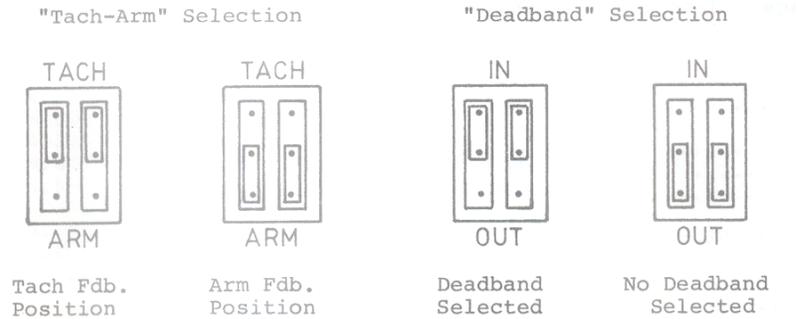


## Addendum to PRD8 Manual F2101-BM

On controls built after September 15, 1988 the "Tach-Arm" (S221) and "Deadband In-Out" (S222) switches may be replaced with mini-jumpers. Since each switch replaced was a DPDT (double pole double throw) switch, each switch replacement requires two mini-jumpers. Therefore, in the PRD8 Manual wherever there is a reference indication that the switch position of one of these two switches is to be changed, two mini-jumpers will have to be moved in order to accomplish the required switch position change.

The following are the equivalent proper mini-jumper positions for the respective switch positions indicated below.



Operation of the PRD8 control is the same either with the switches or the mini-jumpers.

Operation of the PRD8 control is the same either with the switches or the mini – jumpers.

## Addendum to PRD8 Manual F2101-BM

A change has been made on controls built after September 1, 1989 that will be used on 50 HZ AC power. In addition, to the changes as explained in Section 5.4 of the PRD8 manual a board component value changes on the E1511 PC Board if it is to be used on 50 HZ power. Resistor R103 which has a 68K 5% ½ watt resistor on 50 HZ applications.

Polyspede recommends that the control be ordered for the proper AC input frequency application if possible. If the control must be modified in the field, either return the control to the Polyspede factory for modification, or have a qualified electronic technician replace resistor R103 on the E1511 PC board with the value indicted above.

If the above resistor change is not made when changing the control from 60 to 50 HZ use, the control may randomly stop under certain line voltage and/or loading conditions.

TABLE OF CONTENTS

SECTION		PAGE
1.	USING THIS MANUAL.....	1
2.	DESCRIPTION .....	2
2.1	NAMEPLATE EXPLANATION.....	2
2.2	GENERAL FEATURES.....	4
2.3	PROTECTIVE SHUTDOWN CIRCUITS.....	6
2.3.1	“OVERLOAD” .....	6
2.3.2	“OVERSPEED OR LOW LINE” .....	6
2.3.3	“IET” .....	6
2.3.4	“THERMOSTAT” .....	6
2.4	START-STOP METHODS .....	6
2.5	OPTIONS AND MODIFICATIONS.....	7
2.5.1	ACCELERTION OPTION .....	7
2.5.2	POSTIION CONTROL OPTION .....	7
2.5.3	FIELD LOSS RELAY OPTION.....	7
2.5.4	DC LOOP CONTACTOR OPTION.....	8
2.5.5	MOTOR-MOUNTD TACHOMETER.....	8
2.5.6	TORQUE PROGRAMMED DRIVE.....	8
2.6	FUSES.....	8
3.	PRD-8 SPECIFICATIONS.....	9
4.	MOTOR SELECTION.....	11
4.1	LOW SPEED OPERATION	
4.2	MAXIMUM INDUCTANCE.....	12
4.3	COMPENSATING FIELDS.....	12
4.4	MOTORS FOR USE WITH 7 1/2 HP PRD-8 UNIT.....	12
4.5	PRD-8 “MOTOR MATCH” SETTINGS.....	13
5.	ENCLOSURE SELECTION, LAYOUT,AND INPUT SERVICE.....	13
5.1	ENCLOSURE SELECTION & LAYOUT.....	13
5.1.1	ENCLOSURE SIZING, SINGLE UNIT INSTLLATIO.....	14
5.1.2	ENCLOSURE DESIGN,MULTIPLE UNIT INSTALLATIONS	15
5.1.3	ENCLOSURE DESIGN, WHEN OTHER HIGH POWER EQUIPMENT IS ADDED	16
5.2	INPUT SERVICE AND DISCONNECT SWITCHES.....	17
5.3	INPUT SERVICE TRNASFORMERS.....	18
5.4	CONVERSION TO 50 HZ SERVICE .....	19
6.	INSPECTION .....	22
7.	INSTALLATION .....	22
7.1	MOUNTING.....	22
7.2	WIRING PROCEDURE.....	22
8.	INITIAL TURN-ON PROCEDURE .....	24
9.	SET UP SWITCHES.....	25
9.1	“TACH-ARM” SWITCH.....	25
9.2	“DEADBAND” SWITCH .....	26

10	FIELD ADJUSTMENTS.....	27
10.1	ADJUST "IR" POTENTIOMETER.....	28
10.1.1	TACHOMETER FEEDBACK SYSTEMS.....	28
10.1.2	ARMATURE VOLTAGE FEEDBACK SYSTEMS.....	28
10.2	ADJUST "ACC" AND "DEC" POTENTIOMETERS.....	29
10.3	OCCASSIONALLY-USED ADJUSTMENTS.....	29
10.3.1	"ZERO".....	29
10.3.2	"MAX" .....	29
10.3.3	"+LIM.....	30
10.3.4	"-LIM" .....	30
10.3.5	"CROSSFIRE" .....	30
10.3.6	"MOTOR MATCH ADJUSTMENTS "LI" AND "WK2".....	31
10.3.7	ALL OTHER ADJUSTMENTS.....	31
11.	CONVERSION TO ANOTHER HORSEPOWER.....	31
11.1	CHANGE METER SHUNT ("MSH").....	31
11.2	CHANGE NAMEPLATE INFORMATION ON PRD-8.....	32
11.3	RESET "L1" AND "WK2" POTENTIOMETERS.....	32
12.	OPERATION.....	32
13.	TROUBLE-SHOOTING, PRD-8 UNIT.....	32
13.1	OCCASIONAL FUSE BLOWING.....	34
13.2	REPETITIVE FUSE BLOWING.....	34
13.2.1	PROCEDURE IF FUSES 31FU AND 32FU BLOW.....	35
13.2.2	PROCEDURE IF FUSES 1FU,2FU, OR 3FU BLOW.....	36
13.2.3	BENCH TETING OF SCR MODULES.....	40
13.3	PROCEDURE IF MOTOR DOES NOT RUN.....	43
13.4	PROCEDURE IF MOTOR OVERSPEEDS.....	44
13.5	PROCEDURE" UNSTABLE OPERATION.....	46
13.6	CHECK POWER SUPPLY VOLTAGES .....	46
13.7	GENERAL TESTS, CIRCUIT BOARD E1511.....	47
13.8	DESCRIPTION OF ADJUSTMENTS.....	50
14.	TROUBLE-SHOOTING, MOTOR.....	53
15.	REPAIR.....	54
15.1	FUSE REPLACEMENT.....	54
15.2	REPLACE ANALOG MODULE(AM-11 OR AM-12).....	55
15.3	REPLACE CIRCUIT BOARD E1512.....	55
15.4	REPLACE CIRCUIT BOARD E1522.....	56
15.5	REPLACE CIRCUIT BOARD E1511.....	56
15.5.1	REMOVAL.....	57
15.5.2	REASSEMBLY.....	58
15.6	REPLACE SCR MODULE... ..	59
15.6.1	REPLACEMENT PROCEDURE.....	59
15.6.2	CHECK RESISTORS.....	60
15.6.3	REASSEMBLY.....	60
15.7	FAN REPLACEMENT.....	60

16.	MAINTENANCE.....	61
16.1	CONTROL MAINTENANCE.....	61
16.2	MOTOR MAINTENANCE.....	61
16.3	SPEED REDUCER MAINTENANCE.....	61
17.	SYSTEM DESIGN USING THE PRD-8.....	63
17.1	DESCRIPTION OF OPERTAION.....	63
17.1.1	SPEED COMMAND INPUT .....	63
17.1.2	TORQUE COMMAND INPUTS.....	63
17.1.3	SPEED “METER” OUTPUT.....	65
17.1.4	“% TORQUE” OUTPUT.....	66
17.1.5	START-STOP CIRCUITRY.....	67
17.2	START-STOP METHODS.....	68
17.3	RELAY-SELECTED PRESET SPEEDS.....	70
17.4	EXTERNAL SIGNAL CONTROL OF SPEED.....	73
17.5	EXTERNAL TORQUE LIMIT.....	73
17.6	USE AS A PASSIVE BRAKE.....	75
17.7	TURBINE-DRIVEN GENERATOR FOR POWER COST REDUCTION.....	76
17.8	MULTIPLE DRIVES, SINGLE SPEED COMAMND.....	77
17.9	SPEED SLAVING.....	78
17.10	AM-12 (TORQUE-PROGRAMMED) APPLICATIONS.....	79
17.10.1	MATERIAL UNWINDERS.....	80
17.10.2	TORQUE SLAVE.....	81

APPENDIX

III

## 1. USING THIS MANUAL

This manual is intended to specifically cover open chassis PRD-8 units.

If your primary interest is installation and start-up of a unit used with a matched motor on a 230 VAC 60 hz service, and if no application problems are involved, refer immediately to Sections 6 through 10 and to Drawing A2101-000-EW in the appendix.

In some instances the PRD-8 unit may be furnished already mounted in an enclosure. If so, Section 5.1 and 7.1 herein may be disregarded.

In other instances the PRD-8 unit may be furnished mounted in an enclosure with user – specified hardware or with options not covered in this manual. If so, a special external wiring drawing will be furnished and Drawing A2101-000-EW should be disregarded (see section 7.2). Also additional documentation covering the added items will be included along with this basic manual. Refer to the additional documentation (Schematics) wiring diagrams, installation notes, etc.) first. If any conflict appears between instructions in this manual and in the added documentation, assume that instructions in the added documentation are correct.

It is also anticipated that original purchasers of the PRD-8 unit will install this unit as a building block in systems which are then supplied to an end user along with the original purchaser's own installation and operating instructions. In such a case this manual should be regarded as a reference document for servicing, maintenance and adjustment purposes; non-applicable sections should be disregarded.

If your primary interest is in adapting the PRD-8 unit to perform a specific task or integrating it into a larger system, refer to sections 2, 3, 4, 5 and 17 herein, which are intended as design-level guidelines.

## 2. DESCRIPTION

### 2.1 NAMEPLATE EXPLANATION

The nameplate is the primary identifier for factory service, replacement, and reorder purposes. Complete identification is normally provided by the model number and the option codes. If the notation "SPEC" follows the model number, however, the number in the "MOS" block is also required. The "PART NO" block is for insertion of a user part number if applicable.

### SAMPLE NAMEPLATE

SAMPLE NAMEPLATE

Model No.	hp
PRD8-750	7½
PRD8-500	5
PRD8-300	3
PRD8-200	2
PRD8-150	1½
PRD8-101	1
PRD8-76	¾
PRD8-51	½

TABLE 1B, OPTION CODES

OPTION CODE ON NAMEPLATE	DESCRIPTION	SEE MANUAL SECT.	CIRCUIT BOARD SUPPLIED
A1	Acceleration Option, .15-11 SEC.	2.5.1	E1490-11 *
A2	Acceleration Option, .30-24 SEC.	2.5.1	E1490-12
A3	Acceleration Option, .07- 5 SEC.	2.5.1	E1490-13
M	DC Loop Contactor	2.5.4	
F	Field Loss Relay (See Note 1)	2.5.3	E1522-12 **
100F	100 Volt Field Supply (Note 1)	7.2	E1522-22 **
T2	Tach Feedback, 2400 rpm Motors	2.5.5	
AM12	Torque-Programmed Drive	2.5.6	
P1	Position Control, 1-5 ma input	2.5.2	E1491-11
P2	Position Control, 4-20 ma input	2.5.2	E1491-12 *
P3	Position Control, 10-50 ma input	2.5.2	E1491-13
P4	Position Control, 0-6 V input	2.5.2	E1491-14
P5	Position Control, 0-10 V input	2.5.2	E1491-15
P6	Position Control, 0-12 V input	2.5.2	E1491-16

\*Denotes standard range, furnished if range not specified.

\*\*Furnished in place of standard E1522-02 board.

Note 1: Option 100F obsolete after mid 1979. Thereafter board E1522b-02, field convertible 200V to 100V, is standard except when Field Loss Relay is added (See 2.5.3).

\*Denotes standard range, furnished if range not specified.

\*\*Furnished in place of standard E1522-02 board.

Note 1: Option 100F obsolete after mid 1979. Thereafter board E1522b-02, field convertible 200V to 100V, is standard except when field loss relay is added (See 2.5.3).

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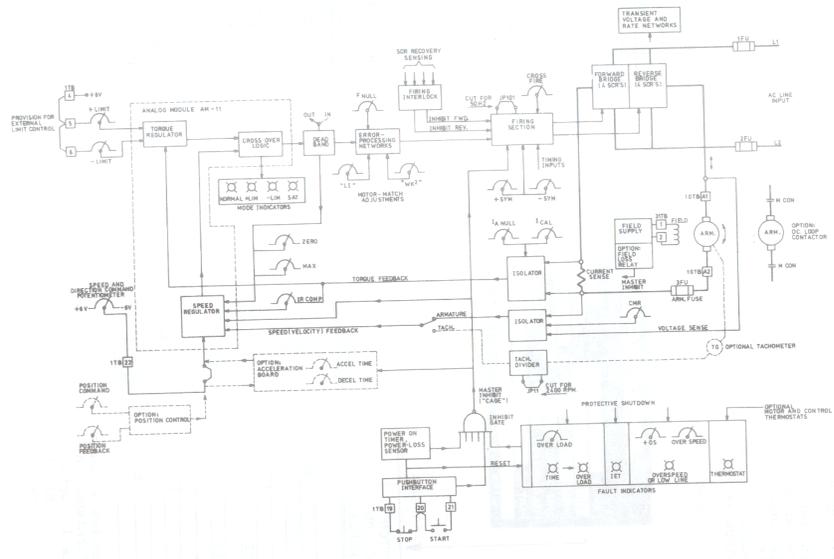


FIGURE 1  
PRD8 BLOCK DIAGRAM

## 2.2 GENERAL FEATURES

The PRD-8 control is a high performance servo-grade regenerative control. Two 4-SCR back-to-back bridges are utilized to provide either positive or negative current to a dc motor. Because of the bridge arrangement used, the PRD-8 may be operated directly from a 230 VAC service; no special transformers are required. Also provision is made for easy conversion to 50HZ service (one jumper is clipped).

Unlike one-bridge controllers, no contactors are required for reversing or for normal operation, although an optional dc loop contactor is available which disconnects the motor armature when the "STOP" pushbutton is activated.

The PRD-8 control will automatically cause the motor to run as a motor or a generator as required to satisfy a given speed command. For example, if the motor is running at a set speed and the speed potentiometer is suddenly turned to the zero speed point, the motor will act as a generator, pumping current into the ac lines to produce the braking torque required to reduce speed to the zero. Both speed and direction of rotation are determined by the speed potentiometer setting. Polarity of the voltage at the speed potentiometer wiper determines direction of rotation; the magnitude of this voltage determines speed.

The system block diagram (Figure 1) shows general system organization.

In the basic system, the speed command signal acts directly on the speed (velocity) regulator. The speed command is nulled against motor speed feedback (normally armature voltage modified by IR compensation). The resultant error signal is used to generate firing pulses which are routed to either the forward or reverse bridge so that speed is regulated at the command value. If a mechanical overload occurs, or if a step function speed command occurs which is too abrupt for the motor to follow, the onset of a current overload is sensed in the torque regulator. The crossover logic then switches the speed regulator out and switches the torque regulator in. The torque regulator controls torque (armature current) at a preset level, usually 150% of rated motor current until the overload passes. At this time the crossover logic again selects the speed regulator and normal operation is resumed. Transition from torque control to speed control occurs in sub cycle times and is accomplished smoothly with no current overshoot and with negligible speed overshoot. This method of control yields a very high velocity loop frequency response (typically 12 hz, adjustable to 20hz with certain motors) , which is ideal for high resolution positioning systems and other high performance power servos. LED indicators activated by the crossover logic show whether the speed loop ("NORMAL" or torque loop (" + LIMIT" or " - LIMIT) is in control, or whether an abnormal condition ("SAT") exists.

Unique design of the firing section permits the forward and reverse bridges to “CROSSFIRE” (4 pulses per cycle) when motor speed is finite and a transition from one bridge to the other occurs. This assures no torque discontinuities. At zero speed where 4 pulse operation is not possible, the forward and reverse bridges fire on alternate half cycles (2 pulses per cycle) at the zero-torque transition point to assure torque continuity as transfer between bridges occurs. The result is ultra smooth operation with no jerks, delays or dead bands.

A circuit board switch is provided to allow insertion of a fixed dead band (approx. 1% of input signal range) to satisfy applications where “no creep” operation at zero speed is a requirement (see section 9.2.). This switch inserts dead band circuitry and reduces gain of the speed regulator to X10. With no dead band introduced, both torque and speed regulators are integrating stages with zero frequency gains in excess of 100,000; very tight control of both speed and torque is inherent.

A second circuit board switch (“TACH-ARM”) allows change-over to tachometer feedback (see section 2.5.5 and 9.1).

The standard PRD-8 utilizes built-in signal isolators for the armature voltage feedback signal and for the armature current feedback signal. As a result, terminals on the signal input terminal block ITB are isolated from the ac power lines and may be earth-ground referenced or may be floated above earth ground as required to interface with process instruments or computer accessories. External signal isolators or isolation transformers are not required.

PRD-8 units supplied after mid year 1978, include a jumper on the field supply board to allow selection of either 200 volt or 100 volt output. Such units are supplied with the jumper in the 200 volt position unless order specifies otherwise.

## 2.3 PROTECTIVE SHUTDOWN CIRCUITS

The PRD-8 includes as standard features four protective shut down circuits as shown in the block diagram, Figure 1. If a fault condition activates one of the protective circuits a master inhibit signal (“CAGE”) instantaneously prohibits further firing of any SCR and the motor coasts to a stop. The fault-indicating LED will remain on to indicate cause of the shutdown. The fault indicators (except “THERMOSTAT”) go off automatically when the PRD-8 is restarted after a fault shutdown. The protective shutdown circuits operate as follows :

### 2.3.1. “OVERLOAD”

This circuit functions as an electronic thermal overload which is activated at any time motor current exceeds rated current. When this occurs the “TIME” light comes on, and after a time which depends on magnitude of the overload current (5 minutes for 10% overload, 1 minute for 50% overload), the “TIME” light goes off, the “OVERLOAD” light comes on, and shutdown occurs.

### 2.3.2. “OVERSPEED OR LOW LINE”

This circuit functions to prevent fuse blowing during generating mode if line voltage is low or if motor speed is excessively high. Preset to shutdown drive system if 230 VAC line voltage is more than 10% low and armature voltage is simultaneously equal to or greater than 180 volts.

### 2.3.3. “IET”

Instantaneous Electronic Trip shuts down drive system if a current peak exceeds 200% of normal worst-case peak current. This is approximately 13 times the current rating engraved on the meter shunt “MSH” (see Table 3 in section 11. 2).

### 2.3.4 “THERMOSTAT”

If motor or control is equipped with a thermostat, an open thermostat shuts down the drive system until the thermostat cools and recloses. The “THERMOSTAT” LED lights at any time a thermostat is open and goes off when the thermostat recloses.

## 2.4 START-STOP METHODS

The motor may be stopped and started by “START-STOP” pushbuttons, by a maintained-contact “ON-OFF” SWITCH, or by a circuit breaker or contactor connected in the 230 VAC lines. See Drawing A2101-000-EW for details. Also see section 5.2 if a line circuit breaker or contactor is used for starting and stopping. It should be noted that pressing the “STOP” button result in a coast-down stop. If a controlled stop is required, speed command voltage from the

speed potentiometer wiper must first be reduced to zero volts; the “STOP” button is then operated as a “make-safe” measure.

## 2.5 OPTIONS AND MODIFICATIONS

The following features are not included on standard PRD-8 units, but may be specified at time of purchase as factory installed items. See Table 1B for identification information.

### 2.5.1 ACCELERATION OPTION

The acceleration option board shown in Figure 1 should be specified if adjustable acceleration and deceleration times are desired. The standard PRD-8 accelerates and decelerates a motor at rates limited only by the torque limit settings. The resultant rapid response is ideal for most servo and closed-loop positioning applications. The acceleration option board should be added for applications in which longer acceleration and deceleration times are desired for “soft” speed changes. When this plug-in circuit board is added, acceleration and deceleration times which result from a 0 to 100% step change in the speed potentiometer setting may be adjusted from .15 seconds to 11 seconds. Alternate ranges per Table 1B are also available.

Internal logic on this board causes the acceleration time potentiometer (“ACC”) and the deceleration time potentiometer (“DEC”) to correctly and independently regulate acceleration and deceleration times regardless of direction or motor rotation.

### 2.5.2 POSITION CONTROL OPTION

The “position control” option board shown in Figure 1 is utilized in applications such as valve positioners or x-ray table positioners. When this option board is installed a speed potentiometer is not connected. The output of the position control board (a position error signal) acts as a speed command signal and causes the motor to automatically drive in the direction required to force agreement between the “POSITION COMMAND” potentiometer setting and the “POSITION FEEDBACK” potentiometer position. If potentiometer command is desired, option P6 (0-12 volts input) is specified. Process instrument or external voltage signals can also be used for position command. Ranges per Table 1B, specified at time of purchase, are available. This board includes provision for a “MANUAL-AUTO” switch and end-of-travel limit switches.

### 2.5.3 FIELD LOSS RELAY OPTION

The field loss relay shown in Figure 1 causes drive shutdown if motor field current falls below 100 milliamps. The indicator light on the field supply board (circuit board E1522) goes off until the defect is corrected. This option is available only with the fixed-voltage 200 volt field supply.

Field loss protection is not normally necessary in a PRD-8 drive system since loss of field current causes the PRD-8 to operate in a current-limit mode. Usually the motor does not rotate due to insufficient torque to turn its load. The PRD-8 ultimately shuts down as the “OVERLOAD” protective circuit trips (per 2.3.1). This option is available, however, for use where job specifications require field loss protection.

#### 2.5.4. DC LOOP CONTACTOR OPTION (“M CON”)

This contactor disconnects motor armature from control when “STOP” button is activated. Otherwise system operation is identical with or without the contactor.

#### 2.5.5. MOTOR-MOUNTED TACHOMETER

This option is utilized for tachometer feedback. A motor –mounted dc tachometer with a nominal output of 50 volts per 1000 rpm (45 volts to 52 volts per 1000 rpm is an acceptable variation) is provided when this option is specified. All circuitry for implementing tachometer feedback is included as standard in the PRD-8 unit provided motor base speed is either 1750 rpm or 2400 rpm. No option code is required to specify tach feedback with 1750 rpm motors. If motor is 2400 rpm, PRD-8 must have option T2 (see section 1B), or field conversion per 9.1 (b) is required.

#### 2.5.6. TORQUE PROGRAMMED DRIVE

This modification is useful in some material winder applications. Specifics of this modification are covered in a separate manual. Basically, the standard AM-11 analog module in the PRD-8 unit is replaced with an AM-12 analog module. The normal “SPEED COMMAND” input becomes a “TORQUE COMMAND” input which commands both magnitude and direction of torque. The “+LIM” and “-LIM” adjustments which normally function as Torque Limit adjustments become Speed Limit adjustments which limit magnitude of speed but do not dictate direction of rotation. The mode indicator lights will show “NORMAL” when the drive is operating in a torque controlled mode and will show “+LIM” or “-LIM” when drive is operating in a speed limited mode. Section 17.10 illustrates applications.

### 2.6. FUSES

#### WARNING

Fuses F1, F2 and F3 in this control unit are fast acting rectifier protection fuses and must not be replaced with unapproved substitutes. If fuse replacement becomes necessary replace only with one of the following fuse types:  
International Rectifier Type SF25x70 Chase-Shawmut type A25x70.

### 3. PRD-8 SPECIFICATIONS

Input voltage (single phase)	230 VAC $\pm$ 20 volts
Input Frequency	60 hz (field convertible to 50 hz)
Armature voltage output	0 to $\pm$ 180 VDC
Field Voltage Output	200 VDC unregulated 2 Amps Maximum (convertible to 100 VDC at 3 Amps Maximum)
Maximum Ambient Temperature, PRD-8 mounted in a 20" x 20" sealed enclosure	40°C
Maximum Allowable Temperature of Air in Users Cabinet :	
a) with in-cabinet fan.	65°C
b) with no cabinet fan	50°C below uppermost PRD-8 (See Figure 2)
Overload Capability, for 1 minute	150% of rated current
Load Regulation for 100% load change: with armature feedback	adjustable to $\pm$ 1% of base speed
with tachometer feedback	$\pm$ .1% of base speed typical
Line Regulation (speed change for $\pm$ 20 VAC line voltage change) :	
a) PM motors and armature feedback, or any motor and tachometer feedback	$\pm$ (.1% of base speed
b) as in (a), above, except shunt field motor and armature feedback	$\pm$ (2% to 8%) of set speed (depends on motor)
Speed Change with temperature, 25°C to max. operating temperature	
a) due to control unit	typically, less than 1% of base speed
b) due to motor or tachometer	varies with motor or tachometer design and tach. mounting method

Cont. on next page

PRD-8 SPECIFICATIONS (CONT.)

Speed Range	0 to $\pm 100$ %
Speed Range, for specified regulation	100 : 1
Speed Program Voltage (voltage on Lug 22 of 1TB) to produce $\pm 100$ % speed	$\pm 6$ VDC
Torque Program Voltage (Lugs 5 and 6 of 1TB) to produce zero to (present max. torque)	0 to +6VDC
Speed Meter Output Voltage (Lug 9 of 1TB), for -100% to +100% speed	-6 VDC to +6 VDC
Torque Meter (%T) output voltage (Lug 8 of 1TB) for -100% to +100% torque	-1 VDC to + 1 VDC

#### 4. MOTOR SELECTION

Selecting a motor suitable for use on a regenerative control involves several factors which are not normally significant in the selection of a motor for service with a non-regenerative control. Since most dc motors are specified for use with non-regenerative controls (type "K" power supplier), a motor randomly selected from a manufacturer's catalog may or may not be suitable for use with regenerative controls.

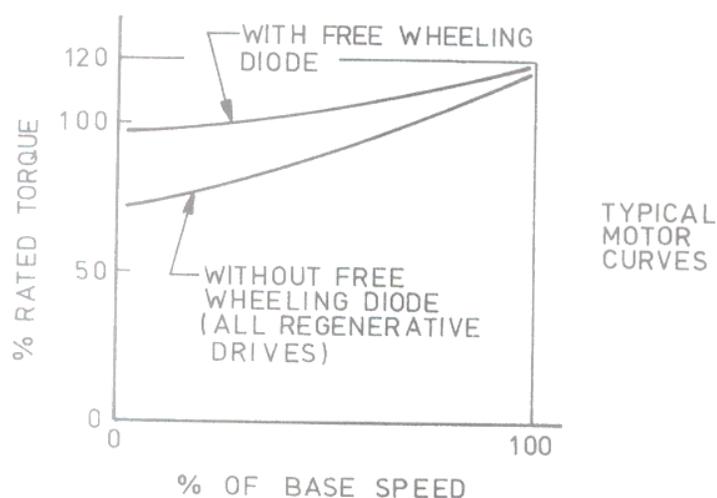
Polyspede offers matched motor-control combinations which eliminate the necessity of the user considering the following factors when selecting a motor. The following information is furnished for the use of those who may wish to mate a PRD-8 control unit to an existing motor.

##### 4.1 LOW SPEED OPERATION

The free-wheeling rectifier used in non-regenerative controls causes a reduction in motor heating at low speeds due to current smoothing. Most published motor ratings assume the use of a free-wheeling rectifier (non-regenerative service). Since free-wheeling rectifiers cannot be used in regenerative controls, continuous operation at speeds below base speed requires rerating of the motor. The graph below illustrates the resultant (typical) reduction in continuous torque capability when a motor is operated at low speeds by a regenerative drive. Obtain manufacture's curves for the specific motor under consideration.

It should be noted that external (constant velocity ) forced-air cooling may be used to avoid derating and to allow continuous operation at full rated torque throughout the speed range.

MAXIMUM CONTINUOUS LOAD FOR MAXIMUM ALLOWABLE TEMPERATURE RISE.





## 4.2 MAXIMUM INDUCTANCE

The armature inductance of a motor with a given horsepower rating must not exceed a certain value or fuse blowing may occur during generating operation. This applies only to regenerative drives. Specifically the fuses may blow when the motor is generating at top speed while ac line voltage is low. (Example : motor is operating at top speed and is suddenly decelerated).

If the motor selected has armature inductance high enough to cause fuse blowing under these conditions, it will be necessary to operate the motor at a maximum speed lower than base speed and/or lower the PRD-8 torque limit settings.

This problem can and should be avoided by selecting a motor which has a maximum inductance as follows :

$$L \times I \text{ less than } .21 \text{ amp-henries}$$

Where L is the actual motor inductance and I is the torque limit (Current limit) setting of the PRD-8 control (typically 150% of rated motor current).

Example : A 5 hp motor has a 24 amp rated armature current ; the PRD-8 current limit is set at 150% or 37.5 amps. The motor selected should have an actual inductance (armature plus commutating field inductance) no higher than:

$$L_{MAX} = .21 \text{ amp-henries} / 37.5 \text{ Amps} = .0056 \text{ henries}$$

Unfortunately, inductances published by motor manufacturers have been found to be as much as 100% higher than the inductance value observed in actual service. As a result, using data sheet values of motor inductance in the preceding formula may rule out motors which are actually suitable for regenerative service.

The preceding formula assures that the motor selected will operate satisfactorily at armature voltages up to 180 volts on line voltages as low as 210 VAC.

## 4.3 COMPENSATING FIELDS

Motors which have series compensating fields (S1 and S2 lead brought out ) are not suitable for use with regenerative drives.

## 4.4 MOTORS FOR USE WITH 7 1/2 HP PRD-8 UNIT

These motors must have actual inductance (armature plus commutating fields) no less than 2 millihenries and no greater than 3.8 millihenries. PRD-8 torque limits must not be set higher than 150% (55.5 amps). See command in 4.2 concerning variance of actual and stated inductance values.

#### 4.5 PRD-8 “MOTOR MATCH” SETTINGS

The “LI” and “WK<sup>2</sup>” compensation potentiometers match control dynamic performance to the characteristics of the motor selected. These potentiometers are pre-adjusted to optimum setting when Polyspede supplies motor and control. When Polyspede supplies the control only, the potentiometers are adjusted to approximate best settings based on motor information furnished by the user at time of purchase; a tag is attached to the PRD-8 indicating the motor to be used. If the motor is not specified at time of purchase, the user must adjust per 10.3.6.

### 5. ENCLOSURE SELECTION, LAYOUT AND INPUT SERVICE

This section is intended as an aid to the OEM in incorporating PRD-8 units into his equipment.

#### 5.1 ENCLOSURE SELECTION AND LAYOUT

The open chassis PRD-8 unit must be mounted in a suitable enclosure. NEMA 1, NEMA 4, NEMA 12 or JIC enclosures available from several manufacturers may be used; Hoffman Engineering Co. is a common supplier. Several PRD-8 units may be mounted in the same enclosure, or a PRD-8 unit may be located in the same enclosure with other equipment. If mounted in an enclosure with other equipment or with other PRD-8's, observe all notes on Drawing A2101-000-EW concerning routing and separation of wiring. Also if the unit is located in close proximity to contactors or control relays, transient voltage suppressors should be used across the contactor or relay coils; examples of such suppressors are given in Note 2, Detail 1, Drawing A2101-000-EW.

In no case should service transformers per Figure 5, Section 5.3 be mounted in an enclosure with control units. Losses in the transformer will raise cabinet temperature out of limits. Avoid mounting transformers of the type shown in Figure 6 in the enclosure for the same reason, although the problem is less severe.

The enclosure selected must be of adequate size and design so that air temperature inside of the enclosure does not rise above acceptable limits under worst case operating conditions. Acceptable temperatures are given below :

- a) Maximum air temperature, around circuit boards – -70°C
- b) Maximum SCR module base plate temperature – -105°C

Condition (b) above is met if temperature of the mounting base of the PRD-8 unit, monitored at a point immediately adjacent to an active SCR module, does not exceed 95°C.

Specific information on single unit installations and multiple unit installations in non-ventilated enclosures (eg : NEMA 12 and NEMA 4 enclosures) is given in sections 5.1.1, 5.1.2 and 5.1.3, following.

### 5.1.1 ENCLOSURE SIZING, SINGLE UNIT INSTALLATIONS

If a single PRD-8 is placed in an unventilated enclosure with no other heat-generating equipment, a 20" x 20" enclosure of minimum clearance depth is of adequate size for 5 hp or 7 1/2 hp units used in 40°C (104°F) maximum ambient temperature. The top edge of the PRD-8 unit must be located at least 4" below the top surface of the enclosure.

For lower horsepower units, physical fit of the PRD-8 unit in the enclosure is the limiting factor in sizing. The following figure, based on actual tests, shows cabinet temperature distribution in a sealed 20" x 20" x 6-5/8" cabinet in which a 5 hp PRD-8 unit was mounted. No fans were utilized and a worst-case motor (Baldor 5 hp, 2400 rpm motor ) operated at 100% rated load was used. Temperatures shown are after 3 hours of operation (stabilized). The 102°C and 76°C temperature readings would be about 5°C lower if higher inductance motors (such as powertron, G.E., or Reliance) were used. Figures 2 and 3 are intended for use as an engineering guide for cabinet selection.

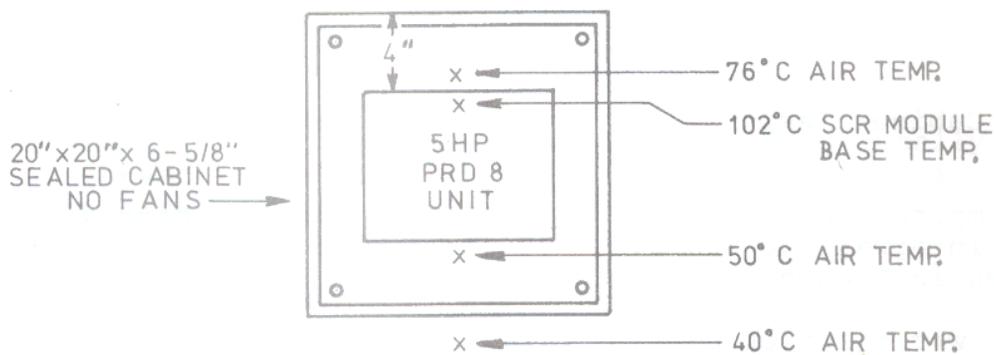


FIGURE 2  
Cabinet Temperature, Single Unit Installation

The temperatures shown in Figures 2 are within acceptable limits. If other equipments which generates significant heat is installed in the cabinet with the PRD-8, however, increase enclosure size or add a circulating fan to distribute heat within the enclosure.

Figure 3 shows the effect of adding a circulating fan (100 cfm) inside of the enclosure to eliminate heat buildup near the top of the enclosure. The data shown in Figures 3 is useful in designing layouts for cases covered in sections 5.1.2 and 5.1.3. Test conditions for Figures 3 are identical to those stated for Figures 2 except for the addition of the fan.

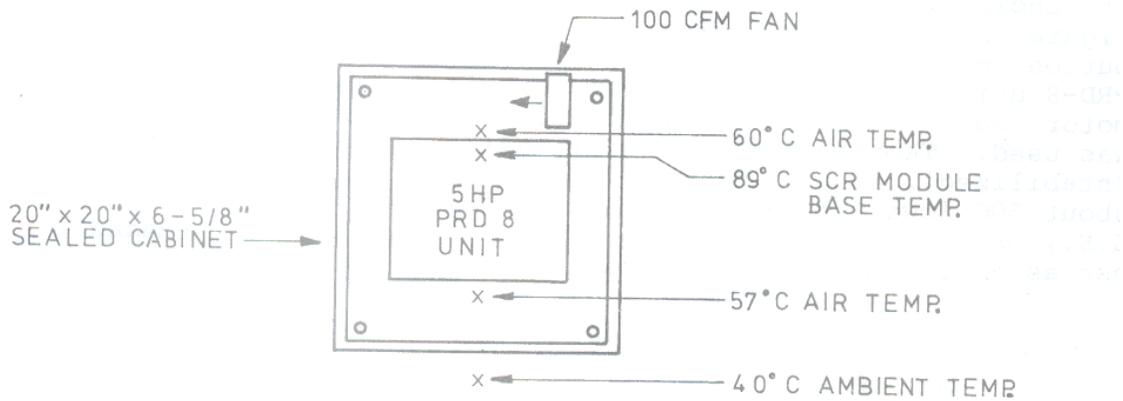


FIGURE 3  
Cabinet Temperature, Single Unit Installation,  
With Internal Fan

Cabinet temperatures for a 7 1/2horsepower PRD-8, which includes an internal 100 cfm fan, will be 5°C to 7°C higher than those shown in Figure 3, which is an acceptable level.

In-cabinet wiring which carries armature current or ac line current for 5 hp and 7½ hp units should be 10 gauge 105°C thermoplastic wire (type TEW or equivalent). Tests have shown that worst-case temperature rise in the wiring at rated load is as follows :

- 5 hp unit, no fan ..... 25°C rise
- 5 hp unit, with forced air..... 15°C rise
- 7 1/2hp unit..... 20°C rise

Since this wiring enters the PRD-8 in the hot area at the top of the cabinet, 105°C wire is recommended.

### 5.1.2 ENCLOSURE DESIGN, MULTIPLE UNIT INSTALATIONS

In general any arrangement of PRD-8 units in a sealed (NEMA 12 or NEMA 4) cabinet will yield acceptable temperatures if in-cabinet fans are used to prevent localized heat buildup such as is shown in Figure 2. A 4" minimum spacing must be provided between the PRD-8 units, top and sides.

The added in-cabinet fans are not required in the following arrangements:

- 1) PRD-8 units of any horsepower rating mounted in a single horizontal row (no PRD-8 mounted above another PRD-8 unit); four inch minimum spacing between units, and 4" minimum spacing to top of surface of cabinet.
- 2) PRD-8 units arranged in two horizontal rows with no units of greater than 3hp rating in the top row ; same minimum spacing as in (1), preceding.
- 3) PRD-8 units, all of 2 hp or lower rating, arranged in three horizontal rows; same minimum spacing as in (1), preceding.

None of the preceding cases are changed significantly if items such as control relays, contactors of less than 100 amp rating, control transformers of less than 250VA rating, and other SCR controls of 3 hp or lower rating are added, provided additional panel space (and thus larger enclosure volume) is allotted for the added components.

#### 5.1.3. ENCLOSURE DESIGN, WHEN OTHER HIGH POWER EQUIPMENT IS ADDED

If PRD-8 units are placed in an enclosure with other equipment which dissipates significant wattage such as three phase SCR controls, it may still be practical to use a totally enclosed non-ventilated cabinet provided adequate air circulation from in-cabinet fans is provided. For cabinets no taller than 36" and with forced in-cabinet air circulation, provide 14 square inches of exterior cabinet wall for each watt of power dissipated in the cabinet. Air temperature inside of the cabinet should then not exceed 60°C when the cabinet is located in a 40°C ambient temperature (20°C cabinet temperature rise).

For example, a 30" wide x 36" high, by 12" deep NEMA 12 cabinet has 3744 square inches of exterior surface area and can enclose 267 watts with an estimated 20°C maximum temperature rise.

Table 2, which gives maximum power dissipated in PRD-8 units of various ratings, is provided as an aid toward cabinet sizing.

TABLE 2

MOTOR HP	MAXIMUM WATTS IN PRD -8
7 ½	123 WATTS
5	81 WATTS
3	57 WATTS
2	49 WATTS
1 ½	42 WATTS
1	34 WATTS

A 100 cfm in-cabinet fan adds about 14 watts to the above figures for 5 hp and smaller units due to losses in the fan itself.

Specifications of “other equipments” placed in the enclosure should be examined to assure that the equipment can tolerate the estimated 60°C cabinet temperature. All Polyspede SCR drives are designed to tolerate this temperature level.

## 5.2 INPUT SERVICE AND DISCONNECT SWITCHES

Certain unique precautions related to input service configuration should be observed in designing systems utilizing regenerative drives. These precautions are primarily related to the ability of the regenerative drive to pump energy from the motor back into of ac line, and the undesirable effects which can occur if an ac disconnect switch is opened while the dc motor is generating. Figure 4 is presented as an example to illustrate problems which can occur.

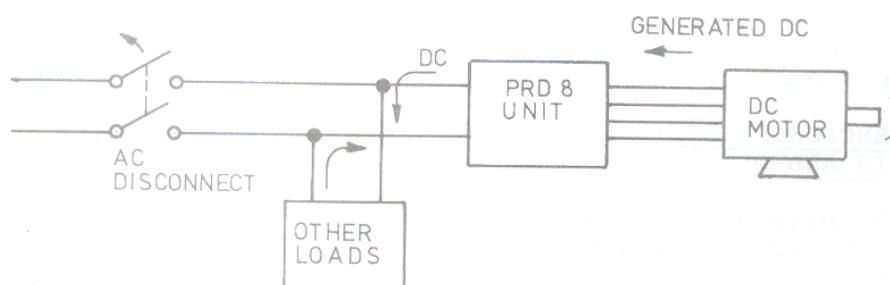


FIGURE 4

AC Disconnect Opened While Motor  
Is Generating

In Figure 4 the “power loss” detector in the PRD-8 prevents any malfunction such as a plug stop of the motor when the ac disconnect is opened, but SCR’s already conducting at the moment the disconnect is opened remain in a conducting state and dc from the motor passes through the “other loads”, typically contactor coils, transformer primaries, etc., which are designed ac services. Fuse-blowing, burnout, or malfunction in these components is possible.

Rule 1 : Avoid connecting any loads other than the PRD-8 to the output side of the ac disconnect. If this is not practical, then :

- (1) Incorporate a shutdown sequence that first programs zero speed, and then after a delay opens the ac disconnect, or

- (2) Assure by other means that the operator manually sets speed to zero or otherwise forces the motor to stop before opening the ac disconnect.

Rule 2 : Do not use a single ac disconnect to supply more than one PRD-8 unit , unless the same two precautions listed in Rule 1 are observed. In this case if the two PRD-8 units are operating at different speeds with one unit generating at the moment the common disconnect is opened, a large loop current may flow which, depending on motor impedances, could blow fuses. The best practice is to use individual disconnect switches for each PRD-8 unit.

### 5.3 INPUT SERVICE TRANSFORMERS

If 230 VAC service is not available one of the following transformer arrangements may be used to provide the required 230 VAC input for one or more PRD-8 units :

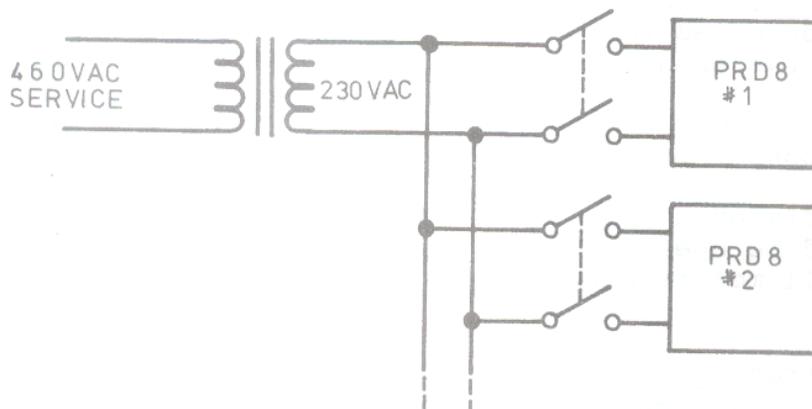


FIGURE 5  
Input Service Transformer

Size the transformer as follows : 13 KVA for each 7 ½ hp motor, 10.6 KVA for each 5 hp motor, 6.7 KVA for each 3 hp motor, 2.4 KVA per hp for each smaller motor.

The transformer in Figure 6 is a 120/240V to 16/32V boost-buck transformer connected for a voltage boost (GE type 9T5 or equivalent). Size the transformer at .64 KVA, per horsepower.

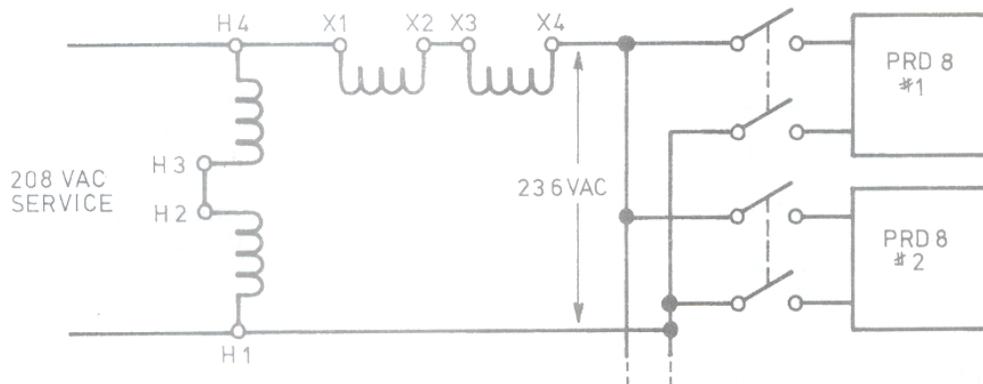


FIGURE 6  
Input Service Auto Transformer

In either transformer arrangements, observe all guidelines outlined in 5.2 concerning disconnect switches.

If a primary disconnect is utilized, all disconnects in the secondary should be opened first, or provisions should be made to assure that all motors are stopped before the primary disconnect is opened.

Do not mount transformers in the enclosure with PRD-8 controls. In nearly every case enclosure temperature will rise out of safe limits.

#### 5.4 CONVERSION TO 50 HZ SERVICE

If the PRD-8 nameplate shows “60” in the “HZ” block, and operation on 50 hz service is required, cut jumper JP101 (on bottom circuit board E1511, behind the “CROSSFIRE” adjustment). Also write “50” in the “HZ” block on the nameplate and mark through “60”. Use a ballpoint pen. Write “50 HZ” on a piece of paper tape and stick it on circuit board E1511 just to the right of the “E1511-( )” identification block or use a “50 HZ” label (E4054) obtained from Polyspede Electronics for the same purpose. This assures that replacement E1511 boards will be furnished with the 50 hz modification made at the factory.

If zero-speed crossfire (dither) seems too harsh or is absent when system is operated on a 50 hz service, see Section 10.3.5 for “CROSSFIRE” fine tuning.



## 6. INSPECTION

Check for shipping damage. If damage is found, report it to the carrier immediately. Do not attempt to operate the drive system if visible damage to the PRD-8 exists.

## 7. INSTALLATION

### 7.1 MOUNTING

Assure that the enclosure and enclosure layout meet the requirements of Section 5.1. Refer to Drawing A2101-000-EW for mounting details. Locate all conduit entry holes, cable duct, and wiring hardware to conform to notes on this drawing. Drill the five holes required for mounting the PRD-8 unit to the enclosure panel. The use of tapped holes is preferable to facilitate servicing without the necessity of panel removal. Debur all holes. Use the preferred mounting centers shown on Drawing A2101-000-EW unless the alternate mounting centers match existing panel holes. WARNING: DRILL AND TAP ALL REQUIRED HOLES IN THE PANEL, PUNCH ALL REQUIRED CONDUIT ENTRY HOLES IN THE CABINET AND BLOW OR VACUUM ALL DRILL CHIPS FROM CABINET BEFORE MOUNTING ANY PRD-8 UNITS. If unforeseen drilling is required after mounting PRD-8 units, do not allow any drill chips to fall into the PRD-8 units.

Clean each PRD-8 mounting area and be sure that the mounting area as well as the PRD-8 base plate is free of chips and burrs and that the mounting area is flat. Good thermal contact between the PRD-8 base and the enclosure panel is important. Mount the PRD-8 unit or units on the enclosure panel.

### 7.2 WIRING PROCEDURE

Use one of the following external wiring diagrams for connecting the control unit :

.....

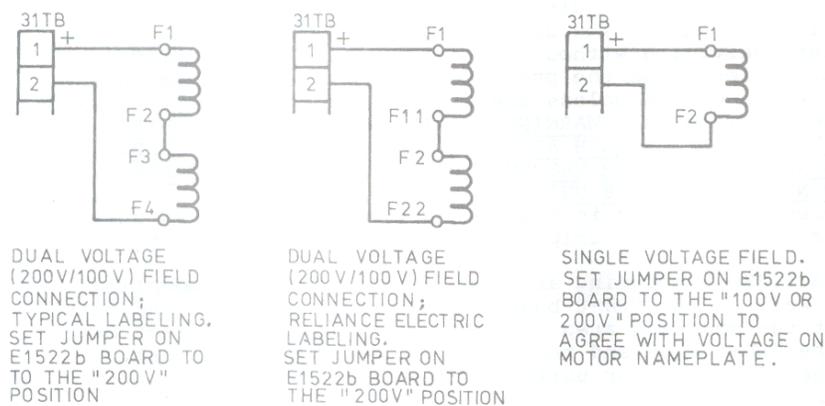
- 1) A2101-000-EW (in the appendix) for all standard open chassis PRD-8 units or for PRD-8 units which have been factory-mounted in an enclosure with no additional circuitry and no additional terminal blocks.
- 2) Special External Wiring Diagram furnished separately with control (drawing number starts with "M" and ends with "-EW," followed by a revision letter) for all other units. This drawing is furnished at any time external connection points not covered in this manual are added.

Wire the control per the applicable external wiring diagram observing all instructions on the drawing related to wire sizing and separation of wiring (wiring

to the motor and ac lines should be separated from wiring to terminal block 1TB). All terminal blocks on the PRD-8 unit are of the wire-clamp type which do not require wire lugging.

Note on Drawing A2101-000-EW that a choice of speed potentiometer connections must be made to achieve the result desired in the particular application. Further information on speed potentiometer connections is given in Section 17 herein. Note also the choice of "START-STOP" pushbuttons or other starting means shown on Drawing A2101-000-EW.

Be very careful to connect the motor field correctly. Most motors of recent design have dual voltage field windings. The high-voltage field connection must be used for these motors. The following figure shows correct field connections.



Note: The "100v-200v" jumper is not included on earlier E1522 boards; consult factory if 100v output is required.

FIGURE 7  
Motor Field Connections

Important Note on PM motors :

Permanent magnet motors (PM Motors) require no field connection (no connection to 31TB Lugs 1 and 2 on the PRD-8 unit). Unfortunately, some motor manufacturers supply PM motors with unlabeled thermostat leads or tachometer leads which may be mistaken for field leads. If you find unlabeled motor leads, check the motor nameplate. If the notation "PM" is found in the "FIELD VOLTS" block, do not connect any wires from the motor to 31TB.

## 8. INITIAL TURN-ON PROCEDURE

If the drive system includes a speed reducer, fill reducer with specified lubricant before startup (see tags on reducer). Reducers are shipped without lubricant even when they are factory installed on motors. Also check coupling (if so equipped) to see if it is a type that requires lubrication.

Before turning on ac power, use an ohmmeter or an insulation tester set up for 800 volts to check for continuity to ground (panel) from the following points :

L1 and L2 lugs  
A1 and A2 lugs on 10TB  
A11 lugs on 31TB.

Motor should be connected for above tests. No continuity to ground should be observed at any of the above points.

Assure that the ac input service is of correct voltage (230 VAC).

Check the “HZ” block on the PRD-8 nameplate, and be sure it agrees with ac input service (50 hz or 60 hz). If nameplate shows “60 HZ” and service is 50 hz, perform the steps in Section 5.4 to convert control for 50 hz use.

Check the tag which is attached to the PRD-8 wire bundle. This tag indicates the motor for which factory adjustments have been preset. Look at the motor nameplate and see if the motor which is installed agrees with the motor listed on the tag (Example : G.E. 3 hp 1750 rpm TEFC). The tag also lists correct settings of the motor-match potentiometers, “LI” and “WK2” These are round potentiometers located on the E1512 circuit board which have calibration dials numbered 0 to 10. Check the settings of the potentiometers against those shown on the tag ; settings should be the same. If settings agree and tag agrees with motor nameplate, remove the tag, write identification of the drive on the tag (such as grinder #4, etc.) and store tag with job records for future reference.

If substitute motors are used, readjust “LI” and “WK2” potentiometers to match the motor used. See Section 10.3.6 for instructions. Record new settings and motor identification on the tag and store the tag with job records.

Turn ac power on. Look at the “PWR (FLD)” indicator light on circuit board E1522 (small board). It should be on.

NOTE : One or more of the fault indicator lights will also come on momentarily when ac power is turned on, but they should go off in about ½ second. This is normal.

Be sure that the “TACH-ARM” switch is in the “ARM” position. Switch is located on circuit board E1512, just to the right of the nameplate.

Set speed potentiometer for zero speed and press the “START” button. The green “NORMAL” indicator light on circuit board E1512 (near nameplate) should come on. No other indicator lights on circuit board E1512 should be on.

Adjust speed potentiometer ; motor should rotate. Check for correct operation of speed potentiometer. If motor does not rotate in the desired direction, press the “STOP” pushbutton, turn ac power off and reverse A1 and A2 wires at 10TB. If the speed potentiometer is connected per the first or second example of Drawing A2101-000-EW, Detail 1, and if speed potentiometer controls speed normally except motor runs at full speed when potentiometer is fully counter-clockwise, press the “STOP” pushbutton, turn power off and reverse the two outer leads of the speed potentiometer.

If the PRD-8 is not equipped with an acceleration option circuit board, the “+LIM” or “-LIM” indicator lights will come on and the “NORMAL” light will go off if setting of the speed potentiometer is changed abruptly. This is normal; the lights indicate that electronic current limit is limiting inrush current into the motor as it accelerates or decelerates.

If the “SAT” indicator light comes on or flickers off and on and the motor will not turn, this usually indicates an open circuit in one of the armature leads or in the motor. Turn power off and check A1 and A2 wiring; check motor (see Section 14 herein). Also if the PRD-8 unit is equipped with a contactor (located under fuses 1FU and 2FU check to be sure no contactor wiring has come loose in shipment and that contactor has not been damaged.

If problems are encountered in any of the preceding steps, refer to Section 13 “TROUBLESHOOTING” for aid in locating the problem.

## 9. SET UP SWITCHES

Set the two switches mounted on circuit board E1512 to the position required for the application as follows :

### 9.1 “TACH-ARM” SWITCH

If tachometer feedback is not to be used, skip to part 9.2. If tachometer feedback is to be used (motor-mounted tachometer installed and wired per Detail 4 of Drawing A2101-000-EW), then this switch must be set to the “TACH” position. Proceed as follows :

- a) If motor is 1725 rpm, 1750 rpm, or 1800 rpm base speed (check motor nameplate), skip (b) and (c) and start with (d).
- b) If motor is 2400 rpm or 2500 rpm base speed, cut jumper JP11 (on E1512 circuit board, behind 1TB Lug 11) and write “T2” in PRD-8 nameplate block below “FAMILY”. Use a

ballpoint pen. Also mark a “1” to the left of whatever number is engraved in the white block which is next to the “E1512” notation on circuit board E1512.

- c) For motor base speeds other than those given in (a) and (b) or for tachometers which do not have the required 45 to 52 Volts per 1000 rpm output, contact a factory representative before proceeding unless supplementary documentation indicates that modifications have been made.
- d) Set the “IR” potentiometer fully counterclockwise.
- e) Start motor with switch in the “ARM” position. Run at low speed. Activate switch to the “TACH” position. If speed increases rapidly, quickly switch back to the “ARM” position. Stop drive, reverse tachometer leads at Lugs 12 and 13 of 1TB and repeat. Motor speed should change only slightly when switch position is changed.

NOTE : If problems are encountered, run system in “ARM” mode and use a meter to check tachometer output voltage (compare with values given in (c) preceding). Check polarity of this voltage as follows:

Use 1TB Lug 1 as a common point and check polarity of Lugs 9 and 13; Voltages must be of opposite polarity on these two lugs.

- f) Adjust the “MAX” potentiometer (on board E1512) as follows; motor should be cold (not up to operating temperature) during this adjustment. With switch in “TACH” position, connect a dc voltmeter to read armature voltage between Lugs “A1” and “A2” on 10TB. Rotate the “MAX” potentiometer fully counterclockwise. Set speed potentiometer for maximum speed. Adjust the “MAX” potentiometer clockwise until motor reaches desired maximum speed or until voltmeter reads 180 volts, whichever occurs first. Do not adjust “MAX” for armature voltage higher than 180 volts

## 9.2 “DEADBAND” SWITCH

This switch is set to the “OUT” position for high-resolution servo applications and other applications where motor speed must respond faithfully to small changes in the speed command signal and where good regulation is needed. This switch is set to the “IN” position for applications in which the motor must not creep when zero

speed is set, and in which load regulation is of secondary importance. This includes most systems in which preset speeds are relay selected. Also if position control board E1491 is installed (under the nameplate) the “DEADBAND” switch must be set to “IN” to activate the “BAND” adjustment on board E1491.

Decide which setting most closely matches requirements of the job and set the “DEADBAND” switch to the appropriate position.

## 10. FIELD ADJUSTMENTS

Check to see if the PRD-8 unit includes one of the following options :

- a) An option board mounted under the nameplate and connected to 3PL (position option or others)
- b) An AM-12 analog module instead of the standard AM-11 analog module (look for the notation “OPTION : AM12” on the nameplate)

If so, perform the adjustments described in the separate manuals furnished with these options before making the following adjustments.

Also if the PRD-8 unit is furnished as a part of a system (on a panel with other circuitry) check the system documentation for instructions before proceeding (system drawings have an “M” prefix).

Adjust all other PRD-8 units per the following instructions.

Most of the adjustment potentiometers on the circuit boards are preset at the factory, and in many cases only the following potentiometer requires adjustment after installation :

“IR” potentiometer

(Adjust per Section 10.1)

If an acceleration option board is installed (on right end of circuit board E1512), then the following two potentiometers located on the acceleration option board must also be adjusted after installation :

“DEC” potentiometer

“ACC” potentiometer

(Adjust per Section 10.2)

Occasionally an application may require changing the preset factory calibration on one or more of the following circuit board potentiometers :

“ZERO”  
“MAX”

“-LIM”  
“+LIM”

“CROSSFIRE”

“LI”  
“WK<sup>2</sup>”

If so, readjust per Section 10.3.

## 10.1 ADJUST “IR” POTENTIOMETER

This potentiometer is located near the nameplate; PRD-8 units are normally shipped with “IR” set fully counterclockwise. This adjustment controls load regulation (the amount of slowdown which occurs when the motor is loaded) when armature voltage feedback is utilized. Adjust the “IR” potentiometer as follows :

### 10.1.1 TACHOMETER FEEDBACK SYSTEMS

Set the “IR” potentiometer fully counterclockwise.

### 10.1.2 ARMATURE VOLTAGE FEEDBACK SYSTEMS

This includes all systems in which the “TACH-ARM” switch is left in the “ARM” position. Three methods of setting “IR” are given below; choose the method which is most convenient. Be sure that the “DEADBAND” switch is set to the desired position before adjusting “IR”; higher “IR” settings are needed with “DEADBAND” switched “IN”.

a) SHAFT STIFFNESS METHOD – Set the speed potentiometer for zero speed. Grasp the motor shaft and rotate it. (If a shaft coupling is exposed, grasp it with a shop cloth and rotate it, otherwise remove the fan cover and rotate the fan blade, but do not apply excessive pressure to the blades. Use adequate safety precautions). If “IR” is set too low the motor will apply very little torque to oppose your rotating motion; adjust the “IR” potentiometer clockwise. The “IR” potentiometer is correctly adjusted when the shaft feels very “stiff” and strongly opposes your turning motion. The “IR” potentiometer is set too far clockwise if the motor actually starts to rotate backwards against the force you are applying.

b) MACHINE-LOADING METHOD – If the preceding method is not practical because of motor accessibility, then operate the PRD-8 at low speed and load the machine which the PRD-8 is driving. (Example : If the machine is a conveyor, place a weight on the conveyor). If the machine slows down when it is loaded, adjust the “IR” potentiometer clockwise and repeat the test. The “IR” potentiometer setting is correct when little or no slowdown occurs as the machine is loaded. Caution – The machine should not speed up when it is loaded. If it does, “IR” is set too far clockwise. Also the machine loading used must not be severe enough to cause the “+LIM” or “-LIM” lights to come on.

c) INSTABILITY-METHOD If neither of the preceding methods are practical, operate the machine and turn the “IR” potentiometer clockwise until

instability occurs (the “+LIM” and “-LIM” lights will alternately blink off and on). Turn the “IR” potentiometer counterclockwise until operation is again smooth and the blinking stops, then turn “IR” a little further counterclockwise (about 20% of the setting). This is approximately the correct setting.

If instability cannot be made to occur, then set “IR” 30% to 50% clockwise and check machine for satisfactory operation in actual service.

## 10.2 ADJUST “ACC” AND “DEC” POTENTIOMETERS

This section applies only if the PRD-8 unit is equipped with an acceleration option board; both of these potentiometers are located on this board.

Check operation of the machine by abruptly changing settings of the speed potentiometer, or by running the machine through a typical cycle.

If speed increases occur too abruptly, turn the “ACC” potentiometer clockwise to increase acceleration time.

If speed decreases occur too abruptly, turn the “DEC” potentiometer clockwise to increase deceleration time.

The “ACC” and “DEC” potentiometers control acceleration and deceleration times respectively, regardless of direction of motor rotation; changing motor rotation does not necessitate resetting of these potentiometers.

## 10.3 OCCASIONALLY-USED ADJUSTMENTS

The following potentiometers are factory preset and do not require readjustment in a normal installation. If requirements of the particular installation indicate the need of fine tune one or more of these adjustments proceed as follows.

In making voltage measurements at the lugs of terminal block 1TB as specified in the following paragraphs, place one lead of the dc voltmeter on the specified lug and the other meter lead on Lug 1 of 1TB (“COMMON”) unless otherwise instructed.

### 10.3.1 “ZERO”

This potentiometer can be adjusted to eliminate zero-speed creeping of motor. Start motor and set zero speed. Temporarily short Lug 22 to Lug 1 on Terminal Block 1TB. Adjust “ZERO” until voltage at Lug 8 (“%Torque”) is zero volts.

### 10.3.2 “MAX”

This potentiometer performs the same function as in one-bridge controllers. Sets maximum armature voltage. Factory preset for 180 volts with speed potentiometer

at maximum setting and with armature voltage feedback utilized. Readjustment is necessary only if tachometer feedback is utilized (in which case readjust per 9.1 (f), or when an external signal is used to control speed. If external signal control is utilized, set the external signal to maximum level, connect a dc voltmeter between 10TB “A1” and “A2” lugs, and start the system. Adjust the “MAX” potentiometer until the voltmeter reads 180 volts.

### 10.3.3 “+LIM”

This potentiometer adjusts current limit (torque limit) for positive armature currents (current leaving the “A1” terminal of the PRD-8). Preset at factory for 150% of rated current (150% of the current engraved on shunt link “MSH”). To readjust, start the motor and load it heavily until the “+LIM” light on circuit board E1512 comes on. (If the “-LIM” light comes on, reverse polarity of the speed command voltage and repeat; the “+LIM” light should come on). With motor loaded so that the “+LIM” light is on, measure the voltage at Lug 8 of 1TB. This voltage indicates how much armature current is flowing as follows :

1.5 volts*	=	150% rated current
1.25 volts	=	125% rated current
1.0 volts	=	100% rated current

\*Factory setting

Readjust the “+LIM” potentiometer until the meter reads the desired voltage. Do not set higher than 150% (1.5 volts) without factory approval.

In the foregoing procedure, loading of the motor can be simplified by disconnecting the field leads (turn power off first; insulate loose wire ends; not applicable if PRD-8 is equipped with a field loss relay on the E1522 board or if motor is a PM type). With no field excitation, the motor will have very low torque output and system friction will impose enough load to cause the “+LIM” light to come on. If motor shaft rotates, slight pressure against the shaft will stop it.

### 10.3.4 “-LIM”

This potentiometer adjusts current limit (torque limit) for negative armature currents (current entering the “A1” terminal of the PRD-8 from the motor). Preset at factory for 150% of rated current. To readjust, proceed exactly as outlines in 10.3.3, except set up direction of rotation and shaft loading so that the “-LIM” light on circuit board E1512 comes on, and adjust the “-LIM” potentiometer as outlined.

### 10.3.5 “CROSSFIRE”

This potentiometer is located on bottom circuit board E1511. Sets the amount of

overlap between positive and negative bridges at the transfer point. Produces alternating positive and negative current pulses (dither) at zero speed setting. If this “dither” is undesirable, turn the “CROSSFIRE” potentiometer one turn counterclockwise to remove the dither. If the PRD-8 is converted to 50 hz operation (per Section 5.4) and zero speed dither is absent or excessive, turn the “CROSSFIRE” potentiometer a maximum of ½ turn clockwise to increase dither or a maximum of one turn counterclockwise to reduce it.

Before adjusting “CROSSFIRE”, start the system, set speed command to zero, and short Lug 22 on 1TB to Lug 1 to assure zero speed command and to insure accurate observation of zero-speed dither.

### 10.3.6 MOTOR MATCH ADJUSTMENTS “LI” AND “WK<sup>2</sup>”

These potentiometers adjust PRD-8 dynamic characteristics to match motor inductance and inertia respectively. Preset at the factory to match the motor furnished by Polyspede or the motor specified by the purchaser. Readjust only if control is used with a motor other than the one originally furnished or specified (see tag attached to the PRD-8). The “LI” and “WK<sup>2</sup>” adjustments are round potentiometers located on circuit board E1512. These potentiometers have dials numbered 0 to 10; a small arrowhead is stamped at one end of the adjustment slot to serve as a dial pointer. Consult Table 8 in the appendix to determine the correct setting numbers for the new motor, or contact the factory. Use a screwdriver to rotate the potentiometer adjustment slot until the arrow-head points at the required number.

### 10.3.7 ALL OTHER ADJUSTMENTS

All other potentiometers are factory preset and should not be changed without specific instructions from the factory. A description of the function of these potentiometers is given in Table 5.

## 11. CONVERSION TO ANOTHER HORSEPOWER

PRD-8 units of 5 hp and lower rating are identical except for the calibrated current monitoring shunt, “MSH”. Conversion of these PRD-8 units from one horsepower rating to another involves changing the shunt link and changing four blocks of information on the PRD-8 nameplate. It may also be necessary to reset the motor-match adjustments “LI” and “WK<sup>2</sup>” on circuit board E1512, particularly if a change in motor manufacturer is also involved. Proceed as follows :

### 11.1 CHANGE METER SHUNT (“MSH”)

It is mandatory that all washers, lugs, and hardware items be replaced in their original order at the conclusion of the conversion. Proceed as follows. Turn ac power off at the ac disconnect. Remove two screws which retain the insulated fuse coverplate. Remove fuse 3FU. Remove the ¼” hex nut that secures the

upper end of shunt link “MSH”. Lift off washers and one wire lug. Remove shunt link “MSH” and replace it with a shunt link which matches the desired motor horsepower. Shunt links are identified by a current rating engraved on the upper lug. See Table 3 for the current rating which matches the desired motor horsepower. Install the new shunt link with its lug barrels facing downward and with the engraved current rating adjacent to the upper stud. Bend link as necessary for fit. Do not disturb position of the small gray and violet wires when replacing the shunt link. Replace fuse 3FU. Replace the wire lug on the upper stud. Replace washers and nuts on 3FU studs and on the upper shunt link stud ; tighten nuts securely. Replace the fuse cover plate.

### 11.2 CHANGE NAMEPLATE INFORMATION ON PRD-8

Change four information blocks on the PRD-8 nameplate to agree with Table 3 and the new shunt rating. This must be done to insure delivery of an exact replacement part if repair or replacement of the PRD-8 unit becomes necessary. This may be done by preparing four small white paper strips with correct information written on them and sticking the strips over the appropriate nameplate blocks with clear Scotch tape, or by obtaining a new blank nameplate (E4015 blank) from Polyspede Electronics. Type all information on the new nameplate exactly as it appeared on the old nameplate except for “MODEL”, “INPUT AMPS”, “ARMATURE OUTPUT AMPS” and “ARMATURE OUTPUT HP”. Type these four blocks per Table 3.

TABLE 3

ENGRAVED ON SHUNT LINK MSH	FOR MOTOR HP	TYPE IN NAMEPLATE BLOCK:			
		“MODEL”	“INPUT AMPS”	“ARM OUTPUT AMPS”	“ARM OUTPUT HP”
37A	7 ½	PRD8-750	55	37	7.5
24A	5	PRD8-500	44	24	5
15A	3	PRD8-300	28	15	3
10.5A	2	PRD8-200	20	10.5	2
7.8A	1½	PRD8-150	15	7.8	1.5
5.5A	1	PRD8-101	10	5.5	1
4.1A	¾	PRD8-76	7	4.1	¾
2.8A	½	PRD8-51	5	2.8	½

Peel off old nameplate and replace it with newly prepared nameplate.

### 11.3 RESET “LI” AND WK<sup>2</sup>” POTENTIOMETERS

Consult Table 8 in the appendix to determine if resetting is necessary. If resetting is necessary follow instructions in Section 10.3.6.

## 12. OPERATION

Post caution signs concerning safe machine operation and necessary sequence of

operations. Clearly mark the ac disconnect and post warnings at motor and control locations that disconnect must be off when servicing control, motor, or machine. Stop the motor before turning off ac power to the PRD-8. If motor stops for unexplained reasons, look at the indicator lights on the PRD-8 unit to see if any of the fault indicator lights are on (located on right-hand side of circuit board E1512). Note the name of the light which is on and restart the drive by normal means. If the fault recurs, refer to Section 13 for trouble-shooting information.

### 13. TROUBLE-SHOOTING PRD-8 UNIT

Procedures contained in this section are intended to assist the user in identifying whether a problem is due to the dc motor, the PRD-8 unit, or to wiring external to the PRD-8 unit. Procedures for locating faulty circuit boards, modules, and subassemblies are also given. Identify the problem area by using the procedures contained in this section. If the problem is in the PRD-8 unit, either replace the entire unit or repair it by replacing the faulty subassembly as described in Section 15.

The following procedures apply only to standard PRD-8 units and PRD-8 units equipped with tachometer feedback, field loss relay, dc loop contactor ("M CON"), or acceleration option board. If the PRD-8 is equipped with a position control board or the optional AM-12 analog module, refer to the separate manuals describing these options for trouble-shooting instructions. Also if the PRD-8 is furnished as a part of a system in which it is interconnected to other equipment, check the system manual for trouble-shooting instructions before proceeding.

#### 13.1 OCCASIONAL FUSE BLOWING

Occasional fuse blowing can be caused by intermittent shorts to ground in the dc motor or in the motor wiring. Check motor connections, especially those in the motor conduit box. Blow carbon dust out of motor using an air hose. Inspect all wiring including motor brush pigtails. Check motor per Section 14.

Occasional fuse blowing can also be caused by power failures, even of a momentary nature, if power is lost while motor is generating (eg : while it is decelerating a load, etc.). This type of fault must be corrected in the power distribution system.

Look for wire clippings, loose washers, etc. around the fuses and SCR modules.

#### 13.2 REPETITIVE FUSE BLOWING

If fuses blow repetitively the problem must be isolated and corrected before further trouble-shooting can be done. Repetitive fuse blowing is usually the result of the same problems as are listed for occasional fuse blowing, but may also be due to a faulty PRD-8 circuit board or a failed SCR module.

#### WARNING

DO NOT REPLACE FUSES WITH UNAPPROVED SUBSTITUTES. INCORRECT FUSES WILL ALSO BLOW, BUT WILL PROBABLY ALLOW FAILURE OF AN SCR MODULE OR OTHER COMPONENTS BEFORE BLOWING. REPAIR COST WILL BE INCREASED AND WARRANTY MAY BE VOIDED. SEE SECTION 2.6 FOR APPROVED FUSE TYPES.

Proceed as follows to isolate and correct the source of the problem :

### 13.2.1 PROCEDURE IF FUSES 31FU AND 32FU BLOW

- 1) Disconnect motor field wires from terminal block 31TB, Lugs 1 and 2. Test motor field for shorts to ground per Section 14 (a). Check motor field resistance per Section 14 (b).
- 2) Remove circuit board E1522 from the PRD-8 unit and perform the following bench test :

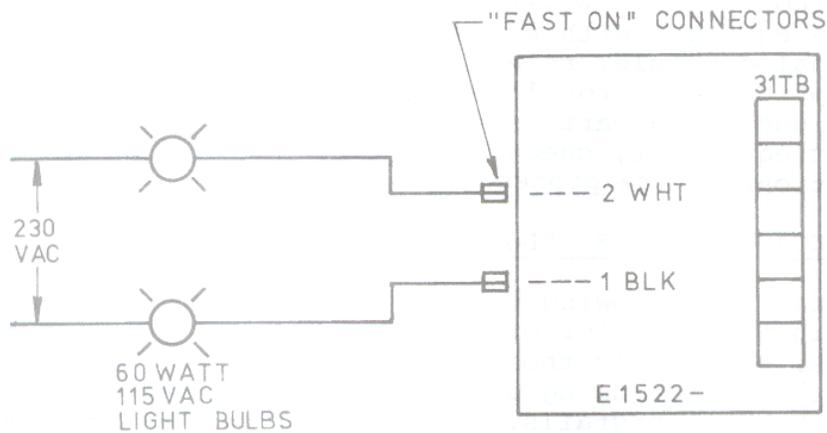


FIGURE 8

Bench Test, E1522 Circuit Board

Replace fuses 31FU and 32FU if blown. Use "Fast-On" connectors to connect to Tabs 1 and 2 of the E1522 circuit board. Place an insulating pad under the E1522 board to avoid shorts. Neither light bulb should burn. If 230 VAC bench power is not available 115 VAC may be used and will indicate most faults.

If either bulb burns the E1522 board is defective and requires replacement. See Section 15.4 for replacement instructions.

- 3) Test resistance between the loose blue and green wires (on the PRD-8 unit) which connect to E1522 tabs. Resistance should be approximately 250 ohms. Readings near zero ohms indicate that transformer T101 on board E1511 is shorted and requires replacement.
- 4) Correct any problems located in the preceding steps, reinstall the E1522 board and reconnect all wiring. If further fuse blowing occurs, it may be due to wiring connected to terminal block 31TB. Isolate the cause of the problem by disconnecting wires one at a time (turn ac power off for all

wiring changes; insulate loose wire ends when testing). Test by turning ac power on and checking for fuse blowing.

### 13.2.2. PROCEDURE IF FUSES 1FU, 2FU, OR 3FU BLOW

- 1) Turn power off at the ac disconnect. Connect light bulbs in series with the ac lines as shown in Figure 9. Also disconnect motor armature wires and short 10TB Lugs A1 and A2 and ground Lug A2 as shown. Replace 1FU, 2FU, or 3FU if blown. Remove Fuses 31 FU and 32 FU from the E1522 board. Disconnect eight gate connectors from SCR modules. (Remove three upper screws on board E1512 and hinge it outward to allow access to the modules).

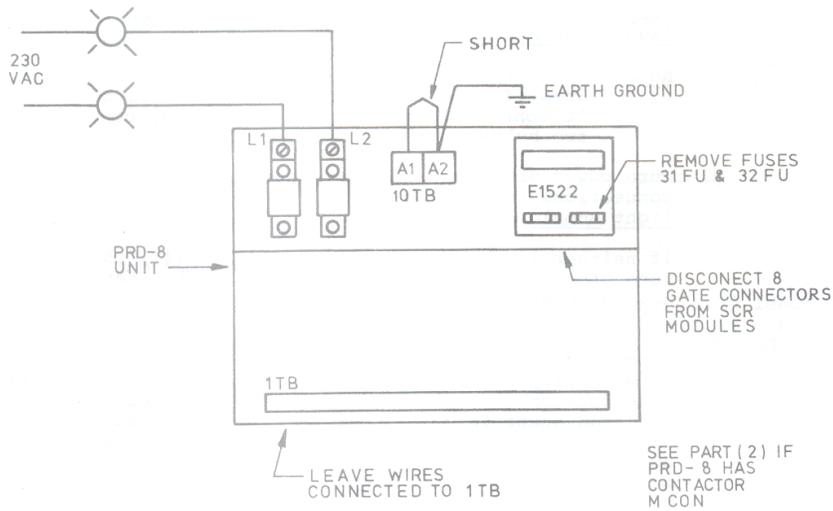


FIGURE 9

Isolating Cause of Main Fuse Blowing

- 2) If the PRD-8 is equipped with a contactor (“M CON”), located under the fuse mounting plate), make the following temporary wiring changes to force contactor to operate :
  - a) Remove the white/black/yellow wire from 31TB Lug 3.
  - b) Remove the white/green wire from 31TB Lug 4.
  - c) Connect these two wires to the 230 VAC lines ahead of the light bulbs.
  - d) Place a temporary jumper between Lugs 14 and 15 on 1TB.
- 3) Be sure no loose wires are touching ground or any circuit component. Turn power on at the ac disconnect. Neither light should burn.

Note :If a light bulb burns out in Step (3) or in Step (4), replace the bulb and skip to step (6). If continued observation is desired, connect two bulbs in series in each ac line.

- 4) Turn power off at the ac disconnect. Reverse L1 and L2 connections to the PRD-8 unit. Turn Power on. Neither light should burn.
- 5) If neither light burns in Steps (3) and (4), then none of the SCR modules are shorted. Skip Step (6) and go to Step (7).
- 6) If one or both bulbs burned in Steps (3) or (4), inspect module wiring for shorts. Look for nuts, washers, or wire clippings wedged between bus bars. Be sure the wire lugs on the two small white wires are not shorting to an adjacent terminal. If no shorts are found, then one or more SCR modules are faulty. Remove SCR modules and bench test them per Section 13.2.3 to locate faulty modules. Replace faulty modules with good modules and reinstall in PRD-8. (Remove and replace modules per instructions in Section 15.6). Repeat steps (3) and (4) preceding. When no light bulbs burn, turn power off and go to Step 7.
- 7) With armature wires still disconnected from the PRD-8, check armature wires for shorts to ground per Section 14. No continuity to ground should be observed.
- 8) Remove the short from Lugs A1 and A2. Remove the ground from Lug A2. Reconnect the motor armature to the PRD-8. If wiring changes were made in Step 2, return wiring to original condition and remove the jumper installed in Step 2 (d).

- 9) Install fuse 31FU (do not install fuse 32FU yet). Turn power on. Lights should not burn. One or both bulbs burning indicates a ground fault in the motor field. Locate and correct before continuing.
- 10) Turn power off. Remove light bulbs from ac lines and reconnect ac lines to PRD-8, Lugs L1 and L2. Install fuse 32FU. Reconnect SCR gates. PRD-8 wiring should now be in original condition and all fuses should be in place.
- 11) Assure that ac power is off and perform the resistance check outlines in Section 15.6.2. If any of the resistors are found to be open it is likely that the related SCR module has failed and has an open (internal) cathode termination. If faulty resistors are found, use the “Pulse Generator Component Table” on Drawing A2101-000-ES to determine which SCR module the failed resistor is connected to. Replace the SCR module with a good module per Section 15.6. The test of Figure 12 can be used to verify the suspected open-cathode termination of the original SCR module. Repair the failed resistor per Section 15.6.2.
- 12) Perform the following test only after correcting any problems which caused bulbs to burn in the previous steps. This test assures that fuses will not blow as the result of problems on circuit boards E1511 or E1512 when motor is connected.

Turn power off. Disconnect motor armature and field leads from the PRD-8. Connect light bulbs in the armature circuit as shown in Figure 10. Be sure all fuses are good. Turn power on; start the PRD-8 and vary the speed command from zero to full speed. Brightness of the lights should vary from zero to maximum. (Bulbs may flicker slightly at the zero-speed setting due to crossfire; this is ok).

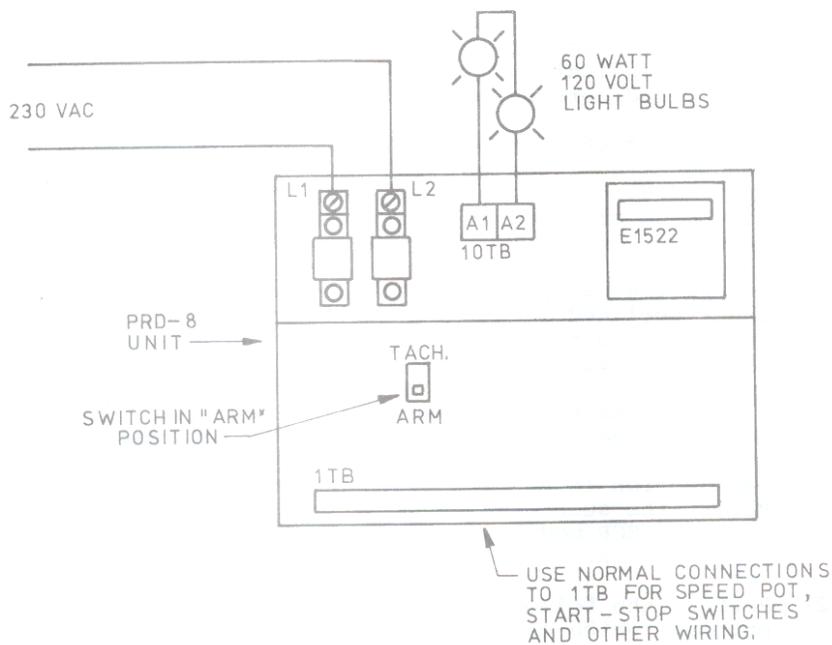


FIGURE 10

Checking Circuit Boards

- 13) If fuses 1FU and 2FU blow in step (12), the problem is on the E1511 circuit board (faulty firing lockout circuitry). This conclusion assumes that the possibility of shorted SCRs was eliminated in Steps 3 and 4, preceding. Replace the E1511 circuit board per Section 15.5.
- 14) If lights cannot be adjusted to nearly zero brightness by setting the speed signal to zero, turn power off and disconnect plug 1PL on board E1512. (Squeeze the release tabs and rock the plug to remove). Turn power back on and start the PRD-8. If bulbs burn brightly, the problem is on the E1511 circuit board. Replace the E1511 board per Section 15.5.
- 15) If bulbs did not burn in Step(14), reconnect plug IPL. Remove the external connection from 1TB Lug 22 and short Lug 22 to Lug 1 (common). If lights do not reduce to near zero brightness, the problem is on the E1512 circuit board or subassemblies mounted on E1512. Be sure the "TACH-ARM" switch is in the "ARM" position. If the PRD-8 is equipped with an

acceleration option board, by-pass this board as described in Section 13.3 Step (5) and repeat test. If operation is now normal (bulbs off) the acceleration board is faulty and requires replacement. If operation is still abnormal, turn power off and replace analog module with a new module and retest. If bulbs burn replace the E1512 circuit board (see Section 15.3)

- 16) When results of Step 15 are satisfactory turn power off, disconnect light bulbs, and reconnect motor armature. Set speed to zero. Turn power on and start the PRD-8. Change the speed setting cautiously to check general operation. Measure the voltage between Lug 8 and Lug 1 of terminal block 1TB. Voltage should be zero when motor is stopped, and should vary with load in the range 0 to  $\pm 1.5$  volts when motor is running. If this voltage is not as described, current limit will not operate correctly and fuses may blow when motor is overloaded or accelerated rapidly. Replace board E1511 (per Section 15.5) if voltage is not as specified.

### 13.2.3 BENCH TESTING OF SCR MODULES

SCR modules may be tested for voltage breakdown or shorted SCRs as shown in Figure 11. One of the bus bars used in the PRD-8 may be used to jumper the terminals shown. Threads in the modules are metric. Use only the screws furnished with the PRD-8 or M5 screws to make connection to the module. Use adequate safety precautions to prevent shock hazard. Test on an insulated pad to avoid accidental grounds. Neither light bulb must burn. If lights burn the module is faulty and requires replacement.

Also test all modules as shown in Figure 12 to detect open cathode leads in the module. Use a multimeter set to measure ohms. Readings will vary from 10 ohms to 150 ohms. Readings much higher than 200 ohms indicate an open cathode lead in the module; such modules should be replaced. Also check resistors on board E1511 per Section 15.6.2.

Before installing modules, examine the gate pins G1 and G2. These pins should be free of potting compound and other contamination all of the way to the bottom of the pin well. Scape off any foreign matter with a small screwdriver.

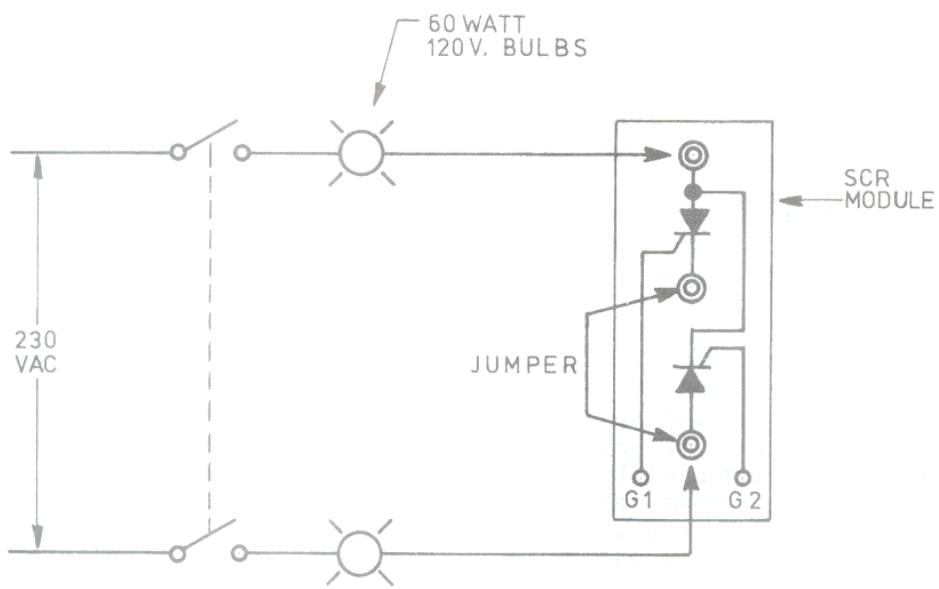


FIGURE 11  
Module Test For Shorts

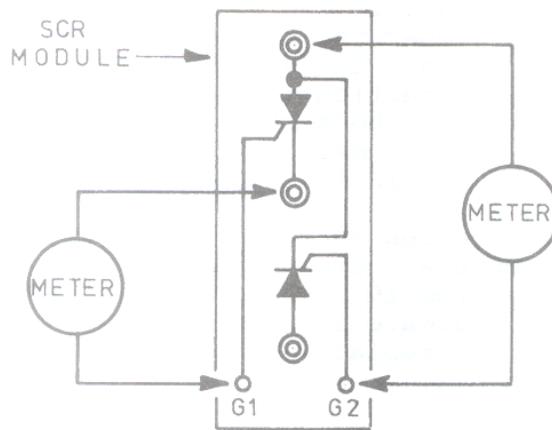


FIGURE 12  
Module Test For Open Cathode

TABLE 4 INTERPRETING INDICATOR LIGHTS

STATUS NO.	INDICATOR LIGHTS ON										THERMO STAT	DESCRIPTION OF WHAT IS HAPPENING OR WHAT HAS HAPPENED. (SYSTEM STATUS). SEE SECT. 13.3 IF MOTOR DOES NOT RUN.
	"PWR (FLD)"	NOR-MAL	+ LIM	- LIM	SAT	TIME	OVER LOAD	OVER SPEED	IET			
1												AC POWER MISSING, OR FUSES 1FU, 2FU, 31FU OR 32FU BLOWN OR MOTOR FIELD CURRENT MISSING (ONLY IF EQUIPPED WITH FIELD LOSS RELAY 3LGE). SEE SECT. 13.3 (2).
2	ON											"STAND BY" STATUS. READY TO RUN, BUT "START" SIGNAL (+12V. AT ITB LUG #1) NOT PRESENT.
3	ON	ON										SYSTEM STARTED, SHOULD RESPOND TO SPEED COMMAND AT ITB LUG 22 (0 TO +6V).
4	ON						ON					A TROUBLE INDICATION. PRD-8 IS RESPONDING TO EITHER A SPEED OR TORQUE COMMAND, BUT UNABLE TO SATISFY COMMAND. IF MOTOR DOES NOT RUN, ARMATURE CIRCUIT PROBABLY OPEN. IF MOTOR RUNS, SEE NOTE 1.
5	ON		ON							ON		OPERATING IN CURRENT LIMIT MODE (TORQUE LIMIT). WILL NOT RESPOND TO SPEED COMMAND. MAY EVENTUALLY TRIP OFF (LIGHTS CHANGE TO STATUS #10, BELOW). CAUSED BY EXCESSIVE MOTOR SHAFT LOAD OR LOSS OF MOTOR FIELD VOLTAGE. THIS STATE ALSO OCCURS TEMPORARILY DURING ACCELERATION OR DECELERATION.
6	ON										ON	SAME AS STATUS 5, ABOVE.
7	ON	ON									ON	OPERATING NORMALLY (RESPONDS TO SPEED COMMAND). MOTOR SHAFT LOAD IS GREATER THAN RATED LOAD, BUT LESS THAN TORQUE LIMIT SETTING. MAY EVENTUALLY TRIP OFF (LIGHTS CHANGE TO STATUS #10, BELOW)
8	ON		ON									OPERATING IN CURRENT LIMIT MODE (TORQUE LIMIT) DUE TO + TORQUE LIMIT SET LOWER THAN MOTOR RATING (VOLTAGE ON ITB LUG 5 LOW, OR "+LIM" POT SET LOW). WILL NOT RESPOND TO SPEED COMMAND.
9	ON										ON	SAME AS STATUS 8 ABOVE, EXCEPT DUE TO VOLTAGE ON ITB LUG 6 LOW, OR "-LIM" POT SET LOW.
10	ON									ON		TRIPPED OFF DUE TO SUSTAINED MOTOR OVERLOAD.
11	ON										ON	TRIPPED OFF DUE TO OVERSPEED (ARMATURE VOLTAGE HIGH), OR LINE VOLTAGE LOW WHILE RUNNING AT FULL SPEED. SEE 2.3.2.
12	ON										ON	TRIPPED OFF DUE TO ABNORMAL CURRENT SURGE.
13	ON											STOPPED DUE TO MOTOR OR CONTROL THERMOSTAT OPENED (EXCESSIVE TEMPERATURE), IF SO EQUIPPED. THERMOSTAT MUST COOL BEFORE SYSTEM CAN BE RESTARTED.

NOTE 1: IF MOTOR RUNS, BUT "SAT" LIGHT COMES ON: (A) MOTOR INDUCTANCE TOO HIGH (SEE SECT. 4.2) (B) LINE VOLTAGE TOO LOW (SEE SECT. 3) (C) TORQUE LIMITS SET TOO HIGH (SEE SECT. 10.3.3, 10.3.4, AND 17.1.2) (D) ONE OR BOTH BRIDGES OPERATING HALF WAVE DUE TO A DEFECT (SEE SECT. 13.7).

### 13.3 PROCEDURE IF MOTOR DOES NOT RUN

The circuit board indicator lights are the primary guide in determining the source of this problem. Use the comments in Table 4 and the following suggestions to isolate and correct the problem. If replacement of circuit boards is required refer to Section 15 for replacement procedures.

- 1) If a fault indicator light is on (Status 10, 11 or 12, Table 4), press the "START" pushbutton to restart, or turn ac power off and then back on. If the fault indicator continues to come on, repairs are required. If the "THERMOSTAT" fault indicator is on (systems in which the PRD-8 and/or the motor are equipped with thermostats) the thermostat must cool before the motor can be restarted.
- 2) If the lights on the PRD-8 are per Status 1, Table 4 (no lights on, including the light on the E1522 circuit board), probable cause is a blown fuse or ac line power missing. If system is equipped with a field loss relay on board E1522, check for +12 volts dc at Lug 11 of terminal block 1TB. If no voltage is present at Lug 11 and if +12 volts dc is present at Lug 10, then the field loss relay has dropped out due to loss of field current. Check for open motor field.
- 3) If lights are per Status 2, Table 4 and motor will not start, probable cause is in the external wiring. Check for +12 volts dc at Lugs 16 and 21 of terminal block 1TB. The specified voltage originates at Lug 19 and is routed to Lugs 16 and 21 through external wiring and contacts. This voltage must be present on Lugs 16 and 21 or motor will not run.
- 4) If the lights are per Status 3, Table 4, and motor will not run, check the speed command voltage at Lug 22 of terminal block 1TB. It should be 6 volts dc for full speed command. If this voltage is absent and the voltage at Lugs 3 and 4 at TB are normal ( $\pm 6$  volts), the problem is in external wiring or components in the speed command circuitry.
- 5) If the PRD-8 is equipped with an acceleration Option circuit board, turn power off and unplug the acceleration option board. Install a temporary jumper to short the two terminals marked "JP20". The terminals are located to the left of the acceleration option board. Turn power on and start the PRD-8. If motor now responds to speed commands, the problem is in the acceleration option board. Turn power off, replace the acceleration board (substitute a new board if required) and remove the jumper from the JP20 terminals.

6) If the lights are per Status 5 or 6, Table 4, the motor may be jammed. Check with power off to see if motor shaft turns freely. If motor is not jammed and is not overloaded, check the torque-command voltage at Lugs 5 and 6 of terminal block 1TB. This voltage should be +6 volts dc to command full torque. Also check to be sure the "+LIM" and "-LIM" potentiometers on board E1512 are set at their factory preset points as indicated by red dots.

7) If all appears normal in the preceding steps, but motor will not run, start the PRD-8 and set speed command for full speed. Measure the voltage at Pin 3 of plug 1PL. (See Drawing A2101-000-ES for pin location; measure with a thin probe inserted between wire and plug shell). If voltage is zero and all previous steps have checked ok, problem is on the E1512 circuit board or in the AM-11 module. Replace these components and retest.

#### 13.4 PROCEDURE IF MOTOR OVERSPEEDS

The most probable causes of this malfunction are loss of speed feedback signal, speed command voltage excessive high, faulty acceleration option board (if so equipped), wrong analog module installed, or motor field voltage low.

1) If the "OVERSPEED OR LOW LINE" fault indicator comes on at high speed but operation is normal at low speed, the problem may be due to low ac line voltage rather than an overspeed condition. Measure ac line voltage; it should be within the limits specified in Section 3. If line voltage is low, the fault indicator will cause shutdown at speeds below motor base speed.

2) Check the speed command voltage between Lug 22 and Lug 1 of terminal block 1TB. This voltage should be in the 0 to 6 volt dc range. If an external signal is being used to control speed and operation is normal except maximum speed is only slightly higher than desired, readjust the "MAX" potentiometer per Section 10.3.2.

3) Check armature feedback signal path as follows. (If the PRD-8 uses tachometer feedback go to Step (4) and skip this step). Be sure that the "TACH-ARM" switch on board E1512 is in the "ARM" position. Turn power off and activate the "TACH-ARM" switch several times to clean the contacts. Set switch to the "ARM" position and retest. Check to be sure that the white/brown and white/red wires which connect to 10TB Lugs A1 and A2 respectively have not come loose and that lug screws are not seated on wire insulation. Also be sure wires have not been switched (the white/brown wire must be on the "A1" Lug). Check the other ends of these same two wires at plug

1PL, Pins 1 and 2 to be sure they are making connection. Push pins down in 1PL to be sure.

Start the motor and measure voltage between Lugs 9 and 1 on terminal block 1TB. Voltage should be in the 0-6 volt range. Also if 10TB Lug A1 is positive with respect to Lug A2, the voltage at 1TB Lug 9 should be positive. If this voltage is absent or is of wrong polarity, replace the E1512 circuit board.

4) Check tachometer feedback signal as follows. (If the PRD-8 does not use tachometer feedback go to Step (5) and skip this step). Problems may be due to tachometer shaft loose in coupling, tachometer wires reversed or loose, wrong tachometer, jumper JP11 incorrect, or erratic “TACH-ARM” switch. The most common faults are mechanical problems in the tachometer coupling.

Set the “TACH-ARM” switch on board E1512 to the “ARM” position and retest. If operation is satisfactory the problem is in the tachometer or tachometer wiring. Turn power off and activate the “TACH-ARM” switch several times to clean the contacts. Set the switch to the “TACH” position and retest. If the system has operated satisfactorily in the past, the problem is probably due to slippage in the tachometer coupling. Tighten all set screws in the coupling and inspect for mechanical damage or misalignment. If the system has not operated before or if repairs have been made recently, repeat the procedures of Section 9.1 to check for correct tachometer phasing, correct tachometer output voltage and correct position of jumper JP11.

If the system does not operate correctly with the “TACH-ARM” switch set to the “ARM” position, perform the tests in Step (3) to locate the problem.

5) Check to be sure that system is equipped with an AM-11 analog module. This module is located under the name-plate. If system is equipped with the optional AM-12 analog module, motor will run only at zero speed or at full speed if motor is not loaded. (See trouble-shooting procedures in separate option manual describing the AM-12 module if this option is installed).

6) If the PRD-8 is equipped with an acceleration option circuit board, by-pass the board to determine if it is at fault. Follow the procedure of Step (5) in Section 13.3 to by-pass this board.

7) Measure the field voltage output of the PRD-8 unit at Lugs 1 and 2 of terminal block 31TB. Compare the observed voltage with the field voltage

rating on the motor nameplate. Also check for correct connection of the motor field wires. Incorrect field voltage will cause overspeed only in systems using armature voltage feedback.

- 8) If the preceding steps fail to locate the problem, perform the tests of Section 13.6 and 13.7 to be sure the problem is not on the E1511 circuit board. If the E1511 board checks OK, replace the E1512 circuit board and/or the analog module.

### 13.5 PROCEDURE : UNSTABLE OPERATION

The following is a check list of causes of and cures for unstable operation :

1. “IR” set too far clockwise. Readjust “IR” per Section 10.1. Note that “IR” must be fully CCW for tachometer feedback.
2. Tachometer shaft slipping or wobbling (tach feedback system only). Check by switching the “TACH-ARM” switch to the “ARM” position. If operation is smooth, problem is in the tachometer..
3. “LI” and “WK2” motor-match adjustments not correctly set. Check settings per Section 10.3.6.
4. Motor unsuitable for regenerative use. Motors with series compensating fields are not suitable (See Section 4.3). If such a motor is used, connections to the series field (S1 and S2 leads) must be omitted for stable operation. If omission of these connections does not result in stable operation, the motor cannot be used.

### 13.6 CHECK POWER SUPPLY VOLTAGES

Check the following power supply voltages if problems exist which were not resolved in the previous sections.

Acceptable readings :

- 11.3 volts to 12.7 volts for 12 volt supplies.
- 5.7 volts to 6.5 volts for 6 volt supplies.

TEST NO	MEASUREMENT POINT	MEASUREMENT COMMON	VOLTAGE
1	1 TB, Lug 19	1 TB, Lug 1	+12v
2	1 TB, Lug 7	1 TB, Lug 1	-12v
3	1 PL, Pin 6(wht / blu wire)	1 TB, Lug 1	+6v
4	1 PL, Pin 5 (wht / grn wire)	1 TB, Lug 1	-6v
5	1 TB, Lug 4	1 TB, Lug 1	+6v
6	1 TB, Lug 3	1 TB, Lug 1	-6v
7	“HOT +12V” Test point*	T101, Lead 1*	+12v
8	“HOT -12V” Test point*	T101, Lead 1*	-12v

\*These points are in lower left corner of board E1511; fold board E1512 out during test. Use small insulated probes or clips; do not allow probes to short to ground or to adjacent components. Caution shock hazard.

Note that the PRD-8 contains eight independent power supplies. All power supplies except those checked in test 5 and test 6 are located on board E1511.

If one or more of the voltages in tests 1 through 4 are low or absent, disconnect plugs 1PL and 2PL and measure the power supply outputs at pins of the plugs. See drawing A2101-000-ES for pin numbers. Note that Pin 7 on plug 2PL is the common point for the measurements. This procedure removes any faults in external wiring or on board E1512 that may be overloading the supplies.

Replace board E1511 if voltages in the first 4 tests or tests 7 and 8 are not as specified when tested with 1PL and 2PL unmated.

If the voltages of tests 5 and 6 are not as specified, disconnect all external wiring to Lugs 3 and 4 of terminal block 1TB and retest. If voltages are still not as specified replace board E1512.

### 13.7 GENERAL TESTS, CIRCUIT BOARD E1511

The test setup of Figure 13 may be used to verify that all functions on circuit board E1511 are operating correctly. Do not use this procedure if the problem involves fuse blowing (1FU, 2FU, or 3FU). See Section 13.2.2 if a fuse-blowing problem exists. The test involves disconnecting the output of board E1512 from board E1511 and using a potentiometer to provide an input to board E1511. A light bulb load is used since current limiting is not operative in this test; a motor load might cause fuses to blow. This test may also be used to detect a half-waving defect in either the forward or reverse bridge.

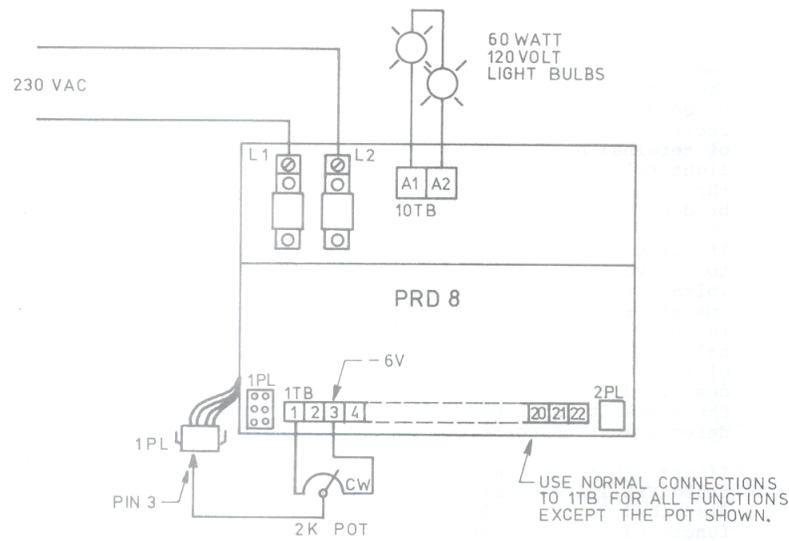


FIGURE 13  
Checking Circuit Board E1511 (Bottom Board)

Turn power off and disconnect the motor armature from the PRD-8. Connect the light bulb load as shown in Figure 13. Unmate plug 1PL and reconnect the speed potentiometer as shown. The potentiometer wiper connects to Pin 3 of the part of the plug to which the cable is attached. (Pin 3 is identified by the white/orange wire which terminates on it). Leave all other jumpers and wires connected to terminal block 1TB.

Turn power on and start the PRD-8 by the normal method.

NOTE : The "NORMAL" light should come on. After a time it may go off and the "SAT" light may come on. This is normal and it will not affect the test. If any of the fault indicators come on, however, the test cannot be made until the fault is corrected.

With the potentiometer set fully counterclockwise the bulbs should not burn or should burn very dimly. Rotate the potentiometer slowly clockwise; bulbs should increase smoothly in brightness. Use a dc voltmeter to read voltage across the bulbs. Continue rotating the potentiometer clockwise until the meter

reads 180 volts dc. Do not exceed 180 volts or the "OVERSPEED" fault indicator may trip. Smooth operation throughout the range 0-180 volts indicates that the forward bridge is operating correctly. Remove the CW wire from Lug 3 and connect it to Lug 4 of terminal block 1TB. Reverse the voltmeter leads at the light bulbs and repeat the previous test. Smooth operation throughout the range 0-180 volts indicates that the negative bridge is operating correctly.

If output voltage in either of these tests reaches only 100 volts to 110 volts for full rotation of the potentiometer, check the voltage at Lugs 3 and 4 of terminal block 1TB (should be approximately  $\pm 6$  volts). If the voltage at Lugs 3 and 4 is correct, the bridge which produces only 100 to 110 volts is operating half wave. The most probable cause is a faulty connection to one of the SCR module gate pins. Check these pins by the procedure described in the paragraph preceding Figure 11 (Section 13.2.3). Check resistors on board E1511 per Section 15.6.2. Half-waving defects must be corrected before placing the PRD-8 in service.

If the PRD-8 performs as described, the primary functions of board E1511 are operating correctly. Perform the additional tests described in the following paragraphs to assure that all secondary functions are also working.

Check the output of the compensation volts generator by measuring the dc voltage on the dotted end of resistor R177 on board E1511 (common is 1TB Lug 1.) Vary armature voltage with the potentiometer. Observed values of voltage should be within  $\pm 10\%$  of the values given in Note 23, Drawing A2101-000-ES. Check with the potentiometer excited by +6 volts (from Lug 4) and then by -6 volts (from Lug 3).

The output of the Power-on Timer can be checked at 2PL, Pin 2 (red wire). Check with plug 2PL mated. Voltage should go to +12 volts about  $\frac{1}{2}$  second after power is turned on, and should go to zero immediately when power is turned off.

The current peak detector which serves as a transmitter for the "IET" (Instantaneous Electronic Trip) fault circuit can be checked as follows if there is reason to believe it is not working properly. Test with care; this circuit is at line voltage potential. With power on, but with the PRD-8 not started, use a 1.5 megohm resistor to temporarily connect test point TP 106 first to "HOT +12 VOLTS" and then to "HOT -12 VOLTS". All three points are well marked on circuit board E1511 near the lower left corner of the board. The "IET" fault indicator light on board E1512 should not come on. Repeat using a 1. megohm resistor. The "IET" fault indicator should come on. (Turn ac power off and then back on between tests to reset the fault indicator).

Check the output of the armature current signal isolator at test point TP105 (measure with respect to Lug 1 on 1TB). Measure with ac power on, but with

the PRD-8 not started (or with load removed from A1 and A2 Lugs). Voltage should be zero volts. If it is not, the "IA NULL" potentiometer may be used to adjust voltage to zero. Further operational checks of this signal isolator cannot be made until the PRD-8 is connected to operate a motor.

If performance is not as specified in each of the preceding steps, replace the E1511 circuit board by following the instructions in Section 15.5.

If performance is as specified in each of the preceding steps, turn ac power off and return all wiring to its original state, reconnect the motor and remate plug 1PL.

If problems occur when the PRD-8 is operated with a motor connected, check the output of the armature current signal isolator (at TP105 on board E1511, or at Lug 8 on terminal block 1TB; Lug 1 on 1TB is common. Measure when motor is loaded or accelerating or decelerating. This voltage varies with motor loading and should be in the range 0 to  $\pm 1.5$  volts. If this voltage is as specified, all functions on board E1511 are verified as being OK by this step and the preceding steps. If further operational problems occur they are probably due to problems on the E1512 circuit board, in the analog module, in the motor, or in control circuitry external to the PRD-8.

### 13.8 DESCRIPTION OF ADJUSTMENTS

Table 5 lists all of the PRD-8 adjustment potentiometers except those included on certain option circuit boards, such as the position control option, which are covered in separate option manuals. The table is primarily for informational purposes. Do not disturb the adjustments indicated as "FACTORY" unless it is certain that an adjustment problem exists.

Adjustments requiring the use of an oscilloscope should be attempted only by qualified personnel familiar with the use of these instruments in testing line-powered equipment. The oscilloscope must be ungrounded or damage to the instrument and the PRD-8 will occur during measurements on unisolated sections of the PRD-8. Shock hazard is present in some oscilloscopes when they are operated ungrounded.

TABLE 5 DESCRIPTION OF ADJUSTMENTS

POT NAME	LOCATED ON PC BOARD	ADJUSTMENT PROC., SECT.NO.	FUNCTION
IR	E1512	10.1	Controls load regulation in armature voltage feedback systems. Adjusted after installation.
ACC	E1490	10.2	Present only when accel option board is installed. Adjusts full scale acceleration time, forward and reverse.
DEC	E1490	10.2	Present only when accel option board is installed. Adjusts full scale deceleration time, forward and reverse.
ZERO	E1512	10.3.1	Can be readjusted to eliminate zero-speed creep of motor.
MAX	E1512	10.3.2	Calibrates speed command input so that armature voltage is 180 volts or less with speed command at maximum level.
+LIM	E1512	10.3.3	Current limit (Torque Limit) for positive armature current.
-LIM	E1512	10.3.4	Current limit (Torque Limit) for negative armature current.
CROSS FIRE	E1511	10.3.5	Controls overlap between + and - bridges at the transfer point.
LI	E1512	10.3.6	Varies gain of regulator circuitry to match motor inductance. Rotate clockwise to match higher inductance.
WK <sup>2</sup>	E1512	10.3.6	Varies lead/lag of regulator circuitry to match motor inertia. Rotate clockwise to match higher inertia. Interacts with "LI".
<p>The following adjustment potentiometers are factory preset and should not require readjustment during the life of the equipment. If damage or field repair of the PRD-8 unit necessitates readjustment, contact the factory for specific instructions.</p>			
+SYM	E1511	Factory	<p>Adjusts firing command generators so that currents from positive bridge (currents leaving 10TB Lug A1) are of uniform height:            Correctly Adjusted:  Incorrectly Adjusted: </p> <p>Requires an oscilloscope to adjust.</p>

-SYM	E1511	Factory	Adjusts firing command generators so that currents from negative bridge (currents entering 10TB Lug A1) are of uniform height. Correctly Adjusted:  Incorrectly Adjusted:  Requires an oscilloscope to adjust.
F NULL	E1512	Factory	Zeros the firing command generators. Does this by inserting a small offset voltage (as required) on LPL Pin 3 so that zero firing command occurs when IC 222 Pin 7 voltage is zero.
CMR	E1512	Factory	"Common Mode Rejection". Adjusts armature volts signal isolator so that armature voltage does not change if signal common (LTB Lug 1) is floated at any potential between ground and +400 volts.
I <sup>A</sup> NULL	E1511	Factory	Adjusts zero of armature current isolator. Adjusted so that voltage at LTB Lug 8 is zero volts, PRD-8 not started, power on.
ICAL	E1511	Factory	Calibrates armature current isolator so that rated armature current generates 1.0 volt at Lug 8 of ITB.
The following adjustment potentiometers are factory preset to protect the control and the motor; readjustment can defeat the protective circuits and cause motor or control damage.			
+0S	E1512	Factory	Adjusts symmetry of the "Overspeed" protective circuit so that trippoff occurs at the same armature voltage for either direction of motor rotation.
OVER-SPEED OR LOW LINE	E1512	Factory	Master adjustment for the "Overspeed" protective circuit. Preset to trip off if arm. voltage exceeds 200 volts with 230 VAC input; will also trip off if armature voltage exceeds 180 volts with only 208 VAC input to the PRD-8. Rotating this pot clockwise raises the trip-out voltage. (See Sect. 2.3.2).
OVER LOAD	E1512	Factory	Adjusts the armature current at which the "TIME" light comes on (which starts the overload timer, see Sect. 2.3.1). Preset so that "TIME" light reaches $\frac{1}{2}$ brilliance when voltage on LTB lug 8 is 1.0 volts (indicating that rated current is flowing in motor). Counterclockwise adjustment of this pot lowers current at which the "TIME" light comes on for greater protection. (See also entries 5,6, and 7 of Table 4.

#### 14. TROUBLE-SHOOTING, MOTOR

The following tests will be helpful in pinpointing possible motor problems. Before making any tests turn power off and disconnect the armature and field leads from the control.

- a) Short To the Frame - Using a megger set for 400 volt test potential, check leakage resistance from motor frame to the A1 and A2 leads and to the motor field leads. Readings of less than 10,000 ohms indicate possible problems. A dead short indicates need for immediate repair. Checks for dead shorts may be made with an ohmmeter or a continuity tester if a megger is not available. Retest while rotating armature by hand.
- b) Open or Shorted Field - Check resistance between motor field leads. Resistance should not be less than 100 ohms or greater than 1200 ohms for fields connected for 200 VDC operation.
- c) Open Armature - An ohmmeter between A1 and A2 should indicate a resistance of less than 10 ohms. Rotate the motor shaft very slowly, while observing the ohmmeter. Because of the residual magnetism in shunt field motors or the field in permanent magnet motors, a CEMF will be produced by rotating. This will cause the ohmmeter readings to change during rotation. Therefore, after moving the shaft a small amount, stop and check the resistance reading. A high resistance reading at any position of the motor shaft when it is stopped is a trouble indication. Armature opens are usually the result of bad brushes, burned commutator segments, or severed wires.

## 15. REPAIR

Field repair operations consists of the following :

- a) Replace fuses.
- b) Replace analog module.
- c) Replace one or more circuit boards.
- d) Replace SCR modules.
- e) Replace fan (if so equipped).

This section gives detailed instructions for performing these operations utilizing factory replacement parts. Repair of faulty circuit boards is not covered since this is not generally a field repair procedure. Factory repair service for these boards is available. If field repair of boards is attempted, such repair should be done only by persons experienced in circuit board repair and equipped for the job, and who should observe the following :

- a) Use a soldering iron with a thermostatically controlled 600°C tip or a 35 watt iron with a small tip.
- b) Use only rosin core solder.
- c) Use a vacuum desoldering tool or solder wick for desoldering and component removal.
- d) Do not apply force to components while circuit board pads are still hot; pads may detach resulting in permanent damage. Wait until parts cool before attempting extraction.

In the following replacement procedures, be careful not to drop loose washers or nuts ; hardware is not captive. Keep track of the order in which hardware stacks (nuts, washers, etc.) were originally assembled; reassemble them identically. Washers are used as spacers in many locations and incorrect assembly will cause bending and misalignment of circuit boards or fuses. This is also important when removing and replacing shunt link MSH; incorrect order of high current wires and sense leads may change the torque limit setting of the PRD-8.

Determine which subassembly requires replacement (Section 13); turn power off, and proceed as follows :

### 15.1 FUSE REPLACEMENT

The two small fuses (31FU and 32FU mounted on circuit board E1522) are commonly available clip-mounted types obtainable from electronic supply houses. Rating and type are shown on the circuit board. Replace as necessary using normal procedures.

The three large fuses, 1FU, 2FU, and 3FU are special silver-link rectifier-protection fuses; unapproved substitutes must not be used. See Section 2.6 for approved replacement types. Turn power off and remove fuse cover plate by

removing two screws. Locate the faulty fuse (check fuse resistance using a multimeter set to lowest ohms scale) and remove it by removing two 1/4" hex nuts and two washers from each mounting stud. Do not remove any washers or lugs located below the fuse. Replace fuse with an approved type. Replace mounting hardware and tighten securely. Replace fuse cover plate.

### 15.2 REPLACE ANALOG MODULE (AM-11 OR AM-12)

Remove the PRD-8 nameplate by removing four screws and loose hardware. (If the PRD-8 has an option circuit board mounted under the nameplate, remove it also). Unplug the analog module (rock it back and forth to aid in removal; pins will be tight). Plug the replacement module in (be sure all pins are straight; guide module pins into the socket holes; do not force the module until you are sure all pins are in sockets). Reassemble by reversing the preceding steps.

### 15.3 REPLACE CIRCUIT BOARD E1512

Compare the number scribed in the white block which follows the "1512" notation on the replacement board with the number scribed at the same location on the original board. These numbers must be the same. If they are not, a correctly equipped board must be obtained or modifications must be made to the replacement board before it is installed. If modifications are required contact a factory representative for instructions; modify the board and scribe a corrected identification number (or return to factory for modification).

Remove the original E1512 board as follows. Disengage plugs 1PL and 2PL by squeezing release tabs on sides of plugs while rocking plugs to free pins. Disconnect all wiring to terminal block 1TB except the lug-to-lug jumpers. Identify all wires to assure correct reconnection. Look at the lug-to-lug jumpers on 1TB of the replacement board and be sure they are in the same positions as on the original board. Move jumpers from original board to replacement board if it has no jumpers in place. If an option board is installed under the nameplate, identify and disconnect all wires from it.

Remove three screws along the top of board E1512. Remove two nuts on bottom corners of board. Lift board E1512 off.

Remove the following items from the original circuit board and install on the replacement board in identical locations :

- a) Phenolic spacers, under circuit board.
- b) Metal spacers and nameplate.
- c) Option board located under nameplate, if so equipped, and option board mounting hardware.
- d) Analog module, unless a new analog module is to be installed.

- e) Acceleration option board, if so equipped (be sure jumper JP20 is cut on the replacement board if an acceleration option board is installed). Also note that components on the acceleration board face the outside edge of board E1512 when it is properly inserted.

Check positions of the two switches on the replacement board and set them to the same position as on the original board ("DEADBAND" switch and "ARM-TACH" switch).

Install the replacement board on the PRD-8 unit. Reconnect all wiring. Reinsert plugs 1PL and 2PL making sure the latches on the sides of the plugs engage. After mating the plugs, use a small screwdriver to push each pin fully into the plug shell to assure good connection even in the event of a damaged plug shell.

All adjustments except "IR" should be correct. Adjust "IR" per Section 10.1.

#### 15.4 REPLACE CIRCUIT BOARD E1522

This is the field supply circuit board. Disconnect and identify all wiring connected to terminal block 31TB. Disconnect "Fast-On" connectors from tabs on bottom of board (wires and board are color-coded for correct replacement). Remove four nuts at corners of board; remove washers; lift board off. Look at the number scribed in the block following the "E1522" or "E1522b" notation on the replacement board; it must agree exactly with the number scribed on the original board. If the replacement board is labeled "E1522b", set the jumper on this board to select the correct field voltage for the motor used (see Figure 7, Section 7.2). Be sure fuses are in place on the replacement board. Install the replacement board. Replace nuts and washers. Reconnect wiring to terminal block 31TB and to tabs on bottom board.

#### 15.5 REPLACE CIRCUIT BOARD E1511

All connections to this board are made through a cable bundle, one end of which is soldered to pads on the circuit board. Replacement boards are furnished with cable bundles already attached so that board replacement does not require soldering.

Compare the number scribed in the block which follows the "E1511" notation on the replacement board with the number scribed at the same location on the original board. These numbers must be the same. If they are not the same, but can be made the same by scribing a "1" to the left of the number in the block on the replacement board, then the only difference is that the original board is set up for 50 hz operation and the replacement board is set up for 60 hz. If this is the case, convert the replacement board to 50 hz operation by cutting jumper JP101 (located near the "CROSSFIRE" adjustment) and scribing a "1" to the left of the existing number in the identification block. The boards should then be identical.

### 15.5.1 REMOVAL

Board E1512 must be removed first. Disengage plugs 1PL and 2PL. Remove three screws which secure the top edge of board E1512. Remove two nuts that secure the bottom of the board. It is normally not necessary to disconnect wiring from terminal block 1TB. Swing board E1512 out of the way and start removal of board E1511.

Unscrew and remove three hex spacers and related washers from the upper edge of board E1511. Remove nut and washers from one stud located near the center of the bottom edge of the board. Remove two hinge assemblies by loosening the lower lock nut on each and unscrewing each assembly with lower hex spacer still attached.

WARNING : Make a sketch showing the order of all nuts and washers in the hinge assembly stack. The hinge assemblies will not adjust if they are not re-assembled correctly.

Loosen and remove the remaining hex nuts and washers which secure the lower corners of board E1511 to two mounting studs.

Disconnect eight gate connectors from the SCR modules, pins G1 and G2.

Clip all cable ties that fasten the wire bundle to the PRD-8 base or to heavy-gauge PRD-8 wiring.

Remove the fuse cover plate. Remove two 1/4" hex nuts and washers that secure fuse 3FU. Lift 3FU from mounting studs; do not remove spacer washers under 3FU studs. Remove the 1/4" hex nut and washers that secure the upper end of shunt link MSH. Lift shunt link from its mounting studs. Lift lugs attached to violet and gray wires from studs; do not remove spacer washers under these lugs. Temporarily replace the three hex nuts to prevent accidental dropping off of the spacer washers.

Unsnap all "Fast-On" connectors which connect to tabs on bottom of field supply board E1522.

Use an offset screwdriver to remove four screws from SCR modules (the screws to which the 18 gauge white, black, white/gray and black/white wires attach). Lift wire lugs of the four wires which connect to the E1511 board.

Clip remaining cable ties as necessary to free the E1511 wire bundles.

Lift the E1511 board from its mounting studs and remove it and attached wire bundles from the PRD-8 unit.

### 15.5.2 REASSEMBLY

Position the replacement board, with wire bundles attached, on the mounting studs. Check the press-on heat sinks or VR101 and VR103. They should not be loose or bent over against any other parts. Straighten or tighten heatsinks as necessary. Arrange all wiring in an approximately correct position and proceed with reassembly.

- a) Install lock washers and hex spacers on studs along top edge of board. Install 2 washers and one hex nut on stud at bottom center of board. Install two washers and one hex nut on each corner stud at bottom of board. Tighten nuts and spacers.
- b) Reinstall the white, black, white/gray, and black/white wires under SCR module screws; position all lugs so they do not short to adjacent lugs, especially the lugs on the white wires.

Tighten SCR module screws securely using an offset screw-driver. See Drawing A2101-000-ES if any questions arise concerning correct connection points for the wires.

- c) Mate "Fast-On" connectors to tabs on bottom of board E1522. Follow the indicated color code.
- d) Dress the gray and violet wires through the wire slot in the fuse mounting plate and place the wire lugs on shunt link mounting studs (violet wires goes to top stud).
- e) Place shunt link on mounting studs with lug barrels down. Place wire lug of large white wire on upper stud. Place fuse 3FU on mounting studs. Place washers and hex nuts on all three studs and tighten securely. Reinstall fuse cover plate.
- f) Mate 8 gate connectors to G1 and G2 pins of SCR modules. These gate leads loop over the main wire bundle and are properly connected when no wires cross. (See Drawing A2101-000-ES).
- g) Place hex nuts on two lower corner studs and screw loosely against existing hardware. Place lock washers on top of hex nuts. Screw two hinge assemblies loosely on same studs. Place board E1512 in position and secure at top edge with three screws and six washers. Insert a flat washer between top of each hinge and bottom of E1512 board if washers were present before disassembly. Adjust hinge assemblies by turning them on their mounting studs until phenolic spacers on board E1512 just touch board E1511, then back off a fraction of a turn so the flat surfaces on hinges are aligned for proper hinge action. Tighten lower locking nut upward against hinge assembly to lock it in this

position. Add hex nuts and washers to fasten top of hinge assembly to board E1512.

- h) Connect plugs 1PL and 2PL to mating connectors on board E1512. Be sure latches on sides of plugs engage. After mating, use a small screwdriver to push each pin down into the plugs to assure contact.
- i) Form wire bundles so that board E1512 may hinge freely when upper screws are removed. Use cable ties to secure wire bundles to metal spacers along the entire route of the bundle. Also tie upper bundles so they do not interfere with hinging of board E1512. Dress wiring so it clears all moving parts of dc loop contactor (if so equipped); secure wiring in place with cable ties.
- j) Check to be sure all wires are connected. All adjustments on the replacement E1511 board should be correct as received; no readjustment should be necessary, but see Section 10.3.5 and Table 5 in Sec. 13.8 if problems arise.

## 15.6 REPLACE FOR MODULE

Identification of failed modules requires removal of all four modules. Bear in mind also that modules often fail in pairs; replacement of two or more modules may be necessary. Also if a module failure is such that a large current "dumps" from the failed SCR into the pulse generators on circuit board E1511, this may cause a resistor to open. Always check resistors R142 through R149 (per 15.6.2, following) before placing unit back into service.

### 15.6.1 REPLACEMENT PROCEDURE

Remove the PRD-8 unit from its enclosure. Disconnect all wiring to the PRD-8; identify wires for proper reconnection.

Remove five mounting bolts and lift the PRD-8 unit out. Remove four screws which secure the phenolic fuse mounting plate and fold back the entire fuse mounting assembly to allow access to SCR modules. Remove as many wire connections and bus bars as necessary to allow removal of the SCR modules, but identify all wires for correct reconnection. Unplug gate connectors (G1 and G2 pins). Unmount the SCR modules by removing two hex nuts (hold screws from opposite side of PRD-8 base plate with a screwdriver).

Perform bench tests per Section 13.2.3 to locate faulty modules. Obtain replacement modules as necessary.

Examine gate pins G1 and G2 of the replacement module under a bright light. Pins should be free of black dye and surplus potting compound all the way to the bottom of the pin well. If contamination is found, clean the pin by scraping it inside of the pin well with a very small screwdriver.

Smear a thin film of silicone thermal grease on the metal base plate of the replacement module. (Use Dow Corning compound #4 or a similar transistor heat sink compound available through local electronic outlet stores such as Radio Shack). Clean the mounting area on the PRD-8 base plate thoroughly to remove any dust, grit, or chips. Mount the module.

#### 15.6.2 CHECK RESISTORS

Remove the three screws which allow circuit board E1512 to fold out. Fold E1512 out. Unplug G1 and G2 gate connectors from all SCR modules. Locate eight resistors labeled R142 through R149 on circuit board E1511 (located just above pulse transformers). Measure resistance value using a multimeter (Simpson 260 or equivalent set to lowest ohms scale). Resistors should read 3.9 ohms; a failed resistor will usually read hundreds of ohms or more.

Replace any resistor which reads significantly higher than the others by one of the following methods :

- a) Remove and replace circuit board E1511 per Section 15.5.
- b) Remove circuit board E1511 and arrange for replacement of the faulty resistor by a local electronic repair shop (specify a 3.9 ohm 1/2 watt 5% resistor)
- c) Repair without removing circuit board E1511 by obtaining a replacement resistor (as specified in (b) preceding; available at electronic outlets) and soldering the replacement part "piggy back" across the failed resistor. Loop wire leads of the replacement part around leads of the failed part and solder. See opening paragraphs of Section 15 for soldering precautions.

#### 15.6.3 REASSEMBLY

Tighten module mounting screws firmly. Reconnect all wiring to module assembly; see Drawing A2101-000-ES if questions on correct wiring arise. Reconnect eight gate connectors to pins G1 and G2 on the modules (connections are correct when no leads cross). Reassemble by reversing all remaining operations performed in disassembly.

#### 15.7 FAN REPLACEMENT

Assure that 230 VAC from terminal block 31TB is present at fan terminals before condemning the fan as faulty. If fan is definitely faulty, obtain a factory replacement part. Check the label on the replacement part to be sure it is labeled "230 VAC". Fan must be installed so that air flows toward the SCR modules (note airflow indicator arrow on fan housing).

## 16. MAINTENANCE

### 16.1 CONTROL MAINTENANCE

The PRD-8 unit requires no maintenance in normal installations. If installed in dusty locations, blow off dust periodically with an air hose. If installed in ventilated cabinets, change cabinet filters regularly.

### 16.2 MOTOR MAINTENANCE

Inspect motor brushes regularly. Polyspede recommends replacement when brushes are worn to one third of original length or at regularly scheduled intervals.

Motor brush life is related to motor speed, loading, cycling rate, ambient temperature, and other variables not controlled by Polyspede. Therefore, only guide lines can be given concerning inspection intervals. Experience has shown that each application has its own wear rate. Removal of the brushes after each three months of operation during the first year will give an indication of the specific wear rate. After three sets of brushes have been used, remove the motor armature for checking by a component motor repair shop for possible commutator refacing.

Armature bearings are sealed and require no additional lubrication. Replacement should be performed by a reputable service shop if bearings become noisy.

Occasional cleaning of motor vent holes or removal of fan guard to remove dust accumulation from fans is the only additional maintenance required.

### 16.3 SPEED REDUCER MAINTENANCE

- a) Reducers are shipped without lubricant. Fill reducer with specified lubricant before startup (see tags on reducer or refer to manufacturer's manual.)
- b) Use type and grade oil specified on the gear reducer nameplate. Keep in mind proper viscosities for various temperatures.
- c) Keep oil at proper level.
- d) Drain, flush, and refill reduction unit after initial run-in period.
- e) Replace shaft seals at first sign of leakage not only to avoid damage due to loss of lubricant, but also to eliminate the possible entrance of contaminants into housing.

- f) If detailed instructions for assembly and disassembly of a particular unit are required, contact the speed reducer manufacturer for this information.
- g) If the drive is connected by a coupling which requires lubricating, the coupling should be checked on start-up and semi-annually.

## 17. SYSTEM DESIGN USING THE PRD-8

The following guide lines and examples are presented to provide the user with a better understanding of how a PRD-8 operates and how the high degree of flexibility inherent in this design can be applied to solve machine design problems. The example given are not intended as complete designs; the user should employ good engineering practice in applying the principles covered and should also read related material elsewhere in this manual before designing a system based on the examples.

### 17.1 DESCRIPTION OF OPERATION

The PRD-8 is programmed by connections which the user adds to terminal block 1TB. Sections 17.1.1. through 17.1.5 are devoted to describing the input/output characteristics of the various terminals on 1TB. Speed commands, torque commands, speed meter output, torque meter output, and start-stop circuitry are described as an aid toward understanding and expanding the concepts presented in the examples of Sections 17.2 through 17.10. The following descriptions apply to PRD-8 units equipped with a standard AM-11 analog module unless otherwise noted.

#### 17.1.1 SPEED COMMAND INPUT (1TB Lug 22)

Polarity of voltage at this input commands direction of motor rotation. Magnitude of this voltage commands motor speed by commanding magnitude of armature voltage. Negative polarity at Lug 22 commands positive armature voltage (Lug A1 positive with respect to Lug A2 on terminal block 10TB), a condition which we will define as "forward" rotation in the example herein and on Drawing A2101-000-EW. A 6 volt input at Lug 22 commands an armature voltage of 180 volts for normal factory setting of the "MAX" potentiometer and if armature voltage feedback with no IR compensation is utilized. The basic speed control loop may therefore be viewed as an inverting amplifier with a voltage gain of X30; introduction of IR compensation or resetting of the "MAX" potentiometer will, however, alter this ratio. The input resistance at Lug 22 is approximately 90 Kohms for normal factory setting of the "MAX" potentiometer. This input resistance must be considered as a loading resistance at the speed potentiometer wiper.

#### 17.1.2 TORQUE COMMAND INPUTS ("+LIM" and "-LIM", ITB Lugs 5 and 6)

The "Torque Regulator" shown in Figure 1 is an armature current regulator and the terms "torque limit" and "current limit" as well as "torque" and "current" are used synonymously. Basic action of the speed and torque regulators is described in Section 2.2.

The magnitude of voltage at Lugs 5 and 6 commands the magnitude of armature current at which the PRD-8 will stop regulating speed and will start regulating armature current. At this "crossover" point the PRD-8 begins to act as a

constant-current device and the motor delivers constant torque rather than running at a regulated speed. The voltage at Lugs 5 and 6 effectively commands the maximum torque which the motor can deliver, thus the name "Torque Command Voltage".

The voltage applied to Lug 5 ("LIM") determines the maximum positive armature current which the PRD-8 can deliver (maximum current leaving 10TB Lug A1). The voltage applied to Lug 6 ("-LIM") determines the maximum negative armature current which the PRD-8 can deliver (maximum current entering 10TB Lug A1). It must be remembered that neither of these command voltages exercise any control over armature current until armature current reaches the commanded value, and that armature current is determined by external motor loading. Also these voltages cannot command or determine direction of motor rotation.

Figure 17 shows the general configuration of the positive torque limit (current limit) circuitry. Negative torque limit circuitry is identical.

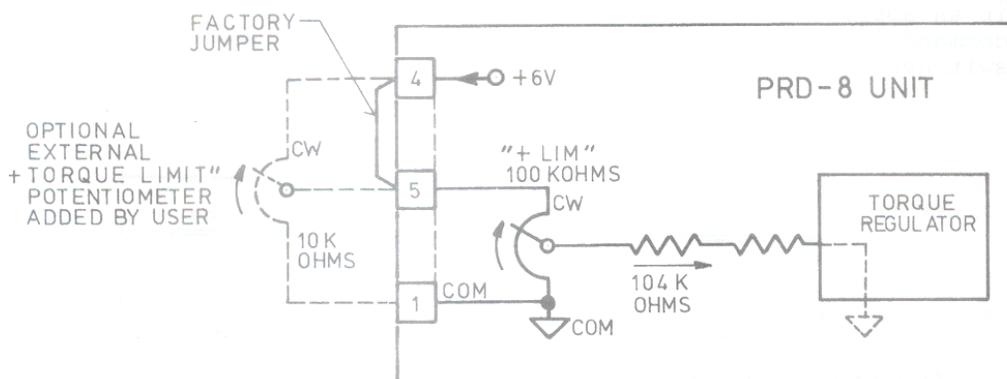


FIGURE 17

Simplified Torque Command Circuitry (+Limit)

The torque command voltage applied to Lugs 5 and 6 in a standard PRD-8 unit is simply a +6 volt potential jumpered from Lug 4. The internal "+LIM" and "-LIM" trim potentiometers are factory set so that this voltage programs 150% of rated motor current as the torque limit setting.

External torque limit potentiometers may be added as shown in Figure 17 and in Detail 2 of Drawing A2101-000-EW. If the factory settings of the internal "+LIM" and "-LIM" potentiometers are not changed, the external potentiometers

can be used to adjust the torque limit point from zero to 150% of rated motor current. It will be noted in Figure 17, however, that the internal "+LIM" and "-LIM" potentiometers serve as calibration adjustments for the external potentiometers. It may be desirable in some applications to reset the internal "+LIM" and "-LIM" adjustments per 10.3.3 and 10.3.4 to recalibrate the external potentiometers so that they adjust 0-100% of rated motor current.

The input resistance of the torque command circuitry viewed from Lugs 5 and 6 of 1TB is approximately 68 Kohms with factory settings, or 82 Kohms if readjusted for 0-100% range. The upper range of the internal "+LIM" and "-LIM" potentiometers is 234% of rated motor current. Consult factory before setting higher than 150%.

If relays or switch contacts are used to change torque command voltages (such as in the example 17.5) gold contacts or sealed reed switches rated for dry-circuit service should be used. Also networks should be provided across all relay coils (as specified in Note 2 of Detail 1, Drawing A2101-000-EW).

Positive and negative armature current may be difficult to define in an application. Table 6 is provided to indicate which torque command input (Lug 5 or Lug 6) exercises control as the drive switches from speed control to torque control :

TABLE 6

Direction of Rotation	Mode of Operation	
	Motoring	Generating
Forward *	Lug 5 (+LIM)	Lug 6 (-LIM)
Reverse	Lug 6 (-LIM)	Lug 5 (+LIM)

\* Forward rotation is defined as 10TB Lug A1 positive with respect to Lug A2.

The applications described in Sections 17.5 and 17.6 illustrate situations in which external adjustment of torque is useful.

### 17.1.3 SPEED "METER" OUTPUT (1TB Lug 9)

Voltage at this output lug indicates direction of rotation and magnitude of speed independent of whether the drive is operating in a speed-controlled or torque-limit mode, and whether an AM-11 or AM-12 analog module is used.

If armature voltage feedback is utilized, the output voltage at Lug 9 is proportional to armature voltage plus IR compensation. If "IR" is optimized, the Lug 9 voltage

is a true speed indicator within accuracy and stability limits of motor  $K_v$  (voltage constant, volts/radian/sec). The output is nominally 6 volts for an armature voltage of 180 volts at no load. Since this output is derived from the armature volts isolator, it is isolated from the power lines and is referenced to 1TB Lugs 1 and 2 (signal common).

If tachometer feedback is utilized and is calibrated per Section 9.1, the voltage at Lug 9 is as described in the preceding paragraph except accuracy and stability is independent of motor  $K_v$  and is dependent on tachometer characteristics. Also the voltage is derived from the tachometer divider rather than from the armature volts isolator.

The voltage at Lug 9 is positive for forward motor rotation (as defined in Section 17.1.1.). It should be noted that the voltage at Lug 9 is opposite in polarity to the speed command voltage on Lug 22. This polarity invention must be considered when the Lug 9 voltage is used to command speed of slave units as described in Section 17.9.

The output voltage at Lug 9 is well filtered and is suitable for use as a command voltage for slaved units, for speed level detection, or for speed meter readout. The output resistance at Lug 9 is 1 Kohm. Motor speed is not affected by external loading at Lug 9.

#### 17.1.4 "% TORQUE" OUTPUT (1TB Lug 8)

Voltage at this output lug indicates polarity and magnitude of armature current independent of whether the drive is operating in a speed-controlled or torque-limit mode, and whether an AM-11 or AM-12 analog module is used.

The output voltage at Lug 8 is 1.0 volts when rated current (as engraved on shunt link MSH) is flowing in the motor armature. Polarity is positive when armature current is flowing out of Lug A1 on 10TB (as occurs in forward motoring when Lug A1 is positive with respect to Lug A2).

Lug 8 serves as a convenient place to monitor armature current thereby eliminating the necessity of opening armature leads for meter insertion. Accuracy of readout is 2% or better. Since this voltage is derived from the current signal isolator, it is well isolated from the power lines and is referenced to 1TB Lugs 1 and 2 (signal common). The output resistance at Lug 8 is 1 Kohm. Torque limit setting are not affected by external loading at Lug 8.

The voltage at Lug 8 is an unfiltered replica of the armature current waveform and requires filtering (smoothing) before use in such control functions as commanding

torque in a torque-slave unit as described in Section 17.10.2. If the PRD-8 is equipped with an AM-12 module, the voltage at Lug 8 is opposite in polarity to the torque-command voltage at Lug 22.

### 17.1.5 START-STOP CIRCUITRY

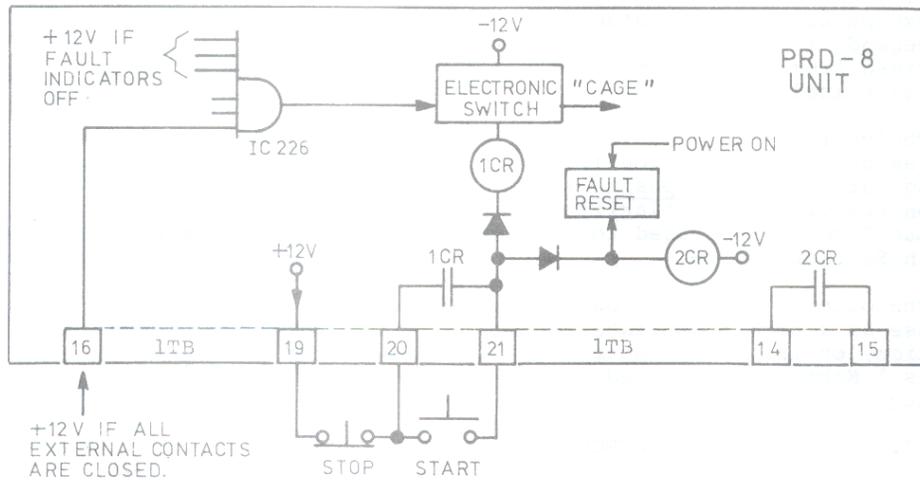


FIGURE 18

Start-Stop Circuitry

PRD-8 units are equipped with circuitry as shown in figure 18 to allow starting and stopping by push buttons. Section 17.2 shows other methods of starting and stopping. Further circuit details is shown on Drawing A2101-000-ES. Pressing the "STOP" push button disables firing circuitry and prevents the PRD-8 from responding to speed or torque commands; if the motor is running it will coast to a stop. See Section 17.2 for application details.

In figure 18, 1CR must be activated to permit operation of the drive; also all inputs to IC 226 must be high (+12V). When the "START" push button is activated, +12V is momentarily applied to Lug 21 which resets all fault indicators (if any are on). If all external contacts are closed, +12V will also be present on Lug 16 and the electronic switch will activate. Activation of the electronic switch allows relay 1CR to close; 1CR latches due to the contact which bridges the "START" Switch. The "CAGE" signal is removed as 1CR coil current flows into the electronic switch. Removal of the "CAGE" signal uncages speed control circuitry and removes lockout from the firing circuitry (see Note 18 on Drawing A2101-000-ES). Relay 2CR is activated by the sustained voltage on Lug 21. The 2CR contact

set is used to activate the optional dc loop contactor; if this contactor is not installed, the 2CR contact set is simply connected in series with Lug 16 and performs no essential function. The "external contacts" referenced above are thermostats and/or the auxiliary contact on the dc loop contactor, if so equipped (see Drawings A2101-000-EW and A2101-000-ES).

If 1CR is released due to removal of voltage from Lug 20 (a "STOP") or by the electronic switch opening (a "fault" condition) the "CAGE" signal is applied. Application of the "CAGE" signal instantaneously inhibits any further SCR firing and sets the speed control circuitry to a neutral (zero) state. If pushbutton operation per Figure 18 is used, relay 2CR releases when a fault occurs and the dc loop contractor (if so equipped) releases.

## 17.2 START-STOP METHODS.

It is basic to realize that regenerative stops can be commanded only by reducing the speed command voltage at 1TB Lug 22 to zero. Activating the "STOP" pushbutton in Figure 18 while the motor is rotating results in a coast-down stop.

It should further be realized that if a stop is achieved by reducing speed command voltage to zero, the motor is not "dead". For example it will apply counter-torque if its shaft is rotated manually, and it will rotate if the speed command is changed. Activation of the "STOP" pushbutton disables SCR firing and causes the PRD-8 to be electronically "off" and unresponsive to speed commands.

Typically, stops during a machine cycle are accomplished by reducing the speed command voltage to zero; the "STOP" pushbutton is activated to permit operations such as reload or jam correction. In some applications it may be desirable to incorporate a sequenced stop by adding external timing circuitry which first commands zero speed and then, after a delay, opens the "STOP" circuit. If external timing such as this is used, it may be more convenient to use the start-stop connection shown in Figure 19.

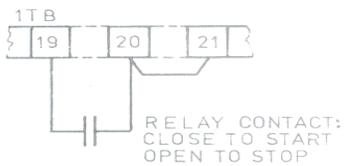


Figure 19  
Start-Stop By  
Relay Contact

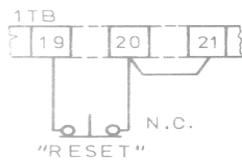


Figure 20  
N.C. Momentary  
"RESET" Pushbutton



Figure 21  
Power-On  
Start

Figures 19, 20 and 21 show alternate connections to the PRD-8 "START-STOP" terminals. Figure 19 is self-explanatory. In Figures 20 and 21 the drive is started and stopped by applying and removing ac line power. In Figure 21, power must be turned off and then back on to restart motor if a fault indicator comes on. In Figure 20 restarting after a fault is accomplished by pressing and releasing the "RESET" button (Note : Pressing "RESET" during normal operation will interrupt motor operation). It should also be remembered that there is an approximate 0.5 second starting delay when the PRD-8 is started by applying ac line power. This delay may limit the use of Figure 21 circuitry in some applications. Also the restrictions described in Section 5.2 must be observed.

The switches and relays shown in Figures 18, 19 and 20 need not be rated for dry circuit operation. Open-circuit voltage across the contacts is 24 volts; current through a closed contact is approximately 27 milliamps. Also Lugs 19, 20 and 21 are within  $\pm 12$  volts of earth ground if Lug 1 of 1TB is grounded.

If job requirements dictate that armature connections to the motor be opened when the drive is in a "stopped" state, a PRD-8 unit with dc loop contactor option should be installed (Section 2.5.4).

If the PRD-8 is not equipped with a dc loop contactor, and if pushbutton start-stop per Figure 18 is utilized, the 2CR contact set which terminates on Lugs 14 and 15 of 1TB may be made available for slave-starting of another PRD-8 or release of a motor mounted mechanical brake. Change jumpers on terminal block 1TB as follows to make these contacts available:

- a) Remove jumper which connects Lug 14 to Lug 17;  
Remove jumper which connects Lug 15 to Lug 16.
- b) Add a jumper between Lugs 16 and 17.

Specification for 2CR use :

1. Contact rating : 3 amps non-inductive  
5 amps inrush.
2. Activate time : 5 milliseconds typical
3. Release time : 20 milliseconds typical.

Provide R-C transient suppression across the coil of any inductive load driven by 2CR contacts. External use of 2CR contacts is normally not practical except when pushbutton start-stop is incorporated; 2CR does not release when a fault shutdown occurs if wiring per Figures 19, 20, or 21 is used.

### 17.3 RELAY-SELECTED PRESET SPEEDS

In this common application relays are used to connect a group of speed potentiometers one at a time to the PRD-8 speed command input (1TB Lug 22). Typically the potentiometers are preset for speeds previously determined to be optimum for various parts of a machine cycle. As the machine operates it activates the relays one at a time. Various speeds, either forward or reverse, are commanded as voltages on the potentiometer wipers are switched to 1TB Lug 22.

Basic Design Rules :

- a) Only one speed potentiometer wiper is to be connected to Lug 22 at any given time.
- b) Maximum permissible loading of the +6 volt and -6 volt power supplies (Lugs 3 and 4 of 1TB) is 8 milliamps each.
- c) Lug 22 should never be left open-circuited; short Lug 22 to common (Lug 1 or 2) when zero speed is desired. Motor may creep if Lug 22 is left open.
- d) Refer to Drawing A2101-000-EW, Detail 1, part 3, concerning relay contact materials and R-C networks for relay coils. It should be added that reed relays which utilize contact materials other than gold are suitable provided they are rated for dry - circuit operation.
- e) A six volt input to Lug 22 commands 180 volts armature voltage (approximate base speed of the motor). Polarity of the voltage determines direction of motor rotation. See section 17.1.1. for further details.

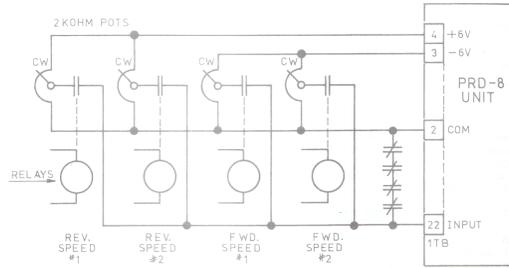


FIGURE 22

Two Speeds Forward, Two Speeds Reverse

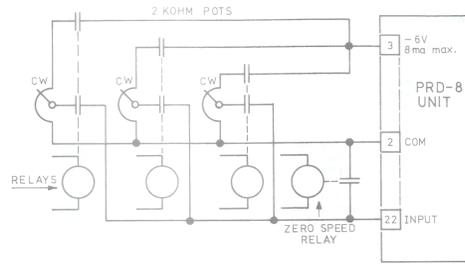


FIGURE 23

Three Speeds Forward

**Figure 23**  
**Three Speeds Forward**  
 71

Figure 22 illustrates a typical situation in which four preset speeds, two forward and two reverse, are selected by four relays. Actually this is a five-speed setup; the fifth speed is zero which occurs when no relay is activated. The series – connected normally-closed contacts, one from each relay, short Lug 22 to Lug 2 when no relay is activated and thus command zero speed. Each of the 2 Kohm potentiometers draw 3 milliamps. The maximum loading is therefore 6 milliamps on the +6 volt supply and 6 milliamps on the –6volt supply which is acceptable. All of the basic rules are met provided machine logic is such that no two relays can be activated simultaneously.

Figure 23 illustrates a similar situation. In Figure 23, however, it is necessary to add a second contact on each relay so that the clockwise terminals of the potentiometers are not connected to the –6 volt power supply (Lug 3) until a particular potentiometer is selected. If all three potentiometers were connected simultaneously to Lug 3, the total current drain would be 3x3 milliamps or 9 milliamps which would exceed the maximum allowable 8 milliamps. In this example a separate relay is used to short Lug 22 to common when zero speed is desired; this arrangement is often preferable when large numbers of relays are involved. The zero speed relay is activated when all other relays are released.

The need for the second relay contact in the clockwise line of each potentiometer of Figure 23 may be eliminated by increasing the value of the potentiometers. For example if 10Kohm potentiometers are used, each one draws only 0.6 milliamps and up to 13 potentiometers can be continually connected to each power supply without overloading the supply. Some linearity of control is sacrificed when 10 Kohm units are used . Specifically the dials must be set at 51.4% rotation rather than the ideal 50% rotation to command 50% speed. This is due to wiper loading imposed by the approximate 90 Kohm input resistance of the PRD-8 speed command input. This is usually of no concern unless precision 10 turn potentiometers with calibrated dials are used. Also the wiring between the potentiometers and the PRD-8 unit is somewhat more prone to electrical noise pickup with the 10 Kohm units. This is not a significant problem unless long runs of unshielded wire are involved. With the exceptions noted, the higher value potentiometers will give results equivalent to those achieved when the normal 2 Kohm potentiometers are used.

#### 17.4 EXTERNAL SIGNAL CONTROL OF SPEED

Refer to Detail 1, Example 4, Drawing A2101-000-EW. Suitable external signal sources include the following :

- a) Process instrument
- b) Microprocessor with D/A converter
- c) Programmable Controller
- d) Polyspede master acceleration unit
- e) Polyspede master reference unit.

The external signal should be a smooth dc voltage, 0 to 6 volt range, of the polarity required for desired direction of rotation. Internal signal isolators in the PRD-8 eliminate the need for external signal isolation, but if the external voltage source in the example cannot tolerate an earth ground on its output lead, then the normal earth ground connection to 1TB Lug 1 should be omitted. This will allow Lugs 1 and 2 (which are connected together internally in the PRD-8) to float.

For external voltages sources with outputs higher than the required 6 volts, provide an external voltage divider. The approximate 90 Kohm input resistance of the PRD-8 should be included in calculations for the divider.

If process instrument outputs (1-5 ma, 4-20 ma, or 10-50 ma) are to be used to program speed, it is recommended that an external signal interface board be purchased from Ployspede Electronics. This board provides the required calibration resistor for converting current span to voltage and provides the required zero offset voltage.

Long leads between an external signal source and the PRD-8 should be shielded and should not be routed in conduit with power wiring.

#### 17.5. EXTERNAL TORQUE LIMIT

Refer to Drawing A2101 – 000 – EW, Detail 2, for typical connections, and to Section 17.1.2. for description of operation. Note that adjustment range extends to zero and that the PRD-8 internal; adjustments ("LIM" and "-LIM" ) can be used to calibrate the full-scale range of the external potentiometers.

Figure 24 illustrates a way in which external torque control can solve a machine design problem.

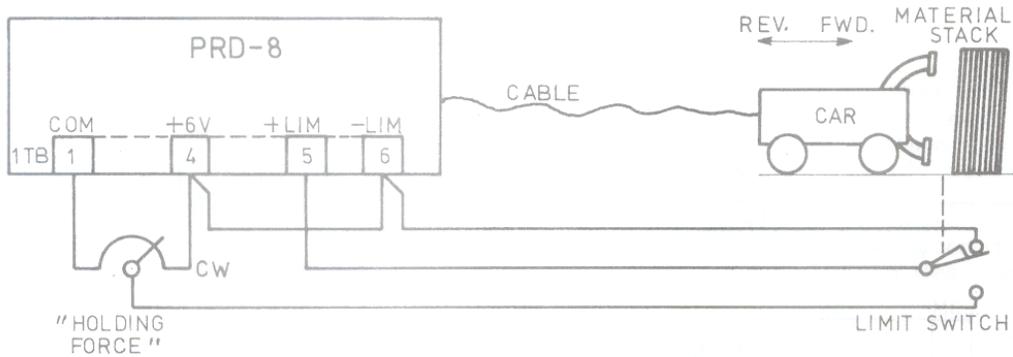


FIGURE 24

Material Transport System

In Figure 24 the car is to drive forward until it nears the material stack, then it must slow down. As the pickup head contacts the material stack, the car is to stop but the pickup head must push against the material stack with controlled holding force. The holding force prevents back-away until a signal is received to reverse, at which time the car is to back away carry a sheet of material.

In a typical implementation of this cycle a programmable controller is used to activate relays, such as are shown in figure 22, to control forward and reverse speeds; the speed-control circuitry is not shown in Figure 24. As the car approaches the material stack at a low speed, it contacts the limit switch shown in Figure 24. As the limit switch activates, voltage at 1TB Lug 5 is reduced from +6 volts to the voltage preset on the "HOLDING FORCE" potentiometer wiper. This reduces the forward motoring torque limit from 150% of rated torque to a lower preset value (see Table 6, section 17.1.2). With a forward speed command still present, the PRD-8 operates in a torque limit mode and the car pushes against the material stack with a force determined by the setting of the "HOLDING FORCE" potentiometer. This force is applied until a reverse speed command causes the car to back away. Full torque is available for backing away (reverse motoring) since the voltage on Lug 6 was not reduced by the limit switch closure (see Table 6).

If the "HOLDING FORCE" potentiometer is set so that the motor supplies less than rated torque, the "TIME" light on the PRD-8 unit will not come on while holding force is being applied and there is no possibility of overload shutdown while awaiting a "reverse" command. (Limit switch contacts must be dry-circuit rated).

17.6 USE AS A PASSIVE BRAKE

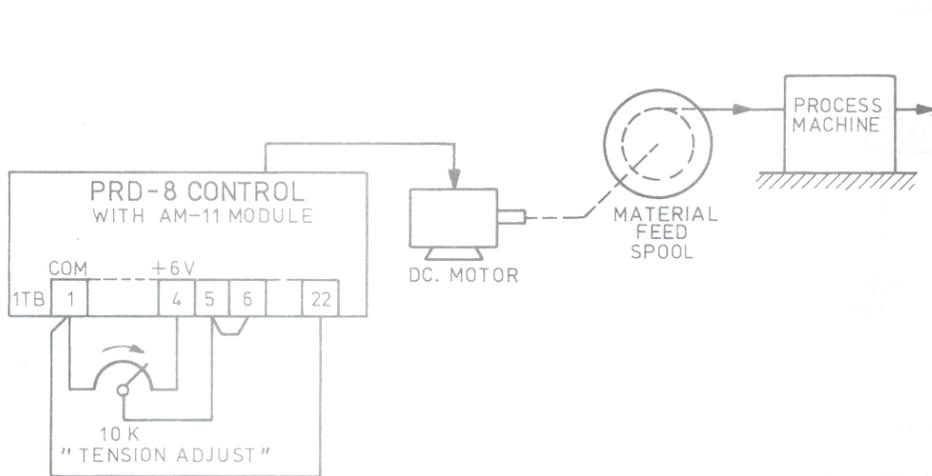


FIGURE 25  
Material Unwinder

In the material unwinder shown in Figure 25 speed is programmed to zero (1TB Lug 22 connected to Common); thus the motor will not turn unless its shaft is rotated by externally-applied force. As the process machine pulls material from the feed spool, it rotates the dc motor shaft. Circuitry in the PRD-8 senses that speed is not zero and causes the motor to apply opposing torque in an attempt to satisfy the zero-speed command. Unable to regulate speed, the PRD-8 automatically switches into torque limit mode and regulates torque at the value commanded by the external torque limit potentiometer, which in this case is labeled "Tension Adjust". With "IR" correctly adjusted, the crossover to torque control occurs at very low speed, typically 1% to 2% base speed or 17 to 35 rpm if a 1750 rpm motor is used. The PRD-8 and dc motor act very much like an eddy current brake, except power is returned to the ac lines rather than being dissipated as heat, thereby reducing machine operating cost and energy consumption. Also low speed performance is greatly improved.

If a speed reducer is used in a setup such as Figure 25 it must be a helical reducer or a reducer with a non-locking ratio.

Several methods might be used to make the potentiometer shown in Figure 25 self adjusting. A rider arm sensing material build on the spool could be coupled to the

potentiometer to change its setting as material build changes, or dancer riding on the material web could be utilized to adjust the potentiometer for constant web tension, or a tension sensor and setpoint controller could be used instead of the "TENSION ADJUST" potentiometer.

The setup of Figure 25 provides performance superior to that of an eddy current brake, but like an eddy current brake it cannot aid in accelerating heavy feed spools up to speed to prevent excessive web tension during startup. Also it cannot provide assisting torque (motoring torque) to aid in unwinding material. If either of these characteristics are desired, a PRD-8 equipped with an AM-12 analog module can be used as an active brake to automatically provide motoring assistance when needed to maintain desired web tension (see Section 17.10.1)

### 17.7 TURBINE-DRIVEN GENERATOR FOR POWER COST REDUCTION

In this application a dc motor is coupled to a turbine which is driven by windpower, waterpower, or by surplus industrially-generated steam. Electrical connections identical to those shown in Figure 25 are used. The potentiometer shown controls the magnitude of current generated into the ac lines regardless of speed and direction of rotation; the potentiometer would logically be labeled "CURRENT ADJUST" or "LOAD ADJUST". A turbine-driven governor could be coupled to the potentiometer by a mechanism which automatically adjusts potentiometer setting for the loading which allows the turbine to run at its most efficient speed. Alternately auxiliary electronics circuitry could be devised for this same purpose.

The power generated is returned to plant power lines and subtracts directly from kilowatt hours registered by the Power Company's metering device.

The zero speed command assures that the motor will not turn unless being driven by the turbine, but excessive speeds must be guarded against by mechanical means external to the PRD-8. Also an external device which automatically disconnects the PRD-8 from the ac lines in the event of an ac power loss must be provided to prevent applying generated dc to the ac lines during a power loss (see Figure 4). Design of the external power loss detector must be such that it discriminates between ac and generated dc.

17.8 MULTIPLE DRIVES, SINGLE SPEED COMMAND

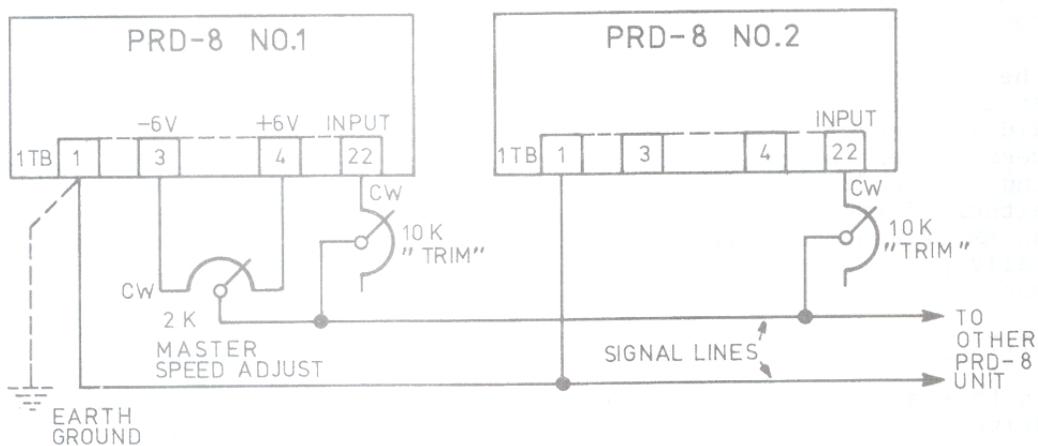


FIGURE 26

Multiple Drives, Single Speed Command

Figure 26 illustrates one way in which a group of PRD-8 units can be operated from a single speed potentiometer. The  $\pm 6$  volt power supplies in PRD-8 No.1 are used to excite the "MASTER SPEED ADJUST" potentiometer so that it can command either forward or reverse speed. The 10 Kohm "TRIM" potentiometers connected in series with each PRD-8 input provide means for trimming speed of any unit downward by 9%; the internal "MAX" potentiometers can be used for additional up/down trim of speed. Because of the finite resistance of the "MASTER SPEED ADJUST" potentiometer, trimming the speed of a drive downward 9% raises the speed of all other drives slightly (about 0.1% of set speed).

The PRD-8 units should not be equipped with acceleration option boards. If adjustable coordinated acceleration and deceleration times are desired, the signal lines should be driven by a Polyspede master acceleration unit in lieu of the potentiometer shown.

If one drive changes speed due to torque limit, the speed of other drives is not affected.

As many as ten PRD-8 units may be connected as shown in Figure 26. Isolation transformers are not required. The signal lines in Figure 26 may alternately be driven by an external voltage signal (see Section 17.4) in lieu the potentiometer shown.

Trim potentiometers of higher value may be used for greater trim range. 100 Kohm potentiometers will give a 33% downward speed trim but adjustment resolution is decreased and maximum interaction increases from 0.1% to 0.5% of set speed.

## 17.9 SPEED SLAVING

### 17.9 SPEED SLAVING

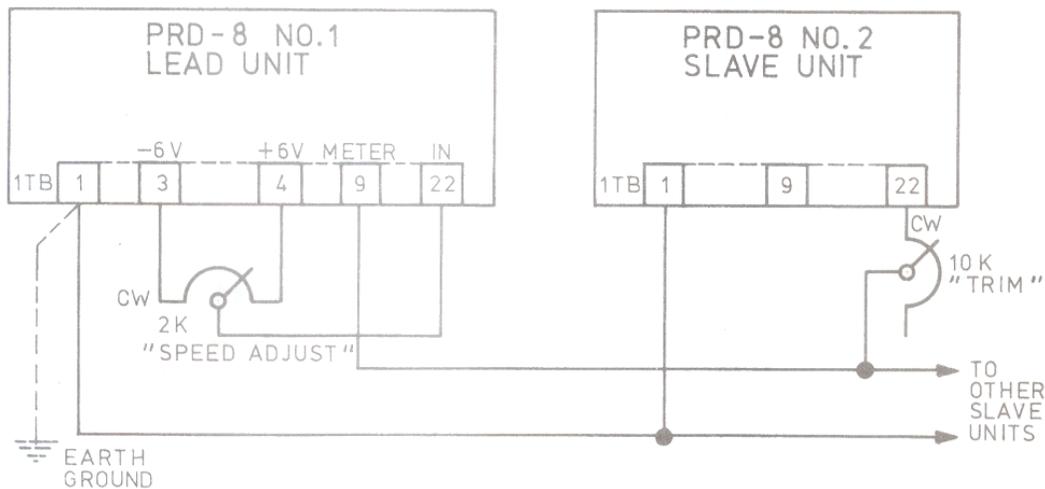


FIGURE 27

Speed Slave

If the lead unit in Figure 27 changes speed for any reason including slowdown due to torque limit, all slave units will faithfully track its speed change. This is true because the output voltage at 1TB Lug 9 of the lead unit is proportional to speed regardless of mode of operation (see Section 17.1.3). If the lead unit is equipped with an acceleration option, the slave units should not include the acceleration option since they will accelerate and decelerate at the rate set by the lead unit.

Slight interaction of the trim potentiometers (due to the 1 Kohm output resistance at Lug 9 of the lead unit is present and is of the same magnitude as described in Section 17.8.

Lug 22 of the lead unit may be driven by an external signal per Section 17.4 in lieu of the "SPEED ADJUST" potentiometer shown.

It is necessary to reverse armature connections of the lead motor to achieve the same direction of rotation in the lead and slave motors. This is true because the voltages at Lug 9 ("METER" output) and Lug 22 ("SPEED INPUT") of a PRD-8 are of opposite polarity.

## 17.10 AM-12 (TORQUE-PROGRAMMED) APPLICATIONS

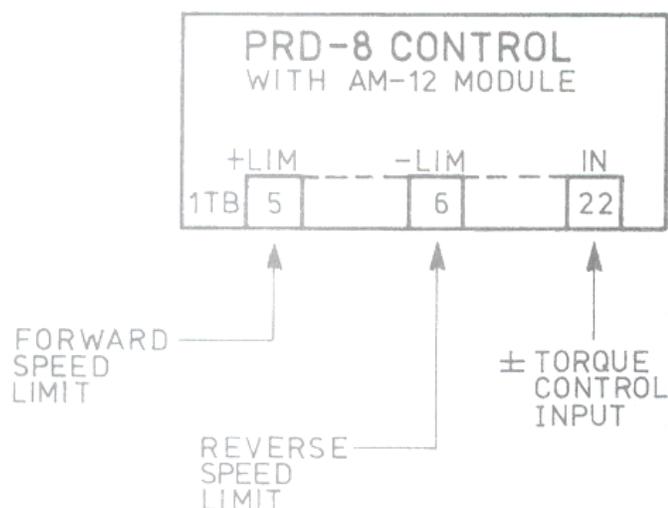


FIGURE 28

### PRD-8 Equipped with AM-12 Module

As illustrated in Figure 28, when the standard AM-11 module is replaced with an AM-12 module the PRD-8 speed and torque program terminals are reversed. The input voltage at Lug 22 now commands direction and magnitude of torque. The input voltages at Lugs 5 and 6 now act as speed limit commands which control maximum allowable motoring speed in the forward and reverse directions respectively, but cannot command direction of rotation. See Section 2.5.6 for further details. The motor rotates in a direction determined by voltage polarity at the torque-control input for motoring operation or by externally-applied forces on the motor shaft for generating operation. The positive and negative speed limits function only during motoring operation and assume control if motor shaft load is low and the commanded value of torque causes motor speed to exceed the limit value. As the unit "crosses over" into speed limit mode it regulates speed at the limit value very much like a standard motor control unit. This continues until shaft load is again increased (by externally applied forces to a level such that the torque command can be satisfied).

The primary use of AM-12 equipped PRD-8 units is in material winders, material unwinders and in torque-slave applications. The following sections describe typical applications.

## 17.10.1 MATERIAL UNWINDERS

### 17.10.1 MATERIAL UNWINDERS

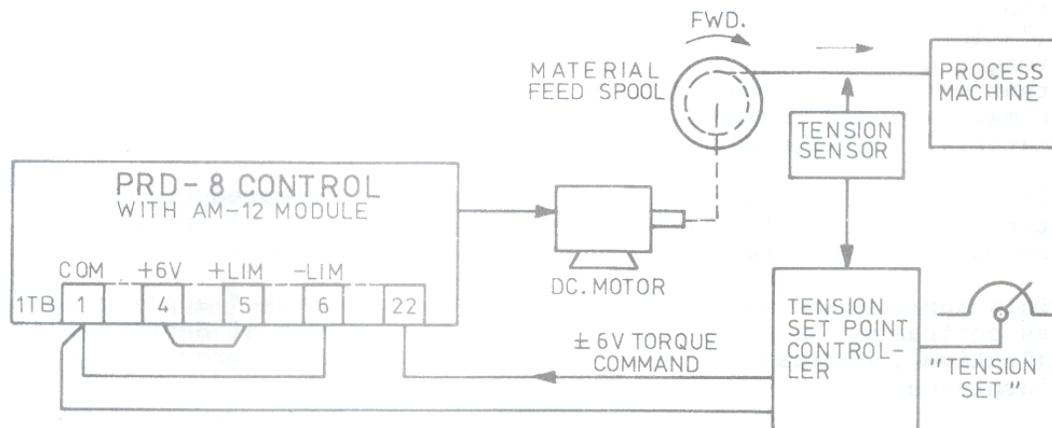


FIGURE 29

#### Controlled-Tension Unwinder

In Figure 29 a process machine pulls material from a spool at a speed which is determined by the process machine. The dc motor is to provide either assisting torque or hold-back torque as required to maintain tension in the material at the desired value. The tension setpoint controller compares measured tension in the material web with desired tension ("Tension Set") and generates a voltage error signal which commands torque of the magnitude and direction required to maintain tension at the desired value. Figure 29 defines forward rotation. For the convention shown armature connections to the motor must be such that 10TB lug A1 on the PRD-8 is positive with respect to Lug A2 during forward rotation. Connections to the setpoint controller must be such that a command for assisting torque (tension too high) delivers a negative signal to Lug 22 of 1TB. The forward speed limit (+ LIM) is set for base speed of the motor by connecting 1TB Lug 5 to Lug 4 (+ 6V). This allows the PRD-8 to deliver either positive or negative current (torque) to the motor as long as rotation is forward and as long as forward speed is not above base speed. The negative speed limit is set for zero speed by connecting 1TB Lug 6 to common (zero volts). This unconditionally prevents the motor from driving the spool in the reverse rotation if material breakage occurs.

If the tension sensor is arranged so that material breakage always causes a "tension too low" signal, then the spool will stop when material breakage or end-of-material conditions occur. The spool stops because a "tension-too-low" condition delivers a torque command signal to Lug 22 which asks for reverse torque (hold-back torque). Since the spool is no longer rotated by the process machine, torque

of this polarity decelerates the spool to zero speed and attempts to drive it in the reverse direction. As the spool reaches zero speed, however, the reverse speed limit ("-LIM"), which is set for zero speed, assume control and the torque command at Lug 22 is disregarded. Thus the net effect is that material breakage causes the motor to brake to a stop and remain stopped, thereby eliminating the need for a separate material breakage detector.

The "STOP" pushbutton on the PRD-8 must be activated before rethreading material (See section 17.2) or motor will apply torque as material is threaded through the tension sensor.

This application is classified as an "active brake" application as contrasted to the "passive brake" application of section 17.6 ("active", because either retarding or assisting torque can be furnished).

### 17.10.2 TORQUE SLAVE

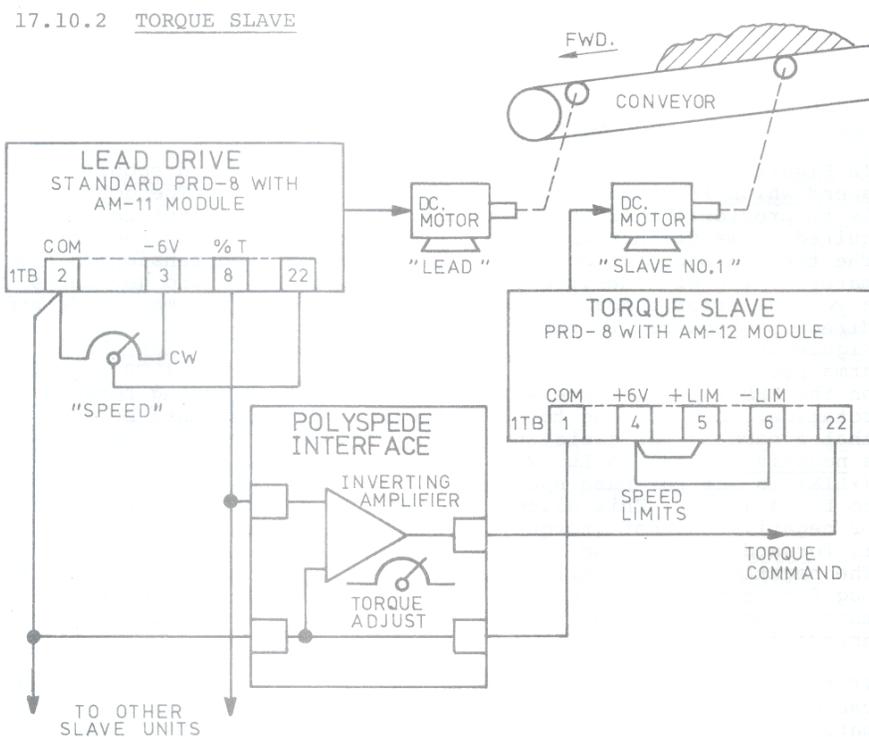


FIGURE 30

Torque Slave

FIGURE 30

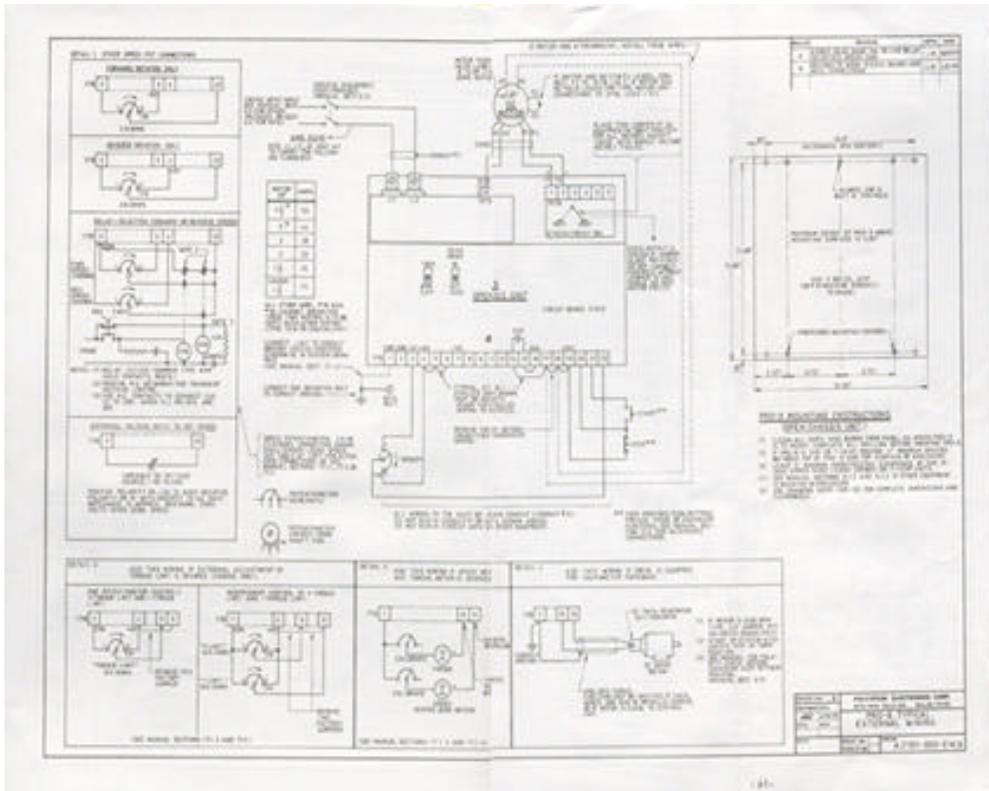
Torque Slave

In Figure 30 the conveyor transports material down a grade. Conveyor design requires multiple drive points to minimize stress on the drive chain. Systems such as this require one speed programmed drive (shown as the "LEAD" drive) which determines direction of rotation and speed of the system. All other drives are torque programmed (torque slaves) to assure load sharing and to avoid fighting between drives for speed control. The voltage at Lug 8 of the lead drive is directly proportional to armature current in the lead motor (See section 17.1.4) but must be increased in amplitude, filtered and inverted to be useful as a command signal. The Polyspede interface performs these functions. When correctly set up, each of the slave drives in Figure 30 furnishes torque equal to that being furnished by the lead drive. All motors are forced to run at identical speeds by virtue of the common mechanical link. Reversal of armature leads in the lead motor is not necessary as was the case in section 17.9 because of the signal inversion provided by the Polyspede interface. The "TORQUE ADJUST" potentiometer shown allows trimming of the slave torque command to adjust torque furnished by the slave unit.

The speed limits ("LIM" and "-LIM") perform no useful function in this application, but must be set higher than maximum system speed by connecting to +6 volts as shown. It may also be necessary to adjust the internal "LIM" and "-LIM" potentiometers further clockwise. It may be desirable to set these speed limits high enough so that overspeed shutdown of a slave unit occurs if a slave drive pinion breaks.

Systems such as the one in Figure 30 should be equipped with a failsafe mechanical brake and an independent overspeed sensing device to apply the brake. Runaway speed could otherwise occur as a result of power failure, of overloading the conveyor, or as a result of protective trip-out of one or more of the PRD-8 units.

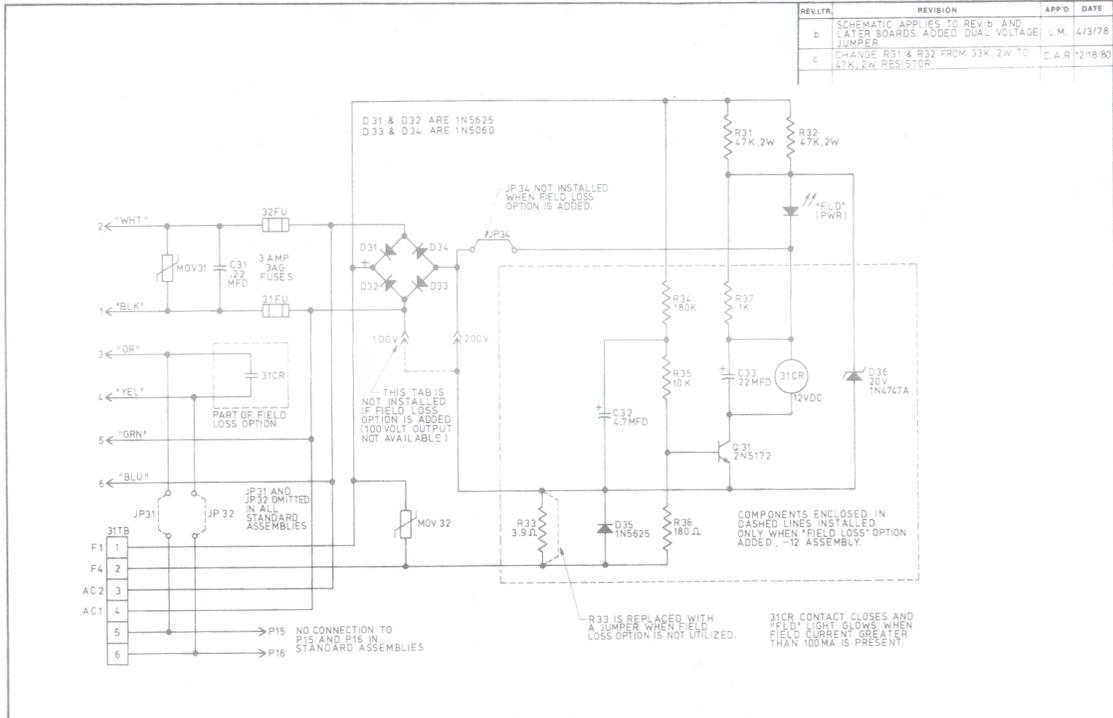
# APPENDIX







REV/LTR	REVISION	APP'D	DATE
B	SCHEMATIC APPLIES TO REV. B AND LATER BOARDS. ADDED DUAL VOLTAGE JUMPER	L.M.	4/3/78
C	CHANGE R31 & R32 FROM 33K, 2W TO 47K, 2W RESISTOR	C.A.R.	12/18/80



E1522b-02 ASS'Y: 230VAC CONTROLS, NO FIELD LOSS RELAY  
 E1522b-12 ASS'Y: 230VAC CONTROLS, WITH FIELD LOSS RELAY  
 NOTE: THIS SCHEMATIC ALSO APPLIES TO EARLIER E1522-02 AND E1522-12 ASSEMBLIES, EXCEPT \*100V-200V\* JUMPER AND JP32 WAS NOT USED ON EARLIER BOARDS.

THIS SCHEMATIC APPLIES TO -02 AND -12 ASSEMBLIES.

DRAWING SIZE	C	POLYSPEDE ELECTRONICS CORP.
DRAFTSMAN	DATE	8770 TWIN HILLS AVE. DALLAS, TEXAS
APP'D	DATE	BOARD, PC, PRD8 FIELD SUPPLY
SCALE	SHEET NO.	FIELD LOSS CIRCUIT
	SHEETS NO.	SCHEMATIC
		E1522-02-ES.c



TABLE 8  
PRD-8 MOTOR-MATCH ADJUSTMENTS

Function of these two adjustments is described in Sections 4.5, 10.3.6, and 13.8 of the PRD-8 manual. This table indicates the dial settings of the "LI" and "WK<sup>2</sup>" potentiometers which match the PRD-8 to the motors listed.

MOTOR TO BE USED					SET LI POT	SET WK <sup>2</sup> POT
MANUFACTURER	HP	RPM	FRAME	DESIGN		
BALDOR (SHUNT)	7 1/2	1750	256U	4 POLE	1	2
BALDOR (SHUNT)	5	1750	256U	4 POLE	0	1
BALDOR (SHUNT)	5	2400	256U	4 POLE	0	0
BALDOR (SHUNT)	3	1750	215	4 POLE	1	1
BALDOR (SHUNT)	3	2400	215	4 POLE	5	2
BALDOR (SHUNT)	2	1750	184	2 POLE	4	3
BALDOR (SHUNT)	1	1750	56	2 POLE	3	4
INDIANA GEN. (PM)	3	1750	143/145T	2 POLE	6	6.5
INDIANA GEN. (PM)	2	1750	143/145T	2 POLE	4	4
INDIANA GEN. (PM)	2	2400	143/145T	2 POLE	4	6
INDIANA GEN. (PM)	1 1/2	1750	143/145T	2 POLE	5	4
INDIANA GEN. (PM)	1	1750	56	2 POLE	5	4.5
INDIANA GEN. (PM)	1	2400	56	2 POLE	5	0
INDIANA GEN. (PM)	3/4	1750	56	2 POLE	6	4
INDIANA GEN. (PM)	3/4	2400	56	2 POLE	6	3
INDIANA GEN. (PM)	1/2	1750	56	2 POLE	4	4
INDIANA GEN. (PM)	1/2	2400	56	2 POLE	4	4
BALDOR (PM)	5	1750	182/184T	2 POLE	4	4
BALDOR (PM)	3	1750	182/184T	2 POLE	4	4
BALDOR (PM)	2	1750	143/145T	2 POLE	4	4
BALDOR (PM)	2	2400	143/145T	2 POLE	4	4
BALDOR (PM)	1 1/2	1750	143/145T	2 POLE	4	4
BALDOR (PM)	1 1/2	2400	143/145T	2 POLE	4	4
BALDOR (PM)	1	1750	56	2 POLE	4	4
BALDOR (PM)	1	2400	56	2 POLE	4	4
BALDOR (PM)	3/4	1750	56	2 POLE	4	4
BALDOR (PM)	3/4	2400	56	2 POLE	4	4
BALDOR (PM)	1/2	1750	56	2 POLE	4	4
RELIANCE (PM)	2	1750	143/145T	2 POLE	4	4
RELIANCE (PM)	1 1/2	1750	143/145T	2 POLE	4	4
RELIANCE (PM)	1	1750	56	2 POLE	4	4
RELIANCE (PM)	3/4	1750	56	2 POLE	4	4
RELIANCE (PM)	1/2	1750	56	2 POLE	4	4
RELIANCE (SHUNT)	5	1750	B1811AT	2 POLE	5	4

Table 8 continued on the next page (notes).

rev.a 6-20-78  
rev.b 9-30-91

NOTES:

- (1) If motor is not listed in Table 8 the following compromise settings may be used with some sacrifice in performance:

2 Pole Motors-----	LI	WK <sup>2</sup>
	4	0
4 Pole Motors-----	0	0

- (2) Warning: If motor is not furnished by Polyspede, User must determine if motor is 2 Pole (brushes located, 180 degrees apart) or 4 Pole (brushes located 90 degrees apart). Rough operation and /or fuse blowing can occur if adjustments are set for 2 Pole motors and a 4 Pole motor is connected.
- (3) Many Permanent magnet motors (2 Pole ) have a very high armature inductance. With this type of motor one of the current limit LED'S may be prematurely illuminated before the actual current limit point is achieved. This generally indicates that the "LI" and "WK<sup>2</sup>" adjustments are set too low. Typically, the current limits on speed programmed drives are set on most controls at the Polyspede factory to limit maximum current to 150% of rated motor current. A 150% current level corresponds to a voltage of approximately 1.5 Volts as measured at the "%T" terminal 9 of 1TB in respect to the common terminal 1 on 1 TB. The premature LED illumination a can be eliminated by setting the "LI" adjustment to 4 and the "WK<sup>2</sup>" to 4 or higher as required for best system response.