

If this is not the master axis, then the acceleration and velocity values will be modified, and the following queue requirements will be added:

Axis Ramp Type	Requirements
Linear (PF, LA)	6
Short Form Parabolic (PN0, PR0)	12
All other Parabolic forms (PN, PR)	26
Cosine (CN, SC)	26
Custom (SR)	6 + (2 x number of ramp segments)
S-curve (AJ)	113

* If the axis is using the cosine acceleration ramp, and velocity needs to be adjusted so the profile is not truncated, add 11 to the command queue:

* If the axis is using the S-curve acceleration ramp, and velocity needs to be adjusted so the profile is not truncated, add 44 to the command queue.

Related commands: GO, GD, GN, MA, ML, MR

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MV MOVE VELOCITY

The MV command causes the current axis to move to a new absolute position (parameter 1) at a new velocity (parameter 2). When the destination is reached control will be passed to the next command which should be another MV command or a SP command. If the command is not received in time the controller will continue to move at the specified velocity. Note that this is a slave mode and it is the responsibility of the user to provide the commands in time. They may be queued ahead of time. If a new MV command is sent after the controller has already passed the destination specified in the command, the controller will continue to move at the old velocity.

The PCIx will ramp up or down as needed at the rate previously set with the AC command and travel at the new velocity until the new position is reached. The controller will not reverse direction if the position has already passed, but will behave as explained above. Thus the direction of the move must be specified before starting the move with the MP or MM commands. All destinations must be in absolute position; no position relative moves are allowed due to the nature of these commands. Cosine and parabolic acceleration will not apply.

RANGE:

-33,544,431 ≤ Parameter 1 (Absolute Position) ≤ 33,544,431

1 ≤ Parameter 2 (Velocity) ≤ 1,043,999

Example: Generate a velocity staircase with the breakpoints given in absolute position. Default acceleration (AC) of 200,000

Enter:
```
MP;
MV10000,30000;
MV20000,50000;
MV30000,10000;
SP35000;
```

Response: None

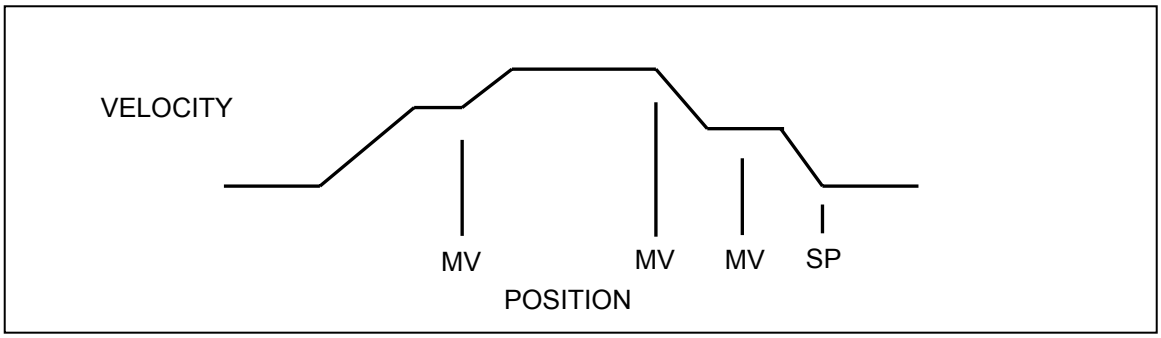


FIGURE 5-4 VELOCITY STAIRCASE PROFILE

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QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
MV#,#;	AX – AT	4*
-	AA-AM	Not Valid
-	AA/CD	Not Valid

* If PA (power automatic) mode is active add 1
* If this axis is a stepper encoder or servo axis add 2

Related commands: FP, MM, MP, SP

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MX MACRO EXECUTE



The MX command will execute the command string stored in the specified macro. The macro number that is entered as the argument of the command must be between 0 and 24.

RANGE: 0 ≤ MX ≤ 24

Example: Execute macro number 6.

Enter: MX6;

Response: None

NOTE: MX itself is an immediate command. However, the commands contained within the macro may have queue requirements.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
MX#;	AX – AT	Immediate
MX#;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: MD, PM, PT

NV NEW CONTOUR VELOCITY



The NV command will set a new velocity for a contour currently in execution. When the velocity changes, the PCIx will switch to the new velocity at the start of the next command in the contour queue without ramping. An NV command issued without a contour currently executing will have no effect.

RANGE: 1 ≤ NV ≤ 1,043,999

Example: The contour is executing at 25,000 counts per second. Change the velocity to 30,000 counts per second upon execution of the next command in the contour queue.

Enter: NV30000;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
-	AX – AT	Not Valid
-	AA-AM	Not Valid
NV#;	AA/CD	Immediate

Related commands: CD, CV

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PA POWER AUTOMATIC



The PA command will turn on or off the auxiliary outputs at the beginning of each GO or GD command execution and complement the outputs after the move is executed. The auxiliary will be turned on; i.e. pulled high, upon the execution of the GO or GD and off at the end of that move if the parameter is zero or not specified in the single axis mode. If the parameter is non-zero, the sense is reversed; i.e. the auxiliary output is turned off (driven low) upon the execution of the GO or GD command and on at the end of the move.

The SE command can be used to apply a settling time at the end of each move before complementing the auxiliary bit. This is useful for systems that need to retain torque for some specific amount of time before allowing the motor drive to reduce current output.

This mode need only be set once and can be turned off by using the AN, AF, PH, or PL commands. Axes can be selectively affected in the AA mode. The values of the included parameters set the state of the auxiliary line during the move. The following queue requirements apply to each GO or GD command in the command stream in the AA and single axis modes. This mode is off by factory default. See the AP command to preserve the PA settings as the Power up/Reset values.

Example: Turn on the Y axis auxiliary output at the beginning of a move and turn the T axis output off at the beginning of a move, while in the AA command mode. (note the reversed logic; i.e. 0 = on, 1 = off. "on" pulls the signal line to ground. "off" lets it rise to 5 volts or its pull-up reference voltage.)

Enter:
```
AA;
PA,0,,1;
```

Response: None

NOTE: PA selects the mode immediately but places entries in the axis command queue to set the state of the aux bit to the idle state.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
PAb;	AX – AT	1*
PAb,b,b,b;	AA-AM	1*
-	AA/CD	Not Valid

* If an auxiliary output bit settle time has been specified add 3

Related commands: ADH, ADL, AF, AN, ?PA, SE

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?PA REPORT POWER AUTOMATIC STATE

The ?PA command reports whether the current axis has power automatic mode enabled. The PA command is used to set this value. If power automatic mode is enabled, it will report whether the Aux bit goes high or low during a move. The axis is stationary if the aux bit is low.

Example: Determine if X axis power automatic is high or low.

Enter: AX;
?PA

Response: pa0<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?PA	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

* Power automatic mode is enabled for X axis such that the aux bit is high during a move.

Related commands: PA, ?SE

PE REPORT ENCODER POSITIONS

The PE command reports the encoder positions of all encoder and/or servo axes. All encoder positions will be reported even in single axis mode. (This is the same as AA;RE;.)

Example: Report the encoder positions of an four axis servo board.

Enter: PE

Response: 0,50,156,0<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
PE	AX – AT	Immediate
PE	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: PP, RE, RP

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PF PARABOLIC OFF

The PF command restores all axes to linear acceleration and deceleration ramps. This command should not be given while an axis is in motion or the results may not be predictable. This command affects all axes even if issued in the single axis mode. PF is the factory default setting. See the AP command to restore the PF setting as the power up/reset mode.

Example: Turn off cosine or parabolic ramps, returning to linear.

Enter: PF;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
PF;	AX – AT	11
PF;	AA-AM	11
-	AA/CD	Not Valid

Related commands: CN, LA, PN, PR, ?RT, SC, SR

PH POWER HIGH

The PH command will turn the currently active axis auxiliary port bit 'on' (high). This command disables power automatic (PA) mode.

Example: Set aux bit of axis T to high.

Enter: AT;
PH;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
PHb;	AX – AT	1
PHb,b,b,b;	AA-AM	1
-	AA/CD	Not Valid

Related commands: PA, ?PA, PL, ?SE

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PL POWER LOW



The PL command will turn the currently active axis auxiliary port bit 'off' (low). This command disables power automatic (PA) mode.



Example: Set aux bit of axis T to low.

Enter: AT;
PL;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
PLb;	AX – AT	1
PLb,b,b,b;	AA-AM	1
-	AA/CD	Not Valid

Related commands: PA, ?PA, PH, ?SE

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PM PRINT MACRO



The PM command will return the command string stored in the specified macro number as a command response. The macro number entered as the argument for this command must be between 0 and 24.

RANGE: 0 ≤ PM ≤ 24



Example: Print the command string contained in macro 19.

Enter: PM19;

Response: If a macro string is defined for macro 19, the macro string will be the response. If no macro is defined there will be no response.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
PM#;	AX – AT	Immediate
PM#;	AA-AM	Immediate
-	AA/CD	Not Valid

NOTE: Macros are stored as ASCII character strings. If <LF> character is used as command terminator it will be sent back to the host computer by the PM command. If the application software stops reading a character string first it will appear that the PM command did not return the macro contents. To avoid this issue, save macros without <LF> terminator. Use semi-colons instead to terminate commands

Related commands: MD, MX, PT

?PM REPORT HOLD STATE



The ?PM command reports whether the PID for the current servo axis is enabled.



Example: A limit switch was hit by servo axis Y. See if the PID is still enabled for that axis.

Enter: AY;
?PM

Response: hf<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?PM	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: HF, HN

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PN PARABOLIC ON



The PN command sets all axes to truncated parabolic ramps. This acceleration profile starts at 100% of the programmed acceleration and decreases in steps of 10% of the initial acceleration down to as low as 10%. The parameter supplied selects the number of steps. It must be in the range of 3 to 10 corresponding to 70% and 10% acceleration at the peak respectively. A parameter out of this range or no parameter supplied defaults to 70% or 3 steps. Note that the parameter is the number of steps, not the acceleration values. The larger number is a lower acceleration at the peak. This command should not be given while an axis is in motion or the results may not be predictable. This command affects all axes even if issued in the single axis mode. The PF command is used to return to the default linear motion profiles. See the AP command to preserve the PN setting as the Power up/Reset ramp.

See PR for single axis.

RANGE: 3 ≤ PN ≤ 10



Example: Set the board to be in the smoothest parabolic acceleration ramp.

Enter: PN10;

Response: None

QUEUE REQUIREMENTS			
FORMAT	**MODE**	**AXIS RAMP TYPE**	**REQUIREMENTS**
PN0;	AX – AT	Short Form Parabolic (PN0)	15
PN≠0;	AX – AT	All Other Parabolic (PN,PN0)	29
PN#,#,#,#;	AA-AM	Short Form Parabolic (PN0)	15
PN#,#,#,#;	AA-AM	All Other Parabolic (PN,PN0)	29
-	AA/CD	Not Valid	

Related commands: CN, LA, PF, PR, ?RT, SC, SR

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PP REPORT MOTOR POSITIONS

The PP command reports the motor positions of all axes in ASCII format. All axes will be reported even in single axis mode. (This is the same as AA; RP)

Example: Report the motor positions of a four axis controller.

Enter: PP

Response: 0,0,0,125<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
PP	AX – AT	Immediate
PP	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: PE, RE, RP

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PR PARABOLIC RAMP PER AXIS

The PR command defines parabolic acceleration/deceleration ramps for use with one or more axes. This command is similar to the PN command except that only the specified axes are affected. The AP command can be used to store the settings of PR as the power-up/reset defaults.

RANGE: 3 ≤ PR ≤ 10

Example: Select a 10 step parabolic ramp for the T axis.

Enter:
AT;
PR10;

Response: None

Example: Select a 10 step parabolic ramp for the Y axis and an 8 step parabolic ramp for the T axis.

Enter:
AA;
PR,10,,8;

Response: None

QUEUE REQUIREMENTS			
FORMAT	**MODE**	**AXIS RAMP TYPE**	**REQUIREMENTS**
PR#;	AX – AT	Short Form Parabolic (PN 0;)	15
PR#;	AX – AT	All Other Parabolic (PN,PR)	29
PR#,#,#,#	AA-AM	Short Form Parabolic (PN0)	15
PR#,#,#,#;	AA-AM	All Other Parabolic (PN,PN0)	29
-	AA/CD	Not Valid	

Related commands: CN, LA, PF, PN, ?RT, SC, SR

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PT PRESERVE A TEMPORARY MACRO

Use PT to save a temporary macro permanently by copying it to non-volatile memory. The temporary macro number, which is entered as an argument for this command, must be between 0 and 4. The non-volatile macro number, which is also entered as an argument for this command, must be between 5 and 24.

RANGE:
0 ≤ Parameter 1 ≤ 4
5 ≤ Parameter 2 ≤ 24



Example: Copy temporary macro 3 to non-volatile macro 19.

Enter: PT3,19;

Response: None

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
PT#,#;	AX – AT	Immediate
PT#,#;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: MD, MX, PM

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QA QUERY AXIS STATUS

The QA command returns the status of the single addressed axis like the RA command except the limit and done flags will not be cleared. Refer to the RA command for details.

Example: Check the status of the X axis.

Enter: AX;
QA

Response: PNNH<LF>

Refer to the table "Character Meaning" in the RA command on page 5-150.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
QA	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: EA, QI, RA, RI

QI QUERY INTERRUPT STATUS

The QI command returns the same information as the QA command but for all axes at once. The 4 character fields for each axis are separated by commas. The state of the status flags for all axes with out clearing the controller's copy of the done flags.

Example: Check the status of a four axis board.

Enter: AA;
QI

Response: PNNN,MNNN,PDNN,MNLN <LF>

Refer to the table "Character Meaning" in the RA command on page 5-150.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
-	AX – AT	Not Valid
QI	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: EA, QA, RA, RI

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RA REPORT AXIS STATUS



The RA command returs the state of the limit and home switches and the done and direction flags for the currently addressed axis. The done flag register will be reset by this command.

See RI command for single axis mode.

The status is returned in the following format:

CHARACTER MEANING		
CHAR	**SENT**	**DESCRIPTION**
1	P	Moving in positive direction
	M	Moving in negative direction
2	D	Done (ID, II or IN command has been executed, set to N by this command or IC command)
	N	No ID executed yet
3	L	Axis in overtravel. Char 4 tells which direction. Set to N when limit switch is not active.
	N	Not in overtravel in this direction
4	H	Home switch active. Set to N when home switch is not active.
	N	Home switch not active
5	LF	Line feed



Example: The Y axis just encountered a limit, verify its status.

Enter: AY;
RA

Response: PNLN<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
RA	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: EA, QA, QI, RI

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RB REPORT BIT DIRECTION



The RB command reports the bit direction of the general I/O bits.



Example: Report direction of all I/O's. In this example I/O bits 0-3 are set as outputs and I/O bits 4-7 are set as inputs.

Enter: RB

Response: 0f<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
-	AX – AT	Immediate
RB	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: None.

RC REPORT ACCELERATION



The RC command will return the current acceleration rate of the current axis. This may differ from the programmed acceleration if a non-linear ramp is being generated. When the stage is stopped, the parameter returned will be zero (0). When the stage is running at programmed speed; i.e. not accelerating, the parameter returned will be zero (0). While a contour is executing, the value computed to generate the appropriate lead in will be returned. The response to the RC command is surrounded by linefeed + carriage return pairs.



Example: Display current acceleration values for all axes on a four axis board.

Enter: AA;
RC

Response: 2000000, 2000000, 2000000, 2000000<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
RC	AX – AT	Immediate
RC	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: ?AC, AC, RV

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RF RESTORE FACTORY DEFAULT VALUES



RF restores the current parameter set to the factory default values. This process does not alter the parameters stored in flash via the AP command. To restore the flash memory to factory default, the RF command must be issued followed by the AP command.



Example: Assign the current parameter set to be the factory default values.

Enter: RF;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
RF	AX – AT	Immediate
RF	AA-AM	Immediate
-	AA/CD	Not Valid

FACTORY DEFAULT SETTINGS
Axis direction bit output state is normal(DBN)
Over travel limits are active low(LL)
Home inputs are active low(HL)
Soft limits are disabled(SF)
Acceleration is 2000000 (AC2000000)
Use linear acceleration ramps(LA)
Early deceleration factor is zero
Velocity is 200000 (VL200000)
Base Velocities zero(VB0)
User units are off(UF)
Auxiliary output bits settle times are zero(SE0)
Auxiliary output bits power control is disabled(AN)
Auxiliary output bit power up states are high(ADH)
Backlash Compensation (BL0)
Software over travel limits are disabled (TL0,0;)

ENCODER MODELS
Motor/encoder ratio is one to one(ER1,1)
Encoder slip tolerance is one(ES1)
Position maintenance dead band is zero(HD0)
Position maintenance velocity limit is zero(HV0)
Position maintenance hold gain is one(HG1)

SERVO MODELS
PID output is bipolar(BI)
PID output voltage is normal(SVN)
PID proportional gain is 10 (KP10.00)
PID differential gain is 20 (KD20.00)
PID integrator gain is 0.04 (KI0.04)
PID acceleration feedforward is zero(KA0.00)
PID velocity feedforward is zero(KV0.00)
PID offset is zero(KO0)

Related commands: AP, RD

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RD RESTORE POWER-UP DEFAULT VALUES



The RD command restores the motion parameters using power-up defaults.



Example: Restore the power-up default parameters from flash memory.

Enter: RD;

Response: None.

NOTE: This command places entries in all axis command queues to set up the motion profile parameters.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
RD	AX – AT	Immediate
RD	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: AP, RF

RE REPORT ENCODER POSITION



The RE command returns the current encoder position of the currently addressed axis or axes in encoder counts.



Example: Examine the current encoder position of the Y axis.

Enter: AY;
RE

Response: 12345<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
RE	AX – AT	Immediate
RE	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: PE, PP, RP

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RI REPORT INTERRUPT STATUS

The RI command is a multi-axis mode command that returns the same status information for all axes as the RA command does in single axis mode. The 4 character fields for each axis are separated by commas. The done flag is reset by this command as it would be via the RA command.

Example: Check the status of a 4 axis board.

Enter: AA;
RI

Response: MDNN,MDNN,PNLN,PNNN<LF>

Refer to the table "Character Meaning" in the RA command on page 5-150.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
-	AX – AT	Not Valid
RI	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: EA, QA, QI, RA

RL REPORT SLIP STATUS

The RL command returns the slip detection status of all axes. S is returned if a slip condition has occurred for that axis, or else an N is returned. The number of characters returned corresponds to the number of axes available on the board. This command is intended to be used with stepper motors with encoders and not with servo motors. Open-loop stepper always returns “n” and servo axes always returns “N” in their RL response.

Example: On a four axis board, see if any axis has slipped.

Enter: RL

Response: NNSN<LF> (The Z axis has slipped.)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
RL	AX – AT	Immediate
RL	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: ES, IS, TF, TN

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RM REMAINDER



The RM command divides the position counter by the parameter supplied and replaces the position counter with the resulting remainder. The parameter must be greater than zero and less than 65,000. This command is used in applications where the controller is managing the motion of a continuously rotating object. It allows the position counter to keep track of the absolute position without regard to the number of revolutions it may have rotated. This command has the same effect on the encoder position register on axes with the encoder feedback enabled.

RANGE: 0 < RM < 65,000



Example: The current position of a rotating stage with a full-revolution count of 6000 is needed. Since this stage has been rotated several times without regard for the position, the position counter has reached 163,279. Send an RM6000 command to find out what the real position of the axis is.

Enter: (Current position is 163,279)
RM6000;
(Current position is now 1,279)

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
RM#;	AX – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: LO, LP, RE, RP, RU

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RP REPORT POSITION



The RP command returns the current position of the currently addressed axis in single axis mode or all positions separated by commas in AA or AM mode. The position will be returned to the host in ASCII format. This command is not queued; i.e. the current position will be returned immediately even if the axis is in motion.



Example: The current position on the Y axis is 12345. Use the RP command to verify the position.

Enter: AY;
RP

Response: 12345<LF>



Example: Verify the positions of all axes.

Enter: AA;
RP

Response: 100,200,300,400<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
RP	AX – AT	Immediate
RP	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: RE, PE, PP

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RQ REPORT QUEUE AVAILABLE

The RQ command reports the number of available entries in the queue.

MAX Value of command space in contour mode= 7160

MAX value of command queue for all axes = 800

Example: Report the command queue space remaining

Enter: RQ

Response: 800, 800, 800, 800<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
RQ	AX – AT	Immediate
RQ	AA-AM	Immediate
RQ	AA/CD	Immediate

Related commands: None.

?RT REPORT RAMP TYPE

The ?RT command reports the current acceleration ramp assigned to the active axis. Possible responses are:

LA	Default linear ramp
PRn	Parabolic where n specifies number of segments
SC	Cosine ramp
SRn	Custom ramp where n specifies the table number
PR	Parabolic ramps
SSn	S-curve ramp where n specifies the S-curve profile number

Example: Make sure custom ramp #3 was assigned to the Y axis

Enter: AY;
?RT

Response: sr3<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?RT	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: CN, LA, PF, PN, PR, SC, SR, SS

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RU REPORT CURRENT POSITION IN USER UNITS

The RU command returns the current position in user units (see UU command on page 5-182). The format of the response is a floating-point number.

Example: One revolution of a motor is 2000 steps. Define user units so moves can be referenced in revolutions. Move the Z axis 3 1/2 revolutions. Use RU to display the position when the move is complete.

Enter:
```
AZ;
UU2000;
LP0;
MR3.5;
GO;        (Wait until move is complete.)
RU
```

Response: uu3.50000<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
RU	AX – AT	Immediate
RU	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: RE, RP, ?UU, UU

RV REPORT VELOCITY

The RV command will return the current velocity at which the axis is moving. This may differ from the programmed maximum velocity if the axis is accelerating or decelerating. If the JF command is executing, the command only reports the integer part of the velocity.

Example: Jog the Y axis at 12345 steps per second.
Display the current velocity.

Enter:
```
AY;
JG12345;
RV
```

Response: 12345<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
RV	AX – AT	Immediate
RV	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: RC, ?VL, VL

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SA STOP ALL



The SA command flushes all queues and causes all axes to decelerate to a stop at the rate previously specified in an AC command. All status and position information is retained. Even when executed in a single axis mode, this command will cause all axes to stop.



Example: Send all axes on a move, then ramp them to a stop before they finish.

Enter:
AA;
VL100,100,100,100;
MR1000,2000,3000,4000;
GO (wait awhile)
SA;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
SA;	AX – AT	1*
SA;	AA-AM	1*
-	AA/CD	Not Valid

* If PA (power automatic) mode is active add 1 to the command queue.
* If an auxiliary output bit settle time has been specified add 3 to the command queue

Related commands: KL, KS, SD, SI, SO, ST

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SC COSINE RAMP PER AXIS



The SC command specifies that the standard cosine acceleration ramp is to be used by the selected axis/axes. This command is similar to the CN command except that only the selected axis or axes are affected. The AP command will store the settings of SC as the power-up/reset defaults.



Example: Select the cosine ramp for the X axis.

Enter: AX;
SC;

Response: None.



Example: Select the cosine ramp for the Y, and T axes.

Enter: AA;
SC,1,,1;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
SC;	AX – AT	29
SCb,b,b,b;	AA-AM	29
-	AA/CD	Not Valid

Related commands: CN, LA, PF, PN, PR, ?RT, SR

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SD STOP AND RESET DONE

The SD command may be substituted for the SA command. It will reset the done flags for all axes, stop all axes at the rates previously specified via the AC command, and then flush all axis command queues. This allows the host to be interrupted when all axes have stopped by using the ID command after the SD. The SA; ID combination may flag the completion early if one of the axes is already done from a previously executed ID.

Example: Stop all axes and reset all done flags. When all axes have stopped set all done flags.

Enter:
AA;
SD;
ID;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
SD;	AX – AT	2*
SD;	AA-AM	2*
-	AA/CD	Not Valid

* If PA (power automatic) mode is active add 1 to the command queue.
* If an auxiliary output bit settle time has been specified add 3 to the command queue.

Related commands: KL, KS, SA, SI, SO, ST

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SE SETTLING TIME



The SE command allows specification of a settling time, in milliseconds, to be used before the auxiliary output is complemented when using PA mode. The parameter may be any value up to 1000 milliseconds. Specification of a parameter of zero disables SE mode.

The factory default settling time is zero. See the AP command to preserve the SE settings as the Power up/Reset values.

RANGE: 0 ≤ SE ≤ 1000

Example: Turn on the Z axis auxiliary output upon execution of a move and have it remain on for 500 milliseconds after the move is complete.

Enter:
AZ;
PA;
SE500;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
SE#;	AX – AT	Immediate
SE#,#,#,#;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: AF, AN, PA, ?SE

?SE REPORT SETTLING TIME



The ?SE command reports the settling time setting (SE) used with power automatic mode (PA) for the current axis.

Example: Report the current settling time for axis X

Enter:
AX;
?SE

Response: se250<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?SE	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?PA, SE

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SF SOFT LIMIT OFF

The SF command restores the default operation of the limit switches; i.e. causes the affected axis or axes to abruptly halt when a limit switch is encountered. If soft limits have been made the power-up default, the AP command must be used to store hard limit operation as the default.

Example: Set up a board to make the X axis stop immediately when a limit is encountered.

Enter:
AX;
SF;

Response: None.

Example: Set up a board to make the Y and T axes to stop immediately when a limit is encountered.

Enter:
AA;
SF,1,,1;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
SF;	AX – AT	1
SFb,b,b,b;	AA-AM	1
-	AA/CD	Not Valid

Related commands: LF, LH, LL, LN, ?SL, SL, TL

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SI STOP INDIVIDUAL

This command can be used to stop only certain axes. In a single axis mode, the SI command behaves identically to ST. In a multi-axis mode, however, SI can be used to stop any number of axes and can be used in place of SA. Like SA, SI will ramp those axes to be stopped using the rate previously specified via the AC command. This command is useful for stopping a specific axis when the current axis mode is unknown and for stopping several axes without affecting current motion on other axes.

Each parameter represents an axis from X through T. Any non-zero value in a parameter will cause the corresponding axis to be stopped.



Example: Start a motion on all four axes. When input bit 1 becomes true, stop axes Y and T without affecting X and Z.

Enter:
```
AM;
MR15000,30000,20000,40000;
GO;
SW1;
SI,1,,1;
```

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
SI;	AX – AT	1*
SIb,b,b,b;	AA-AM	1*
-	AA/CD	Not Valid

* If PA (power automatic) mode is active add 1 to the command queue.
* If an auxiliary output bit settle time has been specified add 3 to the command queue.

Related commands: KL, KS, SA, SD, SO, ST

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?SK REPORT AXIS SLIP KILL MODE SELECTION



The ?SK command reports whether slip kill mode is currently enabled for the active axis.



Example: Find out whether encoder slip kill mode is enabled for axis Z

Enter: AZ;
?SK

Response: tf<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?SK	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: TF, TN

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SL SOFT LIMIT ON



The SL command enables the PCIx to ramp an axis to a stop rather than abruptly killing the motion when a limit switch is encountered on that axis. The output queue is not flushed except for the current move. This mode is effective for point to point and JG moves only. Soft limits can be made the power-up default via the AP command.

Example: Set up a board to allow the X axis to ramp to a stop when a limit is encountered.

Enter: AX;
SL;

Response: None.

Example: Set up a board I/O to allow the Y and T axes to ramp to a stop when a limit is encountered.

Enter: AA;
SL,1,,1;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
SL;	AX – AT	1
SLb,b,b,b;	AA-AM	1
-	AA/CD	Not Valid

Related commands: LF, LH, LL, LN, SF, ?SL, TL

?SL REPORT SOFT LIMIT STATUS



The ?SL command reports whether soft limits are currently enabled for the active axis.

Example: Find out whether soft limits are enabled for axis Z

Enter: AZ;
?SL

Response: sf<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?SL	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: SF, SL

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SO STOP BY RAMPING FROM DISTANCE

The SO command instructs the PCIx to continue moving until reaching a specified distance (parameter 2) from a specified stop point (parameter 1). The axis will then ramp to a stop within the specified distance. This allows the user to control the point at which deceleration begins, the rate of deceleration, and the stop point, all with a single command.

RANGE:

-33,554,431 ≤ Parameter 1 (Stop Position) ≤ 33,554,431
-33,554,431 ≤ Parameter 2 (Distance from Stop Position to Start Decelerating) ≤ 33,554,431

Example: The X axis is jogging at 10,000 steps per second. We want the axis to stop at position 50,000 but it must not start ramping until reaching position 46,000.

Enter: SO50000,4000;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
SO#,#;	AX – AT	5*
-	AA-AM	Not Valid
-	AA/CD	Not Valid

* If the axis is a stepper and encoder or servo axis, add 1
* If PA (power automatic) mode is active, add 1
* If an aux bit settling time has been specified, add 3

Related commands: KL, KS, SA, SD, SI, ST

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?SO REPORT SERVO ANALOG OUTPUT MODE

The ?SO command reports whether the analog output type for the current servo axis is bipolar or unipolar. The possible responses are BI and UN, the same commands used to set one mode or the other.

Example: The Y axis should be setup with unipolar outputs. Use ?SO to make sure.

Enter: AY;
?SO

Response: un<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?SO	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: BI, UN

SP STOP AT POSITION

The SP command will cause the controller to attempt to stop at the specified destination. If there is insufficient distance to stop at the previously specified deceleration when the command is received, the controller will stop as soon as possible at that deceleration. This command is not compatible with the JG command.

Example: (see MV command on page 5-137)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
SP#;	AX – AT	3*
-	AA-AM	Not Valid
-	AA/CD	Not Valid

* If the axis is a stepper and encoder or servo axis add 1
* If PA (power automatic) mode is active add 1
* If an auxiliary output bit settle time has been specified add 3

Related commands: FP, MM, MP, MV

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SR SELECT CUSTOM RAMP

The SR command selects a previously defined custom ramp profile for use with a currently active axis. This command will override previous ramp type selection for the given axis such as PN and CN.

RANGE: 1 ≤ SR ≤ 4

Example: Select custom ramp number 4 for use with axis Y.

Enter: AY;
SR4;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
SR#;	AX – AT	7 + (2* number of segments in ramp definition)
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: CN, DAB, DAE, DAR, LA, PF, PN, PR, ?RT, SC

SS SELECT CUSTOM S-CURVE PROFILE

The SS command selects a custom S-curve profile to use for an axis or axes.

RANGE: 1 ≤ Ramp Number ≤ 4

Example: Selects custom S-curve profile #1 for Y axis.

Enter: AY;
SS1;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
SS#:	AX – AT	117
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?AJ, AJ, ?RT

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ST STOP



The ST command flushes the queue for the current axis or axes only and causes the axis/axes to decelerate to a stop at the rate previously specified via the AC command. This command is used to stop one or more motors in a controlled manner from jog mode or an unfinished GO or GD command. This command is executed immediately upon receipt. All status and position information is retained. When executed in a multi-axis mode, the ST command is equivalent to the SA command.



Example: Move the Y axis for a while at 1200 steps/second and then ramp to a stop.

Enter:
AY;
JG1200;
(Wait awhile)
ST;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
ST;	AX – AT	1*
ST;	AA-AM	1*
-	AA/CD	Not Valid

* If PA (power automatic) mode is active add 1 to the command queue.
* If an auxiliary output bit settle time has been specified add 3 to the command queue.

Related commands: KL, KS, SA, SD, SI, SO

?SV REPORT SERVO VOLTAGE INVERSION STATE



The ?SV command reports the current logical direction for the current servo axis. The state is set with the SVI and SVN commands. The possible responses to the ?SV command are n for normal and i for inverted.



Example: Report whether servo voltage is positive for positive moves on axis X

Enter:
AX;
?SV

Response: svn <LF> (voltage is normal; i.e. positive for positive moves)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?SV	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ?DB, SVI, SVN

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SVI INVERT SERVO VOLTAGE

The SVI command inverts the voltage output for the current axis. After receiving this command, the PCIx will produce a negative voltage for positive motion and a positive voltage for negative motion. To cancel this command, issue an SVN command. To make inverted servo outputs the default at power up or reset, use the AP command.

Example: The Y axis encoder is counting opposite the expected direction. Setup the Y axis to produce a negative voltage when moving positive instead of a positive voltage to correct the problem.

Enter:
AY;
SVI;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
SVI;	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: BI, DBI, DBN, ?SV, SVN, UN

SVN NORMALIZE SERVO VOLTAGE

The SVN command normalizes the voltage output for the current axis, negating the effects of the SVI command. After receiving this command, the PCIx will produce a positive voltage for positive motion and a negative voltage for negative motion, the default behavior. To make this the default behavior (if it has been changed via SVI/AP), use the AP command. (SVN is the factory default setting.)

Example: The Y axis encoder was rewired and now counts in the correct direction. Return the Y axis servo output to normal; i.e. output positive voltage for positive motion.

Enter:
AY;
SVN;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
SVN;	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: BI, DBI, DBN, ?SV, SVI, UN

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SW SYNC WAIT



The SW command allows synchronization of multi-axis moves or other tasks on one or more PCIx boards by using one of the general purpose input lines. This command causes the PCIx to stop processing new commands until the general purpose input line has been released (allowed to go high) before proceeding with the next command.

The SW command can also be used to cause an axis to wait until the others are finished. To do this, wire-OR the auxiliary lines from several axes together and connect them to a general purpose input line. Use power automatic (PA) mode with the SW command on that line. All commands after that will wait until all axes release their auxiliary lines; i.e. come to a complete stop.

RANGE: 0 ≤ Bit Number ≤ 7

NOTE: The parameter used to specify Bit Number must be configured as an input. See RB.



Example: The following command sequence will cause the X axis move to wait until the Y axis has finished its move and turned off its auxiliary output which has been wired to the general purpose input 0 line.

Enter:

```
AY;
AN;
MR2000;
GO;
AF;
AX;
SW0;
MR10000;
GO;
```

Response: None.

The SW command provides a way to synchronize moves on two or more controllers. The following example shows one way to do this.



Example: You have 3 four axis controllers, for a total of 12 axes to move together. Call board 1 the “master” and boards 2 and 3 the “slaves”. Wire board 1’s X axis auxiliary line to the two slave boards’ general purpose input 0 line. Send to the master the command “AX; PA0”, setting the master’s X axis auxiliary line low until its move starts. This also sets the slaves’ general purpose input 0 line low. Enter the “SW0” command to the two slaves, followed by the move and GO commands. On the master, enter the move command, followed by the GO command. When the master’s move starts, the PA command will set the auxiliary line high releasing the wait on the slave boards. All three boards will start their moves. This provides synchronization to within 480µs of each board.

Procedure: Wire board 1’s X axis auxiliary line to board 2’s and board 3’s general purpose input 0 line.

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Enter: (Board 1) AX;
PA0;
(Board 2) AA;
SW0;
MR200,200,200,200;
GO;
(Board 3) AA;
SW0;
MR300,300,300,300;
GO;
(Board 1) AA;
MR100,100,100,100;
GO;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
SW#;	AX – AT	2
SW#;	AA-AM	2
-	AA/CD	Not Valid

Related commands: BW, WA, WQ, WT

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TF TURN OFF SLIP KILL MODE

The TF command disables slip kill mode (enabled with TN).



Example: Slip kill mode is enabled but a move needs to be performed where slip is likely and not important for this move. Disable slip kill mode.

Enter: TF;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
TF;	AX – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ES, IS, RL, TN

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TL SET SOFTWARE OVERTRAVEL LIMITS

The TL command sets logical limits on the range of travel for an axis. Two parameters must be supplied; one for the upper travel limit and the other for the lower travel limit, both as absolute positions. If the axis reaches either of these logical limits, the PCIx will flag a limit condition just as it would be using the physical limit switch inputs. Move Absolute (MA), Move Relative (MR), and Jog (JF, JG) commands are subject to software travel limits because the PCIx checks an internal absolute position register.

Note: Software overtravel limits and physical limit switch inputs can be enabled at the same time.

RANGE: ± 33,544,431

Example: Set logical position limits for the X axis of +/-1,000,000.

Enter:
AX;
TL1000000,-1000000;

Response: None.

Note: TL0,0; Turns software limits off.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
TL#,#;	AX – AT	3
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: LF, LL, LH, LN, SF, SL, ?TL

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?TL REPORT SOFTWARE OVERTRAVEL LIMITS



The ?TL command reports the software travel limits for the current axis assigned via the TL command. The first value returned is the upper (or "positive") limit and the second value is the lower (or "negative") limit. These are not physical limits but rather positional limits that an axis should not exceed. If one of these limits is exceeded, the PCIx will set the current axis' limit flag and notify the host computer of the condition as though the axis encountered a hard limit.



Example: Find out what the software limits of the Y axis are currently set to.

Enter: AY;
?TL

Response: tl101000,-1000<LF>



Example: Find out what the software limits of the T axis are currently set to.

Enter: AT;
?TL

Response: tl0,0;<LF> (software limits for axis T are currently disabled)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?TL	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: TL

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TM TIMED JOG



The TM command performs a jog at the current velocity limits defined for the axis/axes for the specified number of milliseconds. In multi-axis mode, all axes begin moving at the same time and ramp to a stop when their respective jog times have elapsed. The overall jog time will be the parameter passed to the TM command plus deceleration time and acceleration time.

RANGE: 0 ≤ TM ≤ 200,000

Example: Jog the X axis for 1000 milliseconds.

Enter: AX;
TM1000;

Response: None.

Example: Jog the X axis for 1000 milliseconds and the Z axis for 2000 milliseconds, starting both at the same time.

Enter: AA;
TM1000,,2000;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
TM#;	AX – AT	6*
TM#,#,#,#;	AA-AM	6*
-	AA/CD	Not Valid

* If PA (power automatic) mode is active add 1
* If the axis is a stepper and encoder or servo axis add 1

Related commands: JF, JG, SA, ST

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TN TURN ON SLIP KILL MODE

The TN command enables slip kill mode. In this mode, if the motor slips beyond the dead band set by the ES command, the PCIx will kill motion on the axis that slipped as though a KL command had been issued to the axis. This mode can be disabled (default) with the TF command.



Example: X axis is sent on a move. Its encoder cable was not connected to the controller (oops!). The controller issues a KL (Kill) command to the X axis after receiving the slip interrupt. The slip interrupt is generated once the difference between the motor position counts and encoder counts exceed 20.

Enter:
```
AX;
ES20;
TN;
IS:
LP0;
MA30;
GO;
```

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
TN;	AX – AT	2
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: ES, IS, RL, TF

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TX TRACK THE X AXIS



Set up the current axis so that it tracks the X axis. The command argument is the tracking ratio specified as a floating point.

NOTE: If this is a negative, then the axis moves in the opposite direction of the X axis. The command is invalid for the X axis.



Example: Set the Z axis to track the X axis.

Enter: AZ;
TX;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
TX;	AY – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related Commands: EG, EG?, EGF, ET, HF

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UF USER UNITS OFF



The UF command turns off user units returning all numeric commands and responses to their factory default raw representations. This command is equivalent to and preferred over UU1; since it turns off the mode thus minimizing unnecessary overhead. See the AP and command to preserve the UF settings to flash memory.



Example: Turn off user unit conversion on the X, Y, and Z axes.

Enter:
```
AX;
UF;
AY;
UF;
AZ;
UF;
```
Or
```
AA;
UF1,1,1;
```

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
UF;	AX – AT	Immediate
UFb,b,b,b;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: ?UU, UU

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UN UNIPOLAR

The UN command sets the analog torque outputs of servo axes to unipolar. The analog output will range between 0.0VDC and +10VDC when unipolar is enabled. At maximum positive velocity, the board outputs +10VDC. At maximum negative velocity, the board output approaches 0.0VDC. To maintain position the board outputs 5VDC. This command is valid only in single axis mode.



Example: Set up servo axis X for unipolar operation.

Enter: AX;
UN;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
UN;	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: BI, DBI, DBN, ?SO, SVI, SVN

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UU USER UNITS



The UU command converts all move velocities, distances, etc. to user specified units by multiplying by the specified parameter. The UF command is used to terminate this mode. Factory default is with this command off. See the AP or command on to preserve the UU se ttings to flash memory.

NOTE: While the user units' mode provides a certain level of convenience to the user, it does so at a cost, namely accuracy and control. User unit conversions may cause round off error and may possibly truncate key information.



Example: The motor, driver, and gear ratio you are using requires 10,000 steps to move one inch. Set up the X, Y, and Z axes so you can enter move information in inches.

Enter:
AX;
UU10000;
AY;
UU10000;
AZ;
UU10000;
Or
AA;
UU10000,10000,10000;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
UU#;	AX – AT	Immediate
UU#,#,#,#;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: RU, UF, ?UU

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?UU REPORT AXIS USER UNITS



This command returns the current user units' multiplier as set via the UU command.



Example: Make sure the UU512 command we sent earlier is still current. The command will return the UU value with six digits to the right of the decimal point. If the UU value exceeds six digits for the fractional value, the value will be rounded off to the sixth decimal place.

Enter: ?UU

Response: uu512.000000<LF>
If user units are turned off (UF) ?UU returns: uf<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?UU	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: UF, UU

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VB VELOCITY BASE



The VB command allows the acceleration ramp to start off at a specified velocity. This allows faster acceleration and the ability to pass through resonance quickly in some applications. The velocity jumps instantly to the specified velocity, and then accelerates as usual. The deceleration is the same in reverse. This mode is active only for linear ramps; it is ignored for cosine and parabolic ramps but not flagged as a command error. The parameter must be greater than zero and less than the programmed velocity, where the factory default is zero steps per second. This command is not valid with the JG command nor will it work in conjunction with the DC command. See the AP command to preserve the VB settings as the power-up/reset values.

If the VL command is used after the VB command and the velocity value set with VL is less than the previously set VB value, the initial velocity used at the start of a move will be the VL value minus one. This will result in a one-step acceleration ramp and must be taken into consideration in applications making use of the VB command.

RANGE: 0 ≤ VB < VL value

Example: In the single axis mode, set the Y axis velocity base to 200.

Enter:
```
AY;
VB200;
```

Response: None.

Example: In the AA mode, set the X and Y axes velocity bases to 200.

Enter:
```
AA;
VB200,200;
```

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
VB#;	AX – AT	2
VB#,#,#,#;	AA-AM	2
-	AA/CD	Not Valid

Related commands: AC, DC, ?VB, VL

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?VB REPORT BASE VELOCITY



The ?VB command returns the base (starting) velocity setting for the current axis as set by the VB command. Note that the base velocity must be lower than the command velocity.



Example: The acceleration ramp should start at 0 velocity. Make sure we didn't leave it at some other value.

Enter: ?VB

Response: vb1500<LF> (Oops! We forgot to set it back to zero)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?VB	AX – AT	Immediate
	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: VB, ?VL

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VL VELOCITY



The VL command sets the maximum velocity register of one or more axes to the operands which follow the command. The factory default is 200,000 steps per second. See the AP command to preserve the VL settings as the power-up/reset values.

RANGE: 1 ≤ VL ≤ 1044000

Example: In single axis mode, set the X axis velocity to 10,000 counts per second.

Enter: AX;
VL10000;

Response: None.

Example: In the AA mode, set the peak velocities of the X and T axes to 5,000 and 50,000 respectively. Leave the other axes with their previous values.

Enter: AA;
VL5000,,,50000;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
VL	AX – AT	2*
VL#,#,#,#;	AA-AM	2*
-	AA/CD	Not Valid

* PN0 and PR0 ramp selections add 2
* All other PN and PR ramp selections add 9
* CN and SC ramp selections add 9
* SR (custom) ramp selections add (number of steps in ramp -1)

Related commands: AC, DC, VB, ?VB, ?VL

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?VL REPORT PEAK VELOCITY SETTING

The ?VL command returns the peak velocity setting for the current axis as set by the VL command.

Example: Make sure our "AX;VL50000;" command worked.

Enter: ?VL

Response: vl150000<LF>

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
?VL	AX – AT	Immediate
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: VB, ?VB, VL

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VS VELOCITY STREAMING



The VS command will generate a pulse train without acceleration or deceleration at the rates specified using the X and Y axes. The parameters are time in 1 update rate second sample intervals, X velocity, and Y velocity. This is a slave mode and cannot be mixed or queued with other commands; i.e. no other motions involving the X and Y axes or AA mode may be currently in execution when this command is issued. AX mode is the only valid mode for use with this command. The VS command does not require a GO command to start the motion; motion begins immediately upon receipt of the complete VS command.

RANGES:
1 ≤ Parameter 1 (Time in 1 update rate of a second) ≤ 1,043,999
0 ≤ Parameter 2 (X Axis Velocity) ≤ 1,043,999
0 ≤ Parameter 3 (Y Axis Velocity) ≤ 1,043,999

Example: Create a stair step profile on the X and Y axes, with the X axis moving in the negative direction and the Y axis in the positive direction. Make each step last 1 second long and increase velocity by 1,000 steps/second, until a velocity of 3,000 steps/second is reached, then step down to 0 steps/second. (Example assumes an update rate of 1024.)

Enter:
```
AX;
VS1024,-1000,1000;
VS1024,-2000,2000;
VS1024,-3000,3000;
VS1024,-2000,2000;
VS1024,-1000,1000;
VS1,0,0;
```

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
VS#,#,#,#;	AX	5
-	AA-AM	Not Valid
-	AA/CD	Not Valid

Related commands: MV

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WA WAIT FOR AXES



The WA command, valid only in AA mode, allows a command to wait until all moves on all axes are finished before executing any further commands. Some commands which can affect a non-moving axis, such as AN, AF and PA, may execute before a previous move on other axes has finished, especially while in a looping (LS-LE, WH-WG) mode. By preceding these commands with a WA, they will not execute until all previously defined moves have finished.



Example: The Z axis auxiliary line controls a laser beam that you only want on while the Z axis moves in a positive direction. The X and Y axes position the laser. You want to repeat the action 10 times.

Enter:
```
AA;
VL1000,1000,1000;
AC10000,10000,10000;
LS10;
MR1000,1000;
GO;
WA;
AN,,1;
MR,,500;
GO;
AF,,1;
MR,,-500;
GO;
LE;
```

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
-	AX – AT	Not Valid
WA;	AA-AM	2*
-	AA/CD	Not Valid

* This command places entries in all axes' queues.

Related commands: SW, BW, WQ, WT

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WD WHILE END

The WD command serves as the loop terminator for the WS command.

Example: (see WS command on page 5-194)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
WD;	AX – AT	2
WD;	AA-AM	2*
-	AA/CD	Not Valid

* In AA or AM mode, entries are made in all axes' queues.

Related commands: WS

WG WHILE FLAG

The WG command serves as the terminator for the WH command.

Example: (see WH command page 5-191)

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
WG;	AX – AT	2
WG;	AA-AM	3*
-	AA/CD	Not Valid

*In AA or AM mode, entries are made in all axes' queues.

Related commands: CW, WH

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WH WHILE



The WH command will execute all commands between it and the terminating WG command as a loop until terminated by a CW command. This allows repeated execution of a command sequence which can be terminated by the host. These commands may not be nested but may be executed sequentially.



Example: You have a 3 axis platform that you use to drill holes in the center of a ¼ inch thick sheet of metal. The sheet is 6 inch square. The driver / motor / lead - screw pitch provide 10000 steps per inch. The operator must manually insert and remove the square from the platform. The X and Y axes move a drill into the desired position. The Z axis lifts and lowers the drill. The operator presses a switch which tells the motion controller that the square is in place and ready to be drilled. The operator will continuously remove and replace the squares until ready to take a break. The following is a description of how to set up an Pro-Dex, Inc., Oregon Micro Systems board to perform this task.

Procedure: Connect a normally closed momentary switch between user I/O input line 0 and ground. This will be the “Ready to Drill” switch.

Enter:

```
AX;
UU10000;        *set up user units so we can reference move to inches
AY;
UU10000;        *10000 steps = 1 inch
AZ;
UU10000;        *10000 steps = 1 inch
AX;
VL.1;
AC10;               *set up X axis homing velocity and acceleration
AY;
VL.1;
AC10;               *set up Y axis homing velocity and acceleration
AZ;
VL.1;
AC10;               *set up Z axis homing velocity and acceleration
AX;
HR;
AY;
HR;
AZ;
HR;                 *send each axis to home
AA;
VL3,3,.5;           *set normal move velocity for X, Y and Z axes
WH;                 *start of loop to drill squares indefinitely
SW0;                *(operator removes/replaces square into platform)
MA3,3;              *wait until operator presses switch
GO;                 *move to center of square
MA,,.5;
GO;                 *move the drill through the square (1/2 inch
                        move on the Z axis drill through the square)
MA,,0;
```


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```
GO;                 *lift the drill
MA0,0;
GO;                 *move the platform to home position
WG;                 *loop back to starting WH command
(CW;)               *operator wants a break so he/she sends CW
                     from keyboard and presses switch once more
                     (since loop will most likely be waiting for the
                     switch at this point)
                    *the loop ends and the following commands execute
MA0,0,0;
GO;                 *move to home position
```

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
WH;	AX – AT	3
WH;	AA-AM	3*
-	AA/CD	Not Valid

In AA or AM mode, entries are made in all axes' queues.

Related commands: CW, LS, WG, WS

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WQ WAIT FOR QUEUE TO EMPTY

The WQ command is a special command that stops the board from processing any new commands until the command queue for the current axis mode is empty; i.e. all previous moves have finished. This command is not valid in looping (LS-LE, WH-WG) modes.

Example: Move the Y axis 1,000 steps and wait until the move is complete before asking for the position.

Enter:
```
AY;
MR1000;
GO;
WQ
RP;
```

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
WQ;	AX – AT	Immediate
WQ;	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: BW, SW, WA, WT

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WS WHILE SYNC



The WS command will execute the commands between the WS and WD commands as a loop while the specified general purpose input line is true; i.e. low (default). When the line goes high the PCIx will exit the loop and execute the commands which follow the WD command. The test is at the bottom of the loop; i.e. the commands between WS and WD will always be executed at least once.

WD#[,state];

If the optional second parameter, state, is entered then it specifies the input condition to continue the loop. If the state parameter is zero, the loop will continue while the input is low. If the state parameter is non-zero, the loop will continue while the input is high. If the state parameter is not entered, the default behavior is to loop while the input is low.

If the input line specified is already in the specified state to exit the loop when the WS/WD loop is issued to the PCIx, those commands will be executed only once.

#RANGE : 0 ≤ Parameter1 ≤ 3



Example: Execute a continuous loop, moving the X axis 10,000 counts and then move the Y axis -1000 counts, until an external device terminates the loop by setting general purpose input 1 high.

Enter:
```
AA;
WS1;
MR10000;
GO;
MR,-1000;
GO;
WD;
```

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
WS#;	AX – AT	2
WS#;	AA-AM	2*
-	AA/CD	Not Valid

* In AA or AM mode, entries are made in all axes' queues

Related commands: LS, WD, WH

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WT WAIT



The WT command will wait for a specified number of milliseconds before proceeding with the next command in the queue. In the AA mode, all axes will wait and entries are made in all axis queues. Immediate commands will not wait since they are not queued.

RANGE: 1 ≤ WT ≤ 200,000



Example: You want to produce pulses on the X axis at 5,000 steps/second for 2 seconds, then 10,000 pulses/second for 3 seconds, and then stop.

Enter:
AX;
JG5000;
WT2000;
JG10000;
WT3000;
ST;

Response: None.

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
WT#;	AX – AT	3
WT#;	AA-AM	3
-	AA/CD	Not Valid

Related commands: BW, SW, WA, WQ

WY WHO ARE YOU



The WY command returns the model type, firmware revision number, and number of controlled axes of the board being addressed.



Example: You want to examine the board identification string of a four axis PCIx controller with its firmware revision at 1.28.

Enter: WY

Response: PCIx-400 ver:1.26, s/n:000217 - Oregon Micro Systems

QUEUE REQUIREMENTS		
FORMAT	**MODE**	**REQUIREMENTS**
WY	AX – AT	Immediate
WY	AA-AM	Immediate
-	AA/CD	Not Valid

Related commands: None

THIS IS THE END OF THE COMMAND CHAPTER

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6. HOST SOFTWARE

6.1. INTRODUCTION TO PCIx SOFTWARE SUPPORT

A disk containing device drivers, application software, and demonstration code for Pro-Dex, Inc., Oregon Micro Systems PCIx family controllers is supplied with the initial purchase of a PCIx controller. Refer to the text files on the disk for installation instructions and other information.

Some programs on the demo disk that include source code may be adapted for use in application programs that use Pro-Dex, Inc., Oregon Micro Systems motion controls. No license is required.

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7. SERVICE

7.1. USER SERVICE

The PCIx family of controllers contain no user serviceable parts.

7.2. THEORY OF OPERATION

The 68332 microprocessor on the PCIx controller maintains four concurrent processes. The highest priority process calculates the desired velocity 2048 times each second with a proprietary algorithm (patent number 4,734,847). This frequency is written to logic on board which generates the pulses for stepper motor control and/or the appropriate voltage levels for Servo Control. The velocity profile and synchronization of each axis is also handled by the 68332.

The commands from the PCI computer are temporarily stored in a 124 character buffer until the 68332 microprocessor can parse them. The command is then executed immediately or routed to separate command queues for each axis. The command queue contains a list of addresses to execute followed by an optional parameter. A command from the host may be expanded into several commands to the appropriate axis. The GO command, for example, will expand into start, ramp up, constant velocity and ramp down commands. The LS command will save its parameter, the loop count, on a loop stack along with the address of the LS command to be used by the next LE command as a target for a jump command. The LE command will decrement the loop count and jump to the most recent LS command providing the loop count has not reached zero. If the loop count has reached zero and it is not nested inside another loop, the queue space will be flagged as available and the next instruction in the queue will be executed.

The communication interface is performed by a dedicated IC on the PCIx. It is a specialized IC for PCI communication and controls the passing of the register information and data to and from the PCIx CPU. Interrupts from the PCIx to the PCI host are generated by this component. Status of the interrupts and error flags may be read by the host in the status register.

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APPENDIX A

LIMITED WARRANTY

The Seller warrants that the articles furnished are free from defect in material and workmanship and perform to applicable, published Pro-Dex, Inc., Oregon Micro Systems, Inc. specifications for one year from date of shipment. This warranty is in lieu of any other warranty express or implied. In no event will Seller be liable for incidental or consequential damages as a result of an alleged breach of the warranty. The liability of Seller hereunder shall be limited to replacing or repairing, at its option, any defective units which are returned f.o.b. Seller's plant. Equipment or parts which have been subject to abuse, misuse, accident, alteration, neglect or unauthorized repair are not covered by warranty. Seller shall have the right of final determination as to the existence and cause of defect. As to items repaired or replaced, the warranty shall continue in effect for the remainder of the warranty period, or for 90 days following date of shipment by Seller of the repaired or replaced part whichever period is longer. No liability is assumed for expendable items such as lamps and fuses. No warranty is made with respect to custom equipment or products produced to Buyer's specifications except as specifically stated in writing by Seller and contained in the contract.

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APPENDIX B

TECHNICAL SUPPORT

Pro-Dex, Inc., Oregon Micro Systems, Inc. can be reached for technical support by any of the following methods:

1. Internet E-Mail:	support@pro-dex.com
2. World Wide Web:	www.pro-dex.com
3. Telephone:	8:00 a.m. - 5:00 p.m. Pacific Standard Time (503) 629-8081 or (800) 707-8111
4. Facsimile:	24 Hours (503) 629-0688 or (877) 629-0688
5. USPS:	Pro-Dex, Inc., Oregon Micro Systems 1800 NW 169th Place Suite C100 Beaverton OR 97006

RETURN FOR REPAIRS

1. Call Pro-Dex, Inc., Oregon Micro Systems' Customer Service at (503) 629-8081 or (800) 707-8111 or E-Mail to sales@pro-dex.com.

2. Explain the problem and we may be able to solve it on the phone. If not, we will give you a Return Materials Authorization (RMA) number.

   Mark the RMA number on the shipping label, packing slip and other paper work accompanying the return. We cannot accept returns without an RMA number.

3. Please be sure to enclose a packing slip with the RMA number, serial number of the equipment, reason for return, and the name and telephone number of the person we should contact if we have further questions.

4. Pack the equipment in a solid cardboard box secured with packing material.

5. Ship prepaid and insured to:

   PRO-DEX, INC., OREGON MICRO SYSTEMS
   Twin Oaks Business Center
   1800 NW 169th Place, Suite C100
   Beaverton, OR 97006

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APPENDIX C

SPECIFICATIONS

Velocity
0 to 1,044,000 counts per second simultaneous on each axis
Acceleration
0 to 8,000,000 counts per second per second
Position range
67,000,000 counts (±33,500,000)
Accuracy
Position accuracy and repeatability ±0 counts for point to point moves
Velocity accuracy ±0.01% for step pulse output
Environmental
Operating temperature range: 0 to 50 degrees centigrade
Storage temperature range: -20 to 85 degrees centigrade
Humidity: 0 to 90% non-condensing
Power
+5VDC at 1 amp typical
+12VDC at 0.1 amp typical
-12VDC at 0.1 amp typical
Dimensions
Conforms to dimensions for 5V PCI Raw Card (Short Card) in PCI Specification Rev. 2.2
Communication
Meets all signal specifications for PCI Specification Rev. 2.2

Limit switch inputs
Opto-isolated TTL input levels with on board 270Ω current limiting resistor, requires only external switch closure to ground or TTL level input signal. Input sense (low or high true) selectable by command input for each axis.
Home switch inputs
Opto-isolated TTL input levels with on board 270Ω current limiting resistor, requires only external switch closure to ground or TTL level input signal. Input sense (low or high true) selectable by command input for each axis.
User definable I/O
Up to 12 bits of user definable I/O. Factory default sets 4 bits as outputs and 4 bits as inputs. One auxiliary output per axis is included and these are fixed as outputs. General purpose I/O and auxiliary bits are optically isolated. Inputs include an on board 270Ω current limiting resistor. These inputs expect TTL level input signals. I/O Output bits and auxiliary outputs are optically isolated TTL signals with 2.2K Ω pull-up resistors on board (opto, max 50mA).
Analog outputs
+/-10V and 0 to +10V
Step pulse output
Pulse width 50% duty cycle. Open collector TTL level signal (7406, max 48mA).
Direction output
Open collector TTL level signal (7406, max 48mA).

PRO-DEX, INC., OREGON MICRO SYSTEMS, PCIx(PCI) INTELLIGENT MOTION CONTROLS

MODEL	SERVO AXES	STEPPER AXES		USER I/O
		CLOSED LOOP (Encoder)	OPEN LOOP	
PCIx-002			2	10
PCIx-020		2		10
PCIx-202	2		2	12
PCIx-200	2			10
PCIx-004			4	12
PCIx-040		4		12
PCIx-400	4			12

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