Compupmotor

Bulletin OM-8200-R

Operator's Manual

R-Series Motor/Driver

P/N: 88-006222-01

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Parker

COMPUMOTOR CORPORATION

R-SERIES MOTOR/DRIVER OPERATOR'S MANUAL

P/N 88-006222-01

June 6, 1986

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COMPUMOTOR R-SERIES MOTOR/DRIVER SYSTEMS

INSTALLATION AND OPERATION MANUAL

1. INTRODUCTION

The R-Series Motor/Driver is a two phase hybrid step motor with an integral 8 pitch acme screw in place of a standard motor shaft. It comes in two sizes, the R57-55 with 75 pounds of force available, and the R83-96 with 390 pounds of force available. Both units are powered by a bi-polar PWM chopping drive which yields high efficiency and power in a small package.

CAUTION!

> Compumotor Corporation has made a special effort in the design and construction of its products to make them both versatile and easy to use. The mechanical torque produced by these motor/ drivers is capable of damaging or destroying the equipment to which they are connected if improperly installed, operated, or serviced. Only persons qualified in servicing and installing hazardous voltage electrical and limited-travel mechanical systems should attempt this procedure.

The Compumotor Open-Frame Motor-Driver package is functionally similar to boxed-unit Compumotors: The motor is completely unchanged, and the driver package differs only in that it lacks the large finned heat sink, sheet metal cover, and end connector panel with its motor and indexer connectors.

2. INSPECTION

Carefully inspect the shipping carton(s) for any evidence of physical abuse or damage and note any findings on the Waybill at the time of receipt. In cases of severe damage, it is recommended that the shipment be rejected entirely. Parker Compumotor cannot be responsible for in-transit damage.

3. UNPACKING

Use care in opening the shipping carton(s) so that the cables supplied are not cut or damaged. Verify the receipt of the following items:

Qty	Description
1	Compumotor with 10 foot (3M) Drive Cable
1	Driver (Power Amplifier/Translator) Module
1	3-wire AC Line Cord 6 feet (2M) with Ground Pin
1	Pulse Source Cable Kit
1	Standard Product Line Brochure
1	Lead Screw (grease)

Verify that the above items have been included in your shipment for each motor driver (except the instruction manual) and that these items are not cracked, broken or otherwise damaged. It is a good idea to save the unit's packing materials in the event a unit needs to be returned to Compumotor.

4. MOUNTING THE MOTOR AND DRIVER

The R-Series of Parker-Compumotor conform to NEMA Standard frame sizes as follows.

Compumotor Series	NEMA Standard Frame Size	Bolt Size	Bolt Grade SAE
R57	23	#8-32	3
R83	34	#10-32	3

The Compumotor should be mounted rigidly with the proper size and grade of hardware at all four corners, and the motor case should be connected to third wire ground.

The Compumotor's mounting surface acts as a heat sinking device which carries away thermal energy generated by self heating. Temperatures produced by the motor when not mounted may seem excessive, and are the result of the Compumotor having full power applied to the motor at all times, even when not rotating. This heating is normal. The motor temperature will drop considerably when the Compumotor is mounted.

The Driver may be mounted some distance from the motor if the wire lengths and minimum wire sizes listed in Appendix B are observed. Motor cable extensions are available from the factory.

Mount the Driver with the heatsink fins running vertically for best convection cooling. A minimum of 3 inches (7.62 cm) of clearance must surround the Driver on the heatsink top and four sides.

Route the motor cable carefully so that movements of the motor and any attached mechanism(s) will not cause interference. In addition, the motor cable should be routed away from equipment that is sensitive to electromagnetic interference.

4.1. Coupling Methods

The R-Series motors come with a radial thru-hole and a 56 pitch thread tapped into one end of the screw to facillitate the mounting of loads. Loads can also be mounted to the shaft with an open collet.

4.2. Environmental Considerations

The mounting location for the Compumotor and driver must be free from all liquids and protected from conductive chips and dust. The standard Compumotor is not suitable for explosive atmospheres, vacuum beyond 10^{-2} torr, or life-support equipment. The bearings in the motor are not sealed and must be protected from contaminants. Ambient conditions for the Driver are 32 to 122°F (0 to 50°C) and 20 to 90% humidity (non-condensing). The Compumotor can operate from 32 to 150°F (0 to 70°C).

Coil any excess cable at the Driver and secure it with a cable tie. This cable carries high voltage (150 VDC) and all wire runs must conform to all applicable local electrical codes and OSHA requirements. Check that the model number of the Compumotor and the Driver have the same type number (e.g. R83-96).

Standard Compumotor motor and indexer cables will not connect directly to the Driver printed circuit board. To do this, the standard connectors are removed and insulation displacement-type ramp connectors are used. Part numbers and vendor names for these connectors are listed in Appendix D.

If intermediate cabling assemblies are used, it is not necessary to remove the standard motor and indexer connectors. Part numbers for these assemblies may be found in Appendix D.

4.3. Electrical Noise Considerations

The R-Series Motor/Driver systems are not particularly susceptible to electrical noise from other sources. It can in some instances generate electrical noise which will cause interference in sensitive electrical systems. The noise is generated at about 20 kHz, or a multiple of 20 kHz. This noise may be generated in three ways:

A. Conducted through the motor casing
B. Conducted through the power cable.
C. Radiated from the motor, motor cable, and drive.

It is recommended that the grounding techniques described below all be combined to a single point ground. That is to say that all grounds be connected to a low impedance earth ground at only one point. This will minimize the chance of creating ground loops. Logic ground should not be used for noise grounding.

Noise conducted through the motor casing is typically controlled by providing low impedance path to earth ground by mounting the motor to a grounded motor mount. Use of a braided grounding strap is recommended.
Noise conducted through the power cable of the R-Series drives is controllable by using a power line filter such as those provided by Corcom. A 1:1 transformer will also filter out much of the energy of the noise. Using both a transformer and line filter provides maximum protection.

Noise radiated from the various parts of the R-Series can be prevented by grounding the drive and motor with low impedance earth grounds. In some cases this will not be adequate and shielding will have to be used. Shielding should be designed for low frequency signals, therefore solid NEMA enclosures and cable shields may be provided by the user.

5. CONNECTING AC POWER

Select a source of 117 VAC power which is free from line drop outs and transient voltage spikes. The maximum current draw of the various Motor/Driver Systems is listed in Appendix B. Standard practices of sizing wire for these loads must be observed to minimize the voltage drop at the Driver.

Rotate the Motor Cable Connector until it slips into the mating connector on the Driver. Turn the locking collar clockwise until it is tight.

6. CHECKOUT

6.1. Proper Torque

A dummy load with an inertia approximating the one listed in Appendix A for your motor should be mounted securely to the motor shaft for testing. Only collet-style mounting clamps are recommended for security and for concentricity between the load and the motor shaft.

Prior to energizing the Motor/Driver, manually turn the Compumotor shaft by grasping the outer radius of the dummy load. One should feel the magnetic detents characteristic of this type of AC synchronous motor employing permanent magnets.

Connect AC Power to the Motor/Driver.

It is not unusual for there to be a snap or pop caused by the in-rush energy charging the Motor/Driver power supply. Check that the rated holding torque is present at the Compumotor shaft.

This may be done feel, as the magnetic detent torque will have increased by at least an order of magnitude. A standard torque wrench may be used in place of the dummy load if a quick, quantifiable result is desired. Should the torque under power be low or nonexistent, proceed to Section 11, Trouble Shooting (Page 9).

WARNING

> DO NOT connect or disconnect the motor connector while the Motor/Driver is energized because an arc will result in the connector subsequently, and damage the Motor/Driver. To do so voids the Warranty. Multiple motors may be connected, one at a time, to the same driver by use of the Remote Power Shutdown and external switches. Consult the factory if this is required.

6.2. Pulse Source Connection

Prepare the Data Cable Kit according to the following procedures:

Signal	Wire Color	Connector Pin No.	
Direction Input (+)	Green	A	20 mA, TTL level
Direction Return (-)	White	E	
Step Input (+)	Red	B	20 mA, TTL level
Step Return (-)	Black	D	
Remote Shutdown (+)	Blue	C	20 mA, TTL level
Shutdown Return (-)	Brown	F	
Chassis Ground	Shield (Drain)		Not connected at Driver End

Check the data cable for continuity and possible shorts prior to use. Use a dummy load of 180 ohms to ensure that a minimum of 20 mA is available to drive each of the opto-isolators in the Driver (HP #HCPL 2530).

6.3. Pulse Generation

Set the pulse rate of your chosen pulse source to zero. Connect the Pulse Source Cable to the Driver. Make sure that the Remote Power Shut-down signal is not asserted (Logical "0" on Pin C).

Compumotors are designed to be accelerated and decelerated. Parker-Compumotor Corporation provides a complete line of preset indexers for creating the necessary velocity profiles and controlling total distance moved.

Gradually increase the pulse rate until the dummy load begins to move. Decrease again to zero and change the logic state of the Direction Input. Increase the pulse rate and observe the change in direction of the Compumotor shaft. Return the pulse rate to zero. Simple frequency counters are helpful at this stage to observe velocity changes.

6.4. Compumotor Pulse Generation

If you are using one of Compumotor Corporation's Preset Indexers with a 25,000 step per revolution Motor/Drive system, perform the following test:

150, 170 or 2100 Series Preset Indexers

1. Set the Mode Switch to "Preset".

2. Dial in "10" rev/sec^2 on the Acceleration thumbwheels.

3. Dial in "10.00" rev/sec (150 or 170 Series or "10.000" rev/sec (2100) on the Velocity thumbwheels.

4. Dial in "+20.000" revolutions on the Position thumbwheels (151 Series) or 500,000 steps (170 or 2100 Series).

5. Depress "START".

If using the Compumotor 2100 Series Indexer with RS-232C Computer Interface you may transmit the following the following command string to the 2100:

"E MN A10 V10 D500000 G" (Carriage Return)

All of the above will accelerate the motor at the rate of 10 rev/sec^2 until a velocity of 10 rev/sec. is reached (5 complete revolutions in one second). After completing a total of 15 revolutions, the motor will begin to decelerate, at the rate of 10 rev/sec^2, to a stop. When stopped, it will have completed exactly 20 revolutions in three seconds. With a thread pitch of 8, this should move the load approximately 2 inches.

7. LIMITED-TRAVEL MECHANISM

Limited travel mechanisms are those that will do not allow infinite travel of the motor. These mechanisms include X-Y tables, transfer lines, lead screws and so on. These mechanisms generally require load activated switches which signal the indexer of pending problems. Failure to use limit switches in these applications can damage the user's equipment.
Before connecting the actual load to the shaft of the Compumotor, all limited-travel mechanisms must be protected by the use of electrical limit switches. If one of the Compumotor Preset Indexers is used, follow the instructions included with those units. In other cases, a limit switch must signal the need for a controlled deceleration at the maximum rate possible. This rate

must be consistent with load inertia and maximum load of the motor.

Note that since the required limits are not the "End-of-Travel" type, they must be tripped far enough before the mechanical stop to allow the load to be safely decelerated. This distance may be determined empirically by initiating the deceleration cycle in the middle of travel and measuring the distance required to stop.

8. DYNAMIC CHARACTERISTICS OF THE PARKER-COMPUMOTOR

A Parker-Compumotor R-Series Motor/Drive is a special case of a hybrid permanent magnet step motor driven by a 20 KHz, bi-polar, chopper power amplifier. Its complex wave-shaping circuitry allows significant compensation for many of the mechanical and electrical imbalances inherent in step motors. The digitally-controlled proportioning of current simultaneously between multiple windings gives high torque at low speed without the jarring accelerations of traditional step motors.

The precision of Compumotor's power proportioning techniques yields exceptional repeatability while maintaining the open-loop accuracy and ease of use characteristic of stepper motors. The Compumotor shares the dynamic response curve of the stepper motor and its stall characteristics. That is, full torque under acceleration is developed at a lag angle of approximately 1.8^{o}. Loading which causes a larger lag angle will result in the motor losing position.

In cases of severe overloading, the rotor will lose synchronism with the stator and the rotor will stall and stop. The Compumotor has been designed to allow a continuous stall condition while overloaded without damage to the Compumotor or the driver. The motor may make considerable noise when stalled. This does not hurt the motor. If the motor is stalled, however, the rotating magnetic vector must be stopped by halting the input pulses, and the cause of the overload condition remedied before the Compumotor may be restarted and run successfully.

Up to 1.8^{o} of dynamic error under acceleration will be recovered when a constant velocity is reached, or when the Compumotor is stopped. How much error is recovered is proportional to load friction and depends on the stick-slip characteristics of the load. The degree of recovery may, therefore, have to be determined empirically. If using Compumotors or step motors in multi-axis systems, the error under load (if excessive) could be compensated for in the master control system. Decelerating produces a similar error condition as the motor leads the load.

9. ENCODER OPTIONS AND THE R-SERIES

The R-Series is not available from Parker-Compumotor with an encoder. Rotary encoders are unsuitable for most applications requiring use of the R-series. Some linear encoders might be appropriate, however, especially those pre-packaged, aligned and sealed. Some linear encoders make use of spring loaded plunger to contact the device to be monitored. These encoders work well with the R-Series. There are several Parker-Compumotor preset indexers which support encoder feedback for the purpose of position verification and stall detection. Refer to Parker-Compumotor's full line catalog for details.

10. PERIODIC MAINTENANCE

Periodically check the Compumotor mounting bolts and shaft couplings. The ball bearings used in the Compumotor are not sealed but are permanently lubricated and require no maintenance. There are no serviceable items in the Compumotor or maintenance items such as brushes.

The motor strain relief and cable should be inspected at appropriate intervals for signs of wearing or excessive force being applied to the cable. Tighten both cable connectors at the Driver. Check that the Driver heatsink is free of dust and dirt and has a free flow of air over its entire surface.

The Grease that is supplied with the Parker-Compumotor R-Series should be applied to the screw befor initial insertion into the motor. The screw should be checked periodically and re-lubricated as needed.

11. TROUBLESHOOTING

If problems develop in the operation of the Compumotor, refer to the following list of symptoms and causes to identify or localize the problem:

11.1. Motor Fails to Turn

Probable Causes:

(a) No AC power. Check to see if the motor is warm to the touch after 15 minutes of being turned on.
(b) Bad connections or bad cables.
(c) Tripped or faulty limit switches - make sure that control signals are not being inhibited by limit inputs to a preset indexer or supervisory logic.
(d) Load is jammed - remove AC power from the Driver and verify that the load can be turned manually.
(e) No Step signal coming to Driver - check that a pulse train meeting all requirements for voltage, current and pulse width is available (3.5 to 6V @ mA minimum 25 mA

maximum, 500 nsec pulse width minimum).

(f) Driver output is being turned off by Remove Power Shutdown Option - Pin C of the input cable to the Driver should not be high (TTL level) relative to Pin F.

(g) Blown driver AC line fuse. The motor and driver will be cold to the touch 30 minutes after the fuse blows. Disconnect AC power from the Driver and discount it from the surface to which it is attached. Remove the four Phillips-head screws which retain the sheet metal cover on the long sides of the Driver. Remove the four screws on the short edges of the end plates. Slip off the cover and inspect the fuse. If the fuse is blown, return the unit for repair.

NOTICE

Probing of the Driver with AC Power applied should never be done by anyone other than Compumotor qualified personnel. LETHAL VOLTAGES ARE PRESENT and there is no AC line isolation in the Driver.

11.2. Motor Stops During Acceleration

Probable Cause:

This condition indicates an overload condition caused by excessive torque requirements, too steep an acceleration ramp, or a gross mismatch of load inertia and rotor inertia. Refer to the Compumotor full-line catalog. A larger motor and/or lower accelerations may be indicated.

11.3. Motor Fails to Run Above 20 rps (1200 rpm)

This may be a torque problem but, more likely, it has to do with load/Compumotor interactions which can stimulate parametric oscillations and stall the Compumotor. The addition of friction, system dampening or mechanical redesign to minimize mechanical resonances may be required singly or in combination. Standard Compumotor indexers will not allow a motor velocity above 20 rps (1200 rpm).

11.4. Motor is Jerky, Noisy or Weak

Check that there are no mechanical problems at the load causing highly variable loading conditions at the Compumotor shaft. Disconnect the Compumotor from the load and run it with a dummy load connected. If the problem persists, service repair is indicated.

12. FACTORY SERVICE

To return the Compumotor for repair or to order replacement parts, obtain the Model and Serial Numbers of the Motor and Driver. Call the Compumotor Service Department for return authorization. In California call collect (707) 778-1244; otherwise call toll free (800) 358-9068. Return the Compumotor and Driver, freight prepaid, to:

COMPUMOTOR CORPORATION
1179 North McDowell Boulevard
Petaluma, California 94952
Attn: Service Department
RMA # ___________

Note: Please mark both packing slip and packing label with the Return Material Authorization number supplied by Compumotor.

13. FURTHER NOTES

Compumotor Corporation is dedicated to being a leader in digital motion control. We invite your questions, comments, or discussion of problems.

This manual has been designed to provide an introduction for the user with typical applications. Significant departures from the operating parameters outlined here are possible. If you have a volume requirement for our products (of over 250 per year), we would like to discuss your specific needs.

Call or write:

Technical Marketing Group
Compumotor Corporation
1179 N. McDowell Boulevard
Petaluma, California 94952

In California, call collect: (707) 778-1244
Outside California, call toll free: (800) 358-9068

14. SPECIFICATIONS

14.1. Environmental Specifications

Operation:Driver - 32-104°F (0-40°C) ambient assumes driver fins mounted vertically, convection cooling. Maximum fin temperature = 150°F (60°C).
10 to 90% Humidity, Non-condensing

Motor - 32-104°F (0-50°C) ambient - assumes convection cooling. Maximum case temperature (measured mid-case)

- 230°F (110°C).
10 to 90 % Humidity, Non-condensing

Storage:-40 to 185°F (-40 to 85°C)

14.2. Electrical Specifications

Input Power:105 to 125 VAC 50/60 Hz with brownout protection

TTL Inputs: 3.5 to 6.0 V pulse height
500 nsec pulse width minimum
20 mA minimum current
1 MHz maximum pulse rate

Driver Dimensions:	See Appendix K
Driver Weight:	64 oz. (1.81 kg)
Motor Dimensions:	See Appendix K
Motor Weight:	See Table Next Page

Screw Data:	R57-55
Type:	ACME
Size:	1/4 - 16
# of helix (starts):	2
Pitch (threads/inch):	8
Lead, in/pitch (mm/pitch):	0.125 (3.175)
Accuracy in/in (mm/mm):	0.00058 (0.0148)
Length, overall, in (cm):	5.0 (12.7)
Length, usable, in (cm):	3.2 (8.13)
Efficiency, %:	40
Coupling method:	#2-56 X 0.381 dp thread and radial thru hole 0.2360 dia X 0.4775

Screw Data:	R83-96
Type:	ACME
Size:	3/8 - 10
# of helix (starts):	1
Pitch (threads/inch):	10
Lead, in/pitch (mm/pitch):	0.1 (2.54)
Accuracy in/in (mm/mm):	0.00058 (0.0148)
Length, overall, in (cm):	5.0 (12.7)
Length, usable, in (cm):	3.2 (8.13)
Efficiency, %:	40
Coupling method:	#2-56 X 0.381 dp thread and radial thru hole 0.2360 dia X 0.4775

14.3. Operational Specifications

Technical Data for R83-96

Max linear rate of travel @ 1 RPS = 0.1 in/sec, @10 RPS = 1 in/sec.

Rotary-linear conversions:

1 microstep = 4 X 10-6 inch 1 revolution = 0.10 inch

Position errors:

Composite errors in microinches per microstep:

Motor step errors	= +/-0.12
Screw error	= 0.002
1 microstep error	= +/-0.122
Backlash	= 0.005"

Thermal errors for 75oC rise above 25oC ambient:

Housing, inches	= 0.0032
Screw, in/in/oF	= 0.0000063
Hysteresis	= 0.0000020
Helical skew error	= 0.0000030

Table 1: R-Series Linear Resolutions

R Number	inches / thread	steps / rev	inch[2] / step	steps / inch	microns / step	steps / micron
R1	0.125	200	625.0	1,600	15.94	0.06
R2	0.125	400	312.5	3,200	7.97	0.13
R3						
R4	0.125	1000	125.0	8,000	3.19	0.31
R5	0.125	4,096	30.5	32,768	0.78	1.28
R6	0.125	10,000	12.5	80,000	0.32	3.14
R7	0.125	12500	10.0	100,000	0.26	3.92
R8	0.125	16,384	7.6	131,072	0.19	5.14
R9	0.125	20,000	6.3	160,000	0.16	6.27
R10	0.125	21,600	5.8	172,800	0.15	6.77
R11	0.125	25,000	5.0	200,000	0.13	7.84
R12	0.125	25,400	4.9	203,200	0.13	7.97
R13	0.125	36,000	3.5	288,000	0.09	11.29
R14	0.125	50,000	2.5	400,000	0.06	15.68
R15	0.125	50,000	2.5	400,000	0.06	15.68

[2]Millionths of an inch

Appendix A: Dummy Load Parameters

Motor	Inertias: Rotor ($oz-in^2$)	Inertias: Dummy Load Approx. ($oz-in^2$)	Dummy Load Dimensions for an Aluminum Disc: Diameter (in)	Dummy Load Dimensions for an Aluminum Disc: Thickness (in)
M57-51	0.48	2	4.00	0.063
M57-83	1.28	5	4.75	0.063
M57-102	1.75	7	4.50	0.125
M83-62	3.50	10	4.80	0.125
M83-93	6.70	15	5.30	0.125
M83-135	10.24	25	6.00	0.125
M106-120	21.50	50	7.20	0.125
M106-178	44.00	100	8.50	0.125

Note: These dummy load inertias are arbitrary and do not represent the minimum or the maximum inertias that can be applied to the motor.

Appendix B: Maximum Recommended Motor Wire Sizes

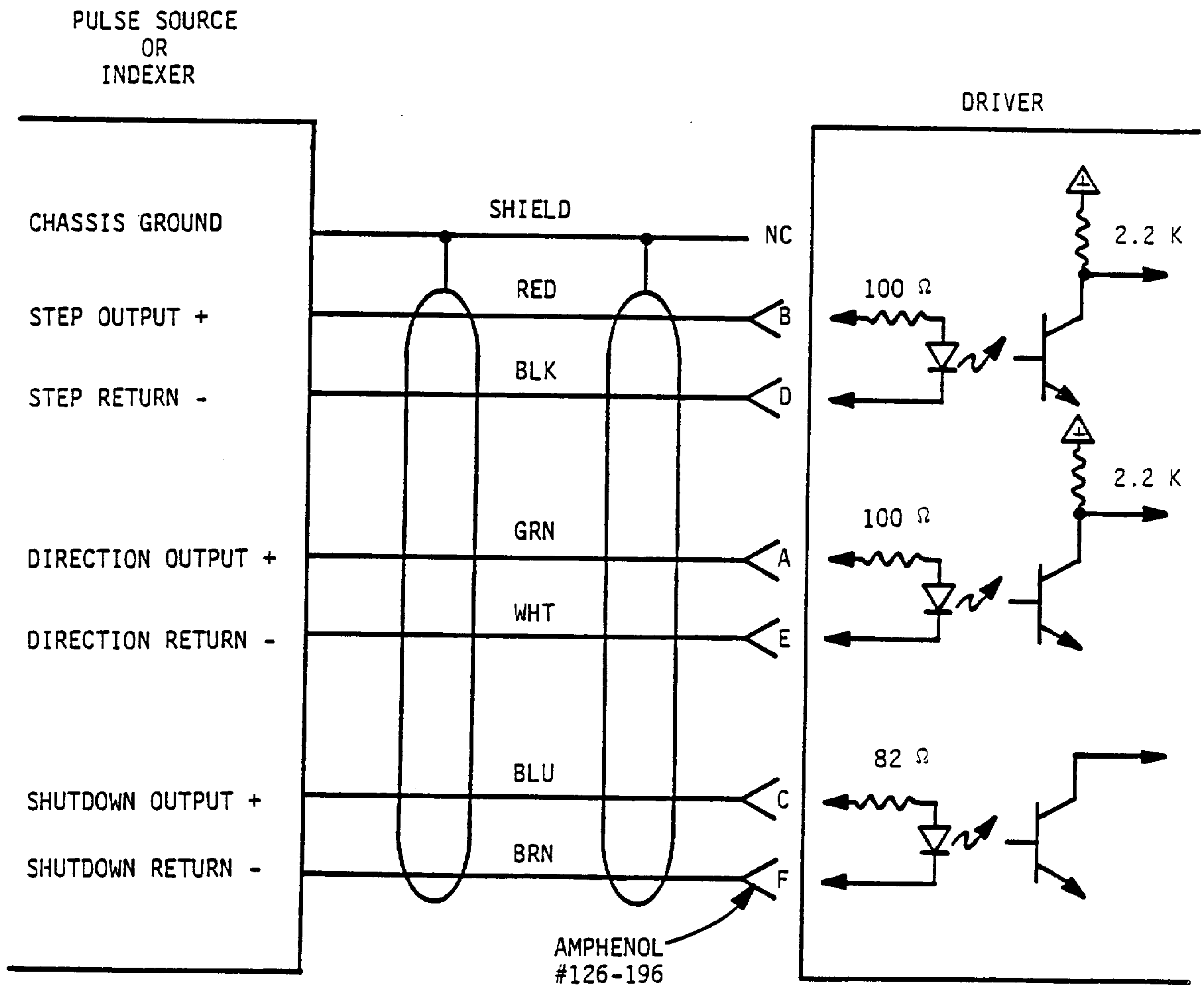
Motor Series	Maximum Current per Phase (A)	Less Than 100 ft.(20.5M)	100-200 Ft. (30.5-71M)
M57	1	22	20
M83	2	20	18
M106	3	18	16

1. Cable runs of over 200 ft. (71) are not recommended.
2. Voltage drop per motor phase = (cable $\frac{\text{length (A)}}{100}$ x 2) X R

where R = wire resistance in ohms per 100 ft.

Wire Size (AWG)	R (ohms/100 ft)
16	.4
18	.64
20	1.0
22	1.6

Appendix C: Wiring Diagram - Driver to Indexer



Appendix D: Mating Connectors and Cables

Description	Qty	Manufacturer's P/N
Power harness (5") (mates with std. cord)	1	Compumotor 71-001536
3 Pin Ramp Connector (female) -connector pins[1]	1 3	AMP 640250-3 AMP 640252-1
3 Pin Ramp Connector -connector pins[2]	1 3	Molex 09-50-3031 Molex 08-50-0105
3 Pin Ramp connector (18 ga)[3]	1	AMP 640426-3
Motor Harness (5") (mates with motor cable)	1	Compumotor 71-001534
Motor Connector (female) (mates with motor cable) -connector pins	1 7	AMP 206433-1 AMP 66569-3
6 Pin Ramp Connector (female) -connector pins	2 6	AMP640250-6 AMP640252-1
6 Pin Ramp Connector -connector pins	1 6	Molex 09-50-3061 Molex 08-50-0105
6 Pin Ramp connector (22ga)	2	AMP 640428-6
Indexer Connector (male) (mates with Compumotor indexer cable)	1	Amphenol 126-197
Indexer Harness (5") (mates with Compumotor indexer cable)	1	Compumotor 71-001535
Driver End Plate Assembly (all mating connectors, mounted)	1	Compumotor 71-01521

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[1]Assembly tool:

insulation diameter	AMP P/N
0.060-0.100"	90123-2
0.043-0.075"	90123-5

[2]Assembly tool Molex HTR-1031-C

[3]Assembly tool AMP P/N 59802-1

Appendix E: Connector Pinout List

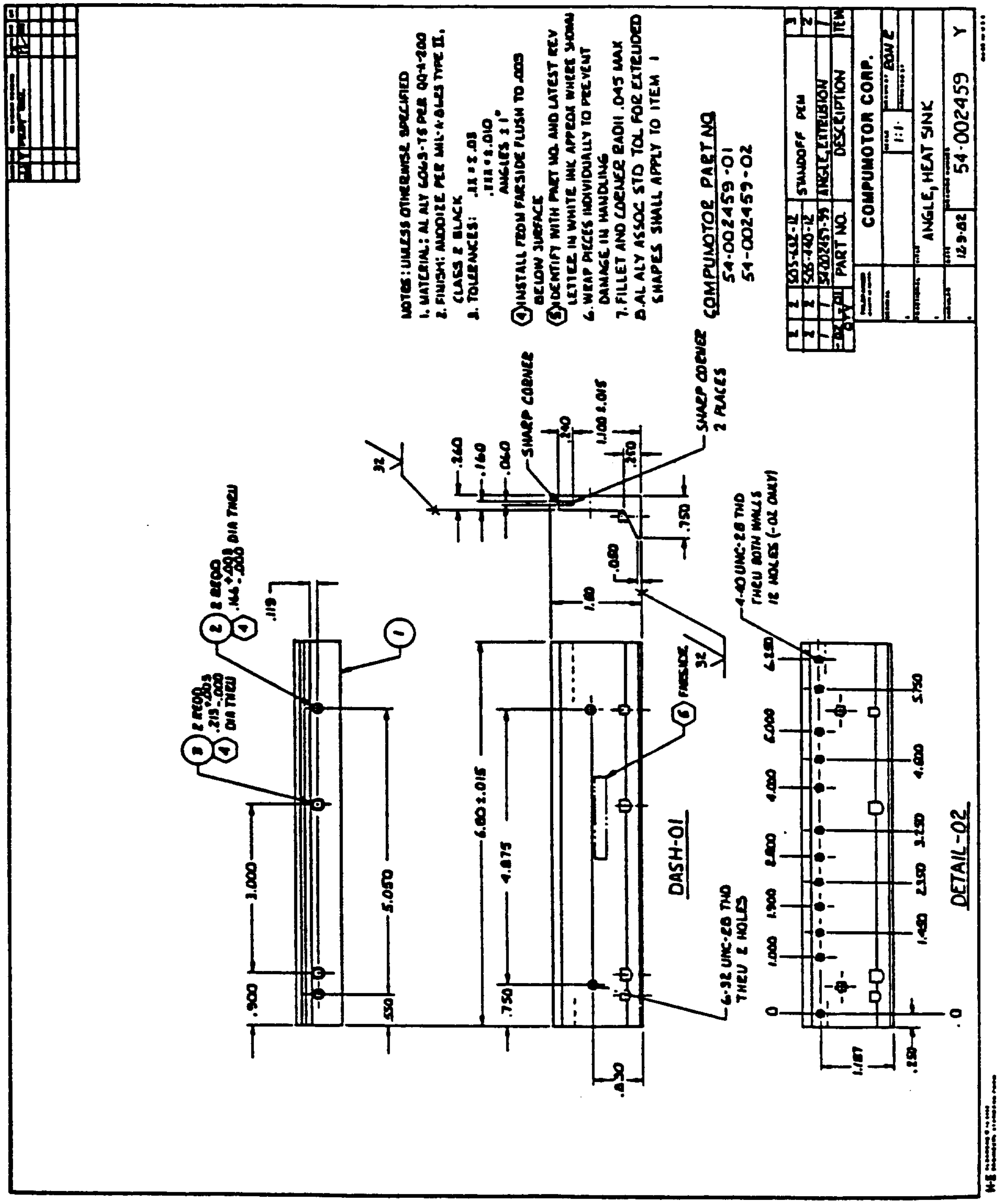
Circuit Board Connectors

	Pin	Signal	Wire Color
AC POWER (P1)			
	1	NEUTRAL	WHT
	2	EARTH	GRN
	3	HOT(117V)	BLK
INDEXER INPUT (P3)			
	1	STEP +	-
	2	DIRECTION +	-
	3	SHUTDOWN +	-
	4	SHUTDOWN -	-
	5	DIRECTION -	-
	6	STEP -	-
MOTOR OUTPUT (P2)			
	1	PHASE 1 +	-
	2	PHASE 1 -	-
	3	INTERLOCK -	-
	4	PHASE 2 +	-
	5	PHASE 2 -	-
	6	INTERLOCK +	-

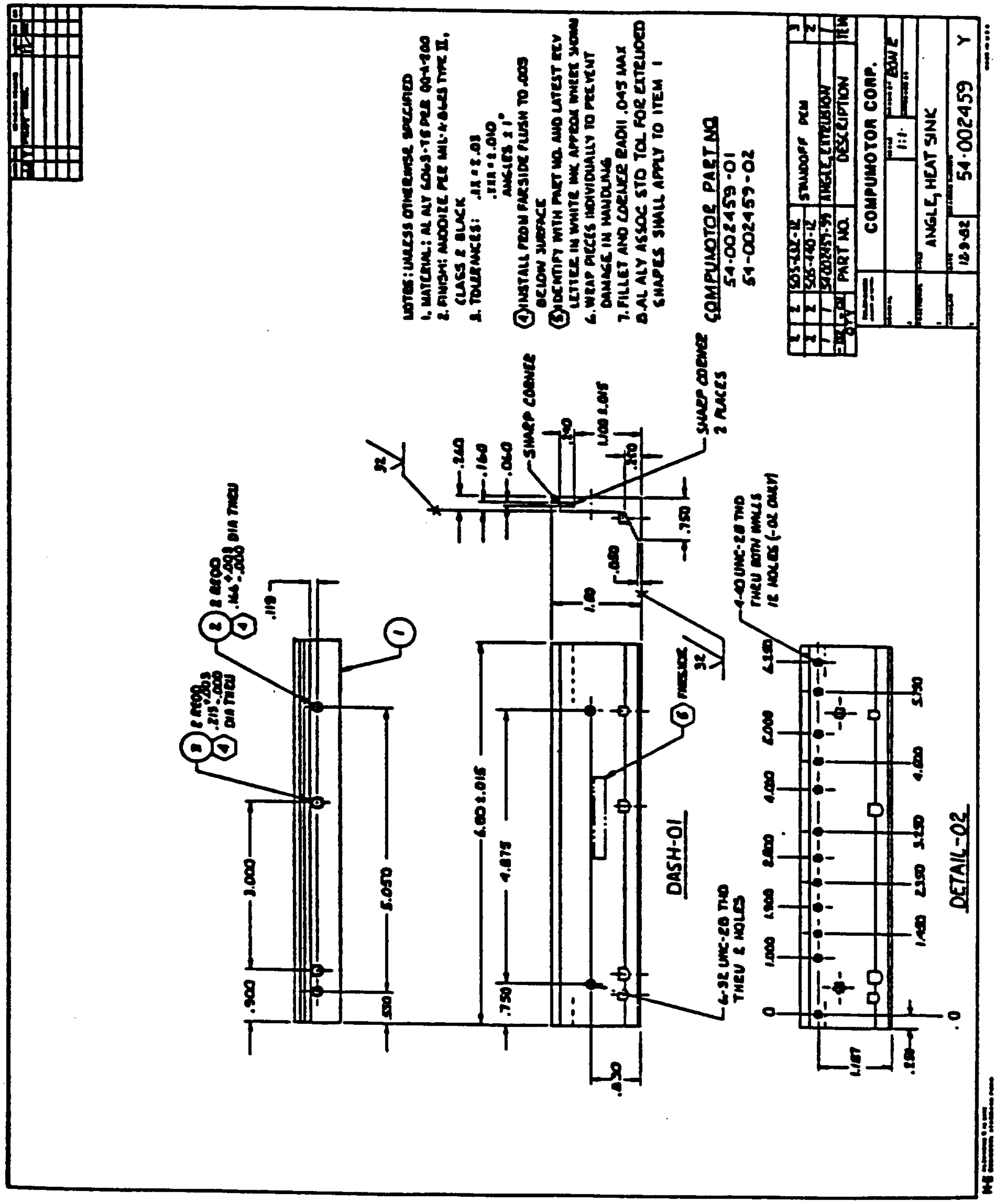
Off Board Mating Connectors

MOTOR CABLE CONNECTOR			
	1	PHASE 2 +	BLK
	2	PHASE 1 -	GRN
	3	INTERLOCK	-Jumper to 7
	4	EARTH	Shield
	5	nc	
	6	PHASE 2 -	RED
	7	INTERLOCK+	Jumper to 3
	8	PHASE 1 +	WHT
INDEXER CABLE CONNECTOR			
	A	DIRECTION +	GRN
	B	STEP +	RED
	C	SHUTDOWN +	BLU
	D	STEP -	WHT
	E	DIRECTION -	BLK
	F	SHUTDOWN -	BRN
	H	nc	

Appendix F: Circuit Board Mounting Dimensions



Appendix G: Heatsink Mounting Dimensions



Appendix H: Driver Thermal Data

The open frame driver circuit board heat sink must be mounted to a thermally conductive surface that will carry away heat dissipated by the power transistors. Either the mounting surface must have enough surface area, or forced air cooling must carry away enough heat to limit the temperature rise of the circuit board heat sink to no more than 60 degrees C. If the circuit resides within an enclosure, the internal air temperature must remain below 50 degrees C.

The amount of heat generated by the drive is proportional to the power delivered. The larger motor drives dissipate more heat than the smaller ones, as follows:

APPROXIMATE HEAT SINK DISSIPATION

Model Number	Static Torque oz-in	Heat Dissipation (WATTS)
M57-51	40	7.5
M57-83	80	10.0
M57-102	120	12.5
M83-62	140	15.0
M83-93	260	25.0
M83-135	400	35.0
M106-120	525	35.0
M106-178	700	55.0

Appendix I: End Plate Mechanical Dimensions