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COMMAND NAME: Read Per Axis Hardware Status

COMMAND ID: 49

Command: Read Per Axis Hardware Status

Command ID. Number: 0x49

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 2 Words

Command Packet Configuration:

	0x2?49	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: 1 Word

Return Packet Configuration:

0x2?49	1st word returned:	Packet ID. Word ? = Axis #1, 2, 3 or 4
0x00??	2nd word returned:	Per Axis Hardware Status Data Word.

This command is used to read the detailed hardware level status for each axis controller circuit. This return data status word contains important hardware status information about each axis which may be used for many reporting and control functions.

See next page for the Per Axis Hardware Status Data Word bit values.

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The Per Axis Hardware Status Data Word returned as a result of this command packet has the following format.

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
0	0	X	X	X	X	1	0	X	0	X	X	X	X	X	X

The value for "X" can be interpreted as follows:

D15 & D14 - Always = 0

D13 - Command Execution Status
1 = Last Command Not Executed
0 = Last Command Executed Successfully

D12 - Present Direction (Valid For Velocity Mode Only!)
1 = Forward
0 = Reverse

D11 - Operation Mode
1 = Velocity Mode Selected
0 = Position Mode Selected

D10 - Profile Complete
1 = True
0 = False

D9 - Always = 0

D8 - Always = 0

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D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
0	0	X	X	X	X	1	0	X	0	X	X	X	X	X	X

The value for "X" can be interpreted as follows:

D7 - Run / Stop Status
1 = Running
0 = Stopped

D6 - Always = 0

D5 - Position Error Status
1 = Position Error Condition
0 = OK

D4 - Wraparound Count Error Status
1 = Wraparound Error Condition
0 = OK

D3 - Index Status
1 = Index Found
0 = Index Not Found

D2 - Motor Status
1 = Motor Off
0 = Motor On

D1 - Home Switch Status
1 = Home Switch Input True
0 = Home Switch Input False

D0 - Limit Switch Status
1 = Limit Switch Condition True
0 = Limit Switch Condition False

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The Command Execution Status bit indicates that the last command to this axis was received but was determined to be illegal due to the operating condition of the axis. The following is a list of illegal conditions that will set this bit:

1) Attempting to execute a Set Direction command in Position Mode.

2) Attempting to execute a Load Target Position command in Velocity Mode.

3) Attempting to execute a FindHome command when
   a) already executing a Find Home sequence.
   b) per Axis Limits and Home are not enabled.
   c) any Trigger Inputs are enabled.
   d) both Forward and Reverse Limits are active.

4) Attempting to execute a Find Index command when
   a) the axis is running.
   b) any Trigger Inputs are enabled.
   c) any Limits are active. (Home active is OK.)

5) Attempting to execute a Start command or Multi-Axis Start command and the desired direction of motion of any axis is blocked by a limit condition.

6) Attempting to execute an Enable Breakpoint command for a loaded time breakpoint and
   a) not in Position Mode
   b) the acceleration value is too high
   c) the move distance is <32 quadrature counts

7) Attempting to execute an Enable Breakpoint command for a loaded position breakpoint and
   a) the breakpoint value is equal to the present position for an absolute breakpoint
   b) the breakpoint value is equal to zero for a relative breakpoint

8) During a Find Home sequence on any axis, attempting to execute any command other than the following:
   Kill Motion
   Stop Motion
   Set Stop Mode
   Read Per Axis Hardware Status
   Read Position
   Read Velocity
   Set I/O Port Output
   Read I/O Port
   Read Communications Status
   Set I/O Port Polarity & Direction
   Set Limit Switch Input Polarity
   Read Limit Switch Status

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COMMAND NAME: Set Limit Switch Input Polarity

COMMAND ID: 4A

Command: Set Limit Switch Input Polarity

Command ID. Number: 0x4A

Command Type: System Level

Command Packet Size: 3 Words

Command Packet Configuration:

	0x304A	-	Command Packet ID. Word
	0x0???	-	Limit Switch Polarity Setup Word
			See The Individual Bit Binary Table.
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command is used to set the input polarity for the limit switch (forward & reverse) and home switch input signals for each axis on an individual signal basis. By using this command in conjunction with the Enable Limit Switch Inputs command, you may custom tailor the limit switch inputs according to your system requirements. The default configuration for limit and home switch polarity is inverting inputs. Inverting input signals provide an active low input signal configuration. Non-inverting input signals provide an active high input signal configuration.

See next page for the Set Limit Switch Input Polarity Data Word bit values.

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D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	X	X	X	X	X	X	X	X	X	X	X	X

Where the value for "X" can be interpreted as follows:

D15 thru D12 - Always = 0

D11 - Axis #1 Home Switch Input Polarity Control
1 = Inverting
0 = Non-inverting

D10 - Axis #2 Home Switch Input Polarity Control
1 = Inverting
0 = Non-inverting

D9 - Axis #3 Home Switch Input Polarity Control
1 = Inverting
0 = Non-inverting

D8 - Axis #4 Home Switch Input Polarity Control
1 = Inverting
0 = Non-inverting

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D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	X	X	X	X	X	X	X	X	X	X	X	X

Where the value for "X" can be interpreted as follows:

D7 - Axis #1 Forward Limit Switch Input Polarity Control
1 = Inverting
0 = Non-inverting

D6 - Axis #1 Reverse Limit Switch Input Polarity Control
1 = Inverting
0 = Non-inverting

D5 - Axis #2 Forward Limit Switch Input Polarity Control
1 = Inverting
0 = Non-inverting

D4 - Axis #2 Reverse Limit Switch Input Polarity Control
1 = Inverting
0 = Non-inverting

D3 - Axis #3 Forward Limit Switch Input Polarity Control
1 = Inverting
0 = Non-inverting

D2 - Axis #3 Reverse Limit Switch Input Polarity Control
1 = Inverting
0 = Non-inverting

D1 - Axis #4 Forward Limit Switch Input Polarity Control
1 = Inverting
0 = Non-inverting

D0 - Axis #4 Reverse Limit Switch Input Polarity Control
1 = Inverting
0 = Non-inverting

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COMMAND NAME: Enable Limit Switch Inputs

COMMAND ID: 4B

Command: Enable Limit Switch Inputs

Command ID. Number: 0x4B

Command Type: System Level

Command Packet Size: 3 Words

Command Packet Configuration:

	0x304B	-	Command Packet ID. Word
	0x0???	-	Limit Switch Enable Word
			See The Individual Bit Binary Table.
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command is used to enable / disable the individual axis limit and home switch inputs. The limit switch inputs have been designed to provide a halt stop on limit switch function, as well as a means of prohibiting motion beyond the limit (as long as the input remains active). In order for the stop on limit switch function to work properly, the limit switch inputs must be correctly configured for polarity by use of the Set Limit Switch Input Polarity command. This must occur prior to the use of this Enable Limit Switch Inputs command to properly enable the limit switch inputs. At power-up, all limit and home switches are disabled by default.

When correctly set for polarity, and enabled by use of this command, the active transition on a limit or home switch input will cause the motion for the corresponding axis to be halt stopped. Valid transitions on enabled limit and home signal inputs are used by the Find Home command. The limit and home switch inputs must be enabled prior to the execution of the Find Home Command. You may enable the home switch inputs for special function purposes in addition to the predetermined Find Home function.

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The Limit Switch Enable Word sent as part of this command packet has the following format. Use this command to enable the individual limit switch and home switch inputs.

Limit Switch Enable Word = 0x0???

Where: Upper Byte (0?) - Home Switch Inputs Enable
Lower Byte (??) - Limit Switch Inputs Enable

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	X	X	X	X	X	X	X	X	X	X	X	X

The value for "X" can be interpreted as follows:

D15 - D12 - Always = 0

D11 - Axis #1 Home Switch Enable
1 = Enable
0 = Disable (Default)

D10 - Axis #2 Home Switch Enable
1 = Enable
0 = Disable (Default)

D9 - Axis #3 Home Switch Enable
1 = Enable
0 = Disable (Default)

D8 - Axis #4 Home Switch Enable
1 = Enable
0 = Disable (Default)

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D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	X	X	X	X	X	X	X	X	X	X	X	X

The value for "X" can be interpreted as follows:

D7 - Axis #1 Forward Limit Switch Enable
1 = Enable
0 = Disable (Default)

D6 - Axis #1 Reverse Limit Switch Enable
1 = Enable
0 = Disable (Default)

D5 - Axis #2 Forward Limit Switch Enable
1 = Enable
0 = Disable (Default)

D4 - Axis #2 Reverse Limit Switch Enable
1 = Enable
0 = Disable (Default)

D3 - Axis #3 Forward Limit Switch Enable
1 = Enable
0 = Disable (Default)

D2 - Axis #3 Reverse Limit Switch Enable Bit
1 = Enable
0 = Disable (Default)

D1 - Axis #4 Forward Limit Switch Enable Bit
1 = Enable
0 = Disable (Default)

D0 - Axis #4 Reverse Limit Switch Enable Bit
1 = Enable
0 = Disable (Default)

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COMMAND NAME: Stop Motion

COMMAND ID: 4C

Command: Stop Motion

Command ID. Number: 0x4C

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 2 Words

Command Packet Configuration:

	0x2?4C	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x000A	-	Command Packet Termiator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command is used to stop the motion for the axis specified in the Command Packet ID. word. This command will stop the motion for the axis specified using the stop mode selected by the Set Stop Mode command. There are three possible stop modes: decellerate to a stop using the programmed acceleration value, halt stop immediately and kill motion by setting the motor control signal to zero.

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COMMAND NAME: Kill Motion

COMMAND ID: 4D

Command: Kill Motion

Command ID. Number: 0x4D

Command Type: **{Priority}** Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 2 Words

Command Packet Configuration:

	0x2?4D	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

Warning: This command will purge the individual axis specific input command buffer of any pending commands!

This command is used to kill the motion for the axis specified in the Command Packet ID. word. This command will stop the motion for the axis specified using the kill stop mode. The kill stop mode stops motion by disabling the motor control signal. For analog output , the voltage is set to zero (0), for PWM output drives, the PWM waveform is set at 50% duty cycle. This will effectively disable power drive to the motor, thereby allowing the motor to freewheel.

Typically, this command is used to evoke an emergency stop situation and clear any pending buffered commands for the axis specified.

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COMMAND NAME: Load Target Position

COMMAND ID: 4E

Command: Load Target Position

Command ID. Number: 0x4E

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 4 Words

Command Packet Configuration:

	0x4?4E	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	Most Significant (upper) Position Word
	0x????	-	Least Significant (lower) Position Word
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

The Load Target Position command is used to load the desired target position value. The value loaded by this command is the target position in quadrature encoder counts.

0x???? ???? = 32 Bit Signed Hexadecimal Position Value

This value is loaded via a complete command packet transfer. The long word value is sent as two word values, with the most significant (upper) word sent first, and the least significant (lower) word sent next.

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The target position value loaded is used by the position servo loop when the axis specified is set in Position Mode. (See: Section #3.7.1, Set Operational Modes.) The actual function of the loaded value will vary with the operational mode selected. For example, if the mode is set as Position Mode - Absolute, then the loaded position value will be the absolute target position count value for a subsequent Start Motion Command. Motion will proceed to the loaded absolute position when a start is issued. However, if the mode is set as Position Mode - Relative, then the loaded position value will be the move distance relative to the last stopped position. Motion will proceed to the relative position when a start is issued. The Operation Mode must be set prior to the loading of a position value for the value to be interpreted in the desired mode.

Position Mode Target Examples:

Position Mode - Absolute:

If the present position is ;	0x0001 0000
and the Target Position is;	0x0004 0000
then, the actual move will be; in the forward direction.	0x0003 0000
The final position at move complete: (Same as Target Position)	0x0004 0000

Position Mode - Relative:

If the present position is;	0x0001 0000
and the Target Position Value is;	0xFFFF 0000
then, the actual move will be; in the reverse direction.	0x0001 0000
The final position at move complete: (Previous Position Plus Relative Position)	0x0000 0000

Position values are 32 bit values (long word) and indicate a desired position and direction of motion with relation to the zero position (absolute) or present position (relative). In order to specify direction of motion, the loaded target position must be specified as a positive value for forward motion with relation to the zero position or present position and as a negative value for reverse motion with relation to the zero position or present position. Therefore, the position value is a signed 32 bit hexadecimal value.

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The maximum position values loaded must remain within the following boundaries:

$$0xC000\ 0000 \leq \text{Loaded Position Value} \leq 0x3FFF\ FFFF$$

$$-2^{30} \leq \text{Loaded Position Value} \leq +(2^{30} - 1)$$

NOTE: All position values must be loaded in quadrature encoder counts. The loaded position values are affected by user programmed scaling and offset parameters. (See commands 0x68 thru 0x6A)

A forward move (relative) of 0x20000 counts would be sent as: 0x0002 0000

A reverse move (relative) of 0x20000 counts would be sent as: 0xFFFE 0000

When a new target position is loaded, it is buffered in the axis specific servo control circuit as the new target position value until a Start Motion command is issued for that axis. New values loaded will constantly overwrite old values until the Start Motion command is executed.

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COMMAND NAME: Load Velocity

COMMAND ID: 4F

Command: Load Velocity

Command ID. Number: 0x4F

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 4 Words

Command Packet Configuration:

	0x4?4F	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	Most Significant (upper) Velocity Word {Integer portion of the velocity value}
	0x????	-	Least Significant (lower) Velocity Word {Fractional portion of the velocity value}
	0x000A	-	Command Packet Termiator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

The Load Velocity command is used to load the desired velocity on a per axis basis. The value loaded by this command is the velocity in quadrature encoder counts per sample period.

This unsigned value is loaded via a complete command packet transfer. The long word value is sent as two word values, with the most significant (upper) word being sent first, and then the least significant (lower) word being sent next.

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The velocity value to be loaded as a long word can be calculated using the following simple formula:

Velocity Value Long Word (32 bits) = (R) * (Ts) * (Ct) * (Vrpm) * (65,536)

Where:
- R = Quadrature Encoder Counts Per Revolution
- Ts = 341 E -6 (Filter Sample Period)
- Ct = 1/60 (Conversion Factor - Minutes to Seconds)
- Vrpm = Desired Velocity in Revolutions Per Minute (RPM)
- 65,536 = Integer / Fraction Scaling Factor

NOTE This formula can also be applied to linear motors by changing the (R) value from Quadrature Counts Per Revolution to Quadrature Counts Per Index Period and by changing the (Vrpm) value to a (Vipm) value for desired velocity in Indexes Per Minute. (If you use Indexes Per Second, then the (Ct) value is no longer necessary.)

Velocity Value Determination Example:

Encoder = 1000 Lines Per Revolution

Thus; R = 4 * 1000 = 4000 Quadrature Counts

Filter Sample Period = 341 E -6 (Seconds)

Thus; Ts = 341 E -6

Desired Velocity (Vrpm) = 2,250 RPM

Velocity Value To Load = (4000) * (341 E -6) * (1/60) * (2,250) * (65,536)

Velocity Value To Load = (51.15 Counts Per Sample Period) * (65,536)

Velocity Value To Load = 3,352,166 (Scaled & Rounded)

Velocity Value To Load = 0x0033 2666 (Hex Long Word Value)

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The velocity value loaded is used differently in the various Operation Modes. (See: Set Operation Modes, Section #3.7.1.) For example, in Position Mode, the loaded velocity value will be the maximum velocity allowed during the trapazoidal move to the target position. In Velocity Mode, the loaded velocity value is the commanded velocity issued at the execution of a Start Motion command. Motion will continue at the last commanded velocity until a new velocity value is loaded and updated by a Start Motion command or a Stop Motion command is executed.

Velocity Mode Example:

If the present commanded velocity is;	0x0010 0000
and the new loaded velocity is ;	0x0020 0000
and a Start Motion command is issued...	
then, the actual velocity will be: (Assuming proper system setup)	0x0020 0000

Velocity values loaded are 32 bit (long word) values and indicate a desired motion velocity. Actual velocity attained is determined by many factors not limited to programmed motion control parameters. Filter parameters as well as target acceleration values will have an affect upon a system's ability to attain a desired velocity. The major limiting factor on motion velocity is the mechanical system configuration and motor / amplifier constraints.

Warning:

Do Not Program Velocity Values That Will Exceed The Safe Operating Range For The Electrical, Mechanical and Motion Components Involved.

In all cases, the maximum velocity values loaded must never exceed the following boundaries.

$$0 \leq \text{Loaded Unsigned Velocity Value} \leq 0x00FF\ FFFF$$

The default value for velocity at power up is: 0x0000 8000

When a new velocity value is loaded, it is buffered in the axis specific servo control circuit as the new velocity value until a Start Motion command is issued for that axis. New values loaded will constantly overwrite old values until the Start Motion Command or Stop Motion command is executed.

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COMMAND NAME: Reset Positon Counter To Zero

COMMAND ID: 50

Command: Reset Positon Counter To Zero

Command ID. Number: 0x50

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 2 Words

Command Packet Configuration:

	0x2?50	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command is used to reset the position counter to zero for the axis specified in the Command Packet ID. word. This command will set the position count value to zero immediately upon execution. If a motion trajectory is in process when this command is executed, the trajectory will be completed using the preprogrammed values. The position readback value read following this command will be the count value relative to the transient position where this command was executed.

Warning:

This command should only be issued when motion is stopped in order to preserve the actual absolute position information.

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COMMAND NAME: Find Home

COMMAND ID: 51

Command: Find Home

Command ID. Number: 0x51

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 3 Words

Command Packet Configuration:

	0x3?51	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	Find Home Search Direction ???? = 0000 Forward ???? = FFFF Reverse
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command is used to initiate the Find Home function for the axis specified in the Command Packet ID. word. This command requires properly connected, configured and enabled limit switch and home switch input signals.

The Find Home command will generate and execute motion profiles that search for the home switch. All motion profiles executed by this command require correctly loaded Velocity and Acceleration parameters.

If The Indicator Word = 0x0000: (Find Home Forward)

The Find Home function will cause motion to begin in the forward direction until the home switch input signal is detected. Motion will then stop. If motion reaches the forward limit switch prior to the home switch, motion will reverse and proceed in the direction of the reverse limit switch. If and when the home switch is encountered, motion will stop. If no home switch is found, motion will reach the reverse limit switch and stop.

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If The Indicator Word = 0xFFFF: (Find Home Reverse)

The Find Home function will cause motion to begin in the reverse direction until the home switch input signal is detected. Motion will then stop. If motion reaches the reverse limit switch prior to the home switch, motion will change direction and proceed towards the forward limit switch. If and when the home switch is encountered, motion will stop. If no home switch is found, motion will reach the forward limit switch and stop.

Many commands are illegal during a Find Home sequence. Attempting to execute any command other than the following will generate a Command Not Executed status. See Read Per Axis Hardware Status (Cmd Id 0x49) and Read Communications Status (Cmd Id 0x41) for more details.

Valid Commands during Find Home:

Kill Motion
Stop Motion
Set Stop Mode
Read Per Axis Hardware Status
Read Position
Read Velocity
Set I/O Port Output
Read I/O Port
Read Communications Status
Set I/O Port Polarity & Direction
Set Limit Switch Input Polarity
Read Limit Switch Status

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COMMAND NAME: Find Index

COMMAND ID: 52

Command: Find Index

Command ID. Number: 0x52

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 4 Words

Command Packet Configuration:

	0x4?52	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	Find Index Data Word - Where ???? is a signed hex value equal to the number of encoder lines per revolution. (Encoder lines between index pulses.) The sign determines the direction of Find Index motion. Data Word = 0x0001 thru 0x7FFF (Find Index Fwd.) Data Word = 0xFFFF thru 0x8000 (Find Index Rev.)
	0x????	-	Index Offset Data Word - Where ???? is a signed hex word equal to the desired position offset value in encoder lines. Data Word = 0x0001 thru 0x7FFF (Index Offset Fwd.) Data Word = 0xFFFF thru 0x8000 (Index Offset Rev.)
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

Return Packet Configuration:

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This command is used to initiate the Find Index function for the axis specified in the Command Packet ID. word. This command requires that the correct value for encoder lines per revolution be entered as the Find Index Data Word and that a properly connected index signal input be present for the specified axis. The signal must be an active low signal. (See Section 2.6 For More Information On Encoder Signal Connections.) Since the data value is a signed word (16 bits), the maximum encoder resolution may be as large as: 32,768 lines per revolution. This value should be sufficient for most all encoder based system applications.

The Find Index command will generate and execute a motion profile utilizing the current velocity and acceleration parameters. Motion is in the direction selected via the loaded Find Index Data Word for one revolution plus one count. This motion profile will allow the pcControl per axis motion control circuitry to locate a single index occurrence. After recording the index location, motion will continue to a new target position equal to the recorded index position plus the programmed Index Offset Word.

During the first move of this sequence, when the board is performing its one revolution search, normal communications are temporarily suspended. Once this first move is complete, this command sets the Index Found status bit indicating the success or failure of the search. At this point, the Index Found status bit can be checked by executing a Read Per Axis Hardware Status command and then reading the data on the return data buffer. The amount of time required to complete the search move is dependent upon the Velocity and Acceleration values preprogrammed for motion trajectory control and the distance required to travel for one index period.

The status of the limit switches is checked prior to the start of the Find Index sequence. Attempting to find the index in the forward direction with the forward limit active or in the reverse direction with the reverse limit active is not allowed and will cause the command to abort.

WARNING: During the Find Index sequence, active transitions on the limit or home switches may cause the axis to stop before it reaches its final target position. In this case, the Index Found status bit will be true but the axis may not be in the desired reference position.

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COMMAND NAME: Read Present Position

COMMAND ID: 53

Command: Read Present Position

Command ID. Number: 0x53

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 2 Words

Command Packet Configuration:

	0x2?53	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: 2 Words

Return Packet Configuration:

0x3?53	1st word returned: ? = Axis #1, 2, 3 or 4	Packet ID. Word
0x????	2nd word returned:	Least significant word of the 32 bit position value. (Lower 16 bits)
0x????	3rd word returned:	Most significant word of the 32 bit position value. (Upper 16 bits)

The readback position value is a signed long word value (32 bits) in the range of:

$$0xC0000000 \leq \text{Read Position Value} \leq 0x3FFFFFFF$$

$$-2^{30} \leq \text{Read Position Value} \leq +(2^{30} - 1)$$

NOTE: All position values are in quadrature encoder counts.

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This command is used to read the value of the position counter for the axis specified in the Command Packet ID. word. The value read is the position at the moment of actual command execution. This command may be executed at any time to determine the present position of the axis in question. The value returned is a signed hexadecimal long word value (32 bits). This value is returned as two consecutive word values where the first word is the least significant portion of the long word and the second word is the most significant portion of the long word.

The value returned is an instantaneous read of the position counter in the servo controller loop for each axis. If motion is in process when this command is executed, the position count will be constantly changing and the value will only reflect the position at the moment it was read.

The position value will be placed in the return data buffer and held until it is read out by the host.

NOTE: The position readback values will be affected by user programmed scaling and offset parameters. (See commands 0x68 thru 0x6A)

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COMMAND NAME: Read Present Velocity

COMMAND ID: 54

Command: Read Present Velocity

Command ID. Number: 0x54

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 2 Words

Command Packet Configuration:

	0x2?54	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: 1 Word

Return Packet Configuration:

0x2?54	1st word returned: ?= #1,2 or 3	Packet ID. Word
0x????	2nd word returned:	Integer Portion Of The Present Velocity Value

The velocity value returned is a signed word (16 bits) in the range of:

$$0xC000 \leq \text{Velocity Value} \leq 0x3FFF$$

This read value shows only the integer portion of the present Velocity being executed by the axis specific controller circuit. Although velocity values are programmed as long word (32 bit) unsigned scaled values including an integer portion (upper 16 bits) and a fractional portion (lower 16 bits), this command will return the actual velocity integer portion only.

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The absolute value of the signed return data word is the integer portion showing present instantaneous velocity at the moment the command was executed. The sign information derived from this word will show actual direction of motion, either forward (positive values) or reverse (negative values).

The velocity valued returned is the real velocity presently being executed by the per axis servo control circuitry. This value may be compared with the integer portion (upper 16 bits) of the programmed velocity value to verify actual velocity obtained.

Please note, actual velocity values obtained may be less than programmed values due to system and mechanical constraints prohibiting the servo loop from attaining the programmed velocity value.

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COMMAND NAME: Set Stop Mode

COMMAND ID: 55

Command: Set Stop Mode

Command ID. Number: 0x55

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 3 Words

Command Packet Configuration:

0x3?55 - Command Packet ID. Word
? = Axis #1, 2, 3 or 4

0xYYZZ - Data Word - YYZZ is the stop mode control word organized as two bytes.

ZZ - Stop Motion Mode Byte
0xYY01 - Decelerate To Stop
0xYY02 - Halt Stop (Default)
0xYY03 - Kill Stop

YY - Home Switch Mode Byte
0x00ZZ - Halt Stop (for compatibility)
0x01ZZ - Decelerate To Stop
0x02ZZ - Halt Stop (Default)
0x03ZZ - Kill Stop

All other values will abort the command.

0x000A - Command Packet Terminator Word
or, 0x000D - "
or, 0x0020 - "

Return Data: None

This command is used to set the stop modes utilized by the axis specified in the Command Packet ID. word. These modes are used by the Stop Motion Command to cause different stop types and by the Find Home command to determine the type of stop executed when the home switch is reached. These stop modes are not used at a Limit Switch occurrence (always a Halt stop) or when a position error is generated (always a Kill stop).

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This command takes a compound data word consisting of two bytes. Each byte sets a different stop mode and can be thought of independantly. The lower bytes sets the stop mode utilized during the Stop Motion command (Cmd. Id. 0x4C). The upper byte sets the stop mode utilized when the home switch is reached during the Find Home command (Cmd. Id. 0x51). Once the modes are programmed, subsequent stops are executed using the stop modes selected with this command. There are three possible stop modes:

Decelerate To Stop

The Decelerate to Stop mode will cause motion to stop by decelerating from the present trajectory being executed. The rate of deceleration will be the same as the preprogrammed acceleration value. Once motion is stopped, the position will be maintained by the position servo.

Halt Stop (Default)

The Halt Stop mode will cause motion to stop by instantaneously terminating the present trajectory being executed. This stop mode will cause an abrupt stop at maximum deceleration by setting the target position equal to the present position at the moment the Stop Motion command is executed. Once motion is stopped, the position will be maintained by the position servo.

Kill Stop

The Kill Stop mode will cause motion to stop by setting the control output to zero when the Stop Motion command is executed. This stop mode will allow the motor to coast to a stop with only frictional forces causing the actual stop. Once motion is stopped, the motor will be able to move freely since the postition servo is disabled.

The stop modes selected by this command will remain in effect until new stop modes are programmed. The default stop modes on power-up are Halt Stop. If this command is not executed to set the stop modes, the Stop Motion command and the Find Home command will utilize the default Halt stop mode.

NOTE: If a home switch is encountered during normal operation (not during a Find Home sequence) it will cause a Halt stop to be executed.

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COMMAND NAME: Load Following Error Count

COMMAND ID: 56

Command: Load Following Error Count

Command ID. Number: 0x56

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 3 Words

Command Packet Configuration:

	0x3?56	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	Data Word - ???? is the Following Error Count in hex.
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command is used to set the value that will be used to determine the maximum following error count causing an automatic Kill Stop for the axis specified in the Command Packet ID. Word.

The internal stop issued when the following error exceeds the value programmed by this command is a Kill Motion stop. Motion will coast to a stop with only frictional forces causing motion stop. Once motion is stopped, the motor will be able to move freely since the position servo is disabled.

This command is used to protect the motion hardware and associated system components from damage when the position or velocity servo looses track of actual position feedback or the following error count exceeds the programmed value. This function is most useful for protection against a stalled motor. The default value for the Following Error Count is: 0x7FFF.

The value programmed by use of this command is a word wide (16 bit) value in the range of:

$$0x0000 < \text{Following Error Count} \leq 0x7FFF$$

If values greater than the maximum value are programmed, then the command will default to the maximum value and function normally.

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COMMAND NAME: Load Filter Derivative Sample Period

COMMAND ID: 57

Command: Load Filter Derivative Sample Period

Command ID. Number: 0x57

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 3 Words

Command Packet Configuration:

	0x3?57	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x00??	-	Data Word - ?? equals the Sample Period Selector Word in hex.
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command is used to set the value of the derivative sampling period for the axis specified in the Command Packet ID. word. The Sample Period Selector Word is used as a multiplier of the base sample period (341 microseconds). The derivative sampling period determines the update rate of the derivative term in the PID loop.

The derivative sample period may be updated at any time to tune the digital filter servo loop for system dependent motion control. Adjustment of this value provides greater flexibility in the tuning the derivative term of the PID loop. Determination of the actual value to be used is dependent upon motion system configuration.

The default value set at power-up for the derivative sampling period is the minimum interval value possible. This would correspond to a Sample Period Selector Word loaded by this command of:

0x0000.

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The actual derivative sampling period is related to the Sample Period Selector Word by the following formula:

$$\text{Derivative Sampling Period} = \frac{(\text{Sample Period Selector} + 1)*(2048)}{(6{,}000{,}000)}$$

Derivative Sampling Period Determination Formula
Figure #24

The sampling period for the default value of the Sample Period Selector of 00 is:

$$\text{Derivative Sampling Period} = \frac{(0 + 1)*(2048)}{(6{,}000{,}000)}$$

Derivative Sampling Period = 341 E -6 Seconds or 341 uSeconds

Since the maximum value for the Sample Period Selector is 0xFF (hex) or 255 (decimal), the maximum Derivative Sampling Period is:

$$\text{Derivative Sampling Period} = \frac{(255 + 1)*(2048)}{(6{,}000{,}000)}$$

Derivative Sampling Period = 87.4 E -3 Seconds or 87.4 mSeconds

The overall range of Sample Period Selector values for the derivative sampling period is:

$$0x00 \leq \text{Sample Period Selector Word} \leq 0xFF$$

The corresponding Derivative Sampling Period range is:

$$341 \text{ E -6 Seconds} \leq \text{Sampling Period} \leq 87.4 \text{ E -3 Seconds}$$

It is typically advisable to start with a short period (Sample Period Selector = 00 or 01) and tune the value according to system requirements. Larger values are useful for higher inertia systems.

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COMMAND NAME: Load Filter Proportional Gain

COMMAND ID: 58

Command: Load Filter Proportional Gain

Command ID. Number: 0x58

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 3 Words

Command Packet Configuration:

	0x3?58	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	Data Word - ???? is the Digital Filter Proportional Gain in hex.
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command sets the value of the proportional gain used by the digital filter servo control loop for the axis specified in the Command Packet ID. word.

The proportional gain determines the contribution of a restoring force proportional to the position error. This restoring force functions in much the same way as a spring in a mechanical system. This value may be changed at any time to tune the digital filter. The default value for the proportional gain is: 0x002D.

The value programmed by this command is a data word (16 bit) in the range of:

$$0x0000 \leq \text{Proportional Gain} \leq 0x7FFF$$

If values greater than the maximum are programmed, the command will default to the maximum and function normally.

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COMMAND NAME: Load Filter Integral Gain

COMMAND ID: 59

Command: Load Filter Integral Gain

Command ID. Number: 0x59

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 3 Words

Command Packet Configuration:

	0x3?59	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	Data Word - ???? is the Digital Filter Integral Gain in hex
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command sets the value of the integral gain used by the digital filter servo control loop for the axis specified in the Command Packet ID. word.

The integral gain determines the contribution of a restoring force that grows with time and thus ensures that the static position error in the digital filter servo loop is zero. This restoring force works against constant torque loads to help achieve zero position error.

In applications with very small or non-existent torque loads, this value may remain at its default value of zero (0). For systems having high torque loads, this value should be tuned to maintain zero position error. This value may be changed at any time to tune the digital filter servo control loop.

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The value programmed by use of this command is a data word (16 bit) and must be in the range of:

$$0x0000 \leq \text{Integral Gain} \leq 0x7FFF$$

If values greater than the maximum value are programmed, the command will default to the maximum value and function normally.

Each sample period, the servo loop position error is added to the accumulation of previous position errors to form the integration sum. The integration sum is scaled by dividing by 256 prior to being multiplied by the integral gain. Therefore, the resulting contribution to the motor control output is:

$$\frac{\text{Integration Sum} * \text{Integral Gain}}{256}$$

Note: The scaling by 1/256 allows the use of integer values for the integral gain even when only a small amount of integral contribution is required.

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COMMAND NAME: Load Filter Derivative Gain

COMMAND ID: 5A

Command: Load Filter Derivative Gain

Command ID. Number: 0x5A

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 3 Words

Command Packet Configuration:

	0x3?5A	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	Data Word - ???? is the Derivative Gain value.
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command sets the value of the derivative gain used by the digital filter servo control loop for the axis specified in the Command Packet ID. word.

The derivative gain determines the contribution of a force proportional to the rate of change of position error. This force acts much like viscous damping in a damped spring and mass mechanical system (similar to a shock absorber). The digital filter computes the derivative every Derivative Sample Period. This value, multiplied by the programmed derivative gain, is used by the PID loop every base sample period (341 μseconds) to update the motor control output signal. This value may be changed at any time to tune the digital filter.

The value programmed by this command is a data word (16 bit) in the range of:

$$0x0000 \leq \text{Derivative Gain} \leq 0x7FFF$$

The default value is 0x0DAC. If values greater than the maximum are programmed, then the command will default to the maximum and function normally.

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COMMAND NAME: Load Filter Integration Limit

COMMAND ID: 5B

Command: Load Filter Integration Limit

Command ID. Number: 0x5B

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 3 Words

Command Packet Configuration:

	0x3?5B	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	Data Word - ???? is the Integration Limit in hex.
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command sets the integration limit used by the digital filter servo control loop for the axis specified in the Command Packet ID. word.

The integration limit is used to restrict the contribution of the integral term in the digital filter servo loop. The integration limit is compared to the scaled integration sum and the lesser of the two values is multiplied by the Integral Gain and then used in the generation of the motor control signal. This integration limit can be used to limit excessive restoring forces. This value may be programmed in conjunction with the integration gain to tune the digital filter servo loop for system dependent torque load conditions. This value may be changed at any time to tune the digital filter servo control loop.

The value programmed by this command is a data word (16 bit) in the range of:

$$0x0000 \leq \text{Integration Limit} \leq 0x7FFF$$

Upon powerup, the integration limit function is disabled until this command is executed. If values greater than the maximum value are programmed, the command will default to the maximum value and function normally.

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COMMAND NAME: Multi - Axis Start

COMMAND ID: 5C

Command: Multi - Axis Start

Command ID. Number: 0x5C

Command Type: System Level

Command Packet Size: 3 Words

Command Packet Configuration:

	0x305C	-	Command Packet ID. Word
	0x000?	-	Multi-Axis Start Specifier Data Word
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command is used to issue a simultaneous start to the axes indicated in the Multi - Axis Start Specifier Data Word. If the normal starting conditions are met for all of the axes in this command, then a start command will be issued to all axes specified. If any of the specified axes fails the starting condition test then this command will be terminated and no starts will be issued. The start commands to each axis will occur within one base Sample Period or less.

See next page for the Multi-Axis Start Specifier Data Word bit values.

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The Multi-Axis Start Specifier Data Word sent as part of this command packet has the following format.

Multi-Axis Start Specifier Data Word = 0x000?

Where: Upper Byte (00) - Always = 0
Lower Byte (0?) - Multi-Axis Start Specifier

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	0	0	0	0	0	0	0	0	X	X	X	X

The value for "X" can be interpreted as follows:

D15 - D14 - Always = 0

D3 - Axis #4 Start Specifier
1 = Start
0 = Do Not Start

D2 - Axis #3 Start Specifier
1 = Start
0 = Do Not Start

D1 - Axis #2 Start Specifier
1 = Start
0 = Do Not Start

D0 - Axis #1 Start Specifier
1 = Start
0 = Do Not Start

This command cannot be used to start a single axis. Attempting to execute a Multi-Axis Start with less then two axes selected will generate a Command Error.

If one or more of the selected axes cannot be started due to a limit switch condition, the Command Not Executed status bit will be set in the Communications Status Register and in the Per Axis Hardware Status for each axis that cannot be started. See Read Per Axis Hardware Status (Cmd Id 0x49) and Read Communications Status (Cmd Id 0x41) for more details.

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COMMAND NAME: Trigger Buffer Delimiter

COMMAND ID: 5D

Command: Trigger Buffer Delimiter

Command ID. Number: 0x5D

Command Type: System Level

Command Packet Size: 2 Words

Command Packet Configuration:

	0x205D	-	Command Packet ID. Word
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command is used during the loading of Trigger Buffers as a delimiter between triggered command sequences. Commands previously stored in a trigger buffer are executed when a Trigger I/O Port # command (Cmd. Id. 0x48) is sent from the host, or when a valid transition occurs on a properly configured and enabled Trigger Input I/O bit.

Multiple command sequences may be loaded into a trigger buffer, separated by the Trigger Buffer Delimiter. Each time the trigger buffer is "fired", all commands are executed until a Trigger Buffer Delimiter is encountered or the end of the buffer is reached. Trigger buffers are cyclical, so that when the last command in the buffer is executed, a subsequent firing of the buffer will begin with commands located at the top.

Placing two Trigger Buffer Delimiters in a row in a trigger buffer will cause a NO-OP like function, and firing the trigger buffer will do nothing.

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Trigger Buffer Size:

Trigger Buffer #1 is 1000 Command Packets Deep.

Trigger Buffer #2 is 1000 or 2000 Command Packets Deep (See Below.)

Trigger Buffer #3 is 1000 Command Packets Deep

Trigger Buffer #4 is 2000 Command Packets Deep.

All Trigger Buffers except Trigger Buffer #2 have permanently allocated memory space. Trigger Buffer #2 can hold up to 1000 command packets without impacting Trigger Buffer #3, or up to 2000 command packets by utilizing the space reserved for Trigger Buffer #3.

Warning: If Trigger Buffer #3 is going to be used, Trigger Buffer #2 must be limited to 1000 commands or less to avoid overwriting commands in Trigger Buffer #3.

Note: This command is designed for use in Trigger Buffer command sequence storage only. Executing this command during normal command processing will cause a Command Error condition.

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COMMAND NAME: Acquire Samples

COMMAND ID: 5E

Command: Acquire Samples

Command ID. Number: 0x5E

Command Type: System Level

Command Packet Size: 3 Words

Command Packet Configuration:

	0x305E	-	Command Packet Id. Word
	0x????	-	Number of Samples Data Word 0 < Number of Samples ≤ 0xC8 (200 decimal)
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: 9 to 1800 Return Data Packets (depending on the number of samples)

Return Packet Configuration:

Standard Return Data Packets

The Acquire Samples command fills the Return Data Buffer with samples of multi-axis Position, Velocity and I/O data with the following structure:

Sample #1

Axis 1 Position (Cmd. Id. 0x53) Return Data Packet	-	3 Words
Axis 1 Velocity (Cmd. Id. 0x54) Return Data Packet	-	2 Words
Axis 2 Position (Cmd. Id. 0x53) Return Data Packet	-	3 Words
Axis 2 Velocity (Cmd. Id. 0x54) Return Data Packet	-	2 Words
Axis 3 Position (Cmd. Id. 0x53) Return Data Packet	-	3 Words
Axis 3 Velocity (Cmd. Id. 0x54) Return Data Packet	-	2 Words
Axis 4 Position (Cmd. Id. 0x53) Return Data Packet	-	3 Words
Axis 4 Velocity (Cmd. Id. 0x54) Return Data Packet	-	2 Words
I/O Port Value (Cmd. Id. 0x47) Return Data Packet	-	2 Words
		---
		22 Words

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Sample #2
Same format as above.

etc...

Each Sample is 9 Return Data Packets long for a total of 22 Words including Packet Id. Words. Samples are placed in the buffer one after another with nothing in between at a rate of approximately one sample every 2.3 msec. The Return Data Buffer has space for 200 Samples = 1800 Return Data Packets = 4400 Total Words.

The recommended procedure for utilizing the Acquire Samples command is to wait at least (3 msec) * (Number of Samples) after executing the command and then read out the entire Return Data Buffer.

Warning: Communicating with the pcControl board while the Acquire Samples function is executing will disturb the uniformity of the sampling period. Executing commands that request data will insert Return Data Packets into the Return Data Buffer and corrupt the sample data format described above.

This command allows the capture of real-time servo performance data that can be used as an aid in tuning the servo PID parameters for optimum performance.

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COMMAND NAME: Begin Trigger # Prestore

COMMAND ID: 5F

Command: Begin Trigger # Prestore

Command ID. Number: 0x5F

Command Type: System Level

Command Packet Size: 3 Words

Command Packet Configuration:

	0x305F	-	Command Packet ID. Word
	0x000?	-	Trigger Buffer Selector Data Word ? = 1, 2, 3, 4
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command is used to initiate the trigger buffer command storage function. All commands sent after this command will be stored in the trigger buffer indicated by the data word value (1 thru 4). The End Trigger Prestore command (Cmd. Id. 0x60) will conclude the trigger buffer storage function and return the pcControl board to normal command execution. Commands loaded during the trigger buffer storage function will not be executed. They will be stored for future execution only by a valid, enabled trigger input or use of the Trigger I/O Port # command. (Cmd. Id 0x48)

When this command is received by the pcControl board, it disables all new command input to the axis specific control circuits. Care should be taken when using this command, since all direct control of the pcControl board is disabled during trigger buffer storage. This command should only be used during system setup prior to motion control processing or when all motion is stopped.

Trigger buffer command storage is a powerful feature providing the ability to prestore a list of commands in a trigger buffer for execution by an external trigger event or by a single ISA Bus command transfer.

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COMMAND NAME: End Trigger Prestore

COMMAND ID: 60

Command: End Trigger Prestore

Command ID. Number: 0x60

Command Type: System Level

Command Packet Size: 3 Words

Command Packet Configuration:

	0x3060	-	Command Packet ID. Word
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command is used to conclude the trigger buffer command storage function. All commands sent after the Begin Trigger # Prestore command will be stored in the trigger buffer indicated by the data word sent in conjunction with the Begin Trigger # Prestore command (Cmd Id. 0x5F). The End Trigger Prestore command will conclude the trigger buffer storage function and return the pcControl board to normal processing. Commands loaded during the trigger buffer storage function will not be executed. They will be stored for future execution by a valid, enabled trigger input or use of the Trigger I/O Port # command (Cmd Id. 0x48).

Trigger buffer command storage is a powerful feature providing the ability to prestore a list of commands in a trigger buffer for execution by an external trigger event or by a single ISA Bus command transfer.

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COMMAND NAME: Start Motion

COMMAND ID: 61

Command: Start Motion

Command ID. Number: 0x61

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 2 Words

Command Packet Configuration:

	0x2?61	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x000A	-	Command Packet Termiator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command is used to start motion for the axis specified in the Command Packet ID. word. When this command is executed and valid conditions exist for starting motion on the axis specified, then the loaded motion trajectory parameters will become the active motion control parameter values and motion will begin utilizing the new parameter values. If no new parameter values (velocity, acceleration and position) were loaded since the last start motion command, then the previous values will be used.

The start motion command verifies that the requested motion is valid by checking limit switch inputs. This prevents unwanted motion beyond a valid limit condition.

The start motion command may be issued at any time. If this command is issued while motion is in progress, a new motion trajectory relating to the most recently loaded position and velocity parameters will be executed, overriding the present motion trajectory being executed. Acceleration parameters may not be updated while motion is in progress. See the Load Acceleration command (Cmd. Id. 0x62).

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An example of this is:

If velocity and acceleration values were loaded and a destination position of:

0x00400000

was loaded for an axis configured in Position - Absolute mode, and the Start Motion Command was issued. Then motion would proceed towards the programmed position value.

However, if a new destination position of:

0x00100000

was loaded and a Start Motion Command was issued, then motion would now automaticaly proceed to the new destination position without stopping. If motion had already proceeded beyond the new destination position then it would reverse direction to find the new position.

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COMMAND NAME: Load Acceleration

COMMAND ID: 62

Command: Load Acceleration

Command ID. Number: 0x62

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 4 Words

Command Packet Configuration: (Send 4 Words)

	0x4?62	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	Most Significant (Upper) Acceleration Word
	0x????	-	Least Significant (Lower) Acceleration Word
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

The Load Acceleration Command is used to load the desired acceleration on a per axis basis. This value is loaded via a complete command packet transfer. The long word value is sent as two word values, with the most significant (upper) word being sent first, and the least significant (lower) word being sent next.

The acceleration loaded is used by the motion trajectory servo control loop to control acceleration and deceleration for all motion trajectories requiring this function. The acceleration is loaded in counts per sample per sample (See section #1.3 for more information on calculating the acceleration parameter).

Warning:

The acceleration value may not be loaded when a motion trajectory is being executed and the motor is running for the Axis ID. # specified. If an acceleration command is received while the axis is in motion, it is ignored. Acceleration values must only be loaded when motion is stopped.

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The maximum acceleration values loaded must remain within the following boundaries.

$$0 \leq \text{Loaded Acceleration Value} \leq 0x00FF\ FFFF$$

The default value for acceleration at power up is: 0x0000 8000

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COMMAND NAME: Set Direction

COMMAND ID: 63

Command: Set Direction (This Command Is Valid For Velocity Mode Only!!!)

Command ID. Number: 0x63

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 3 Words

Command Packet Configuration:

	0x3?63	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	Direction Control Word If ???? = 0000 Velocity Mode Direction = Forward. If ???? = FFFF Velocity Mode Direction = Reverse.
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command is used to set the desired direction of motion for the axis specified in the Command Packet ID. word. This command is only valid when the selected mode is Velocity. It will be ignored if the selected mode is Position. The Set Direction command must be followed by a Start Motion Command to initiate the programmed change of direction request.

If the Set Direction command is issued when a Velocity mode motion trajectory is being executed, and the direction is opposite from that presently being executed, then motion will automatically decelerate, change to the new direction and accelerate to the preprogrammed trajectory velocity.

The default direction at power up is: Reverse.

Warning:

This command is valid for Velocity Mode Only!.

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COMMAND NAME: Set Operation Mode

COMMAND ID: 64

Command: Set Operation Mode

Command ID. Number: 0x64

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 3 Words

Command Packet Configuration:

	0x3?64	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	Operation Mode Control Word
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command is used to set the desired operation mode for the axis specified in the Command Packet ID. word. This command should be issued as part of a system initialization / configuration routine. Since all motion trajectory execution is dependent upon the operation mode selected, mode selection should be completed prior to motion trajectory parameter loading.

The three possible per axis operation mode selections are set using the following Operation Mode Control Words:

0x0000	Will set	-	Position Mode - Absolute (Default)
0x00FF	Will set	-	Position Mode - Relative
0xFFXX	Will set	-	Velocity Mode - Absolute

Note: The Absolute / Relative selections do not apply to Velocity Mode! The velocity parameter is always interpreted in Absolute Mode.

These modes may be set differently for each axis. The operation mode may be changed at any time, but only parameters loaded after the change will be interpreted in the newly selected mode. (See Section #3.7.1 for more information on operation modes.)

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COMMAND NAME: Load Position Breakpoint

COMMAND ID: 65

Command: Load Position Breakpoint

Command ID. Number: 0x65

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 4 Words

Command Packet Configuration:

	0x4?65	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	Most Significant (Upper) Breakpoint Position Word
	0x????	-	Least Significant (Lower) Breakpoint Position Word
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

The value loaded for Position Breakpoint must be within the following range:

$$0xC000\ 0000 \leq \text{Loaded Breakpoint Value} \leq 0x3FFF\ FFFF$$

$$-2^{30} \leq \text{Loaded Breakpoint Value} \leq +(2^{30} - 1)$$

The breakpoint function provides the ability to generate an external signal on a dedicated digital I/O line when the motion position equals the preprogrammed breakpoint position.

Axis #1 utilizes the I/O Port #5 bit as its dedicated breakpoint output line.

Axis #2 utilizes the I/O Port #6 bit as its dedicated breakpoint output line.

Axis #3 utilizes the I/O Port #7 bit as its dedicated breakpoint output line.

Axis #4 utilizes the I/O Port #8 bit as its dedicated breakpoint output line.

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The Load Position Breakpoint command is used to load the desired position count at which an external breakpoint signal is generated for each axis. The value loaded by this command is the breakpoint position in quadrature counts. The default breakpoint value is zero. The breakpoint position is loaded via a complete command packet transfer. The long word value is sent as two word values, with the most significant (upper) word being sent first, and the least significant (lower) word being sent next.

This command utilizes output lines in the digital I/O port that are dedicated on a per axis basis. Special care should be taken to configure the correct coresponding digital I/O port bits as OUTPUT ports with the desired polarity and initial value. When the breakpoint position is reached for a properly setup axis and I/O port configuration, the output level on the digital I/O line changes state. If a particular transition is desired, the output should be preset prior to use of the breakpoint function and reset following the breakpoint position execution. The read I/O port command may be polled to determine whether the breakpoint function has occured.

The typical control and execution sequence for use of this command is:

Step #1) Setup and configure the I/O Port bits as required.

Step #2) Load the breakpoint position. (Cmd. Id. 0x65)

Step #3) Enable the breakpoint function and set the interpretation mode. The breakpoint positon may be entered in absolute or relative mode. (Cmd. Id. 0x66)

Step #4) The I/O Port bit output value will change state when the breakpoint position is reached.

Step #5) *** Optional *** Reset the output value to a desired state. (Cmd. Id. 0x45)

The breakpoint position loaded by this command may be changed at any time. The value utilized is not actually enabled until execution of the Enable Breakpoint Function command (Cmd. Id. 0x66). The value loaded by this command may be used repeatedly by executing the Enable Breakpoint Function command (Cmd. Id. 0x66) following the sucessful execution of a breakpoint. It is not necessary to reload the breakpoint position with this command for each use if the breakpoint position remains the same.

NOTE: Absolute position breakpoints will utilize the user programmed scaling and offset parameters and relative postion breakpoints will utilize the scaling parameters programmed. (See commands 0x68 thru 0x6A)

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COMMAND NAME: Enable Breakpoint Function

COMMAND ID: 66

Command: Enable Breakpoint Function

Command ID. Number: 0x66

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 3 Words

Command Packet Configuration:

	0x3?66	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	0x???? = 0x0000 Position Breakpoint Is Absolute 0x???? = 0xFFFF Position Breakpoint Is Relative
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

The Enable Breakpoint Function is used to set and enable the positon or time at which an external breakpoint signal is generated on the corresponding digital I/O line. The position loaded by the Load Breakpoint Position command (Cmd. Id. 0x65) or the anticipation time value loaded by the Load Anticipation Breakpoint command (Cmd. Id. 0x67) is used as the desired breakpoint location.

Axis #1 utilizes the I/O Port #5 bit as its dedicated breakpoint output line.

Axis #2 utilizes the I/O Port #6 bit as its dedicated breakpoint output line.

Axis #3 utilizes the I/O Port #7 bit as its dedicated breakpoint output line.

Axis #4 utilizes the I/O Port #8 bit as its dedicated breakpoint output line.

Note: The absolute /relative mode indicator in this command is used in conjunction with position breakpoints only. The mode specified here is independent of the Operation Mode selected for the corresponding axis.

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If the breakpoint function is enabled using the absolute mode selector in this command, then the breakpoint output signal will be generated on the corresponding digital I/O line when the absolute axis position is equal to the programmed breakpoint position.

If the breakpoint function is enable using the relative mode selector in this command, then the breakpoint output signal will be generated on the corresponding digital I/O line when the axis position is equal to the sum of the starting position and the loaded relative breakpoint positon.

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COMMAND NAME: Load Anticipation Time Breakpoint

COMMAND ID: 67

Command: Load Anticipation Time Breakpoint

Command ID. Number: 0x67

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 3 Words

Command Packet Configuration:

	0x3?67	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	0x???? = 0x0001 thru 0xFFFF - Anticipation Time in Sample Periods.
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

The anticipation breakpoint function provides the ability to generate an external signal on a dedicated digital I/O line when the axis position equals the preprogrammed anticipation time breakpoint equivalent position.

Axis #1 utilizes the I/O Port #5 bit as its dedicated breakpoint output line.

Axis #2 utilizes the I/O Port #6 bit as its dedicated breakpoint output line.

Axis #3 utilizes the I/O Port #7 bit as its dedicated breakpoint output line.

Axis #4 utilizes the I/O Port #8 bit as its dedicated breakpoint output line.

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The Load Anticipation Time Breakpoint command is used to preload a desired anticipation time relative to the end of a programmed motion trajectory in position mode. When the position corresponding to the desired anticipation time is reached, an external breakpoint signal transition will occur on the dedicated I/O port output line for the axis selected. The anticipation breakpoint function is similar to, and shares the same resources as, the position breakpoint function. (Cmd. Id. 0x65) Because they share the same resources, these two breakpoint configuration commands are mutually exclusive and the last one issued is the one that is utilized by the Enable Breakpoint Function. (Cmd. Id. 0x66)

The anticipation time is the time (measured in Sample Periods) prior to the completion of the preprogrammed motion trajectory. The value is converted by the pcControl board from a number of Sample Periods (Sample Period = 341 microseconds) to the corresponding position during the move. The successful execution of an anticipation time breakpoint function will cause a change of state on the I/O port output bit for the axis selected.

Example of the anticipation breakpoint function:

An I/O port output signal transition is required as an anticipation breakpoint indicator when the motion trajectory is 30 milliseconds from its completion point. The anticipation time multiplier closest to 30 milliseconds is determined by dividing 341 microseconds into 30 milliseconds. This results in a anticipation time multiplier of 0x0058 (hex) or 88 decimal. The multiplier value is sent as the data word for this command. Prior to enabling the breakpoint function with the Enable Breakpoint Function command (Cmd. Id. 0x66), all of the motion trajectory parameters must be loaded for the move that will trigger the breakpoint. When the programmed motion reaches the position corresponding to the desired anticipation time, the corresponding I/O port output bit will change state.

This command will only function with motion trajectory profiles loaded in Position Mode. The anticipation breakpoint function operates with respect to the end of the move regardless of the Operation Mode selected (absolute or relative).

The following is a recommended sequence for utilization of this function: (This assumes a properly initialized and configured pcControl board.)

Note: Be sure that the I/O port bit corresponding to the axis selected has been properly configured as an output port.

Step #1) Load Trajectory
Step #2) Load Anticipation Breakpoint (Cmd. Id. 0x67)
Step #3) Enable Breakpoint Function (Cmd. Id. 0x66)
Step #4) Start Motion (Cmd. Id. 0x61)

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An output transition will occur on the I/O port bit at the programmed anticipation time. Each occurance of a breakpoint will change the state of the output signal level (toggle). If you desire a particular output level transition then you must preset the output bit.

To repeat the anticipation breakpoint function using the same anticipation time, it is not necessary to reload the Anticipation Breakpoint Time. You only have to re-enable the breakpoint function. The sequence is:

Step #1) Load Trajectory
Step #2) Enable Breakpoint Function (Cmd. Id. 0x66)
Step #3) Start Motion (Cmd. Id. 0x61)

Note:

If you attempt to program an anticipation time that would occur prior to the start of motion, then the function will default to a breakpoint 20 quadrature counts after motion start.

In order to maintain the greatest accuracy in calculating the anticipation time breakpoint, care should be taken in the selection of trajectory parameters. The values for acceleration and velocity must remain within the following ranges when using this function:

Velocity $\leq$ 0x007F FFFF

Acceleration $\leq$ 0x0000 FFFF

In addition, if actual motion velocities attained are less than the programmed velocity value, there may be a decrease in the accuracy of the anticipation time breakpoint signal.

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COMMAND NAME: Load Position Reference Offset

COMMAND ID: 68

Command: Load Position Reference Offset

Command ID. Number: 0x68

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 4 Words

Command Packet Configuration:

	0x4?68	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	Most Significant (Upper) Position Offset Word
	0x????	-	Least Significant (Lower) Position Offset Word
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

The value loaded for Position Reference Offset must be within the following range:

$$0xC000\ 0000 \leq \text{Loaded Offset Value} \leq 0x3FFF\ FFFF$$

$$-2^{30} \leq \text{Loaded Offset Value} \leq +(2^{30} - 1)$$

The Load Position Reference Offset command provides the ability to set a user selected offset for motion position and trajectory reference. This command allows you to relocate the zero position by a progammable offset for system specific applications. The pcControl board will maintain this reference offset. If the offset value is not loaded it defaults to zero, and the offset zero coincides with the absolute zero postion.

This command may be used to set a offset zero position at a point other than the absolute zero positon. Typically the absolute zero positon is set at the home switch and/or index position and the offset zero positon is located elsewhere in the system.

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The position reference offset is programmed independently for each axis. The offset value is applied to all absolute positions, including the absolute breakpoint position and read position values. The postion reference offset does not affect relative position values. Anticipation time breakpoints function independent of the position reference offset value. New position reference offset values may be loaded at any time.

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COMMAND NAME: Load Position Scale Factor

COMMAND ID: 69

Command: Load Position Scale Factor

Command ID. Number: 0x69

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 4 Words

Command Packet Configuration:

	0x4?69	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	Scale Factor Numerator Word (0x0001 ≤ Numerator Word ≤ 0xFFFF)
	0x????	-	Scale Factor Denominator Word (0x0001 ≤ Denominator Word ≤ 0xFFFF)
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command when used alone, or in conjunction with the Set Scale Factor Sequence command (Cmd. Id. 0x6A) allows you to enter numerator and denominator values for a position scale factor. This scale factor will be used to scale all position, position breakpoint and read position values. The numerator and denominator loaded by this command must be non-zero, positive integer values. The Set Scale Factor Sequence command (See Cmd. Id. 0x6A) controls the order of execution; either multiply then divide or divide then multiply.

The scale factor has the following format:

$$\text{Scale Factor} = \frac{\text{Numerator Word}}{\text{Denominator Word}}$$

If identical values are loaded for the numerator and denominator, then the value 0x0001 is substituted for both values. If a zero is loaded for either value it is ignored and the existing value remains intact. Both the numerator and denominator scale factors default to 0x0001 at power up.

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The pcControl board calculates all positon values as 32 bit integers. Special care should be taken when chosing scale factor values, to ensure that overflows do not occur during the multiply portion of the scaling and that truncation of fractional results during the divide portion do not adversely affect resolution. In some cases it may be desirable to divide before multipling. The Set Scale Factor Sequence command (Cmd Id. 0x6A) allows you to set the order of operation. Please note that the mathematical precision may be reduced when you divide before multiplying. The correct selection of scaling factors allow you to maintain scaled accuracy within one quadrature count.

Scale factors may be set and changed at any time. Position, breakpoint position and read position values will always reflect the most recent scale factor programmed.

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COMMAND NAME: Set Scale Factor Sequence

COMMAND ID: 6A

Command: Set Scale Factor Sequence (Use In Conjunction With Cmd. Id. 69)

Command ID. Number: 0x6A

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 3 Words

Command Packet Configuration:

	0x3?6A	-	Command Packet ID. Word ? = Axis #1, 2, 3 or 4
	0x????	-	Scale Factor Sequence Control Word
			???? = 0000 Multply First, Then Divide
			???? = FFFF Divide First, Then Multiply
	0x000A	-	Command Packet Terminator Word
or,	0x000D	-	"
or,	0x0020	-	"

Return Data: None

This command when used in conjunction with the Load Position Scale Factor command (Cmd Id. 0x69), allows you to control the order of operation of the scaling function. Depending upon the selection of scale factors, it may be desirable to reverse the order of operation in order to optimize the accuracy of the result.

This command may be issued at any time, but will have no affect unless valid numerator and denominator scale factors have been previously set with the Load Position Scale Factor command (Cmd. Id. 0x69).

The default value for this command at power up is: 0x0000 (multipy first, then divide)

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COMMAND NAME: Set Run / Stop Status Pulse Width

COMMAND ID: 6B

Command: Set Run/Stop Status Pulse Width

Command Id: 0x6B

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 3 Words

Command Packet Configuration:

0x3?6B	-	Command Packet Id. Word ? = Axis #1, 2, 3 or 4
0x????	-	Pulse Width Data Word ???? = Pulse Width in Run/Stop Update Increments.
0x000A 0x000D 0x0020	-	Command Packet Terminator Word

Return Data: None

The Set Run/Stop Status Pulse Width command is used to determine the minimum duration of the "Run" state of the Run/Status indication. (See Cmd. 41 and Cmd. 49.) The Run/Stop status bits will be set to "Run" immediately upon execution of any start command and will remain in the "Run" state for at least this minimum programmed pulse width. At the end of this time, the Run/Stop status bits will revert to their normal mode of determining status by measuring change of position approximately every 20 msec.

The Pulse Width Data Word is an unsigned 16 bit word in multiples of the basic Run/Stop status update rate. For example:

0000 = No minimum pulse width. Run/Stop status is output immediately.

0001 = Run/Stop status is forced high for approximately 20 msec regardless of the true Run/Stop status.

Note: The Run/Stop status bits will indicate "Run" for this minimum pulse width even if the axis does not move, as in the case of a zero move distance.

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COMMAND NAME: Load Rotary Counts

COMMAND ID: 6C

Command: Load Rotary Counts

Command Id: 0x6C

Command Type: Axis Specific (Command Packet ID. Word Contains Axis #.)

Command Packet Size: 4 Words

Command Packet Configuration:

0x4?6C	-	Command Packet Id. Word ? = Axis #1, 2, 3 or 4
0x????	-	Most Significant (Upper) Rotary Count Data Word
0x????	-	Least Significant (Lower) Rotary Count Data Word
0x000A 0x000D 0x0020	-	Command Packet Terminator Word

Return Data: None

The Load Rotary Counts command provides the ability to program the total quadrature counts per revolution or "modulo" for a Rotary axis. If a non-zero Rotary Count value is loaded to an axis, all subsequent Load Target Position commands to that axis will be interpreted modulo the loaded Rotary Counts. The axis will move to the command position by taking the shortest path, either forward or backwards, while remaining within the one revolution defined by the loaded Rotary Counts. Similarly, the value read with the Read Present Position command will be a positive value that is modulo the loaded Rotary Count value.

Rotary Counts is loaded as a quadrature count value and must be within the following range:

$$0x0000\ 0000 \leq \text{Rotary Counts} \leq 0x00FF\ FFFF$$

$$0 \leq \text{Rotary Counts} \leq +(2^{24} - 1)$$

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Upon powerup, the default value for Rotary Counts is zero for all axes. A zero value is specially interpreted and disables the rotary axis functionality. Once a non-zero value is loaded, the pcControl board maintains this Rotary Count value until a new value is loaded or the board is reset. The rotary modulo function on an axis can be disabled at any time by loading a zero value.

This command can be used in conjunction with the user programmed scaling and offset parameters. (See commands 0x68 thru 0x6A) If scaling and offset parameters are used, a loaded target position value is first scaled and then offset prior to being calculated modulo and finally loaded to the pcControl board.

Examples

Position Mode - Absolute

Rotary Counts = 2000 quadrature counts

If the present position is:	530
and the Target Position is:	3600
then the actual move is:	+1070
and the final position is:	1600

Position Mode - Relative

Rotary Counts = 40,000 quadrature counts

If the present position is:	15,000
and the Target Position is:	-30,000 (relative)
then the actual move is: in the forward direction	+10,000 (relative)
and the final position is:	25,000

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5.0 Electrical Specifications

Power Requirements:

+5.0 Volts D.C.	@	1.5 Amps (max.)	±3.0%
+12 Volts D.C.	@	0.1 Amps (max.)	±3.0%
-12 Volts D.C.	@	0.15 Amps (max.)	±3.0%

Power Dissipation: 10 Watts (max.)

Overall Dimensions:

Length	13.3 inches
Height	4.25 inches (includes edge connector.)
Depth	0.6 inches

Input Circuits:
(includes: Limit & Home Switch, Encoder and I/O Port Inputs)

Input Voltage Range: 0 - 15 Volts
TTL and 12 V CMOS compatible

Output Circuits:
(includes: I/O Port and PWM Magnitude and Direction Outputs)

Output Voltage Range: 0 - 5 Volts

Output Current:

Sink:	64 mAmp (max.)
Source:	3.3 kΩ from +5V

Analog Motor Control Output:

Output Voltage Range: ±10.0 Volts (typ.)
±9.5 Volts (min.)

Output Current: ±5.0 mAmps (typ.)
±40 mAmps (short circuit)

Environment:

Temperature Range: 0 to +70 Degrees C.

Relative Humidity Range: 5 to 90% (noncondensing)

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