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USER'S MANUAL

INTELLIGENT MOTOR CONTROLLERS

VMEX FAMILY

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1. GENERAL DESCRIPTION

1.1. INTRODUCTION

The VMEX family of intelligent motion controls can manage as many as 6 axes of motion in one I/O slot of a VME bus computer. They meet the VME C.1 specifications for D08(O) slaves and can be plugged directly into the backplane of these machines. The VMEX-4E can, for example, simultaneously control four axes of step motors while monitoring the actual position of two of them with the built in incremental encoder interface. It can manage coordinated or independent motion on each of the four axes simultaneously. The controller can also generate constant velocity profiles with circular interpolation for cutting and machining type operations.

The VMEX functions as a loosely coupled coprocessor within the VME computer. It utilizes a 68000 microprocessor and patented proprietary technology to control direction of motion, acceleration, deceleration and velocity of an associated motor. In response to commands from the host computer, the VMEX controller will calculate the optimum velocity profile to reach the desired destination in the minimum time while conforming to the programmed velocity and acceleration parameters. A block diagram of the VMEX is shown in Section 9.

The VMEX family of controllers use 'microstepping' techniques for increased position resolution and decreased low speed resonance. When combined with the appropriate driver and step motor, the VMEX can divide the normal step angle into 250 discrete steps of 0.0072 degrees each or 50,000 steps per revolution. The Oregon Micro Systems drivers, models MD10A and MH10 are 10 microstep per step motor drivers which can be driven by the VMEX family of controllers.

Commands may be sent to the VMEX by simple I/O commands using virtually any language on the host VME computer. These controllers are easily programmed with ASCII character strings. For a typical motion requirement of 1,000,000 pulses at 400,000 pulses/sec and an acceleration of 500,000 pulses/sec^2 the following string would be input from the host computer to the VMEX:

VL400000 AC500000 MR1000000 GO

For additional programming examples see Section 7.

1.2. FUNCTIONAL DESCRIPTION

The VMEX, in response to commands from the host computer, provides controlled acceleration to a predefined peak speed followed by a constant velocity and controlled deceleration to a stop. This is achieved by calculating the optimum velocity 1024 times each second, providing a very smooth acceleration curve. This calculation is used to control a

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variable frequency pulse train which is derived from a crystal oscillator providing very accurate pulse rates.

The 68000 microprocessor calculates this velocity profile for each of the axes providing independent but synchronized (if desired) profiles for each axis. The VMEX can perform a smooth coordinated move on up to six axes using linear, parabolic or cosine velocity profiles. It can manage as many as six independent or coordinated processes.

The VMEX will calculate the optimum velocity profile to generate the desired move, while conforming to the acceleration and velocity data input by the host computer. This move will consist of a smooth acceleration, followed by a constant velocity section and a smooth deceleration to the desired distance. A graph of a typical linear velocity is shown in Figure 1-1.

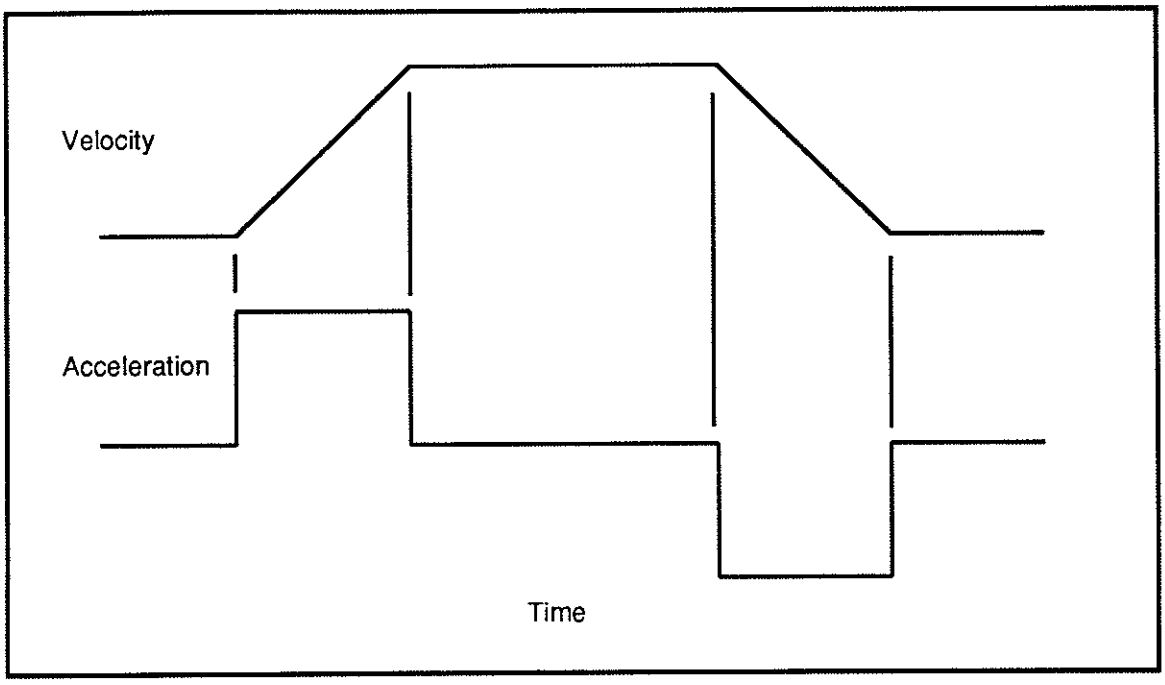


Figure 1-1 TYPICAL VELOCITY PROFILE

If the move parameters do not allow the motor to accelerate to the desired velocity in the desired distance, the VMEX will automatically generate an optimum triangular velocity profile. It can also be commanded to accelerate to a velocity and hold that velocity until told to stop or change to a new velocity. It will then smoothly decelerate to a stop or accelerate/decelerate to the new velocity.

Several moves of this type may be chained together to provide a more complex pattern. The VMEX is able to store up to 124 characters in an input character buffer, plus 200 commands and parameters in separate command queues for each axis, allowing several moves to be made without host intervention. A loop counter is provided to repeat desired sections of a complex move pattern. Loops may be nested up to four levels deep on all axes.

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1.3. VELOCITY PROFILES

The VMEX offers three options for ramping the device to speed. The traditional constant acceleration or linear velocity ramp (see Figure 1-1) is the default at power up or reset. The half sinusoid acceleration or half cosine velocity ramp (see Figure 1-3) is selected by the CN command. Since the acceleration is zero at the velocity inflection points, this offers very smooth operation. It is used in sensitive applications such as wafer handling on a vacuum chuck. The third option is a reverse ramp of acceleration or parabolic velocity curve (see Figure 1-2), which can be selected by the PN command. This ramp is commonly used to compensate for loss of motor torque at high speeds, i.e. since the acceleration is reduced at higher speeds the required forces are reduced proportionally. The parabola may be truncated to allow the user to select, under program control, the reduction in acceleration (force) appropriate for the application.

LINEAR RAMPS. The OMS controls generate a linear velocity ramp in real time, i.e. while the stage is in motion. There is no table building prior to the move and thus minimal latency. The controls will accelerate to the specified velocity and hold that speed until just enough move distance is left, then decelerate to a stop. If the move distance is too short to reach speed, a triangular velocity ramp will automatically be generated. The acceleration is a constant A_m and the velocity is then:

$$v = A_m t$$

A useful relationship is the distance required to accelerate at acceleration A_m to peak velocity V_p is:

$$s = \frac{V_p^2}{2A_m}$$

or the acceleration A_m required to accelerate to peak velocity V_p in distances s is:

$$A_m = \frac{V_p^2}{2s}$$

PARABOLIC RAMPS. The parabolic ramp is generated in a similar fashion except the acceleration is reduced as the stage accelerates to speed thus reducing the velocity slope, as shown in Figure 1-2.

The acceleration follows the equation:

$$a = A_0 - A_0 \frac{t}{T_2}$$

and the velocity is then:

$$v = A_0 t - \frac{A_0 t^2}{2T_2}$$

and the distance traveled in the ramp is:

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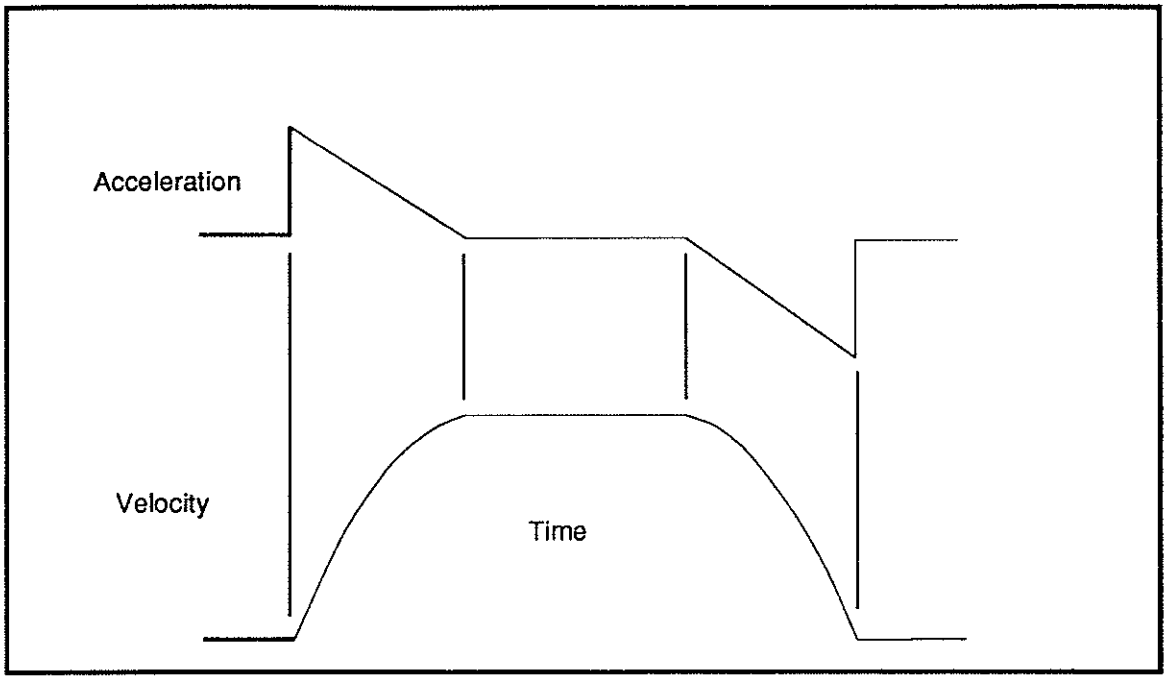


Figure 1-2 PARABOLIC VELOCITY PROFILE

$$s = \frac{A_0 t^2}{2} - \frac{A_0 t^3}{6T_2}$$

where A_0 is the initial acceleration, t is time during the ramp and T_2 is total ramp time if the acceleration had reached zero. The parameter supplied with the PN command is 10 times the ratio $\frac{t}{T_2}$ which can take on values from 3 to 10, allowing the final acceleration to range from 70% to 10% respectively of the programmed or initial value. When a move is specified, the controls will fit the resulting velocity curve to the desired acceleration profile. This ensures that the desired acceleration is always reached at the programmed velocity, as long as the move is long enough for the stage to reach the programmed speed. If the move is too short to reach the programmed speed the curve is truncated, causing the shape of the velocity curve to remain the same up to the velocity reached by the specific move. This is consistent with the desired result of compensating for loss of motor torque. Since the motor has not reached the programmed speed, less compensation is needed. The parabolic ramp mode may result in reduced move time at high speeds, since a larger acceleration may be used.

COSINE RAMPS. The cosine ramps are generated in a similar fashion to the parabolic ramps, except the acceleration is:

$$a = A_m \sin \frac{2A_m}{V_p} t$$

and the velocity is then:

$$v = \frac{V_p}{2} (1 - \cos \frac{2A_m}{V_p} t)$$

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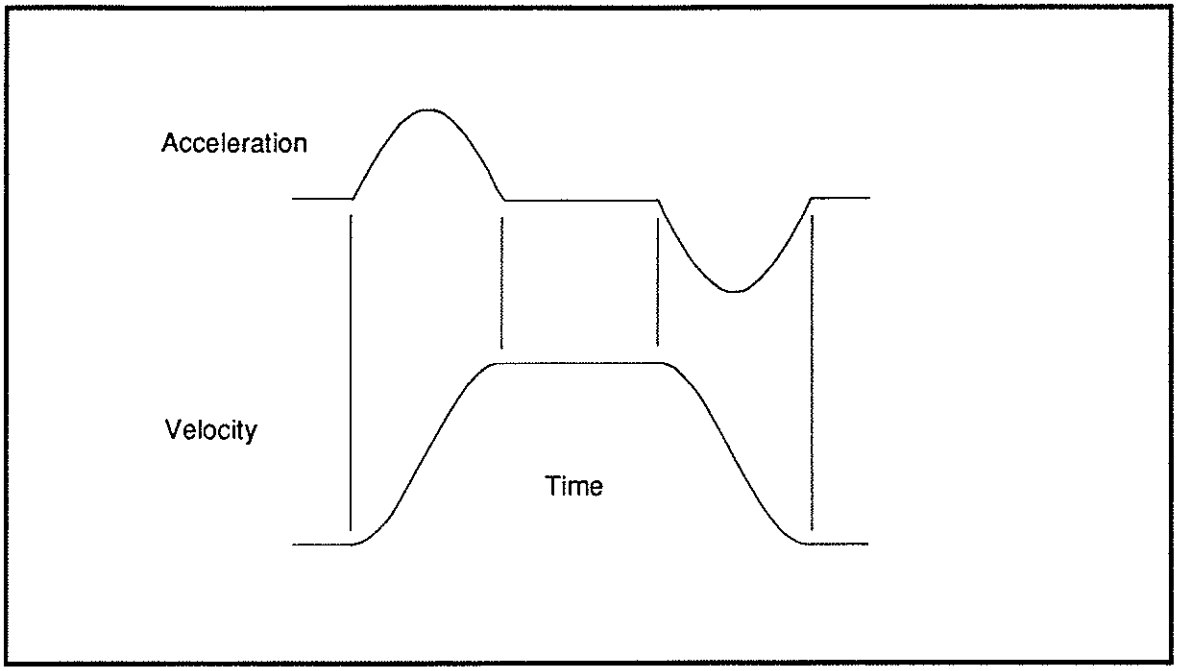


Figure 1-3 COSINE VELOCITY PROFILE

and the distance traveled in the ramp is:

$$s = \frac{V_p}{2}t - \frac{V_p^2}{4A_m}\sin\frac{2A_m}{V_p}t$$

where V_p is the peak velocity, A_m is the peak acceleration. The distance needed to ramp up is then:

$$S_1 = \frac{\pi V_p^2}{4A_m}$$

and the time required to ramp up is:

$$T = \frac{\pi V_p}{2A_m} = \sqrt{\frac{\pi S_1}{A_m}}$$

and the peak velocity is:

$$V_p = \sqrt{\frac{4A_m S_1}{\pi}}$$

The cosine ramp requires $\frac{\pi}{2}$ times longer than a linear ramp to reach the same velocity when using the same peak acceleration.

Since the purpose of the cosine ramp is smooth operation, it is desirable to adjust the velocity parameters such that the desired profile is achieved even when the stage does not reach the programmed speed as opposed to truncating the curve as the parabolic

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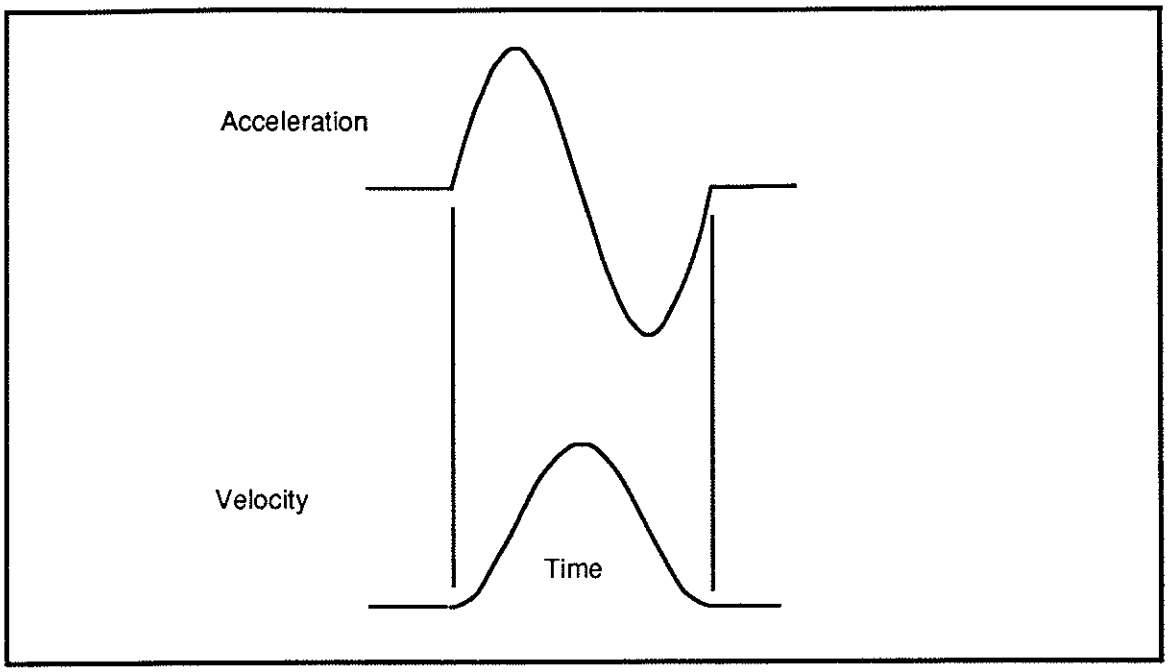


Figure 1-4 SHORT MOVE COSINE VELOCITY PROFILE

modes do. The OMS controls look ahead to determine if the stage will be able to reach speed in the programmed move. If not, the acceleration curve will be adjusted such that the peak acceleration will be the programmed acceleration and the acceleration curve will be 360 degrees of a sine wave (see Figure 1-4).

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2. GETTING STARTED

2.1. INTRODUCTION

The VMEX board requires one full width slot in the VME card cage. In most cases the jumpers on the VMEX board will not have to be changed assuming there are no address or interrupt conflicts with existing boards. The factory default settings for the board have it using a block of 16 contiguous address from FF80 to FF8F in the short address space. If these do not conflict with any previously installed hardware in your computer you will not need to change any jumpers on the VMEX board.

2.2. JUMPERS

There are five blocks of square pin jumpers on the VMEX board. These can be thought of as 3 logical groups: board address selection jumpers, J47 and J48; interrupt selection jumpers, J40 and J49; and limit polarity jumper, J57. See Figure 3-1 for the locations of the jumpers. Recommended jumpers are Molex part number 90059-0007 or equivalent.

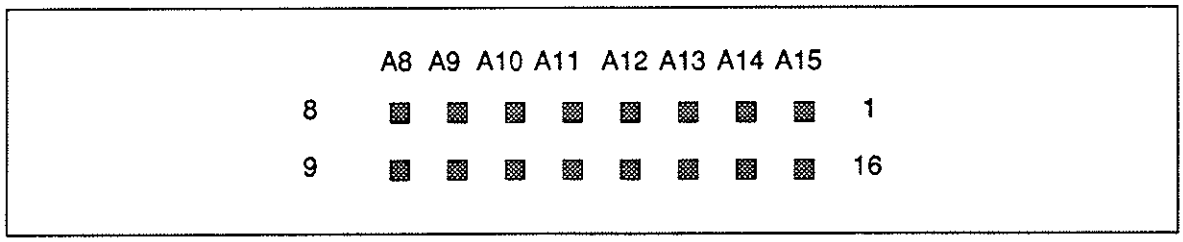


Figure 2-1 J48 ADDRESS SELECT 1 (default setting)

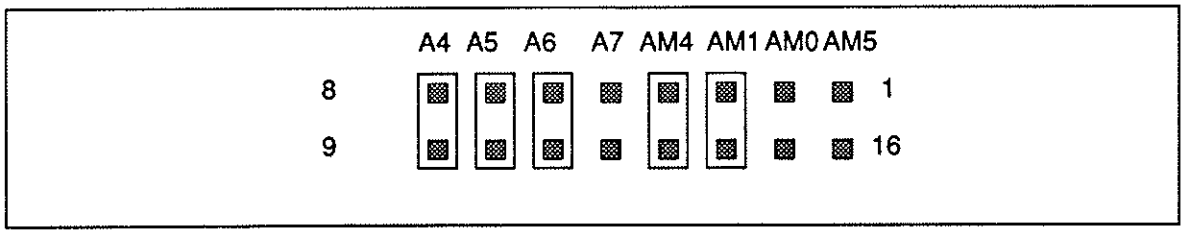


Figure 2-2 J47 ADDRESS SELECT 2 (default setting)

2.3. ADDRESS SELECTION

The VMEX uses a 16 byte block of short address memory. The starting address for this block is selected by square pin jumpers on the board. A jumper across a pair of pins indicates that the bit is a 0, without the jumper the bit is a 1. To decide on jumper settings, choose your starting address. Address lines A0 through A3 are decoded by the VMEX

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board and for base address selection are assumed to be 0. To set the board for the factory default address of FF80, jumpers for address lines A15, A14, A13, A12, A11, A10, A9 and A8 on J48 and A7 on J47 should be absent, selecting a 1 for those lines. Jumpers should be placed on A6, A5 and A4 on J47, selecting a 0 for those lines.

The VMEX allows selection from several address modifier values. Lines AM0, AM1, AM4 and AM5 are user selectable by square pin jumpers on J47. AM2 is always selected as low and AM3 is always selected as high. The hex code for the default address modifier setting is 29 hex. This allows Short Non-Priveleged Access to the VMEX board.

To select this default value a jumper must be placed on lines AM1 and AM4 to decode them when they are low, no jumper should be on AM0 and AM5 so they will be decoded when high.

2.4. INTERRUPT SELECTION

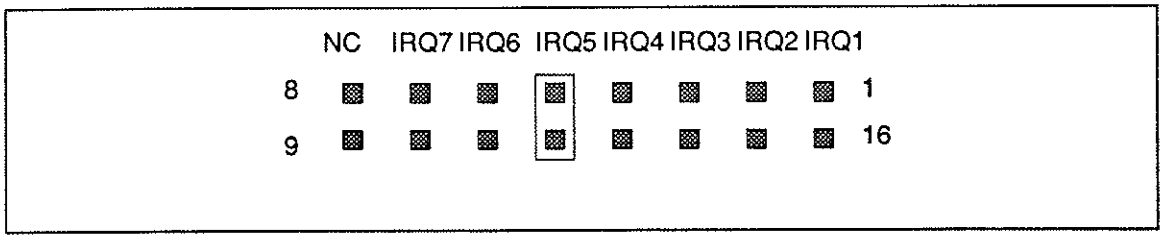


Figure 2-3 J40 INTERRUPT SELECT 1 (default setting)

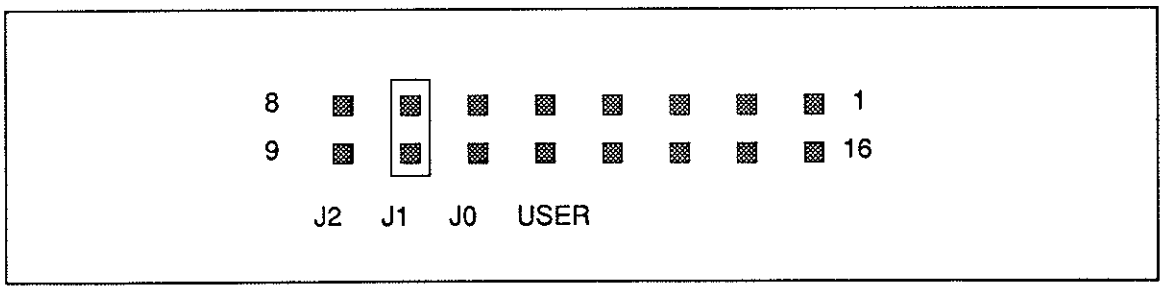


Figure 2-4 J49 INTERRUPT SELECT 2 (default setting)

Two sets of jumpers are used to select which VME bus interrupt signal is used by the VMEX board, J40 and J49. J40 selects to which interrupt request line the VMEX board is wired and J44 selects on-board logic to properly generate the interrupt.

To jumper the board to a given interrupt, place a square pin jumper across the appropriate pin pair on J40, then using the binary equivalent of that interrupt number, place jumpers on J49, J0, J1 or J2 pin pairs, where the desired bit should be a 0.

For example, the factory default interrupt line is IRQ5. To jumper the board for this, place a square pin jumper across pins 5 and 12 of J40. Next, figure the binary equivalent of 5, which is 101. This means that J2 (pin pair 3 and 6) of J49 should have no jumper since bit 2 of 101 is a 1, J1 (pin pair 4 and 5) should have a jumper since bit 1 is a 0, and J0 (pin pair 2 and 7) should have no jumper since bit 0 is a 1.

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2.5. LIMIT POLARITY SELECTION

J57 determines whether the limit inputs to an individual axis are active low or active high. With the jumper in place, the associated axis will stop moving if the limit line, for the direction the axis is moving, is switched to the active voltage level. With the jumper removed, the axis will stop if the limit line is switched +5VDC. These lines are internally pulled-up with a 2.2K Ohm resistor to +5VDC so the opening and closing of a switch to ground can control the limit input signals.

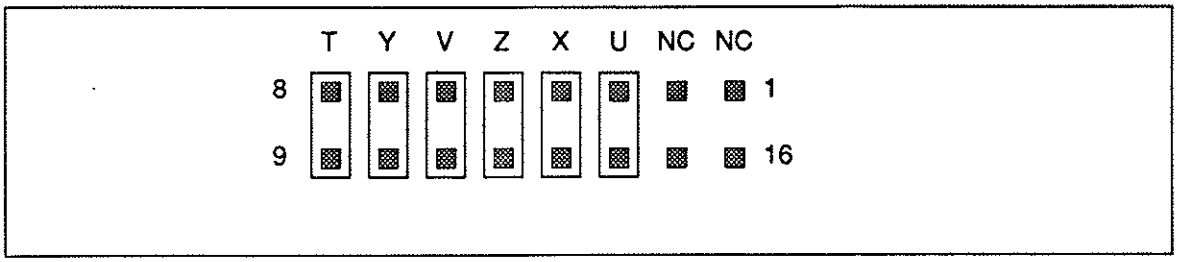


Figure 2-5 J57 LIMIT POLARITY

Factory defaults for J57 set the limits inputs to active low. This requires jumpers on all six pairs of pins for the six axis (VMEX-6) versions.

2.6. MOTOR CONTROL CONNECTOR

The motor control connector (P2) on the VMEX board consists of three rows of pins labeled A, B and C. Each row has 32 pins for a total of 96 pins. The A and C rows contain the motor control lines and encoder inputs.

The motor control lines can be considered as 6 logical sets of 8 pins. Each set is used for an individual axis. The 8 pins of an axis set are: Step Output, +5VDC Output, Auxiliary Output, Direction Output, Negative Limit Switch Input, Ground, Home Switch Input and Positive Limit Switch Input.

The encoder inputs use two sets of 8 pins on the connector as encoder inputs for the X and Y axes. The 8 pins of an encoder pin set are: Index +, +5VDC, Phase A-, Phase A +, Index -, Ground, Phase B -, Phase B +.

See Section 4 for more information on the motor control connector.

2.7. HARDWARE INSTALLATION

1. Turn off power to your computer and disconnect its power cord.

2. Remove the computer's cover.

3. Choose an empty expansion slot in the VME rack and backplane and remove its associated metal cover if one exists.

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4. Slide the VMEX board into the rack and connector, ensuring the board is lined up correctly in the card guides and in the connector.

5. Double check the board to ensure it is properly seated in the connector.

6. Screw the front panel of the VMEX board into the card cage.

7. Replace the cover of the computer.

8. Replace the power cord and turn the computer on.

9. Allow the computer to boot up.

10. To ensure that the VMEX is set up for the proper address, try to read and write a byte to the VMEX's interrupt vector register at short address FF89 (default). See if the value written to it is the same one read back.

11. Using your favorite debug utility, output the following two bytes to the short address FF81 (the VMEX data register default address): 0x57 0x59. These are the hexidecimal equivalents to W and Y. The VMEX board will respond by outputting its board name and firmware version to the data register. If you read the input from the data register (FF81) one byte at a time, you should get the hex equivalent to the ASCII characters: VMEX ver 1.87-4E, which are: 0A 0D 56 4D 45 58 20 76 65 72 20 31 2E 36 30 2D 34 45 0A 0D. If you do, the board is working correctly. If not, recheck the board's jumpers to ensure that they are correct. If the board still fails to work contact Oregon Micro Systems, Inc. for further assistance.

12. Connect the motor drivers and encoders to P2 (see Section 4).

13. Send motion control commands to the VMEX board and see that the motors move. If not, double check your wiring, ensuring that everything is properly connected.

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3. VME BUS INTERFACE

3.1. VME BUS

The VME bus specification allows for a number of different interface complexity options. The VMEX supports the D08(O) short address in either supervisory or non-privileged mode as specified by the VME specification C.1. The base address is jumper selectable to allow positioning the board anywhere in the short address space. VME interrupts are supported at any level. Table 3-1 describes the VME bus interface.

The VME bus P2 connector row B is used to decode additional address bits for 32 bit data transfers and extended addressing in the VME bus specifications. The VMEX does not support either and thus these pins are unused.

3.1.1. DATA BUS

The data bus is a 32 bit, bidirectional, 3-state bus. Direction of data is controlled by the VME bus master. The data bus uses high-level active logic. The VMEX supports only 8 bit odd address transfers.

3.1.2. ADDRESS BUS

The address bus is a 32-bit high-level active bus. This bus is always driven by the VME bus master. The address bus provides the 32 address lines for decoding memory. I/O is memory mapped on the VME bus. The direction of transfer is determined by the state of the write* line which is driven by the current bus master.

3.1.3. CONTROL LINES

The control lines provide the signals for fundamental memory (or I/O operations). They control the size and direction of transfers.

3.1.4. SYSRESET

The Sysreset is a reset driver which is provided on the bus. The VMEX has an on board reset timer and thus uses this signal only to initiate this timer at power up or during a system reset.

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Table 3-1 VME BUS P1 PIN LIST

PIN	ROW C	ROW B	ROW A
1	D08	BBSY*	D00
2	D09	BCLR*	D01
3	D10	ACFAIL*	D02
4	D11	BG0IN*	D03
5	D12	BG0OUT*	D04
6	D13	BG1IN*	D05
7	D14	BG1OUT*	D06
8	D15	BG2IN*	D07
9	GROUND	BG2OUT*	GROUND
10	SYSFAIL*	BG3IN*	SYSCLK
11	BERR*	BG3OUT*	GROUND
12	SYSRESET*	BR0*	DS1*
13	LWORD*	BR1*	DS0*
14	AM5	BR2*	WRITE*
15	A23	BR3*	GROUND
16	A22	AM0	DTACK*
17	A21	AM1	GROUND
18	A20	AM2	AS*
19	S19	AM3	GROUND
20	A18	GROUND	IACK*
21	A17	SERCLK	IACKIN*
22	A16	SERDAT	IACKOUT*
23	A15	GROUND	AM4
24	A14	IRQ7*	A07
25	A13	IRQ6*	A06
26	A12	IRQ5*	A05
27	A11	IRQ4*	A04
28	A10	IRQ3*	A03
29	A09	IRQ2*	A02
30	A08	IRQ1*	A01
31	+12VDC	+5VDC STDBY	-12VDC
32	+5VDC	+5VDC	+5VDC

* low-level active indicator

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3.2. BOARD ADDRESS SELECTION

The VMEX occupies a block of 16 contiguous addresses. The factory default address is FF80 through FF8F hex in the short address space. Refer to Figure 3-1 for configuration of jumpers.[1]

The actual address is chosen by jumpers on J47 and J48. Connecting a jumper selects a binary 0 for that address bit, while no jumper selects a binary 1. The factory default base address of FF80 (hex) is shown in Section 2.

3.3. USING INTERRUPTS

Full interrupt capability is provided in accordance with the VME specification. Interrupts for input buffer full, transmit buffer empty, overtravel fault and operation complete are provided. Interrupt levels 1 through 7 are jumper selectable. Polled operation is also supported with separate status bits for each of the above sources. Table 3-2 shows the detail of the level select jumpers.

Table 3-2 INTERRUPT LEVEL SELECTION JUMPERS

LEVEL	J40 PINS	J49 PINS		
IRQ1	1 - 16		7 - 10	8 - 9
IRQ2	2 - 15	6 - 11		8 - 9
IRQ3	3 - 14			8 - 9
IRQ4	4 - 13	6 - 11	7 - 10	
IRQ5	5 - 12		7 - 10	
IRQ6	6 - 11	6 - 11		
IRQ7	7 - 10			

3.4. VMEX REGISTERS

The VMEX occupies 16 contiguous addresses in I/O space but is responsive to only the odd addresses in this space. The registers associated with each address are described in Table 3-3.

3.4.1. DATA REGISTER

The data register is the data communication port between the VMEX and the VME bus master. All data is passed between the two processors through this port. This port is double buffered in both directions allowing data to be written to the port before the previous byte has been read and processed. This allows for faster processing of the data between the two microprocessors.

1 The jumpers are wire-wrap posts which can be shorted with a shorting plug or by wire-wrapping. For additional shorting plugs see Molex Corp. part number 90050-0007.

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Table 3-3 VMEX REGISTER DESCRIPTION

ADDRESS OFFSET	FACTORY DEFAULT	DESCRIPTION
1	FF81 Hex	Data Register
3	FF83 Hex	Done Flag Register
5	FF85 Hex	Control Register
7	FF87 Hex	Status Register
9	FF89 Hex	Interrupt Vector
11	FF8B Hex	Unused
13	FF8D Hex	Unused
15	FF8F Hex	Unused

3.4.2. DONE FLAG REGISTER

The done flag register is a read only register from the VMEX. The status bit indicating the done status of each axis is written by the 68000 on the VMEX. The host can then read it at any time to determine the status of the motion process. It is cleared by reading the register. The bit definition is shown in Table 3-4.

Table 3-4 DONE REGISTER STATUS BITS

BIT	DESCRIPTION
0	Done Status of X Axis
1	Done Status of Y Axis
2	Done Status of Z Axis
3	Done Status of T Axis
4	Done Status of U Axis
5	Done Status of V Axis
6	Unused, Always 0
7	Unused, Always 0

3.4.3. INTERRUPT CONTROL REGISTER

The interrupt control register allows different interrupt sources from the VMEX to be individually enabled or disabled. A write to this register will change the enabled interrupts at any time. The register may be read back to verify or determine the state of the interrupts at any time.

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Table 3-5 CONTROL REGISTER BIT DEFINITION

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

3.4.4. STATUS REGISTER

The status register is a read only register that provides status information to the host CPU. This status is independent of the enable status of the interrupt, allowing the board to operate in a polled mode, if desired.

In order to resolve the source of a done or error interrupt, the DON_S bit (bit 4) should be read first. This bit in the status register is automatically reset upon reading the status register. If the DON_S flag is true, the error bits should be read to determine if the interrupt was caused by an error condition. If no error condition is present, the done flag register can be read to determine which axes are done. An "IC" command (or Control-Y is preferred) should then be given from within the interrupt service routine or poll routine to reset the done flag register and error bits. The TBE_S bit is reset by writing to the data register and the IBF_S bit is reset by reading the data register. Both bits may remain true after a single read or write since the data port is double buffered and may still remain ready for data.

The error bits, CMD_S, ENC_S and OVRT may also be cleared by sending a Control-X (ASCII value 0X18). This will reset these bits in the status register without altering the state of the done flags. The INIT bit only goes high when the board is initializing and cannot communicate. It will go low and remain low when initialization is complete.

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Table 3-6 STATUS REGISTER BIT DEFINITION

BIT	NAME	DESCRIPTION
7	IRQ_S	Interrupt request status. Bit 7 is the logical OR of bits 4 through 6. It is high when an interrupt is being requested or indicates a request for service in a polled mode.
6	TBE_S	Transmit buffer empty status. This high true bit indicates a character may be written to the transmit buffer.
5	IBF_S	Input buffer full status. This high true bit indicates a character is available in the input buffer.
4	DON_S	Done or error status. This high true bit indicates the command is complete (i.e. an ID command has been executed) or an error has been detected. If bits 0-3 are all false it indicates a command completion. Error bits indicate one or more errors have been detected.
3	OVRT	Overtravel. An overtravel switch was true indicating attempted travel out of bounds.
2	ENCODER	Encoder request. This bit indicates that the encoder option is requesting service.
1	INIT	High during reset then low.
0	CMD_S	Command error. An unrecognizable command has been detected or LS and LE commands are not in matched pairs.

3.4.5. INTERRUPT VECTOR REGISTER

The interrupt vector register is a byte wide read/write register. The host may write the desired vector into this register at an time. It will be returned during an interrupt acknowledge when this VMEX board is the highest priority board in the system at the selected priority level.

3.5. POWER SUPPLY REQUIREMENTS

The VMEX is designed to operate from the power supplied in the VME bus backplane. The host computer or expansion box must be capable of supplying 2.21 amps typical for operation of the VMEX board.

CAUTION:

Under no circumstances should the card be installed in the computer with the power on.

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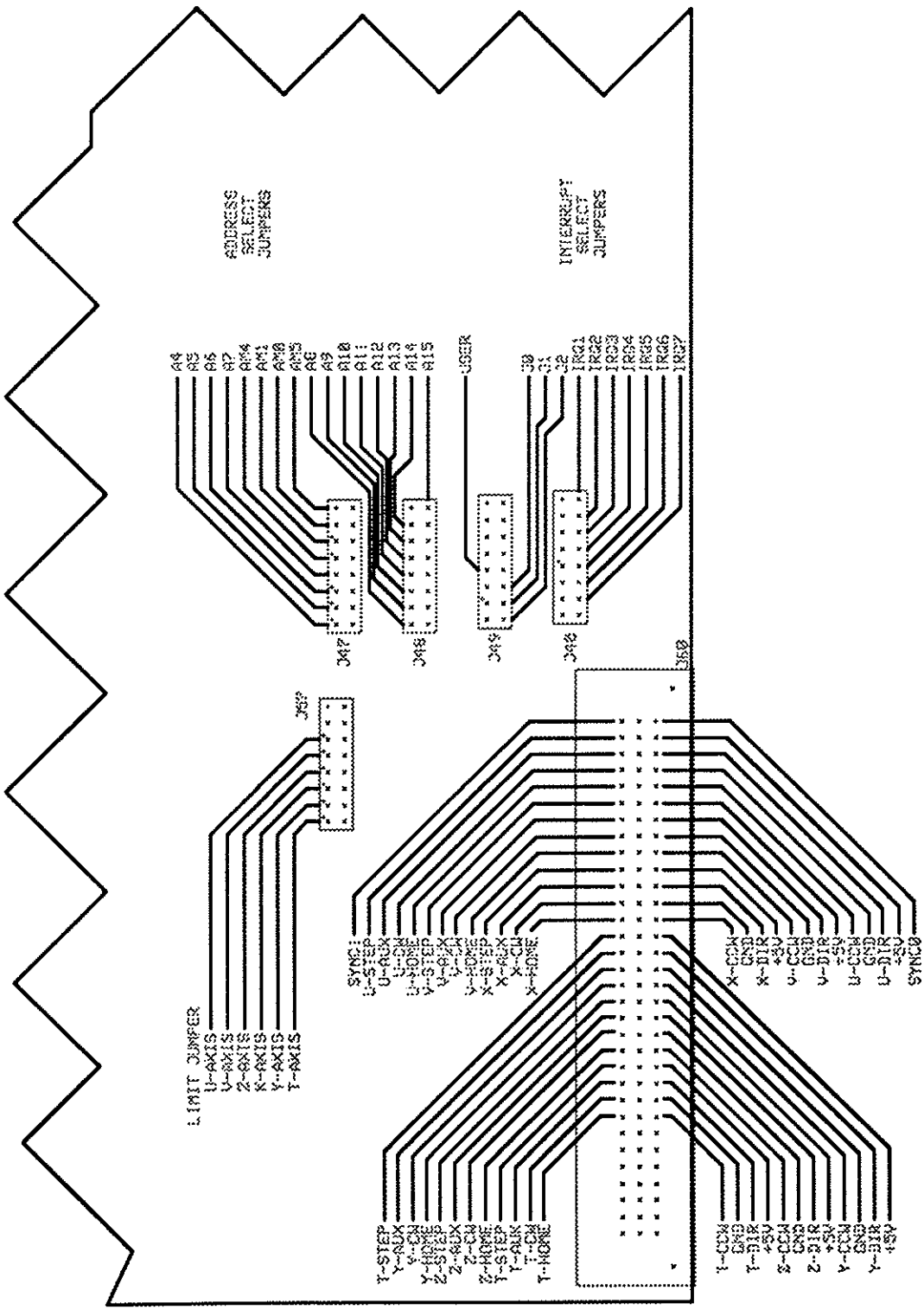


Figure 3-1 VMEX OPTION JUMPER LOCATION

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4. DRIVER INTERFACE

4.1. OUTPUT CONNECTION

Table 4-1 lists the input and output interface signals available at output connector P2 on each VMEX board. The table is shown as seen looking at the end of the connector.

Table 4-1 P2 CONNECTOR PIN ASSIGNMENTS

PIN	ROW C FUNCTION	ROW A FUNCTION
1	Sync 1 Input	Sync 0 Input
2	U Step Output	+5VDC
3	U Auxiliary Output	U Direction Output
4	U Negative Limit Switch	Ground
5	U Home Switch	U Positive Limit Switch
6	V Step Output	+5VDC
7	V Auxiliary Output	V Direction Output
8	V Negative Limit Switch	Ground
9	V Home Switch	V Positive Limit Switch
10	X Step Output	+5VDC
11	X Auxiliary Output	X Direction Output
12	X Negative Limit Switch	Ground
13	X Home Switch	X Positive Limit Switch
14	Y Step Output	+5VDC
15	Y Auxiliary Output	Y Direction Output
16	Y Negative Limit Switch	Ground
17	Y Home Switch	Y Positive Limit Switch
18	Z Step Output	+5VDC
19	Z Auxiliary Output	Z Direction Output
20	Z Negative Limit Switch	Ground
21	Z Home Switch	Z Positive Limit Switch
22	T Step Output	+5VDC
23	T Auxiliary Output	T Direction Output
24	T Negative Limit Switch	Ground
25	T Home Switch	T Positive Limit Switch

Refer to Section 5 for pin assignments on VMEX boards with the encoder option.

A separate 4-conductor shielded cable should be used for each axis for the connections to its associated driver module and must be limited to 50 feet. A connection to the VME

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bus +5VDC power is provided for each axis to supply power to the emitter diode within an opto-isolated motor driver module, such as the MH10. This allows the use of such drivers without the need for an external power supply.

CAUTION:

> This power supply connection must not be connected to any other supply or used for any other purpose or damage may result to the host computer or VMEX or both.

A ground connection is provided for each axis for convenience in connecting up the system. The VMEX is supplied with 7406 open collector TTL drivers as standard. These parts are in sockets and can be replaced with 7404 totem pole drivers for driver modules which do not have opto-isolated inputs. Each device handles the step, direction and auxiliary output for two axes. The cable shields should be connected to the appropriate ground pins as

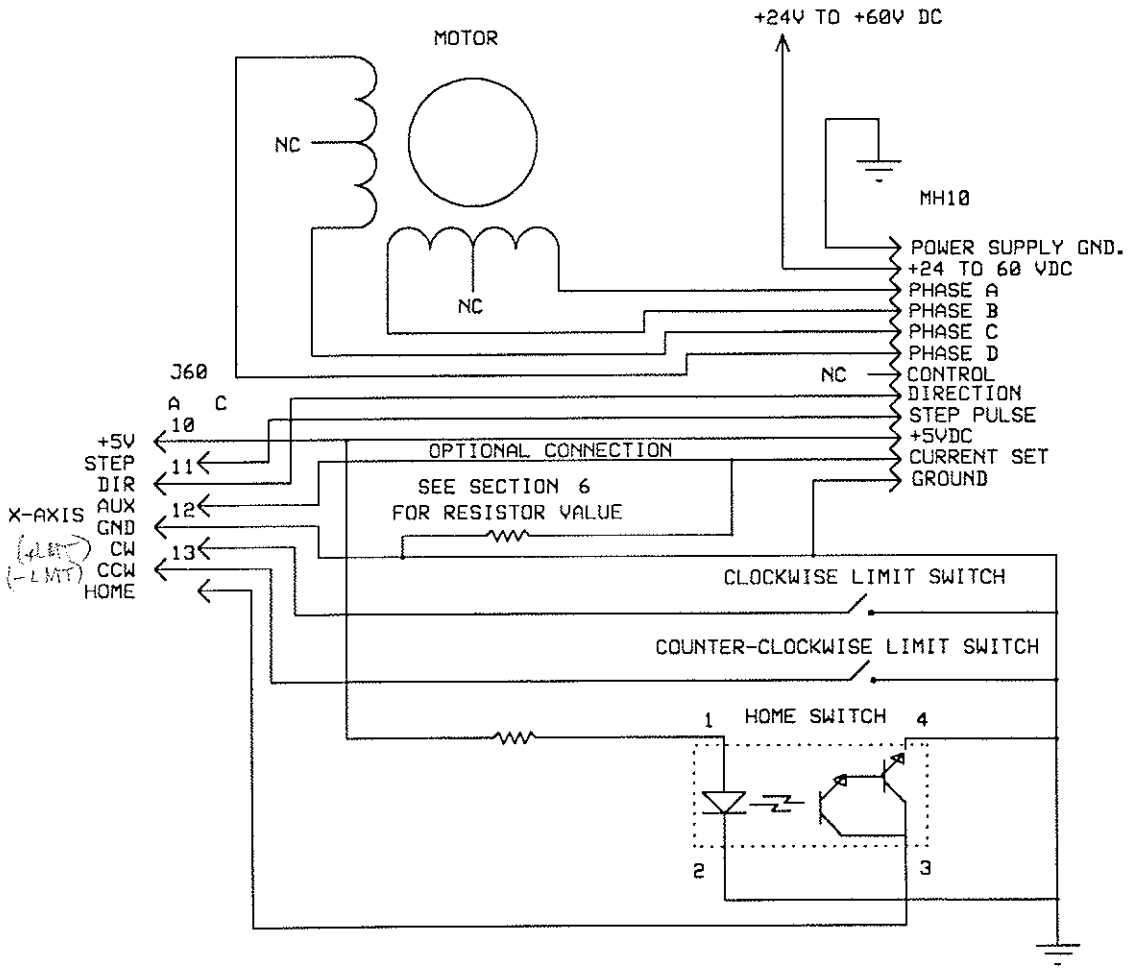


Figure 4-1 VMEX/MH10 INTERCONNECTIONS

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shown in Table 4-1, and left open at the driver end when used with opto-isolated loads to avoid ground loops and ensure isolation.

4.2. MULTI-AXIS SYNCHRONIZATION

Each VMEX has provision for synchronizing several VMEX boards or other OMS VME family motion control boards to drive larger systems. Systems requiring more than 6 axes and thus more than one VMEX can be synchronized by connecting an auxiliary output on one board to the sync input on the other board. The boards can signal each other at the appropriate place in the command stream without interrupting the host computer. Synchronization can be accomplished with other devices as well.

4.3. LIMIT AND HOME LINES

The limit and home lines can be activated using mechanical switches using contact closures or other suitable active switches, such as a hall effect switch or opto-isolator, that connect the line to ground. The limit switch closure will stop the associated pulse stream if the motor travels beyond its allowable limits and trips the switch. The home switch provides a means to synchronize the motor controller with the load at some home or reference position. The home switch, when used with the software HM command, will cause the motor to stop when the switch closes. On finding the home position the internal position counters will be initialized. The sense of the home switches may be changed to true when open, if desired, by use of the HH command. The limit switches may be changed to true when open, if desired, by removing the jumper on J57. Figure 4-1 shows a typical connection between a VMEX board and a motor using an OMS MH10 motor driver.

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5. ENCODER OPTION

5.1. INTRODUCTION

The encoder feedback option is intended primarily for applications where desired positional accuracy exceeds the accuracy of the mechanical drive components, such as lead screws, or where position feedback is required to detect motor slip or stall.

The encoder option accepts quadrature pulse outputs from high resolution optical encoders. Very high resolution encoders may be used while the indexers are generating pulses at their maximum rate. This allows position feedback information to match the resolution to the microstepping motor drive. Two axes may be configured for encoder feedback on each VMEX-2E or VMEX-4E board.

5.2. MODES OF OPERATION

The VMEX-2E or VMEX-4E can monitor the actual position through the encoder pulse train. It can then correct for position errors due to system backlash or mechanical tolerances or report slip or stall of the motor to the host. A tracking mode is also provided which allows one axis to track the activity of another axis or positioning device. These options are selectable by the user through software commands.

5.3. ENCODER SELECTION AND COMPATIBILITY

The VMEX with Option E is compatible with virtually any incremental encoder which provides quadrature outputs. Times four quadrature detection is used to increase resolution. The inputs are compatible with encoders which have single ended TTL outputs as well as differential line drivers. Provisions are also provided for an index pulse (differential or single ended) and an index enable for systems requiring more than one revolution of travel and thus multiple index pulses from the encoder. A biasing network is provided on the board for termination of unused encoder inputs.

The user can specify the encoder count/motor count ratio for position maintenance and encoder tracking mode. This ratio is handled internally in floating point format and can be virtually any ratio. Slip detection requires that the encoder resolution (after the 4X quadrature detection) match the motor resolution.

5.4. ENCODER INTERFACE

The encoder connections are as shown in Table 5-1.

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Table 5-1 P2 PIN ASSIGNMENTS FOR ENCODER OPTION

PIN	ROW C FUNCTION	ROW A FUNCTION
1	Sync 1 Input	Sync 0 Input
2	X Index +	+5VDC
3	X Phase A-	X Phase A+
4	X Index -	Ground
5	X Phase B	X Phase B+
6	Y Index +	+5VDC
7	Y Phase A-	Y Phase A+
8	Y Index -	Ground
9	Y Phase B-	Y Phase B+
10	X Step Output	+5VDC
11	X Auxiliary Output	X Direction Output
12	X Negative Limit Switch	Ground
13	X Home Switch	X Positive Limit Switch
14	Y Step Output	+5VDC
15	Y Auxiliary Output	Y Direction Output
16	Y Negative Limit Switch	Ground
17	Y Home Switch	Y Positive Limit Switch
18	Z Step Output	+5VDC
19	Z Auxiliary Output	Z Direction Output
20	Z Negative Limit Switch	Ground
21	Z Home Switch	Z Positive Limit Switch
22	T Step Output	+5VDC
23	T Auxiliary Output	T Direction Output
24	T Negative Limit Switch	Ground
25	T Home Switch	T Positive Limit Switch

If single ended encoders are used, the unused line receiver inputs must be externally biased at +1.5VDC.

5.5. HOME PROCEDURES

Two logical inputs are provided to synchronize the physical hardware with the VMEX controller, i.e. put the controlled motor in the home position.

The VMEX home inputs can be used with encoders which provide one home pulse for the complete travel of the stage. This signal can be either a logic high or logic low true by using the HH and HL commands. The HM or HR commands are used after reducing the velocity to no more than 1024 pulses per second. This limit on velocity is necessary to avoid ambiguity of the home position if more than one pulse occurs per sample interval.

The index input on VME bus P2 uses internal logic to establish the home position when used with the HE command mode. This position consists of the logical AND of the encoder

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index pulse, the home enable external input (low true only) and a single quadrant from the encoder logic. The home enable pulse must be true for less than one revolution of the encoder thus allowing only one home for the complete travel of the stage. The home logic expressed in boolean terms is:

$$home = phase_A * /phase_B * index * /home_switch$$

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

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6. MD10A AND MH10 DRIVER MODULES

6.1. GENERAL DESCRIPTION

The Oregon Micro Systems model MD10A and MH10 microstepping motor drive modules are designed to run hybrid permanent magnet step motors. The MD10A can drive motors with current ratings between 0.75 and 7.2 amps per phase while the MH10 can operate motors from 1.5 to 14 amps per phase. Motor current regulation is achieved by a high efficiency pulse width modulator (PWM) circuit using power MOSFETs. This results in a cooler running motor with less wasted energy.

Microstepping is a major feature of these drivers. Each motor step is divided into ten substeps called microsteps. As a consequence, a 200 step per revolution motor turns into a 2000 step per revolution motor when driven by the MD10A or MH10. For positioning applications this can mean a ten-fold improvement in resolution in the user's system. A secondary benefit of microstepping is the elimination of low speed resonance and vibration. This is especially noticeable at speeds below 300 full steps per second.

The step pulse rate going to the microstepping drivers will have to be ten times higher in frequency than it would be for a full step drive to get the same angular move or RPMs. This would mean a step pulse generator would have to output 400,000 pulses per second to run the motor at 40,000 full steps per second.

The MD10A and MH10 utilize all of the motor's windings simultaneously instead of half of them as a conventional controller does. The result is a much cooler running motor. These drivers also offer a wide power supply voltage range. This allows the control to be tailored to the application with a minimum of wasted energy. For low speed applications (0 to 5,000 full steps per second), the lower end of the power supply voltage range provides best performance, while the high end of the range is preferred for high speed (up to 40,000 full steps per second) operation. The current requirements will typically be 1/3 of the motor's per phase current rating when operated in the series connection or 2/3 of the motor's per phase current rating when operated in the parallel mode. The power supply for the driver need not be regulated because the driver's PWM circuitry regulates the motor current.

Under most conditions the MD10A does not require a heat sink. It is sufficient to bolt it down to a chassis or metal plate in the user's system using a thermal heat transfer compound. The MH10 requires a heat sink when operated at the higher currents. The small size of these driver modules and absence of any adjustments allows them to be mounted in locations too small or too inaccessible for other drivers.

6.2. DRIVER CONNECTOR DESCRIPTION

There are twelve terminal connections on the MD10A and MH10. Figure 6-1 shows a typical connection setup.

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6.2.1. LOGIC GROUND

This terminal (pin #12) should be used for the low level logic return or ground. It is the same potential as supply ground (pin #1) and is provided as a user convenience. If the logic ground is connected to the power supply ground elsewhere in the user's system, then it is not necessary to use this terminal. To ensure isolation from the host computer this connection should NOT be connected to the step pulse source (VMEX board). The cable shield from the VMEX should NOT be connected to the driver.

6.2.2. CURRENT SET

This terminal (pin #11) is used to set the motor current level, matching the driver's current supply capability to the needs of the user's motor. A single 1/4 watt resistor connected between the current set terminal and logic ground is all that is required. The proper resistor value is selected from Tables 6-1 and 6-2. If a 6 or 8 wire motor is to be series connected use the series column, otherwise use the parallel column for parallel connected or 4 wire motors. The parallel column is the current actually delivered by the driver. The series column is provided for convenience in calculating the resistor value for the series connected case. Match the motor's per phase current to the closest listed value, then pick the resistor value associated for that current. If the motor current falls between the table entries, then interpolate between the entries or use the larger of the two resistor values. Note that most motor manufacturers rate their motors in unipolar current per phase. The MD10A and MH10 are bipolar drivers. The bipolar rating is $\sqrt{2}$ times the unipolar rating and the bipolar series connection would use a current of $\frac{\sqrt{2}}{2}$ times the unipolar rating. Note that the factor of 2 is already taken into account in the series ratings in Tables 6-1 and 6-2.

An optional use for the current set terminal is to set a lower, standby current while the motor is stopped, or shut off the motor current altogether. This is illustrated in Figure 6-1. A standby current can be set by switching another resistor in parallel with the current set resistor. The standby current will be equivalent to the resulting parallel-wired resistor. The following example will illustrate operating a 4 amp per phase motor at 1.5 amps standby:

A 4 amp per phase motor needs a 68k current set resistor with the MD10A. To reduce the current to 1.5 amps per phase standby, the current set resistor must be the equivalent of 12k. The value of the resistor to be wired in parallel with the 68k current set resistor is calculated as follows:

$$68k \times 12k / (68k - 12k) = 14.57k \text{ or } 15k$$

This resistor can be switched in or out with a relay, transistor or an open collector gate such as a 7406 or 7407. The motor can be shut off entirely by shorting the current set terminal to logic ground. This can also be done with a 7406 or 7407 TTL inverter as provided on the auxiliary output of the OMS controllers. If this is done, however, there will no longer be electrical isolation between the driver and the VMEX.

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Table 6-1 MD10A CURRENT SET RESISTOR VALUES

AMPS/PHASE SERIES	AMPS/PHASE PARALLEL	RESISTOR
1.5	0.75	12K
2.0	1.0	15K
2.5	1.25	27K
3.0	1.5	33K
3.5	1.75	47K
4.0	2.0	68K
4.5	2.25	82K
5.0	2.5	120K
5.5	2.75	180K
6.0	3.0	270K
6.5	3.25	360K
7.0	3.5	1.3M

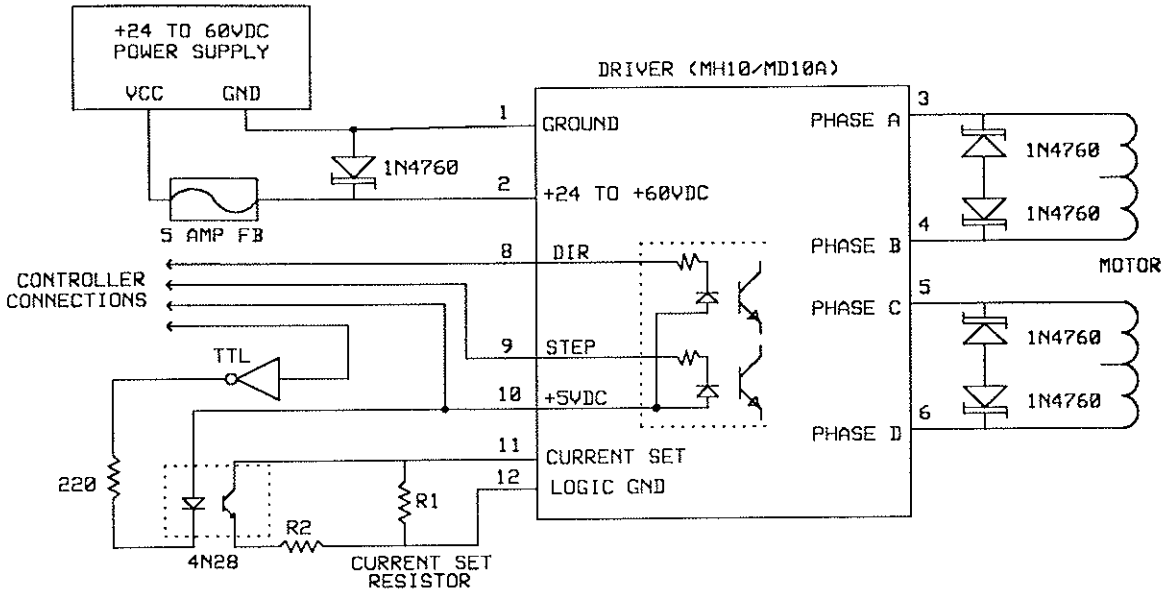
Table 6-2 MH10 CURRENT SET RESISTOR VALUES

AMPS/PHASE SERIES	AMPS/PHASE PARALLEL	RESISTOR
3.0	1.5	12K
4.0	2.0	15K
5.0	2.5	27K
6.0	3.0	33K
7.0	3.5	47K
8.0	4.0	68K
9.0	4.5	82K
10.0	5.0	120K
11.0	5.5	180K
12.0	6.0	270K
13.0	6.5	360K
14.0	7.0	1.3M

6.2.3. +5 VOLT DC

This terminal (pin #10) requires +5VDC from an external source to power the emitter diode in the opto-isolators in the MD10A and MH10.

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NOTE: R2 FOR STANDBY MODE, SHUTOFF MODE WHEN R2 = 0.

Figure 6-1 MD10A CURRENT CONTROL

CAUTION

Do not attempt to operate the MD10A or the MH10 without a current set resistor if the motor rating is below the maximum rating of the driver. Both models of the drivers default to their maximum current and can damage motors with current ratings substantially less than this current level.

6.2.4. DIRECTION

The direction input (pin #8) is an opto-isolated input on the MH10 and the MD10A. It determines the direction the motor will turn when step pulses are applied to the step input terminal. A sink current of greater than 20 ma. will result in a clockwise move on a step pulse input, while any current below 12 ma. will result in a counterclockwise move.

The logic level on this input should not be changed for 20 microseconds after a step pulse active edge to insure the correct step direction. If the direction logic level is changed less than 20 microseconds after a step pulse high to low transition, the direction for the step is undetermined.

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The logic level on this input may be changed at any other time as often as the user wishes. No motor motion will result until a step pulse is applied, then the direction of the motor for that microstep will be set by what logic was present at the moment the step edge occurred.

6.2.5. STEP PULSE

The step pulse (pin #9) input causes the step motor to move one step (microstep) for each input pulse. The direction of the move is set by the logic level on the direction input. The step pulse rise and fall times for this input should each be less than 1 microsecond, otherwise more than one microstep per step pulse may occur. This is an opto-isolated input with the same characteristics as the Direction input.

6.2.6. MOTOR DRIVE TERMINALS

These four terminals (pins #3, 4, 5 & 6) are the step motor outputs. Table 6-3 illustrates the most common wire color codes.

Table 6-3 MOTOR MANUFACTURER'S COLOR CODE

	CONNECTION TO MD10A/MH10 CONNECTOR NUMBER			
MANUFACTURER	**#3**	**#4**	**#5**	**#6**
RAPIDSYN	Red	Red/White	Green	Green/White
SUPERIOR	Red	Red/White	Green	Green/White
SIGMA	Black	Orange	Yellow	Red
BODINE	Brown	Orange	Yellow	Red
ORIENTAL	Blue	Red	Black	Green

The MD10A and MH10 can drive 4, 6 and 8 wire step motors. The hookup considerations for each is as follows:

4 WIRE MOTORS: This motor has the simplest hookup requirements. The motor has two windings, with a pair of wires brought out for each winding. One winding's lead wires go to Term 3 and Term 4, while the other winding's lead wires connect to Term 5 and Term 6. Use the parallel connection current set values in Tables 6-1 and 6-2.

If the user is unsure of which wires are common to one winding, an ohm-meter can be used. The wire pairs that have continuity between them constitute a winding.

With step motors it is not particularly important which wire of a winding pair goes to which terminal of a terminal pair; the motor will run in any case. The motor can be reversed by switching the two connections of one winding.

6 WIRE MOTORS: This is probably the most common lead wire combination. The motor contains two windings, each of which are center-tapped. The MD10A and MH10 do not use these center-taps, which are usually color coded white and black. These lead wire ends should be insulated and left unconnected. This will leave four wires which are connected according to Table 6-3. Use the series column in the Resistor Tables 6-1 and 6-2.

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8 WIRE MOTORS: This motor lead wire combination has four separate windings, each with a pair of wires brought out. These windings are usually connected as a pair of series windings or a pair of parallel windings.

Care must be exercised to pair the correct windings and to insure proper phasing of the paired windings. Consult the motor manufacturer's instructions.

5 WIRE MOTORS: This is the least preferred motor lead wire combination since one end of each winding is connected together inside the motor. This will cause loss of microstepping smoothness compared to the other motor lead wire combinations since the proper currents are not available in each winding. If this type of motor is used, the common lead wire is not used and should be insulated and left unconnected.

CAUTION:

The motor should never be disconnected from the driver while power is applied. The large voltage transients developed by the collapsing magnetic field in the motor will destroy the power MOSFETs. The connection of 68 volt zeners back to back across the driver outputs, as shown in Figure 6-1, will help protect the driver if the motor is accidentally disconnected.

6.2.7. MOTOR POWER

This motor power supply (pin #2) input should be connected to +24 to +60VDC.

6.2.8. SUPPLY GROUND

Motor power supply return (pin #1) or ground. This terminal is also connected internally to the logic ground terminal (pin #12).

6.3. MOTOR POWER SUPPLY

The power supply does not need to be regulated; a transformer, bridge rectifier and filter capacitor are sufficient. All low level voltages required by the MD10A and MH10 are generated internally, so only a single voltage power supply is needed.

The MD10A and MH10 will cease to function normally at voltages below +24VDC. If a low voltage, unregulated power supply is used be sure the ripple voltage does not drop below this voltage.

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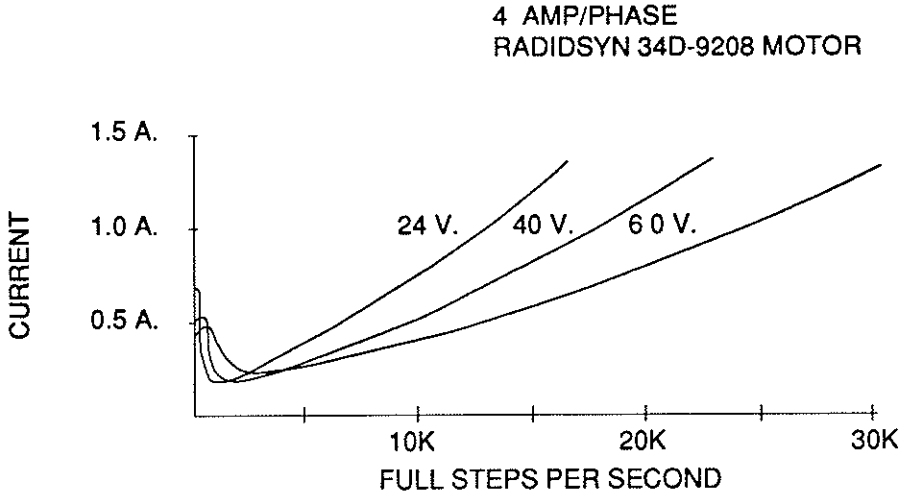


Figure 6-2 POWER SUPPLY CURRENT VS. SPEED

CAUTION:

The power supply voltage must never exceed +60VDC. If an unregulated power supply is used, the peak of the ripple voltage at high power line voltage must not exceed +60VDC. Step motors with large inertial load will generate considerable power during rapid deceleration. This power is returned to the power supply by the stepper motor drive. This may result in damage to the driver, power supply or both. It is recommended that a 68 volt zener (1N4760 or equivalent) be used as a voltage clamp for protection. A 5 amp fast blow fuse should also be used to limit the current returned to the power supply. Figure 6-1 shows the connection detail.

The choice of a power supply voltage is determined primarily by the maximum speed of the motor and the allowed motor heating. Higher power supply voltages yield higher maximum operating speeds, and also hotter running motors. Generally, the power supply voltage should be high enough to meet the user's speed requirements and no higher. Any voltage above that causes the motor to run hotter than necessary at any speed.

The power supply current requirements are going to be at a maximum when the motor is running at the maximum possible speed or delivering torque just short of stalling. The current draw from the power supply under these conditions will be approximately 1/3 the motor's rated per phase current when connected in the series mode or 2/3 of the rated per phase current when connected in the parallel mode. In other words, a motor rated at 4 amps per phase will need a power supply current of only 1.33 amps when connected in the

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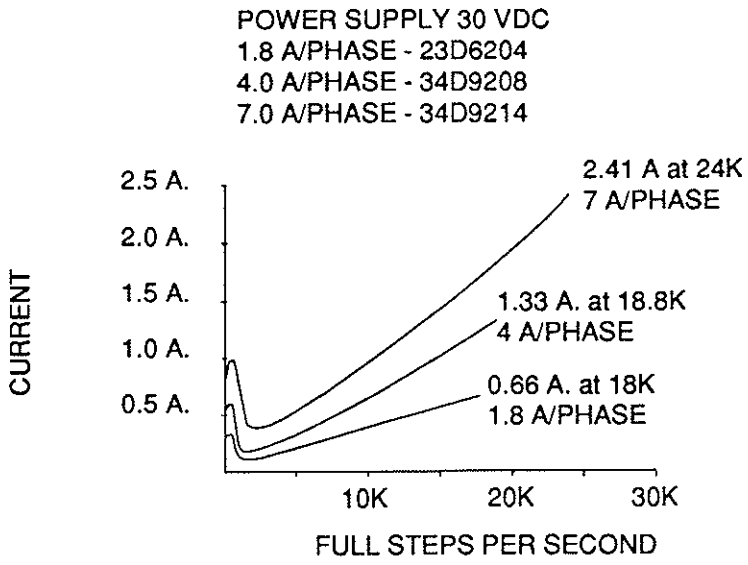


Figure 6-3 MOTOR POWER SUPPLY CURRENT

series connection. That same motor when stopped will need less than 1/2 amp from the power supply.

The current requirements for a motor at a given speed decrease with increasing power supply voltage. The actual current draw from the power supply also depends on the motor's efficiency.

The curves in Figure 6-2 show the power supply current versus speed of a typical 4 amp per phase motor driven by the MD10A. The curves apply for power supply voltages of +24VDC, +40VDC and +60VDC. The motor ran unloaded. Note, that regardless of power supply voltage, the motor never draws more than 1.33 amps from the power supply. At any given speed the motor requires less current with increasing power supply voltage.

The curves shown in Figure 6-2 show the power supply current versus speed for low, medium and high current step motors. The motors are run unloaded and the power supply voltage is +30VDC in each case. Note the stall currents for each motor are approximately 1/3 the motor's rated per phase current. At speeds below stall, the difference between the running current and that motor's stall current is an indication of the reserve torque at any given speed. Figure 6-3 shows the power supply current vs. speed for several motor sizes. Figure 6-4 demonstrates the motor torque and power output vs. speed for a typical motor.

6.4. MICROSTEPPING

The MD10A and MH10 divide each motor step into ten smaller sub-steps called microsteps. Every step pulse input causes the motor to move one microstep, taking ten pulses to move the equivalent of one full step. It is important that these microsteps are evenly distributed over the span of a full step to take full advantage of the benefits of microstepping.

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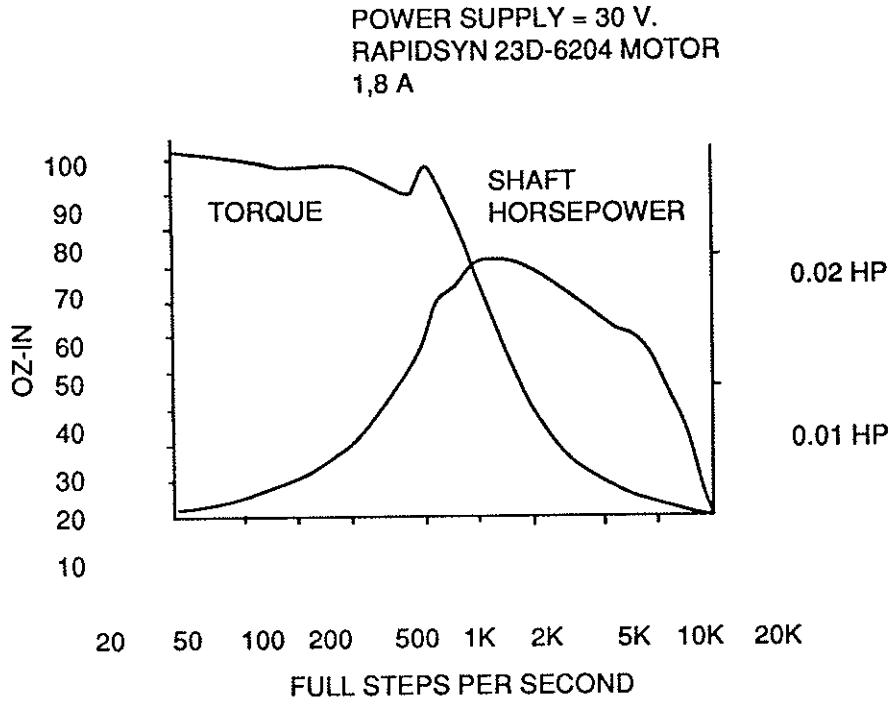


Figure 6-4 MOTOR TORQUE VS. SPEED

If the microsteps are not evenly distributed or bunched up, two performance areas suffer. First, the additional resolution is less useful for positioning applications because the placement accuracy of the microsteps is poor. Second, because of the uneven distribution, the motor has to accelerate and then decelerate over the span of each full step. This causes the motor to vibrate as it runs at low speeds more than it would with accurately placed microsteps. Factors that govern the microstep accuracy are mechanical and electromagnetic motor design variations from manufacturer to manufacturer.

For the most critical applications, the MD10A and MH10 can be matched to a particular motor model by Oregon Micro Systems, Inc. to an accuracy of +/- 1/2 microstep. This accuracy is in excess of what a standard motor can mechanically deliver, being limited by a ±3% non-accumulative full step error.

6.5. THERMAL DESIGN

The MD10A does not need additional heat sinking under most conditions. The driver uses high efficiency power MOSFETs as output drivers and low power CMOS logic to minimize internal heat generation. What heat is generated is easily conducted to the aluminum case of the MD10A by a heat conductive epoxy used as an encapsulant. The major sources of heat, the output drive MOSFETs, are mounted on a heavy gauge aluminum base plate which serves as a mounting plate as well as a heat spreader. The MH10, because of its higher current, may require an external heat sink.

To determine if the available heat sinking is sufficient, allow the driver five minutes to warm up with motor connected but not stepping. This operating condition causes the maximum

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amount of heat to be dissipated by the driver. After five minutes touch the driver. If it is hot to the touch, it is too hot and needs a better heat sink.

The available heat sinking may be enhanced by mounting the MD10A on a metal surface, preferably aluminum, in the user's system such as a panel or chassis. If the mounting surface is painted, the paint may be removed to expose bare metal to the MD10A base plate. If removing the paint is impractical, heat sink compound may be used instead. Should these measures prove to be insufficient or impractical, the most effective solution is to mount the MD10A on a heat sink such as the OMS HS10. For best thermal conductivity use heat sink compound between the finned sink and the mounting plate of the driver module.

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7. COMMAND STRUCTURE

7.1. INTRODUCTION

An extensive command structure is built into the VMEX family of intelligent motor controls. It includes a 200 command and parameter buffer for each axis and a command loop counter which allows multiple executions of any command string.

The following commands in this section are included in the VMEX family of controllers. All the commands are two ASCII characters and may be in upper or lower case. Some of the commands expect a numerical operand to follow. These commands are identified with a '#' after the command. The operand must be terminated by a space, carriage return or semi-colon to indicate the end of the number. No terminator is required on the other commands, but may be included to improve readability. The operand must immediately follow the command with no space or separation character. The '#' indicates a signed integer input parameter or a signed fixed point number of the format ##.# when user units are enabled. With user units enabled distances, velocity and acceleration parameters may be input in inches, revolutions, etc.

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

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

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

7.2. COMMAND QUEUES

The input characters are placed in a character buffer on input then removed and interpreted. The commands are then placed in separate command queues for each axis. As they

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are executed the space is reclaimed allowing the host to pass commands ahead of the moves actually being processed. Most of the commands are placed in the appropriate command queue for execution and others are executed immediately allowing return of status information in a timely way rather than when encountered in the command stream. This information is provided in a table for each command which shows the queue requirements, if any, and indicates immediate in those cases where the command is not queued. The single axis cases are indicated by the mode reference indicating the appropriate axis. The synchronized mode is indicated by the mode identifier AA or AM. The contouring case is indicated by AA/CD for multiple axes in contour definition mode. The RQ command may be used to determine the actual space available at any time. The queues operate independently allowing each axis to perform separate processes simultaneously. The synchronized modes (AA) insert special wait opcodes which allow the axes to be synchronized in this mode. When the commands are nested within loops, the queue space is not reclaimed until after the loop has been executed the programmed number of times. For loops larger than the queue space, the loop may never be completed since it cannot reclaim the queue space and cannot accept the loop terminator. The RQ command may be used to examine the remaining queue space. A Control-D may clear this condition if the input character queue is not also filled since it bypasses the command interrupter.

The following commands are available in firmware revision 1.87 and above.

7.3. AXIS SPECIFICATION COMMANDS

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

AA AXES ALL

The AA command will perform a context switch to coordinated moves.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	2
AA/CD	Not valid

Example: Perform an absolute move using the X and Y axes.

Enter: AA MR12000,14000; GO

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AM AXES MULTITASKING

The AM mode allows several tasks to be managed simultaneously. For instance, a task may be performing coordination motion on 2 axes, while a second task is performing unrelated but simultaneous motion on another axis.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Not valid

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

Enter: AM MR2000,3000; GO MA,,,10000; GO

AX AXIS X

The AX command sets the context to direct all the following commands to the X axis. This is the default mode at power up or reset.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Not valid

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

Enter: AX JG5000;

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AY AXIS Y

The AY command sets the context to direct all the following commands to the Y axis.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Not valid

Example: Examine the status of the Y axis.

Enter: AY RA

AZ AXIS Z

The AZ command sets the context to direct all the following commands to the Z axis.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Not valid

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

Enter: AZ VL500 MR2000 GO

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AT AXIS T

The AT command sets the context to direct all the following commands to the T axis.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Not valid

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

Enter: AT MA-2468; GO

AU AXIS U

The AU command sets the context to direct all the following commands to the U axis.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Not valid

Example: Set the U axis position register to -56789.

Enter: AU LP-56789

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AV AXIS V

The AV command sets the context to direct all the following commands to the V axis.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Not valid

Example: Set the auxiliary line low on the V axis.

Enter: AV AF

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7.4. SYSTEM CONTROL COMMANDS

These commands allow control of various system parameters and operating modes to allow the user to optimize the response of the system for his/her application needs.

EN ECHO ON

The EN command enables echoing. All commands and parameters will be echoed to the host. This mode is useful for debugging command strings from a terminal. This mode also outputs an English readable error message to the host which may be echoed to the terminal or computer to aid in debugging.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Not valid
AA/CD	Not valid

Example: Enable echoing by the VMEX so that commands are echoed and the error message are returned to the host as a readable ASCII string. This command would probably be the first command executed after turning on the system when this mode is desired.

Enter: EN

EF ECHO OFF

The EF command disables echoing from the VMEX motion system. This is the default mode at power up or reset.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Not valid
AA/CD	Not valid

Example: Stop echoing to the host.

Enter: EF

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HH HOME HIGH

The HH command sets the sense of the home switch on the current axis to active high. This allows the use of a normally closed switch.

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	Not valid
AA/CD	Not valid

Example: (see HL command)

HL HOME LOW

The HL command sets the sense of the home switch on the current axis to active low. This is the default mode at power up or reset.

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	Not valid
AA/CD	Not valid

Example: A faster home sequence may be used in applications which have a long distance to travel to reach home. The stage is moved through home at high speed with the home switch set for active high then reversed at low speed to meet the 1024 steps per second requirement of the home command.

Enter:
```
AX VL20000 HH HM0
VL1000 HL HR0
```


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LF LIMITS OFF

The LF command turns off the limit switches for the addressed axis. This allows the stage to move beyond the limit switch and should be used with caution.

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	Not valid
AA/CD	Not valid

Example: Set up a board to ignore the Y axis limit switches.

Enter: AY LF

LN LIMITS ON

The LN command restores the operation of the limit switches for the addressed axis. This is the default state at power up or reset.

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	Not valid
AA/CD	Not valid

Example: Set up the T axis to stop immediately when a limit switch is encountered.

Enter: AT LN

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SL SOFT LIMIT

The SL command changes the operation of the limit inputs causing the output pulse train to ramp down instead of terminating immediately. The output queue is not flushed except for the current move. This mode is effective for point to point moves only. This command is valid in the single axis mode only but affects all axes simultaneously.

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	Not valid
AA/CD	Not valid

Example: Set up a board to allow each axis to ramp to a stop when a limit is encountered.

Enter: AX SL

SF SOFT LIMIT OFF

The SF command restores the normal operation of the limit switches. This is the default mode at power up or reset.

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	Not valid
AA/CD	Not valid

Example: Set up a board to make each axis stop immediately when a limit is encountered.

Enter: AX SF

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CN COSINE ON

The CN command enables cosine velocity ramps, i.e. half sinusoid acceleration profiles for all axes. The cosine is not truncated in moves that do not reach full speed. See Section 1 for an explanation of velocity profiles. This command should not be given while an axis is in motion or the results may not be predictable. This command affects all axes, even if issued in the single axis mode.

Because of the excess processing overhead involved, absolute moves, such as MA and MT, cannot be used within loops (LS-LE, WH-WG) while the board is in the cosine (CN) velocity profile mode. Relative moves, such as MR and ML, will work properly within loops, when in the cosine mode.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Not valid

Example: Set the board to be in cosine mode.

Enter: CN

PN# PARABOLIC ON

The PN command sets all axes to truncated parabolic ramps. This acceleration profile starts at 100% of the programmed acceleration and decreases in steps of 10% of the initial acceleration down to as low as 10%. The parameter supplied selects the number of steps. It must be in the range of 3 to 10 corresponding to 70% and 10% acceleration at the peak respectively. A parameter out of this range or no parameter supplied defaults to 70% or 3 steps. Note that the parameter is the number of steps, not the acceleration values. The larger number is a lower acceleration at the peak. See Section 1 for an explanation of velocity profiles. This command should not be given while an axis is in motion or the results may not be predictable. This command affects all axes, even if issued in the single axis mode.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Not valid

Example: Set the board to be in the smoothest parabolic acceleration ramp.

Enter: PN10;

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PF PARABOLIC OFF

The PF command restores all axes to linear acceleration and deceleration ramps. This is the default mode at power up or reset. See Section 1 for an explanation of velocity profiles. This command should not be given while an axis is in motion or the results may not be predictable. This command turns off the PN and CN modes. This command affects all axes, even if issued in the single axis mode. This is the default mode at power up or reset.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Not valid

Example: Turn off cosine or parabolic ramps, returning to linear.

Enter: PF

RS RESET

The RS command is a software reset which causes the local VMEX microprocessor to reset. All previously entered data and commands are lost. All internal parameters are initialized to defaults. All interrupts are disabled. This command is intended for catastrophic failure recovery only. The KL command should be used to reset queues or return the system to a known state.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Not valid

Example: Clear everything in the board and stop all movement. Reset all hardware registers.

Enter: RS

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7.5. USER I/O COMMANDS

The following commands are for accessing the bit I/O functions of the board. See also the SW and WS commands.

AN AUXILIARY ON

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

A parameter must be supplied for the desired axes when used in the AA mode so that the other axes are not affected. The parameter only serves as a place holder to show which axes should be affected, the value given does not affect the active state of the auxiliary line. No parameter is required in the single axis mode.

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	1
AA/CD	2

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

Enter AY AN

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

Enter: AA AN1,,1;

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AF AUXILIARY OFF

The AF command turns off the selected auxiliary outputs. That is, it causes the open collector line to be driven low. The AF command may be used to change power level on driver modules so equipped or as a user specified output. Same parameter rules apply as the AN command.

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	1
AA/CD	2

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

Enter: AY AF

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

Enter: AA AF1,,1;

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PA# POWER AUTOMATIC

The PA command will turn on or off the auxiliary outputs at the beginning of each GO or GD command execution and complement the outputs after the move is executed. The auxiliary will be turned on, i.e. pulled high, upon the execution of the GO or GD and off at the end of that move, if the parameter is zero or not specified in the single axis mode. If the parameter is non-zero, the sense is reversed, i.e. the auxiliary output is turned off (driven low) upon the execution of the GO or GD command and on at the end of the move.

This mode need only be set once and can be turned off by using the AN or AF command. Axes can be selectively affected in the AA mode by following the syntax as described for the AN command. The values of the included parameters set the state of the auxiliary line during the move. The following queue requirements apply to each GO or GD command in the command stream in the AA and single axis modes.

QUEUE REQUIREMENTS	
MODE	
AX - AV	2
AA,AM	2
AA/CD	Not valid

Example: Turn on the Y axis auxiliary output at the beginning of a move and turn the T axis output off at the beginning of a move, while in the AA command mode.

Enter: AA PA,0,,1;

SE# SETTLING TIME

The SE command allows specification of a settling time, in milliseconds, to be used before the power is reduced, when using the PA mode. The parameter may be any value to 1000 milliseconds. Specification of a parameter of zero turns off the mode. This command is available in single axis mode only. The use of this command requires 3 queue slots with the execution of each GO or GD command.

QUEUE REQUIREMENTS	
MODE	
AX - AV	3
AA,AM	3
AA/CD	Not valid

Example: Turn on the Z axis auxiliary output upon execution of a move and have it remain on for 500 milliseconds after the move is complete.

Enter: AZ PA SE500;

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7.6. MOVE SPECIFICATION COMMANDS

These commands allow specification of move parameters. They allow move parameters to be tailored to the user's system requirements.

AC# ACCELERATION

The AC command sets the acceleration/deceleration register to the operand which follows the command. The parameter must be greater than zero and less than 8,000,000. All the following move commands for the axis being programmed will accelerate or decelerate at this rate until another AC command is entered. All acceleration registers default to 2,000,000 steps per second per second upon power-up or reset.

The acceleration register may be automatically modified by the VMEX if an ML or MT instruction is sent in the AA or AM modes. The user must then redefine them with an AC command, when returning to the single axis mode, or when using move commands in the AA or AM modes which do not do interpolation, such as the MA or MR commands.

QUEUE REQUIREMENTS			
MODE	LINEAR	PARABOLIC	COSINE
AX - AV	4	15	15
AA,AM	4	15	15
AA/CD	Not valid		

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

Enter: AY AC200000

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

Enter: AA AC200000..50000;

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VL# VELOCITY

The VL command sets the maximum velocity register of the axis being programmed to the operand which follows the command. The operand must be greater than zero and less than or equal to 522,000 steps per second. The velocity defaults to 200,000 at power up or reset. This is a write only register and controls the maximum velocity used in relative and absolute position moves except as modified by the linear interpolation instructions.

If the velocity register is modified by an ML or MT instruction in the AA or AM modes, the user must redefine the velocity with a VL command when returning to the single axis mode or using a move command which does not use interpolation in the AA or AM modes.

QUEUE REQUIREMENTS			
MODE	**LINEAR**	**PARABOLIC**	**COSINE**
AX - AV	2	13	13
AA,AM	2	13	13
AA/CD	Not valid		

Example: In the single axis mode, set the X axis velocity to 10,000 counts per second per second.

Enter: AX VL10000

Example: In the AA mode, set the peak velocity of the X axis to 5,000 and the T axis to 50,000 and leave the other axes with their previous values.

Enter: AA VL5000,,,50000;

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VB# VELOCITY BASE

The VB command allows the velocity ramp to start at the specified velocity. This allows faster acceleration and the ability to pass through resonance quickly in some applications. The velocity jumps instantly to the specified velocity, then ramps as usual. The deceleration is the same in reverse. This mode is active only for linear ramps. It is ignored for cosine and parabolic ramps but not flagged as a command error. The parameter must be greater than zero and less than the programmed velocity. This command is not valid with the JG command. The base velocity defaults to zero at power up or reset.

QUEUE REQUIREMENTS			
MODE	**LINEAR**	**PARABOLIC**	**COSINE**
AX - AV	2	2	2
AA,AM	2	2	2
AA/CD	Not valid		

Example: In the single axis mode, set the Y axis velocity base to 200.

Enter: AY VB200

Example: In the AA mode, set the X and Y axes velocity bases to 200.

Enter: AA VB200,200;

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LP# LOAD POSITION

The LP command will immediately load the position supplied as a parameter in the absolute position register of the axis. In models with the encoder option, the parameter will be loaded into the encoder position register and the parameter times the encoder ratio will be loaded into the position counter. If the no parameter is supplied, the value of zero is used. This command turns off the position hold and interrupt on slip modes when used in a VMEX with the encoder option.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AV	2	4
AA,AM	Not valid	
AA/CD	Not valid	

Example: The following would load the X axis position register with 1000.

Enter: AX LP1000

Example: The following would load the Y axis position register with 20,000 and the encoder position register with 30,000 counts, in encoder models.

Enter: AY ER3,2 LP30000

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MA# MOVE ABSOLUTE

The MA command will set up the axis to move to the absolute position supplied as a parameter. The default value of zero is used if no parameter is supplied in the single axis mode. In the AA mode, an axis may remain stationary by entering a comma but omitting the parameter. The move is actually initiated by a GO or GD command.

In the AA mode, each axis will use its predefined acceleration and velocity values to move to the new absolute position. Each axis may, or may not, get to the destination at the same time, because each axis utilizes individual velocities and accelerations.

Because of the excess processing overhead involved, the MA command cannot be used within loops (LS-LE, WH-WG) while the board is in the cosine (CN) velocity profile mode.

The linear move commands (ML and MT) and the constant velocity mode may alter predefined acceleration and velocity values. These values should be redefined if you go from a linear move to a non-linear move, such as an MA or MR type, in both single axis or all axes modes.

QUEUE REQUIREMENTS			
MODE	**LINEAR**	**PARABOLIC**	**COSINE**
AX - AV	2	2	2
AA,AM	2	2	2
AA/CD	Not valid		

Example: In the single axis mode, move the X axis to absolute position 100,000 counts with the previously entered acceleration and velocity parameters.

Enter: AX MA100000 GO

Example: In the AA mode, move the Y axis to absolute position 10,000 counts and the T axis to absolute position 1,000 counts. The other axes will remain in their current positions.

Enter: AA MA,10000,,1000; GO

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MR# MOVE RELATIVE

The MR command will set up the axis to move relative from the current position at the time the move is executed. In the AA mode, an axis may remain stationary by entering a comma but omitting the parameter. The move is actually initiated by a GO or GD command.

In the AA mode, each axis will use its predefined acceleration and velocity values to move to the new absolute position. Each axis may, or may not, get to the destination at the same time, because each axis utilizes individual velocities and accelerations.

The linear move commands (ML and MT) and the constant velocity mode may alter predefined acceleration and velocity values. These values should be redefined if you go from a linear move to a non-linear move, such as an MA or MR type, in both single axis or all axes modes.

QUEUE REQUIREMENTS			
MODE	LINEAR	PARABOLIC	COSINE
AX - AV	2	2	2
AA,AM	2	2	2
AA/CD	Not valid		

Example: In the single axis mode, move the X axis 2468 steps in the negative direction.

Enter: AX MR-2468 GO

Example: In the AA mode, move the X axis 12345 steps in the positive direction and the Y axis 6789 steps in the positive direction. Both axes will start at the same time.

Enter: AA MR12345,6789; GO

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ML#,#; MOVE LINEAR

The ML command uses linear interpolation to perform a straight line relative move to the new location. Input parameters are relative distance for each axis in the move. Velocity and acceleration parameters of each axis may be automatically adjusted by the VMEX controller to perform the linear move. If linear and single axis moves are mixed, it will be necessary to reset the velocity and acceleration parameters for the single axis move following a linear move.

The parameters may have been modified by the VMEX depending on the relative distances of the linear move. The ML command should be followed by a GO or GD to start the axes together. The velocity and acceleration parameters are scaled to allow the axes to move and finish together. All axes are scaled to the axis with the longest move time.

QUEUE REQUIREMENTS			
MODE	**LINEAR**	**PARABOLIC**	**COSINE**
AX - AV	Not valid		
AA,AM	6	30	30
AA/CD	Not valid		

Example: In the AA mode, move the Y, Z and T axes 10000, 100 and 1000 counts respectively with each starting and finishing together. The other axes remain in their previous positions.

Enter: AA ML,10000,100,1000; GO

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MT#,#; MOVE TO

The MT command uses linear interpolation to move to the specified absolute position. The syntax is similar to the ML command. This command is invalid while in the CN mode, if loops are being used. The command will become valid again after executing an ST or KL command. The MT command is not valid in loops (LS-LE, WH-WG) at anytime. When used in the contour definition mode, only the axes being used in the contour must be provided for in the MT syntax. A GO or GD command initiates the move.

The MT command may alter predefined acceleration and velocity values. These values should be redefined if you go from a linear move to a non-linear move, such as an MA or MR type, in both single axis or all axes modes.

QUEUE REQUIREMENTS			
MODE	**LINEAR**	**PARABOLIC**	**COSINE**
AX - AV	Not valid		
AA,AM	6	30	30
AA/CD	4 + number of axes		

Example: In the AA mode, move the X, Y and T axes to absolute positions 1000, 10000 and 100 counts respectively with each starting and finishing together. The unused axes remain in their previous positions.

Enter: AA MT1000,10000,,100; GO

MO MOVE ONE PULSE

The MO command will output one step pulse in the current direction (do not use the GO command). The direction may be reversed by use of the MM or MP command. This command generates the output pulse in one sample interval and thus eliminates the latency of generating a ramp with an MR1 GO command sequence. This command is not available in models with an encoder option.

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	Not valid
AA/CD	Not valid

Example: Move the Z axis one pulse in the negative direction.

Enter: AZ MM MO

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RM# REMAINDER

The RM command will divide the position counter by the parameter supplied and replace the position counter with the resulting remainder. The parameter must be greater than zero and less then 65000. This command is used in applications where the controller is managing the motion of a continuously rotating object. It allows the position counter to keep track of the absolute position without regard to the number of revolutions it may have rotated. This command has no effect on the encoder position register.

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	Not valid
AA/CD	Not valid

Example: An RM2000 command with a position counter of -4050 will return a position of 1950 since it is within 50 counts of rolling over at -4000, i.e. the axis is 1950 counts from the starting point.

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7.7. MOVE EXECUTION COMMANDS

These commands allow execution of the moves which have been previously specified.

GO GO

The GO command will initiate the move which has been previously programmed with such commands as MA, MR, MT, and ML. No operand is required with the GO command.

To find the total queue requirements for a specific application, find the appropriate value in Table A. If the board is an encoder version, add the value found in Table B to the value from Table A, to determine total queue usage.

TABLE A		
QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AV	4	7
AA,AM	5	8
AA/CD	Not valid	

TABLE B			
ADDITIONAL ENCODER QUEUE REQUIREMENTS			
MODE	LINEAR	PARABOLIC	COSINE
AX - AV	0	0	0
AA,AM	6	15	15
AA/CD	Not valid		

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

Enter: AX MA12345 GO

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

Enter: AA MR2468,-2468; GO

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GD GO and RESET DONE

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

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

To find the total queue requirements for a specific application, find the appropriate value in Table A. If the board is an encoder version, add the value found in Table B to the value from Table A, to determine total queue usage.

TABLE A
QUEUE REQUIREMENTS

MODE	NO ENCODER	ENCODER
AX - AV	5	8
AA,AM	6	9
AA/CD	Not valid	

TABLE B
ADDITIONAL ENCODER QUEUE REQUIREMENTS

MODE	LINEAR	PARABOLIC	COSINE
AX - AV	0	0	0
AA,AM	6	15	15
AA/CD	Not valid		

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

Enter: AY MR-12345 GO ID MR12345 GD ID

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

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

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JG# JOG

The JG command is a velocity mode and will step the axis at the velocity supplied as a parameter. The JG command will accelerate to the programmed velocity and run until altered by an ST, SA, KL or another JG command. The jog velocity may be changed by following the command with another JG command of a different velocity. The axis must be stopped before reversing directions. This command modifies the move velocity parameter (VL) for the affected axis. The JG command does not require a GO or GD command to start the motion.

QUEUE REQUIREMENTS			
MODE	LINEAR	PARABOLIC	COSINE
AX - AV	2	Linear ramp	
AA,AM	Not valid		
AA/CD	Not valid		

Example: Jog the motor at 100,000 steps per second then change to 35,000 steps per second when the second JG is entered, then stop by decelerating to a stop.

Enter: JG100000 JG35000 ST

JF# JOG FRACTIONAL VELOCITIES

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

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AV	2	3
AA,AM	Not valid	
AA/CD	Not valid	

Example: Jog the Y axis at 2⅔ steps per second.

Enter: AY JF2.667

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VS#,#,# VELOCITY STREAMING

The VS command will generate a pulse train without acceleration or deceleration at the rates specified. The parameters are time in 1/1024 second sample intervals, X velocity, and Y velocity. This is a slave mode and cannot be mixed or queued with other commands. You must be in the AX mode, since the VS command and all parameters are inserted in the X axis command queue. The VS command does not require a GO command to start the motion.

QUEUE REQUIREMENTS	
MODE	
AX	5
AY - AV	Not valid
AA,AM	Not valid
AA/CD	Not valid

Example: Create a stair step ramp on the X and Y axes, with the X axis moving in the negative direction and the Y axis in the positive direction. Make each step last 1 second long and increase velocity by 1,000 steps/second, until a velocity of 3,000 steps/second is reached, then step down to 0 steps/second.

Enter: AX VS1024,-1000,1000; VS1024,-2000,2000; VS1024,-3000,3000; VS1024,-2000,2000; VS1024,-1000,1000; VS1,0,0;

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7.8. MOVE TERMINATION COMMANDS

The following commands allow termination of move sequences in process.

ST STOP

The ST command flushes the queue for the current axis only, in the single axis mode, and causes the axis to decelerate to a stop at the rate previously specified in an AC command. This command is used to stop the motor in a controlled manner from the jog mode or an unfinished GO or GD command. This command is executed immediately. All status and position information is retained. When executed in the AA mode, the ST command is equivalent to the SA command.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Flush + 2
AA,AM	Flush + 2
AA/CD	Not valid

Example: Move the Y axis for a while at 1200 steps/second, then ramp to a stop.

Enter: AY JG1200 (wait awhile) ST

SA STOP ALL

The SA command flushes all queues and causes all axes to decelerate to a stop at the rate previously specified in an AC command. All status and position information is retained.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Flush + 2
AA,AM	Flush + 2
AA/CD	Not valid

Example: Send all axes on a move, then ramp them to a stop, before they finish.

Enter: AA VL100,100,100,100,100,100,100,100;
MR1000,2000,3000,4000,5000,6000,7000,8000; GO (wait awhile)
SA

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SD STOP AND RESET DONE

The SD command may be substituted for the SA command. It will reset the done flags, then proceed to stop all axes. This allows the host to be interrupted when all axes have stopped by using the ID command after the SD. The SA ID combination may flag the completion early if one of the axes is already done from a previously executed ID.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Flush +2
AA,AM	Flush +2
AA/CD	Not valid

Example: Flag a done when all axes have stopped.

Enter: AA SD ID

KL KILL

The KL command will flush the command queue and terminate pulse generation of all axes immediately. It is intended for emergency termination of any program and to reset the input queues to a known state. The motor may not stop immediately even though no more pulses are delivered due to inertia of the motor rotor and load. Therefore, the position counter may not accurately reflect the true position of the motor following this command. The homing sequence should be used to reestablish the position counters. A Control-D (ASCII 4) will perform the same functions as the KL command. It bypasses the command interpreter and may work when the character buffer is full and the KL command cannot get through the interpreter. A Control-D should be used instead of KL, when the board appears hung-up. This can occur when its input queue is inadvertently filled, by entering a loop sequence that was so long you could not enter the LE command.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Flush + 2
AA,AM	Flush + 2
AA/CD	Not valid

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

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

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7.9. LOOP CONTROL COMMANDS

These commands allow move sequences to be repeated within loops. Loops can be nested up to four levels deep on each axis.

LS# LOOP START

The LS command sets the loop counter for the axis being programmed in the single axis mode and all axes in the AA mode. The command expects a loop counter operand following the command. The commands up to the LE loop terminator will be executed the number of times specified by the operand. Loops may be nested up to four levels deep on each axis. The parameter must be less than 32,000.

The first loop of commands will occur immediately as they are entered. The remaining loops will be executed after the loop terminator LE has been entered.

Because of the excess processing overhead involved, the MA command cannot be used in the loop mode, while the board is in the cosine (CN) velocity profile mode, and the MT command cannot be used in the loop mode at any time.

The axis mode (e.g. AX, AY, AA) must be the same when entering and exiting the loop, otherwise the matching loop termination command will not be found by the board's command processor.

If you want one axis to wait for another in the loop, you must be in the AA mode throughout the loop. If you are in the single axis mode in the loop, each axis' commands will go into their separate queues and execute independently of each other.

Another important thing to note is that the command queue size is 200. Each queued command takes one or more slots. If, when entering a looping sequence of commands, all 200 queue slots are filled, before the LE loop terminator is entered, the board will hang. This is because there is no space for the LE command, or any other commands. To clear this hang up, send the board a Control-D (same as KL, but shorter) to kill all moves and flush all queues. When programming a loop of more than four or five moves, the queue size should be examined with the RQ command to see if it is nearing zero.

QUEUE REQUIREMENTS	
MODE	
AX - AV	2
AA,AM	2
AA/CD	Not valid

Example: Execute a 100,000 count relative move on the Z axis 5 times.

Enter: AZ LS5 MR100000 GO LE

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NOTE: The first move will occur immediately after entering the GO command. The remaining 4 moves will be executed after the loop terminator LE has been entered.

Example: Execute a 100,000 count move relative on the X axis together with a 100 count move on the T axis, followed by a move absolute to 100 counts on the X axis and 200 counts on the T axis, four times.

Enter: AA LS4 MR100000,,,100; GO MA100,,,200; GO LE

LE LOOP END

The LE command terminates the most recent LS command. The axis will loop back and repeat the commands within the loop the number of times specified in the LS command. The loop will start repeating as soon as this command is terminated.

QUEUE REQUIREMENTS	
MODE	
AX - AV	2
AA,AM	2
AA/CD	Not valid

Example: (see LS command)

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WS# WHILE SYNC

The WS command will execute the commands between the WS and WD commands as a loop while the specified sync line is true, i.e. low. When the line goes high it will exit the loop and execute the commands which follow. The test is at the bottom of the loop, i.e. it will always be executed at least once.

QUEUE REQUIREMENTS	
MODE	
AX - AV	2
AA,AM	2
AA/CD	Not valid

Example: Execute a continuous loop, moving the X axis 10,000 counts and then move the Y axis -1000 counts, until an external device terminates the loop.

Enter: AA WS1 MR 10000; GO MR, -1000; GO WD

WD WHILE DONE

The WD command serves as the loop terminator for the WS command.

QUEUE REQUIREMENTS	
MODE	
AX - AV	2
AA,AM	2
AA/CD	Not valid

Example: (see WS command)

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WH WHILE

The WH command will execute all commands between it and the terminating WG command as a loop until terminated by a CW command. This allows repeated execution of a command sequence which can be terminated by the host. These commands may not be nested but may be executed sequentially.

QUEUE REQUIREMENTS	
MODE	
AX - AV	3
AA,AM	3
AA/CD	Not valid

Example: You have a 3 axis platform that you use to drill holes in the center of a 1/4 inch thick sheet of metal. The sheet is 6 inch square. The driver/motor/lead-screw pitch provide 10000 steps per inch.
The operator must manually insert and remove the square from the platform. The X and Y axis move a drill into the desired position. The Z axis lifts and lowers the drill. The operator presses a switch which tells the motion controller that the square is in place and ready to be drilled. The operator will continuously remove and replace the squares until ready to take a break.
The following is a description of how to set up an OMS board to perform this task.

Procedure: Connect a normally closed switch between user I/O line 0 and ground. This will be the "Ready to Drill" switch.

Enter:

```
AX UU10000          *set up user units so we can reference move to
                     inches
AY UU10000          *10000 steps = 1 inch
AZ UU10000
AX VL.1; AC10;      *set up X axis homing velocity and acceleration
AY VL.1; AC10;      *set up Y axis homing velocity and acceleration
AZ VL.1; AC10;      *set up Z axis homing velocity and acceleration
AX HR AY HR AZ HR   *send each axis to home
AA VL3,3,.5;        *set normal move velocity for X, Y and Z axes
WH                  *start of loop to drill squares indefinitely
                    *(operator removes/replaces square into platform)
    SW0             *wait until operator presses switch
    MA3,3; GO       *move to center of square
    MA,,.5; GO      *move the drill through the square (a 1/2 inch move
                     on the Z axis drills through the square)
    MA,,0; GO       *lift the drill
    MA0,0; GO       *move the platform to home position
WG                  *loop back to starting WH command
(CW)                *operator wants a break so he/she sends CW from
                     keyboard and presses switch once more (since
                     loop will most likely be waiting for the switch at this
                     point)
                    *the loop ends and the following commands exe-
                     cute
MA0,0,0; GO         *move to home position
```


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WG WHILE FLAG

The WG command serves as the terminator for the WH command.

QUEUE REQUIREMENTS	
MODE	
AX - AV	2
AA,AM	2
AA/CD	Not valid

Example: (see WH command)

CW CLEAR WHILE

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

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	1
AA/CD	Not valid

Example: (see WH command)

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7.10. HOME AND INITIALIZATION CONTROL COMMANDS

These commands allow the initialization of the physical stage with the controller.

HM# HOME

The HM command will cause the current axis to step in the positive direction at the predefined velocity, until the home input line goes true. The position counter will be initialized to the position supplied as a parameter. The velocity should be less than 1024 counts per second to maintain accuracy of the home position loaded. The axis will not stop at home, but will initialize the position counter when the home switch becomes true and decelerates to a stop. The axis may be commanded to go home by following this command with a move absolute to the same position as specified in the HM command. The parameter defaults to zero if none is supplied.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AV	4	6
AA,AM	Not valid	
AA/CD	Not valid	

Example: Find the physical home position of the X axis of the stage. (NOTE: The velocity should be less than 1024 pulses per second to minimize position error for this command.) The motor runs until the home switch input is activated and then initializes the position counter to the parameter supplied. Since the motor decelerates to a stop after reaching home, it is necessary to do an MA# to the same position as specified in the home command if it is desired to physically position the device at home. The following commands will find home, initialize it to 1000 counts, then return to home. In many cases it will not be necessary to return home, only find the position and synchronize the controller to it.

Enter: AX VL1000 HM1000 MA1000 GO

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HR# HOME REVERSE

The HR command will find home and initialize the position counter to the position supplied as a parameter. It behaves exactly like the HM command above except it travels in the reverse direction. The parameter defaults to zero if none is supplied.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AV	4	6
AA,AM	Not valid	
AA/CD	Not valid	

Example: In a long stage it may be awkward to travel the full distance to home at less than 1024 pulses per second. The following will get close to home at higher speed, then refine the position at lower speed in the reverse direction.

Enter: AX VL100000 HH HM VL1000 HL HR

KM HOME AND KILL

The KM command will find home and stop generating pulses immediately, i.e. no deceleration ramp will be generated. The position counter is not cleared or reset. Due to motor and platform inertia, the load and board may lose position synchronization.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AV	2	2
AA,AM	Not valid	
AA/CD	Not valid	

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

Enter: AY KM

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KR HOME REVERSE AND KILL

The KR command will find home in reverse and stop generating pulses immediately, i.e. no deceleration ramp will be generated. The position counter is not affected. Due to motor and platform inertia, the load and board may lose position synchronization.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AV	2	2
AA,AM	Not valid	
AA/CD	Not valid	

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

Enter: AY KR

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7.11. MOVE SYNCHRONIZATION COMMANDS

These commands allow the synchronization of moves with external events or multiple axis sequences.

ID INTERRUPT DONE

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

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	1
AA/CD	Not valid

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

Enter: AX MA100000 GO ID

II INTERRUPT INDEPENDENT

The II command allows the control to interrupt the host when each axis finishes a move. Only those axes which have been supplied a parameter in the most recent move command will cause interrupts.

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	1
AA/CD	Not valid

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

Enter: MR,1000,,10000; GO II

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IN# INTERRUPT NEARLY DONE

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

QUEUE REQUIREMENTS	
MODE	
AX - AV	2
AA,AM	2
AA/CD	Not valid

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

Enter:
```
AA
IN0,,10000;
MR100000,100000; GO
MR,,50000; GO
```

IP INTERRUPT WHEN IN POSITION

The IP command operates like the ID command, except the interrupt is deferred until the stage is within the specified deadband. The GD command should be used in place of the GO command to reset the done flags before the next move. If the position hold HN is not enabled for an axis, the command will behave like an ID command for that axis. This command is available only in models with the encoder option.

QUEUE REQUIREMENTS	
MODE	
AX - AY	1
AZ - AV	Not valid
AA,AM	Not valid
AA/CD	Not valid

Example: Send DONE when axis is within deadband.

Enter:
```
AX HV1000 HG100 HD10 HN
MR1000 GO IP (DONE will occur after move is complete and in position.)
```


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IC INTERRUPT CLEAR

The IC or the ASCII character Control-Y (hex 19) command is used to clear the done and error flags in the VMEX status register and the done flag register, otherwise the axis would always appear to be "done". This command will be executed immediately and will usually be placed in the done and error handler interrupt service routine to clear the interrupt and the associated flags. The Control-Y version of this command is preferred to minimize the latency in its execution. The flags may be polled by an RA or RI command which will also reset the flags.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Not valid

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

Enter: AX MR5000 GO ID (done flag set) IC

CA CLEAR AXIS DONE FLAG

The CA command operates like the IC command, except it clears the done flag for the addressed axis only.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Not valid
AA/CD	Not valid

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

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

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WA WAIT FOR AXES

The WA command, only valid in the AA mode, allows a command to wait until all moves on all axes are finished before it executes.

Some commands which can affect a non-moving axis, such as AN, AF and PA, may execute before a previous move on other axes has finished, especially while in the looping (LS-LE, WH-WG) mode. By preceding these command with a WA, they will not execute until all previously defined moves have finished.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Not valid
AA,AM	2
AA/CD	Not valid

Example: The Z axis auxiliary line controls a laser beam that you only want on while the Z axis moves in a positive direction. The X and Y axes position the laser. You want to repeat the action 10 times.

Enter:
```
AA VL1000,1000,1000; AC10000,10000.10000;
LS10 MR1000,1000; GO WA AN,,1; MR,,500; GO AF,,1;
MR,,-500 GO LE
```

WQ WAIT FOR QUEUE TO EMPTY

The WQ command is a special command that stops the board from processing any new command until the queue for the current axis mode is empty, i.e. all previous moves have finished. This command is not valid in looping (LS-LE, WH-WG) mode.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Not valid

Example: Move the Y axis 1,000 steps and wait until the move is complete before asking for the position.

Enter:
```
AY MR1000 GO WQ RP
```


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SW# SYNC WAIT

The SW command allows synchronization of multi-axis moves or other tasks on one or more VMEX boards by using one of the sync lines. This command causes the axes to wait until the sync line has been released (allowed to go high) before proceeding with the next command. The SW command can be used to cause an axis to wait until the others are finished. Wire OR the auxiliary lines from several axes together and connect them to a sync line. Use the SW command on that line. All commands after that will wait until all axes release their auxiliary lines.

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	1
AA/CD	Not valid

Example: The following command sequence will cause the X axis move to wait until the Y axis has finished its move and turned off its auxiliary output which has been wired to the sync 0 line.

Enter:
```
AY AN MR2000 GO AF
AX SW0 MR10000 GO
```

The SW command provides a way to synchronize moves on two or more boards. The following example shows one way to do this.

Example: You have 3 six axis boards, for a total of 18 axes to move together. Call board 1 the "master" and boards 2 and 3 the "slaves". Wire board 1's X axis auxiliary line to the two slave boards' sync 0 line. Send to the master the command "AX PA0", setting the master's axis auxiliary line low until its move starts. This also sets the slaves' sync 0 line low. Enter the "SW0" command to the two slaves, followed by the move and GO commands. On the master, enter the move command, followed by the GO command. When the master's move starts, the PA command will set the auxiliary line high releasing the wait on the slave boards. All three boards will start their moves.

Procedure: Wire board 1's X axis auxiliary line to board 2's and board 3's sync 0 line.

Enter:
```
(Board 1) AX PA0;
(Board 2) AA SW0; MR200,200,200,200,200,200; GO
(Board 3) AA SW0; MR300,300,300,300,300,300; GO
(Board 1) AA MR100,100,100,100,100, 100; GO
```


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WT# WAIT

The WT command will wait for the specified number of milliseconds before proceeding with the next command in the queue. In the AA mode, all axes will wait. Immediate commands will not "wait". The parameter must be between 1 and 32,000.

QUEUE REQUIREMENTS	
MODE	
AX - AV	3
AA,AM	3
AA/CD	Not valid

Example: You want to produce pulses on the X axis at 5,000 steps/second for 2 seconds, then 10,000 pulses/seconds for 3 seconds, then stop.

Enter: AX JG5000 WT2000 JG10000 WT3000 JG0

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7.12. SYSTEM STATUS REQUEST COMMANDS

These commands allow the host to request the status of various move parameters, including the status of limit and home switches.

WY WHO ARE YOU

The WY command returns the model type, firmware revision number, and number of controlled axes of the board being addressed, surrounded by line feeds and carriage returns.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Not valid

Example: You want to examine the board information.

Enter: WY

Response: <LF><CR> VMEX ver 1.87-6<LF><CR>

RP REQUEST POSITION

The RP command returns the current position of the currently addressed axis in the single axis mode or all positions separated by commas in the AA or AM modes. The position will be returned to the host via the data port in ASCII format. This command is not queued, i.e. the current position will be returned immediately even if the axis is in motion. The response is surrounded by line feeds and carriage returns.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Not valid

Example: The current position on the Y axis is 12345. Use the RP command to verify the position.

Enter: AY RP

Response: <LF><CR>12345<LF><CR>

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RQ REQUEST QUEUE STATUS

The RQ command returns the number of entries available in the queue of the currently addressed axis, in the single axis mode, or all axes separated by commas, in the AA or AM modes. The ASCII string is surrounded by line feeds and carriage returns. The maximum available in each command queue is 200. The response is at a fixed length of 3 characters. For example, if the current free queue space is 67, the response from the board to the RQ command is <LF><CR>067<LF><CR>.

When issuing an RQ command, while defining a contour, the available space in the contouring queue will be returned. The maximum available is 1016. The response is fixed in length at 4 characters.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Immediate

Example: See the size of the command queue for the T axis.

Enter: AT RQ

Response: <LF><CR>200<LF><CR>

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RA REQUEST AXIS STATUS

The RA command returns the state of the limit and home switches, and the done and direction flags for the currently addressed axis. The limit flag in the hardware status register will be reset by the RA command, providing another axis is not in limit. The done flag register will also be reset by this command. The status is returned in the following format:

CHARACTER MEANING		
CHAR	**SENT**	**DESCRIPTION**
1	LF	Line feed
2	CR	Carriage return
3	CR	Carriage return
4	P	Moving in positive direction
	M	Moving in negative direction
5	D	Done (ID, II or IN command has been executed, set to N by this command or IC command)
	N	No ID executed yet
6	L	Axis in overtravel. Char 4 tells which direction. Set to N when limit switch is not active.
	N	Not in overtravel in this direction
7	H	Home switch active. Set to N when home switch is not active.
	N	Home switch not active
8	LF	Line feed
9	CR	Carriage return
10	CR	Carriage return

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Not valid
AA/CD	Not valid

Example: The Y axis just encountered a limit, verify its status.

Enter: AY RA

Response: <LF><CR><CR>PNLN<LF><CR><CR>

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RI REQUEST INTERRUPT STATUS

The RI command is an AA mode command that returns the same status information on all axes as the RA command in the single axis mode. The 4 character fields for each axis are separated by commas and the string has one line feed and two carriage returns on each end. The done flag is reset by this command.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Not valid
AA,AM	Immediate
AA/CD	Not valid

Example: Check the status of a 4 axis board.

Enter: AA RI

Response: <LF><CR><CR>MDNN,MDNN,MDNN,MDNN<LF><CR><CR>

QA QUERY AXIS

The QA command returns the status of the single addressed axis like the RA command except flags are not affected.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Not valid
AA/CD	Not valid

Example: Check the status of the X axis.

Enter: AX QA

Response: <LF><CR><CR>PNNH<LF><CR><CR>

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QI QUERY INTERRUPT STATUS

The QI command returns the same information for all axes when in the AA mode, as the QA command does in the single axis mode. The 4 character fields for each axis are separated by commas and the string has one line feed and two carriage returns on each end.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Not valid
AA,AM	Immediate
AA/CD	Not valid

Example: Check the status of a four axis board.

Enter: AA QI

Response: <LF><CR><CR>PNNN,MNNN,PDNN,MNLN<LF>CR><CR>

RC REQUEST ACCELERATION

The RC command will return the current acceleration or deceleration of the current axis. This may differ from the programmed acceleration if a cosine (CN) or parabolic (PN) ramp is being generated. When the stage is stopped, the parameter returned will be the acceleration at the beginning of a ramp. When the stage is running at programmed speed, i.e. not accelerating, the parameter returned will be the acceleration at the end of the ramp. While a contour is executing, the value computed to generate the appropriate lead in will be returned. The response to the RC command is surrounded by line feed and carriage return pairs.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Not valid

Example: Display current acceleration values for all axes on a four axis board.

Enter: AA RC

Response: <LF><CR>2000000,2000000,2000000,2000000<LF><CR>

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RV REQUEST VELOCITY

The RV command will return the current velocity at which the axis is moving. This may differ from the programmed velocity if the axis is ramping up to speed or stopping. The response is surrounded by line feed and carriage return pairs. If the JF command is executing, the command only reports the integer part of the velocity.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Not valid

Example: Jog the Y axis at 12345 steps per second.
Display the current velocity.

Enter:
```
AY JG 12345
RV
```

Response: <LF><CR>12345<LF><CR>

RU REPORT POSITION IN USER UNITS

The RU command returns the current position in user units (see UU command). The format of response is a floating point number with five characters to the right of the decimal point. This response is surrounded by line feed and carriage return pairs.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Not valid
AA/CD	Not valid

Example: One revolution of a motor is 2000 steps. Define user units so moves can be referenced in revolutions. Move the Z axis 3½ revolutions. Use RU to display the position when the move is complete.

Enter:
```
AZ UU2000; LP0;
MR3.5; GO
(Wait until move is complete.)
RU
```

Response: <LF><CR>3.50000<LF><CR>

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7.13. USER UNIT COMMANDS

The following commands allow specification of move parameters in user defined units. The OMS controls will automatically convert all move parameters to these units once they have been initialized.

UU# USER UNITS

The UU command converts all move velocities, distances, etc. to user specified units by multiplying by the specified parameter. This command must be given in the single axis mode but will remain effective in the AA or AM mode. The VMEX defaults to user units off at power up or reset.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Not valid
AA/CD	Not valid

Example: The motor, driver and gear ratio you are using requires 10,000 steps to move one inch. Set up the X, Y and Z axes so you can enter move information in inches.

Enter: AX UU10000 AY UU1000 AZ UU10000

UF USER OFF

The UF command turns off user units. This command is equivalent to and preferred over UU1 since it turns off the mode thus minimizing unnecessary overhead.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Not valid
AA/CD	Not valid

Example: Turn off user unit conversion on the X, Y and Z axes.

Enter: AX UF AY UF AZ UF

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7.14. POSITION MAINTENANCE COMMANDS

ER#,# ENCODER RATIO

The ER command allows specification of encoder ratio by entering encoder counts, followed by motor counts, for position maintenance mode. These counts must be integers unless user units are enabled. The ratio of encoder counts to motor counts must be equal to one, i.e. encoder counts must match motor counts when slip detection is enabled. All distance, velocity and acceleration parameters are input in encoder counts when this mode is enabled. The correct number of motor counts are generated, while the user need only be concerned with encoder counts. This mode can be combined with user units, allowing units such as inches or revolutions to be specified in encoder counts. All parameters are then input in the user units which have been defined. The ratio defaults to 1 at power up or reset.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AY	Not valid	1
AZ - AV	Not valid	
AA,AM	Not valid	
AA/CD	Not valid	

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

Enter: ER10000,25000

HV# HOLD VELOCITY

The HV command specifies maximum position hold correction velocity. This is the peak velocity which will be used while making position corrections.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AY	Not valid	2
AZ - AV	Not valid	
AA,AM	Not valid	
AA/CD	Not valid	

Example: (see HN command)

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HG# HOLD GAIN

The HG command allows the user to specify position hold gain parameter. This gain parameter is multiplied by the position error in determining the velocity during correction. The parameter must be between 1 and 32,000. The parameter should be set experimentally by increasing it until the system is unstable, then reducing it slightly below the threshold of stability.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AT	Not valid	2
AU - AV	Not valid	
AA,AM	Not valid	
AA/CD	Not valid	

Example: (see HN command)

HD# HOLD DEADBAND

The HD command specifies deadband counts for position hold. If the stage is within this limit, it is considered in position and no further correction will be made. This parameter interacts with the HG command, i.e. a larger deadband will allow a larger gain parameter in many applications. A parameter of zero is allowed.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AY	Not valid	2
AZ - AV	Not valid	
AA,AM	Not valid	
AA/CD	Not valid	

Example: (see HN command)

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HF HOLD OFF

The HF command disables position hold, stall detection and tracking modes. This is the default mode at power up or reset.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AY	Not valid	2
AZ - AV	Not valid	
AA,AM	Not valid	
AA/CD	Not valid	

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

Enter: AX HF

HN HOLD ON

The HN command enables position correction after a move and activates the HV, HG and HD commands. Hold and slip detection are disabled if an LP, HM, HR, SA, ST or KL command is entered or if a limit is encountered.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AY	Not valid	2
AZ - AV	Not valid	
AA,AM	Not valid	
AA/CD	Not valid	

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

Enter:
```
AX VL100000 AC500000
HV50000 HD10 HG2000 HN
MR200000 GO
```


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IP INTERRUPT WHEN IN POSITION

The IP command operates like the ID command, except the interrupt is deferred until the stage is within the specified deadband. The GD command should be used in place of the GO command to reset the done flags before the next move. If the position hold HN is not enabled for an axis, the command will behave like an ID command for that axis.

QUEUE REQUIREMENTS	
MODE	
AX - AY	1
AZ - AV	Not valid
AA,AM	Not valid
AA/CD	Not valid

Example: Send DONE when axis is within deadband.

Enter: AX HV1000 HG100 HD10 HN
MR1000 GO IP (DONE will occur after move is complete and in position.)

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7.15. SLIP AND STALL DETECTION COMMANDS

ES# ENCODER SLIP TOLERANCE

The ES command parameter specifies tolerance before slip or stall is flagged in the status register and by the RL command. The mode must be turned on with an IS command and off with an HF command.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AY	Not valid	2
AZ - AV	Not valid	
AA,AM	Not valid	
AA/CD	Not valid	

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

Enter: ES5 IS

IS INTERRUPT ON SLIP

The IS command enables the VMEX to interrupt the host on slip or stall detection, if the appropriate bit has been set in the interrupt control register. Hold and slip detection are disabled if an LP, HM, HR, SA, ST or KL command is entered or if a limit is encountered. If a slip occurs, slip detection must be re-enabled.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AY	Not valid	1
AZ - AV	Not valid	
AA,AM	Not valid	
AA/CD	Not valid	

Example: (see ES command)

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RL RETURN SLIP STATUS

The RL command returns the slip detection status of each axis. An S is returned if slip has occurred for that axis, or else an N is returned. The results are bounded by an LF CR pair, as in other status commands. The number of characters returned corresponds to the number of axes available on the board.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AY	Not valid	Immediate
AZ - AV	Not valid	
AA,AM	Immediate	
AA/CD	Not valid	

Example: On a four axis board, see if any axis has slipped.

Enter: RL

Response: <LF><CR>NNSN<LF><CR> (The Z axis has slipped.)

HF HOLD OFF

The HF command disables position hold, stall detection and tracking modes.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AY	Not valid	2
AZ - AV	Not valid	
AA,AM	Not valid	
AA/CD	Not valid	

Example: Disable slip detection on the X axis.

Enter: AX HF

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7.16. ENCODER TRACKING COMMANDS

ET ENCODER TRACKING

The ET command turns on the encoder tracking mode. The axis will track its encoder input, thus allowing one axis to follow the activity of another or a thumbwheel for manual positioning or the movement of another device that produces a signal compatible to the encoder inputs. No acceleration or deceleration ramps are generated. The axis will duplicate the encoder input. The ER command allows the user to scale the motor's movements relative to the encoder.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AY	Not valid	2
AZ - AV	Not valid	
AA,AM	Not valid	
AA/CD	Not valid	

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

Enter: AX ET

HF HOLD OFF

The HF command disables position hold, stall detection and tracking modes.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AY	Not valid	2
AZ - AV	Not valid	
AA,AM	Not valid	
AA/CD	Not valid	

Example: Turn off encoder tracking on X axis.

Enter: AX HF

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7.17. ENCODER HOME CONTROL COMMANDS

HE HOME ENCODER

The HE command enables encoder index mode when an HM or HR command is executed. Home is defined as the logical AND of the encoder index, the external home enable and the encoder quadrant where channel A is positive and channel B is negative. The external enable is low true, i.e. the HH and HL commands are not valid in this mode. The home logic expressed in boolean terms is:

home= phase_A/phase_B* index*/home_switch*

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AY	Not valid	Immediate
AZ - AV	Not valid	
AA,AM	Not valid	
AA/CD	Not valid	

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

Enter: AY HE

HS HOME SWITCH

The HS command enables VMEX home switch mode to determine where home is when an HM or HR command is executed (default at power up or reset). This mode can also be used with encoders which contain internal home logic by connecting their output to the VMEX home input for the appropriate axis. The active level of this input may be controlled by the HH and HL commands.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AY	Not valid	Immediate
AZ - AV	Not valid	
AA,AM	Not valid	
AA/CD	Not valid	

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

Enter: AY HS

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7.18. ENCODER STATUS REQUEST COMMANDS

EA ENCODER STATUS

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

EA COMMAND RESPONSE DESCRIPTION		
CHAR	**SENT**	**DESCRIPTION**
1	LF	Line feed
2	CR	Carriage return
3	CR	Carriage return
4	E	Slip detection enabled
	D	Slip detection disabled
5	E	Position maintenance enabled
	D	Position maintenance disabled
6	S	Slip or stall detected
	N	No slip or stall detected
7	P	Position Maintenance within deadband
	N	Position not within deadband
8	H	Axis is home
	N	Axis is not home
9	N	Unused/reserved
10	LF	Line feed
11	CR	Carriage return
12	CR	Carriage return

QUEUE REQUIREMENTS		
MODE	**NO ENCODER**	**ENCODER**
AX - AY	Not valid	Immediate
AZ - AV	Not valid	
AA,AM	Not valid	
AA/CD	Not valid	

Example: Examine the status of the Y axis encoder.

Enter: AY RE

Response: <LF><CR><CR>EENPNN<LF><CR><CR>

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RE REQUEST ENCODER POSITION

The RE command returns current encoder position of the currently addressed axis in encoder counts. The ASCII string is surrounded by line feed and carriage return pairs.

QUEUE REQUIREMENTS		
MODE	**NO ENCODER**	**ENCODER**
AX - AY	Not valid	Immediate
AZ - AV	Not valid	
AA,AM	Not valid	
AA/CD	Not valid	

Example: Examine the current encoder position of the Y axis.

Enter: AY RE

Response: <LF><CR>12345<LF><CR>

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7.19. VELOCITY STAIRCASE COMMANDS

The following commands describe the velocity staircase mode. This mode is useful in applications requiring a change in velocity at a prescribed position without stopping.

MP MOVE POSITIVE

The MP command sets the direction logic to move in the positive direction.

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	Not valid
AA/CD	Not valid

Example: (see MV command)

MM MOVE MINUS

The MM command sets the direction logic to move in the negative direction.

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	Not valid
AA/CD	Not valid

Example: Set the direction line to move in the minus direction on the Y axis.

Enter: AY MM

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MV#,# MOVE VELOCITY

The MV command causes the motor to run to the new absolute position (parameter 1) at the new velocity (parameter 2). When the destination is reached control will be passed to the next command which should be another MV command or an SP command. If the command is not received in time the controller will continue to move at the specified velocity. Note that this is a slave mode and it is the responsibility of the user to provide the commands in time. They may be queued ahead of time. If a new MV command is sent after the controller has already passed the destination specified in the command, the controller will continue to move at the old velocity. Any number of steps can be specified in this manner with both acceleration and deceleration. The controller will not reverse direction if the position has already passed, but will behave as explained above. Thus the direction of the move must be specified before starting the move with the MP or MM commands. All destinations must be in absolute position, no position relative moves are allowed due to the nature of these commands.

QUEUE REQUIREMENTS		
MODE	**NO ENCODER**	**ENCODER**
AX - AV	4	5
AA,AM	Not valid	
AA/CD	Not valid	

Example: Generate a velocity staircase with the breakpoints given in absolute position.

Enter:
```
MP
MV10000,30000
MV20000,50000
MV30000,10000
SP35000
```

The move as shown in Figure 7-1.

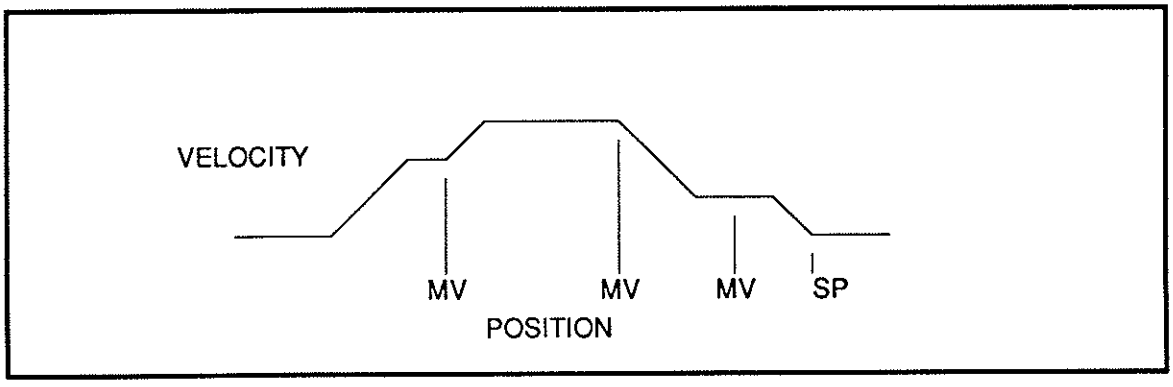


Figure 7-1 VELOCITY STAIRCASE PROFILE

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SP# STOP AT POSITION

The SP command will cause the axis to stop at the specified position. The controller will attempt to stop at the specified destination. If there is insufficient distance to stop at the previously specified deceleration when the command is received, the controller will stop as soon as possible at that deceleration. This command is not valid with the JG command.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AV	3	4
AA,AM	Not valid	
AA/CD	Not valid	

Example: (see MV command)

FP# FORCE POSITION

The FP command will flush the command queue and attempt to stop at the specified position. The axis will overshoot if there is insufficient distance left to stop at the programmed acceleration.

QUEUE REQUIREMENTS		
MODE	NO ENCODER	ENCODER
AX - AV	Flush + 4	Flush + 4
AA,AM	Not valid	
AA/CD	Not valid	

Example: Force axis to stop at 25,000.

Enter: FP25000

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7.20. CONSTANT VELOCITY CONTOURING

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

AF#,# AUXILIARY OFF

The AF command may be used within a contour definition allowing control of other devices at any instruction within the contour. The AA mode syntax is used. Any auxiliary can be exercised with this command. All axes must be specified or specifically skipped, rather than those axes defined within the contour, as the other commands in this section.

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	1
AA/CD	2

Example: (see CD command)

AN#,# AUXILIARY ON

The AN command may be used with a contour by using the AA mode syntax as above. Any auxiliary can be exercised with this command. All axes must be specified or specifically skipped, rather than those axes defined within the contour, as the other commands in this section.

QUEUE REQUIREMENTS	
MODE	
AX - AV	1
AA,AM	1
AA/CD	2

Example: (see CD command)

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CD#,#; CONTOUR DEFINE

The CD command enters contour definition mode. It allows entry of commands for contouring mode. Commands are queued for execution by the CX command. The parameters define the axes for which the contour is defined and the starting position of the contour in absolute units. The contour may be defined on up to 6 axes if circular interpolation is not used, or 2 axes with circular mixed with linear interpolation. Attempting to do circular interpolation in a contour which is being defined for more than 2 axes will be flagged as a command error. This command is executed in the AA mode. The contouring axes must be at positions which allow them to reach the specified contouring velocity by the specified position when the contour is executed. If the actual position of the stage is equal to the starting position as defined by the CD command, the stage will jump to the contouring velocity with no ramp up. This could cause the stage to stall if it is not able to accelerate at this high rate. It is recommended that some ramp up distance be allowed. The distance required may be calculated from the equations in Section 1. There is also some ramp down distance as the stage slows from the constant velocity value to a stop. This distance is adjustable using the AC command. It can almost be eliminated using the CK command.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Not valid
AA,AM	0
AA/CD	Not valid

Example: The following demonstrates cutting a hole with a 10,000 count radius using constant velocity contouring and circular interpolation. The contouring velocity is set to 1000 pulses per second. A contour is then defined beginning at coordinates 0,0 on the Z and T axes. The auxiliary output of the Y axis is turned on, which could turn on the cutting torch or laser starting the cut at the center of the circle. A half circle is cut from the center to the outside of the hole positioning the cutting tool at the start of the desired hole. The hole is then cut, the torch turned off, the stage stopped and the definition is complete. The stage is then positioned and the hole cut with the CX command. Note that no commas are provided in the MT and CR commands for the inactive X and Y axes within the contour definition. The AN and AF commands must have commas for all axes since they can all be addressed from within the contour definition.

Enter:

```
AA
CV1000 CD,,0,0;
AN,0; CR0,5000,3.1415926
CR0,0,6.2831853
AF,0; MT-10,10000
CE
MT,,-1000,0; GO CX
```


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CE CONTOUR END

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

QUEUE REQUIREMENTS	
MODE	
AX - AV	Not valid
AA,AM	Not valid
AA/CD	1

Example: (see CD command)

CK CONTOUR END and KILL

The CK command will end the contour sequence, like the CE command, except there is no ramp down, i.e. the pulses will stop abruptly. This command should be used with caution to prevent the stage from missing steps or loosing its correct position. It is used in place of the CE command.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Not valid
AA,AM	Not valid
AA/CD	1

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

Enter:
```
AA
CV1000 CD,,0,0;
AN,0;CR0,5000,3.1415926
CR0,0,6.2831853
AF,0; MT-10,10000
CK
MT,,-1000,0; GO CX
```


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CR#,#,# CIRCULAR INTERPOLATION

The CR command defines a move in a circular pattern from the entry position. The first two parameters are the center of the circle in absolute units and the third parameter is the distance to move in radians. The distance parameter should be supplied to seven significant digits if a full circle is to be generated.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Not valid
AA,AM	Not valid
AA/CD	8

Example: (see CD command)

CV# CONTOUR VELOCITY

The CV command allows specification of contouring velocity. It is executed from the AA mode before a contour definition. A contour defined by a CD command cannot be executed if followed by a CV command. Changing this parameter will make any previously defined contours invalid. The contour velocity defaults to 1000 at power up or reset.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Not valid
AA,AM	Immediate
AA/CD	Not valid

Example: (see CD command)

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CX CONTOUR EXECUTE

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

QUEUE REQUIREMENTS	
MODE	
AX - AV	Not valid
AA,AM	6
AA/CD	Not valid

Example: (see CD command)

MT#,# MOVE TO

The MT command causes the axes defined by the CD command to move to the specified absolute position using linear interpolation. Only the axes being used in a contour must be specified in the contouring mode.

QUEUE REQUIREMENTS			
MODE	**LINEAR**	**PARABOLIC**	**COSINE**
AX - AV	Not valid		
AA,AM	6	30	30
AA/CD	4 + number of axes		

Example: Make a hexagon in CV mode using the X and Y axes.

Enter:
```
AA CV5000;
CD10000,0;
MT20000,0
MT25000,10000
MT20000,20000
MT10000,20000
MT5000,10000
MT10000,0
CK
CX
```


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RQ REQUEST QUEUE STATUS

The RQ command returns the number of entries available in the contouring queue.

QUEUE REQUIREMENTS	
MODE	
AX - AV	Immediate
AA,AM	Immediate
AA/CD	Immediate

Example: Examine contour queue size.

Enter: AA CD0,0; RQ

Response: <LF><CR>1016<LF><CR>

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7.21. COMMAND SUMMARY

The following commands are included in the VMEX family of motor controllers. The '#' indicates a signed integer input parameter or a signed fixed point number of the format ##.# when user units are enabled. With User Units enabled, distances, velocity and acceleration parameters may be input in inches, revolutions, etc.

SUMMARY OF COMMANDS	
COMMAND	**COMMAND DESCRIPTION**
AA	The following commands are for the AA mode.
AC#	Acceleration, set acceleration/deceleration register
AF	Auxiliary off.
AM	Axes multitasking mode
AN	Auxiliary on.
AT	The following commands are for the T axis
AU	The following commands are for the U axis.
AV	The following commands are for the V axis.
AX	The following commands are for the X axis (default on reset).
AY	The following commands are for the Y axis
AZ	The following commands are for the Z axis
CA	Clear axis done flag
CD#,#;	Define a contour
CE	End contour definition, movement ramps to stop at end of contour
CK	End contour definition, kill movement at end of contour
CN	Cosine on, enable cosine velocity profiles
CR#,#,#	Circular interpolation, move in a circle
CV#	Contouring velocity, definition
CW	Clear while flag, i.e. terminate WH/WG loop
CX	Contour execute
EA	Encoder status, return encoder status of currently addressed axis
EF	Echo off, turn off echo to host (default at power up)
EN	Echo on, turn on echo to host
ER#,#	Encoder ratio, set encoder count to motor count ratio
ES#	Slip tolerance, set tolerance before slip is flagged
ET	Encoder tracking, set encoder tracking mode
FP#	Force position, flush queue and attempt to stop at specified position
GD	Go and reset done flags
GO	Go command, start execution of motion
HD#	Hold deadband, specify deadband tolerance for position hold
HE	Encoder home mode, set home on encoder logic
HF	Hold off, disable position hold, slip detection and tracking modes
HG#	Hold gain, specify position hold gain parameter
HH	Home high, home switches are active high

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SUMMARY OF COMMANDS	
COMMAND	**COMMAND DESCRIPTION**
HL	Home low, home switches are active low
HM#	Home, find home and initialize the position counter
HN	Hold on, enable position correction after move
HR#	Home reverse, find home in reverse direction and initialize position counter
HS	Home switch, enable home switch mode
HV#	Hold velocity, specify maximum position hold correction velocity
IC	Interrupt clear, clear done interrupt status and error flags
ID	Interrupt host when done and set done flag
II	Interrupt independent
IN#	Interrupt when nearly done
IP	Interrupt when axis is in position
IS	Interrupt slip, interrupt host on slip or stall detection
JG#	Jog command, run motor at specified velocity until a new velocity command is sent or it is stopped by an ST or KL command
KL	Kill, flush queue and terminate pulse generation immediately on all axes without decelerating
KM	Home and kill pulse generation
KR	Home in reverse and kill pulse generation
LE	Loop end, terminate most recent LS command
LF	Disable limit switches for selected axis
LN	Enable limit switches for selected axis
LP#	Load position, load position counter with parameter
LS#	Loop start, set loop counter, from 1 to 32000 loops; (may be nested to 4 levels)
MA#	Move absolute, move to absolute position
ML#,#;	Move linear, move specified distance relative from current position
MM	Move minus, set minus direction for MV type move
MO	Move one pulse in current direction
MP	Move plus, set positive direction for MV type move
MR#	Move relative, move specified distance from current position
MT#,#;	Move to, move to specified absolute position.
MV#,#	Move velocity, move to first parameter (absolute position) at second parameter velocity without stopping at end of move
PA#	Power automatic, turn power on before each move
PF	Parabolic off, disable parabolic ramps, i.e. linear ramps will be generated
PN#	Parabolic on, enable parabolic ramps
QA	Query status of switches and flags for addressed axis without affecting flags
QI	Query status of switches and flags on all axes without affecting flags
RA	Return status of switches and flags and reset flags
RE	Request encoder position, return current encoder position

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SUMMARY OF COMMANDS	
COMMAND	**COMMAND DESCRIPTION**
RI	Return status of switches and flags for all axes and reset flags
RL	Return slip status of each axis
RM#	Return remainder of position divided by parameter in position counter
RP	Request position, return current position
RQ	Request queue status, return number of queue entries available.
RS	Software reset of VMEX
SA	Stop all, flush queue and stop all axes with deceleration
SE#	Set settling time before power is reduced in PA mode
SF	Soft limit off, restore normal overtravel operation
SL	Soft limit mode allow pulse train to ramp down on overtravel
SP#	Stop at position, stop at specified position if possible after all commands have been executed
ST	Stop, flush queue and decelerate to stop
SW#	Sync wait, wait for SYNC line to be released by other controllers
UF	User units off, turn off user unit translation
UU#	User units, multiply acceleration, velocity and distance parameters by specified parameter
VB#	Base velocity, set base velocity
VL#	Set maximum velocity to be used in profile
VS#,#,#	Velocity stream, slave velocity mode for profiling
WA	Wait until all moves on all axes are finished
WD	While end, WS loop terminator
WG	Terminate WH loop
WH	While, execute all commands until WG loop terminator, until flag cleared by CW command
WQ	Wait until current axis queue is empty
WS#	While sync, execute while SYNC line is true
WT#	Wait, wait for specified number of milliseconds
WY	Who are you, return model and software revision

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8. HOST SOFTWARE

8.1. HOST SOFTWARE EXAMPLE

The following is an example program for the VME host to access the VMEX motion control board. The program is written in 68000 assembler and runs under and uses system calls from VMEPROM. The program will take characters typed at the VME host console and pass them to the VMEX board and return all characters output by the VMEX to the host console. Invoke the VMEX program and enter the following at the keyboard:

EN WY

This will turn on echoing from the VMEX so you can see what you are typing and should respond with the current firmware revision number so that you know that communication is established with the VMEX board.

VMEX users are welcome to use any of the subroutines in this software for their application. No license is required.

8.2. VMEX DEMONSTRATION PROGRAM

The following is a source listing of the demonstration program which does not use interrupts:

```
MDATA   .equ $FFFF81
MDONE   .equ $FFFF83
MCNTL   .equ $FFFF85
MSTAT   .equ $FFFF87
MVECT   .equ $FFFF89
MIRQE   .equ $80
MTBE    .equ $40
MIBF    .equ $20
MDONE   .equ $10

start:
        move.b  #0,MCNTL

        clr.l  d0
loop:dc.w$a078                  ;char available from console
        beq  L10                ;no.
L1:  move.b  MSTAT,d1           ;get VMEX status
        and.b   #MTBE,d1        ;Transmit buffer empty?
        beq  L1                 ;no wait till it is
        move.b  d0,MDATA        ;yes send char
L10:
        move.b  MSTAT,d1        ;check VMEX status
```


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```
        and.b    #MIBF,d1          ;input buffer full
        beq  loop          ;no go for more
        move.b   MDATA,d0          ;yes get char
        dc.w$a086               ;send to console
        bra  loop          ;and repeat forever

        .end start
```

8.3. VMEX DEMONSTRATION PROGRAM WITH INTERRUPTS

The following is a source listing of the demonstration program which uses interrupts:

```
MDATA   .equ $FFFF81
MDONE   .equ $FFFF83
MCNTL   .equ $FFFF85
MSTAT   .equ $FFFF87
MVECT   .equ $FFFF89
MIRQE   .equ $80
MTBE    .equ $40
MIBF    .equ $20
MDONE   .equ $10

VECADR .equ $100
IVECTOR .equ    $40

start:
    lea  serv-offs+2(PC),a0     ;get actual program counter
offs:
    move.l   #VECADR,a1         ;and vector address
    move.l   a0,(a1)            ;set up interrupt vector
    move.b   #IVECTOR,MVECT
    move.b   #MIBF,d0           ;turn on IBF interrupt
    or.b #MIRQE,d0          ;enable interrupts
    move.b   d0,MCNTL

    clr.l  d0
loop:dc.w$a078              ;char available from console
    beq  L10           ;no.
L1:  move.b   MSTAT,d1          ;get VMEX status
    and.b    #MTBE,d1           ;Transmit buffer empty?
    beq  L1            ;no wait till it is
    move.b   d0,MDATA           ;yes send char
L10:
    bra  loop          ;and repeat forever

serv:move.b   MSTAT,d1          ;check flags
    and.b    #MIBF,d1           ;input buffer full
    beq  sexit
    move.b   MDATA,d0
    dc.w$a086               ;send to console
sexit:   rte

    .end start
```


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