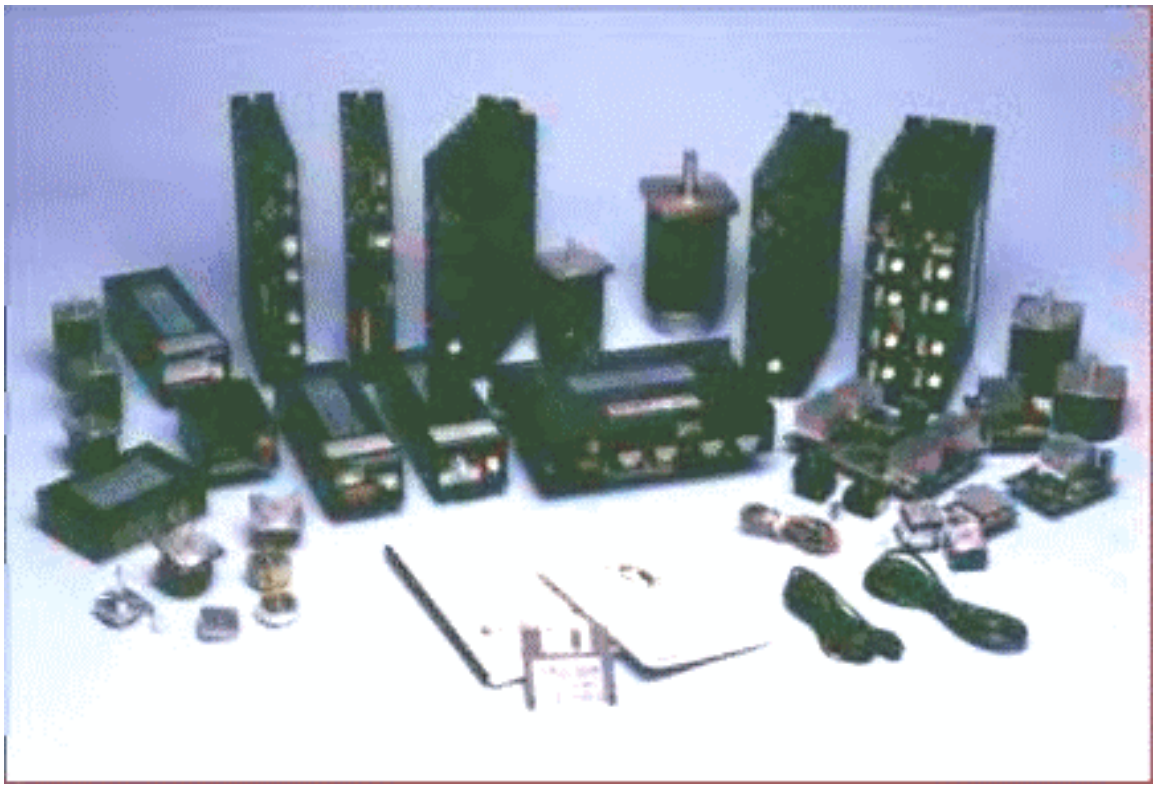
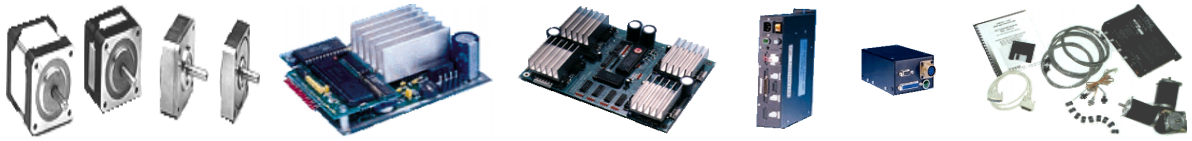
The Motion Group, Inc Product Catalog.



I.	Intro:	The Motion Group, Inc.
III.	Stepper Motors:	Catalog- Motor Cross references- Motor Specifications-
III.	Motor Drivers.	1.2 Amp / Phase Drivers 2.0 Amp / Phase Drivers
IV.	Controllers:	Single Axis controllers- Multiple Axes controllers-
V.	Software:	SIDDEMOB.bas (single axis QBASIC .bas file CyberPro from Graham Automation
VII.	Step Motor Basics:	General theory of operation

TMG
the motion group P.O. Box 669, Clovis CA 93613-0669



The Motion Group, Inc.

Suppliers of stepper motors, stepper motor drivers and multiple axis step control products.

PH: 800-424-STEP (7837) Fax 559-325-7117 E-Mail: **Sales@motiongroup.com**

The Motion Group's product line is based on state-of-the-art, totally accurate technology (+/- 0 steps) which works with any stepping motors and are easily integrated in high-technology applications. As well as being moderately priced, The Motion Group's products arrive with developmental or custom software, are Ready-to-Step and carry a 100% warranty.

The Motion Group has a history of more than twenty years in stepper motor control design and manufacturing of standard OEM products, prototypes and application specific stepper motor controllers.

Our goal is to have your stepper motor project under keyboard control
and stepping to your requirements **within 24 hours of receiving our products.**

.

Industries & Applications

A sample of different industries and applications in which The Motion Groups products have been efficiently and effectively incorporated include:

medical testing (microscopes, automated dispensing devices, and testing equipment)
petroleum (mixing and sampling devices, environmental testing equipment)
packaging (dry and moist food products, "blister packaging")
scientific equipment (chromatographs, observatory telescope positioning)
military (antenna positioners, automated sensing devices, and automated cameras)
aircraft (instruments, sensing devices, antennas, scanning equipment)
machine tooling (retrofitting kits of controllers and motors for computer control).

Top of Page

Facilities

Large production capabilities: OEM custom board design; subcontractors for board level production assemblies and/or systems; military and FAA spec qualified.

Programming: Motion control programming is available either off-the-shelf or for custom applications.

Motors: manufacturing plants in Northern California and Taiwan.

Top of Page

SERVICE

TMG products carry a 100% warranty.
On-Site applications engineer available for technical assistance throughout your project life cycle.

We are "Ready to Step" and ready to ship.

Please contact the service center for details. 800-424-STEP(7837)
or E-Mail

Back to Top of page

Top of Page

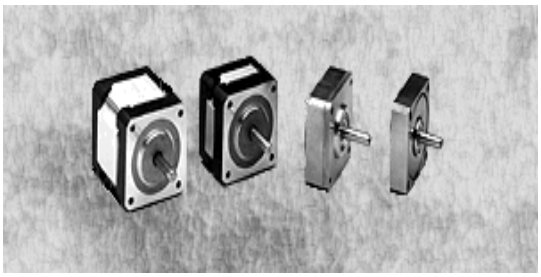
[How to contact us]

E-MAIL: sales@motiongroup.com

Mailing address: The Motion Group, Inc.
P.O. Box 669
Clovis, CA 93613-0669

Call 1-800-424-STEP(7837)
or Fax 1-559-325-7117

Send questions and comments to webmaster@motiongroup.com



Stepper Motors Catalog

The Motion Group, Inc. supplies a large variety of stepper motors for all your motion control needs. We have stepper motors in standard NEMA sizes 17 through 42 and 4, 6 or 8 wire configurations. We also deliver *CUSTOM* stepper motors to meet your individual specs.
Select a motor from the catalog below or Request Info and we can recommend a range of motors to choose from.

Hybrid Step Motors

1.8 Degree (200 step/rev.) Motors
0.9 Degree (400 step/rev.) Motors
Specialty Motors(0.45 & 0.9 degree)

1.8 Degree (200 steps/rev.) Hybrid Stepper Motor

General Specifications
Sizes **17**, **23**,and **34**
frame

Size **17** (40 mm)
Length: J=1.15 S=1.30 M=1.54 L=1.85(inches)

Model No.	Volts Vdc	Amps Phase	Torque Oz-in	Res. Ohms/Ph	Induct. mH/Ph	Iner. Oz-In	Wght. Lbs
4018J-51(F)	4.0	0.80	20.0	5.00	4.00	.087	0.45
4018S-12(F)	2.4	1.20	20.0	2.00	2.00	.093	0.44
4018S-18	4.0	0.95	13.9	4.20	2.20	.093	0.44
4018S-10	9.6	0.40	13.9	24.00	11.00	.093	0.44
4018M-08	6.0	0.80	22.3	7.50	6.00	.136	0.48
4018L-03	4.0	1.20	29.3	3.30	2.70	.200	0.66
4018L-01	6.0	0.80	29.3	7.50	5.70	.200	0.66

Return to Motor Menu

Size **23** (56 mm)
Length: X=1.53 S=1.99 M=2.11 L=3.00 C=4.00 (inches)

Model No.	Volts Vdc	Amps Phase	Torque Oz-in	Res. Ohms/Ph	Induct. mH/Ph	Iner. Oz-In	Wght. Lbs
5618X-11	5.0	1.00	37.0	5.00	5.70	.30	0.75
5618X-24	4.0	1.10	37.0	3.60	4.00	.30	0.75
5618S-15	6.0	0.85	70.0	5.00	8.50	0.60	1.12
5618S-01	5.1	1.00	70.0	5.10	9.00	0.60	1.12
5618S-42	1.4	3.80	70.0	0.37	0.50	0.60	1.12
5618M-06	6.0	1.20	84.0	5.00	8.60	0.74	1.20
5618L-09	1.7	4.60	125.0	0.26	0.70	1.20	1.90
5618L-05	5.4	1.40	125.0	3.80	6.80	1.20	1.90
5618C-02	2.2	4.60	170.0	0.48	1.00	1.90	3.08
5618C-03	6.0	1.80	170.0	3.50	7.30	1.90	3.08

Return to Motor Menu

Size **34** (86 mm)
Length: S=2.46 M=3.70 L=5.04(inches)

Model No.	Volts Vdc	Amps Phase	Torque Oz-in	Res. Ohms/Ph	Induct. mH/Ph	Iner. Oz-In	Wght. Lbs
8618S-01	1.6	6.10	180.0	0.20	1.10	3.10	3.20
8618S-02	1.8	4.50	180.0	0.40	1.40	3.10	3.20
8618M-11	2.0	6.00	350.0	0.33	0.80	6.02	5.78
8618M-02	3.0	4.00	350.0	0.75	4.50	6.02	5.78
8618L-03	3.0	6.70	500.0	0.45	2.00	9.85	8.00
8618L-02	5.0	4.00	500.0	1.25	6.60	9.85	8.00

Return To: **Motor Menu**

0.9 Degree (400 steps/rev.) Hybrid Stepper Motor

General Specifications
Sizes: **17**, **23**,and **34**

Size 17 (40 mm)
Length:
S=1.30 M=1.54 L=1.85(inches)

Model No.	Volts Vdc	Amps Phase	Torque Oz-in	Res. Ohms/Ph	Induct. mH/Ph	Iner. Oz-In	Wght. Lbs
4009S	4.0	0.90	11.1	4.40	2.50	0.88	0.44
4009M	4.0	1.20	16.6	3.30	3.60	0.13	0.55
4009L	4.0	1.20	23.6	3.30	3.10	1.90	0.73

Return to Motor Menu

Size 23 (56 mm)
Length: X=1.53 S=1.99 M=2.11 L=3.00 C=4.00(inches)

Model No.	Volts Vdc	Amps Phase	Torque Oz-in	Res. Ohms/Ph	Induct. mH/Ph	Iner. Oz-In	Wght. Lbs
5609X	5.0	1.00	37.0	5.00	5.70	.30	.75
5609S	6.0	0.85	70.0	5.00	8.50	.60	1.12
5609M	6.0	1.20	84.0	5.00	8.60	0.74	1.20
5609L	5.4	1.40	125.0	3.80	6.80	1.20	1.90
5609C	6.0	0.80	170.0	3.50	7.30	1.90	3.08

Return to Motor Menu

Size 34 (86 mm)
Length: S=2.46 M=3.70 L=5.04

Model No.	Volts Vdc	Amps Phase	Torque Oz-in	Res. Ohms/Ph	Induct. mH/Ph	Iner. Oz-In	Wght. Lbs
8609S-02	1.8	4.50	180.0	0.40	1.30	3.10	3.30
8609M-02	3.0	4.00	350.0	0.75	4.40	6.02	5.78
8609L-02	5.0	4.00	500.0	1.25	6.60	9.85	8.10

Return To: **Motor Menu**

Specialty Hybrid Step Motors

0.9 Degree (size 17) or .45 Degree(size23)

Size 17 (40 mm),0.9 degree(400 Step/Rev)
Length: X=0.65 Y=0.50(inches) Model Volts Amps Torque Res. Induct. Iner. Wght. No. Vdc Phase

Oz-in Ohms/Ph mH/Ph Oz-In Lbs ---------- 4009Y-51 2.4 0.60 6.5 4.00 2.50 0.03 0.20 4009X-51 3.0 0.60 9.0 5.00 2.50 0.04 0.25 ----------
Return to Motor Menu **Size 17 (40mm), 0.9 degree(400Step/Rev)** length: Z=0.38 Y=0.52 X=0.60 V=0.75(inches) Model Volts Amps Torque Res. Induct. Iner. Wght. No. Vdc Phase Oz-in Ohms/Ph mH/Ph Oz-In Lbs ---------- 4109Z-51 1.1 0.5 3.0 3.5 1.5 0.017 0.12 4109Y-51 2.4 0.6 6.0 4.0 2.5 0.03 O.16 4109X-51 3.0 0.6 8.0 5.0 2.5 0.04 0.18 4109V-51 3.6 1.2 15.0 3.0 2.0 0.08 0.28 ----------
Returnto Motor Menu **Size 23 (56 mm), 0.45 degree(800Step/Rev)** Length: M=2.11(inches) Model Volts Amps Torque Res. Induct. Iner. Wght. No. Vdc Phase Oz-in Ohms/Ph mH/Ph Oz-In Lbs
---------- 5604M-51 3.6 1.8 45.0 2.00 2.50 0.50 1.20

Insulation Class = Class B
Insulation Resistance = Min l00 Mohms (@ 500 vdc)
Dielectric Strength = 500 Vac for I min.
Temperature Rise = Max 80 C
Ambient = 0 - 40C

F code = Four Wire
- Code = Six Wire
E Code = Eight Wire
B Code = Double Shaft

Size 42 and Larger Motor Catalog Available upon Request
Return to TOP

Send questions and comments to webmaster@motiongroup.com

GENERAL CROSS REFERENCE TABLE

(Cross References May Not Be Exact - Refer To Motor Data Sheets)

TMG	Oriental	Superior	Astrosyn	Rapidsyn	Other
4018S-18	PX243-01	x=c & C		X=C & D	L43-34(CO)
4018S-10	PX243-02	SEE ***	I5PM-K004	SEE ***	
4018S-20	PX243-03		17PM-M004		
4018S-01*			17PM-M002		480120B348(AI)
4018S-04*			I7FM-M004		
4018S-07*			17FM-MOO8		
4018S-17*			I7PM-M012		
4018M-08	PX244-02				
4018M-03	PX244-03				
4018M-01	PX244-04				
4018L-03	PX245-01				
4018L-01	PX245-02				
4018L-02	PX245-03				

TMG	Oriental	Superior	Astrosyn	Rapidsyn	Other
5618X-11	PH264-01		23LM-C202		
5618X-07	PH264-02		23LM-C226		238HAC-23BU (CL)
5618X-14	PH264-03				238HAC-11BU (CL)
5618S-10	PH265-01	MO61Fx302	23LM-C309		238HAC-27BU (CL)
5618S-10	PH265-01	M57-5ICOM	L57-51COM		48HC06A468 (Al)
5618S-05	PH265-02	M061Fx301			48HG12A468 (Al)
5618S-08	PH265-03	MO61Fx3I1	23LM-C315		48HG24A468 (Al)
5618S-01	PH265-04	MO61FxO2	23LM-C304	23X6102	238HAB-O3BU (CL)
5618S-42	FH265-05	MO61FxO8	23LM-C302	23X6018	238HAB-O9BU (CL)
5618M-06	FH266-01		23LM-C004	M5783C0M	148HG06A568(AI)
5618M-01	PH266-02		23LM-C005		48HG12A568 (Al)
5618M-03	?H266-03		23LM-C006		48HG24A568 (Al)
5618L-09		M062Fx09	23FM-C406	23X6209	
BTO **		MO62FxO4			
5618L-03	PH268-21	MO62Fx03	23PM-C401	23X6204	M57-102 (CO)
5618L-23	PH268-22				
5618L-24					
5618C-02		MO63Fx09	23FM-C501	23X6309	
5618C-03	PH2610-01				
5618C-04		MO63Fx06	23FM-C503	23X6306	
56i8C-11	PH2610-02				
5618C-16	PH2610-03				
BTO **		MO63FxO9			

TMG	Oriental	Superior	Astrosyn	Rapidsyn	Other
8618S-02	PH296-O1	MQ91FxO9	34PM-C049	34X9109	M83-62 (CO)
BTO **		MO91FxO6	34PM-Q041	34X9106	
8618S-03	PH296-02	MO91FxO3	34PM-C007		
BTO **		MO91Fx3O8	34PM-C0O8		
8618S-11	PH296-03		34PM-C009		
BTO **		M092Fx09	34PM-C11O	34X9209	
8618M-02	FH299-01	M092Fx08	34PM-C1OI		M83-93 (CO)
8618M-03	FH299-02				
8618M-12	PH299-03		34PM-C108		
8618L-03		MO93FX14	34PM-C213	34X9314	M83-135 (CO)
BTO **		MO93FX11		34X9311	
8618L-02		MO93FXO7	ERPM-C206		

2 - 4 WEEK DELIVERY
** BUILT TO ORDER 6-8 WEEKS
*** STANDARD STEP ACCURACY ERROR IS LESS THAN 4%. 3% AVAILABLE
(CO) = COMPUMOTOR (CL) = CLIFTON (Al) = AIRPAX

GENERAL CROSS REFERENCE TABLE

(Cross References May Not Be Exact - Refer To Motor Data Sheets)

TMG	Oriental	Superior	Astrosyn	Rapidsyn	Other
4018S-18	PX243-01	x=c & C		X=C & D	L43-34(CO)
4018S-10	PX243-02	SEE ***	I5PM-K004	SEE ***	
4018S-20	PX243-03		17PM-M004		
4018S-01*			17PM-M002		480120B348(AI)
4018S-04*			I7FM-M004		
4018S-07*			17FM-MOO8		
4018S-17*			I7PM-M012		
4018M-08	PX244-02				
4018M-03	PX244-03				
4018M-01	PX244-04				
4018L-03	PX245-01				
4018L-01	PX245-02				
4018L-02	PX245-03				

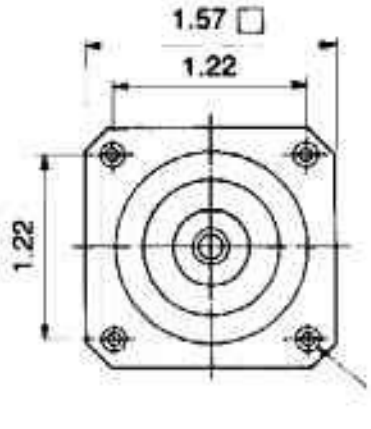
TMG	Oriental	Superior	Astrosyn	Rapidsyn	Other
5618X-11	PH264-01		23LM-C202		
5618X-07	PH264-02		23LM-C226		238HAC-23BU (CL)
5618X-14	PH264-03				238HAC-11BU (CL)
5618S-10	PH265-01	MO61Fx302	23LM-C309		238HAC-27BU (CL)
5618S-10	PH265-01	M57-5ICOM	L57-51COM		48HC06A468 (Al)
5618S-05	PH265-02	M061Fx301			48HG12A468 (Al)
5618S-08	PH265-03	MO61Fx3I1	23LM-C315		48HG24A468 (Al)
5618S-01	PH265-04	MO61FxO2	23LM-C304	23X6102	238HAB-O3BU (CL)
5618S-42	FH265-05	MO61FxO8	23LM-C302	23X6018	238HAB-O9BU (CL)
5618M-06	FH266-01		23LM-C004	M5783C0M	148HG06A568(AI)
5618M-01	PH266-02		23LM-C005		48HG12A568 (Al)
5618M-03	?H266-03		23LM-C006		48HG24A568 (Al)
5618L-09		M062Fx09	23FM-C406	23X6209	
BTO **		MO62FxO4			
5618L-03	PH268-21	MO62Fx03	23PM-C401	23X6204	M57-102 (CO)
5618L-23	PH268-22				
5618L-24					
5618C-02		MO63Fx09	23FM-C501	23X6309	
5618C-03	PH2610-01				
5618C-04		MO63Fx06	23FM-C503	23X6306	
56i8C-11	PH2610-02				
5618C-16	PH2610-03				
BTO **		MO63FxO9			

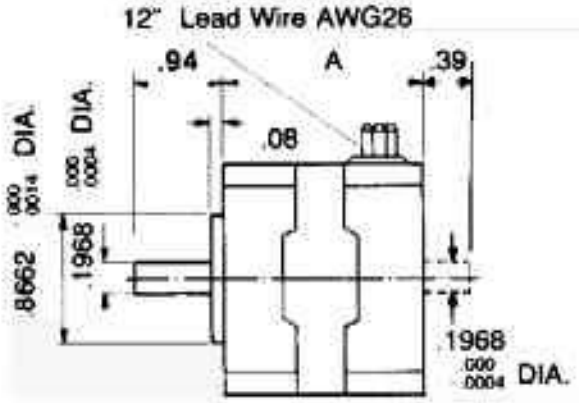
TMG	Oriental	Superior	Astrosyn	Rapidsyn	Other
8618S-02	PH296-O1	MQ91FxO9	34PM-C049	34X9109	M83-62 (CO)
BTO **		MO91FxO6	34PM-Q041	34X9106	
8618S-03	PH296-02	MO91FxO3	34PM-C007		
BTO **		MO91Fx3O8	34PM-C0O8		
8618S-11	PH296-03		34PM-C009		
BTO **		M092Fx09	34PM-C11O	34X9209	
8618M-02	FH299-01	M092Fx08	34PM-C1OI		M83-93 (CO)
8618M-03	FH299-02				
8618M-12	PH299-03		34PM-C108		
8618L-03		MO93FX14	34PM-C213	34X9314	M83-135 (CO)
BTO **		MO93FX11		34X9311	
8618L-02		MO93FXO7	ERPM-C206		

2 - 4 WEEK DELIVERY
** BUILT TO ORDER 6-8 WEEKS
*** STANDARD STEP ACCURACY ERROR IS LESS THAN 4%. 3% AVAILABLE
(CO) = COMPUMOTOR (CL) = CLIFTON (Al) = AIRPAX

Mechanical Specifications

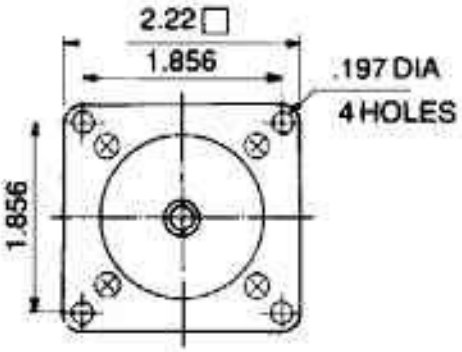
Dimensions (Unit: Inch)

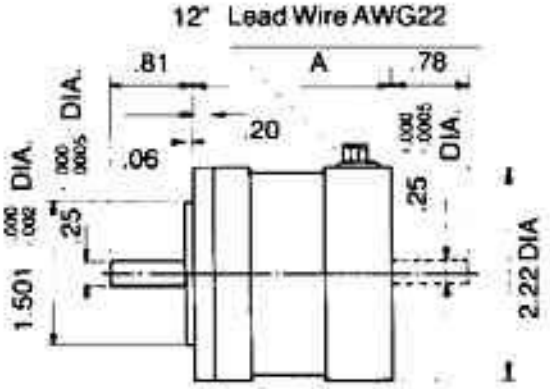




Size 17 (40 mm)

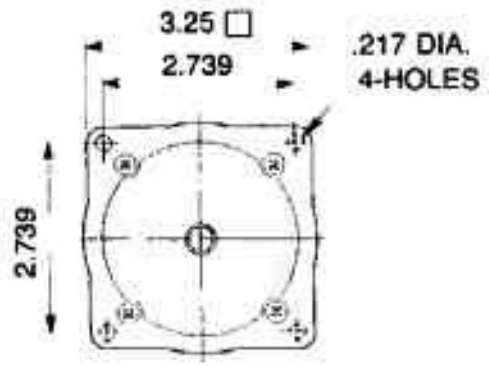
Model	"A"
Y	0.50"
X	0.65"
S	1.30"
M	1.54"
G	1.65"
L	1.85"

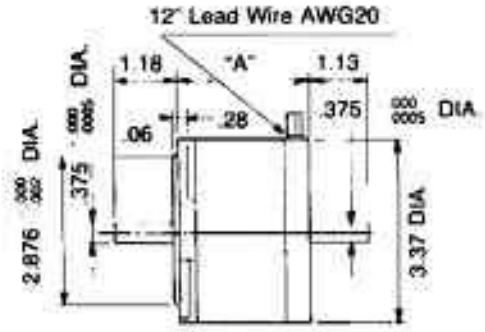




Size 23 (56 mm)

Model	"A"
X	1.52"
S	2.00"
M	2.11"
G	2.62"
L	3.00"
K	3.31"
C	4.00"

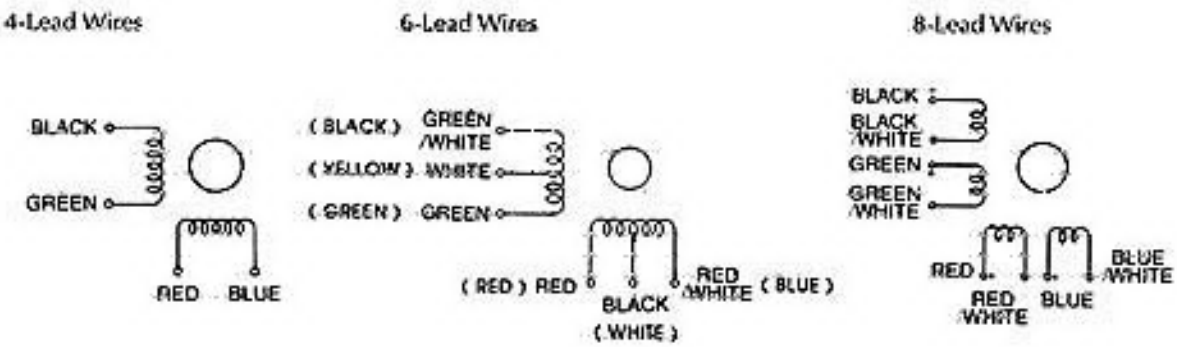




Size 34 (86 mm)

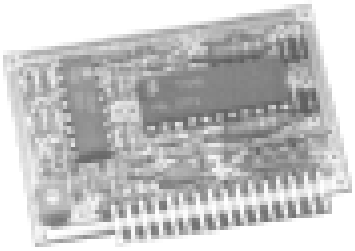
Model	"A"
S	2.46"
M	3.70"
L	5.04"

Color of Lead Wires



OEM- Stepper Motor Drivers

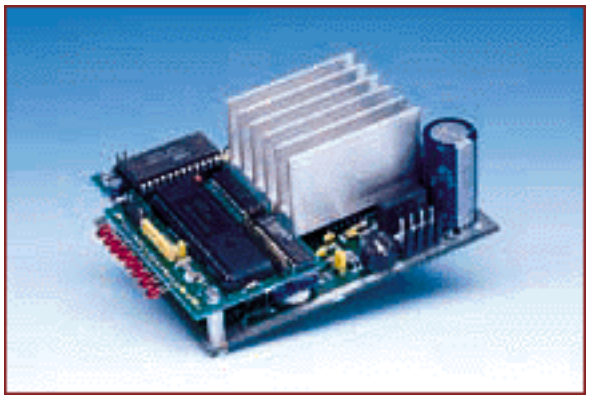
40 Volts/Phase, Bi Polar Chopper, Constant Current



MD 1.2:Miniature Step Motor Driver

Motor compatibility; The MD 1.2 is a high performance 0 - 1.2 Amp (RMS) miniature stepper motor driver that is not only cost effective but powerful enough to handle the most rigorous applications. Through proven stepper motor drive technology the MD 1.2 delivers the power effectively and efficiently (bipolar chopper drive with power reduction at stand still). At 0.275" above board height (horizontal mount) the MD 1.2 allows for easy integration into instrumentation, VME and European rack mount systems Our two mounting options allow for the most flexible use of valuable space in a modular or confined environment. Fully compatible with matching TMG stepper motor controller. Compatible with standard stepper motors (4,6 or 8 wire).
[-View Spec Sheet-]

MS 2.0: 2A Stepper Motor Driver



Shown with CY 5.4 controller

Economical Step Motor Driver

The **MS 2.0** is an extremely **powerful** stepper motor driver / translator unit capable of driving either bipolar or unipolar motors up to **2.0 amps per phase** in Full, Half or **Quad** step (3200 s/rev).
The step sequences are generated on-board, therefor, the MS 2.0 requires only digital step pulses and direction signal. No step software is required (onboard firmware).
The MS 2.0 stepper motor driver features Switch-Mode, Bi-polar, Constant-Current technology (requiring no dropping resistors),**adjustable maximum output current** and **Auto-park** which reduces motor dissipation during non-step periods.

Driver protection includes; over-temp, over-volts, over-current and reversed supplies.
Top speed is limited only by motor type and stepper motor supply voltage.

[-View Spec. Sheet-] for general specifications.
[-View Dimesional Dwg.-]

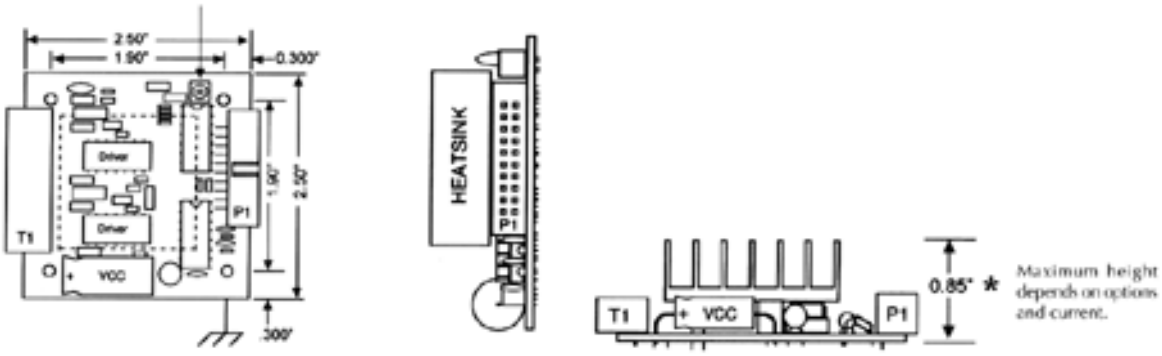
PLC Interface (MS Series) Stepper motor driver

PLC version includes on-board or out-board adjustable oscillator, fail-safe limit loop and Auto-Park. Relay closure or switch to GND inputs (Run, Park and CW - CCW). Available with TST automatic proportional ramping.

DSD Interface (MS Series) Stepper motor driver

DSD version is a dial encoder interface which allows the accurate positioning of a stepper motor by rotating a dial. System includes power-reduction at standstill, over-speed protection, adjustable torque, and built in braking. System retains position during power-on; it will not “servo-crash”. Resolutions to 3200 steps of encoder dial.

MM 2.0 Stepper Motor Driver

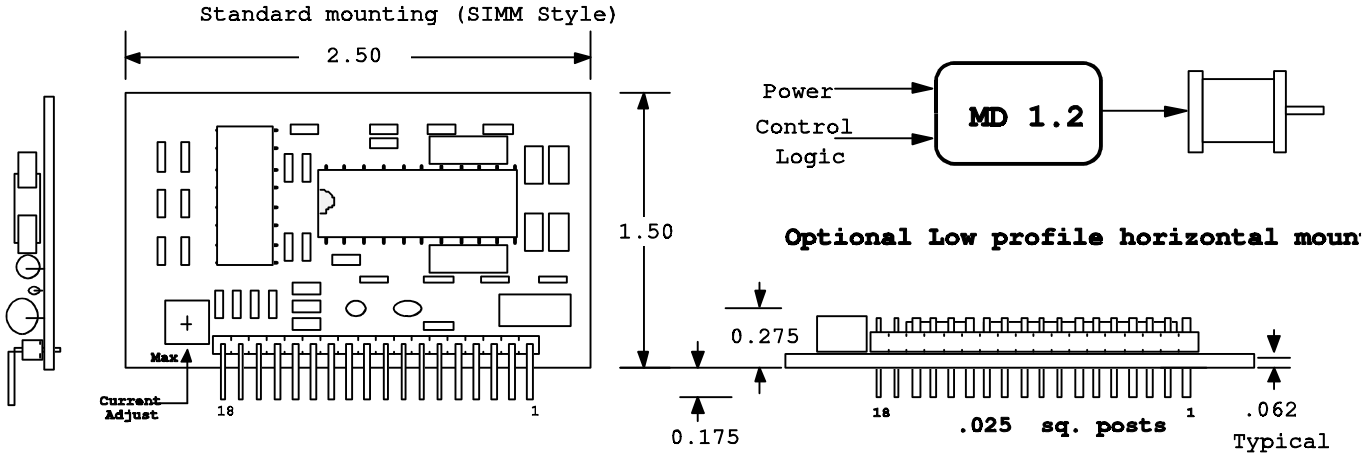


These stepper motor drivers are special order only. Please consult factory.

Send questions and comments to webmaster@motiongroup.com

MD 1.2 High Performance Mini Stepper Motor Driver.

The MD 1.2 is a high performance 0 - 1.2 Amp (RMS) miniature stepper motor driver that is not only cost effective but powerful enough to handle the most rigorous applications. Through proven state of the art technology the MD 1.2 delivers the power effectively and efficiently (bipolar chopper drive with power reduction at stand still). At 0.275" above board height (horizontal mount) the MD 1.2 allows for easy integration into instrumentation, VME and European rack mount systems
Our two mounting options allow for the most flexible use of valuable space in a modular environment
Fully compatible with matching TMG controller. Compatible with standard stepper motors (4,6 or 8 wire).



PIN Functions

1. Motor coil -A Output	7. -VMM Motor Return	13. Step pulse input
2. Motor coil +A Output	8. -VCC supply Return	14. +Control supply (+VCC out)
3. Motor coil -B Output	9. +VCC Logic supply	15. -Control return
4. Motor coil +B Output	10. Inhibit (Free windings)	16. -Return (spare)
5. Key	11. External Parking input	17. -Return (spare)
6. +VMM Motor supply	12. Direction input	18. -Return (spare)

Specifications -

Electrical

Input Voltage - Logic	+5 VDC (TTL)
Input Voltage - Motor	+12 to 48 VDC
Output Current (Adjustable)	0 to 1.2 Amps (RMS)
Step Frequency	13 KHz
Step size	Full & Half
Protection	Over-Temp, Over-Voltage, Over-Current
Current Reduction at standstill	Automatic: 0.5 sec after last step input. Selectable ratio.

Temperature

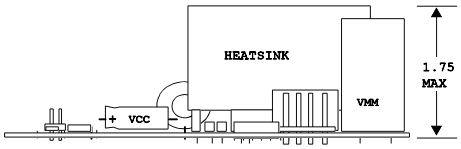
Operating	0 to +70 C
Storage	-40C to +125C
Mounting surface	0 to 70C

Note: For continuous operation at slow speeds and max currents optional heatsink or cooling required to maintain driver temperature below +70C.

TMG the motion group
PO Box 669
Clovis, CA 93613-0669
Ph: 559-325-2727 Fax: 559-325-7117
Sales@motiongroup.com
http://www.motiongroup.com

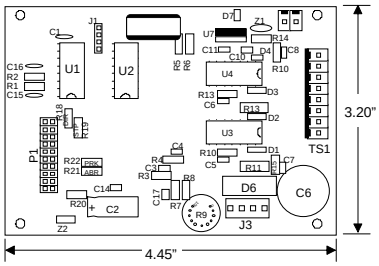
MS 2.0 High Performance Stepper Motor Driver.

The **MS 2.0** is an extremely **powerful** stepper motor driver / translator unit capable of driving either bipolar or unipolar motors up to **2.0 amps per phase** in Full, Half or **Quad** step (3200 s/rev). The MS 2.0 requires only digital step pulses and direction signal (on board step sequences) and No step software required (onboard firmware). The MS 2.0 stepper motor driver features Switch-Mode Bipolar Constant-Current technology, **adjustable output current** and "**Auto-park**" which reduces motor dissipation during non-step periods. Fully compatible with matching TMG controller.



Compatible with standard stepper motors (4,6 or 8 wire).

Shown with CY5.4 controller



TS1 Power & Motor pins

1. VMM IN (+5 - 40VDC @ 10 - 2000 ma)	2. +Coil A (Out)	3. -Coil A (Out)	4. GND
5. GND	6. +Coil B (Out)	7. -Coil B (Out)	8. VCC (+5VDC @ 100ma) IN

J3 AC Input pins

1. N/C	2. 6 - 24 VAC IN from transformer	3. 6 - 24 VAC IN from transformer	4. N/C

P1 Step motor control pins

CLK Input **STEP** pulse	P1-15	1 step per pulse when enabled
DIR Direction Set (Hi/Low)	P1-17	CW / CCW
Enable (ABR)	P1-9 ABR IN P1-10 ABR OUT P1-12 ABR from CPU	Jump P1-9 To P1-10 to Enable motor
Ground (GND)	P1-5 (User GND), P1-19 (CPU)	
+5 VDC	P1-1, P1-6, P1-13, P1-14	

P1 TMG Controller Interface pins

PARK	P1-11	Selects between Hi & Low Power
SENSOR	P1-2 P1-3 P1-4 P1-16	LED +Anode Led -GND Sensor signal IN Sensor to CPU
Spares	P1-7, P1-8, P1-18, P1-20	Unused pins

Electrical Specifications -

Input Voltage - Logic	+5 VDC (TTL)
Input Voltage - Motor	+12 to 40 VDC
Output Current (Adjustable)	0.05 to 2.0 Amps / Phase
Step Frequency	500 KHz Max
Step size	QUAD or Full/Half
Protection	Over-Temp, Over-Voltage, Over-Current
Current Reduction at standstill	Automatic: 0.5 sec after last step input. Selectable ratio.

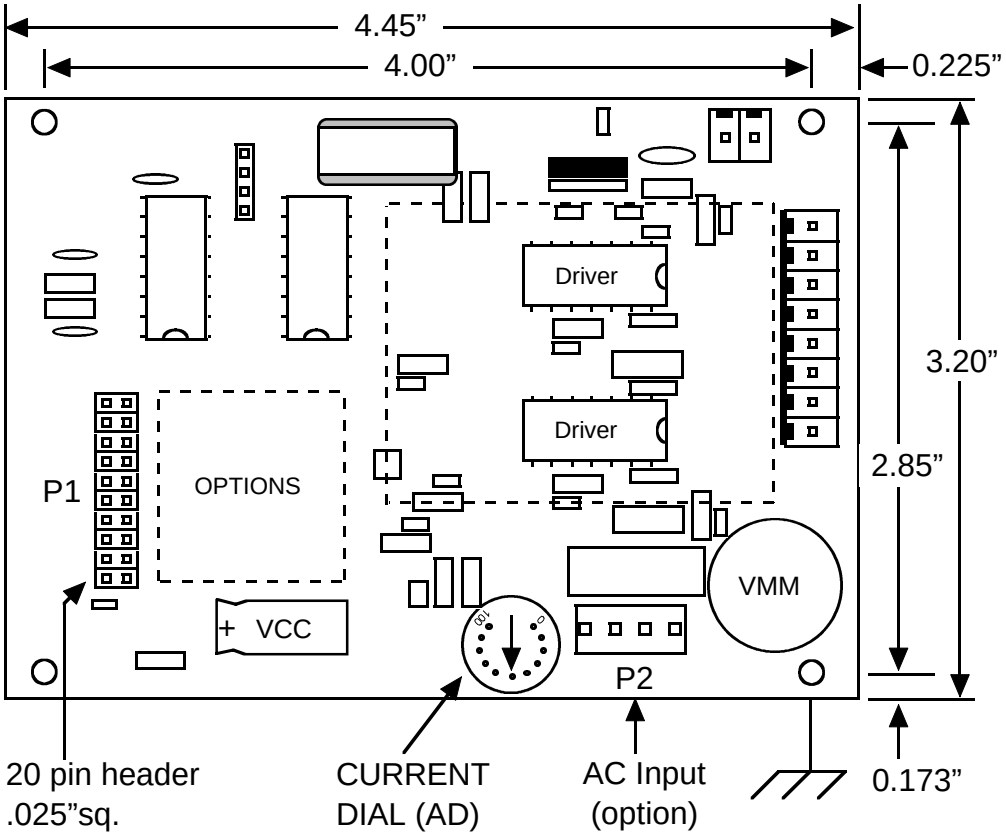
Temperature

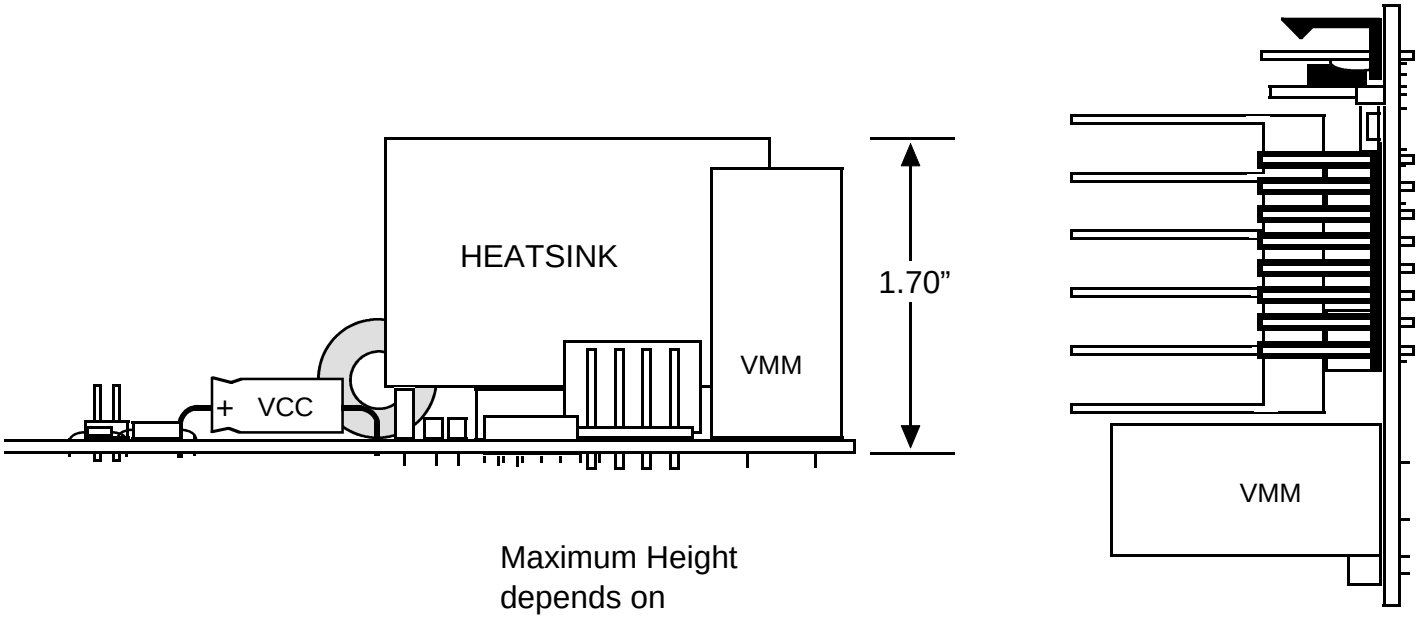
Operating	0 to +70 C
Storage	-40C to +125C
Mounting surface	0 to 70C

TMG the motion group
PO Box 669
Clovis, CA 93613-0669
Ph: 559-325-2727 Fax: 559-325-7117
Sales@motiongroup.com
http://www.motiongroup.com

MS 2.0 2.0 Amp / Phase Stepper Motor Driver

Outline and mounting dimensions





Maximum Height
depends on
options & current

Single Axis Systems- [Multiple Axes Systems]

PLC 2.0/4.0

Created specifically for use with PLC's.
A standard unit requiring only inputs commonly found on PLCs.
Voltage output available to power an external PLC.

TST 2.0/4.0

The TST module combines an on-board oscillator
with a step motor driver and matched power supply.

SID 2.0/4.0

Intelligent Motion Controllers. *Completely integrated package.*
Includes intelligent motion controller, stepper motor translator/driver,
power supplies and RS-232 serial interface (or optional RS-422).

MID 2.0/4.0

Single Axis DC powered controllers The 2.0 Amp (up to 230 in/oz.) system and
The powerful 4.0 Amp System (up to 750 in/oz.)

EID 6/10/15

The EID series is a completely integrated package which includes an intelligent motion controller, Digital-Servo driver, all power supplies an RS 232 interface
(RS 422 optional) for one complete axis.

The PLC 2.0 / 4.0, combines a high-speed, high-power step motor driver with a matched power supply and requires only PLC inputs (step and direction), motor and AC line power.

Any typical unipolar or bipolar motor, regardless of voltage, is connected to the output terminals of the PLC unit. Full, half or quarter step size and also micro-step is available depending on the card style installed.

Max Output current; PLC 2.0 = 2.0 amps per coil **PLC 4.0 = 4.0 amps per coil**.
Max output current is dial-able (dial pot eliminates current measurements).

Parking control reduces power during standstill for reduced motor heating.

Over-voltage (Vmm and Vcc), over-current, over-temp and rev-polarity protection is standard.

"DC OK" indicator lamp.

The PLC Interface Package comes standard with an optically isolated translator-driver card, a 24 VDC motor power supply with fuse, filter and line cord.

Standard input connection is an 8 pin screw terminal connector and outputs are 6 pin Molex. Others on request.

Cooling is convection (no dropping resistors or fans).

Mounting is by tapped holes from the bottom of the case.

The TST 2.0 is an adjustable current, switch mode, chopper style driver with 2.0 or 4.0 amps per phase maximum; torques from 50 to 500 oz.-in.. The system will operate motors with coil currents from 0.5 to 4.5 amps per phase; 4,5,6 or 8 wire. Note that the TST, DSD and PLC physical package is identical.

During operation, any typical motor, either unipolar or bipolar, is connected to the output terminals of the TST. Full, half or quarter step angle is available (step increments of 1/200, 1/400, 1/800, 1/1600 of a rev per pulse). The front panel controls include a speed dial, stop-start switch and direction switch. Standard speeds range from 100 pps to 10k pps depending on the step angle. Speed accuracy is +/- 1%. Automatic proportional ramping is available.

When the unit is in stop mode, the motor will hold (braking) at either 25%, 50% or 0%(free) of full power. This system can be stalled without damage.

Over-temp, over-current, over-voltage and over-drive protection is standard.

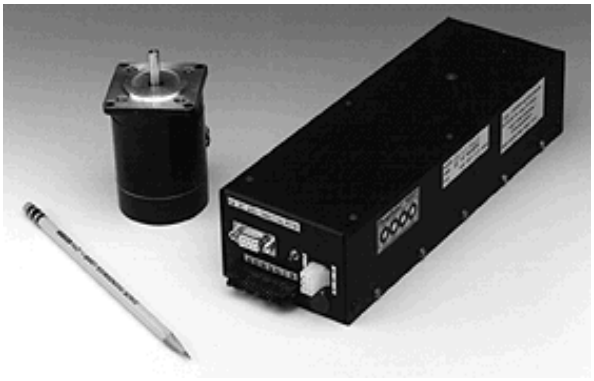
Output current (torque adjust) is dial-able.

In addition to local controls, the system can include a remote panel connector which supports direct interface to digital control, relay logic or PLC’s. Index sensor and safety limit switches are included.

The TST comes standard with translator/ driver card, power supply with fuse, line filter and power cord. Input voltage is 110VAC 60Hz (220VAC 50/60Hz option available). Standard signal connectors are DE-9 for remote control and 6 pin Molex for motor output.

Applications include; mill drill power feeds, progressive grinding, door control, remote valves, steam control and other uses requireing a synchronous, DC brushless motor with variable speed, adjustable torque and built-in braking. Spur gear systems with ratios from 2 to 200:1 and peak torques to 2000 oz-in and planetry systems with 3 to 100:1 and 150 in-lb are available.

The DSD digital servo version locks the motor motion to a remote dial or shaft encoder (cam follower).



The SID 2.0 / 4.0 features adjustable current up to 2 amps (4 amps) per coil and selectable step sizes of Full, Half and Quad (from 200 to 3200 steps per revolution).

Multiple axis adapter option connects up to 4 axes per serial port and up to 16 adapters per port (total of 64 motor controllers).

Eight user I/O lines, Auto-Start and 2K of application memory (EEPROM) allow stand alone operation.

Programmable absolute position with slip detection to +/- 0 steps at 16.7 million steps @ 30K pps. Optional position-verification encoder system.

Performs complex point to point moves including programmable feed profiles, precise velocity control and on-the-fly response to trigger inputs.

Ideal for Medical, Scientific and PLC application requiring teachable motion and I/O operations.

Compatible 4-line LCD with 20 key front panel micro-controller also available (see CyberPro application software). This full-screen software features screen display of position, status and program; all under immediate keyboard control. High-level commands simplify operation and incorporate into any programming language. The serial interface is self-contained and connects to any computer or terminal.

The MID 2.0 / 4.0

Mil-Spec Style Single Axis Step Motion System

Small, completely integrated package including a mini-stepping translator/driver, on-board +5 supply and RS-232 (RS-422 optional) interface for one complete axis.

Adjustable current up to 2 amps (4 amps) per coil and selectable step sizes of Full and Half or Quad (from 200 to 3200 steps per revolution).

Ideal for military, scientific and airborne applications.

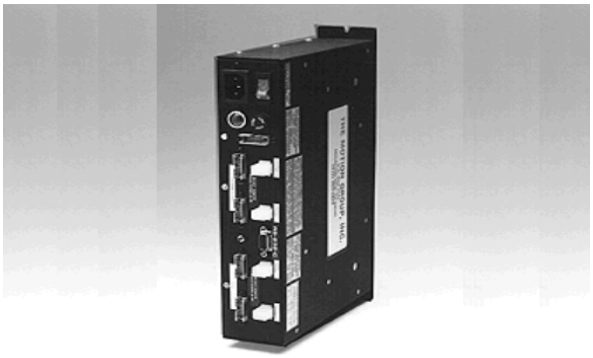
Mil-Spec connectors; on-board encoder, high G package.

Single supply operation from 12 to 35 VDC.

This new model is one hundred percent software compatible with other SID modules.
It is identical to the SID series less the power supply section.

Size is 3.5” x 2.0” x 5.05” long (5.75” including connectors).

Send questions and comments to webmaster@motiongroup.com



The EID 2.0 / 4.0 series is a completely integrated package which includes a CY 545 or CY 550 intelligent motion controller, Digital-Servo driver, all power supplies an RS 232 (RS 422 optional) interface for one complete axis.

Ideal for instrumentation and industrial application such as X-Y tables, pumps dispensers, engravers and mill-drills requiring 1 to 5 horsepower at high speed (30k pps max.).

Programmable absolute position with slip detection to +/- zero steps within 16 million steps in a single motion. On-board encoder system automatically maintains correct motor positioning.

Performs complex point-to-point moves including programmable feed profiles, precise velocity control and response to trigger inputs. Eight user I/O lines, Auto-Start boot and up to 64k of user EEPROM allow for complete stand-alone, front panel or PLC interface operation.

High-level command set, in English, easily creates complex motion and I/O sequences with msec delays, input tests, outputs, loop counters, jumps and messages back to serial host. See CY 545 command set summary.

Network option SR-4 multiplexes up to 4 EID controllers per node x 16 nodes per port (64 axes per port).

Expanded I/O option provides 8 lines of output control for relays, solenoids, valves and input sensing of switches, sensors, etc.

Bullet proof protection includes over-temp, over-volts, open-circuit, short circuit shut down with LED indicators and on-card self-test.

Stepping System for 1 to 5 Horsepower Moters
The Motion Group, Inc. provides 3 models of these EID intelligent motion systems;
the EID 6.0, EID 10.0 and EID 15.0.

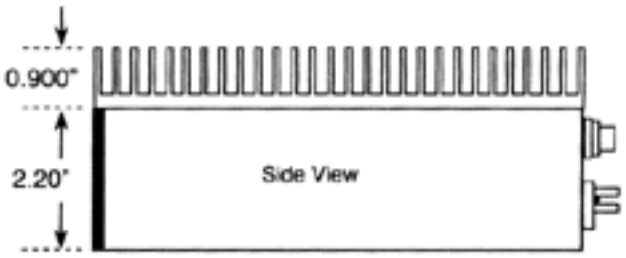
These units control one motor/encoder with continuous current from 6 to 15 amps at 85 to 270 VAC and selectable steps sizes of full, half and quad (from 200 to 8000 steps per revolution). Complete systems with serial and I/O cables including optical home sensor, fail-safe limits, and jog input are available. Position encoders are built in to the matching motor.

The motors come in three frame sizes covering a torque range of 15 to 257 lb-in (peak). For complete details request the Servo Systems Product book.
These large motor drivers are also available as SMD's or TST's.

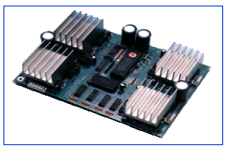
Size is; 7.25" x 11.0" x 3.1"

```
Three Models

SID 6.0     6 amp max @ 80 VDC
SID 10.0    10 amp max @ 80 VDC
SID 12.0    12 amp max @ 80 VDC
(requires external transformer)
```



Multiple Axes Systems- [-Single Axis Systems-]

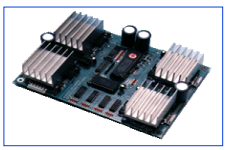


MMC-2/3/4C

The MMC system is a cost effective O.E.M. component for 2, 3, or 4 axes applications. The MMC-4 motion control card (6” x 7” x 2” high) consists of 3 basic elements; the controller unit, the multiplexers and the drivers

MMC-2/3/4S

Multiple Motor Control Systems come as a fully enclosed controller requiring only wall voltage (110VAC/60Hz) and the appropriate motor/control connections. Eliminates the need for DC power supplies.



MMC-5/6/7/8 C/S

The Standard MMC system is available in up to 8 Axes.
(see MMC-2/3/4 for system details)

SR-4

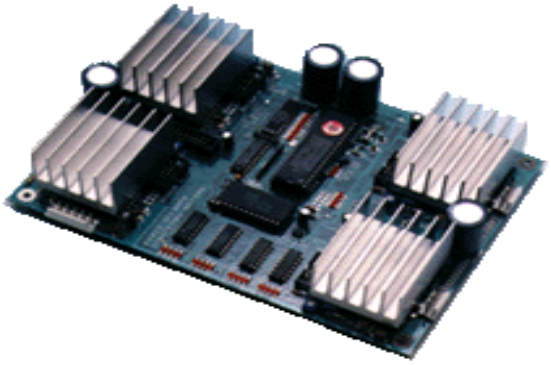
Serial Controllers are used to expand the number of step motion systems that can be connected to a serial port from 1 to 512.

MMD Series

High Power modular stepper motor driver system. Complete system includes multiple motor controller with 6.0 - 12.0 Amp power drive modules and cabling.

Digital CNC

Two Stepper Motor packages to choose from (2Amp/4Amp). Motor Drivers, CNC control software and accessories included.
Stepper Motors sold separately.



The MMC controller contains a ***CY 545*** step motor controller microprocessor. The multiplexer section allows the CY 545 to control up to four step motor channels by multiplexing the motion signals between the channels. All actions of this system are controlled by high-level CY 545 commands. (See SID Command Set Summary).

In this system, the user bits of the CY 545 (USRB 0-7) are assigned to control both the 8 line output mux and the 8 line input mux. The output lines (0, 1, 2 and 3) select a motor channel; the remainder (4, 5, 6, and 7) are available for general purpose output functions. The 8 line input mux inputs the home sensor on lines (0, 1, 2 and 3); the remainder (4, 5, 6 and 7) are general purpose.

When a channel is selected, the step pulses and the direction signal from the CY 545 are directed to the motor driver by the multiplexer. Additionally, selection shifts the driver from park-power to full-power. The muxers also direct the signal from the home sensor, for that channel, back to the controller.

Normally, one channel is selected at a time as the MMC card only generates signals for one step motor. If more than one channel is selected the motors will make identical moves. Only one motor can be homed at a time. Curves and 3-D motions are produced by single stepping the system and switching motors each step. A major advantage of this system is the ability to trace true point-to-point patterns.

The card is self-contained and can operate independently or under the serial command of a host computer. In independent 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 CY 545. A combination of these two modes is also possible; typically macro command strings are loaded to the memory and then executed as required by the host.

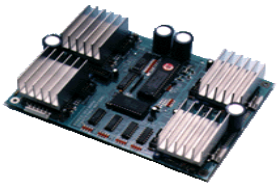
Each axis includes a CI cable (chassis interface cable). This 10 pin cable connects the home sensor, spare user I/O and the limit loop signals back to the controller.

The MMC-8 slave card expands this system to an additional 5, 6, 7 or 8 axes. The MMC-8 is two cards (master and slave) stacked on stand-offs (6” x 7” x 4.2” high).

Complete Enclosed controllers
MMC-2/3/4 S
Encosure dimensions: 7.25” x 11.0” x 3.0"

The MMC system is an enclosed assembly containing a MMC card, power supply, external connectors, and AC power entry (switch, fuse, filter, lamps, and IEC line filter). The unit mounts either flat (bottom mount) or with the edge flange. MMC-8 systems are identical except twice as high with a common flange.

Send questions and comments to webmaster@motiongroup.com



The MMC-5/6/7/8 Multiple motor controller card set.

The MMC-5C = 5 Axes Card set (For OEM applications only)
The MMC-5S = 5 Axes System

The MMC-6C = 6 Axes Card set (For OEM applications only)
The MMC-6S = 6 Axes System

The MMC-7C = 7 Axes Card set (For OEM applications only)
The MMC-7S = 7 Axes System

The MMC-8C = 8 Axes Card set (For OEM applications only)
The MMC-8S = 8 Axes System

All MMC units operate and maintain the maintain specifications. (see MMC2/3/4)

Contact factory for details.

The MMD Series-
Multiple Motor Drivers.

The MMD system is selected for high performance, high power applications such as CNC, material handling, pumping, antenna platforms and warehousing. The MMD controller is an enclosed unit which controls 2, 3 or 4 axes of Step or Servo motion. Up to four SMD units can be connected to the MMD controller. Operation and controls are identical to the MMC. MMD's are powered by their SMD units.

The MMD-8 system consists of a flanged double-high enclosure (7.5"x11.0"6.0") connected to 5, 6, 7 or 8 SMD modules.

For lower torque applications (size 17 & 23 stepper) where the controller is already in place a multiple driver array in a single enclosure is now available (See MMC series controllers).

Send questions and comments to webmaster@motiongroup.com

The SR-4C/E Serial Network Controller.

Each controller can connect a serial path between one computer port and any combination of four motion systems. In addition, up to sixteen controllers can be "daisy-chained" together with simple pin-to-pin DB-9 serial cables. Power for each controller is obtained from the motion systems through the serial cables.

During operation, a three byte address is prefixed to a motion control command string. When the controller receives the address, a serial path is connected to the addressed motion system by a 1 to 4 serial data multiplexer. The motion command is passed to the motion system. The command terminator character (carriage return) also resets the multiplexer. Each command string must start with the controller address. The controller address compares to the setting of the controller switches. The multiplex code selects any combination of the four output paths to the motion system. In general, one system is selected at a time for setup commands and then all systems are directed to execute (Go) simultaneously. When requesting information from a system, only one can be selected.

When a motion system is preforming an operation, the CTS or Busy signal is input to the controller's status register. To monitor the busy status of the motion systems, a Read address, again consisting of three bytes, is sent to the controller. The first byte is the mode (Read); the second is the ID number; the last is always F HEX. The controller will return an ASCII character equal to a binary number. The first four binary bits are fixed at 4 HEX. The second four indicate the status of the four systems.

The host to controller serial ports are wired with standard RS-232 DB-9s connectors. Each controller has two, loop-in and loop out, communication ports. The first goes to the control computer and the second to the next controller in the daisy-chain. The last controller's second connector is terminated with a turn-around plug. The four motion system connectors are DB-9p.

The SR4 operates in RS-232 format using ASCII character mode and will Auto-Baud from 300 to 57K baud. Auto-Baud devices determine the baud rate automatically from two carriage returns sent during initialization of the system. Parity is none, 8 data bits, and 1 stop bit.

All MOTION GROUP (Electronic Products) motion systems connect to the SR4. The SID (Single Independent Drive) system supports up to four independent axes per controller with a maximum of 64 channels. With the MMC - 2S / 4S / 8S (Multiple Motor Controller) multiplex systems, up to 128 / 256 / 512 axes can be controlled from one serial port.

Send questions and comments to webmaster@motiongroup.com

Digital CNC

Machine Control Retrofit kits

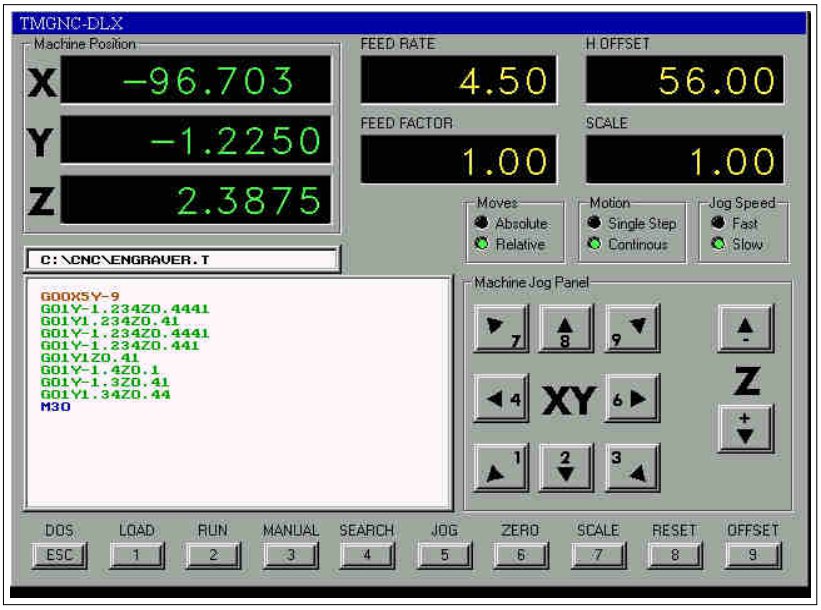
Click here for package prices- CNC package page

TMG's Digital-CNC is a 2 or 3 axes positioning system which translates G&M codes from your personal computer into step motor motion; +/- zero steps. Digital-CNC is intended for mills, mill/drills, lathes, light machines, routers and other industrial motion applications such as glue dispensers, gasket cutters, sign makers and sharpeners. This FN style CNC system is a complete ready-to-step retrofit and includes motors, cables, aluminum-case drivers with power supplies, limits, optical home sensors and CNC software disk.

The CNC electronics is available in three basic packages packages.
The ENC 2.0x3-80/140 ("Engraving Model")is a single enclosure (7"x11"x2") containing the translator, 3 drivers and supply operating at 40 VDC at 2 amps/coil maximum. With 80 or 140 in/oz motors. This unit is intended for smaller mills suited for engineering modelling or hobby work. The CNC 2.0x3-230 is the same system with a 230 in/oz. motor set. The CNC 2.0x3-230 is currently being used on benchtop mill/drills, full sized Tree and Bridgeports, and the most common inexpensive 3-in-1 combination machines. The CNC 4.0x3-750 is a 4 Amp system in a slightly larger enclosure with a full 750 in/oz motor set. This is our high torque - low cost system. For even more power consult the factory (servo available). Standard System configuration is Quarter step with 1.8 degree motors for 800 steps/rev (other configurations available). All systems are protected from under-volts, over-volts, over-temperature and over-current. No cooling fans are required. A major safety feature is the abort loop which stops all motors if any limit switch is opened.

The CNC software includes milling, drilling and letter engraving routines. Additional features are a DFX translator which translates DFX files from CAD systems to G-code files, a backplotter which plots G-code files on the computer display and a text editor which can create or modify these files. Examples and exercises are included. The CNC also supports manual entry of G-code commands from the computer keyboard. The X, Y, and Z readouts are displayed as well as each command as it is executed. All machine parameters such as speeds, resolution, scaling and backash are programmable.

This is a DOS program!



Digital-CNC retrofits require a computer (DOS clone) with the LPT1 printer port. Programming ability, CAD package or Windows is not necessary. However, computer and CNC machine experience is recommended. Motor mount fabrication and limit switch mounting is required. This system does not support encoders and must be operated within the speed and power range of the motors. Operation at +/- steps, with automatic backlash compensation requires that the optical home sensor package be installed.

Send questions and comments to webmaster@motiongroup.com

DIGITAL-CNC
TMG CNC retrofit packages come in two sizes.

The 2.0 Amp (up to 230 in/oz.) system and
The powerful 4.0 Amp System (up to 750 in/oz.)
***Stepper Motors sold seperately.**

2.0 AMP 3 Axes System for 50 - 900 lb. Mill Drills.

CNC 2.0x3 (3 Axes) **2.0Amp/phase, 40 VDC system**	**Package Price**	**$750.00** **motors not-included**
CNC 2.0x3E QUAD-STEP 3 Axes Translator/Driver/ Pwr. supp.	1 ea.	inc.
TMG-CNC-PRO Machine controller software	1 ea.	inc.
Motor extension cable set	1 ea.	inc.
Mechanical limit & Home switches	9 ea.	inc.
CNC Retrofit instruction manual	1 ea.	inc.
Motor bracket Dwg. (general)	1 ea.	inc.
Optional accessories		
80 in./oz Stepper Motor Size 23, 200 (1600) SPR (pricing for sale with CNC systems only)	(3 ea.) = 1 set	(3 x $39.00) = $117.00
230 in./oz Stepper Motor Size 34, 200 (1600) SPR (pricing for sale with CNC systems only)	(3 ea.) = 1 set	(3 x $80.00) = $240.00
Size 34 belt/pulley set 3/8" (32:16 tooth)	1 ea.	$37.00 ea.
Optical HOME 3 switch set (no lash)	1ea.	$75.00 ea.
4 axis system upgrade	1 ea.	CALL

4.0 AMP 3 Axes System for 500 - 1200 lb. Mills.

CNC 4.0x3 (3 Axes) **4.0Amp/phase, 40 VDC system**	**Package Price**	**$1449.00** **motors not-included**

CNC 4.0x3 OCTAL-STEP 3 Axes Translator/Driver/ Pwr. supp.	1 ea.	inc.
TMG-CNC-PRO Machine controller software	1 ea.	inc.
Motor extension cable	1 ea.	inc.
Mechanical limit & Home switches	9 ea.	inc.
CNC Retrofit instruction manual	1 ea.	inc.
Mounting bracket set Dwg. (general)	1 ea.	inc.
Optional accessories		
750 in./oz Stepper Motor Size 34, 200 (1600) SPR (pricing for sale with CNC systems only)	**(3 ea.) = 1 set**	**(3 x $150.00) = $450.00**
Size 34 belt/pulley set 1/2" (20:10 tooth)	1 ea.	$37.00 ea.
Optical HOME 3 switch set (no lash)	1 ea.	$75.00 ea.
4 axis system upgrade	1 ea.	CALL

Important! Warranty Information

The Above Motion Group Stepper Motor Systems come fully tested with a 100% WARRANTY against any manufacturers defect. The stepper motors come terminated, and ready to plug into any TMG Product.

If you supply your own Stepper motors for these systems remember:

A miswired motor (shorted coil) or intermittent open/short in motor wiring can blow the drive circuitry.

*** Most Field Sytems Damage and failures are due to bad motor wiring (shorts and poor interconnect) or the use of improper motors (i.e small high inductance motors or old surplus motors with unknown characteristics).**

Damage determined to be from miswired motors or intermittent motor interconnection problems from work not performed by the manufacturer - WILL NOT - be covered under Warranty repair.

The repair charges are low for most damaged units (approx $50.00 - $100.00) but the loss is the down time which can be avoided.

You should check your motor wiring using the appropriate equipment to ensure the coils are not shorted together prior to connecting to the Translator/Driver box.

If you have any concerns about your stepper motors or motor wiring schemes
please call 800-424-7837 and we'll see what we can do for you.

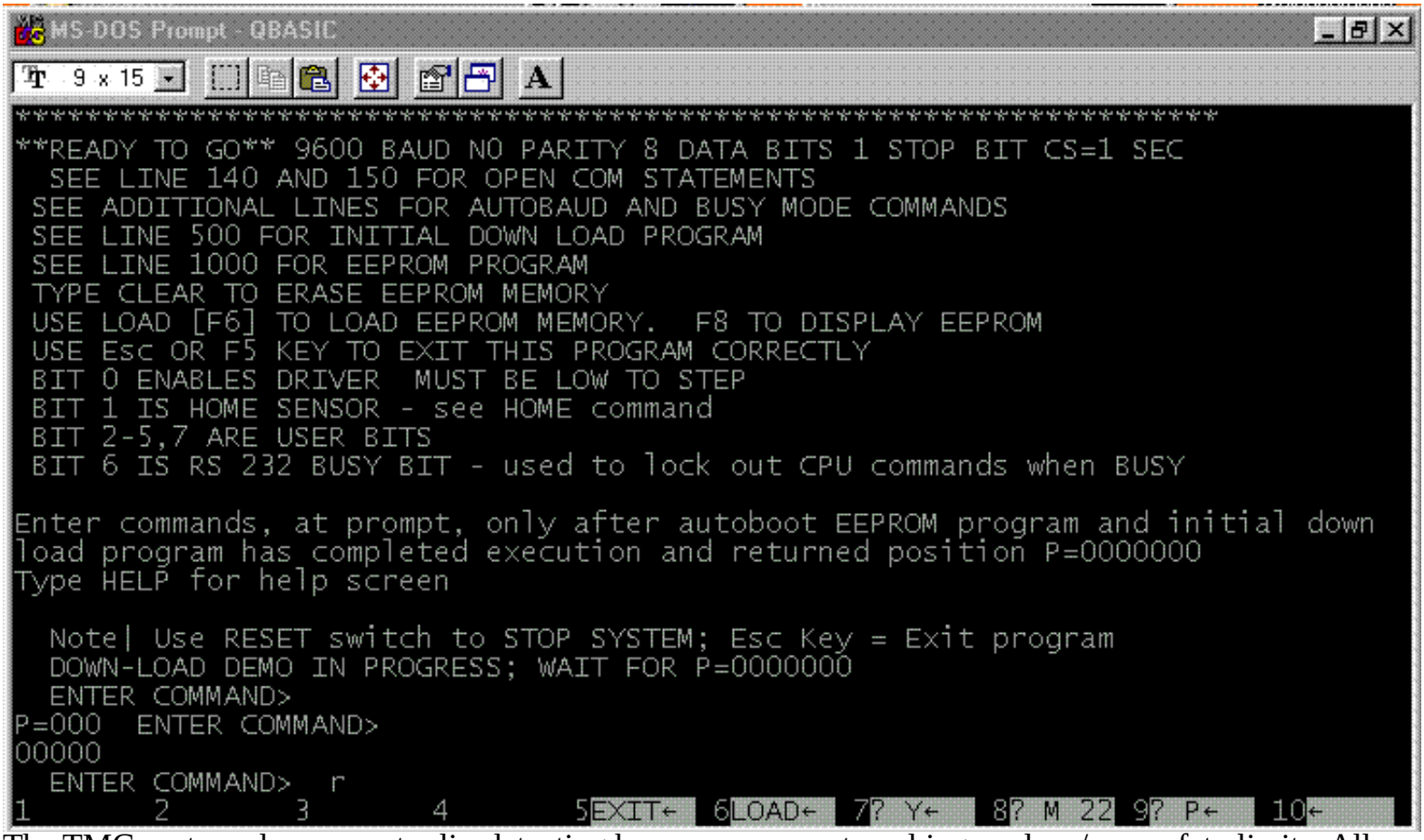
Send questions and comments to webmaster@motiongroup.com

	Three different software solutions for your motion control needs
SIDDEMO	Demo disk provided in QBASIC with redefinable parameters
CyberPro	Windows application software from Graham Automation
Digital-CNC	CNC control software for TMG's Digital CNC retrofit packages.

SID Software System. [Download Demo]

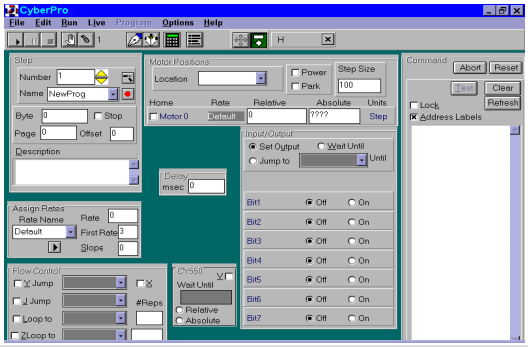
The SID software (firmware) system used in all TMG intelligent motion controllers; SID, MID, MMC, MMD, is based on the Cybernetic 545/550 series of motion processors. The Cybernetics are High-level command processors (see Command Set) and communicate in ASCII characters over the RS-232 serial connection in any DOS-clone computer, dumb terminal or keypad. Any program language can be used to generate motion control sequences; Basic, C, Pascal, Forth, and Assembly (see binary mode command). In addition TMG intelligent controllers include general purpose I/O (input or output) control lines. The Cybernetics command set supports I/O control, on-board memory programming, counting, and auto-starting. This complete programmability, similar to PLC's, allows for the direct creation of complex machine sequences.

DOS promp window running SIDDEMOB.bas listing.



The TMG system also supports slip-detecting home sensors, external jog, and cw/ccw safety limits. All TMG systems can include a Development / Documentation kit which contains all cables and software examples of typical motion and I/O routines. The demonstration disk is in QBASIC and includes listings.

Back to top.

CyberPro Software for Windows.[Download Demo] 	Cyberpro automates generation of optimized code for TMG controllers from a customizable point-and-click Windows interface. Cyberpro eases rapid development of stand-alone motion control applications. The keypad shown below is a screen shot of an application on the CyberTerm terminal emulator within CyberPro. (back to top)
CyberTerm 	CyberTerm is a hand held terminal, controlled by a Motorola 68HC11 based single board computer with a four line by 20 character backlit LCD display and 20 character keypad. It is powered through the serial cable connection to TMG hardware. It can be used to manually control and display the positions (in user definable units) of up to four axes. In addition, it runs custom code created from within the CyberPro environment as described above. Integrate CyberTerm into your own custom housing for production. Custom programming is available to allow use of a wide range of additional capabilities, including additional serial ports, I/O, A/D and D/A.

The CyberPro system is a professional level code generator used primarily for three applications. The single axis version generates code sequences for complex single channel systems. The multi-axis version supports 2 to 8 channels. The maximum package also supports CyberTerm programming.

The main function of CyberTerm is to create an instant single-board computer for an embedded system (no display or keypad) or a front panel system with LCD display and 20 assignable keys. The LCD/keypad can be any style and remotely mounted as required. Initially the CyberTerm is a virtual computer created within the CyberPro system. First, the functions of the CyberTerm, including the LCD display (graphics or dot matrix) and the key-cap labels are defined. Next, the TMG motion system is connected to the CyberPro host serial port and the CyberTerm program is simulated on the host screen. The keypad window (see insert) will respond to key-cap mouse clicks and the LCD will display as required. When the simulation is satisfactory the physical CyberTerm module is connected to the host serial port and this program is downloaded to the CyberTerm. Next the motion system is connected to the CyberTerm. When the motion system is powered on, the stand-alone CyberTerm and motion system will perform exactly as the simulation. This system will create process controllers, lab instruments, product dispensers, samplers, and vision platforms with or without front panel controls. Special temperature control features are also available. Send questions and comments to webmaster@motiongroup.com

Stepper Motor Basics

Stepper Motors and Step Motor Drivers
This is information on the basics of stepper motors and step motion control. The following should give you a brief yet overall understanding of the operation of stepper motors.

Stepper Motors and Stepper Motion - Introduction

A stepper motor system is an electro-mechanical rotary actuator that converts electrical pulses into unique shaft rotations. This rotation is directly related to the number of pulses.
The speed is synchronous to the rate of pulsing.
The result is absolute speed and position.

Stepper motors feature bi-directional control, built-in braking, variable torque, power control, precision accuracy, high resolution, open-loop control, and direct interface to digital systems.
Compared to other servo systems, steppers exhibit an excellent power to weight ratio, minimum rotor inertia, no drift, no starting surge, and no cumulative errors. Note: the following descriptions start from the motor and progress to the control electronics.

Stepper Motors - General Description
A step motor converts electrical energy into discrete motions or steps. The motor consists of multiple electrical windings wrapped in pairs (phases) around the outer stationary portion of the motor (stator). The inner portion (rotor) consists of iron or magnetic disks mounted on a shaft and suspended on bearings. The rotor has projecting teeth which align with the magnetic fields of the windings. When the coils are energized in sequence by direct current, the teeth follow the sequence and rotate a discrete distance necessary to re-align with the magnetic field.
The number of coil combinations (phases) and the number of teeth determine the number of steps (resolution) of the motor. For example, a 200 step per rev (spr) motor has 50 rotor teeth times 4 coil combinations to equal 200 spr.

There are no brushes between the rotor and stator assembly; a stepper motor is a multipole (polyphase) brushless DC motor. These multiple coil pairs can be connected either positive or negative resulting in four unique full steps. When the coils are sequenced correctly, the motor rotates for- ward. When the sequence is reversed, the motor rotates in reverse.

When the sequence is held, the rotor locks (brakes) in place.

The amount of torque required to force the rotor from position is the holding or static torque. If the rotor slips (step loss), it will align with the next available coil combination; either four steps forward or four steps backwards.

Steppers can be stalled or held indefinitely without damage.

If the sequencing is faster than the rotor can move, the rotor will slip until sequencing is slowed enough for the rotor to again lock-in to the sequence. The rotor requires a minimum settling time (ringing) to stop when held. This limits the minimum time for the motor to change direction successfully.

PM motors settle faster than hybrids. If the sequencing frequency (step rate) is close to the natural frequency Of the coils, the motor will attempt to resonate at sub- multiples of this period; resulting in step loss and unusual noise (growling).

The low-frequency resonant point of a typical motor is 100 full steps/second or slower; the mid-frequency point is between 900-1200 spr. Resonant behavior (electro-mechanical feedback phenomena) can be minimized by reducing the current (gain reduction), isolating the mechanical connection (de-coupling), reducing the step angle to half or micro step, and not operating the motor, continuously, in the resonant bands (ramping).

Electrical Types of Stepper Motors VR, PM, Hybrid
VR (Variable Reluctance) motors have soft iron rotors with teeth and are mostly used for specialty applications.
Permanent magnet motors have magnet rotors with no teeth.
Hybrid motors are hybridization of both VR and PM and have magnetic rotors with teeth. mostly used for

Mechanical Types of Stepper Motors - Pressed Case (PC) and Machined Case (MC)
Pressed Case (tin can) motors are stamped, mated shells with sleeve bearings. Machined case motors have cast aluminum end-bells with ball hearings; the bodies are stacks of laminations held together with screws. A PC is generally the permanent magnet type and has a 7.5 or 15 degree step angle.

MC motors typically are 1.8, 0.9 or 0.45 degree and exhibit positional accuracies of 3 to 5% Also the air gap (the space between the motor and the stator) is tighter and therefor pro- duces more torque. PC motors because of their thin cases are more limited in the amount of heat they can handle. The torque of a stepper is a function of the magnetic field (guassian strength) produced by the direct current flowing in the coils. The subsequent heating of the coils limits the motor case to a wattage that the case can dissipate before the insulation is damaged (temperature rise).

Motor Case Sizes - Size 17, 23, 34, 42 There are NEMA standards for the MC case front view and the mounting flange holes. The most common are;
size 17 (1.7 sq. or 40 mm) with a 5 mm shaft,
size 23 (2.3" dia. or 56mm) with a 1/4" shaft,
size 34 (3.4" dia. or 86 mm) with a 3/8" shaft,
and size 42 (4.2" dia. or 107 mm).

Step Motor Windings - 2-Phase, 4-Phase, 5-Phase
Common step motors have 2 sets of windings. Each can be energized positive or negative; therefore the minimum number of connections (lead wires) is four.
Four wire motors are 2-phase (bipolar).

For electrical convenience (L/R driver) each winding is center tapped into two coils (Bifilar winding).

The result is a six wire or 4/1 phase motor (unipolar).
Unipolar can also have the center taps in common creating a 5-wire motor.
An 8-wire, the most versatile configuration, has 8 leads available.
5-phase motors have 5 coils (10 wires) and require a 5-phase driver.

Driver Electronics - Unipolar and Bipolar
A stepper motor requires an electrical sequencer called a driver, a specialized type of DC power supply. If the driver can reverse the polarity of its outputs, it is bipolar (4 leads). Simple, less expensive (but less effective and efficient) are drivers that cannot reverse polarity, called unipolar (6 leads). Bipolars can drive 4, 5, 6 or 8-lead motors.

To correctly connect a 5-wire to a bipolar drive, the center tap must be connected to the motor supply. To convert 6-wire to bipolar only the center tap and one leg are connected. Half of each winding is not used.
8-lead motors are connected as 6-wire in unipolar and in parallel for bipolar (more torque and efficiency).
Bipolars use 8 transistors arrayed in 2 H-bridge arrays; unipolars use 4.

Driver Types -
L/R Driver
A stepper motor is nameplate rated to a voltage and current based on the resistance of the winding and the maximum power (torque) the case can dissipate.
The resistance and inductance produce a time constant for the charging of the coils to full torque. The voltage and the time constant deter- mine the top speed of the motor. lf the step rate is faster than charge time, then the torque will diminish. lf the rated voltage is applied, the motor is said to be configured in L/R.

If dropping resistors, equal to the motor resistance, are inserted in series with the coils, then the configuration is L/2R. Also twice the voltage is applied across the motor. This will decrease the charge time (faster) and increase the torque at specific step rates. However, the resistors dissipate wasted energy equal to one motor.

Bi-level unipolar drivers use two voltages. The higher voltage is turned on for a burst (kicker pulse) at the start of each step. The integrated bipolar driver circuit obsoleted the L/R and bi-level.

Switch Mode Drivers
In switching drivers, current control circuits (sensing resistor and comparator) are inserted in series with the motor coils and a higher than rated voltage is applied. The sense the coil and then rapidly turns the power circuit on/off continuously to regulate coil current (constant current). This technique is called chopping or switch mode. Two to fifty times the rated voltage is applied across the motor. The resulting performance (speed) of the driver is the equivalent of L/2R to L/50R.
Switchers have a second preset for reduced current when the motor is not rotating (parking); otherwise the motor rises to maximum temperature at standstill. Parking allows motor running current (torque) to be increased (overdrive) based on the reduced duty-cycle of the system. The current of a switcher is easily adjusted by varying the reference voltage to the comparator.

Step Angle Reduction - Full, Half and Micro-Step
If both coils are equally energized (full-step), the rotor rests at the resultant vector between two intersecting fields in the neutral (dead band) region. If one coil is de-energized (zero current), the rotor sweeps to a position in the center of the energized field.

Alternately inserting this condition (one coil off) into the stepping sequence (half step) steps the motor a total of eight unique positions; four half and four full. By controlling the reference voltage, in a chop- per drive, to both coil drivers with a dual D/A converter and subsequently stepping the output coil current from 1OO (full) to 0 (half) percent, the motor microsteps between these two pole positions. Microstep typically increases the resolutions of the motor 4 to 64 times. The D/A table must match the guassian distributor of the motor, a function of motor quality and magnet style.

Microstep based simply on a sine/cosine function **does not take equally spaced steps** as a sine function is not a guassian curve. Also, **microstep does not improve the base accuracy of a motor;** a function of the number of rotor teeth and the manufacturing quality.

Translators - Step and Direction

The phase polarity signals (step sequence) between driver and coils is based on the step function which can take the form of logic gates or memory (step table). If this logic is configured to increment from a single pulse (clock), the circuit is called a translated driver or step/ direction driver. The direction input controls the direc- tion of sequencing. A translated driver is easily connected to a source of clock pulses (pulse generator) called an indexer or controller.

Intelligent Motion Control - Indexers and Controllers
Controllers are logic or processor circuits (programmable motion) which accept command or switch inputs. The specific distance of rotation (number of steps), the speed at which the pulses are issued (rate), and a function of speed increments (slope) is preset or input to the con- troller. The slope function (ramping) allows the motor to accelerate to a speed greater than the instantaneous stop/start speed. In this case, a starting speed (first rate) and a top speed (slew rate) is input. The controller accelerates the motor through the motion and decelerates to a stop after the present number of steps (target). Ramping allows the motor to advance through the resonance bands. Open Loop Control - Homing and Slip Detection In typical operation of the motion system, the motor initially steps backwards until a reference position (home) is detected and the position counter in the controller is set to zero. The motor is then moved to positions by incriminating or decrementing the position counter (absolute motion) or repeatedly cycling the counter a fixed amount (incremental). In open loop control, it is conditional that the load is within the motor speed and torque range. A positioning system, when successfully returned to the home sensor under command (slip detection), is said to operate plus or minus zero steps (no error).
