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VMC-2000

Servo/Stepper Motion Controller

Technical Reference Manual

Part Number: 4004-00-R1-TRF

3870 Del Amo Blvd. Suite 503, Torrance CA, 90503
www.varedan.com

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Revision	Date	Reason
1.0	3/6/03	Original
2.0	4/14/03	Corrected description of 0x0006, 0x0018 commands
3.0	5/15/03	Add programmable Limit and Home switch states
4.0	6/24/03	Minor changes/corrections
5.0	10/24/03	Add commands for Rev 2.
6.0	11/07/03	Add ordering information
6.1	03/10/04	Minor corrections & changes to GP IO commands
7.0	12/1/04	Changes to reflect VMC naming convention
7.1	07/10/05	Driver installation information

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CAUTION! READ THIS BEFORE PROCEEDING.

- This product contains static sensitive devices and requires proper handling with ESD protection.
- Do not connect the motor to the system during initial testing and installation.
- Be sure power is off when inserting or removing this card from a PC.
- This board expects normally open limits. Limits are on by default.

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Introduction

The VMC-2000 Motion Card is designed to provide up to eight axes of independent motion control via analog voltage or step and direction outputs. The Texas Instruments TMS320LF2407 Digital Signal Processor with 32K of RAM powers each axis. This parallel processing architecture allows for simultaneous motion control of all axes. Commands are issued to each axis from a host IBM compatible Personal Computer over the PCI bus interface. This interface to the host PC is via a 32k byte dual port memory (DP memory) mapped into the PC address space.

The Motion Card can execute a variety of user programmable motion profiles, with no under or overshoot at the end points. Limits are continually monitored while moving and will instantly stop motion if enabled. Hardware capture inputs allow position detection using limits, encoder index or home input.

The Motion Card conforms to PCI Specification Revision 2.2 for 3.3 volt signaling environments and the full-length card dimensions with a PCI retainer bracket.

Key Features:

- PCI 2.2 Compliant for the new 3.3 volt signaling environment
- 1 - 8 Axes control per card
- Standard Full Length PCI Card Form Factor
- Step rates from 1 to 2,000,000 steps/sec
- Step rates programmable in steps/sec or timer ticks
- Isolated axis inputs for limits (+/-), home, amp fault, GP I/O
- Isolated axis output for amp enable
- Line driver inputs for encoder (1 set per axis) and GP I/O (3 per axis)
- Two independent DAC outputs for each axis (+/- 20 vdc differential)
- Relative or absolute Indexing ± 2,147,483,648 steps
- Programmable Acceleration Profiles (Parabolic, Linear, S-Shape)
- Built in Homing routines
- Sixteen general purpose isolated I/O
- Built in programmable “Hardware Settling” time delays
- Acceleration times programmable in Milliseconds
- Simple communication with PC via memory mapped interface

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Ordering Information

The following shows the part numbering scheme and options for ordering.

VMC-2400-PCI – 4 axes stepper only version
VMC-2401-PCI – 4 axes servo/stepper version

VMC-2800-PCI – 8 axes stepper only version
VMC-2801-PCI – 8 axes servo/stepper version

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Installation and Operation Overview

The Motion Card requires a single full size PCI slot in the PC chassis. Installation to prepare for use only requires a few steps, which are described in following sections.

- No IRQ is required (the motion card can be configured for 1 IRQ)
- With the computer ***unplugged***, fully insert the card into an empty PCI slot
- At a minimum, connect one of the step and direction outputs to a driver
- Connected the limits and additional I/O to the header connectors
- Power up the PC.

PC Driver Installation

The PC should recognize the new hardware and prompt for installation of the driver. Insert the driver disk supplied with the VMC 2000 board. Use the “Have disk” option and navigate to the root directory on the supplied disk. The file “VMC 2000.INI” should be used for installing the driver. Choose this file and click “OK”. The following files are installed on the computer:

- mfc42.dll
- pcidp.vxd
- pcidp_if.dll

Verify successful installation of the driver by rebooting the computer and navigating to the Device Manager screen from Control Panel (Control Panel->System->Device Manager). There should be a subheading for “Motion Control” with a “VMC 2000 Motion Controller” listed under that subheading. The card is now ready for use.

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Demo Application

A test program is supplied on the driver disk. The file “Varedan PCI Motion Card Demo Application.Exe” is a small program that can be used to verify the operation of the motion controller. The source code for this program is provided as a programming example.

Run the Varedan PCI Motion Card Demo Application program and select the “Configure” menu pull-down. Click the “Reset Card” menu item. All axis led’s on the card should flash when this command is executed. This verifies successful installation of the card.

The remaining menu items allow for testing of the other features of the motion card. A summary is provided below:

Configure->Move Parameters Allows changing the default move parameters for each axis. Enter the desired axis in the “Axis” text box and set the parameters as needed.
Configure->Position Allows setting/getting the axis position information.
Move->Relative Move Sets up and sends a relative move to an axis
Move->Absolute Move Sets up and sends an absolute move to an axis.
DAC’s->Set Voltage Allows setting the DAC output voltage for an axis.

Note: Some commands are not available depending on the configuration of the motion card.

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Connector Pin Outs

The following tables show the pin outs for the 68 pin VHDCI connectors.

Axis 0-1

1	Not Used	Not Used	35
2	Not Used	Not Used	36
3	Gnd	Gnd	37
4	Enc0_A+	Enc0_A-	38
5	Enc0_B+	Enc0_B-	39
6	Enc0_I+	Enc0_I-	40
7	Home0_IN	5V_OUT	41
8	Pos_Lim0_IN	Gnd	42
9	Neg_Lim0_IN	HomeLim0_Rtn	43
10	Cmd_Dac_OUT_0+	Cmd_Dac_OUT_0-	44
11	Aux_Dac_OUT_0+	Aux_Dac_OUT_0-	45
12	Amp_Flt0_IN	Amp_Flt0_Rtn	46
13	Amp_En0_Collector	Amp_En0_Emitter	47
14	UserIO_A0	UserIO_A0_Rtn	48
15	XcvroA+	Xcvr0A-	49
16	XcvroB+	Xcvr0B-	50
17	XcvroC+	Xcvr0C-	51
18	Enc1_A+	Enc1_A-	52
19	Enc1_B+	Enc1_B-	53
20	Enc1_I+	Enc1_I-	54
21	Home1_IN	5V_OUT	55
22	Pos_Lim1_IN	Gnd	56
23	Neg_Lim1_IN	HomeLim1_Rtn	57
24	Cmd_Dac_OUT_1+	Cmd_Dac_OUT_1-	58
25	Aux_Dac_OUT_1+	Aux_Dac_OUT_1-	59
26	Amp_Flt1_IN	Amp_Flt1_Rtn	60
27	Amp_En1_Collector	Amp_En1_Emitter	61
28	Gnd	Gnd	62
29	Xcvr1A+	Xcvr1A-	63
30	Xcvr1B+	Xcvr1B-	64
31	Xcvr1C+	Xcvr1C-	65
32	UserIO_A1	UserIO_A1_Rtn	66
33	RESET_IN*	UserIO_A2	67
34	ESTOP_IN*	UserIO_A2_Rtn	68

Axis 2-3

1	Not Used	Not Used	35
2	Not Used	Not Used	36
3	Not Used	Not Used	37
4	Enc2_A+	Enc2_A-	38
5	Enc2_B+	Enc2_B-	39
6	Enc2_I+	Enc2_I-	40
7	Home2_IN	5V_OUT	41
8	Pos_Lim2_IN	Gnd	42
9	Neg_Lim2_IN	HomeLim2_Rtn	43
10	Cmd_Dac_OUT_2	Cmd_Dac_OUT_2-	44
11	Aux_Dac_OUT_2	Aux_Dac_OUT_2-	45
12	Amp_Flt2_IN	Amp_Flt2_Rtn	46
13	Amp_En2_Collector	Amp_En2_Emitter	47
14	UserIO_A3	UserIO_A3_Rtn	48
15	Xcvr2A+	Xcvr2A-	49
16	Xcvr2B+	Xcvr2B-	50
17	Xcvr2C+	Xcvr2C-	51
18	Enc3_A+	Enc3_A-	52
19	Enc3_B+	Enc3_B-	53
20	Enc3_I+	Enc3_I-	54
21	Home3_IN	5V_OUT	55
22	Pos_Lim3_IN	Gnd	56
23	Neg_Lim3_IN	HomeLim3_Rtn	57
24	Cmd_Dac_OUT_3	Cmd_Dac_OUT_3-	58
25	Aux_Dac_OUT_3	Aux_Dac_OUT_3-	59
26	Amp_Flt3_IN	Amp_Flt3_Rtn	60
27	Amp_En3_Collector	Amp_En3_Emitter	61
28	Gnd	Gnd	62
29	Xcvr3A+	Xcvr3A-	63
30	Xcvr3B+	Xcvr3B-	64
31	Xcvr3C+	Xcvr3C-	65
32	Gnd	AGnd	66
33	Not Used	Not Used	67
34	Not Used	Not Used	68

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Connector Pin Outs (Cont.)

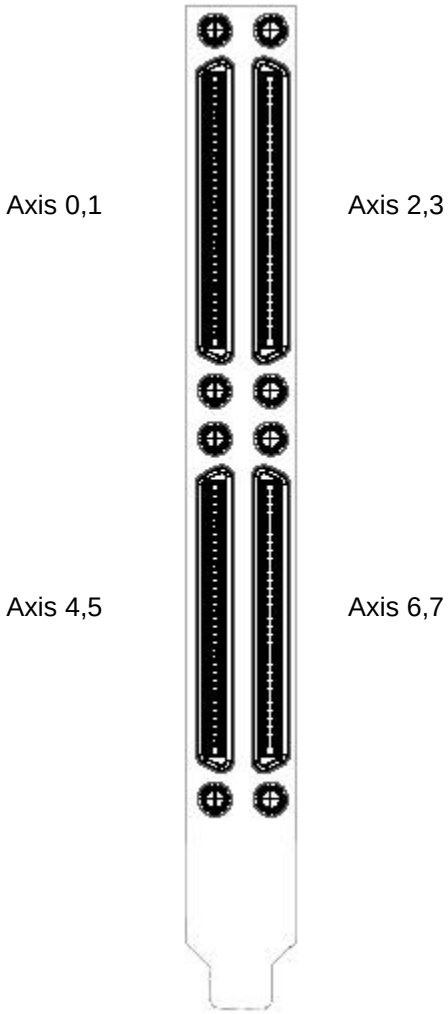
	Axis 4-5		
1	UserIO_B0	UserIO_B0_Rtn	35
2	UserIO_B1	UserIO_B1_Rtn	36
3	Gnd	Gnd	37
4	Enc4_A+	Enc4_A-	38
5	Enc4_B+	Enc4_B-	39
6	Enc4_I+	Enc4_I-	40
7	Home4_IN	5V_OUT	41
8	Pos_Lim4_IN	Gnd	42
9	Neg_Lim4_IN	HomeLim4_Rtn	43
10	Cmd_Dac_OUT_4	Cmd_Dac_OUT_4-	44
11	Aux_Dac_OUT_4	Aux_Dac_OUT_4-	45
12	Amp_Flt4_IN	Amp_Flt4_Rtn	46
13	Amp_En4_Collector	Amp_En4_Emitter	47
14	UserIO_B2	UserIO_B2_Rtn	48
15	Xcvr4A+	Xcvr4A-	49
16	Xcvr4B+	Xcvr4B-	50
17	Xcvr4C+	Xcvr4C-	51
18	Enc5_A+	Enc5_A-	52
19	Enc5_B+	Enc5_B-	53
20	Enc5_I+	Enc5_I-	54
21	Home5_IN	5V_OUT_2	55
22	Pos_Lim5_IN	Gnd	56
23	Neg_Lim5_IN	HomeLim5_Rtn	57
24	Cmd_Dac_OUT_5+	Cmd_Dac_OUT_5-	58
25	Aux_Dac_OUT_5+	Aux_Dac_OUT_5-	59
26	Amp_Flt5_IN	Amp_Flt5_Rtn	60
27	Amp_En5_Collector	Amp_En5_Emitter	61
28	Gnd	Gnd	62
29	Xcvr5A+	Xcvr5A-	63
30	Xcvr5B+	Xcvr5B-	64
31	Xcvr5C+	Xcvr5C-	65
32	GndA	AGnd	66
33	Not Used	Not Used	67
34	Not Used	Not Used	68

	Axis 6-7		
1	Not Used	Not Used	35
2	Not Used	Not Used	36
3	Gnd	Gnd	37
4	Enc6_A+	Enc6_A-	38
5	Enc6_B+	Enc6_B-	39
6	Enc6_I+	Enc6_I-	40
7	Home6_IN	5V_OUT	41
8	Pos_Lim6_IN	Gnd	42
9	Neg_Lim6_IN	HomeLim6_Rtn	43
10	Cmd_Dac_OUT_6+	Cmd_Dac_OUT_6-	44
11	Aux_Dac_OUT_6+	Aux_Dac_OUT_6-	45
12	Amp_Flt6_IN	Amp_Flt6_Rtn	46
13	Amp_En6_Collector	Amp_En6_Emitter	47
14	UserIO_B3	UserIO_B3_Rtn	48
15	Xcvr6A+	Xcvr6A-	49
16	Xcvr6B+	Xcvr6B-	50
17	Xcvr6C+	Xcvr6C-	51
18	Enc7_A+	Enc7_A-	52
19	Enc7_B+	Enc7_B-	53
20	Enc7_I+	Enc7_I-	54
21	Home7_IN	5V_OUT	55
22	Pos_Lim7_IN	Gnd	56
23	Neg_Lim7_IN	HomeLim7_Rtn	57
24	Cmd_Dac_OUT_7+	Cmd_Dac_OUT_7-	58
25	Aux_Dac_OUT_7+	Aux_Dac_OUT_7-	59
26	Amp_Flt7_IN	Amp_Flt7_Rtn	60
27	Amp_En7_Collector	Amp_En7_Emitter	61
28	Gnd	Gnd	62
29	Xcvr7A+	Xcvr7A-	63
30	Xcvr7B+	Xcvr7B-	64
31	Xcvr7C+	Xcvr7C-	65
32	Not Used	Not Used	66
33	Not Used	Not Used	67
34	Not Used	Not Used	68

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Connector Locations

The following drawing shows the end view of the board with the right angle of the mounting bracket at the top.



The connectors used on the board are 68 pin VHDCI manufactured by Molex and Honda. The mating connector part numbers are shown below:

Molex – 71425
Honda – HDRA-E68MA1

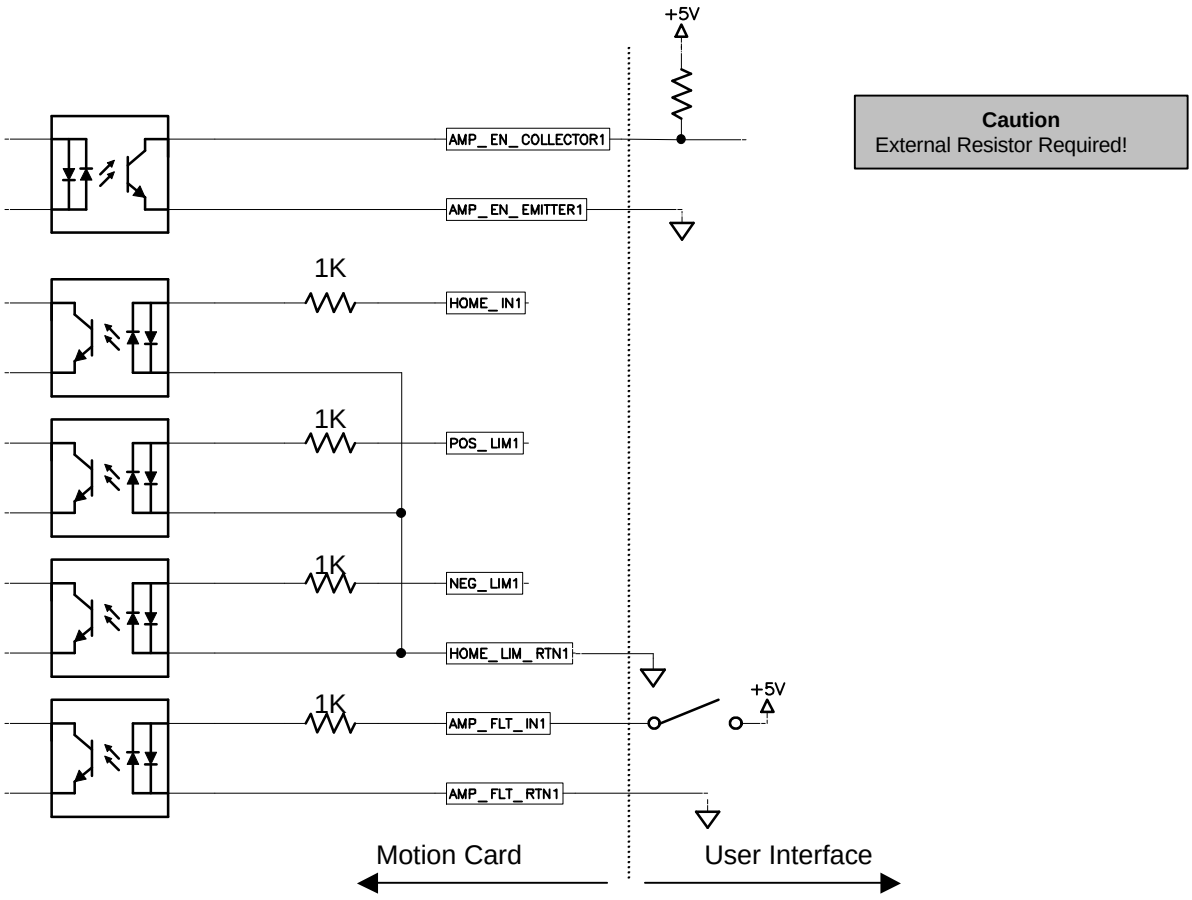
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Motion Board I/O

Dedicated I/O Connections

The following diagrams show the typical circuitry for the dedicated inputs and outputs. The circuitry is designed to be used with 5 vdc external logic. Do not attempt to connect higher voltages as this will cause permanent damage to the Motion Board. Home and Limit inputs can be directly wired to an external switch and power as the current limiting resistors are internal to the Motion Card. See the section on ESTOP and Reset for wiring examples.

Note that an external pull up or pull down resistor is required for the Amp Enable output. A 2.2k ohm resistor is recommended for 5vdc operation.

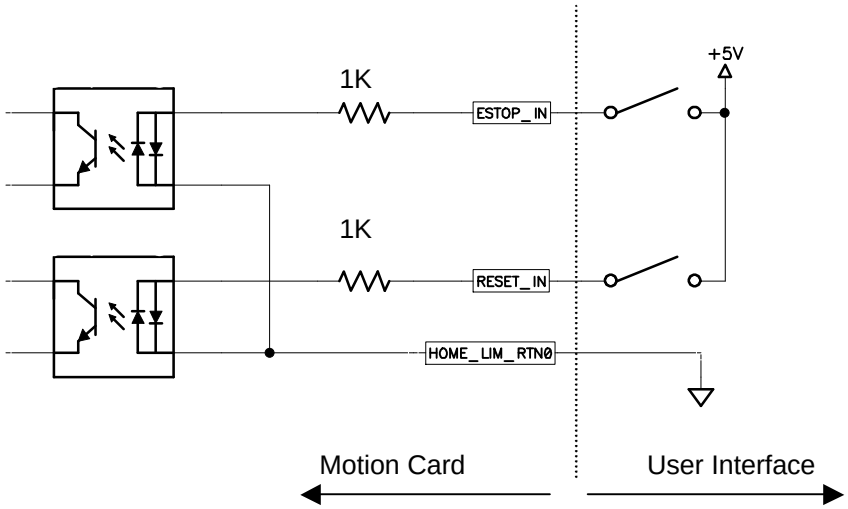


CAUTION:
This circuitry is designed to be used with 5 vdc external logic. Do not attempt to connect higher voltages, as this will cause permanent damage to the Motion Board.

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ESTOP & Reset

The ESTOP and Reset inputs are similar to the Home and Limit inputs. The common for these inputs is the Home Return 0 connection. These inputs can be directly wired to an external switch and power as the current limiting resistors are internal to the Motion Card.

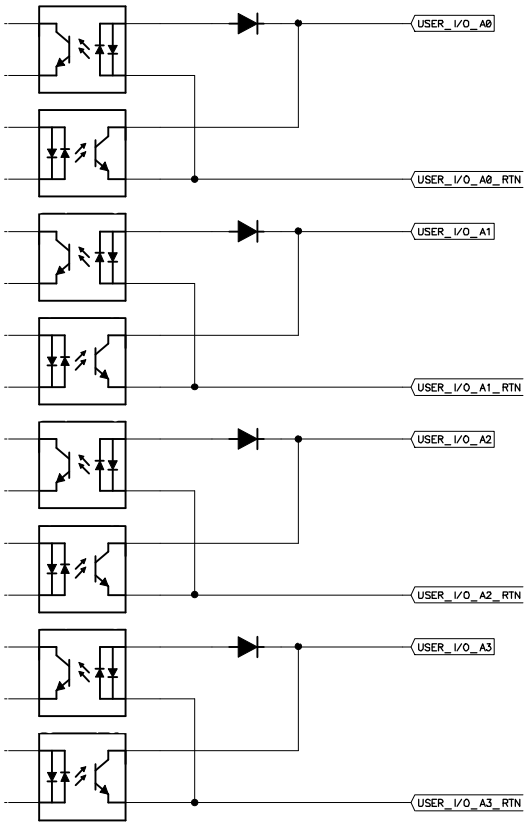


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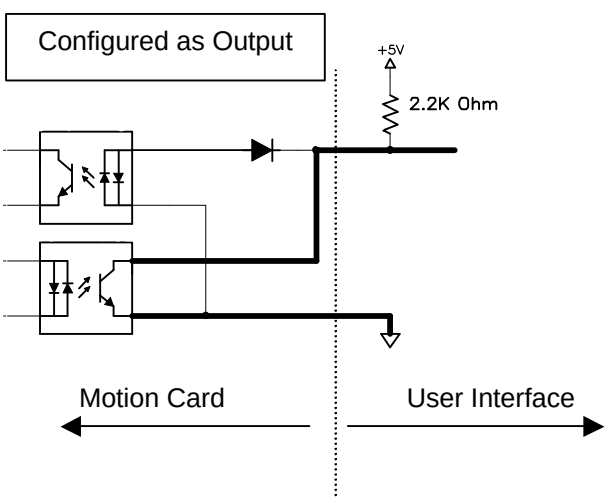
User I/O Connections A0-A3, B0-B3

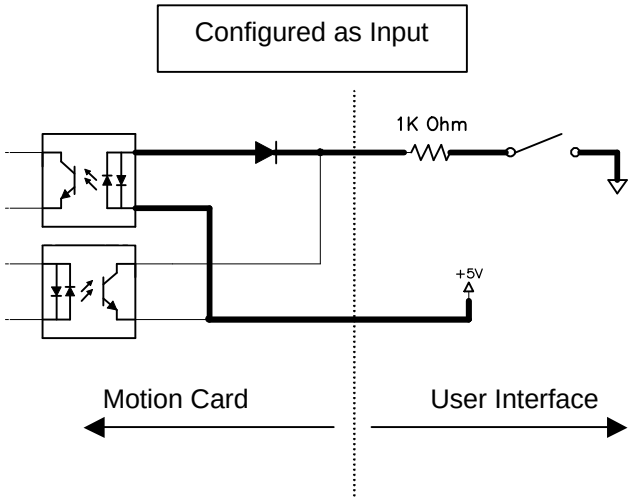
The following drawing shows the typical user I/O circuitry for A0-A3. Connections for B0-B3 are identical. Each pin can be configured as either an input or an output, but not both.

Note that external resistors are required to limit current when used as either an input or output. When used as an output, a pull up or pull down of 2.2K Ohm is recommended. When used as an input, a 1K Ohm series current limiting resistor is recommended.



Caution
External Resistors Required!
See Examples Below.





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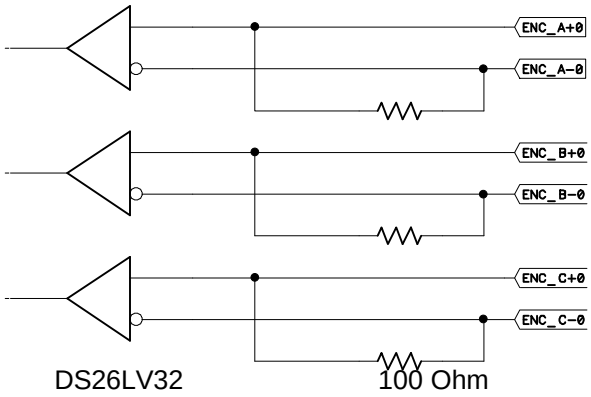
Encoder Connection

The Motion board can accept either single ended or differential encoders. A 100-ohm termination resistor is installed across each differential input

Encoder inputs for axis 0 are shown for clarity. The encoder circuitry for the remaining axes is identical.

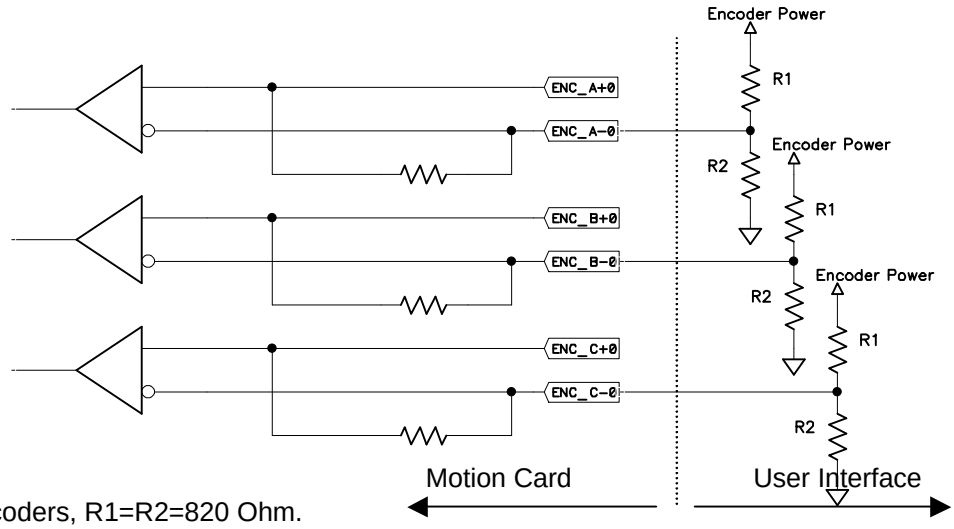
Differential Encoder Connection

When using a differential encoder with the motion card, the encoder outputs can be directly connected to the motion card inputs as shown below. Termination resistors are provided on the motion card for each channel as shown below.



Single Ended Encoder Connection

When using an encoder with single ended outputs, an external resistor network must be provided as shown below. The resistor values depend on the output drive capability of the encoder.



For 5 volt encoders, R1=R2=820 Ohm.
For 3.3 volt encoders, R1=620, R2=330 Ohm.

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Encoder Enable/Disable Operation

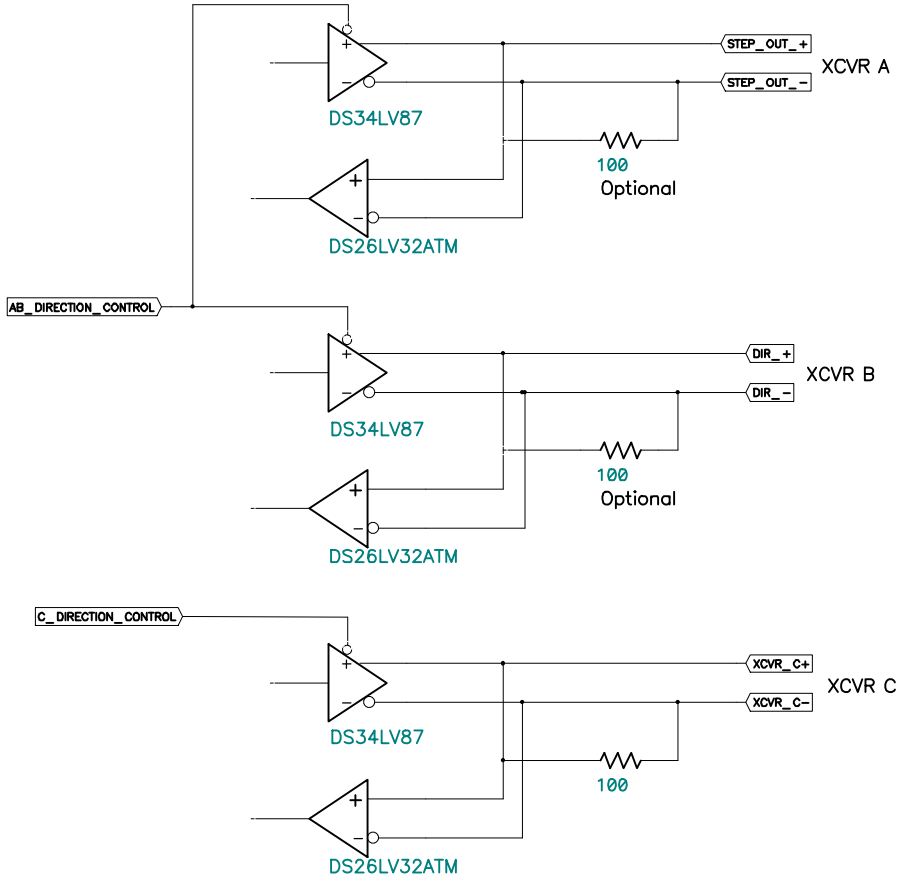
The Encoder Status command (0x0001) enables or disables encoder feedback. When encoder feedback is enabled, all position reporting commands return the encoder position data. When encoder feedback is disabled, all position reporting commands return command position data in place of encoder position data.

XCVR Input / Output Signals

Each of the axes on the board has 3 differential transceiver channels labeled XCVR A, XCVR B and XCVR C. XCVR A and XVCR B outputs are dedicated to the step and direction signals for the axis. XCVR A and B inputs are general purpose (if the outputs are not used for step and direction). XCVR C is a general-purpose input / output channel.

The following drawing shows the connections for the XCVR input/output circuitry. The direction control bit enables or disables the output drivers. The XCVR direction control commands 0x0019 and 0x001D are used to enable or disable the outputs. Writing a “1” using these commands enables the output drivers. A “0” disables the output drivers and allows the inputs to be read.

There are optional 100 ohm termination resistors for each XCVR channel. These can be populated at the factory.



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Digital To Analog Converter Output Signals

The VMC-2000 motion card has 2 differential Digital to Analog Converters (DAC's) per axis, for a total of 16 DAC channels. Each axis has a Command DAC output and an Auxiliary DAC output. The voltage on these outputs is set via software and can range from +10 vdc to –10 vdc with respect to ground. Each DAC is controlled by writing a 16-bit word to the VMC-2000 using either the Set Command DAC (0x0002) command or Set Auxiliary DAC (0x0003) command.

LED Indicators

The motion card has one LED to indicate power is present on the board. There are also 8 axis LED's, one for each of the 8 channels. These LED's flash once following a reset and will stay on constant if an internal fault is found on an axis. If there are no axis faults, each LED will turn on during motion and turn off when motion is complete.

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PCI Interface

The motion card is memory mapped into the PC address space by the BIOS enumerator following a reset to the PC. Windows software may also re-map the card as required. The following addresses are offset from the base address assigned by the operating system.

PCI Configuration Space

PCI Configuration Space				
31 16		15 0		Address, Byte Offset
Device ID, *RO*		Vendor ID, *RO*		0x00
Status, *CS*		Command, *CS*		0x04
Class Code, *RO*			Revision ID, *RO*	0x08
BIST (not used) 0x00	Header Type 0x00	Latency Timer, *RW*	Cache Line Size, *RW*	0x0C
Base Address Register #0 -- 32KBytes Memory Space, *RW*				0x10
Base Address Register #1 -- 8 Bytes I/O Space, *RW*				0x14
Base Address Register #2 (not used) 0x0000				0x18
Base Address Register #3 (not used) 0x0000				0x1C
Base Address Register #4 (not used) 0x0000				0x20
Base Address Register #5 (not used) 0x0000				0x24
Cardbus CIS Pointer, *RO*				0x28
Subsystem Device ID, *RO*		Subsystem Vendor ID, *RO*		0x2C
Expansion ROM Base Address (not used) 0x0000				0x30
Reserved 0x0000				0x34
Reserved 0x0000				0x38
MAX_LAT, RO	MIN_GNT, RO	Interrupt Pin, RO	Interrupt Line, RW	0x3C

Before any communication with the card can start, the host software must perform an initialization of the Windows driver and obtain the base address of the card. This can be done using the provided software interface routines. See the appendix for information on the software interface to the supplied software driver routines.

NOTE: All commands to the card are written to memory locations that are offsets from the base address (BAR).

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Dual Port Address Map

The following table lists the important dual port (DP) RAM addresses on the motion card. Most registers in the DP RAM are initialized automatically on power up to the card from values stored in a local EEPROM.

Memory Contents	Address [14:0], Byte Offset	Size
I_2O Specific Registers	0x0000 - 0x03FF	1 KB
Operations Registers	0x0400 - 0x07FF	1 KB
reserved	0x0800 - 0x1FFF	6 KB
Direct Access to PCI Bus (this is a window into PCI space; this window is only available to the Local bus)	0x2000 - 0x3FFF	8 KB
Shared Memory	0x4000 - 0x7FFF	16 KB

Address Map Details

Address (offset from BAR)	Size	Function	Write/Read
0x04E0	32 bits	Host Control Register	
0x04E4	32 bits	Host Interrupt Control and Status	
0x04E8	32 bits	Host to Local Data Mailbox	
0x04F4	32 bits	Local Interrupt Control and Status	
0x04F8	32 bits	Local to Host Data Mailbox	
0x4000	16 bits	Opcode/Parameter1	
0x4002	16 bits	Operand 1/Parameter 2	
0x4004	16 bits	Operand 2/Parameter 3	
0x4006	16 bits	Operand 3/Parameter 4	
0x4008	16 bits	Operand 3	
0x400A-0x7FFF		Not used	

The following paragraphs show the details of each of the addresses shown above.

NOTE: All addresses shown are offsets from the base address register (BAR).

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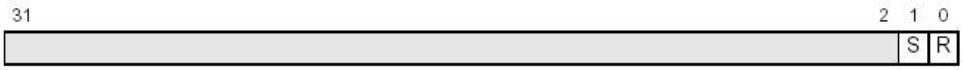
0x4E0 Host Control Register (HCTL)

Type: Read/Write Size:32 bit DWORD

The Host Control Register contains bits that control the reset of the local DSP's and the Dual Port chip. Typically only the Local Processor Reset bit (0) is used. The Soft Reset bit 1 should be left at 0.

To reset the DSP's on the board (local processors), bit 0 of this word is set to 1 then set to 0. All 8 DSP's will assume a power on condition following a reset.

Host Control Register – HCTL0x04E0



Bit	Description
1 -- S	**Soft Reset** – This bit controls the internal reset for the CY7C09449PV. 1 = reset active 0 = not reset (default)
0 -- R	**Local Processor Reset** – This bit controls the $\overline{\text{RSTOUTD}}$ and RSTOUTD pins. 1 = reset active (default state, $\overline{\text{RSTOUTD}}$ pin is LOW, RSTOUTD pin is HIGH) 0 = not reset ($\overline{\text{RSTOUTD}}$ pin is HIGH, RSTOUTD pin is LOW)

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0x4E4 Host Processor Interrupt Control and Status (HINT)

Type: Read/Write Size:32 bit DWORD

The HINT register is used to configure the interrupt for the Host processor from the local DSP's. Bit 19 is used to enable the interrupt to the Host. This bit should be set to 1 by the Host upon initialization.

Bit 3 is set when the local DSP's write to the Local to Host Mailbox register, 0x4F8. Writing a "1" to Bit 3 will clear this bit for the interrupt sequence. The Host can poll bit 3 to determine when the command sequence has completed and the result code can be read fro LHDATA 0x4F8.

The VMC-2000 can generate an interrupt to the host when Bit 3 is set. All that needs to be done for the interrupt to occur is to set the INTA enable bit in the EEPROM setup. The host will need to provide the interrupt handler code to service the interrupt. Note that if the INTA bit is set in the EEPROM map, an interrupt method must be used since Bit 3 polling will not work.

If interrupts are used, be sure the PCI enumerator at boot up configures the VMC-2000 for a unique interrupt. If the interrupt is shared with another device, that device's interrupt handler may try to service the Local to Host interrupt event.

Upon initialization of the host software and whenever a command sequence has competed, a 0x008008 should be written to HINT. This will enable the interrupt to Host and clear any prior pending interrupts.

Host Interrupt Control and Status Register – HINT0x04E4



Bit	Description
25:16 Interrupt Enable	Interrupt Enables 0000000000 =no interrupts are enabled (default) xxxxxxxx1 =I_2O Local FIFO overflow interrupt enabled xxxxxxx1x =I_2O PCI FIFO overflow interrupt enabled xxxxxx1xx =reserved - always read as 0 xxxxx1xxx =Local to host, mailbox interrupt enabled xxxx1xxxx =Local to host, external signal interrupt enabled xxx1xxxxx =DMA complete interrupt enabled xx1xxxxxx =I_2O inbound post FIFO not empty interrupt enabled x1xxxxxxx =I_2O outbound post FIFO not empty interrupt enabled 1xxxxxxxx =PCI target abort interrupt enabled Note: All enable bits are initially cleared.
9:0 Interrupt Status	Interrupt Event Status 0000000000 = no events active xxxxxxxx1 =I_2O Local FIFO overflow xxxxxxx1x =I_2O PCI FIFO overflow xxxxxx1xx =reserved - always read as 0 xxxxx1xxx =Local to host mailbox xxxx1xxxx =Local to host external signal interrupt xxx1xxxxx =DMA complete xx1xxxxxx =I_2O inbound post FIFO not empty (mirror of I2OLISR[3] - read only at this address) x1xxxxxxx = I_2O outbound post FIFO not empty (mirror of I2OHISR[3] - read only at this address) 1xxxxxxxx = PCI target abort Note: When an event status bit is active, writing a '1' to that bit location will clear the bit except for bits 6 and 7. All event status bits are initially cleared.

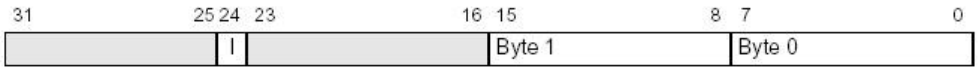
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0x4E8 Host to Local Mailbox (HLDATA)

Type: Read/Write Size:32 bit DWORD

The HLDATA register is use to communicate a new command to the motion card. Bit 24 of this double word controls the interrupt to the local DSP's. Bits 0-7 of this DWORD are set to the axis number for the command (0-7). Following a write of new command data to the DPRAM area at 0x4000-0x4007, the host writes the address of the axis into bits 0-7 (valid values are 0-7). When the host sets bit 24 of this DWORD an interrupt is generated at the local DSP level. When the local DSP's receive this interrupt, they each read the low byte of this DWORD and compare the axis number to their own axis id. If a match is found, that DSP reads the command data from locations 0x4000-0x4007 and executes the command. The rest of the bits in this DWORD are don't cares. Bit 24 is write only.

Host to Local Data Mailbox – HLDATA0x04E8



Bit	Description
24 -- I	Interrupt to Local This bit enables the host to send an interrupt to the Local. When it is set to 1 by the host, it triggers a mailbox interrupt to the local processor. The interrupt remains active until it is cleared by writing to the Local Interrupt Control and Status Register - LINT. 0 = inactive 1 = active This bit is write only.
15:8 -- Byte 1 7:0 -- Byte 0	Data byte Two bytes of data that can be written by the host and read by the local processor.

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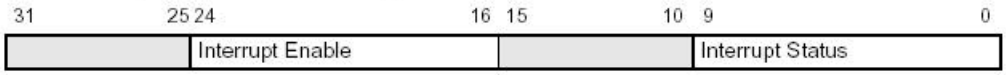
0x4F4 Local Processor Interrupt Control and Status (LINT)

Type: Read/Write Size:32 bit DWORD

The LINT register is use to configure the interrupt for the local DSP's. Bit 19 is used to enable the interrupt to the DSP's. Bit 3 is used to signal the interrupt. Writing a "1" to Bit 3 will clear this bit to enable the DSP's to begin reading commands. Writing to Bit 3 should only be done during initialization and should not be necessary during normal operation.

Upon initialization of the Host software, a 0x008008 should be written to LINT. This will enable the interrupt to the local DSP's and clear any prior pending interrupts.

Local Interrupt Control and Status Register – LINT0x04F4



Bit	Description
25:16 Interrupt Enable	Interrupt Enables 0000000000 = no interrupts are enabled (default) xxxxxx xxx1 = I_2O Local FIFO overflow interrupt enabled xx xxxx xx1x = I_2O PCI FIFO overflow interrupt enabled xx xxxx x1xx = reserved - always read as 0 xx xxxx 1xxx = Host to Local mailbox interrupt enabled xx xxx1 xxxx = reserved - always read as 0 xx xx1x xxxx = DMA complete interrupt enabled xx x1xx xxxx = I_2O inbound post FIFO not empty interrupt enabled xx 1xxx xxxx = I_2O outbound post FIFO not empty interrupt enabled x1 xxxx xxxx = PCI target abort interrupt enabled 1x xxxx xxxx = PCI master abort interrupt enabled **Note:** All enable bits are initially cleared.
9:0 Interrupt Status	Interrupt Event Status 00 0000 0000 = no events active xx xxxx xxx1 = I_2O Local FIFO overflow xx xxxx xx1x = I_2O PCI FIFO overflow xx xxxx x1xx = reserved - always read as 0 xx xxxx 1xxx = Host to Local mailbox xx xxx1 xxxx = reserved - always read as 0 xx xx1x xxxx = DMA operation complete xx x1xx xxxx = I_2O inbound post FIFO not empty (mirror of I2OLISR[3] - read only at this address) xx 1xxx xxxx = I_2O outbound post FIFO not empty (mirror of I2OHISR[3] - read only at this address) x1 xxxx xxxx = PCI target abort 1x xxxx xxxx = PCI master abort **Note:** When an event status bit is active, writing a '1' to that bit location will clear the bit except for bits 6 and 7. All event status bits are initially cleared.

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0x4F8 Local to Host Mailbox (LHDATA)

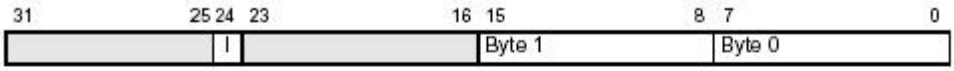
Type: Read/Write Size:32 bit DWORD

The LHDATA register is use to signal an interrupt to the Host by the local DSP's when they are ready for the next command. Bits 0-7 of this DWORD contain the result code for the command, 0 if OK, 1 if failed.

The local DSP's set Bit 24 of this DWORD when a command has been processed. When Bit 24 is set, the Local to Host interrupt register 0x4E4 can signal an interrupt to the Host, or the Host can poll bit 3 of 0x4E4 to know when to proceed with a new command.

The rest of the bits in this DWORD are don't cares. Bit 24 is write only. The Host should not read from this DWORD until the interrupt is received on bit 3 of 0x4E4 (HINT).

Local to Host Data Mailbox – LHDATA0x04F8



Bit	Description
24 -- I	Interrupt to Host When this bit is written to 1 by the local processor, it causes a mailbox interrupt to the host. The interrupt will remain active until it is cleared by the host in the Host Interrupt Control and Status Register - HINT 0 = inactive 1 = active This bit is write only.
15:8 -- Byte 1 7:0 -- Byte 0	Data bytes Two bytes of data written by the local and read by the host processor.

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0x4000 Opcode/Parameter1

Type: Read/Write Size:16 bit WORD
This location is used for the Opcode when sending commands to the motion card. The 16 bit Opcode value is written to this location before loading the HLDATA register. When requesting data from the motion card, the first 16 bits of data will be returned in this location.

0x4002 Operand1/Parameter2

Type: Read/Write Size:16 bit WORD
This location is used for the first word of operand data associated with any command being written to the motion card. When requesting data from the motion card, the second group of16 bits of data will be returned in this word.

0x4004 Operand2/Parameter3

Type: Read/Write Size:16 bit WORD
This location is used for the second word of operand data associated with any command being written to the motion card. When requesting data from the motion card, the third group of 16 bits of data will be returned in this word.

0x4006 Operand3/Parameter4

Type: Read/Write Size:16 bit WORD
This location is used for the third word of operand data associated with any command being written to the motion card. When requesting data from the motion card, the fourth group of 16 bits of data will be returned in this word.

0x4008 Operand4

Type: Read/Write Size:16 bit WORD
This location is used for the fourth word of operand data associated with any command being written to the motion card.

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Sending data from the PC to the Motion Card

When communicating from the PC Host to the Motion Card the following convention should always be followed. The Opcode is loaded into location 0x4000. The operand data is loaded next, always loaded LOW byte first starting at location 0x4002.

		Operand # 1	2	3	4
Address	->	0x4002	0x4004	0x4006	0x4008
4 words to send	->	word0, word1, word2, word 3			
3 words to send	->	word0, word1, word2			
2 words to send	->	word0, word1			
1 word to send	->	word0			

Note that some commands do not require any operand data.
Negative values are represented in 2's complement format.

Command Sequence

Sending Commands to axis (n) is done in the following sequence

1. Verify motion card is ready. (LINT bit3 =0 and HINT bit 3 =0)
2. Write the Command Opcode to 0x4000
3. Write command parameter(s) if any to 0x4002-0x4008
4. Write the Axis ID to bits 0-7 and set bit 24 of HLDATA
5. Poll/Read HINT for bit 3=1 (or wait for interrupt event)
6. Read LHDATA for result code.
7. Write 0x008008 to HINT to clear the interrupt
8. Read any result data if required

Receiving data from the Motion Card

The Motion Card will only send data when requested to do so. The communications follow the following convention: The PC Host requests data via a command as described above and waits for LINT bit 3 (Ready) to go low. The PC can then read the data starting at 0x4000 and progressing for as many words as requested. This process prevents both sides (host and DSP's) from accessing the memory at the same time. The Host PC can then reconstruct the full data as follows.

		Parameter # 1	2	3	4
Address	->	0x4000	0x4002	0x4004	0x4006
4 words to get	->	word0, word1, word2, word 3			
3 words to get	->	word0, word1, word2			
2 words to get	->	word0, word1			
1 word to get	->	word0			

Negative values are represented in 2's complement format.

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Special Data Format for Velocity

The following commands use a special format when communicating velocity information between the PC Host and Motion Card. These commands specify velocity as 10MHz clock ticks. This format is used to free the Motion Card from doing the long division, which would otherwise be required for the conversion.

0x0037H	- Set Slew Speed
0x0038H	- Move Constant Velocity Positive
0x0039H	- Move Constant Velocity Minus
0x0043H	- Homing, Set move to limit speed
0x0061H	- Dump next byte from acceleration ramp table

The conversion is done in the following way.

Velocity Ticks (10 MHz ticks) = 10,000,000 / Velocity(Steps/Sec);

Example:

200,000 Steps/Sec converted to 10MHz clock ticks

10,000,000 / 200,000(Steps/Sec) = 50 (10MHz clock ticks)

*A Special form of this speed is 0 Steps/Sec, this is specified by using 0xFFFFFFH. This form, 3 bytes of FF, is interpreted as 0 Steps/Sec.

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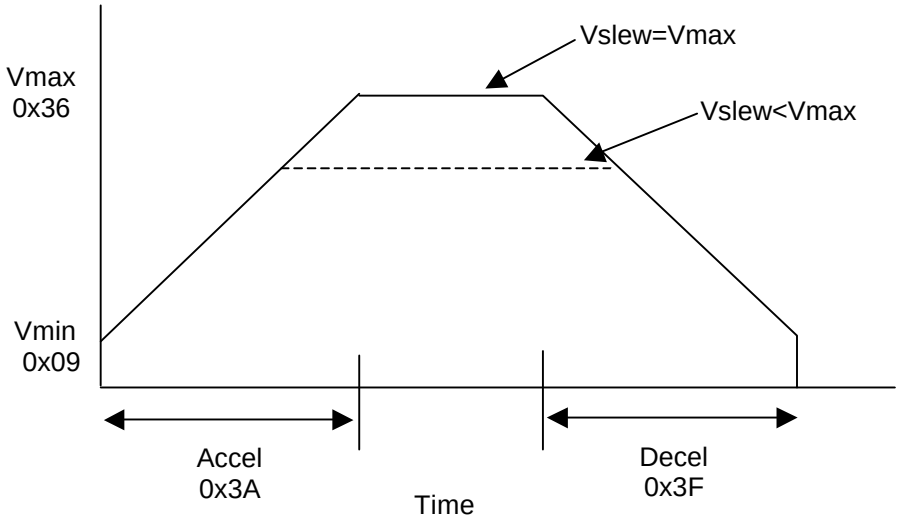
Move Profile Information

Before a move is commanded, the parameters that control the ramp profile should be configured and a ramp generated. The values that control the ramp profile are shown below. When a move is commanded, the step clock output frequency will begin at Vmin (0x09) and ramp to Vslew (0x37) (distance permitting) using a 50% duty cycle. If the move distance is not long enough to reach Vslew, a triangular shaped move will result where the accel and decel portions of the move profile are equal in time.

Move Profile Parameters	Command
Vmin	0x0009
Vmax	0x0036
Vslew	0x0037
Accel Time	0x003A
Decel Time	0x003F
Ramp Type	0x0030, 0x0031, 0x0032

When creating a ramp profile, the motion card uses Vmin, Vmax, Accel Time, Decel Time and Ramp Type to create a lookup table of velocity values in memory. When a move is commanded, the velocities for the ramp are read from this table. If the value for Vslew (0x37) is less than Vmax (0x36), the output clock will only ramp to the specified Vslew value using the slope of the ramp in the lookup table. If the value for Vslew is greater than Vmax, the output clock will ramp up to Vmax then a step change will occur to Vslew (without a ramp). This can cause the motor to stall if care is not taken in selecting Vslew. For most applications, set Vslew <= Vmax.

This move shows two examples, one with Vslew=Vmax and one with Vslew<Vmax to show the effect on the profile. Note how the ramp is cut off at Vslew in the case where Vslew<Vmax.



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Move Handshake Information

When any move is commanded by the host, the motion card sets the MOVING bit in the status register for the commanded axis *before* the READY bit is released. This allows the host to immediately begin polling the MOVING bit after READY is de-asserted to determine when motion completes. Command 0x001E allows reading of the status bits. See the command description in the next section.

The VMC-2000 always sets MOVING before returning control back to the host via the Local to Host interrupt or bit methods.

Home & Limit Switch Actions

The Motion Card can be configured to perform various actions when the Home and Limit switch inputs are active. Using commands 0x001F through 0x0024, the host can set and view the different configurations.

The programmable options for each switch are as follows:

None – No action occurs when the switch is active
Abort – The clock will be shut off and no deceleration occurs.
Stop – The motor will stop using the programmed accel/decel rate

The active state of each switch can also be programmed.

Motor Events

When a motor is stopped due to a Home or Limit Switch action, a value is loaded into Motor Event to indicate the source of the event. Motor Event can be read using the 0x0026 command. Values returned for Motor Event are as follows:

None – 0 – No event has occurred. This is set at the start of a move.
Amp Fault – 1 – Motor stopped due to an Amp Fault input.
Home – 2 – Motor stopped due to the Home input.
Negative Limit Switch – 4 – Motor stopped due to Limit – input.
Positive Limit Switch – 5 – Motor stopped due to Limit + input.
Encoder Fault – 8 – Motor stopped due to Encoder wiring fault.

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Command Reference

Caution
Do not use any commands other than what are listed here.

Command: 0x0000H - Abort Move
Data: None
Result: None

Description: This command will stop ALL motion. This should be used with care as it will stop the motion without deceleration. This sudden stop can cause the axis to lose position.

Command: 0x0001H - Set Encoder Status
Data: 0 (default, disable encoders) or 1 (enable encoders)
Result: None

Description: This command sets the encoder enable status. When encoders are enabled (1), all position reporting uses the encoder position counter. When encoders are disabled, position reporting substitutes command position for encoder position. The default setting is disabled (0).

Command: 0x0002H - Command DAC Output
Data: 0-65535
Result: None

Description: This command sets the value for the Command DAC output. The 16-bit data value linearly represents voltage output from the DAC *with respect to ground* as follows:

DAC Output	Data
-10 Vdc	0000H
0 Vdc	8000H
+10 Vdc	FFFFH

Command: 0x0003H - Auxiliary DAC Output
Data: 0-65535
Result: None

Description: This command sets the value for the Auxiliary DAC output. The 16-bit data value linearly represents voltage output from the DAC *with respect to ground* as follows:

DAC Output	Data
-10 Vdc	0000H
0 Vdc	8000H
+10 Vdc	FFFFH

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Command: 0x0004H - Get DAC Output Values
Data: None (1 Byte)
Result: 0-65535, 2 Words

Description: This command returns the 16 bit values for the Command and Auxiliary DAC's as follows:

0x4000 (Param 1) = Command DAC value
0x4002 (Param 2) = Auxiliary DAC value

Command: 0x0005H - Get Motor Inputs
Data: None
Result: 1 word

Description: This command returns the values for the axis motor input bits as follows:

```
AMP_FAULT       =  /* bit 0  */
NOT USED        =  /* bit 1  */
HOME            =  /* bit 2  */
LIMIT_HW_POS    =  /* bit 3  */
LIMIT_HW_NEG    =  /* bit 4  */
NOT USED        =  /* bit 5-15  */
```

Command: 0x0006H - Set Motor Outputs
Data: 1 word
Result: None

Description: This command sets the value for the amp enable output as follows. The actual hardware output transistor will be turned on when this bit=0 and off if this bit =1.

```
AMP_ENABLE      =  /* bit 0  */
```

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Command: 0x0007H - Set General Purpose Outputs A0-A3, B0-B3
Data: 1 word (Must always be sent to Axis 1)
Result: None

Description: This command sets the user outputs A0-A3 and B0-B3 as follows. A “1” in the bit location turns off the opto transistor, allowing the output to be pulled high. A “0” turns on the output transistor, driving the output low. These conditions assume the outputs are pulled up through a resistor. Note that the all GP I/O is set to the output state following the execution of this command.

Output Bit	Operand1 Bit
A0	0
A1	1
A2	2
A3	3
B0	4
B1	5
B2	6
B3	7

Command: 0x0008H - Get Capture State
Data: None
Result: 1 word

Description: This command reads the state of the capture state machine. The capture state is returned as follows:

Capture State IDLE	= 0	(Capture is disabled)
Capture State ARMED	= 1	(Capture is enabled)
Capture State CAPTURED	= 2	(Capture edge has occurred)
Capture State CLEAR	= 3	(Not used)

Command: 0x0009H - Set Vmin
Data: 1 - 2000 (2 Bytes)
Result: None
Total Bytes: 3

Description: This command is used to select the start / stop rate used by the axis. This is also 1 of the 4 commands which control the shape of the acceleration / deceleration profile.

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Command: 0x000AH - Get General Purpose Inputs A0-A3, B0-B3
Data: None (Must always be read from Axis 0)
Result: 1 word

Description: This command gets the user inputs A0-A3 and B0-B3 as follows. A "1" in the bit indicates the input is high. These conditions assume the inputs are pulled up through a resistor. Note that the GP I/O is left in the input state following execution of this command.

Input Bit	Parameter 1 Bit
A0	0
A1	1
A2	2
A3	3
B0	4
B1	5
B2	6
B3	7

Command: 0x000CH - Set Settle on Stop Status
Data: 0 (default, disable settle on Stop) or 1 (enable settle on Stop)
Result: None

Description: This command sets the settle on Stop status to enabled (1) or disabled (0). When the settle on Stop status is disabled, no settling time delay is executed after a move. When the settle on Stop status is enabled, the regular system settling time is used after a move. This command applies when a Stop event is issued due to a Limit or Home event, and the Limit or Home action is set to Stop or EStop. See commands 0x001F, 20 and 21. The default setting is disabled (0).

Command: 0x000FH - Set Command Position
Data: -2,147,483,647 to +2,147,483,647 Two's Complement format, (2 words)
Result: None

Description: This command will set the Command position counter to the value passed. The position data is two's complement format. The first word (Operand 1) is the low word of the position; the second word (Operand 2) is the high word of position.

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Command: 0x0010H - Setup Capture
Data: Operand 1= Capture Source
Operand 2= Capture Edge
Result: None

Description: This command configures the capture feature. The input value to use as the capture source is specified in Operand 1. The edge to capture is specified in Operand 2. Once this command is issued, the Capture State Machine is set to Armed and will capture Encoder and Command positions whenever the specified edge occurs. When a Capture edge occurs, the state machine is set to Captured. Setting the Capture Source to “None” resets the Capture State Machine to “Idle”.

Operand 1 defines the capture source:

Source	Value
HOME	0
ENCODER INDEX	1
LIMIT_HW_NEG	2
LIMIT_HW_POS	3

Operand 2 defines the Edge:

Edge	Value
NONE	0
RISING	1
FALLING	2
EITHER	3

Command: 0x0011H - Get Capture Positions
Data: None
Result: Encoder Position, Command Position (4 words)

Description: This command returns the values for Encoder Position and Command Position following a successful capture operation. The return values are structured as follows:

Address	Value
0x4000	Encoder position low word
0x4002	Encoder position high word
0x4004	Command position low word
0x4006	Command position high word

Note: If the Encoder Status is set to disabled (command 0x0001=0), then Command Position is returned in place of Encoder Position.

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Command: 0x0012H - Set Encoder Position
Data: -2,147,483,647 to +2,147,483,647 Two's Complement format, (2 words)
Result: None

Description: This command will set the Encoder position counter to the value passed. The position data is two's complement format. The first word (Operand 1) is the low word of the position; the second word (Operand 2) is the high word of position.

Command: 0x0013H - Set Axis Origin
Data: -2,147,483,647 to +2,147,483,647 Two's Complement format, (2 words)
Result: None

Description: This command will set the Encoder and Command position counters as offsets to the origin value passed as follows:

Command position = Command position - origin value
Encoder position = Encoder position - origin value

Command: 0x0015H - Index Positive
Data: -2,147,483,647 to +2,147,483,647 Two's Complement format, (2 words)
Result: None

Description: This command will perform a relative move in the positive direction using the specified number of steps. Care should be taken to prevent overflow of the position counter. Note that if limits are enabled, motion will depend on the state of the positive limit switch. See Command 0x0052.

Command: 0x0016H - Index Negative
Data: -2,147,483,647 to +2,147,483,647 Two's Complement format, (2 words)
Result: None
Total Bytes: 4

Description: This command will perform a relative move in the negative direction using the specified number of steps. Care should be taken to prevent overflow of the position counter. See 0x0F command for the position counter range. Note that if limits are enabled, motion will depend on the state of the negative limit switch. See Command 0x0052.

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Command: 0x0017H - Set Motion Position
Data: Operand 1,2 = Encoder Position
Operand 2,3 = Command Position
Result: None

Description: This command will set the Encoder and Command position counters to the values passed. The position data is two's complement format. The first word (Operand 1) is the low word of the Encoder position; the second word (Operand 2) is the high word of Encoder position. The third word (Operand 3) is the low word of the Command position; the fourth word (Operand 4) is the high word of Command position.

Command: 0x0018H - Get Motion Position
Data: None
Result: Operand 1,2 = Encoder Position
Operand 3,4 = Command Position

Description: This command will return the Encoder and Command position counter values. The position data is two's complement format, returned as follows:

Address	Value
0x4000	Encoder position low word
0x4002	Encoder position high word
0x4004	Command position low word
0x4006	Command position high word

Note: If the Encoder Status is set to disabled (command 0x0001=0), then Command Position is returned in place of Encoder Position.

Command: 0x0019H - Configure XCVR A & B Direction
Data: 0 (input), 1 (output), default
Result: None

Description: This command sets the XCVR A&B direction based on the input value. The XCVR A & B output controls operate together. A "0" configures XCVR's A&B as inputs, a "1" configures XCVR's A&B as outputs. XCVR A&B must be configured as outputs for step and direction outputs to be active. The default setting is outputs.

Command: 0x001AH - Read Command Position
Data: None
Result: 2 word Position -2,147,483,647 to +2,147,483,647 Two's Complement format, (2 words)

Description: This command is used to read the value of the Command position counter. The position data is in two's complement format. See 0x000F command.

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Command: 0x001BH - Set XCVR C Output State
Data: 0, 1
Result: None

Description: This command sets the XCVR C output to the value passed in. The XCVR section is left in the output state following the execution of this command.

Command: 0x001CH - Get XCVR C Input State
Data: None
Result: 0, 1

Description: This command returns the XCVR C input state. The XCVR C should be set to input using the 0x001D command before using this command, otherwise the XCVR C output driver state will be returned.

Command: 0x001DH - Configure XCVR C Direction
Data: 0 (input), 1 (output)
Result: None

Description: This command sets the XCVR C direction based on the input value. A “0” configures XCVR C as an input, a “1” configures XCVR C as an output.

Command: 0x001EH - Read Axis Status
Data: None
Result: 2 Words. Lower word (0x4000) has moving status. Upper word has system status register contents.

Description: This command will report the current moving status of the axis in the low word, and the system status bits in the high word.

Result Low Word (0x4000)
0 = Not moving and 1 = Moving.
Result High Word (0x4002)
System Status Bit Definition:

Usage	Bit	
DIRECTION BIT	0	positive direction=1
NEG_LIMIT BIT	1	switch status 0=limit on
POS_LIMIT BIT	2	switch status 0=limit on
LIMIT_STATUS	3	enable state 0=limits disabled
FATAL_LIMIT_STATUS	4	0=no fatal limit
FATAL_LIMIT_ENABLE	5	0= fatal limit disabled
REVERSE_PENDING	6	
NEXT_DIRECTION	7	
AXIS_MOVING	8	moving=1

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Command: 0x001FH - Set Positive Limit Switch Action
Data: 1 word => None=0, Abort=1, Stop=2, EStop=3
Result: None

Description: This command sets the action for an active Positive Limit switch input. If the motor is moving and the switch input becomes active, the programmed action will take place. Motor Event will be set to Positive Limit.

Command: 0x0020H - Set Negative Limit Switch Action
Data: 1 word => None=0, Abort=1, Stop=2, EStop=3
Result: None

Description: This command sets the action for an active Negative Limit switch input. If the motor is moving and the switch input becomes active, the programmed action will take place. Motor Event will be set to Negative Limit.

Command: 0x0021H - Set Home Switch Action
Data: 1 word => None=0, Abort=1, Stop=2, EStop=3
Result: None

Description: This command sets the action for an active Home switch input. If the motor is moving and the switch input becomes active, the programmed action will take place. Motor Event will be set to Home input.

Command: 0x0022H - Get Positive Limit Switch Action
Data: None
Result: 1 word => None=0, Abort=1, Stop=2, EStop=3

Description: This command returns the action for an active Positive Limit switch input.

Command: 0x0023H - Get Negative Limit Switch Action
Data: None
Result: 1 word => None=0, Abort=1, Stop=2, EStop=3

Description: This command returns the action for an active Negative Limit switch input.

Command: 0x0024H - Get Home Switch Action
Data: None
Result: 1 word => None=0, Abort=1, Stop=2, EStop=3

Description: This command returns the action for an active Home switch input.

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Command: 0x0026H - Get Motor Event
Data: None
Result: 1 word

Description: This command returns the source of a motor stop event. When the motor is stopped due to an external event, the source of the event will be set in Motor Event. Valid Motor events are:

None	0 (Set at the start of all moves)
Amp Fault	1
Home	2
Neg Limit	4
Pos Limit	5
Encoder Fault	8

Command: 0x0027H - Set Positive Limit input active state
Data: Active State, 0 or 1
Result: None

Description: This command sets the active state for the Positive Limit switch input to 0 or 1. The default is 0.

Command: 0x0028H - Set Negative Limit input active state
Data: Active State, 0 or 1
Result: None

Description: This command sets the active state for the Negative Limit switch input to 0 or 1. The default is 0.

Command: 0x0029H - Set Home input active state
Data: Active State, 0 or 1
Result: None

Description: This command sets the active state for the Home switch input to 0 or 1. The default is 0.

Command: 0x0030H - Calc Parabolic Ramp
Data: None
Result: None

Description: This command will calculate a Parabolic Acceleration / Deceleration profile. The parameters that affect the shape of the ramp are VMIN, VMAX, AT. See the section on Ramp equations for more detail.

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Command: 0x0031H - Calc Linear Ramp
Data: None
Result: None

Description: This command will calculate a Linear Acceleration / Deceleration profile. The parameters that affect the shape of the ramp are VMIN, VMAX, AT. See the section on Ramp equations for more detail.

Command: 0x0032H - Calc S-Shaped Ramp
Data: None
Result: None

Description: This command will calculate a S-Shaped Acceleration / Deceleration profile. The parameters that affect the shape of the ramp are VMIN, VMAX, AT. See the section on Ramp equations for more detail.

Command: 0x0036H - Set Vmax
Data: 2000-2,000,000
Result: None

Description: This command is used to set the Vmax value used in Acceleration / Deceleration profiles. This value sets the maximum velocity used when creating a ramp table. See the section on Ramp equations for more detail. Default is 25000 sps.

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Command: 0x0037H - Set VSlew Speed
Data: 10,000,000 - 5, or 0xFFFFFFh
Result: None

Description: This command sets the slew speed used during a move. The speed is specified as 10 MHz clock ticks. 0xFFFFFFh indicates zero speed.
NOTE: The motion card limits slew speed to Vmax. If values less than Vmin are commanded, the motion card immediately sets the speed to the commanded slew speed with no ramp. See “Data Communications”…”Special Data format for Speeds” for more detail. Default is 1000 sps.

Command: 0x0038H - Move Constant Velocity Positive
Data: 10,000,000 - 5, or 0xFFFFFFh
Result: None

Description: This command will cause the axis to move positive at the speed specified. The speed is specified as 10 MHz clock ticks. 0xFFFFFFh is a special case for zero speed. See “Data Communications”…”Special Data format for Speeds” for more detail. This command is used for VELOCITY based positioning.
NOTE: Speed should be limited to Vmin <= Speed <=Vmax to ensure speeds fall within the calculated ramp table. Motion will depend on the Limit + input Limit Enable (0x0052)

Command: 0x0039H - Move Constant Velocity Minus
Data: 10,000,000 - 5, or 0xFFFFFFh
Result: None

Description: This command will cause the axis to move negative at the speed specified. The speed is specified as 10 MHz clock ticks. 0xFFFFFFh is a special case for zero speed. See “Data Communications”…”Special Data format for Speeds” for more detail.
NOTE: Speed should be limited to Vmin <= Speed <=Vmax to ensure speeds fall within the calculated ramp table. Motion will depend on the Limit - input Limit Enable (0x0052)

Command: 0x003AH - Set Acceleration Rate In Milliseconds
Data: 10 - 2000
Result: None

Description: This command is used to set the variable used in calculating the Acceleration Profile. The number specifies the number of milliseconds (0.001 Seconds) used to reach Vmax. See the section on Ramp equations for more detail. Default is 120mS.

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Command: 0x003BH - Report Firmware Version
Data: None
Result: Firmware version

Description: This command will cause the motion card to report the firmware version. The version is reported as version * 10. For example version 0.8 is reported as 8, this allows fractional versions to be sent back using 1 byte. The host should divide the version number by 10.

Command: 0x003CH - Boot Motion Card, Firmware reset
Data: None
Result: None

Description: This command has been removed. Please use the Host Control Register 0x4E0 to reset the DSP's.

Command: 0x003DH - Home AXIS on Positive Limit
Data: 0 to +2,147,483,647 (2 words)

Result: None

Description: This command will cause the axis to home using the Limit + switch. Homing consists of moving some distance to find the limit switch, stopping, settling, stepping off of the switch, and performing a final move. This command tells the axis which way to start moving to find the Limit + switch and how far to go before giving up. The following variables can be modified to change the way that an axis performs when homing, it is not necessary to change them as each one is setup with default values. See each command for defaults.

Variable	Set Using
Direction / Distance	- 0x003DH, Home axis on Positive switch, move distance specified - 0x003EH, Home axis on Negative switch, move distance specified
Step off move size	- 0x0041H, The distance to move each time the axis tries to step off of the limit switch
Home Settling Time	- 0x0042H, Dwell x Milliseconds after hitting switch before stepping off
Move to limit Speed	- 0x0043H, This command sets the speed used to move to the limit switch
Move after off switch	- 0x0044H, This command specifies a distance to move after the home is complete
Max number of loops	- 0x0050H, This command specifies the maximum number of tries when stepping off the switch
Report status	- 0x004BH, This command will report the status of the last homing command

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Command: 0x003EH - Home AXIS on Minus Limit
Data: 0 to +2,147,483,647 (2 words)
Result: None

Description: This command will cause the axis to home using the Limit - switch. Homing consists of moving some distance to a limit switch, stopping, settling, stepping off of the switch, and performing a final move. See 0x003D for more details.

Command: 0x003FH - Set Deceleration Rate In Milliseconds
Data: 10 - 2000
Result: None

Description: This command is used to set the variable used in calculating the Deceleration Profile. The number specifies the number of milliseconds (0.001 Seconds) used to decelerate to 0 steps per second. Default is 120mS.

Command: 0x0040H - Set Move Settling Time for axis in milliseconds
Data: 0 - 65535
Result: None

Description: This command sets the settling time for an axis. Settling time is used to allow a mechanical system time to settle after the pulse train ends. When a settling time is specified the axis will wait after the last step pulse is sent, before signaling “NOT MOVING”. Note: Axis moving can be determined several ways, hardware moving bit, axis moving bit, and software moving status command. Default is 0 ms.

Command: 0x0041H - Homing, Set step off limit move size
Data: 1-65535
Result: None

Description: This command sets the distance moved when stepping off of a limit switch during a home sequnce. The axis will move the number of steps set by this command and recheck the switch. The default is 1 step.

Command: 0x0042H - Homing, Set Settling Time after hitting switch
Data: 0 - 65535
Result: None

Description: This command is used to specify the time delay, which allows for mechanical settling after the axis hits the limit switch, during a home command. This is NOT the same a 0x040H which is used after all other moves. Default is 50 ms.

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Command: 0x0043H - Homing, Set move to limit speed
Data: 5-10,000,000 (10MHz clock ticks)
Result: None

Description: This command specifies the speed used for moving to the limit switch. Speed is specified as 10,000,000 / (SPEED steps/sec), this is clock ticks @ 10 MHz. Default is 1000 steps/sec.

Command: 0x0044H - Homing, Set move distance after off switch
Data: 0 to +2,147,483,647
Result: None

Description: This command sets the distance of the move to make after hitting the limit switch in Homing. Default is 0 steps.

Command: 0x0045H - Query Limit Status flag
Data: None
Result: Fatal Limit Status

Description: This command returns the status of the fatal limit flag. A return value of 1 means that a FATAL limit occurred during the last move. This is only valid if fatal limit trapping is enabled, see 0x051H - Enable Fatal Limit Trapping.

Command: 0x0046H - Clear Fatal Limit Status flag
Data: None
Result: None

Description: This command will clear the Fatal Limit Trap Flag. If fatal Limit trapping is enabled and a limit is hit, no moves can occur until this flag is cleared.

Command: 0x0047H - Report Acceleration ramp size in bytes
Data: None
Result: 0-65535

Description: This command will report this size of the ramp table stored in RAM.

Command: 0x0048H - Perform RAM Memory check and report result
Data: None
Result: Pass=0/Fail=1

Description: This command will check the RAM used to store acceleration tables. The command will return 0 = FAIL or 1 = PASS. The command may take several hundred milliseconds since all of RAM is being checked several ways. It does not destroy the contents of RAM.

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Command: 0x0049H - Report Positive Limit switch status
Data: None
Result: Limit Status 0 =Limit off, 1 = Limit on.

Description: This command will report the status of the positive limit switch.

Command: 0x004AH - Report Negative Limit switch status
Data: None
Result: Limit Status 0 =Limit off, 1 = Limit on.

Description: This command will report the status of the negative limit switch.

Command: 0x004BH - Report result of the last HOMING move
Data: None
Result: Homing Status

Description: This command will report the status of the last or current homing move.
0 = Home function Not Done.
1 = No limit switch found after home to limit move.
2 = Could not come off limit switch.
3 = Home Complete

This command should be sent after the axis is done homing to check the result. Normally the moving bit is check to see when the homing routine is complete and then this command is sent.

Command: 0x0050H - Homing, Set number of loops moving off switch
Data: 1 - 65535
Result: None

Description: This command is used to specify how many times the axis should step and check the limit switch before reporting a failure. This will prevent the system from hanging if a switch becomes stuck on.

Command: 0x0051H - Enable Fatal Limit trapping
Data: 0 or 1
Result: None

Description: This command will enable or disable fatal limit trapping. 0 = Disable, 1 = Enable Fatal Limit Trapping will stop all motion once a limit is detected. If enabled, the axis will not move again until the flag is cleared using 0x046H - Clear Fatal Limit. Default is 0, Disabled.

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Command: 0x0052H - Enable / Disable Limit Switches
Data: 0 or 1
Result: None

Note: New designs should use the 0x001F-0x0021 commands for switch actions.

Description: This command will enable or disable the limit switches. 0 = Disable, 1 = Enable
CAUTION!
When limit switches are DISABLED motion will not stop when limit switches are hit. Switches can be disabled while a move is in progress and limits will be ignored. Switches can be Enabled while moving but will NOT become active until motion is stopped and restarted.
Default is 1, Enabled.

Command: 0x0060H - Reset ramp table dump routine
Data: None
Result: Resolution of table

Description: This command will reset the ramp table dump routine. The data returned is 1 byte containing the resolution of the ramp. (1 - 20). To unload a ramp table, first send this command, it will reposition the pointer to the beginning of the table. Next use 0x061H- Dump Byte.

Command: 0x0061H - Dump next byte from acceleration ramp table
Data: None
Result: Tick Data

Description: This command is used to dump the acceleration table from RAM. The speeds are returned in low word and high word in 10 MHz clock ticks.
Convert by 10,000,000 / (HIGH * 65536 + LOW) = Steps/sec
The end of the ramp table is marked by HIGH = 0x0FFH, MED = 0x0FFH, LOW = 0x0FFH. This command is useful to plot the actual ramp calculated in the Motion card.

Command: 0x0080H - Soft Stop
Data: None
Result: None

Description: This command will cause the axis to decelerate and stop. This is equivalent to sending a zero velocity slew rate. This command will decelerate and not lose position or steps.

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Command: 0x0081H - Move to Absolute Position
Data: -2,147,483,647 to +2,147,483,647 Two's Complement format
Result: None

Description: This command will execute a move to the absolute position specified by the data. The data is in two's complement format.



Caution
Do not use any commands other than what are listed here.

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Command Summary Table

	Word Parameters	
OpCode Command	Input	Output
0x0000H - Abort Move	0	0
0x0001H – Set Encoder Status	1	0
0x0002H - Command DAC Output	1	1
0x0003H - Auxiliary DAC Output	1	1
0x0004H - Get DAC Output Values	0	2
0x0005H - Get Motor Inputs	0	1
0x0006H - Set Motor Outputs	1	0
0x0007H - Set General Purpose Outputs	1	0
0x0008H - Get Capture State	0	1
0x0009H - Set Vmin	1	0
0x000AH - Get General Purpose Inputs	0	1
0x000CH – Set Settle on Stop Status	1	0
0x000FH - Set Command Position	2	0
0x0010H - Setup Capture	2	0
0x0011H - Get Capture Positions	0	4
0x0012H - Set Encoder Position	2	0
0x0013H - Set Axis Origin	2	0
0x0015H - Index Positive	2	0
0x0016H - Index Negative	2	0
0x0017H - Set Motion Position	4	0
0x0018H - Get Motion Position	0	4
0x0019H – Set XCVR AB Direction	1	0
0x001AH - Read Command Position	0	2
0x001BH - Set XCVR C Output State	1	0
0x001CH - Get XCVR C Input State	0	1
0x001DH - Configure XCVR C Direction	1	0
0x001EH - Read Axis Status	0	1
0x001FH – Set Positive Limit Action	1	0
0x0020H – Set Negative Limit Action	1	0
0x0021H – Set Home Action	1	0
0x0022H – Get Positive Limit Action	0	1
0x0023H – Get Negative Limit Action	0	1
0x0024H – Get Home Action	0	1
0x0026H – Get Motor Event	0	1
0x0027H – Set Pos Limit State	0	1
0x0028H – Set Neg Limit State	0	1
0x0029H – Set Home State	0	1
0x0030H - Calc Parabolic Ramp	0	0
0x0031H - Calc Linear Ramp	0	0
0x0032H - Calc S-Shaped Ramp	0	0
0x0036H - Set Vmax	2	0
0x0037H - Set VSlew Speed	2	0
0x0038H - Move Constant Velocity Positive	2	0

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0x0039H - Move Constant Velocity Minus	2	0
0x003AH - Set Accel Rate	1	0
0x003BH - Report Firmware Version	0	1
0x003CH - Deleted	0	0
0x003DH - Home AXIS on Positive Limit	2	0
0x003EH - Home AXIS on Minus Limit	2	0
0x003FH – Set Decel Rate	1	0
0x0040H - Set Move Settling Time	1	0
0x0041H - Homing, Set step off size	2	0
0x0042H - Homing, Set Settling Time	1	0
0x0043H - Homing, Set move to limit speed	2	0
0x0044H - Homing, Set Move Post Distance	2	0
0x0045H - Query Limit Status flag	0	1
0x0046H - Clear Fatal Limit Status flag	0	0
0x0047H - Report Ramp Size	0	1
0x0048H - Perform RAM Memory check	0	0
0x0049H - Positive Limit switch status	0	1
0x004AH - Negative Limit switch status	0	1
0x004BH - Home Status	0	1
0x0050H - Homing, Set number of loops	1	0
0x0051H - Enable Fatal Limit trapping	1	0
0x0052H - Enable / Disable Limit Switches	1	0
0x0060H - Reset ramp table dump routine	0	0
0x0061H - Dump next accel table byte	0	0
0x0080H - Soft Stop	0	0
0x0081H - Move to Absolute Position	2	0

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Acceleration / Deceleration Ramp Types

The Motion Card will support 3 different types of Acceleration Profiles.
The following parameters can be used to describe any desired motion profile.

Vmin	= Start / Stop Rate of motor, command 0x09
Vmax	= Maximum speed of motor, command 0x36
At	= Acceleration time in mS from vmin to vmax, command 0x3A
Dt	= Deceleration time in mS from vmax to vmin, command 0x3F
ramp_type	= Parabolic, Linear or S-Shape, commands 0x30, 0x31, 0x32

Vslew specifies the speed at which the motor will move during an index move (Commands 0x15, 0x16). Vslew should be limited to Vmin <= Vslew <= Vmax.

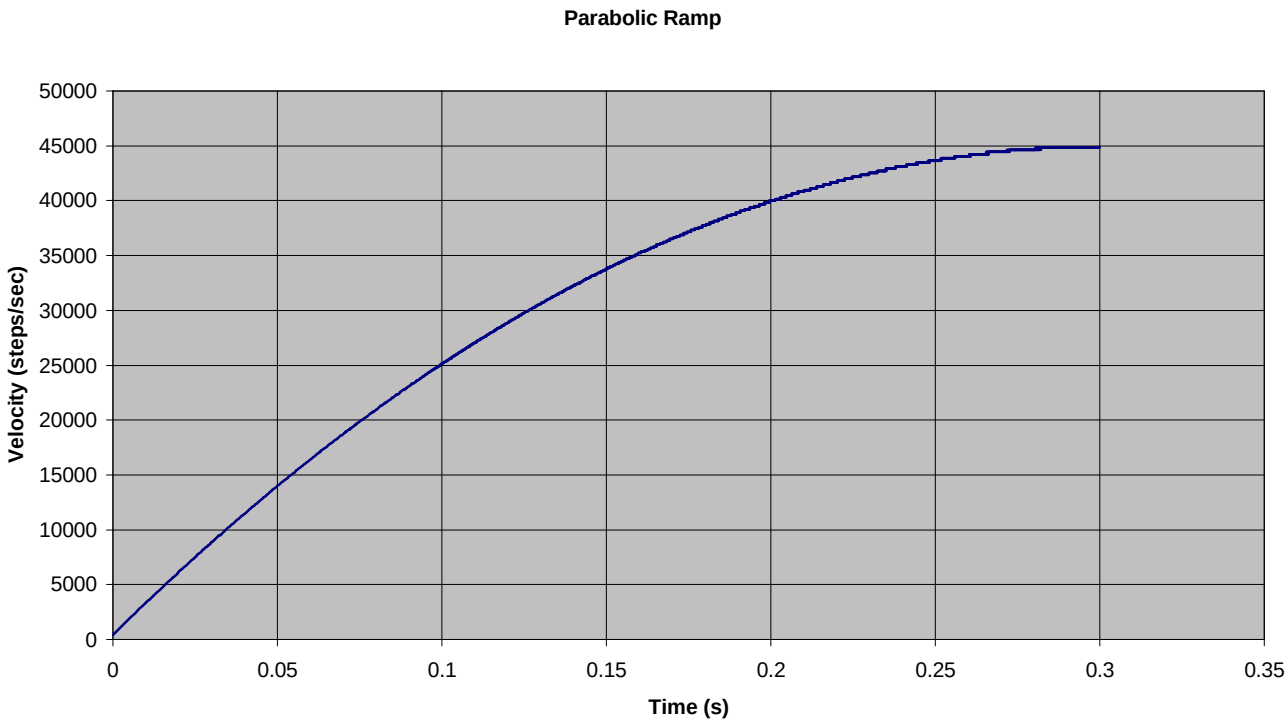
To set up a move profile, send the desired values for Vmin, Vmax, At, and Dt to the card. Then set the ramp type. When the ramp type is sent to the card this causes the card to calculate a ramp table, which consists of velocity values from Vmin to Vmax. The card uses this table to determine the velocities used during changes in speed. The value for Vslew should fall within the bounds of Vmin to Vmax to allow ramp table values to be used for velocity changes. Values for Vslew can fall outside the range of Vmin to Vmax, but the card will not provide smooth velocity transistions. Vslew will be instantaneously set once the desired velocity falls outside the bounds of Vmin to Vmax,

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Parabolic Acceleration Graphs

The following graphs are actual acceleration data plots generated by the SSC432 ramp algorithms.

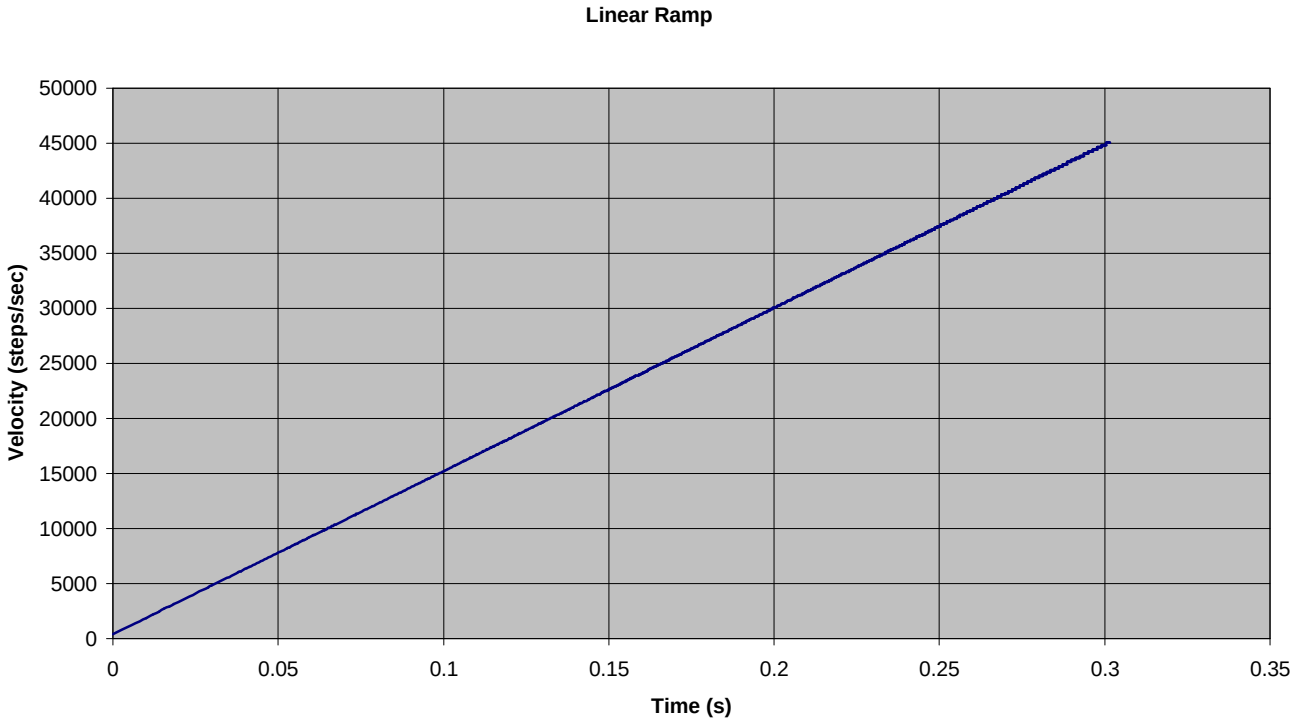
Vmin = 400 Steps/Sec
Vmax = 45000 Steps/Sec
At = 300 mS



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Linear Acceleration Graphs

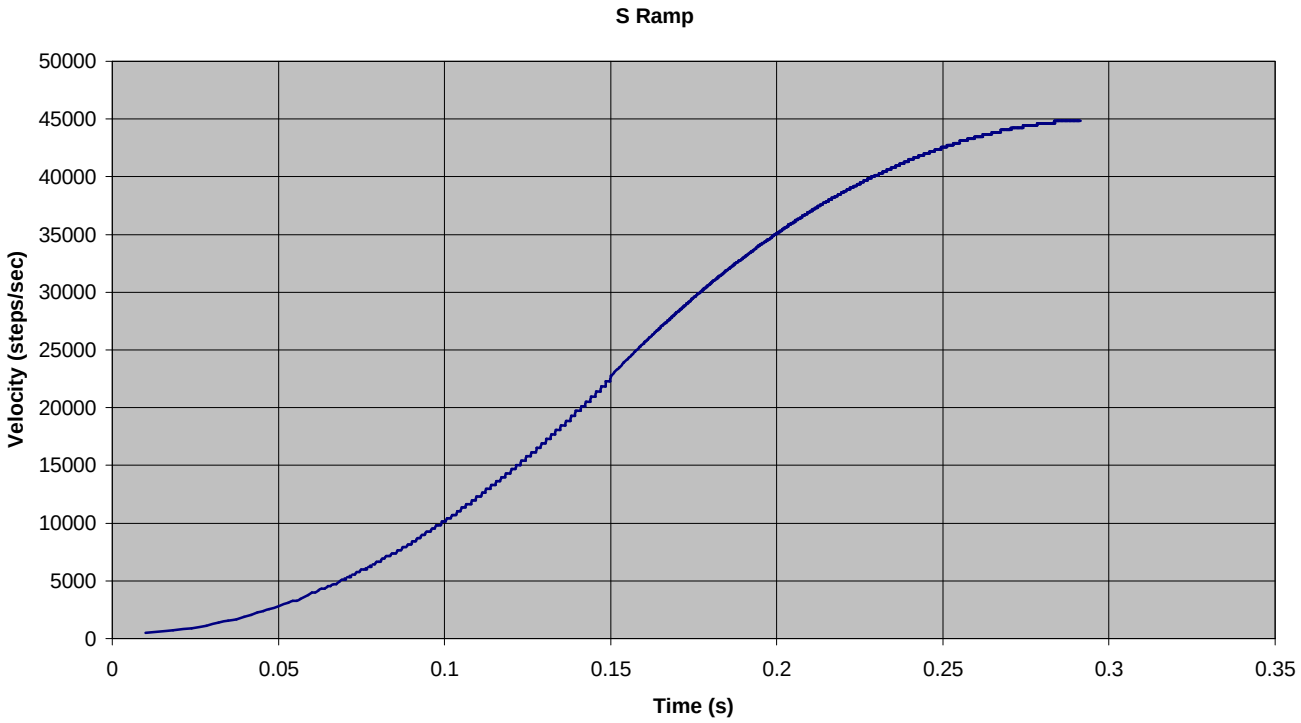
Vmin = 400 Steps/Sec
Vmax = 45000 Steps/Sec
At = 300 mS



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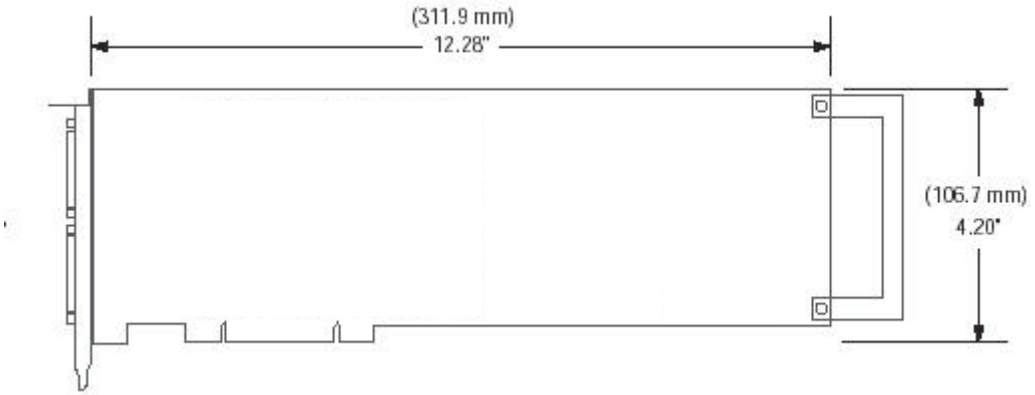
S-Shaped Acceleration Graphs

Vmin = 400 Steps/Sec
Vmax = 45000 Steps/Sec
At = 300 mS



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Appendix A – Board Dimensions



PCI Card Dimensions (Universal and 3.3volt)

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Appendix B - API Functions

The application software communicates with the motion card through a driver module loaded at power up. For more information, please refer to the file “PCIDEVGuide.pdf” on the distribution disk. The Cypress Semiconductor Dual Port CY7C09449 chip provides the PCI interface for the motion card. Cypress Semiconductor provides the driver and software for the API interface to their chip. This documentation is provided as a reference for programming. Please consult the Cypress website for the most up to date information. Section 4 of this document provides the reference for the API functions.

The most common driver functions used for communication are listed below.

API Function	Description
OpenPCIDP	The **OpenPCIDP** service establishes communication between the host PC and the PCIDP device. This is the first service your application will invoke. The service returns a handle that is required to invoke any of the other services. Based on the board number, it tries to establish communications with the appropriate PCI-DP board. If it is successful, it returns a valid handle to that board. Success or failure is determined by examining the value of the return status. This routine need only be called once per session per board.
MapBaseRegister	The **MapBaseRegister** service provides mapping to the physical address described by one of the board's PCI base registers. If the address space is memory, the service returns a pointer that can be used to reference the memory directly. If the address space is I/O space, the service returns the I/O address from the base register. The VMC2000 uses memory rather than I/O for access.

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