

# MID 2.0 STEP MOTION SYSTEM

## OPERATION AND INSTALLATION

### MANUAL

SECTION 1: SMC CONTROLLER CARD

SECTION 2: SMD DRIVER CASE

SECTION 3: MS DRIVER CARD

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# TURNKEY MOTION SYSTEM / COMPONENTS

MOTION IN MINUTES - PLUG AND GO SYSTEM - Features CY 545

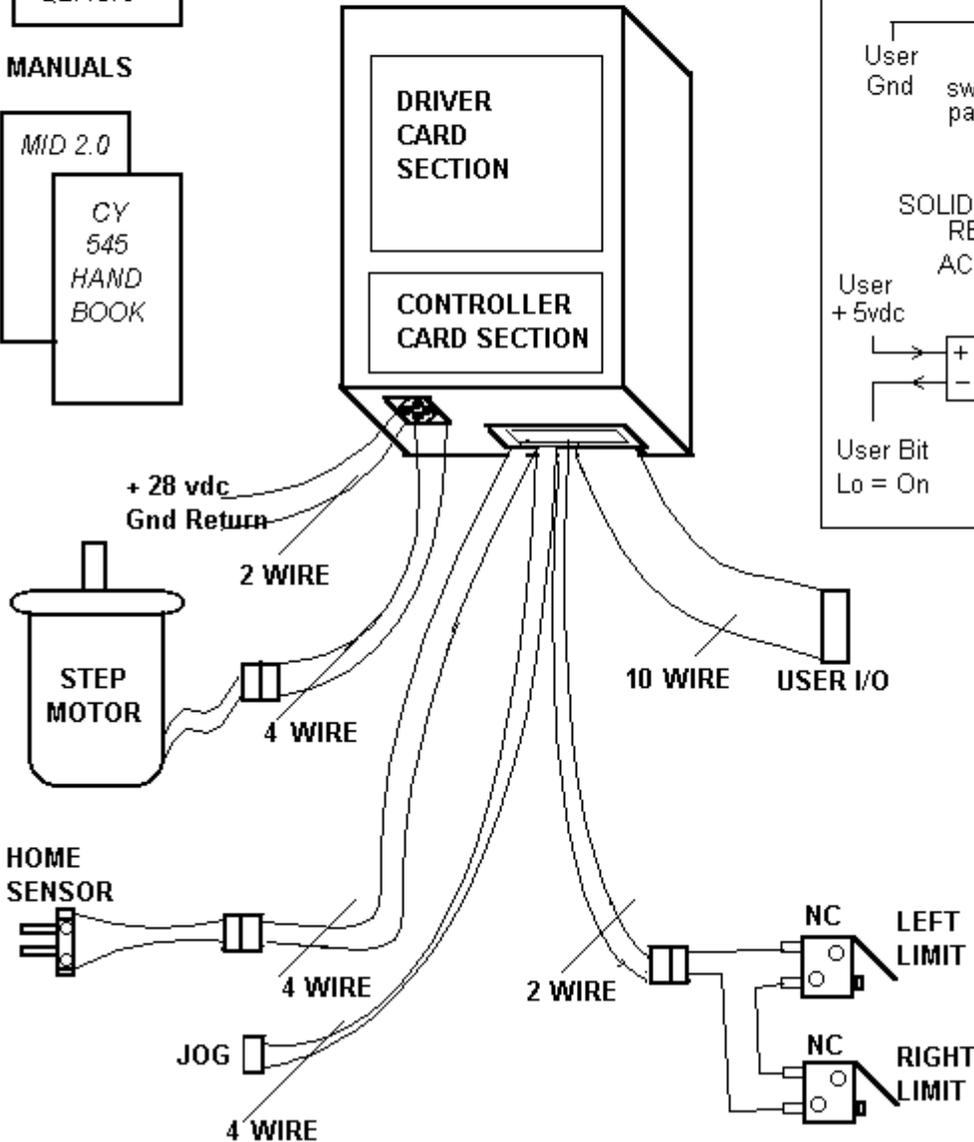
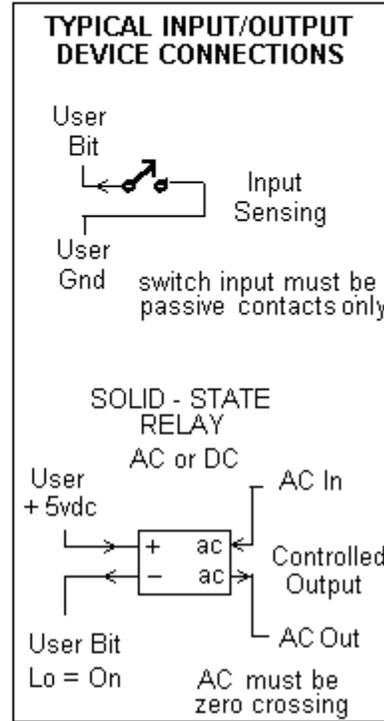
## SOFTWARE



## MANUALS



THE MID SYSTEM IS IDENTICAL TO THE SID SYSTEM WITH THE EXCEPTION THAT THE MID REQUIRES AN EXTERNAL POWER SOURCE OF + 12 TO + 40 VDC



## **INTRODUCTION**

The MID motion control system consists of three basic elements; the controller card, the MS driver card and their power supplies (VCC and VMM). The controller card (CY5.4) contains the Cybernetic CY 545 Step Motor Controller and a 2048 character EEPROM (non-volatile) for storing application routines. Refer to the Cybernetics 545 manual for a description of the 545 microprocessor and its "High-Level" command set (26 characters and symbols). All actions of this system are controlled by these commands.

Two of the eight User Bits of the 545 (USRB 0-7) are assigned to a specific function; Enable and Home. The remainder are for general purpose Input and Output functions (I / O) such as controlling relays or valves (output) and reading switches (input). The command set of the Cybernetic 545 contains instructions such as Test, Wait, Delay, Loop which are used along with the motion instructions to provide a wide range of machine operations. The MID system can be described as a "mini-PLC with motion".

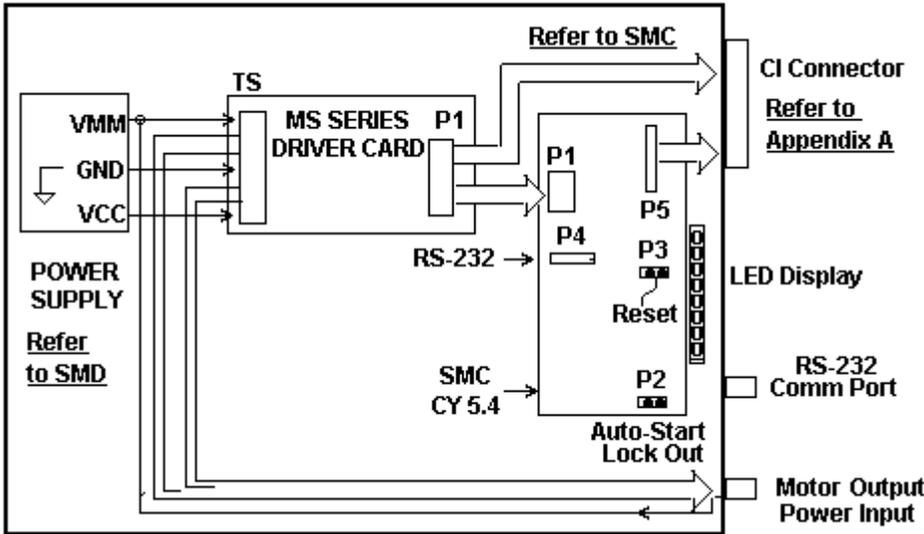
The Step pulses and the Direction signal from the CY5.4 controller are connected to the motor driver. Additionally, the Stop (PWR) signal shifts the driver from Park power to Full power. A Home Sensor channel is also part of the system.

Each system includes a CI cable (controller interface cable). This 20 pin cable is divided into two sections. The I / O section contains + 5 v power and ground as well as six User Bits. The Chassis section connects the Home Sensor, User Bit 2, Jog Switch, and Limit Loop signals back to the controller. Refer to Appendix A for details.

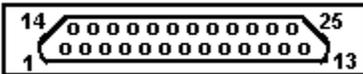
This system is self-contained and can operate independently or under the direct command of a host computer. In Memory Mode, the host computer is used to "teach" the system by sending a string of commands which are stored, for later execution, in the on-board memory of the controller card. In Direct Mode, the host commands are executed immediately by the CY545. A combination of these two modes is also possible; typically macro command strings are loaded to memory and then executed as required by the host.

**MID SERIAL INTERFACE DRIVER SYSTEM BLOCK DIAGRAM**

The MID system consists of power supplies, motor driver card, motion controller card  
 Refer to the specific section for details of each element



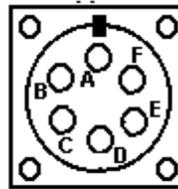
see appendix A for pinouts



DB-25 S  
 CONNECTOR  
 MS18275-1  
 (3M 8325-6003)

NOTE: Internal DC fuse  
 All grounds are common  
 Power off when connecting  
 Remove lid to adjust current  
 See Appendix C

see appendix D



14 S - 6 S AMP  
 (AMP 97-3102A-14S-6S)

A = + 28 VDC  
 B = COIL A +  
 C = COIL A -  
 D = GRN RTH  
 E = COIL B +  
 F = COIL B -

# SMC

## OPERATION AND INSTALLATION

ALSO REFER TO: Cybernetic Micro Systems - CY 545 Motion Controller  
SIDDEMO program - Software Listings & Comments

### SECTION 1

CONTENTS	PAGE
Hardware Configuration	1- 3
Displays & Controls	1- 4
Programming & Listings	1- 5
Installation & Test	1- 12
Serial Cable Diagrams	1- 14
CY 5.4 Card Block Diagram	1- 15
CY 5.4 Card Schematic Diagram	1- 16
CY 545 Rate Tables	1- 17

### CY 545 COMMAND SET SUMMARY

<u>Command</u>	<u>Function</u>
A val 24	set position counter to At value
B bit #	set or clear (/B) User Bit
C	set Continuous stepping mode
D val 16	Delay for value in milliseconds
E	Enter commands to user mem
F val	First (starting) speed of motor
G	motor Goes the number of steps
H bit #	Home motor on bit #
I	Initialize 545; software reset
J add	Jump to address on mem page
L cnt add	Loop to address for count value
N num 24	Number of steps; see Go
O mode	set mOdes of CY controller
P val 24	moves to an absolute Position
Q	Quit Enter commands to mem
R val	set Ramp (top) speed of motor
S val	Slope (acceleration) of F to R
T bit # add	jump to add unTil Bit matches
W bit #	Wait at add until Bit matches
X	eXecute commands at Y add
Y add 16	set mem address counter to Y
Z cnt 16 add	Zillion Loops to add for cnt value
0 (number)	end of program or stop program
+ (plus)	set CW direction for Go move
- (minus)	set CCW direction for Go move
/ (forslash)	negate prefix for /Bit commands
? command	send back command val to host

"message"                    send back message to host

**Note:** Commands are upper case ASCII letters, followed by a space, and a value if required.  
Values without a suffix are 0 to 255 max. Values with 16 suffix are 65535 (64K) max.  
Values with 24 suffix are 16777215 (16 Meg). Add (byte count) is 64K max. Bit # is 0 to 7.

**!!!! ATTENTION !!!!**

Mis-wiring of motor or power supplies **WILL** damage motor drivers **IMMEDIATELY**. Motor coils A or B can be reversed; motor will run in the opposite direction. Pairs can be reversed; pair A in coil B for example. **CROSS-WIRING**, an A and B wire crossed, **WILL** damage driver. Allowing exposed motor leads to touch each other, ground, or power **MAY** damage driver. Refer to Appendix D in the MS driver section for wiring schemes.

**SMOKE, POPPING, ELECTRONIC ODOR, OR LAMP FAILURE INDICATES DRIVER FAILURE.**

Call the Service Center. Do **NOT** change fuse or attempt repair without instructions. **ADDITIONAL DAMAGE CAN OCCUR !!!** Shorted drivers can easily be repaired by replacing the socketed driver arrays.

**!!!! WARNING !!!!**

**NEVER** connect or disconnect any of the motor leads or power supply (VMM) leads before disconnecting DC power! Unit may be safely operated **WITHOUT** motor. However, pause 30 seconds after power off before reconnecting motor (Bleed-Down time).

## **HARDWARE CONFIGURATION**

The SMC controller card contains the CY 545 motion controller, EEPROM memory, memory latches (2 each), RS-232 receiver / driver, LED status lites and standard crystal (11 MHZ).

**Serial Format.** The SMC is connected as a RS-232 serial device and communicates with the host computer through the front panel DB-9 S connector (AT style). The serial format is configured in the following manner: ASCII characters, Adaptive Baud, 8 data bits, no parity, and one stop bit. The CTS (Clear To Send) feature of the 545 (User Bit 6) is used as the hardware hand-shake to control communication between the host and the 545. When the 545 is busy, it will set the CTS to hold off transmission.

The SMC is configured that the CTS signal is busy when power is applied to the system. It is sometimes necessary to defeat this function when communicating with the system for the first time. There are two techniques. One is to set the Mode command (O) as part of the Auto-Start routine. The other is to OPEN with the CS = 0, send the mode command, and then re-OPEN with the CS set to the desired value. Refer to the software examples.

During operation from memory or when homing, the CTS function is not fully operational. This is to allow interruption of these routines by the host computer sending a stop command (0 or CR). If other data is sent, incorrect operation will result. To set the SMC 100% busy during operations; 1) disable the CTS function with a Mode command, 2) User Bit 6 will set HI or busy, and 3) as the last instruction, re-enable the CTS.

**NOTE:** the correct Mode command to defeat the CTS is: O 80H.  
the correct Mode command to enable the CTS is: O 0A0H  
(Any Hex value starting with a letter must be preceded by a zero)

When the Busy feature is not required, for example during memory operation, then Bit 6 is available as a User I/O control bit.

**Memory Format.** The memory is configured as 2K bytes of EEPROM (RAM is optional). It is not possible to access memory above address 2047. Note that the memory is in pages of 256 bytes; the CY545 does not allow Jump, Test, or Loop operations across page boundaries. The pointer command (Y) is used to move across boundaries. A feature of the 545 memory system is the Auto-Start function which recognizes special character flags in the first bytes of memory as a command to run the following program at power-on.

**Disabled Functions.** The Limit function of the 545's pin 4 & 5 is not enabled. The driver card will go "free" when the Limit Loop is opened (Fail-Safe, Hard-Soft limits). The Limit Loop is enabled by User Bit 0. Refer to Appendix B of the driver card section of this manual. The Inhibit / Abort (pin 8) is not used in this system. This Abort is not the same as the driver abort (ABR). External thumbwheel (pin 12) is also not used.

The Jog function (pin 6) is available at the Molex connector of the C I Cable (see Appendix A).

## DISPLAYS & CONTROLS

**Internal Displays.** (OFF = Logic High or true; ON = Low or false). Pin numbers refer to CY 545 pinout. Remove the cover of the controller to adjust current and observe programming displays.

**BZ** Indicates the inverse polarity of pin 27(User Bit 6)Off = Ready;On = Busy  
**DR** Indicates the polarity of pin 2 (direction) Lo = CW  
**ST** Indicates the polarity of pin 1 (step) Lo = Step pulse  
**PW** Indicates the polarity of pin 3 (stop) Lo = Stepping  
**SW** Indicates the polarity of pin 6 (slew) Lo = Ramp speed  
**B0** Indicates the polarity of pin 21 (User Bit 0) Lo = Enable all drivers  
**B1** Indicates the polarity of pin 22 (User Bit 1) Lo = Home Sensor blocked  
**B2** Indicates the polarity of pin 23 (User Bit 2) General Purpose User Bit

### Special Aspects of Some Commands.

**W** The Wait command causes the 545 to wait at the instruction, therefore incoming stop commands will not be processed. Use a T command in a jump to itself.

**L & Z** These loop instructions assume that the first pass of a routine before reaching the loop command was the 1st loop pass. In general, the loop count must be one more than required.

**T,H,W** These commands are followed by a numeric value in Hexdecimal which is desinated by the H following the value. The decimal values for 0 to 7 are the same and the H is omitted.

and hex

**H** Homing is a single stepping operation. The Busy signal is not continuously set during homing but cycles every step. It is best therefore that homing is executed from memory.

**AUTO-START DEFEAT.** In the event an incorrect program is loaded to the memory and the Auto-Start flags are set, the system will lock-up in Auto-Start. See Section 12-4 of the CY545 manual. To by-pass the Auto-Start:

- A) Remove the cover of the controller, if present.
- B) Locate the Auto-Start lock-out pins, per the drawing in this manual, SECTION 2: SMD - Stepper motor drive assembly.
- C) Short the Auto-Start Lockout pins with a clip or jumper.
- D) Reset the controller. Short the Reset pins with a clip or jumper. Controller will by-pass the Auto-Start.
- E) Remove the jumper. Re-run the demo program. CLEAR or over-write the faulty program.

It is good practice NOT to arm the Auto-Start flags before the program has been tested using the Y address and X commands. When using the Demo program, simply REMark out the flags and change the starting address from Y = 0 to Y = 3.

#### **Reserved User Bits.**

- B 0 Enable Driver; must be Lo to step.
- H 1 Bit 1 is always the Home Sensor.
- B 6 Bit 6 Is the Busy Bit option. See mOde Command.

#### **Reserved Software Commands.**

- CLEAR Writes 0's and CR's to memory.
- LOAD Loads memory. Not same function as Basic F3 key.
- EXIT Required to close comm port, close file, and clear error traps. Do not use ESC key.
- comma Do not use comma to separate elements of 545 commands (T, L, and ? M xx as comma is reserved as a Basic word; use space.
- [a,b,c] HP-LED command string is not used.
- C Continuous Step Mode is not used.

## **PROGRAMMING**

The software program used with the MID system is only a "Serial Driver" routine. The main purpose of the program is to send and receive commands between the host and the CY 545 microprocessor. The motion control software (firmware) is contained only in the 545. The serial driver contain examples of typical operations required by the host computer software, such as: opening the comm (serial) port, sending/receiving characters, loading the 545 memory, handling the Busy (CTS), and diagnostic capability. Included in the sample program are routines of 545 commands which exercise the motion system during manufacturing tests. Two types of routines are demonstrated; (1) downloading a string of commands from a keyboard file and (2) loading a string of commands to EEPROM memory. The memory routine example is an Auto-Start program referred to as a Self-Test. This routine will run when the system is powered-on as proof that the system is operating correctly.

The sample listing is commented and contains information about how to operate a 545 system. It is helpful to "read the listing" even for non-computer types.

Line 0-20 defines the variables and create symbols for control characters.

Line 30-100 assigns the Basic function keys for common functions.

Line 120 creates the time delay used between characters so that fast computers do not get ahead of the serial card and the 545.

Line 130 defines the serial port as the ACTIVE device; PRINT #ACTIVE sends characters to the active port.

Line 200-400 creates the introduction screen display

Line 500-999 is the down-load test routine which is sent to the 545 when this program is first run.

Line 1000-1799 is the Self-Test EEPROM program. Note that Lines 1030-1050 send the Auto-Start flags in their decimal values. The semi-colons inhibit the carriage return (Enter) until the colon at Line 1060. Refer to the CY 545 manual for the Auto-Start format. The GOSUB 2500 is the time delay for the write cycle of the EEPROM memory.

Line 1800 asks the 545 a question (? command). The return of the answer from the 545 indicates that the system is responding to the host.

**Line 2000-2510 assembles keyboard entries and sends them to the 545 at the Enter key ( CR = carriage return or enter key). Note the special commands at Line 2210-2270 which are created commands not part of the 545 command set.**

**Line 2600-2750 reads any incoming characters from the 545 and prints to the host display screen.**

**Line 2910-3000 closes the comm ports on Exit (F5) or a computer error code other than ERROR = 24 (comm port is busy).**

**Line 3000-3150 writes zeros (545 stop command) and carriage returns over the entire memory (Clear command) which erases the memory. The opposite is the Load command which writes the memory.**

**Line 3300-3400 is the busy error routine.**

## INSTALLATION AND SELF-TEST PROCEDURE

1. Remove lid to observe status LED's.
2. Connect motor, verify that driver current is correct for motor. See Appendix C for current adjustment and Appendix D for motor wiring.
3. Connect CI cable. Limit Loop must be closed for motor to run.
4. Connect the serial cable and turn-on computer system. Do NOT run the computer program at this time.
5. Connect the DC power and turn-on power supply. Verify that DC lamp is on; motor power (VMM) is OK.

System will run the Auto-Start self-test program as described in the listings; EEPROM sample program. Refer to lines 1000-1800 of the listings in this manual. This test proves that the MID system is operating correctly. Note, this demo will include "homing". The motor will run backwards until the home sensor is blocked (block the sensor with a pencil tip). Then, typically, motor will run back and forth several times. To defeat the self-test, refer to Auto-Start Lockout procedure later in this section. Observe the LED indicator lites while the test is running and note that each action of the system can be monitored and that this self-test is the series of commands listed between the quotes in lines 1000-1800. All actions of the system are the result of COMMANDS, refer to the back cover of the CY 545 manual, either stored in the external memory (Memory Mode) or sent from the host computer (Direct Mode). The third mode (Programming Mode) is when commands are sent from the host and written into the external memory.

## COMPUTER TEST PROCEDURE

1. Wait till Auto-Start self-test has completed; B2 LED comes on; PW LED is off.
2. LOAD and RUN the Demo program which will down-load another self-test. Refer to lines 400-800 of the listings. The system will return position when finished: P= 00000000 NOTE: If the return is in vertical segments:

```
      P=  
      00  
00  
      00  
      00
```

exit the program (F5), refer to line 120, and set the correct timebase (T value) for the host computer. Re-start (shift-F5) the program.

NOTE: If the message "system is busy or not connected....." appears, enter Ctrl-Break. The system IS busy (self-test ?) or NOT connected to COMM 1. RESET the MID and allow self-test to finish or correct the serial cabling.

### 3. Motor Commands.

**NOTE:** Enter commands (Direct Mode), at the prompt;  
Caps Lock on; < = the Enter key; F x = function key.

F9 the MID returns position; this indicates communication is OK  
/B 0< enables motor, B 0 LED is ON or LO  
H 1< motor 0 will home until the sensor is blocked  
P 2000< motor will move to position 2000 ( 2000 steps CW )  
F9 ? P returns P=0002000; position is 2000  
P 0< motor returns to position 0  
B 0< free motor

### 4. Memory Commands.

F7 ? Y where is memory byte pointer; Y=xxxx is last byte of self- test  
Y 0< sets pointer to byte location 0  
? m 22< displays 22 "command lines" of memory (F8 and type 22<)

Note the Auto-Start flags, arrow, 4, V, at byte location 0,1,2 (refer to lines 1030,1040,1050); followed by the first command, O 80H (mode = BUSY, line 1060).

CLEAR< fill the memory with 0's and carriage returns; STOP commands  
Y< yes; wait till 0 0 0 0....DONE.  
F7 Y=0000  
F8 22< memory is cleared  
F6 load memory; host goes to line 1000; returns ? P when done  
F7 Y=xxxx; last byte of program  
Y 0< set memory byte pointer to byte 0  
F8 22< memory is loaded  
CLEAR<  
Y< remove the Auto-Start program at this time, if desired

**Auto-Start Defeat.** In the event an in-correct program is loaded to the memory, and/or the system locks-up in Auto-Start, it is necessary to manually by-pass the Auto-Start:

- A) Locate the Auto-Start Lockout pins; see drawing in this manual, SECTION 2:  
SMD - Stepper motor drive assembly.
- B) Carefully, short the pins with a #2 phillips driver tip or ballpoint pen.
- C) While maintaining the short, power cycle the MID. Controller will by- pass the  
Auto-Start program.
- D) Remove the short. Re-start (shift-F5) the computer demo and CLEAR or over-  
write the memory program.

It is good practice NOT to arm the Auto-Start flags before a program has been tested using the Y address and X commands. When using the demo program, simply REMark out the flags and change the starting address from Y = 0 to Y = 3; reserves three bytes.

**Parameterizing.** Refer to the CY 545 MANUAL, SECTIONS 1-12 (Commands), 16 (see StepMotor and Home), 17 (Rate Tables), 19 (good sample program); sections 13,14,15 not used. Typical commands will duplicate the down-load with different values of R, S, and F used in order to determine the best parameters for moving the motor. Refer to the Rate Tables. Repeat Step 3 with different parameters.

**Resonance.** Resonance (feed-back oscillation between the motor rotor and the motor coils) is a vibration which affects the motor behavior. Typical symptoms are shuttering, dropping steps, jumping back and forth, hard running, and excessive noise (unpleasant). All step motors exhibit resonance at approximately 100 full step/sec (Low Frequency) and at 1000 full steps/sec (Mid Frequency). This behavior is affected by motor load, power, and speed. The normal procedure is to start at a speed (F command) above the low point and ramp through the mid point (S command) to a higher speed (R command).

To determine the resonance points, set F and S to the lowest value and R above mid freq. Move the motor sufficient steps to reach top speed. Note the points during this acceleration where the motor exhibits abnormal behavior; these are the low frequency nodes. The motor will stall at the mid freq. point. Resonance can be reduced by less power, decoupling the motor and load (isolating couplers; not metal to metal), higher speeds, faster acceleration, and/or smaller step angles.

## SERIAL CABLES

<u>XT TYPE.</u>	CPU DB-25 (IBM STYLE)	CONTROLLER DB-9S
PIN 1	Frame Ground	<-----> Shell (solder)
PIN 2	TX Transmit	-----> PIN 3 RX Receive
PIN 3	RX Receive	<----- PIN 2 TX Transmit
PIN 5	CTS Clear	<----- PIN 8 DSR Ready
PIN 7	Signal Ground	<-----> PIN 5 Signal/Frame

DB-25 to DB-9 Adaptor

<u>AT TYPE.</u>	CPU DB-9P (IBM STYLE)	CONTROLLER DB-9S
<u>Note : DB-9 Controller is wired as a Null Modem ( pin to pin )</u>		
PIN 3	TX Transmit	-----> PIN 3 RX Receive
PIN 2	RX Receive	<----- PIN 2 TX Transmit
PIN 8	CTS Clear	<----- PIN 8 DSR Ready
PIN 5	Signal Ground	<-----> PIN 5 Signal/Frame
Shell	Frame Ground	<-----> Shell Signal/Frame

pin to pin cable

<u>MAC DIN.</u>	CPU DIN-8 (EIA-422)	CONTROLLER DB-9S
PIN 5	RX In-	<----- PIN 2 TX Transmit
PIN 3	TX Out-	-----> PIN 3 RX Receive
PIN 2	CTS Hand In	<----- PIN 8 DSR Ready
PIN 4	Signal Ground	<-----> PIN 5 Signal/Frame
PIN 8	RX In+	<-----' jumper to Signal Ground
Shell	Frame Ground	<-----> Shell Signal/Frame

MAC to IBM Adaptor Cable

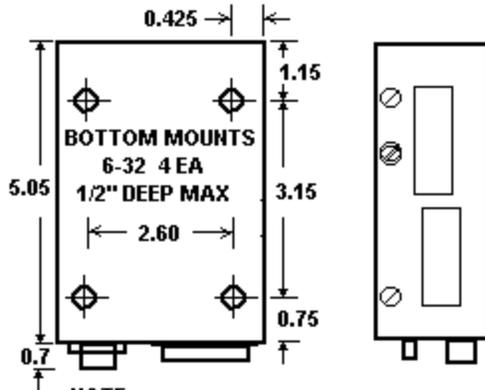
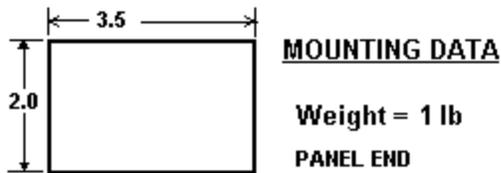
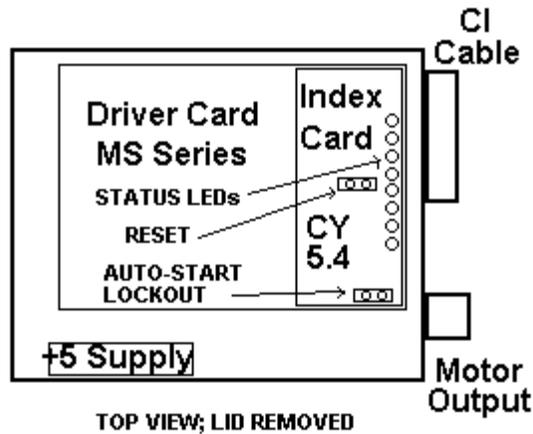
The Controller signal DSR (Data Set Ready) is wired to the host CPU signal CTS (Cleared To Send). When the controller is busy, the DRS will set HI or or busy and pull CTS HI or not Clear To Send; CPU will not send.

If the CS parameter in the OPEN COM statement of the host software is zero (or the CTS signal connection is incorrect), the CTS signal will be ignored and commands sent to the controller will be lost or jam the controller. Typical indications of the host failing to see the CTS (increase delay value) or miswiring are: motion or homing stops when host program is run, motor runs backwards at high speed forever, or only part of the Self-Test memory routine is completed.

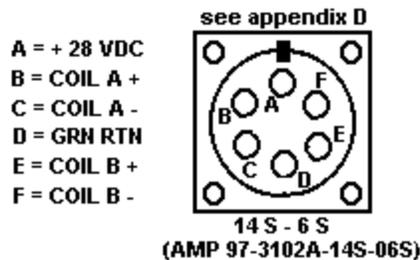
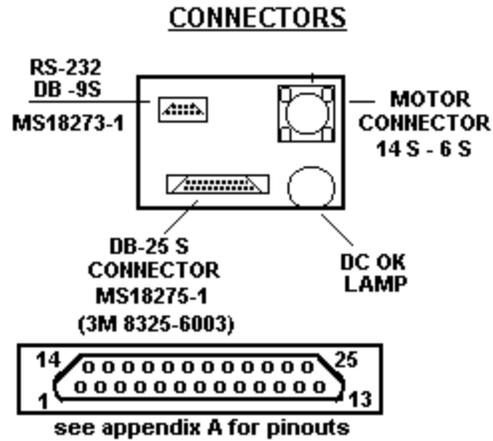
# SMD

## SECTION 2: SMD - Stepper motor drive assembly

5 " long x 3.5" wide x 2" high



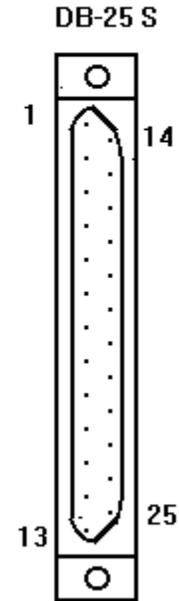
**NOTE:**  
Internal DC fuse  
All grounds are common  
Power off when connecting  
Remove lid to adjust current  
See Appendix C



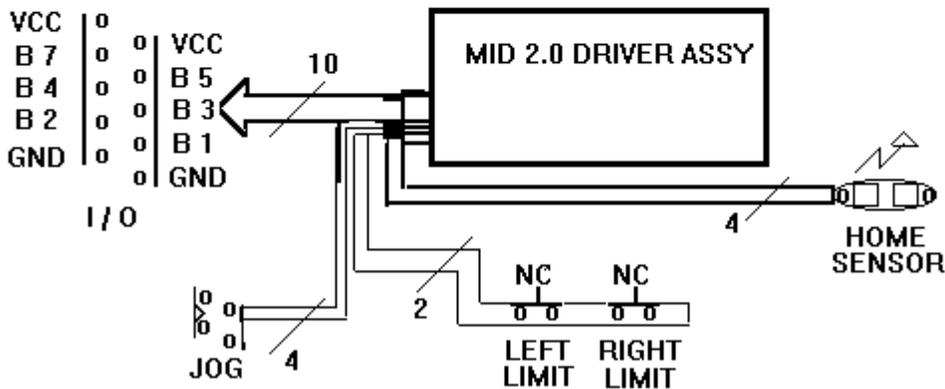
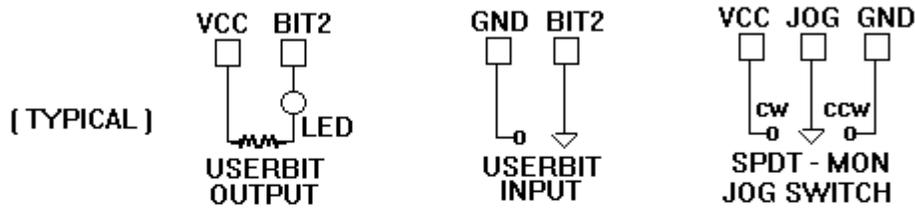


**APPENDIX A: CI CABLE DIAGRAM FOR MID SYSTEMS  
DB-25 CONNECTOR CABLING AND I/O CONNECTIONS**

1 BLK	14 WHT	VLED +5 V	HOME SENSOR
2 GRY	15 PUR	HOME GROUND	
3 BLU	16 GRN	+5 V GROUND	USER FUNCTION
4 YEL	17 ORN	B2 JOG	
5 RED	18 BRN	CPU ABR [B0] DRV ABR	LIMIT LOOP
6 BLK	19 WHT	I/O +5 V I/O +5 V	
7 GRY	20 PUR	B7 B5	INPUT OUTPUT FUNCTION
8 BLU	21 GRN	B4 B3	
9 YEL	22 ORN	B2 SAME AS PIN 4 B1 SAME AS PIN 2	
10 RED	23 BRN	I/O GROUND I/O GROUND	
11	24	SPARE	
12	25	SPARE	
13		SPARE	



**COLOR CODES FOR 20 PIN FLAT CABLE WITH  
DB25 MASS TERM**





**HOMING.** A major advantage of a digital Open-Loop step system is the ability to operate plus or minus zero steps (no error). Two conditions are required. One is that the motor is sufficient for the load in normal operation and second, that a reference position, commonly called the "home position", be consistently established during initialization of the system. When step motors are rotated by counting (clocking) out a number of steps, in theory, the motion will take place +/- zero steps. The exact mechanical position of the motor can vary by the motor step accuracy; typically +/- 3 % of one step (non-cumulative). A proof of +/- zero step operation is, first, to reference a starting position of the motor or "home". During homing, the motor is stepped backwards into a switch, reversed, and then stepped forward until the switch opens. The point of interest is not the exact mechanical position but rather on which step the switch changed state. For that reason, only high resolution "PHOTO-LOGIC" optical-beam switches are used in TMG systems.

**SLIP-DETECTION.** After the motor is home, the controller position counter is reset to the home position, typically position 1 (one step out of the sensor). The motor is then stepped CW to any position. To slip-detect the system, the motor is returned to position 1. If the sensor remains open, then the motor is stepped to position 0. If the sensor closes, the system is operating +/- zero steps (error free). Note that a single step lost (slip) will always result in at least a movement of 4 full steps away from the correct position. Open loop systems are slip-detected at regular intervals to prove continuing slip-free operation.

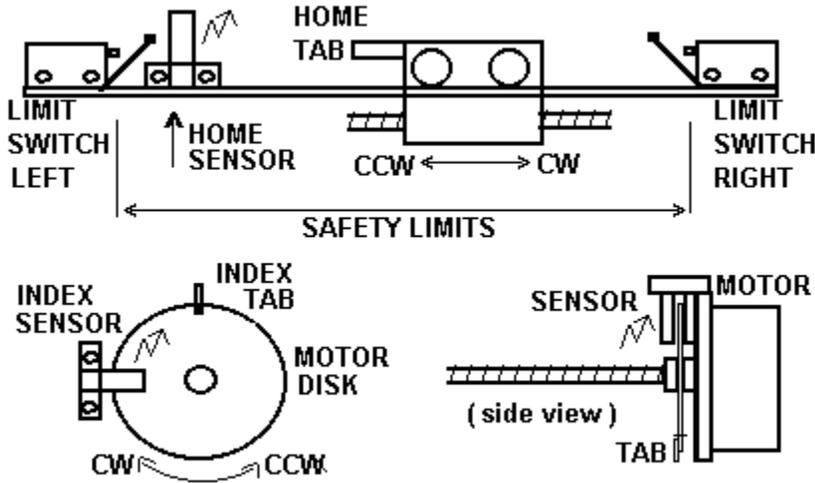
**CENTER HOME AND CONTIGUOUS SLIP DETECTION.** If the home sensor is located at the center of axis motion and a step bar is mounted along the entire motion path, then the home position can be verified each time the system crosses the center line. A stepped bar is thin strip with a left high side and a right low side. The high to low edge is the center line.

**LASH COMPENSATION.** A major advantage of steppers is in their "repeatability" which is typically less than .01 % because the digital controls are not affected by temperature, aging, voltage or adjustment. This allows errors such as lash and distortion to be zeroed-out.

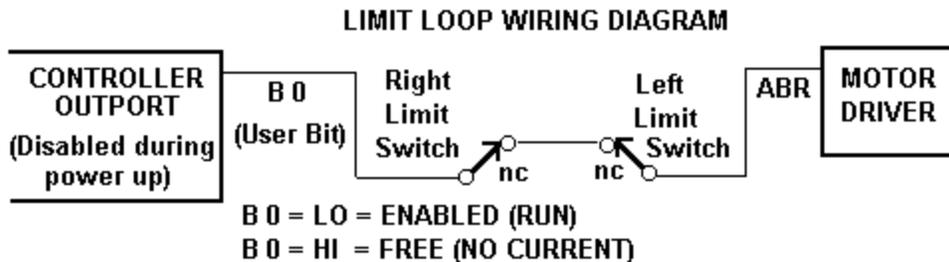
Lash compensation adds or subtracts steps, at each change of direction or because of other forces, to take-up the lash error. Lash compensation is accomplished during the slip-detection process. When the system is slip-detected the first time, the sensor will not close at position 0 because of the lash; home LED remains off. At this point, the system is single-stepped CCW until the sensor closes; home LED is on. The number of CCW steps is the lash compensation value. The system is re-homed and the counter loaded with this value (see At home command). The motor is then moved some number of steps CW, returned to position 1 (sensor open), and finally position 0 (sensor closed). The system is +/- zero steps.

Screw distortion error occurs when the screw pitch, which is so many turns per inch, does not move the correct distance after the correct number of turns of the motor. For example, a 10 turn screw should cause linear travel of 1 inch every 2000 steps (200 step/rev motor). If, rather than commanding the motor controller to go in 2000 step increments, the controller moves to absolute positions such as 2000, 4001, 6003, 7999, ect.; the error is eliminated. This technique requires a control system which carries a "map" with each individual machine. The EEPROM memory is suitable for this purpose.

**SUPER HOMING.** In high resolution systems, two sensors are used. The first sensor, the home sensor, is mounted to the motion platform in the typical configuration. The second sensor, the index sensor, is located as an index detector on the motor shaft. The index can be either a disk with a tab or a long pin. During the homing operation, the motor is stepped backwards until the first sensor is blocked. The motor, however, continues to rotate until the second or index mark is detected. The system is now "homed to the step". TMG systems with Super-Homing use two identical "PHOTO-LOGIC" sensors wire-ORed together so that both must be blocked before the home signal is detected. The H or home command of the motion controller will operate with either single or double sensors.



**ABORT LOOP FUNCTION.** In TMG systems, the ABORT loop is used to remove all winding power to the motor during an out-of-bounds condition. The ABORT feature can be used to provide hard-limits, emergency stop, door inter-locks, and other safety features. As the ABR input, to the driver, must be LO (ground) for the driver to step; opening the loop will stop (free) the motor regardless of the control logic. The diagram is typical of TMG "Fail-Safe, Hard-Soft" limit loops.



**NOTE: CONTRARY TO POPULAR PRACTICE, IT IS UNWISE AND UNSAFE TO SENSE LIMITS AND OTHER SAFETY CONDITIONS THROUGH THE COMPUTER INPUTS PORTS.**

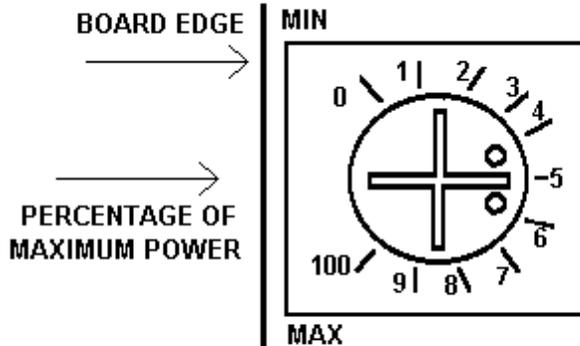
All motion products, regardless of their final intended form, should initially incorporate home sensors and slip-detection in order to prove correct positioning during product development, particularly during software de-bugging. Typically, a test routine is established which passes slip-detection. Any detrimental modification or code flaw will be flagged by this routine.

**APPENDIX C: MOTOR CURRENT ADJUSTMENT MM 2.0 (2 AMP MAX) SERIES**

**TO SET CURRENT; ALIGN SLOT TO MARK; CAREFULLY.  
 POT ADJUSTS PERCENTAGE OF MAX POWER. 2 AMP x 50 % = 1 AMP /COIL**

**IN GENERAL:**

- CURRENT TOO LOW; MOTOR SLIP FROM REDUCED TORQUE**
- CURRENT CORRECT; SMOOTH ROTATION WITH NO SLIP OR RESONANCE**
- CURRENT TOO HIGH; EXCESSIVE NOISE, SLIP, MOTOR OVERHEATING  
 (ABOVE 85 C), AND POOR RAMP PERFORMANCE**



**NOTE:**  
 DRIVER WILL REDUCE  
 CURRENT IF OPERATED  
 CONTINUOUSLY AT SLOW  
 RATES (200 PPS) WITH  
 CURRENT SET ABOVE 60 %.

**WARNING: CONSTANT CURRENT, AUTO-PARKING, BI-POLAR DRIVERS !  
 DO NOT ATTEMPT TO MEASURE CURRENT WITHOUT SPECIAL INSTRUCTION**

Performance of a stepper motor based system depends more on the electronic drivers used than it does on the motor itself. A step motor (both PM and Hybrid type) is made to step by sequencing the orientations of the magnetic fields in two coils. The UNIPOLAR drive method of is illustrated, in the figure, using just ONE coil of the motor. Note that the center tap of the coil is connected to the positive motor supply voltage. An electronic circuit, represented by the switch, then connects one end or the other to ground for current to flow from the center tap to the grounded end. The most significant factor is that only one-half of the coil is used at any given time and that the magnetic field intensity (motor torque) is proportional to the product of the number of turns in the coil and the current passing through the coil.

Motors designed for BIPOLAR drivers will often have only four leads. However some manufactures will provide the motors in 8 wire versions to offer a performance choice for bipolar drive users as in figures C & D. Four lead bipolar motors may use larger wire, since only half the windings are required in the given space of the motor body. The paralleling in figure C is the equivalent of this to achieve lower winding resistance and thereby doubling motor efficiency. The other alternative for the motor designers is to use a greater number of turns in the winding space. This is shown by figures B & D and results in more torque with a lower coil current but a subsequent loss of high speed torque.

Although step motors are often classified as bipolar or unipolar (2 phase or 4 phase), these terms are more accurately applied to the types of electronic circuit used to drive the motor. Bipolar drivers can drive 4,5,6 and 8 wire motors. When the motor is described as unipolar, the specifications are presented with the assumption that the motor will be driven with a unipolar drive. Therefore the specifications must be translated to bipolar when the motor is used with a bipolar driver. In general, the translation is similar to a unipolar driver with dropping resistors in series with the center taps; referred to as  $L$  over  $xR$  with  $R$  equal to the motor winding resistance. For example, a  $L$  over  $4R$  unipolar driver has a resistor equal to 4 times the winding resistance. In bipolar, the  $L$  over  $R$  ratio is the ratio of the motor voltage to the supply voltage. A  $L$  over  $4R$  bipolar drive, for example, would be a 6 volt motor and a 24 volt power supply. Performance would be similar to the  $L/4R$  torque curve of a unipolar motor. The figures identify the various connection options when using a bipolar driver with 6 or 8 wire motors.

**A: SINGLE COILS.** Identical to unipolar specification (if the supply voltage equals the specified motor voltage). Normal connection of a bipolar driver to 6 wire motor.

**B & D: SERIES COILS.** This configuration will produce torque greater than the unipolar specification indicates. To stay within the power (wattage) rating of the motor, reduce the unipolar specified current by 30%; depending on the duty-cycle of the system (park time). Note that the torque curve of this configuration is considerably fore-shortened as this motor is now the same as a motor with a rating of twice the voltage (slower motor).

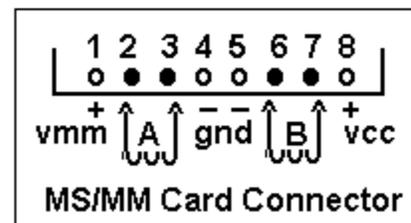
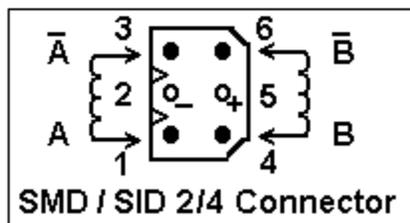
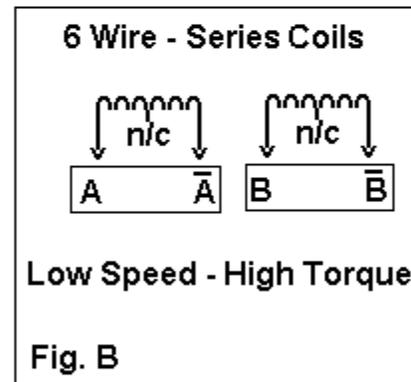
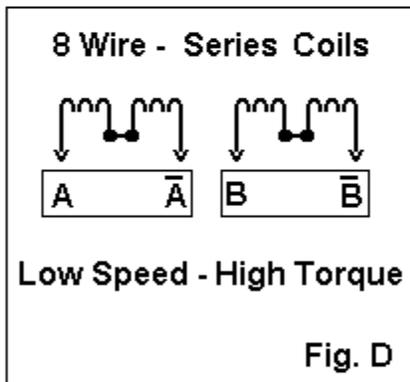
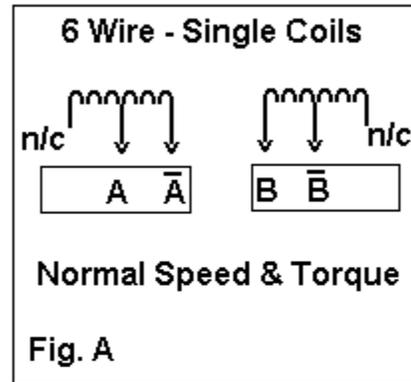
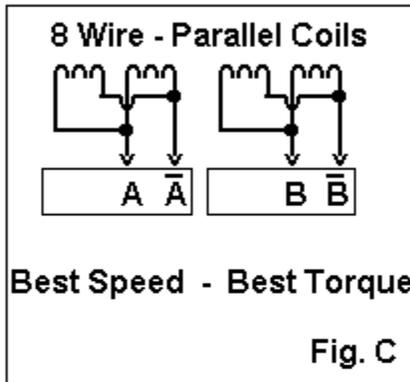
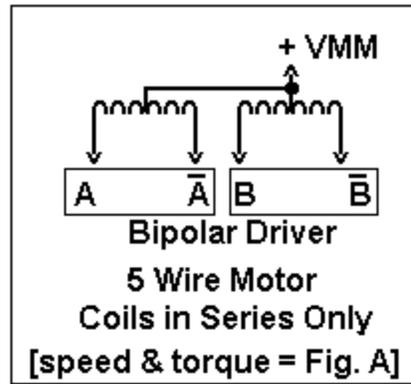
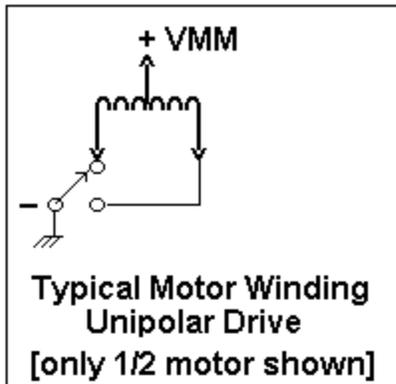
**C: PARALLEL COILS.** When this configuration is driven at the unipolar current, the motor will perform identical to the specification but the motor will dissipate only one-half the power (it is twice as efficient). When the current is increased by 1.414, to drive the motor at it's full power rating, the motor torque is increased by approximately 60% Note that this torque curve is extended by four times (high speed system).

Resonance (vibration) of a step motion system depends on the speed and power range of the motor. Fast windings (A & C) are "quicker" and may break into resonance easier than slow (B & D). Power windings (B & D) may deliver "excessive" power (torque) to the system and produce resonance. In general, resonance indicates, except at the low (100 sps) and mid-frequency (1000 sps) bands, excessive power; therefore reduce the driver current for smoother operation or wire the motor for "softer" response.

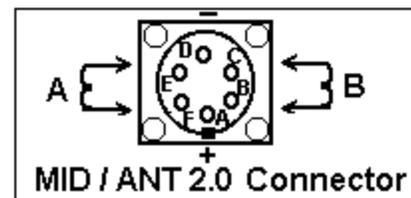
**NOTES:** If a motor runs "backwards" with respect to software direction, transpose the connections of ONE coil. For MS series driver cards, pins 2 & 3 or 6 & 7; SID / SMD driver boxes, pins 1 & 3 or 5 & 6.

Five wire motors are really 6 wire motors with the center tap common. The center tap must be connected to the motor supply voltage. If phases 1, 2, 3 or 4 are crossed, motor will not rotate (hums). For MS cards, pin 1 is VMM, for SID /SMD (if connected), pin 5 is VMM and pin 2 is GND.

Systems with pin 5 & 2 connected are used to power external relays or solinoid valves. The pins are keyed (reversed). Never attempt to connect any motor leads to pin 2 and only 5 wire center taps to pin 5. Pins 2 & 5 are normally not connected and used to store the unused leads of 6 or 8 wire motors.



**MOTION GROUP MOTOR CONNECTORS**







**MOLEX - WALDOM NYLON CONNECTOR SYSTEM USED BY THE MOTION GROUP**

The connectors used on Motion Group equipment are nylon connectors are manufactured by Molex and are referred to as .062 style (pin diameter) or .093 (large driver motors only). They are available from Newark, Allied, and Digi-Key and come in 1 to 36 positions with locking and mounting tabs which snap-in to punched holes on brackets or enclosures.

TYPICAL \$	POLES	TYPE	PART #	NEWARK #	USED ON
5.84/10	4 (.062)	MALE HOOD	03-06-2041	31F1004	HOME SENSOR ASSY
5.95/10	4 (.062)	FEMALE RECT	03-06-1041	31F1005	HOME SENSOR CABLE
1.86/5	6 (.062)	MALE HOOD	03-06-2062	31F1008	STEP MOTOR ASSY
2.07/5	6 (.062)	FEMALE RECT	03-06-1061	31F1009	MOTOR OUTPUT
1.86/5	6 (.093)	MALE HOOD	03-06-2062	31F1008	STEP MOTOR ASSY
2.07/5	6 (.093)	FEMALE RECT	03-06-1061	31F1009	MOTOR OUTPUT

(Strain Relief Hoods are available on request)

Contacts for Connector Sets .062 SIZE

6.79	FEMALE SOCKETS	LARGE TAB	02-06-1103	31F1027	22-18 GAUGE WIRE
	MALE PINS	LARGE TAB	02-06-2103	31F1026	22-18 GAUGE WIRE
	FEMALE SOCKETS	SMALL TAB	02-06-1132	31F1029	30-22 GAUGE WIRE
	MALE PINS	SMALL TAB	02-06-2132	31F1028	30-22 GAUGE WIRE

Contacts for Connector Sets .093 SIZE

6.79	FEMALE SOCKETS	LARGE TAB	02-06-1103	31F1027	22-18 GAUGE WIRE
	MALE PINS	LARGE TAB	02-06-2103	31F1026	22-18 GAUGE WIRE
	FEMALE SOCKETS	SMALL TAB	02-06-1132	31F1029	30-22 GAUGE WIRE
	MALE PINS	SMALL TAB	02-06-2132	31F1028	30-22 GAUGE WIRE

In general, single wires use small tab contact; double wires the large tab

Tooling

105	RATCHET TOOL .062 DIA	HTR-2262 11-01-006 30F338	MAKES PERFECT CRIMPS
105	RATCHET TOOL .093 DIA	HTR-XXXX 11-01-006 30F338	MAKES PERFECT CRIMPS
13	HAND TOOL	HT-1921 11-01-0015	31F1049 REQUIRES PRACTICE
12	EXTRACTOR .062 DIA	HT-2285 11-03-0002	30F773 SPRING LOADED PUNCH-OUT
12	EXTRACTOR .093 DIA		

Nylon Connector Designer/Service Kit

Contains male/female housing assortment, hand crimper, pin extractor (not as easy to use as spring extractor; see above), contacts, and case.

40	DESIGNER KIT	.062	WM-072	30F774
40	DESIGNER KIT	.093		

All of the above, including custom cable sets are available from the factory.

Note: When disconnecting, grasp the mounting tabs, (not the wires) and rock from top to bottom (unseat the locking bump) rather than side to side and then pull the connection apart. The connections unseat easily with the right technique.

Contact factory for Heavy Duty Connectors with Metal Shells, Retainers, and Strain-Reliefs.

## SPECIFICATIONS - MID 2.0

PARAMETER		MIN	MAX	UNIT
Power				
Motor supply voltage		12	40	VDC
Current (no motor)		150	160	ma
PWM frequency				
MD10A	18	24		Khz
Motor current				
MS2.0		0.05	2.0	Amp
Step pulse input				
Voltage	0	+5.0		VDC
Sink current		12	20	ma
Pulse high		1		uSec
Pulse low		1		uSec
Rise time			0.5	uSec
Fall time			0.5	uSec
Frequency			500	KHz
Logic '1' volts	+1.8	+2.0		VDC
Direction input				
Voltage	0	+5.0		VDC
Sink current		12	20	ma
Logic '1' volts		+1.8	+2.0	VDC

Note: The step pulse input must be a logic 1 (high) during direction input change.

Environmental				
Operating temperature	-20	+50		C
Humidity (non-condensing)		0	95	%
Shock		100		G
Altitude		30,000		FT
Mechanical				
Weight		1.0		lb
Dimensions		2" x 3.5" x 5.0"		
Mounting hole centers		2.60" x 3.250"		
Mounting screw size		#6-32 x 1/2" max		

**THE MOTION GROUP** SERVICE CENTER  
800-424-STEP  
motiongroup.com  
PO BOX 669 CLOVIS, CA 93613-0669 TEL: 559-325-2727 FAX: 559-325-7117

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MINI-STEP QUAD-STEP AUTO-PARK DIAL-POT MMA PRINTER PORT DRIVER

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