MANUAL ADDENDUM FOR ENCLOSED (NEMA 12) SC SYSTEMS CONTROLS

I. GENERAL DESCRIPTION

When ordered, any SC System Control, BSC, FSC, or RSC, can be supplied in a NEMA 12 enclosure. When supplied in this manner, the SC System Control is furnished with a power "Off-On" switch and separate pilot light indication. In addition, the enclosed control can be furnished with an optional operator control station mounted on the enclosure cover. This operator control station has a Speed Adjust Potentiometer. Start, Stop, and Run-Jog selector switches. In addition, on controls that have either a signal isolator or tach follower option, an Auto-Man selector switch is furnished. On RSC (reversing) controls, the Start selector switch is replaced with a FWD-REV selector switch.

II. CONTROL PART NUMBER

On the inside cover of the control will be a red and silver nameplate. This nameplate will basically duplicate another nameplate located on the control except for one or two extra option codes marked in the option code space. The second to last option code should be N12. If the control is supplied with an operator control station, the last option code will be LOC1, LOC2, LOC, or LOC4. The suffix number identified which of the four operator control stations is supplied. Refer to schematic A1751-100-ES for specifics on the operator stations.

It is also possible to specify the remote operator station in its own separate enclosure instead of being mounted in the NEMA 12 SC control enclosure front.

III. MOUNTING

The enclosed SC control must be mounted in an environment that does not exceed 40^{o}C. Since this control uses the back of the box for cooling, the control should be mounted in a location to permit adequate air flow over the back of the enclosure. On 5 HP SC controls it is mandatory that the enclosure back be spaced at least 1/2 inch from any restricting or thermally non-conductive walls. (On 5 HP controls, 5/8 inch spacers are provided to help facilitate installation.) On controls smaller than 5 HP, spacing the back of the enclosure from an insulating wall is not mandatory, but is recommended especially when mounted in environments approaching the maximum 40^{o}C.

IV. WIRING

In wiring the control refer to drawing A1799-008-WD. This drawing shows SC controls with and without an operator control station which can be supplied in the enclosure cover or supplied in a separate remote box. Reference is made in this drawing to drawings A1799-006-ES and A1799-07-EW found in Basic Manual F1700-BM. It will be necessary to refer to these drawings for proper wire size of AC input lines, motor connections, and wiring connection for other options furnished with speed potentiometer connections for those controls furnished without one of the four standard operator control stations.

V. OPERATION

The control should be started and stopped in the following manner to guarantee long life :

1) Turn on power to the control with the power "Off-On" selector switch.

(The following procedure specifically refers to the operation of the control with the standard operator control stations. Operation should be similar if using customer supplied operators.)

2) There are three or four selector switches on the operator control stations. (The fourth selector switch is an Auto-Manual selector switch that is only supplied on controls having a signal isolator or tach follower option. If this switch is present, set to the manual mode; the motor spped will be set by the speed potentiometer.) The Jog-Run selector switch should be placed in the Run Mode. Press the momentary Start switch. The control will energize and run at a speed as set by the manual speed potentiometer. The motor will run at this speed until the Stop switch is pressed. (On reversing controls the two position start selector switch is replaced with a three position "FWD-REV" spring return to center selector switch. Operation is the same except that directional rotation can also be selected.

3) If the center selector switch is placed in the "Jog" position, the motor will run only as long as the Start (FWD or REV on RSC controls) switch is pressed. Speed reference in this mode will be from either the Jog pot on the Jog Speed board (J2 option) or the speed as set by a pot on the preset speeds option board. If neither of these two options is supplied, the speed reference will come from the same source as if the control were operating in the Run mode.

4) This step pertains only to reversing (RSC) drives. When operating in the Run mode and the opposite speed direction pushbutton is pressed, the drive will stop in the same manner as if the Stop selector switch had been pressed. After the motor has dynamic braked to a stop, the drive will restart only if either the Forward or Reverse selector switch position is pressed. This applies to controls that are not equipped with the "Automatic Reversing" feature. When so equipped, the motor will start up in the opposite direction automatically after dynamic braking when the opposite speed is selected.

5) In shutting down the control, first press the Stop selector switch. Then place the power "Off-On" selector switch in the power "Off" position.

For additional information pertaining to adjustments, specifications, troubleshooting, etc. on the SC control, refer to instruction manual F1700-BM.

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1. USING THIS MANUAL

This manual is intended to specifically cover open chassis SC units.

If your primary interest is installation and start-up of a unit, and if no application problems are involved, refer immediately to Section 6 through 10, and to Drawing A1799-007-EW in the Appendix.

In some instances the SC unit may be furnished already mounted in an enclosure. If so, Sections 5 and 7.1 herein may be disregarded.

In other instances the SC 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 A1799-007-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 SC 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 SC unit to perform a specific task or integrating it into a larger system, refer to Sections 2 through 7 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 options codes listed in the block below the "FAMILY" block. However, if the notation "SPEC" follows the model number, the number in the "MOS" block is also required. The "PART NO." block is for insertion of a user part number, if applicable. For further explanation of the entires refer to the illustration below and Tables 2.1 (A), 2.1 (B), and 2.1 (C).

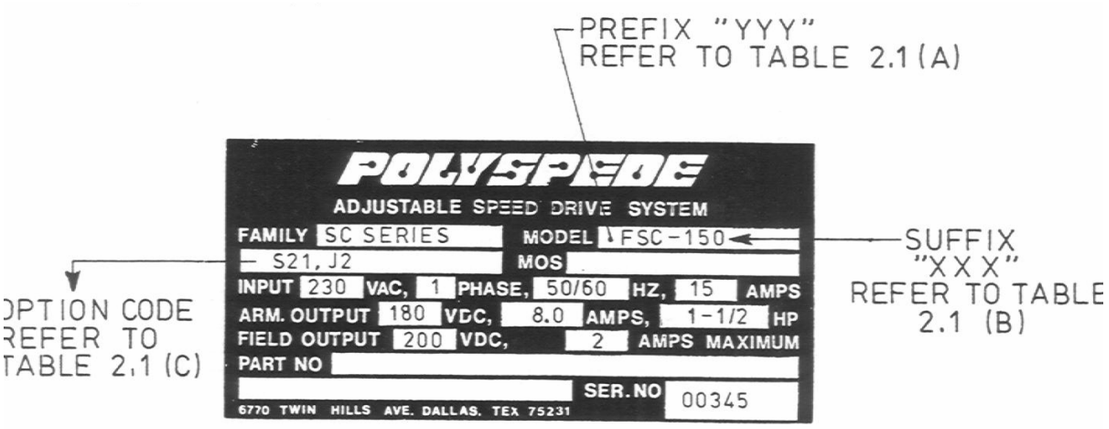


FIGURE 2.1

SAMPLE NAMEPLATE

TABLE 2.1 (A)

MODEL NO. PREFIX "YYY"	DESCRIPTION OF DRIVES
BSC	Basic Systems Control, unidirectional, without any armature disconnect contactors.
FSC	Forward Systems Control, unidirectional, with one forward contactor.
RSC	Reversing Systems Control, bidirectional, forward and reversing contactors and dynamic braking.

TABLE 2.1 (B) ELECTRICAL SPECIFICATION

MODEL NO. SUFFIX "XXX"	INPUT		ARMATURE OUTPUT			FIELD OUTPUT	
	VAC (rms)	AMPS (rms)	VDC	AMPS	HP	VDC	AMP (MAX)
-12	115	2.5	90	1.45	1/8	100	2
-16	115	4.0	90	1.75	1/6	100	2
-25	115	6.0	90	3.0	1/4	100	2
-33	115	6.5	90	3.75	1/3	100	2
-50	115	10	90	6.0	1/2	100	2
-75	115	14	90	8.0	3/4	100	2
-100	115	18	90	10.5	1	100	2
-26	230	3.0	180	1.45	1/4	200	2
-34	230	4.0	180	1.75	1/3	200	2
-51	230	6.0	180	3.0	1/2	200	2
-76	230	7.0	180	3.75	3/4	200	2
-101	230	12	180	6.0	1	200	2
-150	230	15	180	8.0	1 ½	200	2
-200	230	20	180	10.5	2	200	2
-300	230	30	180	15.0	3	200	2
-500	230	43	180	24.0	5	200	2

TABLE 2.1 (C)

STANDARD OPTIONS AND MODIFICATIONS		OPTION CODE ON NAMEPLATE	SEE MANUAL SECT.	CIRCUIT BOARD SUPPLIED
Dynamic Braking		D	2.4.1	NONE
Signal Isolator	1-5 ma input	S11	2.4.2	E1531-11
	4-20 ma input	S12	2.4.2	E1531-12
	10-50 ma input	S13	2.4.2	E1531-13
	0-6 VDC input	S21	2.4.2	E1531-21
	90 VDC max input	S31	2.4.2	E1531-31
	180 VDC max input	S32	2.4.2	E1531-32
	240 VDC max input	S33	2.4.2	E1531-33
	550 VDC max input	S34	2.4.2	E1531-34
	10-20 VDC max input	S41	2.4.2	E1531-41
	20-40 VDC max input	S42	2.4.2	E1531-42
	40-80 VDC max input	S43	2.4.2	E1531-43
	75-150 VDC max input	S44	2.4.2	E1531-44
Tach Follower	6-20 VDC max input	TF1	2.4.3	E1535-01
	20-65 VDC max input 25-75 VAC max input	TF2	2.4.3	E1535-02
	65-200 VDC max input 75-230 VAC max input	TF3	2.4.3	E1535-03
Preset Speeds	7 external signal	PS0	2.4.4	E1532-07
	3 int. & 1 ext. signal	PS3	2.4.4	E1532-31
	4 internal signal	PS4	2.4.4	E1532-40
	6 int. & 1 ext. signal	PS6	2.4.4	E1532-61
	7 internal signal	PS7	2.4.4	E1532-70
Jog Speed	0-100% adjustable	J2	2.4.5	E1534-01
Tach Feedback BSC & FSC Controls with 50V/1000 RPM Tachometers	For 1150 RPM motors	T1	2.4.6	NONE
	For 1750 RPM motors	T2	2.4.6	NONE
	For 2400 RPM motors	T3	2.4.6	NONE
Reversing Tach Feedback RSC Controls with 50V/1000 RPM Tachometers	For 1150 RPM motors	TR1	2.4.6	NONE
	For 1750 RPM motors	TR2	2.4.6	NONE
	For 2400 RPM motors	TR3	2.4.6	NONE
Torque Program		TP	2.4.7	NONE
Auto Reversing		AR	2.4.8	NONE

2.2 GENERAL FEATURES

The SC Series is a family of open chassis mini-systems, which can be used as a complete DC motor control system by itself or as a modular building block for more sophisticated systems. The SC series by itself has several levels of sophistication which can be furnished readily depending on the application. Refer to A1799-002-BD, SC series block diagram. The features common to the entire series are discussed in the following paragraphs of this section.

The SC mini-systems, in the simplest form, can be viewed as having two basic building blocks : 1) The control circuitry, and 2) The Input/Output circuitry.

The Control Circuitry

The Control circuitry incorporate the use of a power bridge (two SCRs, two diodes, and a freewheeling diode) and a sophisticated regulator scheme that maintains motor speed precisely at the set level within the advertised motor and control speed ranges. There are two control loops, speed and torque, that operate simultaneously and independently of each other. In most cases speed loop is in control. (The speed loop can use either armature voltage or tachometer voltage feedback.) When in control the speed loop maintains speed constant at the desired value until the motor load (torque) requirements exceed a preset value, normally 150% of rated motor torque. As this occurs, the torque regulator assumes control of the SCRs and allows speed to drop as is necessary in order to maintain and not exceed the preset limit value. If motor load continues to increase, as would be the case if a driven machine had jammed, the torque limit is capable of holding this preset value of torque precisely without running down to locked rotor or zero speed condition. Operation in both speed and torque modes is smooth and stable, and through the use of optimized networks transfer between the two loops is smooth and bumpless.

In the speed mode the control holds the motor speed constant at a value determined by the voltage present at the Speed Input. In a basic control this voltage is set by a Speed Adjust potentiometer, but as well as explained later, could be set by other means of external speed programming. In most controls armature voltage is used as feedback in the speed (velocity) loop. When using armature voltage feedback, load changes are compensated for by an "IR" compensation circuit which senses any increase in armature current and raises the armature voltage to compensate for the increased voltage drop in the motor armature. This circuit thus controls the regulation (speed changes) due to load changes. The motor current is continuously monitored by a very low wattage dissipation current shunt. The signal from this shunt which is also used in the torque loop, is then fed to the "IR" circuit which permits the achievement of no load to full regulation of less than 1% of base speed. In applications requiring load regulation better than 1% of base speed, tachometer feedback must be used.

The SC family covers horsepower sizes 1/8 through 5 HP. It is possible to field convert the supplied control to some other horsepower size by changing the current shunt link. Refer to Section 13 for possibilities and limitations of field conversion.

The SC power bridge is protected against excessive current overloads by the outstanding torque (current) limit circuitry. In addition the SC unit is protected against damage due to accidental wiring shorts or ground in the AC input line(s). (In 115 VAC controls only one fuse is provided. Therefore the unfused AC line must be the ground line.)

Input/Output Circuitry

The SC input/output circuitry is used as an interface between the control circuitry, the drive command operators and options. There are several assembly levels of this circuitry, furnished economically depending on the application of the system. CMOS logic gates have been used to economize space. Reeds and DIP relays are used on the front end to keep industrial noise glitches from fouling the sequence of operations. This circuitry has its own latching networks, which make it possible for the user to wire in simple pushbuttons with momentary contacts for operator commands. These latches may be disarmed by simply removing terminal block jumpers, which transfers the control to the "JOG" mode. In the "JOG" mode the motor runs only as long as the operators are held activated. Refer to A1799-007-EW external wiring diagram.

The input/output circuitry has its own isolated +12V and −12V power supplies which are isolated from the AC line and earth ground. These power supplies are also used to drive the options boards. There is a power-on timer which keeps the control disabled for 200 msec after power is initially turned on. This allows all the power supplies to stabilize before any operator command is passed down to the firing circuit of the control circuitry and contractors (if used). Electronic timing and interlocks are provided to prevent making and breaking of current through contacts in contactor equipped models, thus resulting in long contactor life. The circuitry is designed such that in reversing models, where two contactors are used, the first contactor disengages before the other one is engaged. All models have an LED marked "FWD" and reversing models also have one marked "REV". They indicate that the motor has been given the command to turn in the respective direction.

2.3 DRIVE CONFIGURATIONS

For better understanding of the SC mini-systems one must recognize the fact that each of these systems specifically belongs to one of the following drive configurations : BSC, FSC, and RSC. Hereafter, these terms will be used freely throughout this text.

2.3.1 BSC – Basic System Control

BSC is a unidirectional control without any armature disconnect contactors. All standard options and modifications listed in Section 2.4 apply to this configuration, except dynamic braking and auto reversing. The motor is always connected to the output of the

power bridge. In this configuration power to the motor is cut off by inhibiting the firing circuit from firing the SCRs.

2.3.2 FSC – Forward System Control

FSC is a unidirectional control with an armature disconnect contactor (FCON). All standard options listed in Section 2.4 apply to this configuration, except auto reversing. The contactor timing network is such that the contactors physically disengage the motor from the bridge "after" the SCRs have stopped firing, thus eliminating arcing at the contacts.

2.3.3 RSC – Reversing System Control

RSC is a bidirectional control with forward (FCON) and reverse (RCON) contactors. Dynamic braking is a standard feature on all RSC units. With respect to FCON, RCON is wired in such a way that, when energized, it reverses the polarity of the voltage and the direction of the current going to the armature. Since the field voltage polarity is kept unchanged, energizing RCON causes a DC motor to reverse its direction of rotation. The same arcless feature described for FSC units in Section 2.3.2 applies for RSC units. However, some arcing may be seen when the system first enters the dynamic braking cycle. Also refer to Section 2.4.1 on dynamic braking.

2.4 STANDARD OPTIONS AND MODIFICATIONS

Options and modifications described in this section have been pre-designed for the SC Series. Addition of these options does not change the footprint of the control.

2.4.1 Dynamic Braking (D)

This is a factory installed option. Dynamic braking is achieved due to the fact that when the armature of a DC motor is disconnected from the power bridge, the motor operates as a generator. (Power must be supplied to the field coils of a shunt wound motor.) Dynamic braking is achieved on SC controls by allowing the motor, which is operating as a generator, to dump its energy to an appropriate resistor, R53 (or R53/R54). Refer to A1799-006-ES in Appendix. During dynamic braking the current from the motor is routed to the dynamic braking resistor(s) through the normally closed (N.C.) contacts of FCN and RCON (were applicable). When the motor first begins the dynamic braking circle, some arcing may be seen on the N.C. contacts of the contactor due to contact bounce.

Dynamic braking is not applicable to BSC units and is always installed on RSC units. It is a factory installed option on FSC units.

All controls that are furnished with dynamic braking are also equipped with an anti-plug circuit. Once the control begins dynamic braking, this circuit inhibits the "FWD" or

REV" command until the dynamic braking cycle is completed. As a general rule, the frequency of stops of reversals should be limited to no more than one per minute, and the load inertia reflected at the motor shaft be no larger than the motor armature inertia. (Consult factory for more frequent braking and high inertial load.)

Table 2.4.1 lists the values of dynamic braking resistors used in different SC models.

TABLE 2.4.1

MODEL NO. SUFFIX	INPUT SERVICE (VAC)	CONTROL HORSEPOWER (HP)	DYNAMIC BRAKING RESISTOR(S)
-12	115	1/8	20 ohms, 135 watts
-16	115	1/6	20 ohms, 135 watts
-25	115	1/4	10 ohms, 135 watts
-33	115	1/3	10 ohms, 135 watts
-50	115	1/2	5 ohms, 135 watts
-75	115	3/4	5 ohms, 135 watts
-100	115	1	5 ohms, 135 watts
-26	230	1/4	20 ohms, 135 watts
-34	230	1/3	20 ohms, 135 watts
-51	230	1/2	20 ohms, 135 watts
-76	230	3/4	20 ohms, 135 watts
-101	230	1	10 ohms, 135 watts
-150	230	1 ½	10 ohms, 135 watts
-200	230	2	10 ohms, 135 watts
-300	230	3	5 ohms, 270 watts
-500	230	5	5 ohms, 270 watts

2.4.2 External Signal Isolator (S11, S12, S13, S21, S31, S32, S33, S34, S41, S42, S43, and S44)

The external signal isolator is a factory or field installed option. It is compatible with all other standard options except Tachometer/Voltage Follower. This option incorporates the use of E1531 PC board assembly mounted on four nylon standoffs above the input/output PC board, E1530. There are twelve variations of this option to be used with different external signals. The user should refer to Table 2.4.2. to verify that the E1531 PC board assembly furnished is compatabile with the external signal used. The external signal should be wired to terminal block 60TB lugs 2 and 3. A precision absolute value circuit is used in this option. This makes the option insensitive to the external signal polarity.

The E1531 PC board has three adjustments, "ZERO," "CAL" (calibration) and "RATIO". The "RATIO" potentiometer is normally set fully clockwise and may be trimmed down by the user if desired. The "ZERO" and "CAL" potentiometers are set at the factory for proper application and input signal. However, on options S41, S42, S43, and S44, the "CAL" potentiometer is set at the safe level and is to be adjusted by the user during actual operation. (Refer to Section 9.1)

All variation of this option utilizes an "AUTO-MANUAL" relay. Isolated +12V applied at terminal 100TB-8, with respect to ISO.COM. 100TB-22, energizes this relay and the "AUTO" LED on E1531 PC board lights up. In this "AUTO" mode the control speed is programmed by the external signal. In the manual mode the "auto-manual" relay is de-energized and the control speed is programmed by the voltage on the manual pot wiper anchored at 100TB-12. Refer to drawing A1799-006-ES and A1799-007-EW in the Appendix. The output of the signal isolator can be monitored at 100TB-21 with respect to COM., 100TB-11. If the system is set up right, in the "auto mode" this voltage should vary linearly from zero to +6 volts DC for the entire operating range of the external signal.

TABLE 2.4.2

OPTION CODE	PC BOARD ASSEMBLY	INPUT VOLTAGE OR CURRENT RANGE	VALUE OF INPUT RESISTORS IN OHMS			APPLICATION
			R82	R83	R84	
S11	E1531-11	1-5 ma DC, INPUT	JUMPER	1K	JUMPER	PROCESS INSTRUMENT FOLLOWER
S12	E1531-12	4-20 ma DC, INPUT	JUMPER	270Ω	JUMPER	
S13	E1531-13	10-50 ma DC, INPUT	JUMPER	100Ω	JUMPER	
S21	E1531-21	0-6 VDC, INPUT	JUMPER	100K	JUMPER	VOLTAGE ISOLATOR
S31	E1531-31	90 VDC, MAX INPUT	150K	22K	150K	ARMATURE VOLTAGE FOLLOWER
S32	E1531-32	180 VDC, MAX INPUT	330K	22K	330K	
S33	E1531-33	240 VDC, MAX INPUT	470K	22K	470K	
S34	E1531-34	550 VDC, MAX INPUT	1MEG	22K	1MEG	
S41	E1531-41	10-20 VDC, MAX INPUT	15K	22K	15K	LINE TACHOMETER FOLLOWER
S42	E1531-42	20-40 VDC, MAX INPUT	39K	22K	47K	
S43	E1531-43	40-80 VDC, MAX INPUT	68K	22K	120K	
S44	E1531-44	75-150VDC, MAX INPUT	150K	22K	220K	

2.4.3 Tachometer/Voltage Follower (TF1, TF2, and TF3)

The Tachometer/Voltage Follower is a factory or field installed option. It is compatible with all other standard options except the external signal isolator, E1531 PC board. This option incorporates the use of E1535 PC board assembly mounted on four nylon standoffs above the input/output PC board, E1530. There are three variations of this option to be used with different line-isolated external signals, such as a tachometer or an isolated voltage source. The user should refer to Table 2.4.3 to verify that the E1535 PC board assembly is compatible with the tachometer or voltage source used for external signal. The external signal should be wired to terminal block 60TB. Lugs 60TB-2 and 60TB-3 are to be used for wiring in line-isolated DC signals. Refer to external wiring diagram A1799-007-EW for correct polarity connections. Lugs 60TB-4 and 60TB-5 are to be used for wiring in line-isolated AC signals. Connections should be made to only one set of input terminals for any given application. The use of AC voltage signals is applicable only on TF2 and TF3 and should not be used on TF1 (refer to Table 2.4.3).

The E1535 PC board is basically a voltage divider network with one adjustment potentiometer, "CAL" (calibration). The "CAL" potentiometer is set at the factory at safe level and is to be adjusted by the user during actual operation. (Refer to Section 9.2)

All variation of this option utilizes an "AUTO-MANUAL" relay. Isolated +12V applied at terminal 100TB-8, with respect to ISO.COM 100TB-22, energizes this relay and the "AUTO" LED on E1535 PC board lights up. In this "AUTO" mode the control speed is programmed by the isolated external signal. In the manual mode the "auto-manual" relay is de-energized and the control speed is programmed by the voltage on the manual pot wiper anchored at 100TB-12. Refer to drawing A1799-006-ES and A1799-007-EW in the Appendix. The output of the tach/volt follower can be monitored at 100TB-21 with respect to COM. 100TB-11. If the system is set up right, in the "auto mode" this voltage should vary linearly from zero to +6 volts DC for the entire operating range of the external signal.

TABLE 2.4.3

OPTION CODE	PC BOARD ASSEMBLY	INPUT VOLTAGE RANGE	VALUE OF INPUT RESISTORS IN OHMS	
			R62	R63
TF1	E1535-01	6-20 VDC maximum	3.9	3.9
TF2	E1535-02	20-65 VDC maximum or 25-75 VAC maximum	15K	12K
TF3	E1535-03	65-200 VDC maximum or 75-230 VAC maximum	68K	56K

2.4.4. Preset Speeds (PSO, PS3, PS4, PS6 and PS7)

This option is a factory or field installed option. It is compatible with all other options except adjustable jog speed. There are five variations of this option, depending on the application requirements (Refer to Table 2.4.4)

TABLE 2.4.4

OPTION	DESCRIPTION	PC ASS'Y
PS0	7 speeds set by remote pots or external signals.	E1532-07
PS3	4 speeds, 3 set by internal pots, and 1 controlled by external signal.	E1532-31
PS4	4 internal speed pots.	E1532-04
PS6	7 speeds, 6 set by internal pots, and 1 controlled by external signal.	E1532-61
PS7	7 internal speed pots.	E1532-70

All seven speed channels are available with PS0, PS6, or PS7 options. Only four speed channels are available with PS3 and PS4 options. Options PS0, PS3, and PS6, which are designed to accomodate external signals, have an eight place terminal block 153TB installed on the E1532 PC board. The PC board is not furnished with 153TB for options PS4 and PS7.

This option basically enables the user to program the system so that different preset speed-program voltages are automatically selected during different modes of operation. The speed program voltages are set between zero and +6 volts DC with respect to COM. (100TB-11 on E1530 PC board). Each speed channel is selected through four-input AND logic. The preset voltage corresponding to the selected speed channel is transmitted directly to the control circuitry, E1507 PC board. At any instant, the voltage programming the speed of the motor can be measured at 100TB-13 (SPD), with respect to 100TB-11 (COM), on the E1530 PC board. This option can be programmed by one of the following methods.

Method 1 consists of removing terminal block jumpers from 150TB and replacing them with maintained normally open remote switches. Gold contacts are required if relays are used. Positions for wiring these switches are cleary marked as S1, S2, S3, etc. on the silk-screen of the E1532 PC board. For example, closure of the switch wired in position marked S1 enables speed number 1 to be selected. In this case the motor speed is controlled by setting of speed pot number 1 or external signal number 1 (as in the case of PS0).

Method 2 consists of programming the E1532 PC board so that conditions to select a certain speed channel are set by operator commands; namely AUTO or MAN, RUN or

OG, and FWD or REV. Each speed channel has an eleven place programming strip designated to it. Operator command functions are clearly marked on the silkscreen. Refer to Figure 2.4.4.

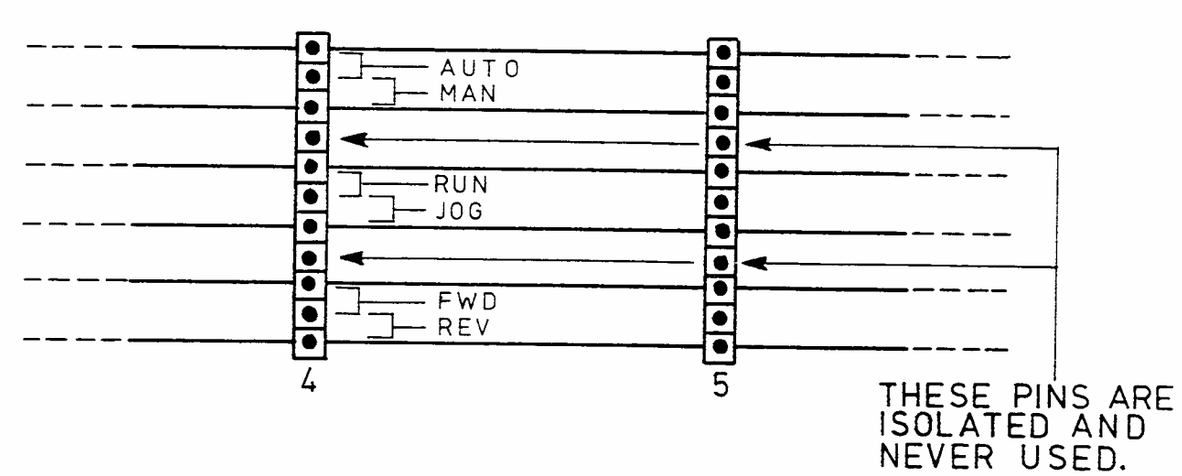


FIGURE 2.4.4: PROGRAMMING STRIPS

Conditions for selecting a speed channel are set by placing program plugs over appropriate pairs of pins on the designated programming strip. In other words, each strip is functionally equivalent to three independent SP3T switches. Ten program plugs are furnished with each preset speeds option. Additional program plugs are available from Polyspede Electronics and can be ordered separately if necessary (Berg Part No. 65474-001). Any operator command not exclusively picked up by placing the plugs is ignored by the "AND" logic, i.e., logic inputs not pinned down by the program plugs are automatically always "HI" and pulled up to +12 volts. In order for method 2 to be workable, the terminal board jumpers placed on 150TB should be left in place.

Method 3 is a combination of methods 1 and 2. Conditions set by operator commands and the closure of switches wired to 150 TB determine whether a certain speed channel is enabled.

There is another feature of this circuitry that deserves mentioning at this point. If during any mode of operation of the system conditions set up by any of the three methods described above enables two or more speed channels simultaneously, then the output will be selected by the speed channel designated by the highest number. For example, if conditions prevail to enable both speed channels number 3 and 7 simultaneously, then the speed number 7 will be selected at the output. This feature could be used to simplify programming if the application permits.

The E1532 PC board has three LED indicators marked "1", "2", and "4". The LEDs indicate in BCD (binary coded decimal) the designation number of the selected speed channel. The LED marked "4" represents the most significant bit and the LED marked

1" represents the least significant bit. For example, say the LEDs marked "4" and "1" are in the ON state and the one marked "2" is in the OFF state. This indicates that speed channel number 5 is selected. In other words, the sum of the numbers represented by the LEDs in the ON state indicates the selected speed channel number.

For further guidelines on programming the E1532 PC board, refer to the Appendix.

2.4.5 Adjustable Jog Speed (J2)

This is a factory or field installed option and is available on all three drive configurations, BSC, FSC and RSC. It is compatible with all other standard options except preset speeds. This option consists of an E1534 PC board assembly mounted on the imput/output PC board, E1530, which snap-on nylon standoffs. The jog speed board assembly includes a JOG speed potentiometer, a relay and an LED indicator, and is linked with a ribbon cable to the E1530 PC board. The potentiometer adjusts jog speed 0-100% of base speed. Unless specified otherwise, jog speed potentiometer is set at the factory at 10% of full scale. When +12 volts is applied to 100TB-7, the LED lights and the relay is activated. The activated relay disconnects any other speed input and feeds the JOG command to the SCR drive. Refer to external wiring diagram A1799-077-EW for use of RUN-JOG selector switch (not supplied with control, unless specified). The JOG command is accomplished if the RUN-JOG switch is in the JOG position and the FORWARD (or REVERSE) switch is held activated.

The Adjustable Jog Speed option can be used in conjunction with the External Signal Isolator or the Tachometer/Voltage Follower. However, the "JOG" command always overrides the "AUTO" or “MANUAL" commands.

2.4.6 Tachometer Feedback (T1, T2, T3, TR1, TR2, and TR3)

Using Tachometer Feedback improves load regulation to 0.1% of base speed and minimizes speed change due to motor heating and line voltage variation. There are six standard variations of this option. Refer to Table 2.4.6 for matching option code vs. application. Tachometer Feedback option requires a simple modification which can be performed at the factory or in the field. However, the motor base speed must be known before the control can be modified correctly. The modification to the SC unit includes replacement of the armature voltage feedback with tachometer feedback and provision of the correct tachometer scaling network, but it does not include the required motor-mounted tachometer generator. A motor-mounted DC tachometer generator with an appropriate 50 volts per 1000 RPM output must be specified separately. This option for RSC (reversing) units also includes the addition of a circuit board mounted tachometer reversing relay.

TABLE 2.4.6

OPTION CODE	DRIVE CONFIGURATION	MOTOR BASE SPEED	FACTORY MODIFICATIONS	
			RESISTORS CLIPPED ON E1507 PC BOARD	ON E1530 PC BOARD
T1	BSC OR FSC	1150 RPM	NONE	NONE
T2	BSC OR FSC	1750 RPM	R22	
T3	BSC OR FSC	2400 RPM	R18	
TR1	RSC	1150 RPM	NONE	RELAY 104CR IS ADDED AND JUMPERS JP104 AND JP105 ARE CUT
TR2	RSC	1750 RPM	R22	
TR3	RSC	2400 RPM	R18	

2.4.7 External Torque Program (TP)

This simple modification of SC units can be done either at the factory or in the field. This modification is accomplished by simply removing the terminal board jumper between 100TB-9 and 100TB-10. A voltage of +6 volts DC at 100TB-10 (TORQ) with respect to 100TB-11 (COM) will give that torque preset by the internal "TORQ" pot on the E1507 PC board. If larger value of programming voltage is available it must be scaled down by a voltage divider network so that the maximum voltage that appears at 100TB-10 (TORQ) with respect to 100TB-11(COM) is +6 volts. A zero to +6 volts voltage variation between terminal lug 10 (TORQ) and 11 (COM) on 100TB will vary the maximum torque capability from zero to that value preset by the internal "TORQ" pot. Normally the internal torque pot is set to limit the current at 150% of rated current. However, in some external torque program applications it may be required that the control be run at torque limit for prolonged length of time. In this case the user should adjust the internal torque pot so that with +6 volts DC at 100TB-10 (TORQ) the torque (current) limits is set at 100% rated current. (See Section 9.3 for adjustment). Refer to A1799-007-EW for directions on wiring an external torque pot.

2.4.8 Auto Reversing

This option is applicable to RSC (reversing) units only. It is compatible with all other standard options. It requires a simple modification which can be implemented at the factory or in the field. The modification consists of removing the jumper JP106 and changing the identification "dash number" or assembly number on the E1530 PC board

assembly. With this modification, the motor will reverse if the applicable operator switch, "FORWARD" or "REVERSE", is momentarily activated. (Note : Without this modification, the operator must first allow the motor to "STOP" before a reversal command is registered, or the operator must hold the switch activated until motor stops before a reversal can occur.) This modification simplifies certain limit-switch applications on reversing machines and is not recommended in cases where it might introduce operator hazard.

2.5 FUSES

WARNING

FUSES F1 AND F2 IN SC UNITS ARE FAST ACTING RECTIFIER PROTECTION FUSES AND MUST NOT BE REPLACED WITH UNAPPROVED SUBSTITUTE. IF FUSE REPLACEMENT BECOMES NECESSARY REPLACE ONLY WITH APPROPRIATE FUSES SPECIFIED IN TABLE 2.5 FOR CONTROLS WITH DIFFERENT HORSEPOWER RATING.

TABLE 2.5

CONTROL HORSEPOWER RATING	FUSES F1 AND F2*	FUSES F3** AND F4**
1/8HP - 2HP	International Rectifier SF25X25 Chase Shawmut A25X25	---
3HP	International Rectifier SF25X30 Chase Shawmut A25X30	---
5HP	International Rectifier SF50P60 Chase Shawmut A50P60	Littelfuse 3AG, 5AMP

- Units with 115VAC line service are not equpped with F2. Therefore, L2 must be connected to the grounded side of 115VAC line.
- Fuses F3 and F4 are only included in 5 HP units.

3. SC SERIES SPECIFICATIONS

Input voltage (single phase).....	115VAC ± 10 volts (115V models) 230VAC ± 20 volts (230V models)
Input frequency.....	50/60 Hz
Output voltage :	
a) To armature (rectified & unfiltered)...	0-90VDC (115V models) 0-180VDC (230V models)
b) To field (rectified & unfiltered).....	100VDC (115V models) 200VDC (239V models) unregulated, 2 amps max
Maximum ambient temperature, SC unit mounted in a 20" x 20" sealed enclosure.....	40°C
Maximum allowable temperature of air in user's cabinet :	
a) With in-cabinet fan.....	65°C
b) With no cabinet fan.....	55°C below uppermost SC unit
Overload capability for 1 minute	150% of rated current
Load regulation for 100% load change :	
a) With armature feedback.....	adjustable to 1% of base speed
b) With tachometer feedback.....	1% of base speed typical
Line regulation (speed change for ± 10VAC line voltage change in 115V models and for ± 20VAC change in 230V models) :	
a) PM motors and armature feedback, or any motor and tachometer feedback.....	1% of base speed
b) Shunt field motor and armature feedback.....	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
Speed range.....	0 to 100%
Speed range for specified regulation.....	30:1 with PM motors 20:1 with shunt motors
Speed program voltage (voltage on lug 13) with respect to lug 11 of 100TB) to produce zero to 100% speed.....	0 to 6VDC
Torque program voltage (voltage on lug 10 with respect to lug 11 of 100TB) to produce zero to preset max torque limit.....	0 to 6VDC
Acceleration time (zero to 100% base speed).....	Linear .5 to 15 sec adjustable
Torque limit (% of rated motor current).....	Approx. 75 to 150% adjustable
Envelope dimensions (physical size) :	
a) 1/8 through 2 HP.....	10½"H x 14"W x 5"D
b) 3 HP.....	10½"H x 14"W x 5½"D
c) 5 HP.....	10½"H x 14"W x 6"D
Mounting centers, all models.....	10" x 12" (symmetrical) (4 holes, 7/32" diam.)

4. MOTOR SELECTION

Polyspede offers matched motor-control combinations which eliminate the necessity of the user considering the following guidelines when selecting a motor. However, the following precautions must be taken by those who wish to mate an SC series control to an existing motor.

The performance of a DC motor, operated from a rectified alternating-current supply, differs significantly from that of the same motor operated from a direct current source. The DC motor selected to be used with SC series controls must be rated appropriately for single phase, full-wave, SCR drives. DC motors for use with SCR drives are readily available from several motor manufacturers. The user should refer to the motor manufacturer's specifications to verify whether the motor in question is rated for full-wave rectified AC power – Horsepower rating, armature voltage and field voltage specified on the motor nameplate should match those specified on the control nameplate.

5. ENCLOSURE SELECTION AND LAYOUT

This section is intended as an aid to the OEM in incorporating SC units into his equipment. Polyspede offers SC units pre-installed in appropriate enclosures which eliminates the necessity of the user considering the following factors for selecting enclosures and layout positions.

The open chassis SC 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 Enginering Company is a common supplier. Several SC units may be mounted in the same enclosure or a SC unit may be located in the same enclosure with other equipment. If mounted in an enclosure with other equipment or with other SC units, all notes on Drawing A1799-007-EW concerning routing and separation of wiring must be observed. 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.

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

a) Max. air temp. around circuit boards..... $70^{o}C$

b) Max. power cube or power module base plate temp..... $105^{o}C$

Condition (b) above is met if temperature of the mounting base of the SC unit is monitored at a point adjacent to power cube, and does not exceed $95^{o}C$.

Specific information on single unit installation in non-ventilated enclosures is given in Section 5.1. Methods for determining optimum layout and enclosure size for multiple installations and installations with other high power equipment are given in Section 5.2 and 5.3 respectively.

To avoid any undesirable thermal problems affecting the components on the PC boards, the user should comply with either of the two mounting orientations shown in Figure 5.

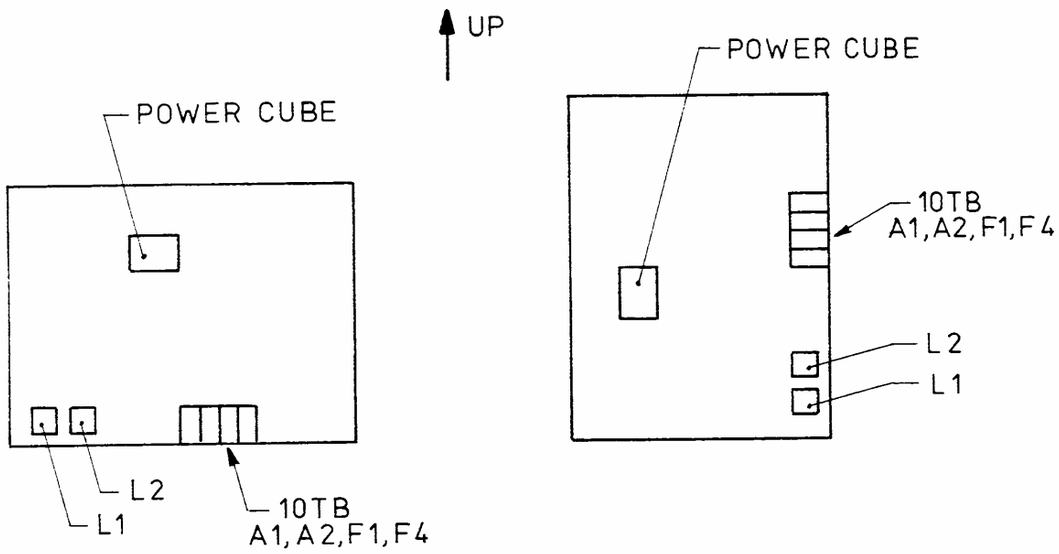


FIGURE 5

RECOMMENDED MOUNTING ORIENTATION

5.1 Enclosure Sizing, Single Unit Installation

If a single SC unit is placed in an unventilated enclosure with no other heat generating equipmnet, then the minimum size of the enclosure can be selected from Table 5.1 Before using this table, one must ascertain whether the system has dymanic braking. If the system includes dynamic braking then TDB, the average interval between consecutive dynamic braking cycles, must be approximated for the particular application. The minimum enclosure sizes in the table have been suggested under the assumption that the load inertia reflected at motor shaft is no larger than motor armature inertia. (FOR HIGH INERTIAL LOADS WITH DYNAMIC BRAKING CONSULT FACTORY)

TABLE 5.1

MOTOR HP	CONDITIONS		MINIMUM ENCLOSURE SIZE	INCLUDE 100 CFM FAN?
	*DYNAMIC BRAKING INCLUDED?	**T_{DB}		
5	NO	---	20" x 20" x 6"	NO
	YES	MORE THAN 10 MIN	20" x 20" x 6"	NO
	YES	5 TO 10 MIN	20" x 20" x 6"	YES
	YES	1 TO 5 MIN	24" x 24" x 6"	YES
3	NO	---	20" x 20" x 6"	NO
	YES	MORE THAN 10 MIN	20" x 20" x 6"	NO
	YES	1 TO 10 MIN	20" x 20" x 6"	YES
2 AND UNDER	ALL MODELS	MORE THAN 1 MIN	LIMITED BY THE PHYSICAL FIT OF THE SC UNIT	NO

- Dynamic braking is not applicable to BSC units. It is optional of FSC units and comes as a standard feature on RSC units.

- TDB is the average period between consecutive dynamic braking cycles.

5.2 Enclosure Sizing, Multiple Unit Installations

All models and applications of SC units except 5HP and 5HP units with dynamic braking cycles more frequent than once every 10 minutes are considered in this section. For enclosure sizing of multiple unit installations using 5HP and 3HP SC units with dynamic braking cycles more frequent than once every 10 minutes, the user should refer to the method described in Section 5.3.

In general all SC units, besides the exceptions defined above, installed in any arrangement in sealed (NEMA 12 and NEMA 14) cabinets will yield acceptable temperatures if in-cabinet fans are used to prevent localized heat buildings. A 4" minimum spacing must be provided between the SC units, top and sides.

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

1) SC units of any horsepower rating and application mounted in single horizontal row (except 5HP and 3HP units with dynamic braking cycles more frequent than once every 10 minutes); four inch minimum spacing between units and 4" minimum spacing to top surface of cabinet.

2) SC units (besides the exceptions defined in (1)) arranged in two horizontal rows with no 5HP units in the top row; same minimum spacing as in (1), preceding.

3) SC units, all of 2HP or lower rating, arranged in three horizontal rows; minimum spacing as in (1), preceding.

The user should limit the mounting orientation to either of the two ways illustrated in Figure 5. None of the preceding cases are changed significantly if items such as control relays, contactors of less than 10 amp rating, control transformers of less than 250 VA rating, and other SCR controls of 3HP or lower rating are added, provided additional panel space (and thus larger enclosure volume is allotted for the added components.

5.3 Enclosure Sizing, When Other High Power Equipment Is Added

If SC units are placed in the 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 by 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 5.3.1 is provided as an aid toward cabinet sizing. It gives the maximum power dissipated in various horsepower SC units without the dynamic braking feature.

TABLE 5.3.1

230 VAC INPUT SERVICE	
MOTOR HP	MAXIMUM WATTS DISSIPATED IN SC UNITS W/O DYNAMIC BRAKING
5	80
3	46
2	39
1 ½	31
1	23
3/4	16
1/2	14
1/3	10
1/4	9

115 VAC INPUT SERVICE	
MOTOR HP	MAXIMUM WATTS DISSIPATED IN SC UNITS W/O DYNAMIC BRAKING
1	37
3/4	29
1/2	21
1/3	14
1/4	12
1/6	8
1/8	7

If an SC unit is equipped with dynamic braking (all RSC units, and FSC units with D option), then additional average power dissipation due to dynamic braking can be calculated as shown in the following steps.

Step 1. First the energy (in joules) dissipated during each dynamic braking cycle is calculated using the equation below.

$$W_{DB} = \frac{2.16 \times 10^{-4} (J_{MOTOR} + J_{MACHINE}) (VM)^2 R_{DB} \text{ Joules}}{R_{DB} + R_{ARM}}$$

Where,

W_{DB} = Energy (in joules) dissipated during each dynamic braking cycle.

J_{MOTOR} = Armature inertia of motor in lb-ft^2.

$J_{MACHINE}$ = Inertia of machine and/or load, reflected at the motor shaft in lb-ft^2.

V_M = Motor speed (in RPM) at which dynamic braking cycle begins. For worst case consideration, use motor base speed.

R_{DB} = Value of dynamic braking resistor in ohms. Refer to Table 2.4.1.

R_{ARM} = Value of armature resistance in ohms.

Step 2. Now the average power dissipated (in watts) due to dynamic braking :

$$P_{DB} \text{ (watts)} = \frac{W_{DB} \text{ (joules)}}{T_{DB} \text{ (sec)}}$$

where,

P_{DB} = Average power dissipated (in watts) due to dynamic braking.
T_{DB} = Average interval (in sec) between dynamic braking cycle.

A 100 CFM in-cabinet fan adds about 14 watts to the power dissipation in the cabinet.

Specifications of "other equipment" placed in the enclosure should be examined to assure that the equipment can tolerate 60^{o}C temperature. All Polyspede SCR drives are designed to tolerate this temperature.

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 circuit board or other components exists.

7. INSTALLATION

7.1 Mounting

Assure that the enclosure and enclosure layout meet the requirements of Section 5. Refer to Drawing A1799-007-EW for mounting details. Locate all conduit entry holes, cable duct, and wiring hardware to conform to notes on this drawing.

Drill the four holes required for mounting the SC unit to the enclosure panel. The use of tapped holes is preferable to facilitate servicing without the necessity of panel removal. Deburr all 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 SC UNITS.

If unforeseen drilling is required after mounting SC units, do not allow any drill chips to fall into the SC units.

Take special care while mounting all 5HP SC units. Clean each mounting area and be sure that the mounting area as well as the 5HP SC base plate is free of chips and burrs and that the mounting area is flat. Good thermal contact between all 5HP SC base and the enclosure panel is important.

7.2 Wiring Procedure

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

1. A1799-007-EW (in the Appendix) for all standard open chassis SC units or for SC unit 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 100TB). All terminal blocks on the SC unit are of the wire-clamp type which do not require wire lugging.

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 the correct field connections.

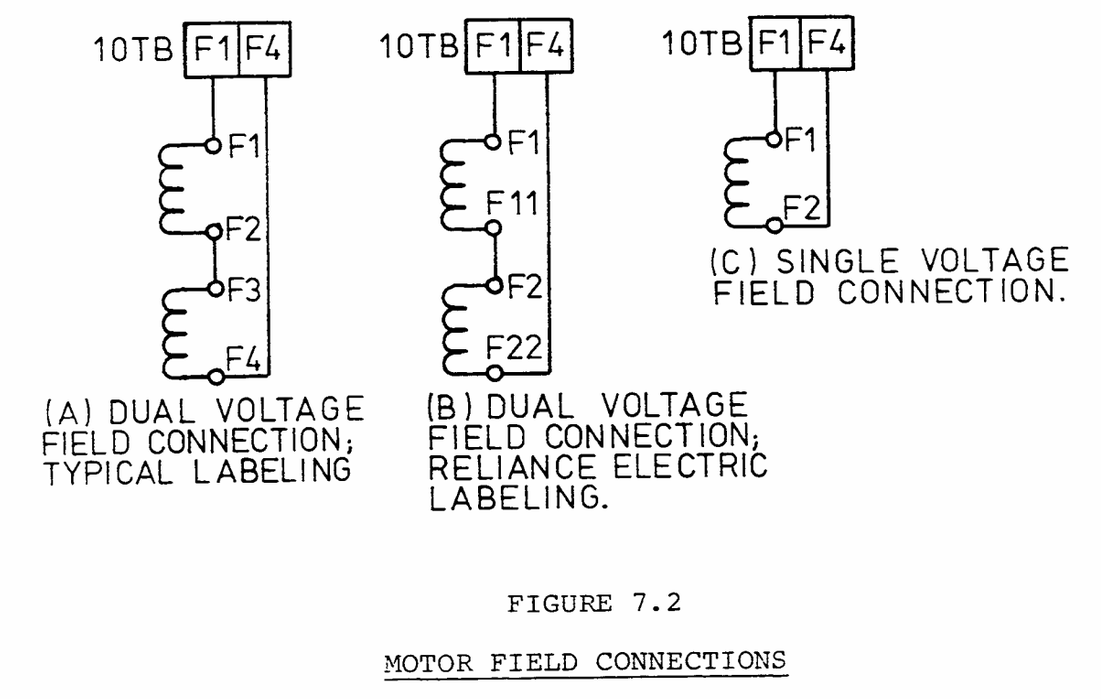


FIGURE 7.2

MOTOR FIELD CONNECTIONS

Important Note on PM motors :

Permanent magnet motors (PM motors) require no field connection (no connection to 10TB lugs F1 and F4 on the SC unit). Unfortunately, some motor manufacturers supply PM motors with unlabeled thermostart 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 10TB lugs F1 and F2.

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.

Recheck all wiring. Accidental grounds on any of the motor leads or speed potentiometer wires may damage the unit when power is applied. Make sure that the AC service is of the correct voltage as indicated by the voltage warning label located on the control.

Perform the following instruction steps in order. Bypass any step that is not applicable. Use only ungrounded meters for measuring. All controls are tested prior to shipping. However, if necessary refer to Section 11 for trouble-shooting procedure.

Step 1. Apply power from the AC disconnect switch. The "POWER ON" LED indicator on the E1507 PC board will light indicating that power is applied.

Step 2. If the unit is furnished with signal isolator option (E1531 PC board), or tachometer/voltage follower option (E1535 PC board), place the "Auto-Manual" switch in the "Auto" position. Then verify that the voltage at 100TB-21 (SIG) with respect to 100TB-11 (COM) varies from zero to +6 VDC for the entire operating range of the external signal. If the calibration is not correct, then refer to Section 9.1 for E1531 PC board or Section 9.2 for E1535 PC board.

Step 3. Monitor the voltage at 100TB-13 (SPD) with respect to 100TB-11 (COM) with a voltmeter. Place the "Run-Jog" selector (if used) in the "Run" position and the "Auto-Manual" switch (if used) in the "Manual" position. Rotate the manual "Speed" pot from completely clockwise (CW) position to completely counterclockwise (CCW) position. The voltmeter reading should change from +6 VDC to zero volts. If the voltmeter reading is backward, then reverse the speed pot leads wired to 100TB-9 (hot +6V) and 100TB-11 (COM). ALWAYS TURN POWER OFF TEMPORARILY WHILE RE-ARRANGING ANY WIRING CONNECTION TO THE SC UNIT.

Step 4. If the control is equipped with external torque program (option TP on nameplate), check the voltage at 100TB-10 (TORQ) with respect to 100TB-11 (COM). Before proceeding to step 5, set this voltage at +6 VDC by rotating the "EXT.TORQ" pot fully clockwise or by applying a +6 VDC external torque signal. If the control is not equipped for torque program, a factory jumper should be in position between 100TB-9 and 100TB-10.

Step 5. As described in Step 3, monitor the speed command voltage at 100TB-13 (SPD). With this voltage set at zero volts, initiate a start command by pushing the "START" (or "FWD") switch. The "FWD" LED on the E1530 PC board should light indicating that the control is in the forward or run mode. If the motor does not turn or

turns very slowly, go directly to step 6. But if the control is equipped for tachometer feedback and the motor runs at high speed with zero volts at 100TB-13, immediately push the stop button and disconnect AC power. This is obviously due to wrong polarity of the tach feedback signal. Interchange the tachometer leads connected at 100TB-16 and 100TB-17. Turn AC power on again and repeat Step 5.

Step 6. Increase the speed command voltage monitored at 100TB-13 (SPD) to 1 volt. The motor will now rotate (in the FWD direction). If the direction of rotation is correct, proceed directly to Step 7. But if the motor rotates in the wrong direction, stop the control and disconnect the AC power. Interchange A1 and A2 connections to the motor at terminal block 10TB and on units equipped with tach feedback it is also mandatory to interchange the tachometer leads connected at 100TB-16 and 100TB-17. Turn AC power on again and repeat Steps 5 and 6.

Step 7. Refer to Section 9.3 and verify the calibration of the E1507 PC board.

Step 8. Perform this step only on RSC (reversing) units. As described in Step 3, monitor the speed command voltage at 100TB-13 (SPD). With this voltage set at zero volts, initiate a run command by pushing the "REV" switch. The "REV" LED on the E1530 PC board should light indicating that the control is in reverse mode. At this time, with zero volts reading at 100TB-13 (SPD), the motor should not turn. But as this voltage is increased to +6 VDC, the motor should begin to turn and attain maximum speed.

Step9. If the control is equipped with auto-reversing, preset speeds, or adjustable jog speed options, refer to Sections 2.4.8, 2.4.4, and 2.4.5 respectively for description. Check for satisfactory operation of each of these options.

9. ADJUSTMENTS

Before leaving the factory, all units are tested under realistic conditions. Adjustments are made to check each SC unit for proper performance. In numerous cases, the user will find that the adjustments made at the factory are adequate and correct for his application. However, there are some adjustments that can only be set correctly in the field. All internal adjustments on the SC unit are permanent and periodic readjustment is not necessary. While going through the stepwise initial turn-on procedure in Section 8, the user is referred to the following subsections.

9.1 E1531 PC Board, External Signal Isolator

This Section is only applicable to SC units that are furnished with E1531 PC board, the external signal isolator.

The E1531 PC board has three internal adjustments : "ZERO," "CAL" (calibration), and "RATIO." Before making any adjustments, the "Auto-Manual" switch should be placed in the "Auto" position energizing the relay 60CR on the PC board. The adjustments should be made in the following order :

1. "ZERO" and "CAL" Adjustments. Before making any of these adjustments the "Ratio" potentiometer is first set fully clockwise. Then, depending on the application, the "Zero" and "Cal" adjustments are made following the procedure described in either of the paragraphs (a) or (b).

   (a) Process (Current) Follower Applications (S11, S12 or S13) :
   In this case there is interaction between "Zero" and "Cal" adjustments and some repetition is necessary before proper adjustment is achieved. With the E1531 PC board input terminals 60TB-2 and 60TB-3 disconnected from the process control instrument (zero current), set the "Zero" pot such that −1.5 VDC output appears at terminal 100TB-21 (SIG) with respect to 100TB-11 (COM). Reconnect the process signal lines and apply maximum signal current (5 ma, 20 ma or 50 ma as the case may be), then adjust the "Cal" pot so that +6 VDC is read at 100TB-21 (SIG) with respect to 100TB-11 (COM). Iterate the procedure described above at least two times. Now with minimum signal current (1 ma, 4 ma or 10 ma as the case may be) the voltage read at 100TB-21 (SIG) should be zero volts (± 20 mV). At this time adjust the "Zero" pot if necessary and check the "Cal" pot setting for maximum signal current.

   (b) Voltage Follower Applications (S21 through S44) : There is no interaction between adjustment pots for voltage follower applications. With zero input voltage across input terminals 60TB-2 and 60TB-3, adjust the "Zero" pot so that zero volts DC (±20 mV) appears at 100TB-21 (SIG). After properly zeroing the "CAL" pot should be set so that +6 VDC appears at 100TB-21 (SIG) with respect to 100TB-11 (COM) when maximum signal voltage is applied to the input terminals 60TB-2 and 60TB-3.

2. "RATIO" Adjustment. After calibrating for a +6 VDC at 100TB-21 (SIG) with respect to 100TB-11 (COM) for maximum input signal, the "RATIO" pot can be adjusted counterclockwise to set for any lower desired voltage at 100TB-21 (SIG). The ratio pot will permit an adjustment anywhere from zero to 100% of calibrated input current or voltage.

9.2 E1535 PC Board, Tachometer/Voltage Follower (Non-Isolated)

This section is applicable only to SC units that are furnished with E1535 PC board, the tachometer/Voltage follower.

The E1535 PC board has only one internal adjustment : "CAL" (calibration). Before any adjustment is made, the "Auto-Manual" switch should be placed in the "Auto" position. The adjustment is made by setting the "Cal" pot so that +6 VDC appears at 100TB-21 (SIG) with respect to 100TB-11 (COM), when maximum input voltage is applied at the input terminals. Input terminals 60TB-2 and 60TB-3 are polarity sensitive and should be used for line isolated DC signals only. On the other hand, input terminals 60TB-4 and 60TB-5 are insensitive to polarity and are to be used with line isolated AC signals or DC signals that may periodically change polarity.

9.3 E1507 PC Board, Control Circuit

This board has five internal adjustments :

a) IR (load) compensation ("IR")
b) Minimum speed ("MIN")
c) Maximum speed ("MAX")
d) Torque (current) limit ("TORQ")
e) Acceleration ("ACC")

All the above adjustments except "IR" and "ACC" are preset at the factory. A typical test motor is utilized. The "MAX" and "TORQ" adjustments do not depend on individual motor characteristics and therefore should be correct as received for armature feedback. However, for tachometer feedback, the user will have to reset the "MAX" adjustment. The "IR" and "MIN" adjustments are somewhat dependent on charactertistics of the particular motor used, and should therefore be made by the user when the drive is installed. Job-site adjustment of "IR" is necessary to achieve specified regulation for control using armature feedback. The "IR" potentiometer is set fully counterclockwise when using tachometer feedback.

Table 9.3 gives the adjustment procedure for the E1507 PC board. The adjustments are completely independent of each other except as noted below :

i) "IR" has a slight effect on "MIN",
but "MIN" does not affect "IR".
ii) "MIN" has a slight effect on "MAX".

Thus, performing adjustments in the order listed in Table 9.3 eliminates any necessity for repeating a calibration operation.

Note that the torque limit ("TORQ") is independent of the other adjustments. Since this is basically a protective adjustment, preset at the factory, it should not be re-adjusted except to decrease the limit point.

TABLE 9.3 ADJUSTMENT PROCEDURE FOR E1507 PC BOARD

ADJUSTMENT NAME	DESCRIPTION OF FUNCTION: NOTES	ADJUSTMENT PROCEDURE
"IR"	Sets the load regulation (% slowdown of motor as shaft load is changed from zero to full rated load). If load slowdown is of no concern, rotate "IR" trim pot fully counterclockwise. (In tach feedback systems this pot must be turned fully counterclockwise.)	Approximate Method: a) Set speed control knob for 20% speed. b) Rotate "IR" trim pot clockwise until motor begins to hunt. c) Back off "IR" trim pot 1/3rd of the span between this setting and zero setting. This method usually results in slight over-compensation. Exact Method: a) Turn drive power off and connect a DC ammeter in series with the A1 motor lead between motor and control. Do not use clamp-on meter. b) Set speed control knob for 20% speed. c) Turn drive power on. With motor shaft loaded lightly, read motor speed with a strobe light or a tachometer. d) Load the motor shaft until ammeter reads rated motor current (see nameplate). Read motor speed with strobe light or tachometer. e) If motor speed decreased as motor was loaded, adjust the "IR" trim pot and repeat c) and d) until little or no speed decrease is noted. f) In performing d) and e), be sure motor is not loaded heavily enough to cause torque limiting to occur. g) Remove ammeter and reconnect A1 motor lead. Recheck control at very low speed for cogging.
"MIN"	Sets the zero calibration of the speed control knob (speed program voltage at 100TB-13 SPD is 0 volts with respect to 100TB-11 COM). Clockwise rotation of "MIN" trim pot increases speed.	a) Set speed control knob to zero. b) Rotate the "MIN" trim pot clockwise until motor starts to rotate. c) Decrease the "MIN" trim pot setting until motor rotation stops.

TABLE 9.3 (CONTINUED)

"MAX"	Calibrates the speed at which motor turns when speed control knob is fully clockwise. (Speed program voltage at 100TB-13 SPD is +6 volts DC with respect to 100TB-11 COM.) Clockwise rotation of the "MAX" trim pot increases maximum motor speed.	a) Turn drive power off. b) Connect a DC voltmeter between A1 and A2 motor leads at the motor. c) Set meter scale so that rated armature voltage (90 volts or 180 volts as noted on motor nameplate) may be read. d) Turn power on. Turn speed control knob fully clockwise. e) Adjust "MAX" trim pot until meter reads nameplate rated voltage (90 volts or 180 volts). NOTE: If desired, a tachometer or strobe light may be used in lieu of the DC voltmeter. Proceed as described above, except adjust "MAX" trim pot until tachometer or strobe light indicates that motor is turning at base speed.
"TORQ"	(Torque Limit) Sets the maximum torque that can be obtained from the motor, and the maximum armature current that the control unit will deliver. Torque adjustment is preset at the factory, usually for 150% of rated motor torque (current). Clockwise rotation of the "TORQ" trim pot increases the torque that the motor will deliver.	a) Turn power off. b) Connect a DC ammeter (not a clamp-on type) in series with the A1 motor lead between motor and control unit. c) Turn power on. d) Verify that voltage at terminal 100TB-10 (TORQ) with respect to 100TB-11 (COM) is +6 VDC ±5%. e) Set speed control knob for low speed (e.g., 10% setting). f) Apply friction braking to the motor shaft until motor stalls out. CAUTION: Watch ammeter to assure that control is limiting current. g) Stall current should read maximum 150% of rated armature current (see motor nameplate). h) If current is too high, rotate the "TORQ" pot counterclockwise to decrease.
"ACC"	Acceleration adjustment sets time for motor to reach set speed.	Adjust to desired acceleration time. Clockwise rotation increases time. (Adjustment range is 0.5 to 0.15 sec.)

9.4 E1532 PC Board, Preset Speeds Board

Unless additional documentation, furnished with a control, indicates special factory modifications on the E1532 PC board, all internal speed pots range from zero to 100% of base speed. At the factory, all internal speed pots on the preset speeds board are set fully counterclockwise, zero speed. Job-site adjustments must be made by the user to obtain the desired speeds. Clockwise rotation of a preset speed pot increases the related speed.

9.5 E1534 PC Board, Adjustable Jog Speed Board

This board has only one adjustment; "JOG" speed. Unless additional documetation, furnished with the control, indicates special factory modification on the E1534 PC board, the "JOG" speed is adjustable from zero to 100% of base speed. At the factory, the "JOG" potentiometer is set at 10% of base speed and may be readjusted by the user to any desired speed. Clockwise rotation of the "JOG" pot increases the jog speed.

10. OPERATING GUIDELINES

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 service disconnect must be off when servicing control, motor or machines.

Prior to shipment, all SC units are tested at the Polyspede factory. Therefore, after properly wiring and following the "Initial Turn-on Procedure" in Section 8, and adjustments in Section 9, the control should be functioning properly. Occasional checking, to ensure that motor is not loaded to the extent where it is required to continuously deliver over 100% rated torque, can prove beneficial in terms of longer motor life. This check can be done by temporarily wiring a DC ammeter in series with the motor armature lead, and is only necessary if the situation is questionable.

If at any time a fault occurs, where the motor speed cannot be controlled, fuses blow, or other problems are experienced with the control, refer to Section 11 for trouble shooting information.

11. TROUBLE-SHOOTING THE SC UNIT

The procedures contained in this section are intended to aid the user in identifying whether a problem is due to the DC motor, SC unit, or wiring external to the SC unit. Procedure 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 SC unit, either replace the entire unit or repair it by replacing the faulty subassemblies as described in Section 14.

A VOM and a DC ammeter (0-50 amps range) are all that is required for field test and adjustments. If an oscilloscope is ever used on an SC unit, it must be ungrounded, or damage to the instrument and/or control could occur during measurements of un-isolated sections of the SC unit. Shock hazard is present in some oscilloscopes when they are operated ungrounded.

WARNING

DANGEROUS VOLTAGES ARE PRESENT ON THE SC UNIT. ONLY PERSONNEL FAMILIAR WITH ELECTRICAL TEST PROCEDURES, TEST EQUIPMENT, AND SAFETY PRECAUTIONS SHOULD ATTEMPT THESE TESTS.

11.1 OCCASIONAL FUSE BLOWIG

Occasional fuse blowing can be caused by intermittent shorts to ground in the DC motor or in motor wiring. Check motor connections, especially in motor condut box. Blow carbon dust out of the motor using an air hose. Inspect all wiring including motor brush pigtails. Check motor per Section 12. Look for wire clippings, loose hardware, etc. around the fuses, power bridge, and contactors (if furnished)

WARNING

DO NOT REPLACE FUSES WITH UNAPPROVED SUBSTITUTES. INCORRECT FUSES WILL ALSO BLOW, BUT WILL PROBABLY ALLOW FAILURE OF THE POWER BRIDGE OR OTHER COMPONENTS BEFORE BLOWING. REPAIR COST WILL BE INCREASED AND WARRANTY MAY BE VOIDED. SEE SECTION 2.5 FOR APPROVED FUSES.

11.2 REPETITIVE FUSE BLOWING

If fuses blow repetitively, the problem must be isolated and corrected before further trouble-shooting can be done. Reptitive fuse blowing is usually the result of the same problems that are mentioned for occasional fuse blowing, but may also be due to a faulty PC board or failed power bridge. A light bulb checkout procedure may be used without danger of damaging the control and without excessive fuse blowing during checkout.

Trouble-shooting procedure for repetitive fuse blowing is given in flow chart form on page 35. Proceed systematically with this flow chart. Follow all instructions accurately. DO NOT TAKE ANY SHORTCUTS. Use drawing A1799-006-ES in Appendix to aid in identifying terminal blocks and terminal lugs mentioned on the flow chart.

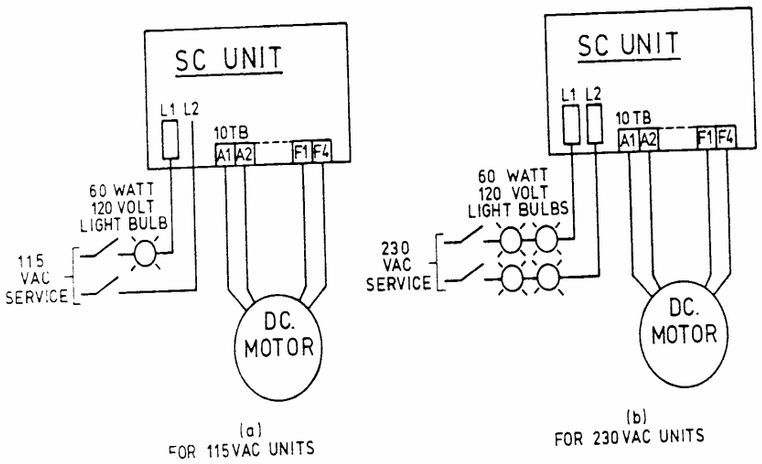
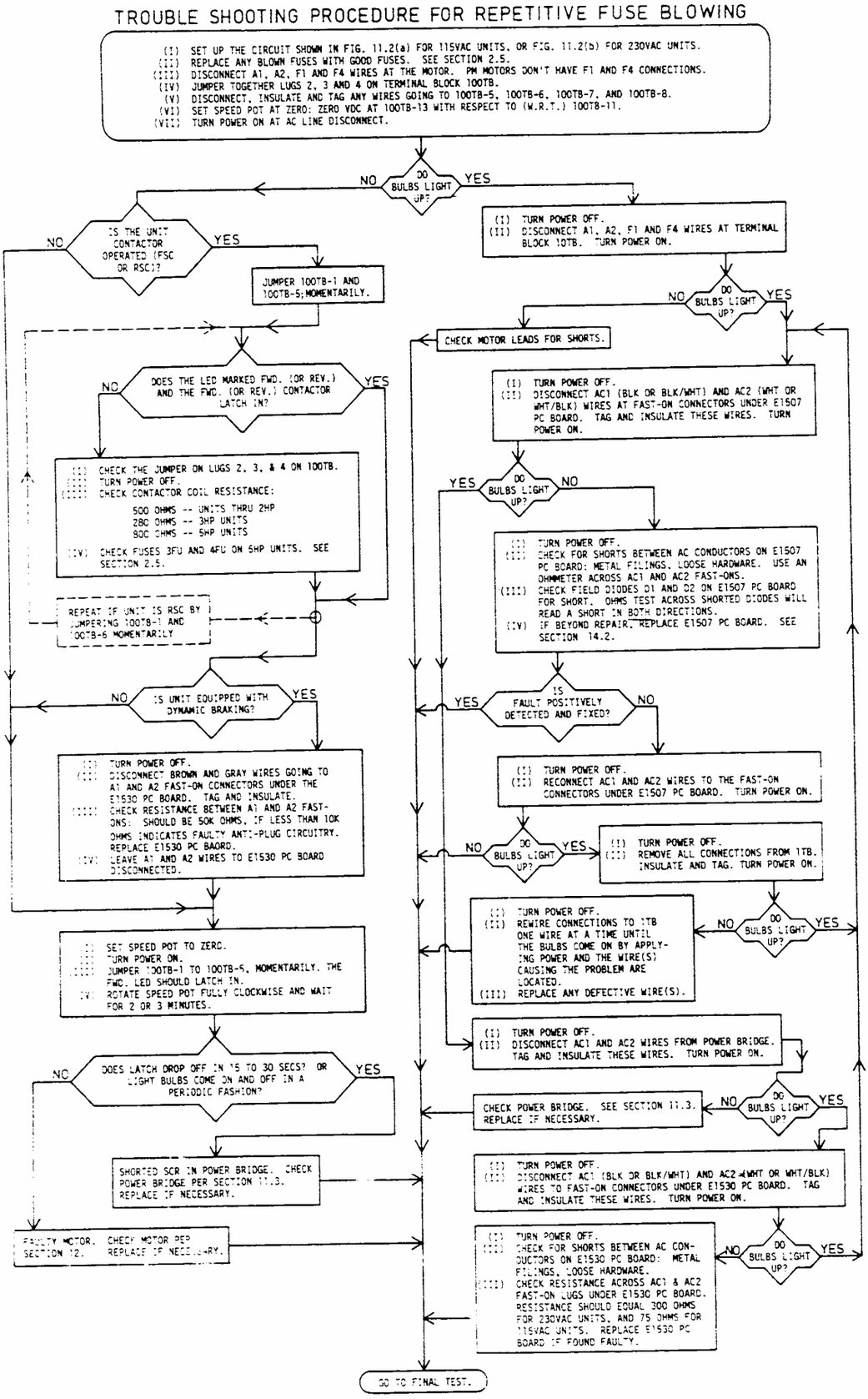


FIGURE 11.2 SETUP FOR LIGHTBULB CHECKOUT PROCEDURE

TROUBLE SHOOTING PROCEDURE FOR REPETITIVE FUSE BLOWING



TROUBLESHOOTING PROCEDURE FOR REPETITIVE FUSE BLOWING: (CONT'D.)

FINAL TEST

(I) Check motor field with ohmmeter. Reassure that the field wiring is set up correctly; see section 7.2 (figure 7.2). Field resistance should be between 100 ohms to 600 ohms. Omit this step for PM motors.

(II) Replace any faulty wires, PC boards, power bridge, motor, etc.

(III) Reconnect all the wires to 10TB, if removed previously.

(IV) Reconnect A1 and A2 wires to the motor but leave F1 and F4 wires off.

(V) Reconnect all other wirings that may have been disconnected, except wires going to 100TB-5, 100TB-6, 100TB-7, and 100TB-8.

(VI) On units equipped with dynamic braking, leave A1 (Brn) and A2 (Gry) wires going to fast-on connectors under E1530 PC board disconnected. Check resistance between these fast-on connectors; should be around 50K.

(VII) Set speed pot to zero.

(VIII) Turn power on.

(IX) Jumper 100TB-1 and 100TB-5; momentarily. Fwd. command circuit should latch on, but the bulbs should not light up.

(X) Rotate the speed pot 20% clockwise. One of the following observations should be made:

(a) All models except 5 HP FSC or RSC units: The light bulbs should come on and stay. Randomly on certain units the light bulb will phase back on turning the speed pot back to fully counterclockwise.

(b) 5 HP FSC or RSC units: The light bulbs will come on until the contactor drops off due to not having sufficient voltage at the coil. On certain random cases the latch circuit may not drop off completely. This will send the bulbs and the contactors in a periodic on-off cycle, which is quite normal.

(XI) If the results of this final test prove out normal, disconnect the light bulb(s) and re-connect any remaining loose wires and wire the control for normal operation. Refer to drawings A1799-006-ES and A1799-007-EW in the appendix.

11.3 PROCEDURE FOR TESTING POWER BRIDGE

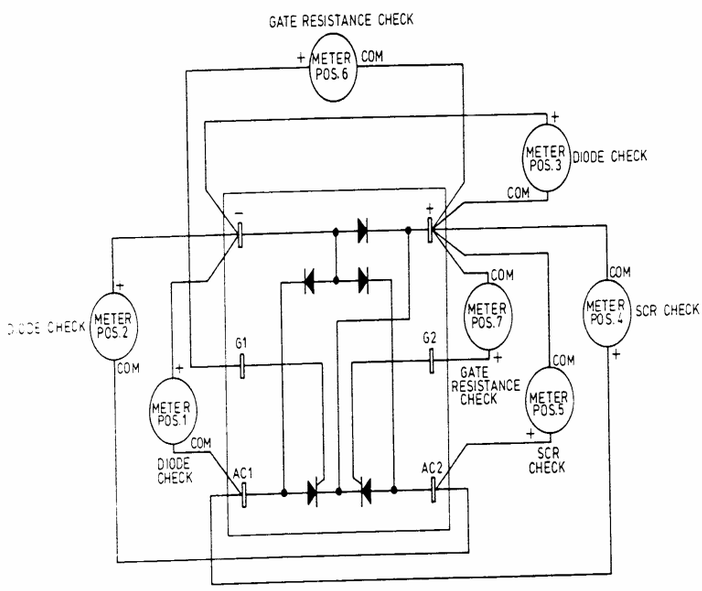
The power bridge is comprised of 2 SCR's and 3 diodes in a configuration shown in Fig. 11.3 (a) for SC units through 3HP and Fig. 11.3 (b) for 5HP SC units. Simple test with an ohmmeter cannot conclusively show that an SCR or diode is good, but shorted or open SCR's or diodes can be detected. The power bridge is easily accessible for ohmmeter test by simply removing the 2 screws securing the E1507 PC board to its standoffs on the right and then rotating the PC board on its hinges to the left. With power turned off, remove all wires connected to the power bridge. (On 5HP units, also remove all buss bar linking the power modules together ; bend the wires attached to the freewheeling diode so that they don't accidentally touch the binding posts on the power modules). Refer to Fig. 11.3 (a) or (b) depending on the unit's horsepower size. Using a Simpson 260 or equivalent, verify the measurements listed in Table 11.3 for meter positions 1 through 5. Check both for meter polarity shown in Fig. 11.3 and the reverse.

After the measurements listed in Table 11.3 have been verified, measure the gate resistance of the SCR's as indicated by pos. 6 and pos. 7 on Figure 11.3. This value could fall anywhere between 15 ohms and 4K ohms, which is okay. Typical values of gate resistance range between 20 ohms and 150 ohms.

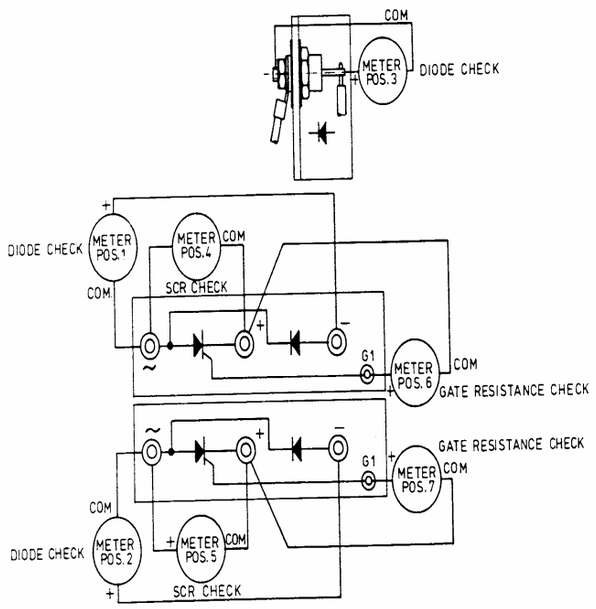
Replace the bridge if found faulty. Reconnect the bridge as shown in drawing A1799-066-ES in Appendix. For 5HP units, also refer to Figure 14.3 for proper location of lugs and hardware.

TABLE 11.3 OHMMETER VERIFICATION FOR POWER BRIDGE

SC UNIT HP SIZE	METER POLARITY	METER POSITION FIG. 11.3(a) OR (b)				
		1	2	3	4	5
THRU 3HP	AS SHOWN IN FIG. 11.3(a)	400Ω - 1K ON Rx100 SCALE	400Ω - 1K ON Rx100 SCALE	400Ω - 1K ON Rx100 SCALE	VERY HIGH RESISTANCE ON Rx10,000 SCALE	VERY HIGH RESISTANCE ON Rx10,000 SCALE
	REVERSE OF FIG. 11.3(a)	∞	∞	∞	"	"
5HP	AS SHOWN IN FIG. 11.3(b)	350Ω - 1K ON Rx100 SCALE	350Ω - 1K ON Rx100 SCALE	350Ω - 1K ON Rx100 SCALE	VERY HIGH RESISTANCE ON Rx10,000 SCALE	VERY HIGH RESISTANCE ON Rx10,000 SCALE
	REVERSE OF FIG. 11.3(b)	∞	∞	∞	"	"



(a.) FOR SC UNITS THRU 3HP.



(b.) FOR 5HP SC UNITS.

FIGURE 11.3 METER POSITIONS FOR TESTING POWER BRIDGE

11.4 PROCEDURE IF MOTOR DOES NOT RUN

In this section the assumption is that there are no PC board or interconnection type problems with the SC unit. Verify this first by attempting to start the unit such that the "FWD" LED lights up. Verify the voltage at terminal 6 (SPD) with respect to (W.R.T.) terminal 5 (COM) on 1TB (E1507 PC board). This voltage should be anywhere from zero to +6 VDC. At zero volts the motor should not run ; at +6 VDC it should run at top speed. Also verify that the reset voltage at terminal 11 on 1TB is at +2.4 VDC W.R.T. 1TB-5 (COM). If the motor still does not run, or will not run to top speed, the possible causes and remedies are listed below.

(a) AC input to the SC unit is missing and the "PWR ON" on E1507 PC board does not light. Check the AC line voltage. Check if fuses have blown and if necessary replace fuses. For repetitive fuse blowing, refer to Section 11.2.

(b) Motor may be jammed mechanically. Check by rotating the shaft manually.

(c) Field voltage low or missing causing insufficient torque under heavy loads. (Does not apply to PM motors). Check field voltage between terminals F1 and F4 on 10TB. This should read 100 VDC on 115 VAC input controls and 200 VDC on 230 VAC input controls.

(d) Motor field open or disconnected and operating under heavy load. (Does not apply to PM motors). With power off, check motor field wiring and field resistance as described in Section 12.

(e) Gate leads to the power bridge do not make good connections. Check for corrosion and bad connections.

11.5 PROCEDURE IF MOTOR OVERSPEEDS

In this section the assumption is that there are no PC board or interconnection type problems with the SC unit. Verify this first by measuring the voltage at terminal 1TB-6 (SPD) with respect to 1TB-5 (COM). Rotating the speed pot from fully counterclockwise to clockwise should vary this voltage from zero to +6 VDC . Now initiate a forward command such that the "FWD" LED lights. If it is still found that either the motor overspeeds, runs only at full speed, or in tach feedback systems proper maximum speed cannot be adjusted, the possible causes and remedies are as follows.

(a) Motor field voltage low or missing and operating under light load. (Does not apply to PM motors). Check field voltage between terminals F1 and F4 on 10TB. This should read 100 VDC on 115 VAC units and 200 VDC on 230 VAC units.

(b) Motor field open or disconnected and operating under light load. (Does not apply to PM motors). With power off, check motor field wiring and field resistance as described in Section 12.

(c) Mini jumper missing on FB SELECT plug 2 PL on E1507 PC board. For armature feedback, pins 1 and 2 should be jumped with a tiny 2-position encapsulated jumper module (Berg part number 65474-001) while for tach feedback, pins 2 and 3 should be jumpered. Replace the jumper if missing or reposition if it is not mounted appropriately.

(d) In tach feedback systems, control board is improperly set up for tach and motor combinations. Refer to Section 2.4.6 for tach feedback and proper board set-up.

11.6 PROCEDURE IF UNSTABLE OPERATION EXISTS

(a) The "IR" adjustment may be set too far clockwise, which can cause instability by overcompensating for the losses in the armature. Turn the "IR" potentiometer on the E1507 PC board fully counterclockwise. The instability and oscillation should go away. Readjust the "IR" pot as described in Section 9.3.

(b) On tach feedback system, the tachometer shaft could be slipping or wobbling. Check by replacing the "FB SELECT" mini jumper to the "ARM" position. If the operation is smooth, the problem could be in the tachometer. On tach feedback systems, the "IR" pot must be set fully counterclockwise. Before making any conclusions of a faulty tachometer, reassure that the "IR" pot is fully counterclockwise.

11.7 PROCEDURE FOR ISOLATING FAULTY PC BOARDS

Polyspede Electronics does not recommend field repair of PC boards, but highly recommends isolating a faulty PC board and replacing it with a good one of identical assembly number or "dash number"; this can reduce down time significantly.

Trouble-shooting to isolate a faulty PC board in any SC unit is really no black magic. However, dangerous voltages are present on the SC unit. Only personnel familiar with electrical test procedures, test equipment and safety precautions should attempt these tests.

Isolation of faulty PC board(s) can be easily achieved by following in steps the guidelines given below. Attempts to take short-cuts could make the task tedious and confusing.

STEP 1. The trouble-shooter should first define the problem. If this problem as defined is not covered by Sections 11.1 through 11.6, then it is most likely that the fault is PC board related, either with components or interconnections. At this time the trouble-shooter should review Sections 2.1 through 2.3 to familiarize himself with the capabilities of the SC units.

STEP 2. If the unit is equipped with standard options, then the trouble-shooter should also review the related sub-sections of Section 2.4.

STEP 3. There is good possibility that the problem may be redefined at this stage or defined in more detail. Either way, the trouble-shooter should perform the "INITIAL TURN-ON PROCEDURE" as described in Section 8; without any shortcuts. This should allow further closing in on the problem.

STEP 4. The trouble-shooter should first verify per drawing A1799-007-EW in the Appendix that all wiring external to the SC unit is legal and the external operators are functioning properly. This drawing also indicates proper placement, or appropriate removal, of certain terminal block jumpers for different applications. Also refer to drawing A1799-006-ES in the Appendix to assure that factory-installed wiring from one terminal lug to another has not accidentally been cut or become loose.

STEP 5. If the fault is not yet exactly determined or fixed, the trouble-shooter should verify the power supply voltages as listed in Table 11.7 (a). There are basically two separate references for the power supply voltages : HOT COM and ISO COM. Before checking the voltages in Table 11.7 (a) the continuity of the two supply references should be checked out with power off and using an ohmmeter. Refer to schematic A1799-006-ES in Appendix for help. However, there should be no continuity between HOT COM and ISO COM. Check supply voltages at all locations listed in Table 11.7 (a) with respect to the proper reference. Ignore those locations listed for optional PC boards that may not be furnished with the unit in question. If a supply voltage does not show up properly at one location, check other listed locations for that voltage. Refer to schematic A1799-006-ES in the Appendix to trace down the spot where the problem actually originates.

STEP 6. If the fault is not yet precisely determined or fixed, the trouble-shooter should verify the signal voltages as listed in Table 11.7 (b). Refer to schematic A1799-006-ES for help. Check signal voltages at all locations listed in Table 11.7 (b) with respect to proper reference. Ignore those locations listed for optional PC boards which are not furnished with the unit in question. For analog signals, "SPD," "POT W" and "SIG" verify the full range. And for the remaining step signals, verify both ends of the step by actuating the appropriate operators. This may be difficult if the trouble-shooter has not read through Section 2 as required in steps 1 and 2. If a signal voltage does not show up properly at one location, check other listed locations for that voltage. Refer to schematic A1799-006-ES in Appendix to trace down the spot where the problem actually originates.

STEP 7. When the fault is precisely determined and if found to be a PC board component, it is not repairable in the field. Refer to Section 14 for replacement of the PC board. Complete PC board identification number including the suffix, also known as the "dash number" or "assembly number", is required for ordering an identical PC board from Polyspede Electronics.

TABLE 11.7(a) SUPPLY VOLTAGE CHECK LIST

MARKED VOLTAGES	ACCEPTABLE READINGS (VDC)	REFERENCE (HOT COM OR ISO COM)	LOCATION(S)	
			PC BOARD	COMPONENT DESIGNATION
+6V	6.2 ±5%	HOT COM 1TB-5 ON E1507 PC BD	E1507 E1530 E1532 E1534	1TB-7 100TB-9 R164 R150 (TOP SIDE)
-12V	12 ±5%	HOT COM	E1507	D7
-24V	23 ± 5%	HOT COM	E1507 E1531	1TB-10 R61
-8.2V	8.2 ±5%	HOT COM	E1531	R70
-Ve	-3 to -18	HOT COM	E1531	D60
-12V	12 ±5%	ISO COM 100TB-22 ON E1530 PC BD	E1530 E1531 E1532	100TB-1 R79 150TB-2
-12V	-12 ±5%	ISO COM	E1530 E1531 E1535	100TB-15 R75 D60

NOTES:

TABLE 11.7(b) SIGNAL VOLTAGE CHECK LIST

SIGNAL SYMBOL	EXPECTED VOLTAGES (VDC)	REFERENCE (HOT COM OR ISO COM)	LOCATION(S)	
			PC BOARD	COMPONENT DESIGNATION
RESET	24 OR 0	HOT COM	E1507 E1530	1TB-11 101PL-4
SPD	0 TO 6	HOT COM	E1507 E1530 E1534 E1532	1TB-6 100TB-13 151PL-1 151PL-1
POT W	0 TO 6	HOT COM	E1530 E1531 E1535	100TB-12 60TB-1 60TB-1
SIG	0 TO 6	HOT COM	E1530 E1531 E1535	100TB-21 61J-7 61J-7
*TORQ	6	HOT COM	E1507 E1530	1TB-8 100TB-10
LAT F	12 OR 0	ISO COM	E1530	100TB-3
LAT R	12 OR 0	ISO COM	E1530	100TB-4
FWD	12 OR 0	ISO COM	E1530	100TB-5
REV	12 OR 0	ISO COM	E1530	100TB-6
JOG	12 OR 0	ISO COM	E1530 E1532 E1534	100TB-7 R168 D150 (ANODE)
AUTO	12 OR -12	ISO COM	E1530 E1531 E1535 E1532	100TB-8 D63 (CATHODE) D60 (CATHODE) R166
**ANTI-PLUG SIGNAL	0 OR +12	ISO COM	E1530	R129 (DOTTED SIDE)

* If external torque programming is used, this voltage could be a variable from 0 to 6 VDC.

** Applicable only to RSC or FSC units furnished with dynamic braking.

12. TROUBLE-SHOOTING THE MOTOR

The following tests will be helpful in pinpointing possible motor problems. Before making any tests, **remove** the armature and field leads from the SC unit at 10 TB.

(a) Shorts to the frame - Using a Megger set for 400 volt test potential, check leakage resistance in the motor between the A1, A2, motor field leads and the motor frame. 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. Shock hazard is present if motor frame is not grounded.

(b) Open or shorted field - A resistance check between F1 and F2 (also F3 and F4) should indicate a resistance between 75 to 600 ohms.

(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 on shunt field motors or the field on permanent magnet motors, a CEMF will be produced in 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 rotated 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.

13. CONVERSION TO ANOTHER HORSEPOWER

The scope of this section is to help in modifying an SC unit of a certain horsepower to another horsepower, while keeping the drive configuration (Section 2.3) and the options (Section 2.4) unchanged. All SC units, with 115 VAC input through 1HP range, can be easily converted to another standard horsepower size within the range listed for Group 1 in Table 13. Likewise, all SC units, with 230 VAC input through 2HP range, can also be easily converted to another standard horsepower size within the range listed for Group 2 in Table 13**. SC units of 3HP AND 5HP are not field modifiable.** If an existing SC unit falls in either Group 1 or Group 2 categories of Table 13 and if it is desired to change it to another horsepower size within its respective group, proceed with the following subsections for proper instructions.

Whenever the horsepower size of an SC unit is modified in the field, a Field modification Form must be completed and mailed to the factory. (See Appendix).

13.1 CHANGE METER SHUNT ("1MSH")

The shunt links in the categories of group 1 and Group 2 are identified by a designation letter, printed on a heat-shrink covering one of the lugs. Select from Table 13 the appropriate shunt link for the new horsepower size. Replace the existing link, which is mounted on the E1507 PC board, with the new link. Refer to Figure 13.1 for proper mounting of the new link. It is mandatory that all washers, lugs, and hardware items be replaced in their original order.

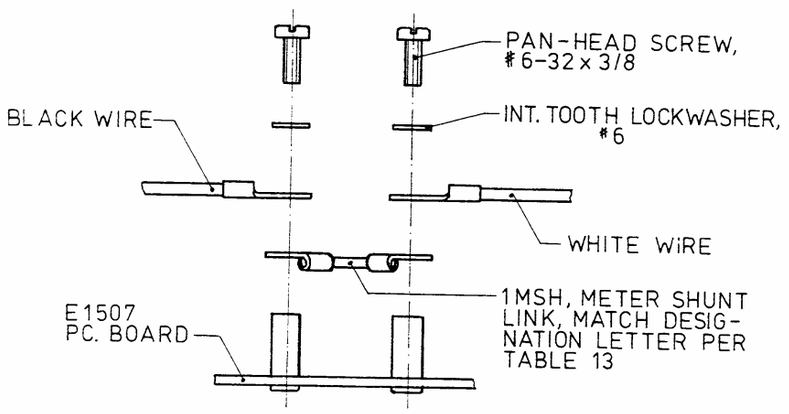


FIGURE 13.1 DETAILS FOR MOUNTING SHUNT LINK

TABLE 13

GROUP	DESIGNATION LETTER ON SHUNT LINK "IMSH"	INPUT VOLTS (VAC)	CHANGE IN NAMEPLATE BLOCK				DYNAMIC BRAKING RESISTOR *
			MODEL NO. SUFFIX	INPUT AMPS (RMS)	ARM OUTPUT AMPS (DC)	ARM OUTPUT HP	
1	A	115	-12	2.5	1.45	1/8	20 , 135W
	B	115	-16	4.0	1.75	1/6	20 , 135W
	E	115	-25	6.0	3.0	1/4	10 , 135W
	G	115	-33	6.5	3.75	1/3	10 , 135W
	K	115	-50	10	6.0	1/2	5 , 135W
	M	115	-75	14	8.0	3/4	5 , 135W
	N	115	-100	18	10.5	1	5 , 135W
2	A	230	-26	3.0	1.45	1/4	20 , 135W
	B	230	-34	4.0	1.75	1/3	20 , 135W
	E	230	-51	6.0	3.0	1/2	20 , 135W
	G	230	-76	7.0	3.75	3/4	20 , 135W
	K	230	-101	12	6.0	1	10 , 135W
	M	230	-150	15	8.0	1½	10 , 135W
	N	230	-200	20	10.5	2	10 , 135W

* Applicable only for FSC units with option "D" and RSC units.

13.2 CHANGE DYNAMIC BRAKING RESISTOR

This section is applicable only to those SC units that come equipped with the dynamic braking feature, which includes FSC units with option “D” (Section 2.4.1) and all RSC units (Section 2.3.3). If the unit awaiting modification falls under these categories, then it is mandatory that the dynamic braking resistor for the new HP rating be matched appropriately as listed in Table 13. If Table 13 indicates that the dynamic braking (D.B.) resistor for the new HP rating is different than the one for the existing rating, then it is also mandatory to change the D.B. resistor. Refer to Section 14.5 for proper procedure.

13.3 CHANGE NAMEPLATE INFORMATION ON SC UNIT

Change the contents of four information blocks on the SC unit nameplate to agree with the listing in Table 13 for the new horsepower size. This must be done to ensure delivery of an exact replacement part if repair or replacement of the SC unit becomes necessary. This may be done by preparing four small white paper strips with correct information typed on them and sticking the strips over appropriate nameplate blocks with clear Scotch tape. Note that for the block marked “MODEL” the alphabetical prefix remains

unchanged, only the numerical suffix needs to be changed. At this stage the "Field Modification Form" must be completed to be mailed to the factory. (See Appendix)

13.4 ADJUST "TORQ" POTENTIOMETER

The "Torq" potentiometer is located on the E1507 PC board. If the new shunt is mounted properly on the standoffs and the lug barrels of the sense wires do not touch the lug barrels of the shunt, readjustment of the "Torq" pot is not necessary. However, to eliminate any doubt it may be a good idea to verify this adjustment per Section 9.3.

14. REPAIR

Field repair operations on the SC unit should be limited to the replacement of fuses, faulty circuit board(s), power bridge, contactor(s) and dynamic braking resistor(s). Section 11 on trouble shooting should be helpful in pinpointing a fault. Replacement of faulty parts in the field with a good one could save the customer both time and shipping charges. However, if it is not possible to pinpoint a problem, then the entire unit should be removed from the panel and sent for repair to the factory, or to a service center designated by Polyspede.

In following the 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.

If any wire is removed, either within or external to the SC unit, the wire ends should be tagged with masking tape and the original location of the wiring should be marked on the tape. To ensure proper wiring during reassembly, refer to drawings A1799-006-ES and A1799-007-EW in the appendix. Wiring error could cause permanent damage to the unit if power is turned on.

CAUTION : ALWAYS TURN POWER OFF DURING REPAIR PROCEDURES.

14.1 Fuse Replacement.

SC unit with 115VAC input service has only one fuse, 1FU, in series with line L1. The line L2 is not fused and therefore should be the grounded side of the input service line for 115VAC units. On the other hand all 230VAC SC units are equipped with two line fuses, 1FU and 2FU.

Fuses 1FU and 2Fu are special silver-link rectifier protection fuses, unapproved substitutes must not be used. See Section 2.5 for approved replacement types. These fuses are easily replaceable on SC units through 3HP, since they are clip-mounted types. But on 5HP units, fuses 1Fu are mounted by a blot and nut arrangement. Replacement of these fuses on 5HP units requires removing the nut and the hardware, replacing the blown fuse(s) with good one(s), replacing the fastening hardware in the original order, and tightening the nuts down with 3 ft. lbs. of torque.

Five horsepower SC units are also equipped with two small clip mounted fuses; 3FU and 4FU. See Section 2.5 for rating.

14.2 Replace Circuit boards

When printed circuit boards are replaced on an SC unit, they should be replaced with one that has not only the same PC board number (prefix) but also identical assembly number or “dash number” (suffix) scribed in the appropriate block. Therefore **when ordering a replacement board the proper assembly number (suffix) must also be specified**

For better results, include control's "model" number and the OPTIONS code indicated on the nameplate.

Repair work should be done with power disconnected and any wiring disconnected should be tagged to indicate original location. Power should **not** be turned on until the replacement board has been rewired properly and all the hardware fastening the PC board to the standoffs are in place. Loose metal standoffs could cause a short between etched conductors under the PC boards and could possibly destroy the PC board.

Sections 14.2.1 through 4.2.6 give specific instructions on replacing different PC boards. **Keep track of the order in which the hardware is used in mounting PC boards**.

14.2.1 Replace E1507 PC Board

The E1507 PC board is mounted on four metal standoffs. Two of these standoffs are hinged. For proper replacement proceed with the following steps.

(a) Remove the two #6 screws fastening the board to the standoffs on the right.

(b) Remove all wiring going to the PC board; all wires going to terminal block 1TB and the fast-on disconnects under the PC board.

(c) Remove the #6 nuts fastening the board to the hinged standoffs on the left. This will allow the board to be completely removed from the SC unit.

(d) Replace a good board on the hinged standoffs. Tighten the nuts with the board in a vertically hinged position with the hinges at 90^{o} angle; this insures that the board will rotate on the hinges easily.

(e) Reconnect all loose wiring back to the new board, assuring that the wires go to the correct locations.

(f) Rotate the board back down to the standoffs on the right and fasten it down to these standoffs with #6 screw, lock washer and flat washer.

14.2.2. Replace E1530 PC board

The E1530 PC board is mounted on five standoffs with #6 hardware. **Quite often other optional PC boards such as adjustable jog speed board (E1534), signal isolator (E1531) or tach/voltage follower (E1535) may be stacked on the E1530 PC board**. These boards, when included, are stacked on E1530 PC board using nylon snap-on type spacers. The nylon spacers are designed in such a way that only the end that is inserted into the E1530 PC board is detachable, while the other end once inserted into the option board remains permanently attached. Refer to Figure 14.2.2 If the SC unit is equipped

with these option boards, it is necessary to remove these option boards before the E1530 PC board can be replaced. Refer to sections 14.2.3, 14.2.4, and 14.2.6 for removal of these option boards.

On certain SC units **shipped before May, 1981,** the nylon spacers were installed in exactly the opposite manner shown in Figure 14.2.2, i.e., the permanently attached end is inserted into the E1530 PC boards. In this case, along with the replacement for E1530 PC board, four nylon spacers (E. F. Johnson part no. 115-0260-009) for each of the above mentioned options should be ordered from polyspede and these spacers should be correctly installed as shown in Figure 14.2.2.

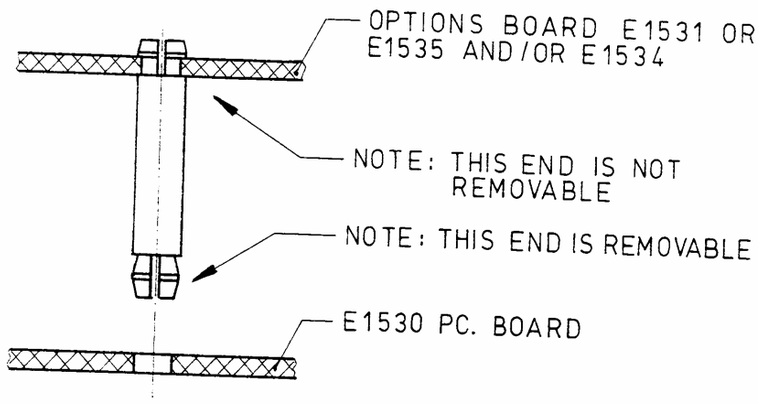


Figure 14.2.2 Proper Installation of Nylon Spacers

Proceed with the following steps for easy replacement of E1530 PC board :

(a) If either of the external signal option boards (E1531 or E1535) and/or the adjustable jog speed option board (E1534) are included in the SC unit, remove these boards first. See Sections 14.2.3, 14.2.4, and 14.2.6.

(b) Remove all wiring going to terminal block 100TB. Identify the wires for proper replacement. Make a sketch to show the proper position of all terminal block jumpers. Save this sketch to insure proper replacement of jumpers on 100TB of the new E1530 PC board.

(c) Unplug the cable bundle going to plug 101 PL on E530 PC board.

(d) If preset speeds option (E1532) or adjustable jog speed option (E1534) is included,

then unplug the ribbon cable going to DIP socket J103 on E1530 PC board. Be very careful not to bend the pins.

e) Unscrew and remove the five #6 screws that secure the E1530 PC board to its standoffs. Lift off the PC board and this will give access to the wiring underneath. Remove and identify all wires connected to the fast-on connectors under the E1530 PC board.

f) Take the replacement E1530 PC board and reconnect the wires going to the fast-on connectors underneath. Place the PC board o its standoffs and secure it with 36 screws. Reassure that all terminal block jumpers on 100TB match with the sketch made in step (b). Reconnect all wires going to terminal block 100TB.

g) If the SC units is equipped with the options mentioned in step (a), snap on these option board(s) back in place on the E1530 PC board.

h) Reconnect the cable bundle plug to 101 PL. If option boards E1534 or E1532 are included in the SC unit, then carefully connect the ribbon cable to the DIP socket J103. Connect the ribbon cable in such a way that the marked edged of the cable falls toward the days of the E1530 PC board.

14.2.3.1. Replace Circuit Board E1531

This PC board is mounted above the E1530 PC board by four snap-on type, nylon spacers.

(a) Disconnect wires going to terminal block 60TB.

(b) Remove the E1531 PC board along with the snap-on spacers from the E1530 PC board, one spacer at a time. On a few units shipped before May, 1981, the nylon spacers were installed in such a way that the permanent end was inserted into the E1530 PC board.

(c) Four nylon snap-on type spacers are supplied with the E1531 replacement. Before mounting the new board, insert the permanent end of these spacers into the mounting holes. Refer to Figure 14.2.2.

(d) Take the new E1531 PC board, with its spacers already installed, and align it over the E1530 PC board. The 7 pins of 102PL should line up with the 7 holes, immediately under the receptacle 61J, on the E1531 PC board. Lower the E1531 board so that the pins make good connection with the receptacles and then finally snap the other ends of the nylon spacers into the appropriate holes on the E1530 PC board. Reassure visually that the pins of 102PL are making good electrical contact with the pins of 61J.

14.2.4 Replace Circuit Board E1535

Same as for E1531 (Section 14.2.3).

14.2.5. Replace Circuit Board E1532

When the preset speeds option (E1532 PC board) is included in an SC unit, the control nameplate on top of this board using four nylon spacers. For proper replacement procedure, proceed with the following steps.

(a) Remove the nameplate along with its nylon spacers from the E1532 PC board, one spacer at a time.

(b) This will expose the array of programming strips that are programmed with little blue jumpers. Make a sketch, like Figure 2.4.4 in Section 2.4.4, of all the programming strips and mark the positions of these jumpers on the sketch. This sketch should be saved to be used for replacing the jumpers on the new E1532 board.

(c) Disconnect the wires going to terminal block 150TB and also make a sketch of the jumper arrangement on 150Tb.

(d) Disconnect the wires going to 151Tb. Make a sketch to show the exact original location of these wires.

(e) Disconnect the ribbon cable from the DIP socket J103, located on E1530 PC board.

(f) Remove the faulty E1532 PC board from its standoffs. Replace with a good board. Reconnect wires on the new board per sketch made in steps (c) and (d). Replace the programming jumpers per sketch made in step (b).

(g) Connect the ribbon cable to the DIP socket J103 on E1530 PC board. Note: The marked edge of the ribbon cable should fall toward the edge of the E1530 PC board. Be very careful not to bend the pins.

(h) Replace the control nameplate, over the array of programming strips, by snapping in the nylon spacers in the appropriate holes of the new E1532 PC board.

14.2.6 Repalce Circuit Board E1534

This circuit board is mounted on the E1530 PC board by four snap-on type nylon spacers.

(a) A white (WHT) wire which has one end soldered to E1534 PC board has a ring lug on the other end. This end with the ring lug is either connected to lug 12 (POT W) or lug 21 (SIG) on terminal block 100TB.

(b) Carefully remove the ribbon cable connector from the DIP socket J103 located on E1530 PC board.

c) Snap off the E1534 PC board along with its nylon spacers from E1530 PC board, one spacer at a time. On a few units shipped before May, 1981, the nylon spacers were installed in such a way that the permanent end was inserted into the E1530 PC board.

d) Four nylon snap-on type spacers are supplied with the E1534 replacement. Before mounting the new board, insert the permanent end of the spacers into the mounting holes. Refer to Figure 14.2.2.

e) Align the new E1534 PC board so that the four nylon spacers hanging down from it line up with the matching holes on the E1530 PC board. Snap these one at a time in the holes on the E1530 PC board.

f) Reconnect the ribbon cable connector to the DIP socket J103 located on the E1530 PC board. The marked edge of the cable should fall toward the edge of the E1530 PC board.

g) If the SC unit is equipped with external signal option (E1531 or E1535 PC board), connect the ring-lugged end of the white wire, mentioned in step (a), to lug 21 (SIG) of 100TB. Otherwise connect to lug 12 (POT W) of 100TB.

14.3 Replace Power Bridge

This procedure requires the removal of the four mounting bolts and lifting off the SC unit from the mounting panel. Therefore, before attempting to replace the power bridge, it would be preferable to positively verify per section 11.3 that the bridge is actually faulty. The test points on the bridge are easily accessible by removing the two mounting screws on the right side of E1507 PC board. This allows the E1507 PC board to be rotated on its hinges to the left, thus clearing the part for testing the power bridge.

If the power bridge is to be replaced, proceed with the following steps.

(a) Disconnect all external wiring to the SC unit and identify them for proper replacement.

(b) Remove the four mounting bolts and lift off the SC unit from the mounting panel.

(c) On SC units through 2HP, the power bridge is an integrated module with two SCR`s and three diodes; while on the 5HP SC units, the power bridge has the same electrical configuration but is comprised of two power modules, with an SCR and a diode each, and a freewheeling diode, which is mounted on an aluminum bracket. Remove all wires connected to the power bridge and identify them for proper rewiring. Remove the power bridge, but keep track of the order in which the hardware is used for mounting the bridge to the SC panel.

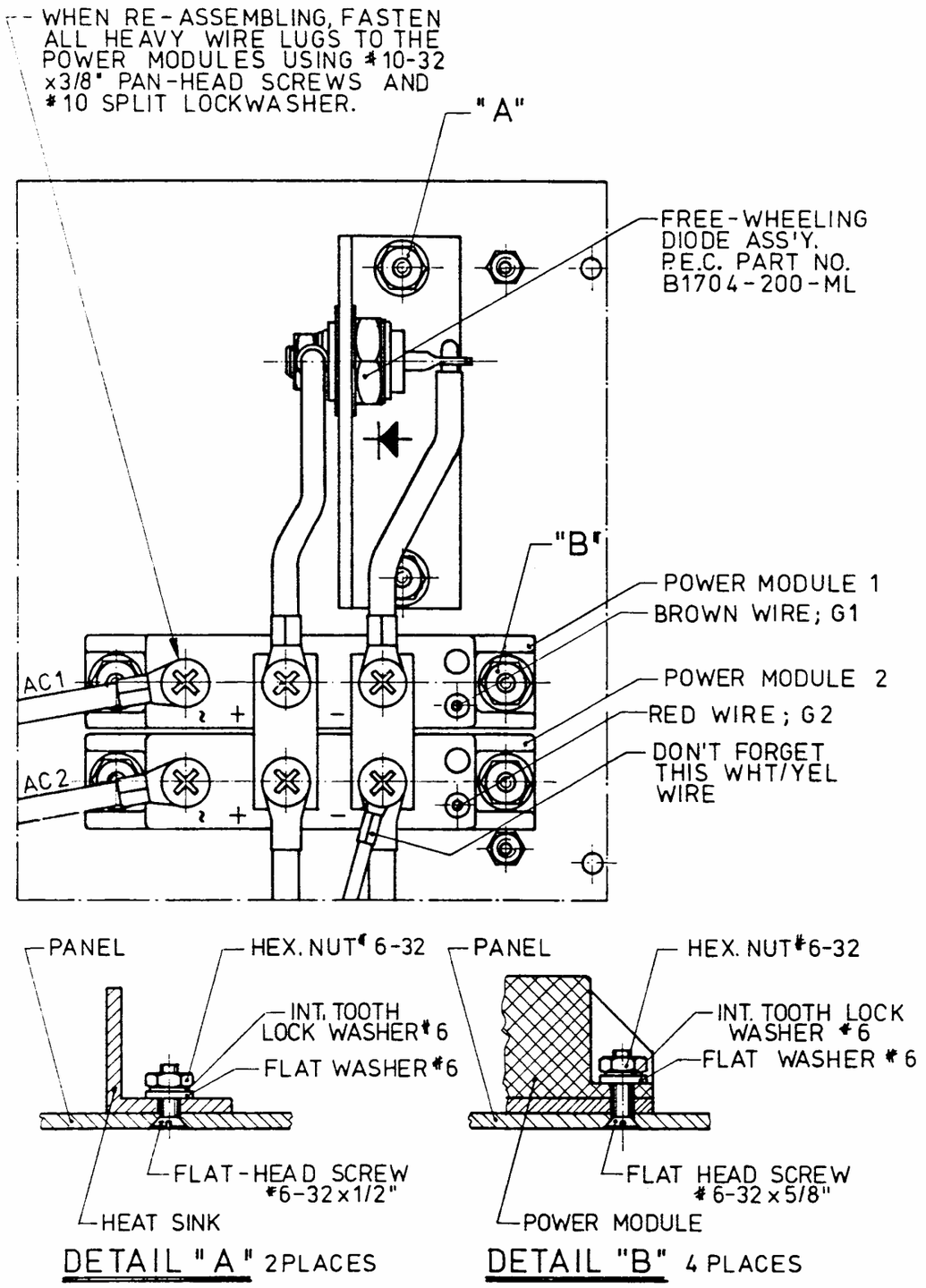


FIGURE 14.3 MOUNTING DETAILS FOR 5HP BRIDGE

For mounting details of 5HP bridge, refer to figure 14.3.

(d) Before replacing the faulty bridge with a new bridge, clean the mounting area on the panel with a cleaning solvent. Reapply a fresh layer of thermal compound, such as Dow Corning #4 compound, under the power bridge, or its components (as in the case of 5HP units).

(e) Mount the power bridge at its appropriate place on the panel. Units through 3HP take a 7/16 inch #8-32 screw from the top, which is secured by a flat washer, an internal tooth lock-washer and a #8-32 nut underneath the panel. See Figure 14.3 for details on 5HP unit.

(f) Reconnect the loose wiring back to the power bridge and mount the SC unit back on the mounting panel. The 5HP SC units are units, the bottom side of the 10½" x 14" SC panel should be cleaned and coated with a fresh layer of thermal compound, before installing it on the mounting panel.

(g) Reconnect all external wiring back to the SC unit. Rotate the E1507 PC board down to its standoffs and secure it with #6 hardware.

14.4 Replace Contactor (s)

(a) On SC units through 2HP, the contactors are socket mounted DPDT relays that are mounted on the E1533 PC board. This may be done easily by removing the E1530 PC board from its standoffs and then replacing the faulty contactor (s) with new ones. It is not necessary to replace the E1533 PC board unless circuit conductors on it have burned out.

(b) For 3HP and 5HP SC units, it is necessary to first remove the SC unit from its mounting panel and then remove the E1530 PC board out of the way, before replacement of the contactors can be possible. During disassembly, identify each wire for proper reconnection. For removing contactor(s) on 3HP and 5HP units it is necessary to reach under the SC panel with a nut driver or screwdriver. For proper re-assembly, note down the order in which the hardware is used in mounting the contactor (s).

14.5 Replace Dynamic Braking Resistor (s)

SC units equipped with dynamic braking use rib-wound 135W resistors. Three horsepower and 5HP units use two resistors in parallel. While other units, of 2HP and under, use a single resistor. Each resistor is mounted with two brackets. If it is necessary to replace these resistor(s), proceed with the following steps.

(a) Remove the SC unit from the mounting panel. It may not be necessary to disconnect the external wiring as long as there is enough room to reach under the SC panel with a nut-driver or a screwdriver.

b) Remove the hardware, securing only one mounting bracket per resistor; the bracket closest to the corner. Slide this bracket out of the resistor and then slide off the resistor from the bracket that is still attached to the SC panel.

c) Loosen and remove the hardware securing the wires going to the resistor lugs. Note the order in which the hardware is used.

d) Replace the wires back on the lugs of the new resistor(s). Slide the resistor(s) back on the bracket that is still mounted on the SC panel. Now slide the loose bracket that was removed into the resistor(s); one bracket per resistor. Finally, secure this bracket to the SC panel.

e) Reassure that there is no loose hardware, metal filings under the SC panel; especially for 5HP units. Then mount the SC unit back on the mounting panel.

14.6 Replace Entire SC unit

If an SC unit is to be replaced with an identical one, refer to section 2.1 for locating the nameplate information that will be required for proper replacement. Proceed with the following steps for proper replacement.

(a) Disconnect all external wiring from the existing SC unit and identify them for proper reconnection.

(b) If the unit under replacement is of 5HP rating, the mounting surface should be cleaned and should be free of bumps and burrs. A thin layer of thermal compound, such as Dow Corning #4 compound, should be applied under the SC panel before positioning it on the mounting panel.

(c) Install the new SC unit in the same position as the original one. Secure the new unit with #10 bolts and hardware.

(d) Reconnect the loose external wirings at their proper locations on the new unit.

15. MAINTENANACE

15.1 Control Maintenance

The SC 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.

Motor Maintenance

Inspect motor brushes regularly. Polyspede recommends replacement when brushes are worn to one-third 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 guidelines can be given concerning inspection intervals. Experience has shown that each application has its own wear rate. Removal of the brushers 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 competent 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.

15.2 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.

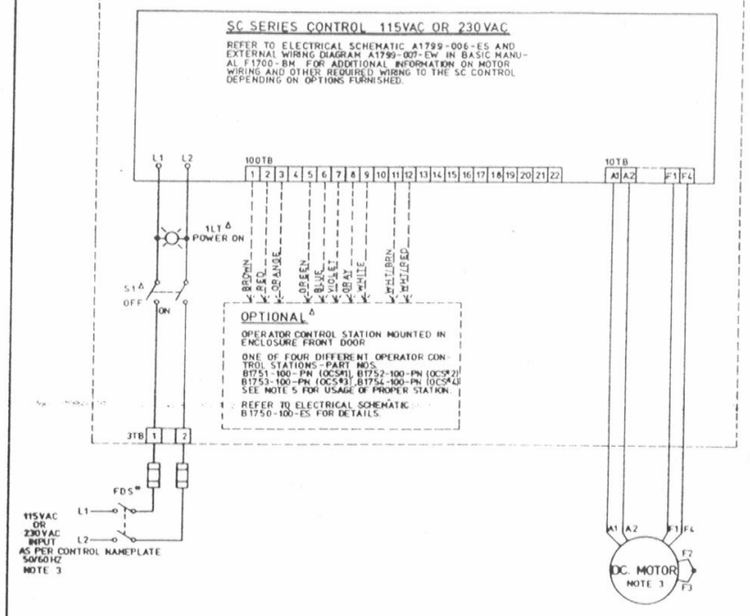
(f) If detailed instructions for assembly and disassembly of a particular unit are required, contact the speed reducer manufacturer for this information.

(g) If the drive is connected by a coupling which requires lubricating, the coupling should be checked on start-up and semiannually.

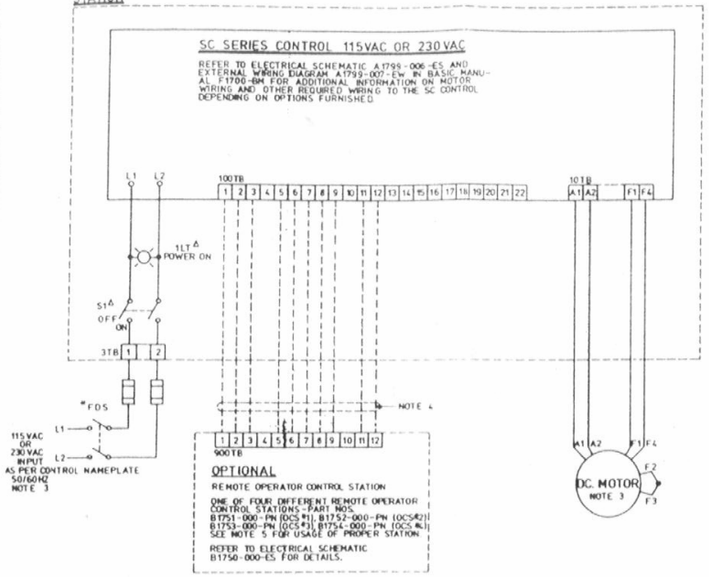
APPENDIX

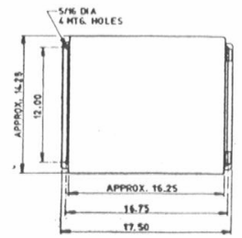
REV LTR	REVISION	APP'D	DATE

SC SERIES CONTROL IN NEMA 12 ENCLOSURE WITH OPTIONAL OPERATOR CONTROL STATION ON ENCLOSURE FRONT



SC SERIES CONTROL IN NEMA 12 ENCLOSURE WITH OPTIONAL REMOTE OPERATOR CONTROL STATION

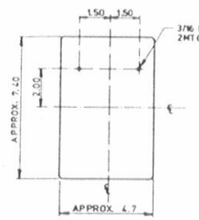




OVERALL DIMENSIONS ALL CONTROLS (115VAC & 230VAC)

SC CONTROL IN AN ENCLOSURE WITH OR WITHOUT AN OCS IN ENCLOSURE COVER.

MAXIMUM DEPTH INCLUDING THE FARTHEST PROTRUDING COMPONENT ON THE COVER WITH THE OCS IS 2-3/8".
ON 5HP CONTROLS ADD 5/8" TO MAXIMUM DEPTH (SEE NOTE 6).



OVERALL DIMENSIONS OF THE REMOTE OPERATOR STATION.

MAXIMUM DEPTH INCLUDING THE FARTHEST PROTRUDING COMPONENT ON THE COVER IS 4-1/8".

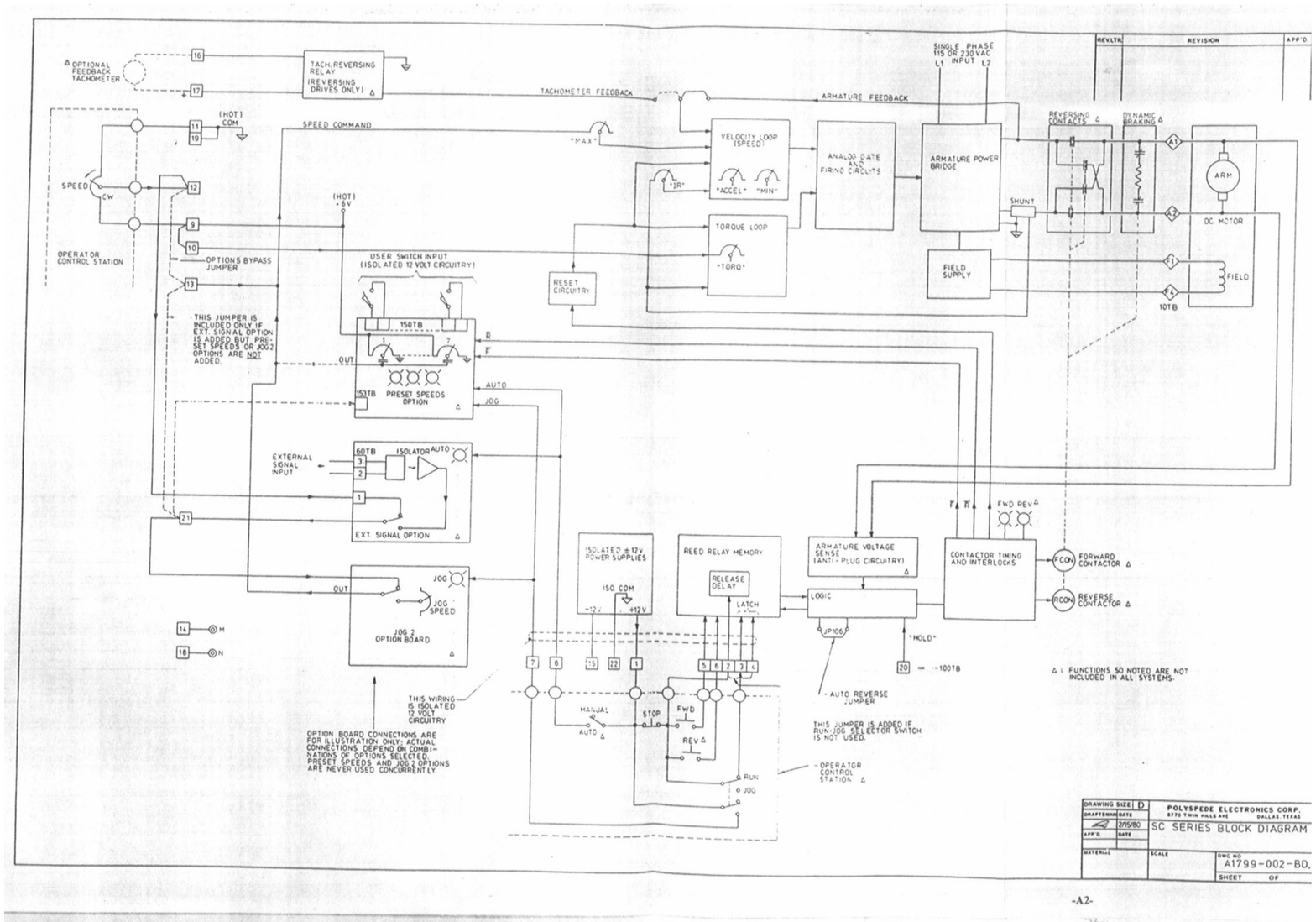
NOTES:

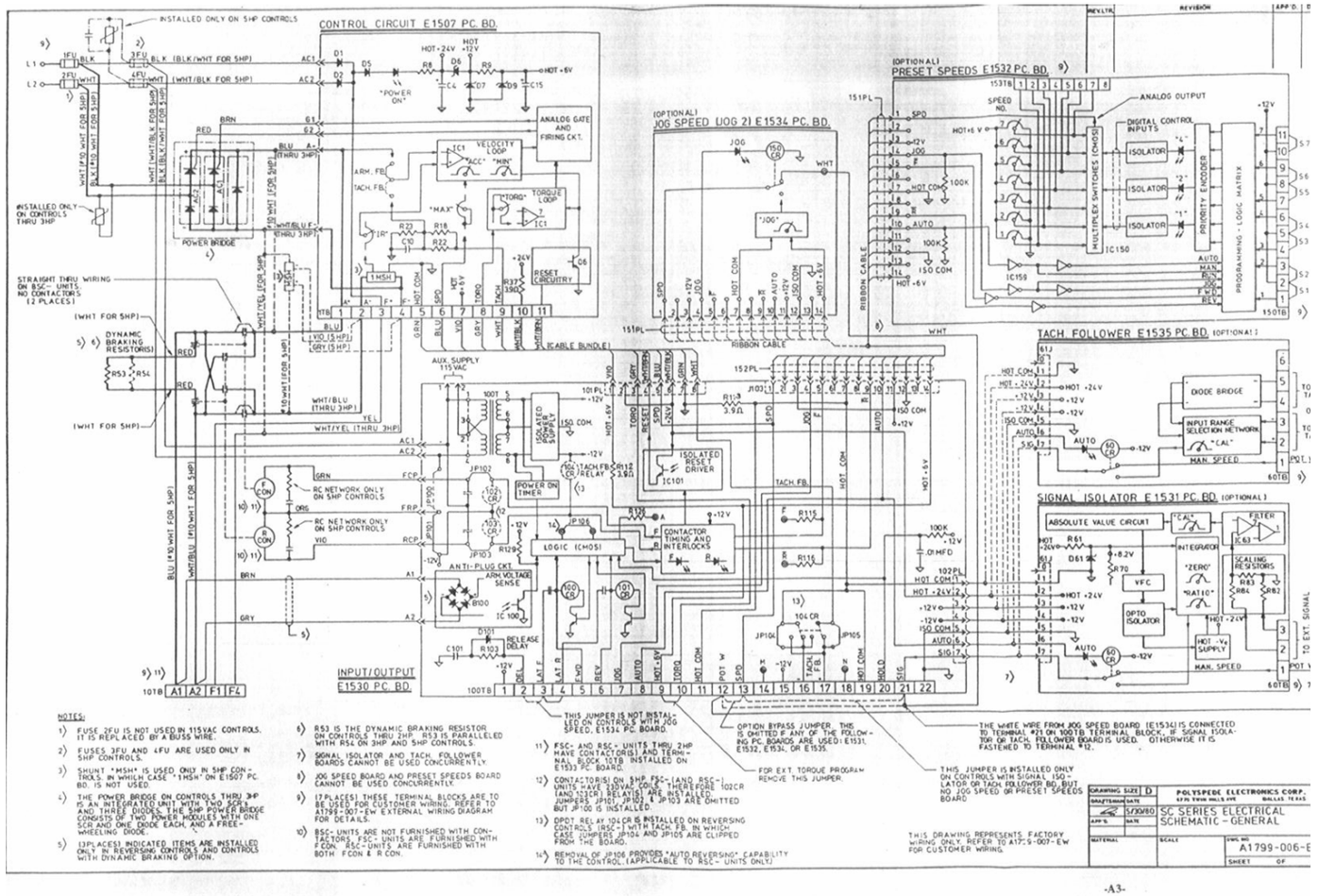
1. * - INDICATES COMPONENTS SUPPLIED BY CUSTOMER.
2. Δ - INDICATES COMPONENTS MOUNTED ON THE FRONT OF THE ENCLOSURE COVER AND PRE-WIRED BY POLYSPEDE.
3. ONLY THE AC LINE CONNECTED TO 3TB-1 IS FUSED ON 115VAC CONTROLS. THEREFORE L1 MUST BE THE GROUNDED AC LINE. REFER TO DRAWING Z3 IN THE INSTRUCTION MANUAL F1700-BM FOR PROPER SIZING OF L1, L2, A1, A2 AND MOTOR FIELD CONNECTIONS IF A PERMANENT MAGNET MOTOR IS NOT USED.
4. USE #18 AWG OR LARGER WIRE ON WIRING FOR THE REMOTE OPERATOR STATION. RUN IN SEPARATE CONDUIT FROM AC POWER AND MOTOR CONNECTIONS. THE CONNECTIONS BETWEEN TERMINALS 6 AND 8 OF TERMINAL BLOCK 100TB AND 900TB ARE NOT REQUIRED ON SOME REMOTE OPERATOR STATIONS. SEE ELECTRICAL SCHEMATIC B1750-000-ES FOR MORE DETAILS.
5. THE FOLLOWING TABLE TABULATES PART NUMBERS AND GIVES THE PROPER USAGE OF THE FOUR OPERATOR CONTROL STATIONS WHICH CAN BE INSTALLED IN THE CONTROL ENCLOSURE COVER, OR SUPPLIED IN A SEPARATE ENCLOSURE.
6. MOUNT SC 5HP CONTROL TO MOUNTING SURFACE USING THE SPACER KIT PROVIDED WITH THE CONTROL REFER TO A1771-000-MA SECTION III.

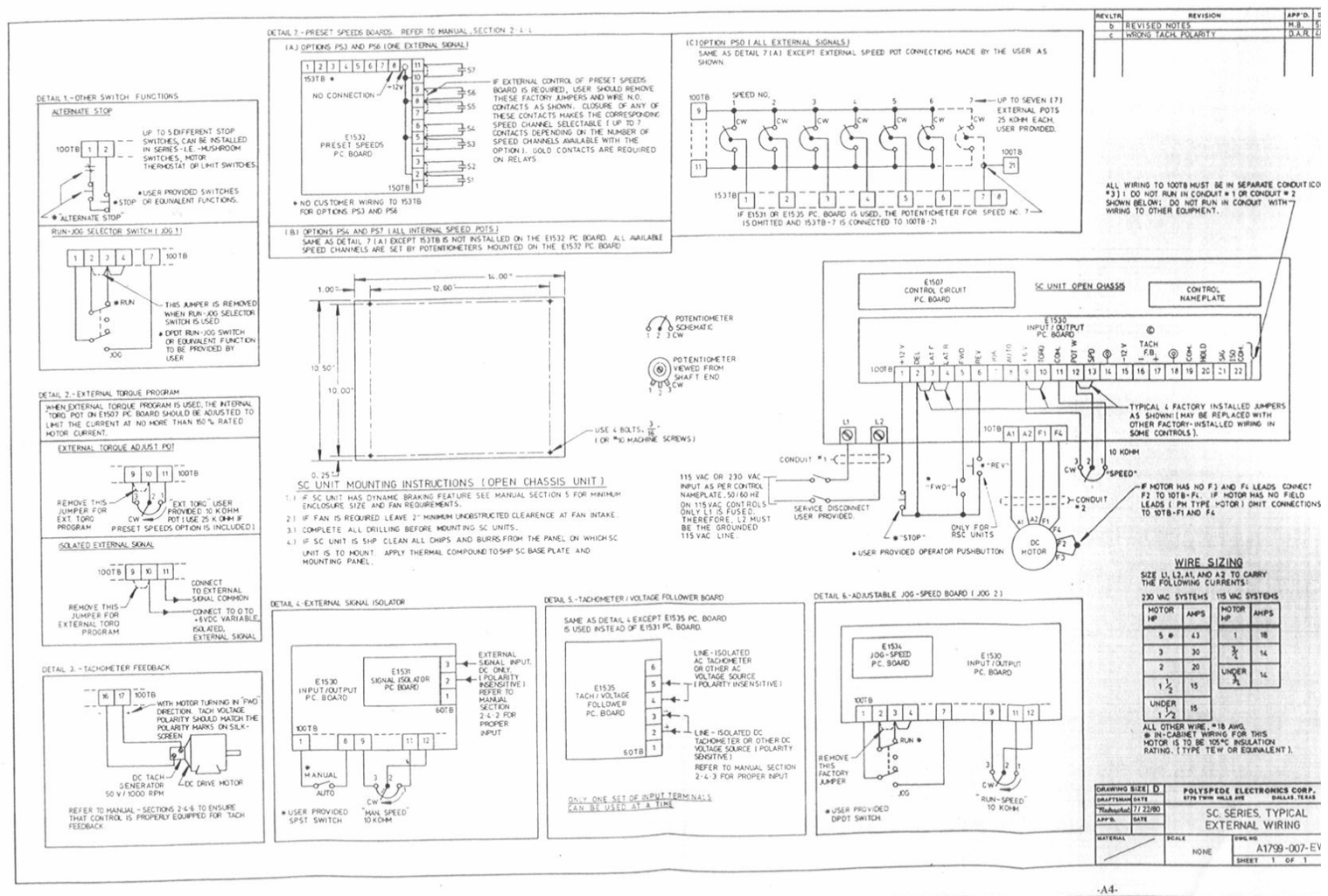
OCS PART NUMBER TABLE

OCS #	PART NO. IF INSTALLED ON CONTROL FRONT	PART NO. IF SUPPLIED IN SEPARATE BOX	CONTROLS WHERE USED
1	B1751-100-PN	B1751-000-PN	RSC & FSC WITHOUT SIGNAL ISO. AND TACH. FOLLOWER
2	B1752-100-PN	B1752-000-PN	BSC & FSC WITH SIGNAL ISO. OR TACH. FOLLOWER
3	B1753-100-PN	B1753-000-PN	RSC WITHOUT SIGNAL ISO. AND TACH FOLLOWER
4	B1754-100-PN	B1754-000-PN	RSC WITH SIGNAL ISO. OR TACH. FOLLOWER

DRAWING SIZE D	POLYSPEDE ELECTRONICS CORP.	
DRAFTSMAN DATE 10/01/92	NEMA 12 ENCLOSED BSC, FSC AND RSC 115 OR 230VAC CONTROLS-WIRING DIAGRAM	
APP'D. DATE		
MATERIAL	SCALE	DRWG. NO. A1799-008-WD,0
		SHEET 1 OF 1


REV LTR
REVISION
APP'D
SINGLE PHASE 115 OR 230 VAC INPUT L1 L2
Δ OPTIONAL FEEDBACK TACHOMETER
TACH. REVERSING RELAY (REVERSING DRIVES ONLY) Δ
TACHOMETER FEEDBACK
ARMATURE FEEDBACK
(HOT) COM
SPEED COMMAND
"MAX"
VELOCITY LOOP (SPEED)
"IR"
"ACCEL"
"MIN"
ANALOG GATE AND FIRING CIRCUITS
ARMATURE POWER BRIDGE
REVERSING CONTACTS Δ
DYNAMIC BRAKING Δ
SHUNT
ARM
DC MOTOR
FIELD
10TB
SPEED
CW
OPERATOR CONTROL STATION
(HOT) +6V
OPTIONS BYPASS JUMPER
TORQUE LOOP
"TORQ"
FIELD SUPPLY
RESET CIRCUITRY
USER SWITCH INPUT (ISOLATED 12 VOLT CIRCUITRY)
150TB
PRESET SPEEDS OPTION Δ
153TB
OUT
AUTO
JOG
* THIS JUMPER IS INCLUDED ONLY IF EXT. SIGNAL OPTION IS ADDED BUT PRE-SET SPEEDS OR JOG 2 OPTIONS ARE NOT ADDED.
60TB
ISOLATOR
EXTERNAL SIGNAL INPUT
EXT. SIGNAL OPTION Δ
JOG
JOG SPEED
JOG 2 OPTION BOARD Δ
ISOLATED ±12V POWER SUPPLIES
ISO COM
-12V
+12V
REED RELAY MEMORY
RELEASE DELAY
LATCH
ARMATURE VOLTAGE SENSE (ANTI-PLUG CIRCUITRY) Δ
LOGIC
JP106
"HOLD"
CONTACTOR TIMING AND INTERLOCKS
FWD REV Δ
FCON
RCON
FORWARD CONTACTOR Δ
REVERSE CONTACTOR Δ
100TB
* AUTO REVERSE JUMPER
THIS JUMPER IS ADDED IF RUN/JOG SELECTOR SWITCH IS NOT USED.
MANUAL
AUTO Δ
STOP
FWD
REV Δ
RUN
JOG
OPERATOR CONTROL STATION Δ
THIS WIRING IS ISOLATED 12 VOLT CIRCUITRY
OPTION BOARD CONNECTIONS ARE FOR ILLUSTRATION ONLY; ACTUAL CONNECTIONS DEPEND ON COMBINATIONS OF OPTIONS SELECTED. PRESET SPEEDS AND JOG 2 OPTIONS ARE NEVER USED CONCURRENTLY.
Δ : FUNCTIONS SO NOTED ARE NOT INCLUDED IN ALL SYSTEMS.
DRAWING SIZE D
POLYSPEDE ELECTRONICS CORP.
8770 TWIN HILLS AVE DALLAS, TEXAS
DRAFTSMAN DATE
2/15/80
APP'D DATE
SC SERIES BLOCK DIAGRAM
MATERIAL
SCALE
DWG NO A1799-002-BD,
SHEET OF


CONTROL CIRCUIT E1507 PC BD.
(OPTIONAL) PRESET SPEEDS E1532 PC BD.
(OPTIONAL) JOG SPEED (JOG 2) E1534 PC BD.
TACH FOLLOWER E1535 PC BD. (OPTIONAL)
SIGNAL ISOLATOR E1531 PC BD. (OPTIONAL)
INPUT/OUTPUT E1530 PC BD.
INSTALLED ONLY ON 5HP CONTROLS
INSTALLED ONLY ON CONTROLS THRU 3HP
STRAIGHT THRU WIRING ON BSC- UNITS, NO CONTACTORS (2 PLACES)
DYNAMIC BRAKING RESISTOR(S)
POWER BRIDGE
ANALOG GATE AND FIRING CKT.
VELOCITY LOOP
TORQUE LOOP
RESET CIRCUITRY
ISOLATED POWER SUPPLY
ISOLATED RESET DRIVER
POWER ON TIMER
LOGIC (CMOS)
CONTACTOR TIMING AND INTERLOCKS
ANTI-PLUG CKT.
ARM VOLTAGE SENSE
RELEASE DELAY
RIBBON CABLE
MULTIPLEX SWITCHES (CMOS)
PRIORITY ENCODER
PROGRAMMING - LOGIC MATRIX
DIGITAL CONTROL INPUTS
ANALOG OUTPUT
DIODE BRIDGE
INPUT RANGE SELECTION NETWORK
ABSOLUTE VALUE CIRCUIT
INTEGRATOR
SCALING RESISTORS
VFC
OPTO ISOLATOR
FILTER
NOTES:
1) FUSE 2FU IS NOT USED IN 115VAC CONTROLS. IT IS REPLACED BY A BUSS WIRE.
2) FUSES 3FU AND 4FU ARE USED ONLY IN 5HP CONTROLS.
3) SHUNT "MSH" IS USED ONLY IN 5HP CONTROLS, IN WHICH CASE "1MSH" ON E1507 PC BD. IS NOT USED.
4) THE POWER BRIDGE ON CONTROLS THRU 3HP IS AN INTEGRATED UNIT WITH TWO SCRS AND THREE DIODES. THE 5HP POWER BRIDGE CONSISTS OF TWO POWER MODULES WITH ONE SCR AND ONE DIODE EACH, AND A FREE-WHEELING DIODE.
5) (3 PLACES) INDICATED ITEMS ARE INSTALLED ONLY IN REVERSING CONTROLS AND CONTROLS WITH DYNAMIC BRAKING OPTION.
6) R53 IS THE DYNAMIC BRAKING RESISTOR ON CONTROLS THRU 2HP. R53 IS PARALLELED WITH R54 ON 3HP AND 5HP CONTROLS.
7) SIGNAL ISOLATOR AND TACH. FOLLOWER BOARDS CANNOT BE USED CONCURRENTLY.
8) JOG SPEED BOARD AND PRESET SPEEDS BOARD CANNOT BE USED CONCURRENTLY.
9) (7 PLACES) THESE TERMINAL BLOCKS ARE TO BE USED FOR CUSTOMER WIRING. REFER TO A1799-007-EW EXTERNAL WIRING DIAGRAM FOR DETAILS.
10) BSC- UNITS ARE NOT FURNISHED WITH CONTACTORS. FSC- UNITS ARE FURNISHED WITH F CON. RSC- UNITS ARE FURNISHED WITH BOTH FCON & RCON.
11) FSC- AND RSC- UNITS THRU 2HP HAVE CONTACTOR(S) AND TERMINAL BLOCK 101B INSTALLED ON E1503 PC BOARD.
12) CONTACTOR(S) ON 3HP FSC- (AND RSC- UNITS HAVE 230VAC COILS. THEREFORE 102CR (AND 103CR) RELAY(S) ARE INSTALLED. JUMPERS JP101, JP102, & JP103 ARE OMITTED BUT JP100 IS INSTALLED.
13) DPDT RELAY 104CR IS INSTALLED ON REVERSING CONTROLS (RSC-) WITH TACH FB. IN WHICH CASE JUMPERS JP104 AND JP105 ARE CLIPPED FROM THE BOARD.
14) REMOVAL OF JP106 PROVIDES "AUTO REVERSING" CAPABILITY TO THE CONTROL (APPLICABLE TO RSC- UNITS ONLY)
THIS JUMPER IS NOT INSTALLED ON CONTROLS WITH JOG SPEED, E1534 PC BOARD.
OPTION BYPASS JUMPER. THIS IS OMITTED IF ANY OF THE FOLLOWING PC. BOARDS ARE USED: E1531, E1532, E1534, OR E1535.
FOR EXT. TORQUE PROGRAM REMOVE THIS JUMPER.
THE WHITE WIRE FROM JOG SPEED BOARD (E1534) IS CONNECTED TO TERMINAL #21 ON 100TB TERMINAL BLOCK, IF SIGNAL ISOLATOR OR TACH. FOLLOWER BOARD IS USED. OTHERWISE IT IS FASTENED TO TERMINAL #12.
THIS JUMPER IS INSTALLED ONLY ON CONTROLS WITH SIGNAL ISOLATOR OR TACH FOLLOWER BD., BUT NO JOG SPEED OR PRESET SPEEDS BOARD
THIS DRAWING REPRESENTS FACTORY WIRING ONLY. REFER TO A17:9-007-EW FOR CUSTOMER WIRING.
POLYSPEDE ELECTRONICS CORP.
SC SERIES ELECTRICAL
SCHEMATIC - GENERAL
A1799-006-E



REV. LTR.	REVISION	APP'D.	D
b	REVISED NOTES	M.B.	5
c	WRONG TACH. POLARITY	D.A.R.	C

DRAWING SIZE D	POLYSPEDE ELECTRONICS CORP. 8720 TWIN HILLS AVE DALLAS, TEXAS	
DRAFTSMAN DATE		
Technician 7/22/80	SC SERIES, TYPICAL EXTERNAL WIRING	
APP'D. DATE		
MATERIAL	SCALE NONE	DWG NO A1799-007-EV
		SHEET 1 OF 1

GUIDELINES FOR PROGRAMMING PRESET SPEEDS OPTION

The preset speeds option for the SC series has been designed with flexibility in mind. There are multitudes of applications for which this option can be used. Therefore, it is impossible to provide a hard and fast procedure to program this option for every upcoming application. The intent of the following steps and examples is to guide a programmer so that he may easily, with some trial and error, come up with an appropriate scheme for his particular application. Bear in mind that two people working on the same application may come up with different results, both of which may be correct. It is definitely helpful, for a first-time programmer, to have an SC unit on hand while going through the following steps, and to have read through the description of this option in the SC series manual. (Section 2.4.4)

Step 1. Determine the total number of different speeds that the SC unit will be subjected to, during different modes of operation.

For example, say there are four speeds required; three programmed by PC board mounted posts and one by an external signal. For this particular example the requirements could be satisfied by option PS3. But, say PS6, which has seven speed channels, was ordered. This leaves three extra speed channels to be moved out of the way.

Step 2. Disarm extra speed channels, if any, by removing the appropriate terminal block jumpers on 150TB. Refer to A1799-006-ES. Our hypothetical example requires access to external signal. Therefore, speed channel No.7 must be used. But any three of the other channels, No.1 through No.6 may be disarmed.

Step 3. Now, let us take a look at what causes a particular speed channel to be selected. Refer to Figure A.

In order for a speed channel to be selected, all four inputs of its corresponding "AND" gate must be Hi; at 12VDC W.R.T. 100TB-22 (ISO COM). The status of the first three inputs of each "AND" gate is determined by the placement of program jumpers on the PROGRAMMING STRIP, while the status of the fourth input is determined by the wiring on terminal block 150TB on the E1532 PC board.

If a program jumper is placed in the "AUTO" position, then a Hi Signal is applied at input No.1 of the "AND" gate, whenever a +12VDC (W.R.T. 100TB-22) is applied at terminal 100TB-8 (AUTO) on the E1530 PC board. Refer to Detail 4 on external wiring diagram A1799-007-EW. But if the program jumper is in the "MAN" (manual) position, then input No.1 is Hi when +12VDC is not applied at 100TB-8. Again, if the program jumper is neither in the "AUTO" nor "MAN" position for any particular gate, then the input No.1 for that gate is Hi regardless of the status of 100TB-8. In other words, there are three conditions for input No.1 of each gate; "AUTO", "MAN", and "none". Likewise there are three conditions for each of the inputs No.2, No.3 and No.4. Refer to Table A for characteristics.

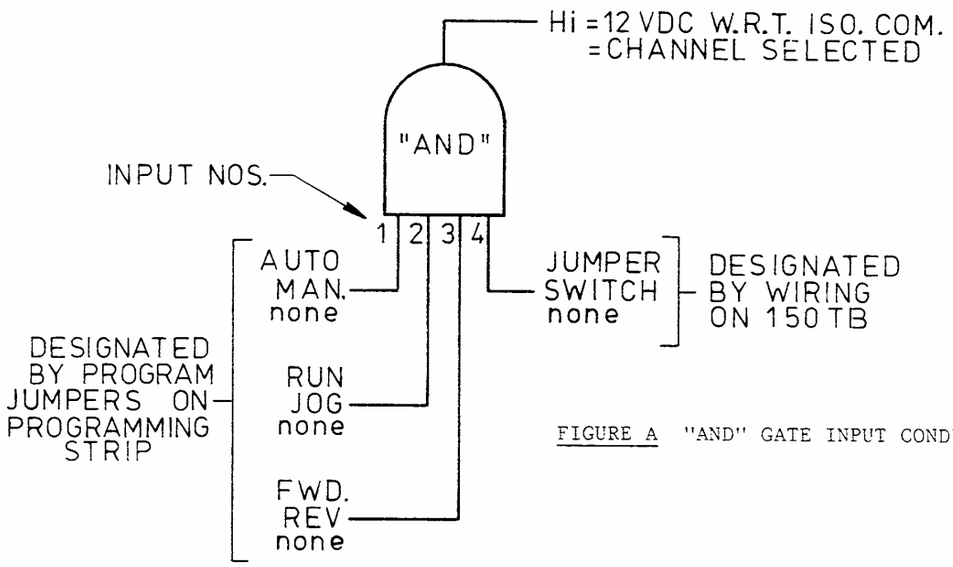


FIGURE A "AND" GATE INPUT CONDITIONS

TABLE A

INPUT NO.	PROGRAM CONDITIONS PLACED	CHARACTERISTICS
* 1	AUTO	Hi if and only if +12VDC applied at 100TB-8.
	MAN	Hi if and only if +12VDC is not applied at 100TB-8.
	none	Hi regardless of the status of 100TB-8.
* 2	RUN	Hi if and only if +12VDC is not applied at 100TB-7.
	JOG	Hi if and only if +12VDC is applied at 100TB-7.
	none	Hi regardless of the status of 100TB-7.
* 3	FWD	Hi if and only if FWD command is activated, i.e., FWD LED on E1530 PC board is ON.
	REV	Hi if and only if REV command is activated, i.e., REV LED on E1530 PC board is ON.
	none	Hi regardless of the status of the FWD or REV circuits.
** 4	JUMPER SWITCH	Hi always.
		Hi if and only if contacts are closed. Refer to A1799-007-EW, detail 7(A).
	none	Lo always. Handy method of disarming a speed channel completely.

* Input No. 1, 2 and 3 are programmed by placement of program jumpers over appropriate pins on the programming strip.

** Input No. 4 is programmed by proper connections on terminal block 150TB. Refer to Detail 7(A) on drawing A1799-007-EW external wiring diagram. Note: If this connection is left open the input is LO, unlike the characteristic for input Nos. 1, 2 and 3.

All four inputs of the "AND" gate must be Hi simultaneously before the output can be Hi, otherwise the gate output will be Lo and its corresponding speed channel will be inhibited. If operator conditions and programming is such that outputs of more than one gate is Hi, then the speed program voltage (zero to +6VDC) will be selected by that speed channel which is designated by the highest number.

Step 4. Now begin to program by filling out the worksheet given below. If this is your first time, use a pencil, because there may be some erasing before you are finally satisfied. Read through the following example for helpful hints.

ROUGH WORKSHEET

"AND" GATE INPUT NO.	SPEED CHANNEL NO.						
	1	2	3	4	5	6	7
1							
2							
3							
4							

Example : Let us continue with our hypothetical example that we mentioned in the beginning steps of this guideline. Say we are still working with option PS6 which is capable of seven speeds, six set by PC board mounted pots and one using a signal external to this PC board. Again, we hypothetically allocate speed channels to the functions as given below.

Speed channel No. 1 is enabled anytime the "RUN-JOG" operator is in "JOG" mode, regardless of other operator situations.

Speed channel No. 2 is enabled when the control is in the "MAN" mode, i.e., the "AUTO-MANUAL" operator is in the "MAN" mode, the "RUN-JOG" operator is in the "RUN" mode, and the "FWD" command is enabled.

Speed channel No. 3 is enabled whenever the control is in the "RUN" mode and "REV" command is enabled, regardless of whether it is in "AUTO" or "MAN" mode. But remember we still want speed channel No. 1 to take over when the control is reversing in the "JOG" mode.

Speed channel No. 7 is enabled when the "RUN-JOG" operator is in the "RUN" mode, the "AUTO-MANUAL" operator is in the "AUTO" mode, and the "FWD" command is enabled.

Speed channel No. 4, No. 5 and No. 6 should be disarmed by removing the appropriate jumpers on terminal block 150TB. Refer to drawing A1799-006-ES.

For the example described above with option PS6, the worksheet turns out to be as follows.

SAMPLE WORKSHEET #1

"AND" GATE INPUT NO.	SPEED CHANNEL NO.						
	1	2	3	4	5	6	7
1	none	MAN	none	none	none	none	AUTO
2	JOG	RUN	RUN	none	none	none	RUN
3	none	FWD	REV	none	none	none	FWD
4	JUMPER	JUMPER	JUMPER	none	none	none	JUMPER

The same example could be done using a PS3 option instead of PS6, and the work sheet would turn out as follows.

SAMPLE WORKSHEET #2

"AND" GATE INPUT NO.	SPEED CHANNEL NO.						
	1	2	3	4	5	6	7
1	none	MAN	none	AUTO			
2	JOG	RUN	RUN	RUN			
3	none	FWD	REV	FWD			
4	JUMPER	JUMPER	JUMPER	JUMPER			

Let us take another look at the sample worksheet #1. The only difference between the programming of channel No. 2 and No. 7 is that for input No. 1, channel No. 2 has a jumper in the "MAN" position and channel No. 7 has a jumper in the ; "AUTO" position. If the SC series external signal option is used in your particular system, it already has the capability of channeling either the process signal or the signal from manual speed pot whose wiper is tied at 100TB-12 of the E1530 PC board. The programming can be modified so that instead of using PC board mounted pot for functions listed for channel No. 2, the external manual speed pot can be used. Refer to sample worksheet #3.

Note that the program jumper which was in the "AUTO" position on speed channel No. 7 has been removed and speed channel No. 2 has been completely disarmed. Three channels of E1532 PC board, which is possible because of the "sub-channeling" capability of the external signal option.

SAMPLE WORKSHEET #3

"AND" GATE INPUT NO.	SPEED CHANNEL NO.						
	1	2	3	4	5	6	7
1	none	none	none	none	none	none	none
2	JOG	none	RUN	none	none	none	RUN
3	none	none	REV	none	none	none	FWD
4	JUMPER	none	JUMPER	none	none	none	JUMPER

Step 5. SC Units that are equipped with the preset speeds options have the nameplate mounted above the E1532 PC Board with four nylon spacers. Remove this nameplate by snapping off the spacers from the E1532 PC board. This will expose an entire array of programming strips. Start programming the unit by placing program jumpers on these terminal strips and/or arranging jumpers and switches on the terminal block 150TB. Use the plan that was devised on the Rough Worksheet in Step 4.

Step 6. Turn power on and put the control through trial runs. Verify that each designated speed channel gets selected when its programmed conditions are met. The LED's display in BCD (binary coded decimal) the speed channel number that is selected at the output. If the results are satisfactory as expected move on to Step 7. But if the results are not satisfactory then the possible probelms and solutions are given below.

(a) Certain designated speed channels do not get selected. Probable cause is a missing jumper on 150 TB.

(b) Wrong channel gets selected. If you take a closer look at the program conditions that have been set, you will probably find that more than one channel is eligible to be selected simultaneously, but the channel with the highest designation number gets the priority.

(c) Unused channel gets selected. Probably because the appropriate jumper on terminal block 150TB has not been removed.

(d) If it is found that the preset signal of two or more speed channels will be set identical, or very close, for the entire application scope of the system, then it is possible that you have used more speed channels than necessary. By proper programming it is possible to reduce all the speed channels with identical speed settings to just one speed channel. For example, if a "JOG-FWD" and a "JOG-REV" channels were programmed and it was found that the speed settings on both these channels were always identical, then these channels can be reduced to just one speed channel ("JOG") by leaving the program jumper off the FWD/REV positions.

Step 7. Once it is found that the programming is satisfactory and the system changes speeds appropriately, then the Final Worksheet should be filled out and saved for future reference.

FINAL WORKSHEET

"AND" GATE INPUT NO.	SPEED CHANNEL NO.						
	1	2	3	4	5	6	7
1							
2							
3							
4							

Step 8. Write or type the information from the Final Worksheet on 3/8" X 1¼" Avery labels. Stick these labels in their appropriate blocks on the E1532 PC board, so that the program information for each channel falls next to the speed pot for that channel. Figure B is an example for Sample Worksheet #1 of Step 4.

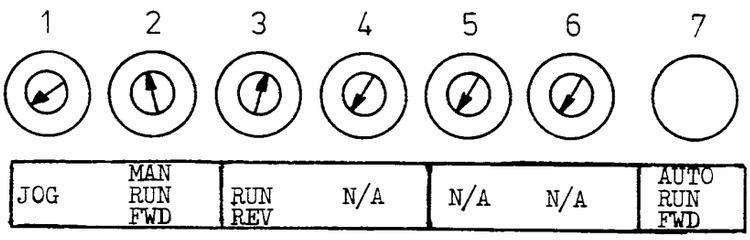


FIGURE B Sample of Information Typed on Avery Labels

This helps the operator to associate the speed settings with the program conditions for each channel. Figure C gives examples of notations on the Avery labels for the case where external control switches are wired to terminal block 15TB.

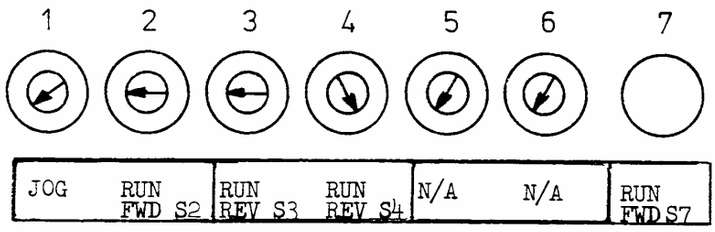


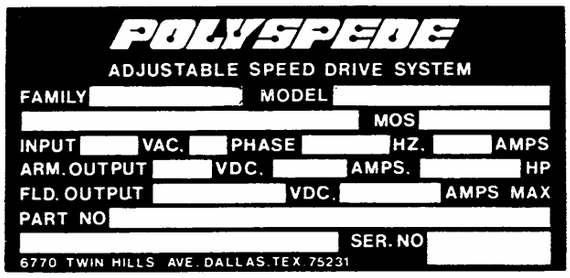
FIGURE C Sample of Information Typed on Avery Label

Step 9. The nameplate is the only convenient means of identifying an SC unit accurately. Therefore, the last but not the least step is to replace the nameplate, back to its proper place on the E1532 PC board, so that it doesn't get lost.

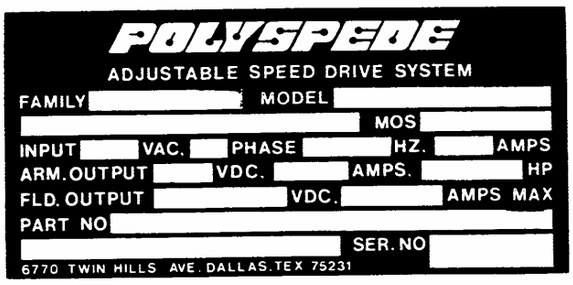
FIELD MODIFICATION FORM

INSTRUCTIONS: When an SC unit is subjected to modification in the field, this form must be completed in detail and mailed to Polyspede Electronics, P.O. Box 31024, Dallas, Texas, 75231. Mail the form to the attention of the "Test Department."

1. Fill in all blocks completely for both (a) before modification and (b) after modification.



(a) Nameplate Information Before Modification



(b) Nameplate Information After Modification

CUT HERE

2. Briefly describe the modification. _____

_____

_____

_____

3. Name (of person making the modification) _____

Company Name _____ Phone: ( ) _____

Address _____

_____

4. Final Location:

Company Name _____ Phone: ( ) _____

Address _____

_____

Filename: scs.doc
Directory: C:\My Documents
Template: C:\WINDOWS\Application Data\Microsoft\Templates\Normal.dot
Title: A 1771-000-MA,b
Subject:
Author: domnic
Keywords:
Comments:
Creation Date: 3/16/03 3:50 PM
Change Number: 1
Last Saved On: 3/16/03 3:50 PM
Last Saved By: domnic
Total Editing Time: 2 Minutes
Last Printed On: 3/16/03 3:53 PM
As of Last Complete Printing
Number of Pages: 72
Number of Words: 16,337 (approx.)
Number of Characters: 93,127 (approx.)