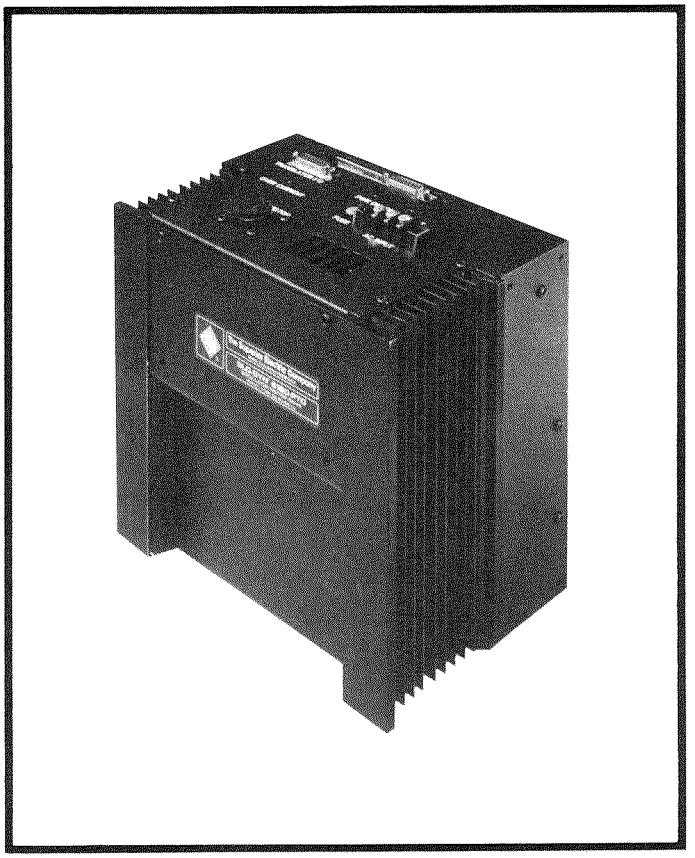
PRICE: $7.50

INSTRUCTIONS for SLO-SYN® MICRO SERIES MOTION CONTROLS PACKAGED OSCILLATOR/DRIVES TYPES 6180-PTO, 6180-PTO10, 6180-PTO125



QUALITY ASSURED FIRM ISO 9002 SGS

Manufactured under an ISO 9002 compliant manufacturing system

WARNER ELECTRIC

DANA

USEFUL INFORMATION

Fuse: 125 volt, 10 ampere (Littelfuse part number 314010)

Motor Connector: mates with male connector, AMP part number 211400-1, pin part number 66098-9, clamp part number 206966-1

STEPS NECESSARY TO BECOME OPERATIONAL

The following list outlines the minimum steps necessary for the Oscillator/Drive to become operational. **FAILURE TO PERFORM THESE STEPS MAY RESULT IN DAMAGE TO THE UNIT.**

CAUTION: Never connect or disconnect anything from the unit with the power on.

DRIVE

1. Connect 120 volts, 50/60 Hz to the AC input terminal strip. The terminal labeled "H" is hot, "C" is common and "G" is ground.
2. Check to see that the motor used is compatible with the drive. A list of compatible motors is given in Section 3.3.
3. Set the correct current level for the motor being used per the instructions given in Sections 3.3 and 3.6.
4. Wire the motor per Section 2.2, "Motor Connections".
5. Caution: Always disconnect the ac power to the unit when connecting or disconnecting the motor connector or leads.
6. Caution: Always run the motor and the drive **grounded**. Be sure to twist the wires for each motor phase. Six twists per foot is a good guideline.
7. Connect the customer control logic to connector J1. Refer to Section 5 for descriptions of operation.

OSCILLATOR

1. Set up switch S1 on the oscillator properly.

   a. Select a frequency range of operation for the oscillator as shown in the following chart. The pulse output is square waves.

S1-1	S1-2	S1-5	S1-6	Range Selected
X	X	off	off	no pulses out of oscillator
off	off	on	off	0 to 1 MHz
off	off	off	on	0 to 500 kHz
on	off	on	off	0 to 20 kHz
on	off	off	on	0 to 10 kHz
off	on	on	off	0 to 100 kHz
off	on	off	on	0 to 50 kHz

Note: X denotes either position.

   b. High Speed Adjustment Select:

      If S1-3 is in the On position, the high speed is adjustable using "R3" on the oscillator board only.

      If S1-3 is in the Off position, the high speed is adjustable using an external potentiometer connected between J1-8 and J1-15. A 500k ohm multi-turn potentiometer is suggested.

   c. Translator Pulse Source Select:

      If S1-4 is in the On Position, the drive translator is connected to the oscillator output.

      If S1-4 is in the Off position, the drive translator input is J1-3.

2. Adjust the base speed of the oscillator at a nonresonant starting speed, preferably above the mechanical resonance speed of the motor. This is accomplished by adjusting "R4" with the "RUN" (J1-6) and the "BASE SPEED ONLY" (J1-14) inputs tied to SIGNAL COMMON (J1-7 or J1-12).
3. Adjust the high speed of the oscillator to the desired high speed. Close position 3 of switch S1, or temporarily short J1-8 to J1-15, and adjust "R3" with the "RUN" (J1-6) input tied to SIGNAL COMMON (J1-7 OR J1-12). If the motor stalls, adjust "R3" clockwise to lower the high speed limit. Remove the "RUN" input to SIGNAL COMMON.
4. Adjust the Acceleration and Deceleration potentiometers on the oscillator board if you desire. The procedure is described in the manual. The factory preset value is 1 second for both the acceleration and deceleration rates.

INSTALLATION GUIDELINES FOR REDUCED NOISE INTERFERENCE

I General Comments

SLO-SYN Micro Series drives use modern solid-state electronics such as microprocessors to provide the features needed for advanced motion control applications. In some cases, these applications produce electromagnetic interference (EMI, or electrical "noise") that may cause inappropriate operation of the microprocessor logic used in the Micro Series product, or in any other computer-type equipment in the user's system.

This guide is aimed toward helping users avoid such problems at the start by applying "good engineering practices" when designing their systems. Following these guidelines will usually prevent EMI noise from interfering with drive operation.

II Noise Sources

What causes electrical noise? In general, any equipment that causes arcs or sparks or that switches voltage or current at high frequencies can cause interference. In addition, ac utility lines are often "polluted" with electrical noise from sources outside a user's control (such as equipment in the factory next door).

The following are some of the more common causes of electrical interference:

- power from the utility ac line
- relays, contactors and solenoids
- light dimmers
- arc welders
- motors and motor starters
- induction heaters
- radio controls or transmitters
- switch-mode power supplies
- computer-based equipment
- high frequency lighting equipment
- dc servo and stepper motors and drives

III Mounting Location

When selecting a mounting location, it is preferable to keep the drive away from obvious noise sources, such as those listed above. If possible, locate the drive in its own metal enclosure to shield it and its wiring from noise sources. If this cannot be done, keep the drive at least three feet from any noise sources.

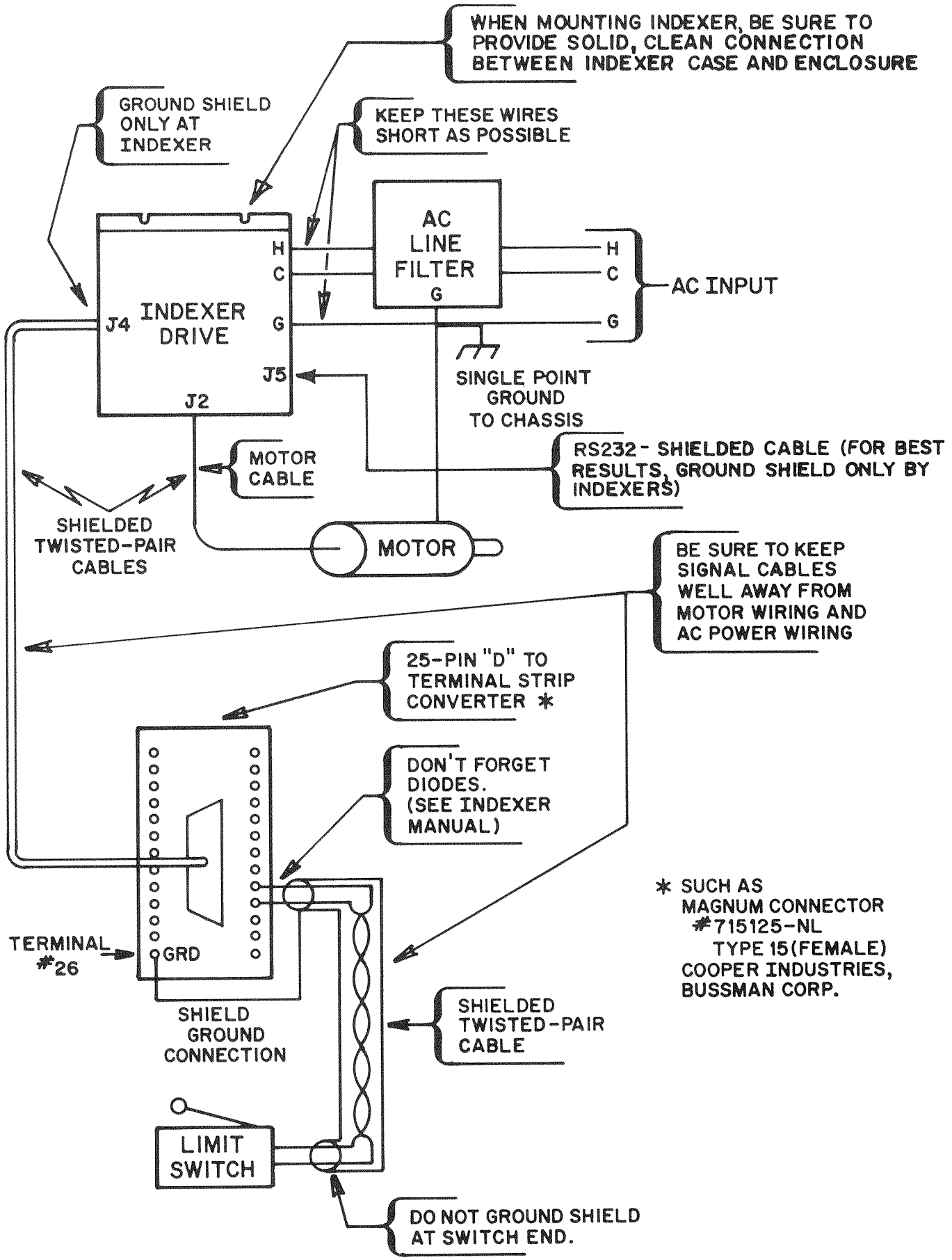
IV Wiring Practices - "Dos and Don'ts"

Do the following when installing or wiring your drive or indexer:

- **Do** keep the drive and its wiring as far away from noise sources as possible.
- **Do** provide a good, solid ground connection to the ac system earth ground conductor. Bond the drive case to the system enclosure.
- **Do** use a single-point grounding scheme for all related components of a system (this looks like a "hub and spokes" arrangement).
- **Do** keep the ground connection short and direct.
- **Do** use a line filter on the ac input (Corcom type 10B1, 10S1 or 10K1 or equivalent) for noisy ac lines. Particularly bad ac lines may need to be conditioned with a ferroresonant type isolation transformer to provide "clean" power to the drive or indexer.
- **Do** keep signal and drive wiring well separated. If the wires must cross, they should do so at right angles to minimize coupling. Power wiring includes ac wiring, motor wiring, etc. and signal wiring includes inputs and outputs (I/O), serial communications (RS232 lines), etc.
- **Do** use separate conduits or ducts for signal and I/O wiring. Keep all power wiring out of these signal line conduits.
- **Do** use shielded, twisted-pair cables for indexer I/O lines.
- **Do** ground shields only at one end, the indexer/drive end.
- **Do** use twisted-pair, shielded cable for the motor wiring.
- **Do** use solid-state relays instead of electromechanical contact types wherever possible to minimize noise generation.
- **Do** suppress all relays to prevent noise generation. Typical suppressors are capacitors or MOV's. See manufacturers literature for complete information.
- **Do** use shielded, twisted-pair cable for connection to RS232 serial port..

Do not do the following when installing your drive or indexer:

- **Do not** install sensitive computer-based equipment (such as an indexer/drive) near a source of electromagnetic noise.
- **Do not** bundle power and signal lines together.
- **Do not** bundle motor cables and signal lines together.
- **Do not** fail to use shielded, twisted-pair cables for signals.
- **Do not** fail to properly connect the system grounds.
- **Do not** use "daisy-chained" grounds.
- **Do not** fail to ground signal cable shields at only one end.
- **Do not** assume that power from the ac line is adequately "clean".



RECOMMENDED WIRING PRACTICE

V Troubleshooting Guide

Electrical interference problems are common with today's computer - based controls, and such problems are often difficult to diagnose and cure. If such a problem occurs with your system, it is recommended that the following checks be made to located the cause of the problem.

1. Check the quality of the ac line voltage using an oscilloscope and a line monitor, such as Superior Electric's VMS series. If line voltage problems exist, use appropriate line conditioning, such as line filters or isolation transformers.

2. Be certain all of the previous Dos and Don'ts are followed for location, grounding, wiring and relay suppression.

3. Double check the grounding connections to be sure they are good electrical connections and are as short and direct as possible.

4. Try operating the drive with all suspected noise sources switched off. If the drive functions properly, switch the noise sources on again, one at a time, and try to isolate which ones are causing the interference problems. When a noise source is located, try rerouting wiring, suppressing relays or other measures to eliminate the problem.

TABLE OF CONTENTS
6180-PTO, 6180-PTO10, 6180-PTO125 MICRO SERIES OSCILLATOR/DRIVE MODULE

WARNINGS:

- **Voltages present in this unit can cause serious or fatal injury. Only qualified personnel should install or perform servicing procedures on this equipment.**
- **Voltage is present on unprotected pins when unit is operational.**
- **The red "POWER" light must be off before unplugging the motor connector.** Do not connect or disconnect motor connector unless the ac power has been off for at least 2 minutes, or the drive will be damaged.
- **Before making changes to the motor or control wiring, turn off all power to the unit, and disconnect its AC power source.**
- **When power is applied, all parts of the drive circuit should be considered hazardous.**
- **Allow at least ten minutes for capacitors to discharge as they will remain at high voltages for several minutes after power is removed.**
- Motors powered by this drive may develop extremely high torque. Use caution! Disconnect AC supply to drive before doing any mechanical work.

CAUTIONS:

- Assure motor compatibility before using the unit.
- Observe all cooling and temperature limitation. Heat sink temperature must be maintained between 0°C and 80°C (32°F and 176°F). Unit must not be operated in ambient temperatures below 0°C (32°F) or above 50°C (122°F). An optional fan is available. **A fan is required when operating at 6 amperes.**
- All Windings Off should be used with caution, as all holding torque is lost.
- Do not connect or disconnect motor or signal cables while AC power is applied.
- Do not apply AC power until all connections have been made correctly.
- Do not exceed specified input voltage.
- Do not operate unit without the enclosures in place, as high voltages are present.

LIMITS OF USE:

- Reconfiguration of the circuit in any fashion not shown in this manual will void the warranty.

NOTE:

1. **Clockwise and counterclockwise directions are properly oriented when viewing the motor from the label end.**

SECTION 1: INTRODUCTION

1.1 FEATURES OVERVIEW

The 6180-PTO provides the following output capacility:

	MOTOR CURRENT PER PHASE	VA PER PHASE
6180-PTO	6 Amps peak	1000 VA nominal

The 6180-PTO motor drive/translator/oscillator package is a line-operated, energy efficient, self-contained motor drive module. An integral power supply provides the necessary DC voltages required to operate the drive. This module is capable of driving a wide range of Superior Electric Slo-Syn stepper motors, and has several features, including:

- Integral multi-range ramped oscillator for speed control.
- Full/half, 1/10, or 1/125 step resolution, depending on model.
- Speeds up to 10,000 full steps per second.
- Motor current adjustable from 1.0 to 6.0 amperes per phase.
- Reduce-current and boost-current functions.
- Power On, Overcurrent and Fault LED indicators.
- Over-temperature and short circuit protection.

1.2 INSPECTION PARTS LIST

The drive comes fully assembled as a single unit and is marked with the part number, either 6180-PTO (full/half step), 6180-PTO10 (1/10 microstep), or 6180-PTO125 (1/125 microstep).

1.3 USING THIS MANUAL

This manual is an installation and operating guide to the 6180-PTO motor drive. All the necessary information is provided for using the 6180-PTO successfully.

We strongly recommend that this manual be read thoroughly and completely before attempting to install and operate the equipment.

1.3.1 ORGANIZATION

This manual is organized for the convenience of the operator. Section 2, "Mounting, Connections, and Pin Assignments," provides diagrams and reminders that are necessary for even the experienced user and installer.

Complete specifications, listed in Section 3, will provide easily referenced information concerning all aspects of installation, power and interface requirements, as well as performance specifications.

Section 4 gives a functional description of the drive, and Section 5 explains in detail each of the input/output signals.

The remaining sections contain additional drawings and information useful for setting up and operating the drive.

1.3.2 LOGIC CONVENTIONS, INDICATOR LAMPS, AND AC FUSE

- All logic is LOW TRUE. This means that a logic function is **active when low** and inactive when high. The low true condition is designated by a bar. For example, in the case of $\overline{AWO}$ (All Windings Off), the windings are OFF when the input is low.
- A red "PWR ON" LED indicator shows the presence of the + 5 Vdc drive logic power supply; this shows the unit is energized.
- A red "Drive Fault" LED indicator, without the "Overcurrent" LED, detects a drive over-temperature condition. A red "Drive Fault" LED with the "Overcurrent" LED shows an over-current condition. During these conditions, the power is removed from the motor windings so that no holding torque is being applied. Recovery from this condition necessitates removing and then reapplying the AC power source.
- The unit's AC input is internally fused. A blown AC input fuse will prevent the power supply from energizing any of its outputs, hence, the unit will not operate. Usually, the only reason this fuse will open ("blow") is if an internal failure occurs. If an open fuse occurs, return the unit to the factory for service. **DO NOT REPLACE THE FUSE OR THE UNIT MAY BE FURTHER DAMAGED.**

SECTION 2: MOUNTING, CONNECTIONS AND PIN ASSIGNMENTS

2.1 MOUNTING

The 6180-PTO is mounted by affixing its enclosure to a flat surface in one of two possible configurations. Figure 2.1 shows the mounting hole locations and diameters. It is important to leave at least two inches (50.8mm) of space between the drive's top, bottom, and sides to allow proper airflow for cooling.

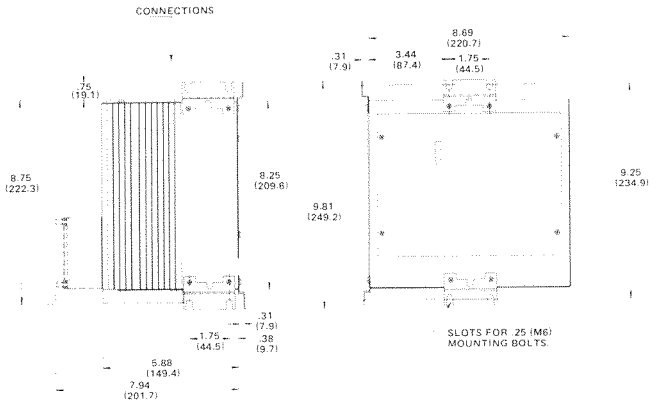
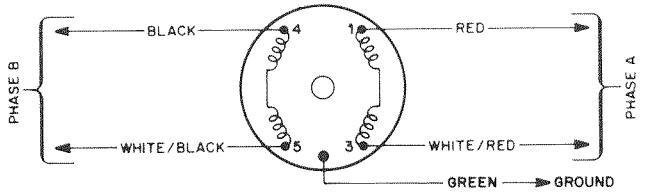


Figure 2.1: Mounting Diagram

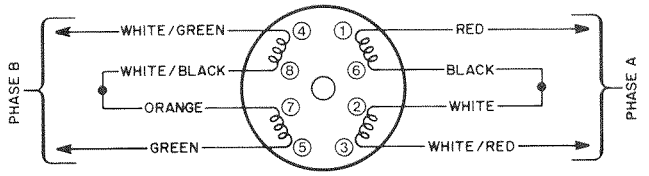
The heat sink should always be mounted with the fins oriented vertically, or proper cooling will not occur. Air flow should not be obstructed. The maximum heat sink temperature must be held below 176 degrees F (80 degrees C).

2.2 MOTOR CONNECTIONS

All motor connections are made via the 7 pin circular AMP connector. Figure 2.2 shows the possible motor wiring configurations.



Four Lead Motors



Eight Lead Motors, Series Connection (M112-FJ8020)
Figure 2.2, Motor Connections

J2: Motor Connections

Cabling: Shielded, twisted-pair cable is highly recommended. Twist together the wires for each motor phase; six twists per foot (305mm) is a good guideline.

Superior Electric Motor cables are available as follows:

Length	(Unterminated Leads on Motor End) Part Number
10 feet (3 meters)	216830-001
25 feet (7.6 meters)	216830-002
50 feet (15.2 meters)	216830-003

2.3 CONNECTORS

2.3.1 J1: Do Not Use

2.3.2 J2: Motor (see 3.5.2.1 for pin assignments)

2.3.3 J3: AC Power Input (see 3.5.1.2 for screw assignments)

2.3.4 J4: Signal I/O Connections (15-pin "D" type connector, female) (see 3.5.3.2 for pin assignments)

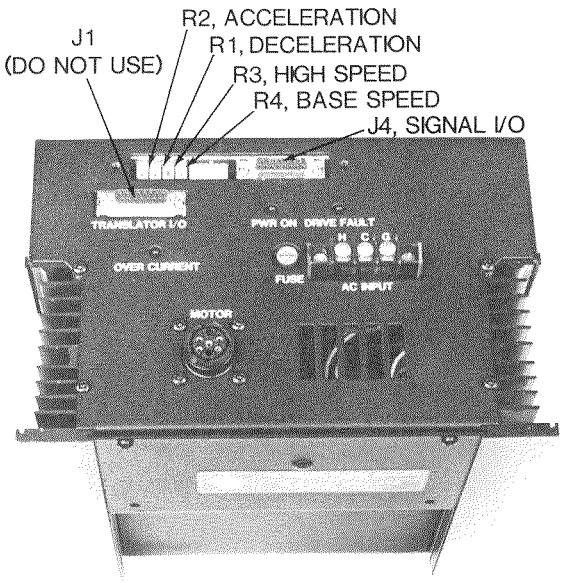


FIGURE 2.3 6180-PTO Connectors and Adjustments

SECTION 3: SPECIFICATIONS

3.1 DRIVE DESCRIPTION

Bipolar, speed adjustable, 2-phase, line operated chopper drive with translator, oscillator, and all power supplies.

Full, half, 1/10, or 1/125 step (Step resolution dependent on model type).

Power semiconductor type: N-channel FET

Chopping frequency: 20 kHz.

Control signals are optically isolated from the internal motor drive circuit.

3.2 DRIVE PERFORMANCE

Resolution: Half-step or full-step (6180-PTO)
1/10 microstep (6180-PTO10)
1/125 microstep (6180-PTO125)

Step Rate: 0 to 10,000 full-steps/sec. (6180-PTO)
0 to 20,000 half-steps/sec. (6180-PTO)
0 to 100,000 1/10 microsteps/sec. (6180-PTO10)
0 to 1,250,000 1/125 microsteps/sec. (6180-PTO125)

Oscillator base-speed frequency range: 0-150 kHz in 6 ranges

Oscillator high-speed frequency range: 0-1 mHz in 6 ranges

Accel/Decel adjustable range: 50ms to 2 seconds

Oscillator stability: Velocity and Accel/Decel, plus/minus 5% over full range of temperature and input power

Speed/Torque: See Section 7 for typical Speed/Torque curves.

3.3 MOTOR COMPATIBILITY

6180-PTO

Motor types:	Superior Electric F Series motors are recommended
Frame Sizes:	93mm to 172mm
No. of Leads:	4
Min. Inductance:	8.0 mH
Max. Inductance:	64 mH
Voltage to Motor:	170-190 Volts
Max. Motor Cable Length:	100 ft (30.5m)

MOTORS FOR USE WITH 6180-PTO

SECO Type Number	6180 Current Setting (Amperes)*
M093-FF402	3.0
M111-FF401	3.0
M112-FF401	4.0
M112-FF401	6.0 (motor fan kit FAN112 required)
MH112-FJ8020	6.0 (series connection)
M113-FF401	6.0
M172-FF401	6.0

* Use this number to set the drive's "nominal" current as described in Section 3.6.1.

3.4 DRIVE MECHANICAL SPECIFICATIONS

Size
Inches: 8.875L x 5.88W x 8.75H
mm: 225.4L x 149.4W x 222.2H

Weight
Pounds: 10.5
kg: 4.8

3.5 ELECTRICAL SPECIFICATIONS

3.5.1 AC INPUT

3.5.1.1 Power and Voltages

AC Input Range: 102 – 132 Vac, 60Hz

Fuse Rating: 125 volts, 10 amperes (**Littelfuse part number 314010**)

Drive power dissipation (worst case)

6180-PTO: 160 watts

3.5.1.2 AC Input Connections

J3: 3-pin screw terminal strip

Pin	Assignment
"H"	Hot (black)
"C"	Common or Neutral (white)
"G"	Ground (green)

3.5.2 OUTPUT TO MOTOR

3.5.2.1 Motor Connections

J2: 7-pin twist - lock circular female AMP connector

Pin	Assignment
1	M5
2	M1
3	No Connection
4	Ground
5	No Connection
6	M4
7	M3

NOTE: Motor phase A is M1 and M3, and phase B is M4 and M5.

Mates to male connector, AMP part number 211400-1 (**AMP pin part number 66098-9 and AMP cable clamp part number 206966-1**).

3.5.3 CONTROL SIGNAL INTERFACE

3.5.3.1 Signal Requirements

All connections are made via the J4 15-pin female "D" type connector. Optical isolation is used internally to separate all oscillator control signals from the motor drive circuitry. However, the J4 connector signals are not optically isolated from the user's circuitry; these signal characteristics are described below:

3.5.3.1 Signal Requirements

All connections are made via the 15-pin female "D" type connector. Figure 3.1 shows a typical external interface to this connector. Optical isolation is used internally to separate all oscillator control signals from the motor drive circuitry. However, the J4 connector signals are not optically isolated from the user's circuitry; these signal characteristics are described below:

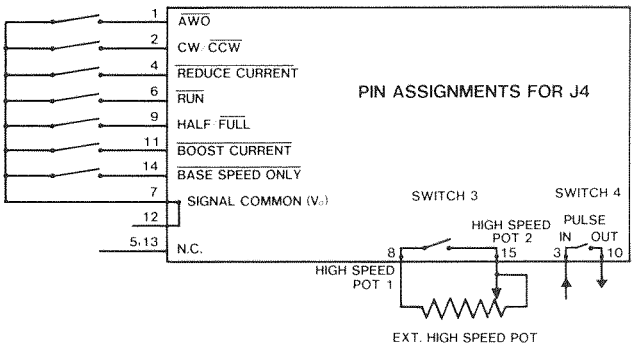


FIGURE 3.1, Typical Control Signal Interface

NOTE: Do not use the J1 connector for any purpose.

PULSE IN input characteristics:

Current sink from + 5 Vdc internal source	
Min. pulse width, low:	250 nanoseconds
Low level input current:	7 to 10 mA
Min. pulse width, high:	250 nanoseconds
High level input current:	less than 1 mA

RUN, BASE SPEED ONLY input characteristics:

High level voltage:	+ 5.5 Vdc to + 15 Vdc
High level current:	600 microamperes max.
Low level voltage:	0 Vdc to + 4.5 Vdc
Low level current:	1.8 milliamperes max.

AWO, CW/CCW, HALF/FULL, REDUCE CURRENT, BOOST CURRENT input characteristics:

Current sink from + 5Vdc internal source

High level input current:	less than 1 mA
Low level input current:	10 mA to 20 mA

PULSE OUT output characteristics:

High level output voltage (open collector):	+ 24Vdc max.
Low level output voltage:	+ .7Vdc at 40 mA max.

Wire Size: 28 AWG minimum

Run length: 50 feet (15 meters) max.; 15 feet (4.6 meters) max. for HI SPEED POT 1 and HI SPEED POT 2. Shielded cable must be used for highest noise immunity. Be sure to ground the shield only at one end of the cable.

3.5.3.2 Pin Assignments for J4

Pin #	Assignment
1	All Windings Off (AWO)
2	CW/CCW (Direction)
3	PULSE IN (PU)
4	Reduce Current
5	(N.C.)
6	Run
7	Signal Common (Vo)
8	High Speed Pot 1
9	Half/Full (H/F)
10	PULSE OUT
11	Boost Current
12	Signal Common (Vo)
13	(N.C.)
14	Base Speed Only
15	High Speed Pot 2

Notes:

1. **N.C. = No Connection**
2. **The bar denotes "active low" logic. These inputs are tied to Signal Common to activate (low level) and open-circuited to deactivate (high level).**

3.6 SWITCHES AND POTENTIOMETERS

3.6.1 CURRENT SETTINGS

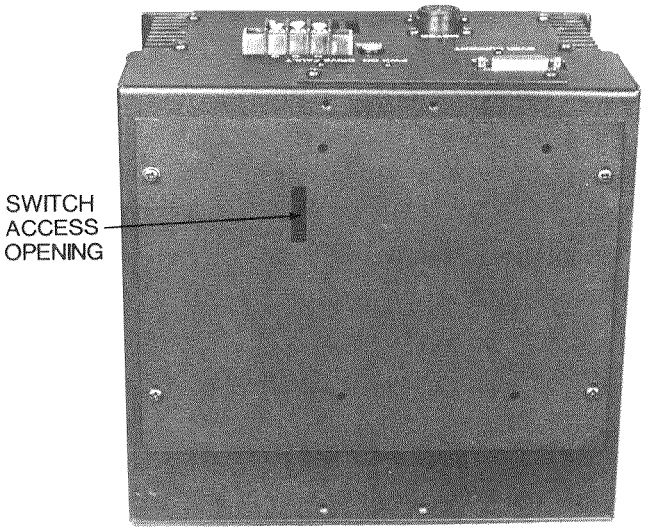
The current applied per motor pahse is switch-selectable by a "DIP" switch (S2) accessible through an opening on the back of the indexer-drive (see Fig. 3.2 for switch location).

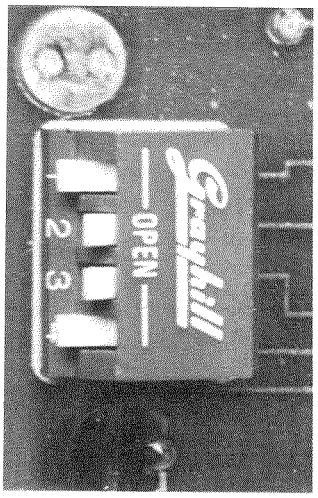
NOTE: Before making this adjustment, be sure to disconnect the drive's 120 volt AC power source and wait 10 minutes for the power supply capacitors to discharge. Set the switch as follows for the appropriate current, based on the motor's rating:

CURRENT (AMPERES)			SWITCH POSITION			
NOMINAL	REDUCE	BOOST	S1	S2	S3	S4
1.0	0.5	1.5	OFF	OFF	ON	OFF
2.0	1.0	3.0	OFF	ON	OFF	OFF
3.0	1.5	4.5	ON	OFF	OFF	OFF
4.0	2.0	6.0	OFF	OFF	OFF	OFF
6.0	3.0	6.0	OFF	OFF	OFF	ON

Boost and Reduce functions are controlled via the appropriate input signals.

Note: When using BOOST, be sure that the motor maximum shell temperature is not exceeded. In some cases, it may be necessary to limit boost duty cycle to keep the motor below its maximum shell temperature, which is 105 degrees C (221 degrees F) for "M"-type motors and 125 degrees C (257 degrees F) for "MH"-type motors.





OPEN = UP (TOWARD ACCESS OPENING)

CLOSED = DOWN (TOWARD CIRCUIT BOARD)

FIGURE 3.2 Current Setting Dip Switch for 6180 Series Drive

3.6.2 POTENTIOMETERS (See Figure 2.3 for potentiometer locations)

R1 Deceleration
R2 Acceleration
R3 High Speed
R4 Base Speed

The potentiometers are accessible from the top of the unit and a label identifies the function of each potentiometer. See Section 6 for adjustment procedures.

3.6.3 SWITCH S1, a 6-position DIP switch, is provided for setting speed ranges and for other functions. See Section 6 for proper set up. This switch is adjacent to J4 (see Figure 2.3).

3.7 ENVIRONMENTAL SPECIFICATIONS

Operating Temp:	+ 32 F to 122 F (0 C to + 50 C) Free Air Ambient
Storage Temp:	– 40 F to + 167 F (– 40 C to + 75 C)
Humidity:	95% max., noncondensing
Altitude:	10,000 feet max. (3048 meters)
Cooling:	Will operate up to 122°F (50°C) so long as maximum heat sink temperature of 176°fF (80°C) is maintained; forced air (fan) cooling is required when operating at 6.0 ampere motor current setting.

SECTION 4: FUNCTIONAL DESCRIPTION

4.1 OVERVIEW

The 6180-PTO Oscillator/drives can be functionally divided into four componets:

1. Motor drive circuitry
2. Translator circuitry
3. Oscillator/pulse generator circuits
4. Logic control functions

The 6180-PTO drives electronically convert input pulses into drive signals of the proper sequence and power required to operate a stepping motor: one input pulse being "translated" into one motor step. To drive the motor, a technique called **"chopping"** is used. Compared to older drive techniques, chopping gives improved motor performance while allowing the drive circuitry to dissipate less power. The voltage applied to the motor windings is turned on and off very rapidly, or **chopped** so that the desired current is produced.

The translator circuitry accepts a single pulse at a time as an input and determines which windings (phases) of the motor must be turned on and off in order to advance the motor shaft one step. The translator circuit is fully self-contained and is not accessible through any of the function pins.

The pulse input to the translator is internally generated by the oscillator. **This is accomplished by setting switch S1, position 4 to the "on" (closed) state, unless an external pulse source is utilized.** The oscillator circuitry controls the frequency of the pulse train for acceleration, deceleration, high and base speeds in accordance with the settings of the appropriate potentiometers.

The logic control circuitry accepts high or low logic levels through the pins on connector J4 and adjusts the motor operational parameters as described in Section 5.

The user may remotely control the high speed rate by connecting a 500k ohm potentiometer between pins 8 & 15 on connector J4. **If no external potentiometer is required, set position 3 of switch S1 to the "on" (closed) state.**

4.2 SIGNAL FUNCTIONS

Input pulses, one for each desired motor step, are received by the translator circuit on the $\overline{\text{PULSE IN}}$ ($\overline{\text{PU}}$) pin.

Two input control signals alter the sequence of motor windings which will be energized. The CW/$\overline{\text{CCW}}$ pin controls which direction the motor will move and the HALF/$\overline{\text{FULL}}$ (H/$\overline{\text{F}}$) pin determines whether a half or full step is taken. (Note: H/$\overline{\text{F}}$ is only active on the 6180-PTO; the microstepping versions, 6180-PTO10 and 6180-PTO125 do not use this signal.)

Even when the motor is stationary, current is flowing through one or two of the windings. The magnetic field produced by this current holds the shaft firmly with a force specified as the "holding torque." The input control signal, $\overline{\text{ALL WINDINGS OFF}}$ ($\overline{\text{AWO}}$), turns off all current to the motor, thus allowing the shaft to be turned manually.

Additional motor torque for acceleration may be obtained by using the $\overline{\text{BOOST}}$ input. This increases current per phase by 50%, up to a maximum of 3 amperes.

If desired, current may be decreased by 50% using the $\overline{\text{REDUCE}}$ input. This function allows for cooler motor operation at standstill in cases where the resulting lower holding torque can be accommodated.

SECTION 5: CONTROL SIGNAL DESCRIPTIONS (Reference Figure 2.3)

Connector J4, 15-pin "D" type connector, female

5.1 $\overline{\text{AWO}}$ ($\overline{\text{ALL WINDINGS OFF}}$) – Pin 1

A logical low sets the average motor current to zero. Voltage is present at the motor terminals.

WARNING:

Holding torque is eliminated when this signal is active. Insure that the motor load, when released by this command, will not injure property or personnel.

5.2 CW/$\overline{\text{CCW}}$ (DIRECTION) – Pin 2

A logical high or an open connection causes the motor shaft to step in the clockwise direction as viewed from the label end of the motor. A logical low results in counterclockwise rotation.

5.3 $\overline{\text{PU}}$ ($\overline{\text{PULSE IN}}$) – Pin 3

A low to high (positive going edge) transition on this pin causes the motor to take one step. Maximum frequency is 1.25 MHz.

5.4 $\overline{\text{REDUCE CURRENT}}$ – Pin 4

A logical low decreases motor current to 50% of the value set by the current-set "DIP" switch S2.

5.5 NOT CONNECTED – Pin 5

5.6 $\overline{\text{RUN}}$ – Pin 6

When connected to "SIGNAL COMMON" (logic low) enables the oscillator.

If BASE SPEED ONLY is open (logic high) when RUN is activated (logic low), the motor will accelerate according to the set rate, to the predetermined high speed. When RUN is open (logic high), the motor will decelerate according to the set rate until base speed is reached, and will then stop.

5.7 SIGNAL COMMON (Vo) – Pin 7

Reference point for all inputs and outputs.

5.8 HI SPEED POT 1 – Pin 8

Allows for control of high speed by means of an external 500k ohm potentiometer, when used in conjunction with HI SPEED POT 2 (pin #15). This is also a test point for acceleration and deceleration.

5.9 H/$\overline{\text{F}}$ (HALF/$\overline{\text{FULL}}$) – Pin 9

A logical low causes the motor to step the full step angle indicated in its specifications. A logical high (open) causes the motor to take a "half step" equal to half of its specified step angle. When operated in half-step mode the motor provides smoother motion with finer resolution, but at approximately 30% less torque.

Note: This input is only used on the 6180-PTO full-step, half-step translator drives. It is inactive on the 6180-PTO10 and 6180-PTO125 microstepping drives.

5.10 $\overline{\text{PULSE OUT}}$ – Pin 10

Produces a pulse (square wave output) from oscillator. Connect to "$\overline{\text{PULSE IN}}$" by placing position 4 of switch S1 in the "on" (closed) state if an external source is not required.

This is also a test point for monitoring base speed and high speed. This output is an open collector output and should be connected to $\overline{\text{PULSE IN}}$ if used for monitoring purposes.

5.11 BOOST CURRENT – Pin 11

A logical low increases current to 1.5 times the value set by the current-set "DIP" switch S2, up to 6.0 amperes maximum.

5.12 SIGNAL COMMON (Vo) – Pin 12

5.13 NOT CONNECTED – Pin 13

5.14 BASE SPEED ONLY – Pin 14

When connected to "SIGNAL COMMON" (logic low), permits only base speed velocity from oscillator.

There is no acceleration or deceleration when operating at base speed.

If this pin is open (logic high), high speed mode is selected.

5.15 HI SPEED POT 2 – Pin 15

Allows for control of high speed by means of an external potentiometer when used in conjunction with HI SPEED POT 1 (pin #8). As an alternative to using an external potentiometer, the high speed can be controlled by connecting an analog voltage (5 to 9 volts dc) to this input. It will be necessary to "ramp" the analog input to control acceleration and deceleration of the pulse train. Position 3 of switch S1 must be "off" (open) when using analog voltage.

NOTE: 500k ohm (connected across pins #8 and #15) is recommended when external control is required and position 3 of switch S1 must be "off" (open).

SECTION 6: OPERATING INSTRUCTIONS

6.1 INTRODUCTION

This section outlines the procedures for adding an external high speed potentiometer to the oscillator/drive for setting base speed, and for adjusting high speed, acceleration and deceleration.

6.2 OPERATION FROM EXTERNAL OR ON BOARD POTENTIOMETER

1. HI SPEED POTS 1 and 2 allow connections to a **remote potentiometer for control of HI SPEED setting.**

2. Connect a 500k ohm potentiometer between J4 pins #8 and #15 for external control. A maximum cable length of 15 feet (4.6 meters) is permitted. Shielded, twisted-pair cable should be used for this connection; be sure to tie the shield to ground only at the oscillator end.

OR:

Connect HI SPEED POT 1 to HI SPEED POT 2 by placing position 3 of switch S1 in the "on" (closed) position when no external control is required.

6.3 BASE SPEED

Base speed is the rate at which a specific motor and load will start or stop with no acceleration or deceleration.

1. Connect $\overline{\text{BASE SPEED}}$ ONLY (J4, pin #14) to SIGNAL COMMON.
2. Connect $\overline{\text{RUN}}$ (J4, pin #6) to SIGNAL COMMON.
3. Turn "Base Speed Pot" (R4) clockwise to **increase** base speed.

Speed (pulse frequency) can be monitored at J4 pin #10 ($\overline{\text{PULSE OUT}}$). Position 4 of switch S1 should be "on" (closed).

Three ranges of Base Speed and High Speed can be selected with DIP switch S1 as follows:

RANGE	APPROX BASE SPEED RANGE	APPROX HIGH SPEED RANGE	SWITCH POSITIONS			
			S1-1	S1-2	S1-5	S1-6
1	0 – 1250 HZ	0 – 10 KHZ	ON	OFF	OFF	ON
2	0 – 2500 HZ	0 – 20 KHZ	ON	OFF	ON	OFF
3	0 – 5000 HZ	0 – 50 KHZ	OFF	ON	OFF	ON
4	0 – 10 KHZ	0 – 100 KHZ	OFF	ON	ON	OFF
5	0 – 75 KHZ	0 – 500 KHZ	OFF	OFF	OFF	ON
6	0 – 150 KHZ	0 – 1 MEG HZ	OFF	OFF	ON	OFF

The following tables list the approximate settings for Base Speed Potentiometer R4 and High Speed Potentiometer R3 for the different frequency ranges.

BASE SPEED (%)	POTENTIOMETER R4 SETTING (APPROX # OF TURNS CW FROM FULLY CCW POSITION)		
	FREQUENCY RANGES		
	0-2500 HZ	0-10 KHZ	0-150 KHZ
0	4	2	3/4
10	8 1/4	4 3/4	3 3/4
20	13 3/4	8 1/2	6 3/4
30	17 1/4	12	10
40	19 1/4	14 3/4	13 1/4
50	20 1/2	16 1/2	15 1/4
60	21 1/2	17 1/2	16 3/4
70	22 1/4	18 1/2	17 3/4
80	22 3/4	19 1/4	18 1/2
90	23 1/2	19 3/4	19 1/4
100	23 3/4	20 1/4	20

HIGH SPEED (%)	POTENTIOMETER R3 SETTING (APPROX # OF TURNS CCW FROM FULLY CW POSITION)		
	FREQUENCY RANGES		
	0-20 HKZ	0-100 KHZ	0-1 MEG HZ
0	2 1/4	2 1/4	2 1/4
10	3 1/2	3 1/2	3 1/8
20	4 1/2	4 1/2	3 5/8
30	5 1/2	5 1/4	4 1/8
40	6 3/4	6	4 1/2
50	7 3/4	7	5 1/8
60	9	8	5 3/4
70	10 1/4	9 1/4	6 1/4
80	11 3/4	10 1/4	6 7/8
90	13 1/2	11 1/2	7 1/2
100	14 3/4	13	8 1/4

Setting Base Speed using chart:

1. Connect BASE SPEED ONLY (J4, pin #14) and RUN (J4, pin #6) to SIGNAL COMMON (J4, pin #7).
2. Adjust R4 potentiometer CCW until motor stops.
3. Adjust R4 potentiometer CW until motor is just running; this is approximately the 0% setting on the chart.
4. Adjust R4 potentiometer CW. The number of turns required is the difference between the desired speed and the 0% speed.

Example:

The desired Base Speed on the 0-2500 HZ range is 250 HZ (10%). The 10% setting is 8 1/4 turns from the fully CCW position. The 0% setting is 4 turns from the fully CCW position. Thus, R4 must be adjusted 4 1/4 turns CW from the 0% setting.

Setting High Speed using chart:

1. Connect RUN (J4, pin #6) to SIGNAL COMMON (J4, pin #7).
2. Adjust R3 potentiometer CW until motor is running at base speed.
3. Adjust R3 potentiometer CCW until motor is just above Base Speed; this is approximately the 0% setting on the chart.
4. Adjust R3 potentiometer CCW. The number of turns required is the difference between the desired speed and the 0% speed.

Example:

The desired High Speed on the 0-20K HZ range is 10 KHZ (50%). The 50% setting is 7 3/4 turns from the fully CW position. The 0% setting is 2 1/4 turns fom the fully CW position. Thus, R3 must be adjusted 5 1/2 turns CCW from the 0% setting.

HIGH SPEED (%)	APPROXIMATE VOLTAGE INPUT ON J4 – 15		
	FREQUENCY RANGES		
	0 – 20 KHZ	0 – 100 KHZ	0 – 1 MEG HZ
0	+ 5.43 V	+ 5.43 V	+ 5.43 V
10	+ 5.82 V	+ 5.78 V	+ 5.69 V
20	+ 6.08 V	+ 5.99 V	+ 5.82 V
30	+ 6.34 V	+ 6.21 V	+ 5.95 V
40	+ 6.62 V	+ 6.44 V	+ 6.08 V
50	+ 6.92 V	+ 6.68 V	+ 6.22 V
60	+ 7.24 V	+ 6.94 V	+ 6.37 V
70	+ 7.60 V	+ 7.22 V	+ 6.52 V
80	+ 7.98 V	+ 7.52 V	+ 6.69 V
90	+ 8.41 V	+ 7.84 V	+ 6.87 V
100	+ 8.89 V	+ 8.20 V	+ 7.06 V

NOTE: Because of the oscillator design, the high speed cannot be set lower than the speed set on the base speed potentiometer. For example, if base speed is set to 200 Hz, the high speed can be set no lower than 200 Hz.

6.4 HIGH SPEED

HIGH SPEED POTS 1 AND 2 TERMINALS ARE EITHER CONNECTED TOGETHER (BY CLOSING POSITION 3 OF S1 FOR ON-BOARD OPERATION) OR ARE CONNECTED TO A REMOTE POTENTIOMETER. (Potentiometer set at minimum resistance.)

1. Make sure that BASE SPEED ONLY (J4 pin #14) is OPEN.
2. Connect RUN (J4 pin #6) to SIGNAL COMMON.
3. Turn HIGH SPEED POT (R3) **counterclockwise** to increase velocity to desired maximum limit.

Speed (pulse frequency) can be monitored at J4, pin #10 ($\overline{\text{PULSE OUT}}$). Position 4 of switch S1 should be "on" (closed).

The settings of "DIP" switch S1, described in 6.3, also affect the High Speed Range as noted in 6.3.

6.5 ACCELERATION

Acceleration time to high speed, with the Accel potentiometer (R2) fully counterclockwise is approximately 50 milliseconds. Range is from 50 milliseconds to 2 seconds (approximately).

Measure acceleration with an oscilloscope connected between HI SPEED POT 1 and SIGNAL COMMON. Oscilloscope should be triggered when RUN (J4 pin #6) goes low.

Then make the following settings:

1) Make sure $\overline{\text{BASE SPEED ONLY}}$ is Open.
2) Set $\overline{\text{RUN}}$ to Open.
   This signal must be open circuited long enough to allow complete deceleration.
3) Connect $\overline{\text{RUN}}$ to SIGNAL COMMON (logic low).
4) Measure acceleration time.
5) Adjust Acceleration potentiometer (R2) clockwise to increase acceleration time.
6) Repeat steps 2 – 5 until acceleration is attained.

The following table gives approximate settings for the Acceleration Potentiometer (R2).

ACCELERATION TIME (milliseconds)	POTENTIOMETER R2 SETTING (number of turns CW from fully CCW position)
22	0
60	1/2
100	1
200	2
300	3
400	4
500	5
600	6
800	8
1000	10
1250	12 1/2
1500	15
1750	17 1/2
2000	20
2200	22

The acceleration times are essentially unaffected by any potentiometer or switch settings.

6.6 DECELERATION

Deceleration time from high speed to base speed, with the Deceleration potentiometer (R1) fully counterclockwise is 50 milliseconds. Range is from 50 milliseconds to 2 seconds. **Measure deceleration with an oscilloscope connected to HI SPEED POT 1 and SIGNAL COMMON.** Oscilloscope should trigger when RUN (J4 pin #6) goes high.

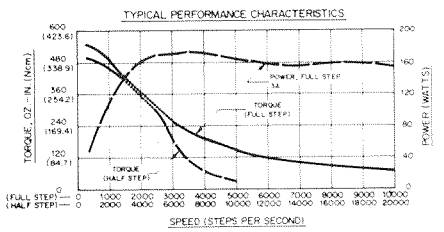
Then make the following settings:

1. Make sure $\overline{\text{BASE SPEED ONLY}}$ is Open.
2. Connect $\overline{\text{RUN}}$ (J4 pin #6) to SIGNAL COMMON (low). Maintain low until high speed is achieved.
3. Remove $\overline{\text{RUN}}$ connection to SIGNAL COMMON. Maintain until measurement is complete.
   (Oscilloscope will be triggered when $\overline{\text{RUN}}$ is open. This signal must be open circuited long enough to allow complete deceleration.)
4. Measure deceleration time.
5. Adjust Deceleration potentiometer (R1). Clockwise movement increases deceleration time.
6. Repeat steps 2 – 5 until desired deceleration is reached.

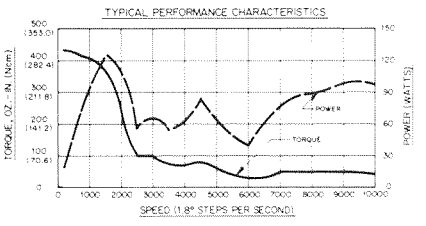
The following table gives approximate settings for the Deceleration Potentiometer (R1).

DECELERATION TIME (milliseconds)	POTENTIOMETER R1 SETTING (number of turns CW from fully CCW position)
22	0
60	1/2
100	1
200	2
300	3
400	4
500	5
600	6
800	8
1000	10
1250	13
1500	15 1/2
1750	18
2000	20

SECTION 7: SPEED/TORQUE CURVES

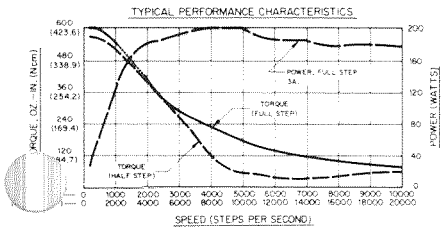


FULL/HALF STEP



1/125 MICROSTEP

M093-FF402 MOTOR
3 AMPERES PER WINDING



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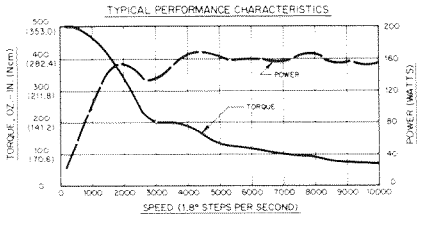
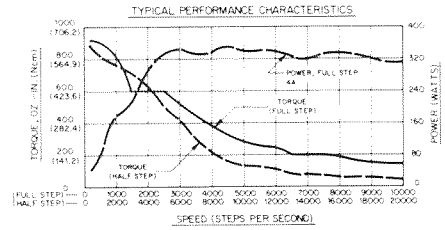


1/125 MICROSTEP

M111-FF401 MOTOR
3 AMPERES PER WINDING



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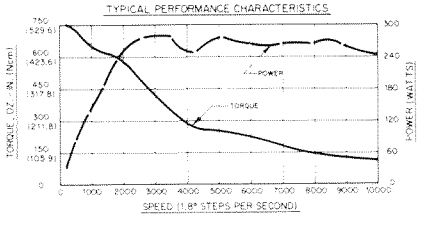
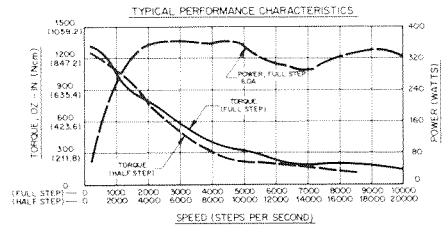
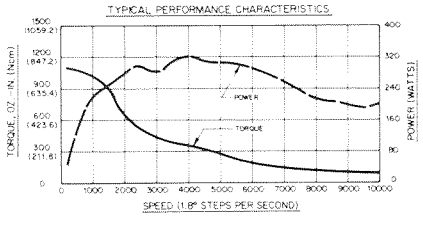


1/125 MICROSTEP

M112-FF401 MOTOR
4 AMPERES PER WINDING

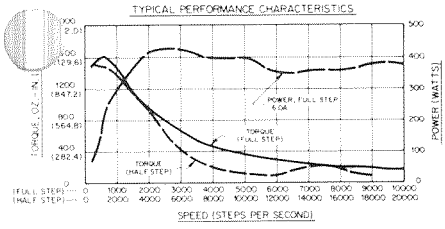


FULL/HALF STEP



1/125 MICROSTEP

M112-FF401 MOTOR
6 AMPERES PER WINDING



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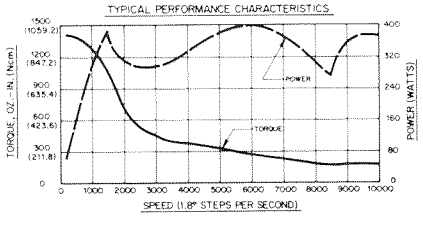
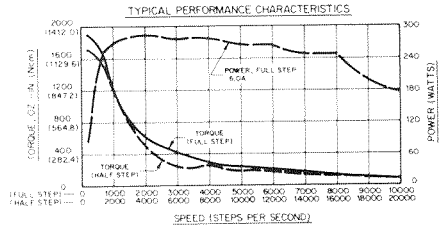
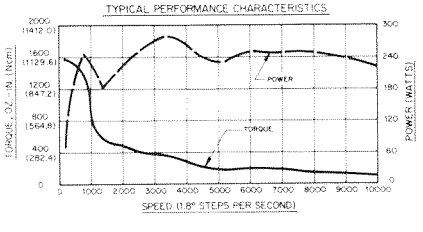


1/125 MICROSTEP

MH112-FJ8020 MOTOR
6 AMPERES PER WINDING
(SERIES CONNECTION)

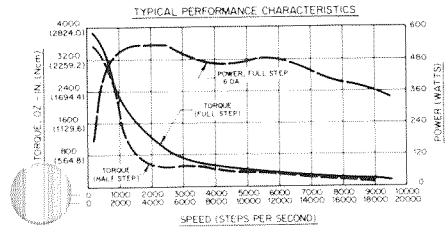


FULL/HALF STEP

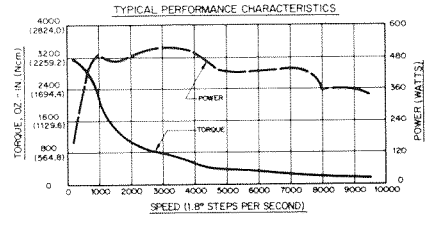


1/125 MICROSTEP

M113-FF401 MOTOR
6 AMPERES PER WINDING



FULL/HALF STEP



1/125 MICROSTEP

M172-FF401 MOTOR
6 AMPERES PER WINDING

7.1 MOTOR PERFORMANCE

All stepping motors exhibit instability at their natural frequency and harmonics of that frequency. Typically, this instability will occur at speeds between 50 and 500 full steps per second and, depending on the dynamic motor load parameters, can cause excessive velocity modulation or improper positioning.

There are also other instabilities which may cause a loss of torque at stepping rates outside the range of natural resonance frequencies. One such instability is broadly identified as mid-range instability. This is identified by the dotted area (....) on the speed torque curves.

Usually, the dampening of the system and acceleration/deceleration through the resonance areas aid in reducing instability to a level that provides smooth shaft velocity and accurate positioning. If instability does cause unacceptable performance under actual operating conditions, the following techniques can be used to reduce velocity modulation.

1. Avoid constant speed operation at the motor's unstable frequencies. Select a base speed that is above the motor's resonant frequencies and adjust acceleration and deceleration to move the motor through unstable regions quickly.
2. The motor winding current can be reduced as discussed in Section 3.6. Lowering the current will reduce torque proportionally. The reduced energy delivered to the motor can decrease velocity modulation.
3. Use half-step mode of operation (6180-PTO only). Note that this also halves the shaft speed for a given input pulse rate. Microstepping (6180-PTO10 and 6180-PTO125) inherently provides smoother operation, and reduces the effects of instability.

SECTION 8: TROUBLESHOOTING

WARNING:

Motors connected to this drive can develop high torque and large amounts of mechanical energy.

Keep clear of the motor shaft, and all parts mechanically linked to the motor shaft.

Turn off the power to the drive before performing work on parts mechanically coupled to the motor.

If installation and operation instructions have been followed carefully, this unit should perform correctly. If motor fails to step properly, the following checklist will be helpful.

In General:

- Check all installation wiring carefully for wiring errors or poor connections.
- Check to see that the proper AC voltage level is being supplied to the unit.
- Be sure the motor is compatible for use with this unit.

8.1 IF MOTOR DIRECTION (CW, CCW) IS REVERSED, Check:

Connections between the drive and the motor. Motor wires may have been reversed accidentally on one phase. For example, swap the positions of the M1 and M3 (red and white/red wires).

8.2 IF THE MOTOR MOTION IS ERRATIC, Check:

- Input pulses not of proper level or width.
- Supply voltage out of tolerance.
- Operation in area of motor instability (dotted portion of torque/speed curve).
- Electrical noise on signal inputs (especially pule and direction lines).
- Bad motor.
- Mechanical problems in load, such as worn bearings, excessive friction, parts binding, etc.

8.3 IF TORQUE IS LOW, CHECK:

- $\overline{\text{AWO}}$ (All Windings Off) active or $\overline{\text{REDUCED CURRENT}}$ active.
- Improper supply voltage
- Operation in area of motor instability (dotted portion of torque/speed curve).
- Bad motor.
- Mechanical problems in load, such as worn bearings, excessive friction, parts binding, etc.
- Incorrect current setting.

8.4 IF FAULT LIGHT IS ON, Check:

8.4.1 If the Overcurrent light is also on, check for a bad motor, short in the motor wiring, or incorrect motor wiring.

8.4.2 If the Overcurrent light is not on, check the drive ambient temperature, drive heat sink temperature, and fan operation. Keep within the limits specified in Section 3.7.

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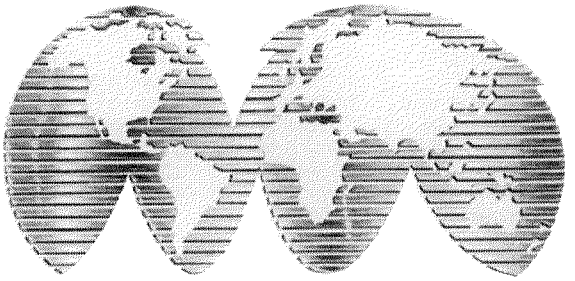

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