Boston Gear®
Ratiotrol®

DC Motor Speed Controllers

Installation and Operation

Doc. No. 57768

VE Plus Series
Single Phase
Adjustable-Speed
1/6-5 HP

Boston Gear

Inside Front Cover

BLANK

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WARNINGS

The following safety precautions must be strictly adhered to at all times.

1. **YOU AS THE OWNER OR OPERATOR OF BOSTON GEAR EQUIPMENT HAVE THE RESPONSIBILITY TO HAVE THE USERS OF THIS EQUIPMENT TRAINED IN ITS OPERATIONS AND WARNED OF ANY POTENTIAL HAZARDS OF SERIOUS INJURY.**

2. **THE DRIVE EQUIPMENT SHOULD BE INSTALLED, OPERATED, ADJUSTED, AND SERVICED ONLY BY QUALIFIED PERSONNEL FAMILIAR WITH THE CONSTRUCTION AND OPERATION OF THE EQUIPMENT AND THE HAZARDS INVOLVED INCLUDING THOSE DESCRIBED BELOW. FAILURE TO OBSERVE THIS PRECAUTION CAN RESULT IN PERSONAL INJURY, LOSS OF LIFE, AND PROPERTY DAMAGE.**

3. **THE NATIONAL ELECTRICAL CODE REQUIRES THAT AN AC LINE FUSED DISCONNECT OR CIRCUIT BREAKER BE PROVIDED IN THE AC INPUT POWER LINES TO THE CONTROLLER. THIS DISCONNECT MUST BE LOCATED WITHIN SIGHT OF THE CONTROLLER. DO NOT OPERATE THE CONTROLLER UNTIL THE CODE REQUIREMENT HAS BEEN MET.**

4. **THE DRIVE EQUIPMENT IS AT AC LINE VOLTAGE POTENTIAL WHENEVER AC POWER IS CONNECTED TO THE DRIVE EQUIPMENT. CONTACT WITH AN ELECTRICAL CONDUCTOR INSIDE THE DRIVE EQUIPMENT OR AC LINE DISCONNECT CAN CAUSE ELECTRIC SHOCK RESULTING IN PERSONAL INJURY OR LOSS OF LIFE.**

5. **BE SURE ALL AC POWER IS DISCONNECTED FROM THE DRIVE EQUIPMENT BEFORE TOUCHING ANY COMPONENT, WIRING, TERMINAL, OR ELECTRICAL CONNECTION IN THE DRIVE EQUIPMENT.**

6. **ALWAYS WEAR SAFETY GLASSES WHEN WORKING ON THE DRIVE EQUIPMENT.**

7. **DO NOT REMOVE OR INSERT CIRCUIT BOARDS, WIRES, OR CABLES WHILE AC POWER IS APPLIED TO THE DRIVE EQUIPMENT. FAILURE TO OBSERVE THIS PRECAUTION CAN CAUSE DRIVE DAMAGE, PERSONAL INJURY, OR LOSS OF LIFE.**

8. **ALL DRIVE EQUIPMENT ENCLOSURES, MOTOR BRAKES, MOTOR FRAMES, AND REMOTE OPERATOR STATIONS MUST BE CONNECTED TO AN UNBROKEN COMMON GROUND CONDUCTOR. AN UNBROKEN GROUNDING CONDUCTOR MUST BE RUN FROM THE COMMON GROUND CONDUCTOR TO A GROUNDING ELECTRODE BURIED IN THE EARTH OR ATTACHED TO A PLANT GROUND. REFER TO THE NATIONAL ELECTRICAL CODE AND LOCAL CODES FOR GROUNDING REQUIREMENTS.**

9. **THE ATMOSPHERE SURROUNDING THE DRIVE EQUIPMENT MUST BE FREE OF COMBUSTIVE VAPORS, CHEMICAL FUMES, OIL VAPOR, AND ELECTRICALLY CONDUCTIVE OR CORROSIVE MATERIALS.**

10. **SOME COMPONENTS IN THE CONTROLLER CAN BE SEVERELY DAMAGED BY STATIC ELECTRICITY. THEREFORE, BE SURE YOUR BODY IS FREE OF STATIC ELECTRICITY BY TOUCHING A GROUNDED METAL OBJECT BEFORE TOUCHING INTERNAL COMPONENTS.**

Section I – General Information

INTRODUCTION

This manual contains installation, operation, and maintenance and repair instructions for Boston Gear VEplus Single-Phase Adjustable-Speed DC Motor Controllers. A parts list, ratings, list of options, specifications, and drawings are included.

GENERAL DESCRIPTION

VEplus Controllers statically convert AC line power to regulated DC for nonregenerative, adjustable-speed armature control of shunt-wound and permanent-magnet motors.

VEplus Controllers comply with applicable standards established by the National Electrical Code and NEMA for motor and industrial control equipment. The controllers are Underwriters Laboratories Listed (File No. E60207) and CSA approved (File No. LR19781).

MODEL TYPES AND SELECTION

Consisting of eighteen models, the VEplus Series offers either an open chassis configuration or NEMA 3/4/12 enclosed controllers with a choice of blank operators' panels (for use with external pilot devices) or panels with Run/Stop/Jog switch, speed pot and, when desired, Forward/Reverse selection switch as well.

TABLE 1. VEplus MODEL MATRIX

Item Code	Cat. No.	Line Voltage† HP Range		Construction		Function			Operator's Controls		Wiring Diagram Figure #
		115VAC	230VAC	Open Chassis	Enclosed	Run/ Stop	Arm. Cont. Run/Stop W/D.B.	Arm. Cont. Rev. W/D.B.	Local (Integral)	Remote	
64883	VES3			X		X				X	2, 4
57904	VES3U			X			X			X	4A, 4B
64884	VES3M			X				X		X	5, 6
64885	VES3B				X	X				X	2, 4
57910	VES3UB	1/6-1	1/2-3		X		X			X	4A, 4B
64887	VES3MB				X			X		X	5, 6
64886	VES3S				X	X			X		2
57930	VES3US				X		X		X		4A
64889	VES3MR				X			X	X		5
64890	VES5			X		X				X	2, 4
57909	VES5U			X			X			X	4A, 4B
64891	VES5M			X				X		X	5, 6
64892	VES5B				X	X				X	2, 4
57926	VES5UB	1/6-1	1/2-5		X		X			X	4A, 4B
64894	VES5MB				X			X		X	5, 6
64893	VES5S				X	X			X		2
57935	VES5US				X		X		X		4A
64896	VES5MR				X			X	X		5

(†)Note: All units are shipped calibrated for the maximum horsepower ratings shown. Units may be calibrated for other standard ratings by changing the position of a jumper. Units are connected for 230 VAC and are easily reconnected for 115 VAC input.

MOTOR SELECTION

VEplus Controllers control the operation of general purpose DC motors designed for use with solid-state rectified power supplies. The Motors may be shunt-wound, stabilized shunt-wound, or permanent magnet. For maximum efficiency, any motor should be rated from operation for a NEMA Code K power supply.

Section II – Installation

Before starting the installation, read this section thoroughly. In addition, a thorough review of the Ratings and Specifications (Section VII) is recommended. The following installation guidelines should be kept in mind when installing the controller.

INSTALLATION GUIDELINES

1. **CONTROLLER MOUNTING** – Controllers rated 1/6-3 HP may be wall mounted either vertically or horizontally. Controllers rated at 5 HP may only be mounted vertically. Never mount the controller upside down, immediately beside or above heat generating equipment, or directly below water or steam pipes.

   The controller must be mounted in a location free of vibration.

   Multiple controllers may be mounted sided by side, as close to each other as the mounting feet will allow. However, if a Controller enclosure has Cover Hinges (Option 50), 4 inches (102 mm) clearance must be provided on the hinged side of the enclosure to accommodate the swing of the cover.

   The minimum clearance at the top and bottom of the controller may be as narrow as the conduit fittings allow.

2. **ATMOSPHERE** – The atmosphere surrounding the controller must be free of combustible vapors, chemical fumes, oil vapor, and electrically conductive or corrosive materials.

   The air surrounding an enclosed controller must not exceed 40°C (104°F), and the air surrounding an open-chassis controller must not exceed 55°C (131°F). Minimum air temperature is 0°C (32°F) for enclosed and open-chassis controllers.

   VEplus Controllers (except 5 HP enclosed models) require a natural convection flow of air over the pins on the back of the controller to dissipate the heat generated by the controller. Allow 4 inches (102 mm) clearance on all sides from solid objects which block the flow of air to the pins. Note: 5 HP enclosed models are fan-cooled.

3. **CONTROLLER CONSTRUCTION** – VEplus controller bases are made of die-cast aluminum with a powdered epoxy finish.

   VEplus Controller enclosures are totally enclosed, nonventilated, and comply with NEMA type 4 and 12 standards. There is an oil resistant synthetic rubber gasket between the cover and base. Those models with integral operator controls include flexible boots to seal the switches, and a seal for the Motor Speed potentiometer.

   Enclosure covers are molded of Noryl®, which is not affected by most water-based solutions, detergents, acids, and bases. However, the cover may be softened by heptane, acetone, and other halogenated and aromatic hydrocarbons, so install these controllers in a location free of such substances.

4. **BRANCH CIRCUIT PROTECTION** – The National Electrical Code states that a two-pole fused disconnect switch be installed in the AC line supply to the controller. Although an optional two-pole circuit breaker (Option 30) is available for VES5 Controllers, this circuit breaker should not be considered as branch circuit protection. However, the existing branch circuit **may** already provide the required protection. Refer to the National Electrical Code and local codes.

5. **LINE SUPPLY** – The controller should not be connected to a line supply capable of supplying more than 100,000 amperes short-circuit current. Short-circuit current can be limited by using an input supply transformer of 50 KVA or less, or by using correctly sized current limiting fuses in the supply line ahead of the controller. Do not use a transformer with less than the minimum transformer KVA listed in Table 8, page 26.

   If rated line voltage is not available, a line transformer will be required. If the line supply comes directly from a transformer, place a circuit breaker or disconnect between the transformer secondary and the controller. If power is switched in the transformer primary, transients may be generated which can damage the controller. See Table 8 (page 26) for minimum transformer KVA.

Do not use power factor correction capacitors on the supply line to controller.

A 12-joule metal oxide varistor (MOV) is connected across the controller terminals. If higher energy transients are present of the line supply, additional transient suppression will be required to limit transients to 150% of peak line voltage.

When a 115 VAC line supply is used, connect the white (common) wire to Terminal L2 and connect the remaining (hot) wire to Terminal L1.

6. **ISOLATION TRANSFORMER** – While not required, an isolation transformer can provide the following advantages:
   - **a.** Reduce the risk of personal injury if high voltage drive circuits are accidentally touched.
   - **b.** Provide a barrier to externally generated AC supply transients. This can prevent controller damage from abnormal line occurrences.
   - **c.** Reduce the potential for damaging current if the motor armature, motor field, or motor wiring become grounded.

7. **GROUNDING** – Connect the green or bare (ground) wire of the line supply to the ground screw located near the top conduit entry hole in the controller base. Then ground the controller base by connecting the ground screw to the earth ground.

   The motor frame and operator control stations must also be grounded.

   Personal injury or loss of life may occur if the controller, motor, and operator stations are not properly grounded.

8. **WIRING PRACTICES** – The power wiring must be sized to comply with the National Electrical Code, CSA, or local codes. Refer to the controller data label for line and motor current ratings.

   Do not use solid wire.

   Signal and control wiring refers to wiring for potentiometers, tachometers, run/stop pushbuttons, etc. Power wiring refers to AC line input wiring, and motor armature (or stator) and field connections. Signal and control wiring should not be run in the same conduit with power wiring and should be kept separated from power wiring in an enclosure. The exception to this is that 115 VAC control wiring should be considered as low power wiring and kept separate from other control and signal wiring, as well as other power wiring.

   Multi-conductor twisted cable (Alpha 5630B1801 or equal) is recommended for signal and control wiring.

   If shielded wire is used, shielded, *twisted* wire (such as Alpha 2422-two conductor, 2423-three conductor, 2424-four conductor) for signal and control wiring is recommended. Connect the shields to chassis ground (ground screw or terminal on the controller base) and tape the opposite ends of the shields. Do not connect the shield at both ends.

   Two 3/4-14 NPT threaded holes are provided for conduit entry, one each in the top and bottom of the controller base.

9. **OPTIONS** – This equipment manual is for use with the basic controller. If options are installed in the controller, they will be identified on the controller data label. The instruction sheets supplied with the options should be reviewed before the controller is installed.

INSTALLING THE CONTROLLER

1. Remove the controller front cover (if used) by removing the four cover screws.
2. Check components in the controller for shipping damage. Report shipping damage to the carrier.
3. Check the controller and motor data labels to be sure the units are electrically compatible.
4. Be sure the controller has been calibrated correctly for the motor being used. Calibration is performed by changing the position of a Jumper (J4) on the controller control board to comply with Table 2, page 8. To change the position of Jumper J4, pull the jumper from the control board and then push it onto the appropriate two pins on the board. For the location of J4, see Figure 19 (page 35) or Figure 20 (page 36) as applicable.

TABLE 2. JUMPER J4 POSITIONS

JUMPER POSITION	MOTOR ARMATURE CURRENT RATING (AMPERES)*	
	3 HP Maximum	5 HP Maximum
100%	15	25
80%	12	20
60%	9	15
40%	6	10
20%	3	5

*Select the position closest to the motor nameplate armature current rating.

5. Check the positions of Jumpers J1*, J2, and J3 on the control board. The locations of J1*, J2, and J3, see Figure 19 (page 35) or Figure 20 (page 36) as applicable. For a 230 VAC line supply and a 180V armature motor, Jumper J1* must be in the 230V position, and Jumpers J2 and J3 must both be in the 180V position. For a 115 VAC line supply, J1* must be in the 115V position, and J2 and J3 must be in the 90V positions. *For controllers supplied with factory installed contactor or interface board, Jumper J1 has been moved to one of these adjacent option boards. Do not offset the five-position plug with ribbon cable (Connector J1 supplied with option board) at Connector J1 on the control board. The four-position plug (Jumper J1) now located on the option board should be moved for input voltage calibration. Refer to the specific option board instruction for further information. All controls are shipped with Jumper J1 connected for 230 VAC.

6. Mount the controller Mounting dimensions are shown in Figure 1.

7. Install conduit and connect the power wiring to Terminals L1, L2, ground to ground lug, motor armature leads to A1 (+) and A2 (-) or M1 and M2*, and field leads to F+ and F-. Be sure to observe Installation Guidelines 5 and 8 on pages 6 and 7. In half-wave shunt field voltage is desired, connect the motor shunt field leads to Terminals F+ and F/2 (Table 13, page 29). Note: Low inductance motors require a full wave field to prevent current instability. *Refer to model matrix on page 5, table 1 referencing proper wiring diagram for specific model.

8. If the controller contains any options that require external wiring, follow the wiring instructions in the instruction sheet supplied with the option.

9. If remote operator control wiring and/or signal wiring is required, connect the controller as shown in the appropriate connection diagram (Figures 2 through 15A). Figures 2 through 7 show operator control connections, and Figures 8 through 15 show signal connections.

10. Set the DIP Switch (S3) as shown in the appropriate connection diagram. See Figure 19 (page 35) or Figure 20 (page 36), as applicable, for the location of DIP Switch S3. Also refer to Table 12, “DIP Switch Settings”, page 29.

11. Installed the controller cover, if used.

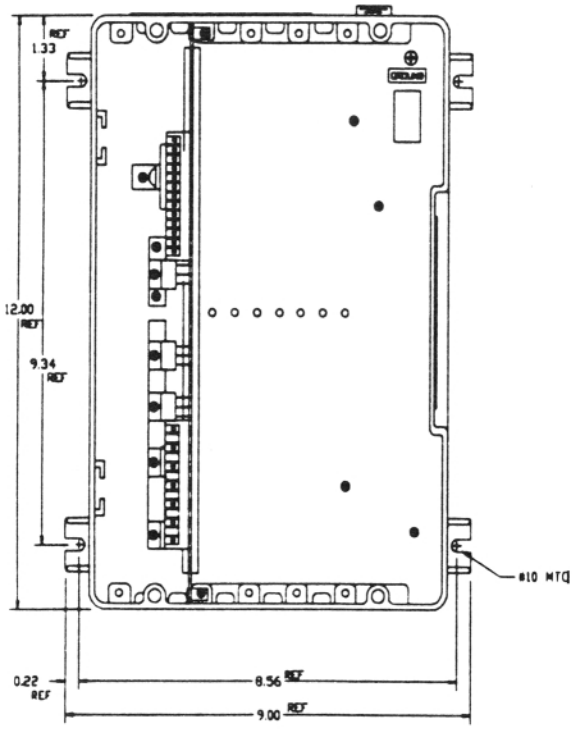


FIGURE 1. CONTROLLER MOUNTING DIMENSIONS

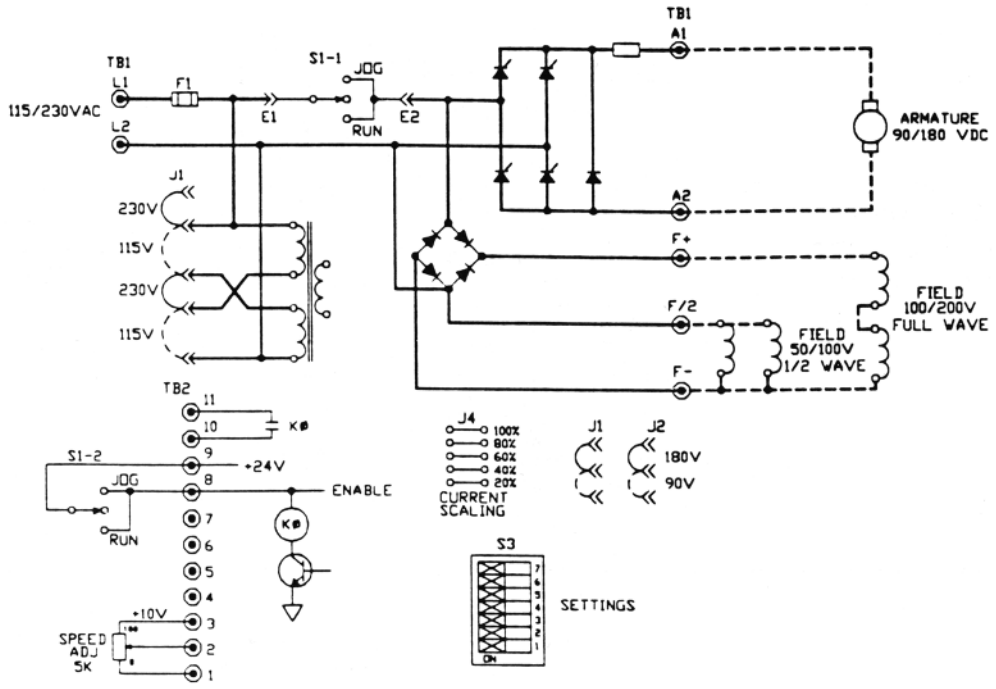


FIGURE 2. LOGIC CONNECTION DIAGRAM, RUN-STOP-JOG SWITCH, 1/6 - 2 HP

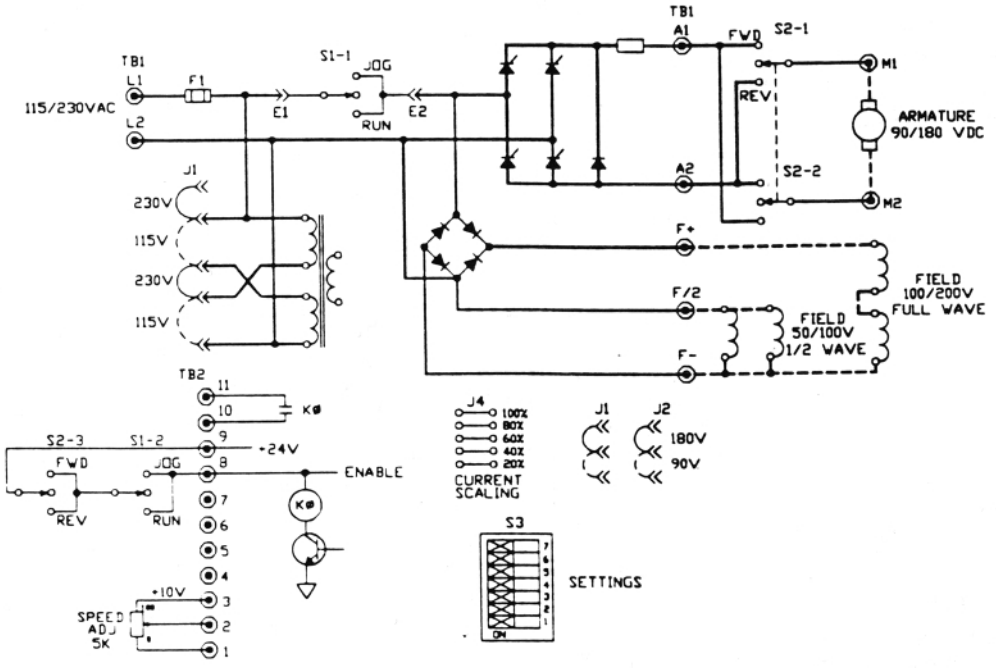


FIGURE 3. LOGIC CONNECTION DIAGRAM, FORWARD-REVERSE SWITCH AND RUN-STOP-JOG SWITCH, 1/6 - 2 HP

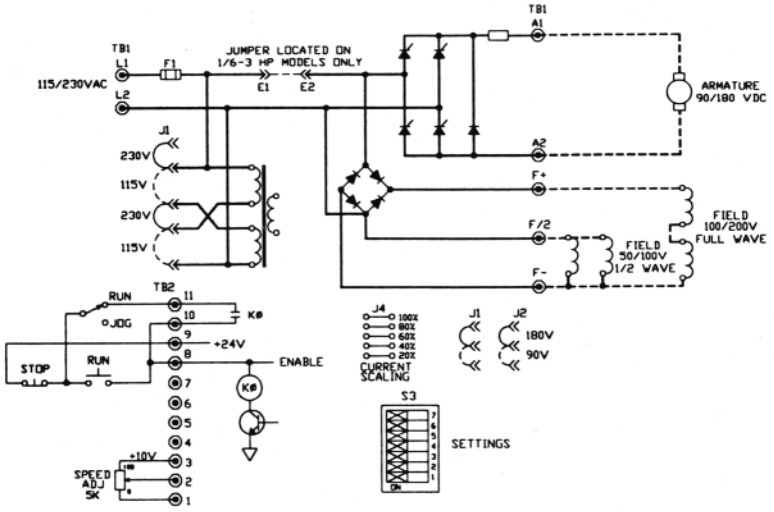


FIGURE 4.
LOGIC CONNECTION DIAGRAM, RUN-STOP PUSHBUTTONS AND RUN-JOG SWITCH, 1/6 - 5 HP

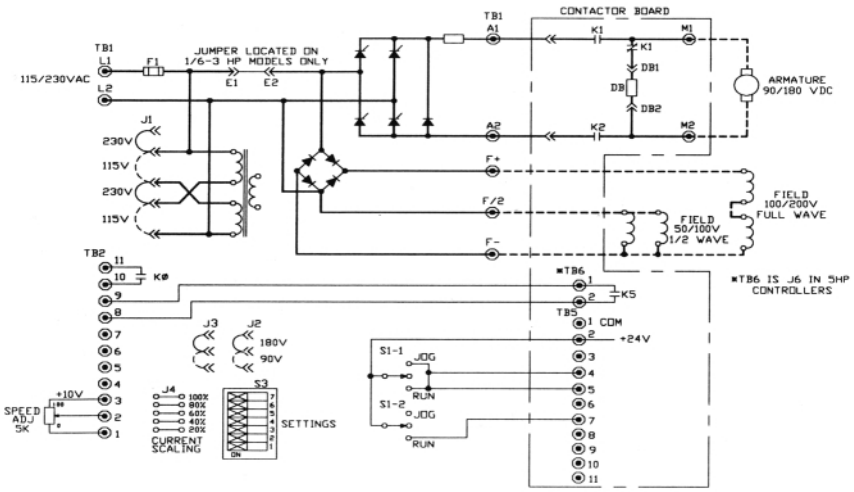


FIGURE 4A.
LOGIC CONNECTION DIAGRAM, WITH UNIDIRECTIONAL ARMATURE CONTACTOR USING RUN-STOP-JOG SWITCH

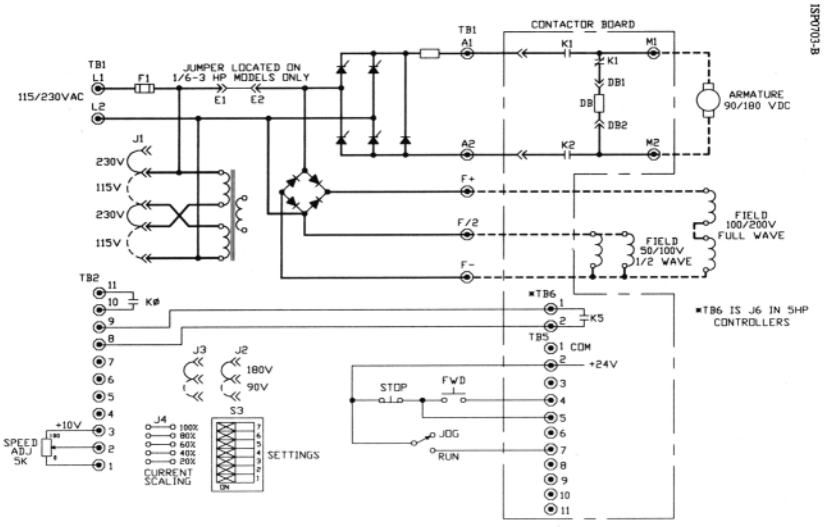


FIGURE 4B.
LOGIC CONNECTION DIAGRAM, WITH UNIDIRECTIONAL ARMATURE CONTACTOR USING RUN-STOP PUSHBUTTONS AND RUN-JOG SWITCH

FIGURE 5.
LOGIC CONNECTION DIAGRAM, WITH ARMATURE CONTACTOR REVERSING USING SWITCHES, 1/6 - 5 HP

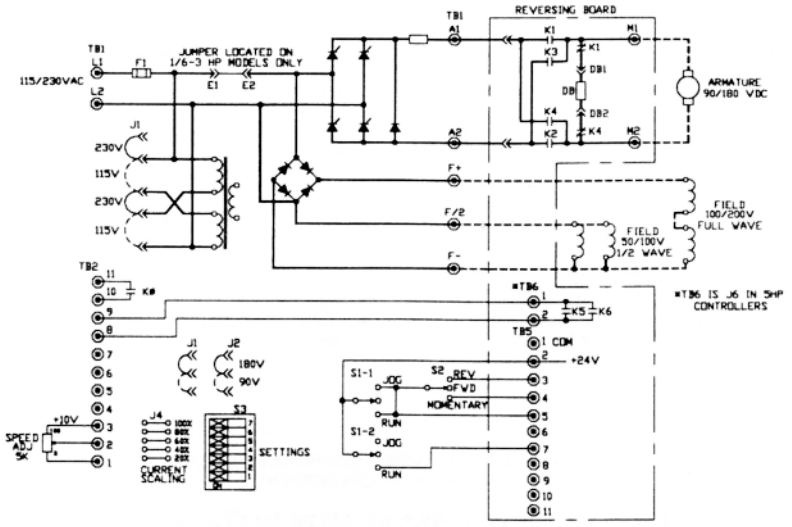


FIGURE 6.
LOGIC CONNECTION DIAGRAM, WITH ARMATURE CONTACTOR REVERSING USING PUSHBUTTONS AND RUN-JOG SWITCH, 1/6 - 5 HP

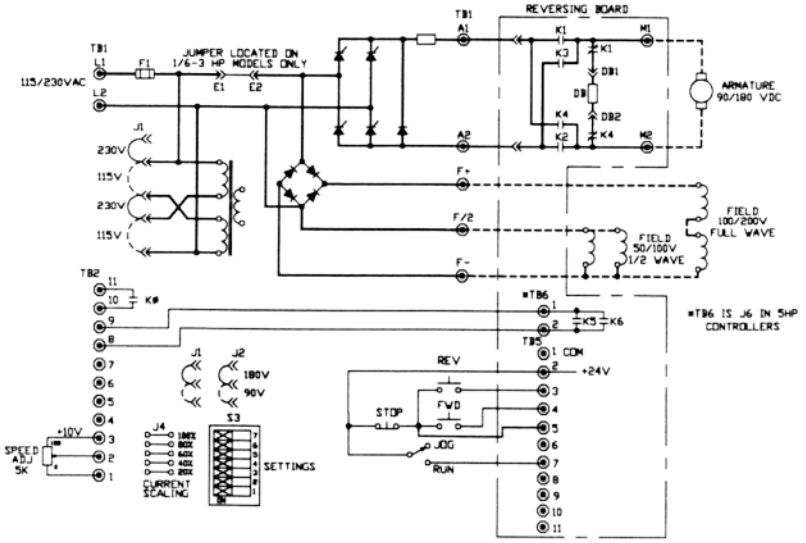
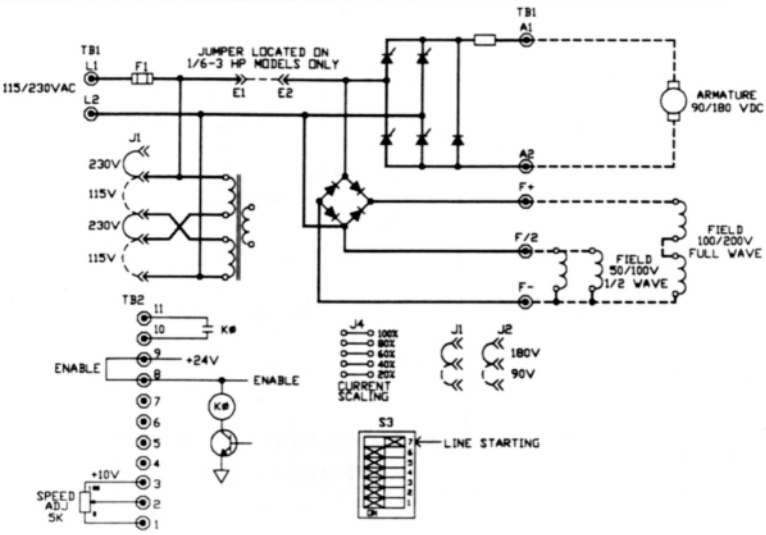


FIGURE 7.
LOGIC CONNECTION DIAGRAM, LINE STARTING WITH MOTOR SPEED POTENTIOMETER 1/6 - 5 HP



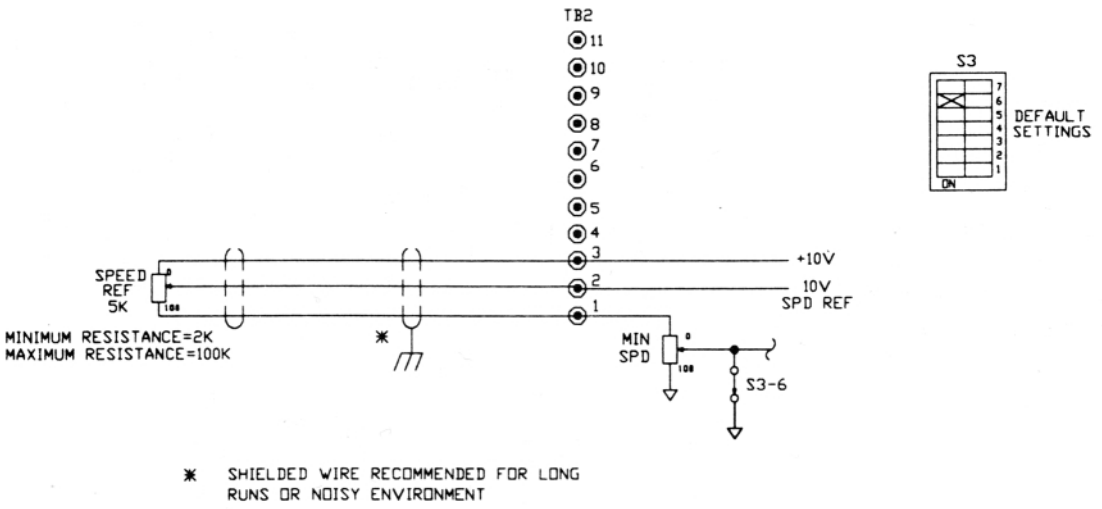


FIGURE 8. SIGNAL CONNECTION DIAGRAM, MOTOR SPEED POTENTIOMETER

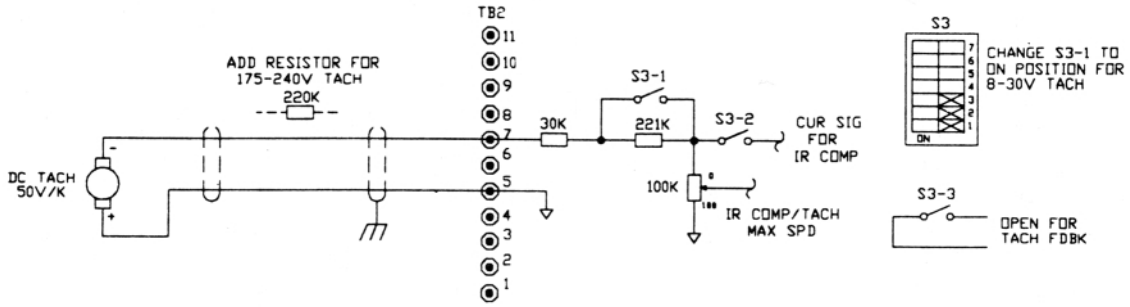


FIGURE 9. SIGNAL CONNECTION DIAGRAM, TACHOMETER FEEDBACK

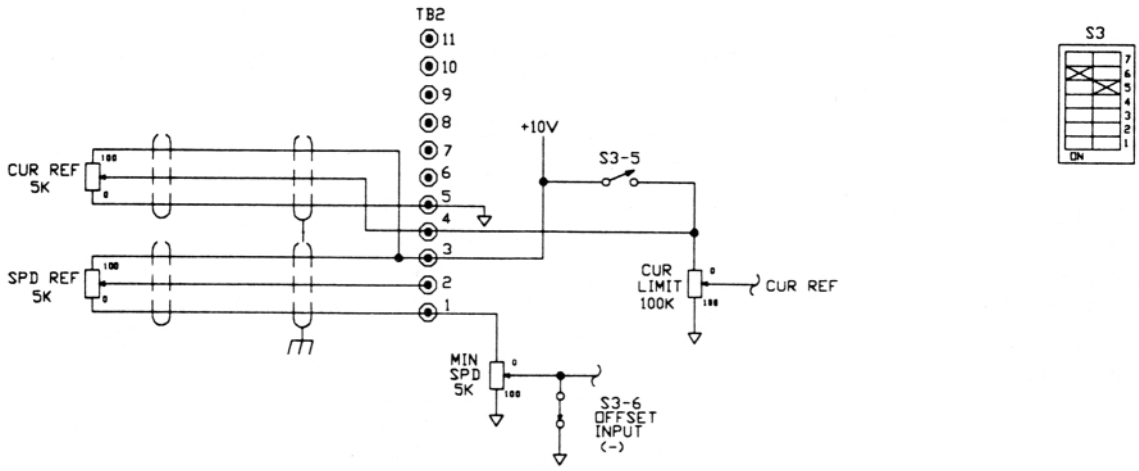


FIGURE 10. SIGNAL CONNECTION DIAGRAM, CURRENT (TORQUE) REFERENCE POTENTIOMETER

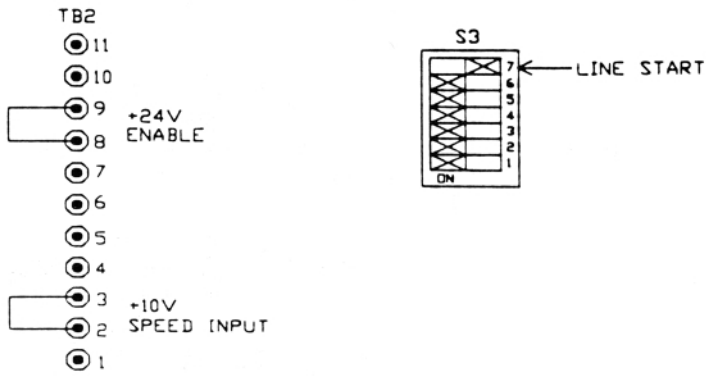


FIGURE 11. SIGNAL CONNECTION DIAGRAM, LINE STARTING WITHOUT A MOTOR SPEED POTENTIOMETER

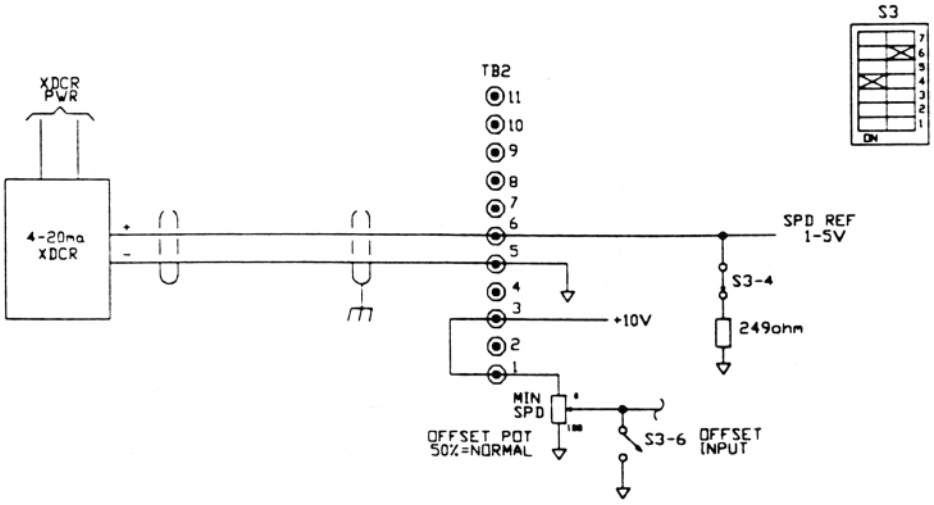


FIGURE 12. SIGNAL CONNECTION DIAGRAM, 4 - 20 MA INTERFACE

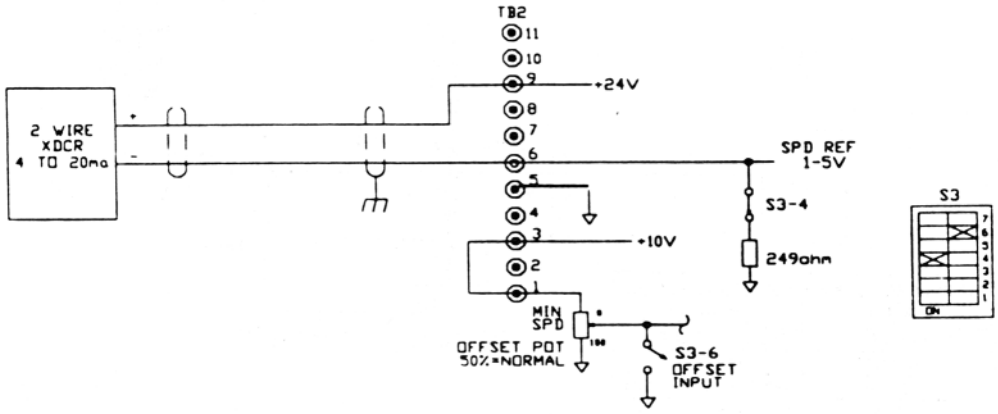


FIGURE 13. SIGNAL CONNECTION DIAGRAM, 2-WIRE TRANSDUCER

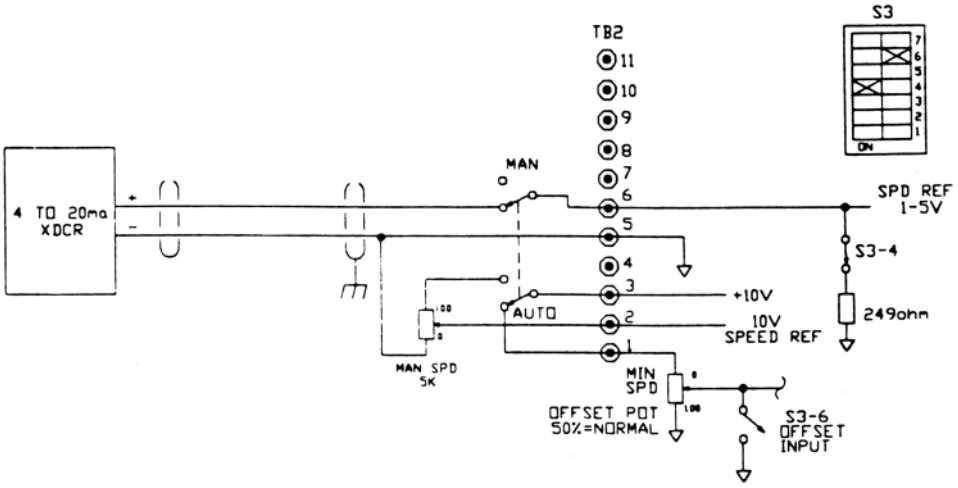


FIGURE 14. SIGNAL CONNECTION DIAGRAM, 4 - 20 mA TRANSDUCER WITH MANUAL/AUTO SWITCH

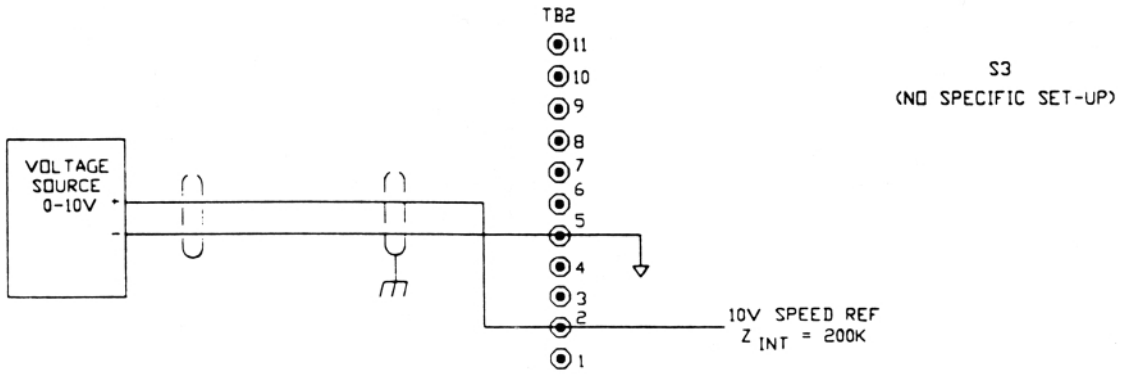
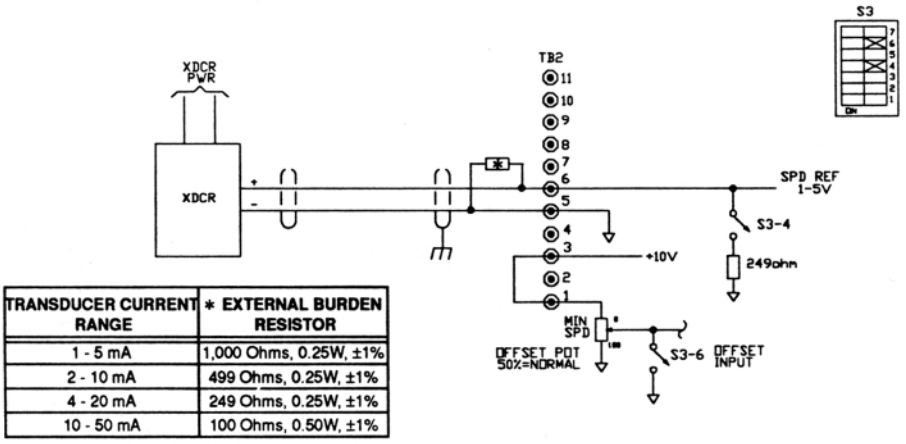


FIGURE 15. SIGNAL CONNECTION DIAGRAM, 0 - 10 VDC EXTERNAL SPEED REFERENCE SIGNAL



TRANSDUCER CURRENT RANGE	* EXTERNAL BURDEN RESISTOR
1 - 5 mA	1,000 Ohms, 0.25W, ±1%
2 - 10 mA	499 Ohms, 0.25W, ±1%
4 - 20 mA	249 Ohms, 0.25W, ±1%
10 - 50 mA	100 Ohms, 0.50W, ±1%

FIGURE 15A. SIGNAL CONNECTION DIAGRAM, TRANSDUCER WITH EXTERNAL BURDEN RESISTOR

INITIAL STARTUP

1. Remove the controller cover (if used) by removing the four cover screws.

2. Be familiar with any options installed in the controller by reviewing the instruction sheets supplied with the options.

3. Be sure all wiring is correct and all wiring connections are tightened securely.

4. Be sure the controller is calibrated correctly. See steps 4 and 5 under "Installing The Controller" on pages 7 and 8.

5. Be sure the AC line voltage to the controller agrees with the controller nameplate.

6. The potentiometers in the controller are factory adjusted as shown in Table 3. These settings will provide satisfactory operation for most applications. If different settings are required, refer to "Adjustment Instructions" starting on page 18.

TABLE 3. INITIAL POTENTIOMETER SETTINGS

POTENTIOMETER	SETTING	DESCRIPTION
IR/TACH	Fully Counterclockwise (0%)	0% Boost
MIN SPD (Offset)	Fully Counterclockwise (0%)	0% Speed
CUR LMT	Fully Clockwise (100%)	150% Load
MAX SPD	3/4 Turn Clockwise	100% Speed
DECEL	2/3 Turn Clockwise	8 Seconds
ACCEL	2/3 Turn Clockwise	8 Seconds

7. Replace the cover, if required, and secure it with the four cover screws.

8. Switch on the AC supply to the controller.

9. Check motor rotation, as follows:

a. If a MOTOR SPEED Potentiometer is used, turn it fully counterclockwise. If an external signal is used for the speed reference, set it at minimum.

b. If a RUN-STOP-JOG switch is used, place it in RUN position. Otherwise, initiate a RUN command.

c. Turn the MOTOR SPEED potentiometer clockwise or increase the speed reference signal, as applicable. To stop the motor, place the switch in STOP position or initiate a STOP command, as applicable.

If the motor rotates in the wrong direction, disconnect the AC supply to the controller, and then interchange the motor armature leads at the motor connection box or at the controller terminal board.

10. Refer to Section III, "Operation" for operating instructions.

Section III – Operation

POWER ON/OFF

The controller energizes when AC voltage is supplied to the controller.

If the AC supply is interrupted and the controller is not set up for line starting, the motor will not restart when the AC supply is restored until the controller is reset by initiating a stop command and then a start command. If the controller is set up for line starting and the AC supply is interrupted, the motor will restart when the AC supply is restored.

CAUTION: The line starting feature is not recommended for use on equipment where personnel have direct access to operating machinery. Personal injury or loss of life could occur due to the instantaneous starting of the motor without warning when AC power is restored.

NOTE: Whenever the AC supply voltage is applied to the controller, the motor shunt field is energized with rated voltage, and potentially hazardous voltage is present at the motor armature terminals. These voltages can cause electric shock resulting in personal injury or loss of life.

RUN

If a RUN-STOP-JOG switch is used, place the switch in RUN position. Otherwise, initiate a RUN command. A RUN command will accelerate the motor to the setting of the MOTOR SPEED potentiometer or external speed reference signal, as applicable. The rate of acceleration is preset by the ACCEL potentiometer on the controller control board.

STOP

If a RUN-STOP-JOG switch is used, place the switch in STOP position. Otherwise, initiate a STOP command. A STOP command will stop the motor at a rate proportional to the stopping rate of the motor load.

If the controller has dynamic braking, the motor stopping time will be reduced. Dynamic braking provides exponential rate braking of the motor armature, which occurs when the circuit is opened between the controller and the motor armature, and one or more resistors are connected across the motor armature.

The dynamic braking resistors provide initial braking torque as shown in Table 4.

TABLE 4. DYNAMIC BRAKING CHARACTERISTICS*

	RATED	RATED HORSEPOWER									
COMPONENT	VOLTAGE	1/6	1/4	1/3	1/2	3/4	1	1-1/2	2	3	5
BRAKING TORQUE (%)	115V	300	215	170	110	75	60	–	–	–	–
	230V	–	–	–	400	320	220	145	105	85	96
STOPS PER MINUTE	115V	9	6	5	5	4	4	–	–	–	–
	230V	–	–	–	5	4	4	3	3	2	2

*High Inertia Loads may extend braking time and cause overheating of the dynamic braking resistors.

An antiplug feature, present in the armature contactor reversing board, prevents restarting the motor before the motor has been braked to a stop.

SPEED CONTROL

Motor speed is directly proportional to the setting of the MOTOR SPEED potentiometer or the magnitude of an external speed reference signal, as applicable. This potentiometer or the speed reference signal may be adjusted while the motor is running or may be preset before the motor is started.

The rates of acceleration and deceleration are preset by the ACCEL and DECEL potentiometers, respectively, located on the controller control board.

Maximum speed and minimum speed (or offset) are preset by the MAX SPD and MIN SPD potentiometers, respectively, located on the control board.

REVERSE

To reverse motor rotation on controllers with reversing capabilities, initiate a STOP function and then initiate a REVERSE command. The motor will then accelerate to the setting of the MOTOR SPEED potentiometer or external speed reference signal, as applicable. Forward and reverse speed ranges are identical.

If a FWD-REV switch is used, it must have a center position interlock, which requires a momentary relaxation of pressure before the opposite position can be engaged. The center position causes a STOP command and allows time for the motor to stop before a REVERSE command is initiated. If a REVERSE command is initiated while the motor is rotating, motor and controller damage may occur.

Armature Contactor Reversing incorporates an antiplug feature which requires the motor be stopped before it can be reversed.

JOG

If a RUN-STOP-JOG switch is used, place the switch in JOG position. Otherwise initiate a JOG command. Jog is momentary, causing motor rotation only while the switch is held in JOG position or while a JOG command is active. Release the switch to stop the motor. Note: This control jogs at run speed.

INOPERATIVE MOTOR

If the motor stops and/or won't start, disconnect AC power to the controller, remove the controller cover (if used), and check the AC line fuse on the controller control board. For the location of the fuse, see Figure 19 (page 35) or Figure 20 (page 36), as applicable. If the fuse is blown, refer to the Troubleshooting Table (Table 5). Pages 21-23.

If the fuse is not blown, the internal overload monitor may have shut down the controller. The overload monitor will shut down the controller if the motor armature current exceeds 120% of rated for a length of time of continuous operation. The length of time is determined by the amount of the overload. If the overload monitor trips, reset the controller by initiating a STOP command, removing the overload, and then initiating a RUN command to restart. Repeated shutdown indicates an overload condition (mechanical or electrical) which must be removed. Refer to the Troubleshooting Table (Table 5).

Section IV – Maintenance and Repair

GENERAL

1. Keep the controller dry and free of dust, dirt, and debris. No parts require periodic replacement.

2. Periodically disconnect the AC line to the controller and check all wire terminations to be sure they are tight.

3. Visually check components for damage due to overheating or breakage. All damaged and/or faulty components must be replaced for satisfactory operation.

4. Maintain the motor according to maintenance instructions supplied by the motor manufacturer.

ADJUSTMENT INSTRUCTIONS

ACCELERATION

1. Set the MOTOR SPEED potentiometer at 100% or the external speed reference signal at maximum, as applicable.

2. Initiate a RUN command and observe the time required for the motor to reach maximum speed.

3. Adjusted the ACCEL potentiometer for the desired rate. Full clockwise rotation is the fastest acceleration (0.2 second), and full counterclockwise rotation is the slowest acceleration (30 seconds).

4. The acceleration time may be extended by the addition of a capacitor to the control board (contact factory for instructions).

DECELERATION

1. With the motor running at maximum speed, quickly reset the MOTOR SPEED to zero, and observe the time required for the motor to reach minimum speed.

2. Adjust the DECEL potentiometer for the desired rate. Full clockwise rotation is the fastest deceleration (0.2 second), and full counterclockwise rotation is the slowest deceleration (30 seconds).

3. The deceleration time may be extended by the addition of a capacitor to the control board (contact factory for instructions).

IR COMPENSATION

IR compensation is used only when the controller is programmed for armature feedback. The IR/TACH potentiometer is factory set at zero (full counterclockwise rotation) for satisfactory operation with most motors. If improved speed regulation is desired, readjust IR compensation as follows:

1. Be sure Segments 2 and 3 of DIP Switch S3 are in ON (Closed) position.

2. If the motor is shunt-wound, run it at rated base speed. If the motor is a permanent-magnet type, run it at about 1/3 speed.

3. Turn the IR/TACH potentiometer clockwise slowly until motor speed becomes unstable. Then turn the potentiometer counterclockwise until motor speed stabilizes.

MAXIMUM SPEED (ARMATURE FEEDBACK)

The MAX SPD potentiometer adjusts maximum speed by setting maximum armature voltage. The voltage range is from 50% to 100% of rated armature voltage. If the controller is programmed for tachometer feedback, the MAX SPD potentiometer sets the armature backup voltage.

1. Be sure Segments 2 and 3 of DIP Switch S3 are in ON (Closed) position.

2. Turn the MAX SPD potentiometer fully clockwise (100%). This setting provides 90 VDC armature voltage with a 115 VAC line, or 180 VDC armature voltage with a 230 VAC line.

3. Run the motor at maximum speed, and turn the MAX SPD potentiometer counterclockwise for the desired maximum speed.

NOTE: If the MAX SPD potentiometer is turned too far counterclockwise, speed instability may occur.

MAXIMUM SPEED (TACHOMETER FEEDBACK)

1. Be sure Segments 2 and 3 of DIP Switch S3 are in OFF (Open position).

2. Set Segment 1 of DIP Switch S3 for the expected tachometer generator speed at maximum speed, as follows:

SEGMENT 1 POSITION	TACH VOLTAGE
ON (Closed)	8 - 30 VDC
OFF (Open)	31 - 175 VDC

3. Turn the IR/TACH potentiometer fully clockwise. This setting provides minimum motor speed with Tach Feedback.

4. Be sure the MAX SPD potentiometer (R10) on the control board is turned fully clockwise.

5. Run the motor at maximum speed, and start turning the IR/TACH potentiometer counterclockwise until motor speed increases to desired maximum speed with Tach feedback.

NOTE: If DC Tach signal is lost, the motor may go faster than motor base speed.

MINIMUM SPEED

1. Be sure Segment 6 of DIP Switch S3 is in ON (Closed) position.

2. Turn the MIN SPD potentiometer fully counterclockwise (0%) for zero speed.

3. Set the MOTOR SPEED potentiometer at 0% or the external speed reference signal at minimum, as applicable.

4. Initiate a RUN command and adjust the MIN SPD potentiometer for the desired minimum speed (adjustable from 0 to 40% of motor base speed).

OFFSET

An offset adjustment is desirable when a 4 to 20 mA speed reference signal is used. The MIN SPD potentiometer compensates for the 4 mA offset.

1. Be sure Segment 6 of DIP Switch S3 is in OFF (Open) position, and a wire jumper connects between TB2-1 and TB2-3.

2. Set the speed reference signal at 4 mA and initiate a RUN command.

3. Adjust the MIN SPD potentiometer as desired.

NOTE: The MIN SPD potentiometer may be ineffective between 50% and 100%.

CURRENT LIMIT

1. Turn the CUR LMT potentiometer fully clockwise (100%) to limit motor armature current to 150% of rated.

2. Turn the CUR LMT potentiometer counterclockwise to reduce maximum motor armature current.

NOTES:

a. An LED glows red on the controller control board when motor armature current is being limited.

b. An external 5K ohm Current (Torque) Reference potentiometer can be used as shown in Figure 10 on page 12. Segment 5 of DIP Switch S3 must be in OFF (Open) position if an external Current (Torque) Reference potentiometer is desired.

TROUBLESHOOTING

The following table is provided as a guide to common problems that may occur with a DC motor controller and the corrective action that may resolve that problem.

TABLE 5. TROUBLESHOOTING

INDICATION	POSSIBLE CAUSE	CORRECTIVE ACTION
1. Motor won't start (See "Inoperative Motor" page 17.)	AC line open	Be sure rated AC line voltage is applied to the controller
	Operator controls inoperative or connected incorrectly.	Repair accordingly.
	Open circuit between Connectors E1 and E2 in 1/6-3HP controllers	A wire jumper or switch must connect E1 to E2.
	Controller not reset	Initiate a STOP command and then a START command
	Line Voltage Selection Jumper J1 in wrong position	See Step 5 on page 8 under, "Installing The Controller."
	Controller not enabled	Be sure +24 VDC is applied to Terminal TB2-8.
	Loss of speed reference signal	Check for 0-10 VDC, 4-20mA, or 0-5 VDC speed reference signal, as applicable.
	Controller not adjusted correctly	Turn the ACCEL and CUR LMT potentiometers fully clockwise (100%).
	DIP Switch S3 not set correctly	See Table 12, page 29.
	Open shunt field winding or wiring to the motor shunt field, causing loss of torque (1)	Check the motor shunt field and associated circuitry for a loose connection or a broken wire. Repair accordingly.
	Motor failure	Repair or replace the motor.
	Control board failure	Replace the control board.
2. Controller line fuse blows when AC line power is applied to the controller	Wiring faulty or incorrect	Check all external wiring termination in the controller. Correct accordingly.
	Circuit, component, or wiring grounded	Remove ground fault.
	Two or more SCR's shorted	Replace shorted SCR's or the control board.
	Varistor RV1 shorted	Replace RV1 or the control board.
	Shunt field bridge BR1 shorted (1)	Replace BR1 or the control board.
	Motor shunt field shorted or grounded (1)	Repair or replace the motor.
	Control board failure	Replace the control board.
3. Controller line fuse blows when a START command is initiated	One or more SCR's or diode D1 shorted	Replace shorted devices or the control board.
	Motor shorted or grounded	Repair or replace the motor.
	Control board failure causing SCR's to turn-on fully	Replace the control board
4. Controller line fuse blows while the motor is running	Motor overloaded	Check shunt field current. (1) Low shunt field current causes excessive armature current. If field current is adequate, check for a mechanical overload. If the unloaded motor shaft does not rotate freely, check motor bearings. Also check for a shorted motor armature. Motor overload can also be caused by incorrect gear ratio. Correct accordingly.
	Loose or corroded connection. Wiring faulty, incorrect, or grounded	Check all terminals, connections, and wiring between the line, controller, and motor.
	Motor shorted or grounded	Repair or replace the motor.
	One or more SCR's or diode D1 breaking down (shorting intermittently)	Replace shorted devices or the control board.
	Control board failure causing SCR false firing or misfiring	Replace the control board.

(continued)

TABLE 5. TROUBLESHOOTING (CONTINUED)

INDICATION	POSSIBLE CAUSE	CORRECTIVE ACTION
5. Minimum speed excessive	Minimum speed not adjusted correctly	Turn the MIN SPD potentiometer counterclockwise.
	Control board failure	Replace the control board.
6. Maximum speed excessive	Maximum speed set too high.	Turn the MAX SPD potentiometer counterclockwise.
	Controller not calibrated correctly	Refer to Steps 4 and 5 on pgs. 7 & 8.
	Open shunt field winding or wiring to the motor shunt field (1)	Check the motor shunt field and associated circuitry for a loose connection or a broken wire. Repair accordingly.
	Motor field demagnetized (2)	Replace the motor.
7. Motor won't reach top speed	Low line voltage	Check for rated line voltage, ±10%, on the controller line terminals.
	Motor overloaded	Check shunt field current (1) Low shunt field current causes excessive armature current. If field current is adequate, check for a mechanical overload. If the unloaded motor shaft does not rotate freely, check motor bearings. Also check for a shorted motor armature. Motor overload can also be caused by incorrect gear ratio. Correct accordingly.
	Maximum speed set too low	Turn the MAX SPD potentiometer clockwise.
	Current limit set too low	Turn the CUR LMT potentiometer clockwise.
	Current scaling jumper J4 in wrong position	See Step 4 (page 7) and Table 2, (page 8).
	Motor field demagnetized (2)	Replace the motor.
	Control board failure	Replace the control board.
8. Unstable speed	AC line voltage fluctuating	Observe line voltage with a voltmeter or oscilloscope. If fluctuations occur, correct condition accordingly.
	Loose or corroded connection. Wiring faulty, incorrect, or grounded	Check all terminals, connections, and wiring between the line, operator controls, controller, and motor.
	Oscillating load connected to the motor	Stabilize the load. Turning the IR/TACH potentiometer counterclockwise may minimize oscillation.
	Voltage selection jumpers J1, J2, J3 in wrong position	See Step 5 on page 8 under, "Installing The Controller."
	IR compensation not adjusted correctly	See the IR Compensation adjustment instructions on page 18.
	Maximum speed not adjusted correctly	See the Maximum Speed (Armature Feedback) adjustment instructions on page 19.
	Motor faulty	Check motor brushes. Replace if needed. Repair or replace the motor.
	Tachometer generator or coupling faulty (if used)	Repair accordingly.
9. Line and motor armature current excessive	Motor overloaded	Check shunt field current. (1) Low shunt field current causes excessive armature current. If field current is adequate, check for a mechanical overload. If the unloaded motor shaft does not rotate freely, check motor bearings. Also check for a shorted motor armature. Motor overload can also be caused by incorrect gear ratio. Correct accordingly.

(continued)

TABLE 5. TROUBLESHOOTING (CONTINUED)

INDICATION	POSSIBLE CAUSE	CORRECTIVE ACTION
10. Shunt field current too low (1)	Open shunt field winding or wiring to to the motor shunt field	Check the motor shunt field and associated circuitry for a loose connection or a broken wire. Repair accordingly.
	Shunt field connected for incorrect voltage	Check motor rating and refer to Table 13, page 29
	Shunt field bridge BR1 failure	Replace BR1 or the control board.
11. Shunt field current too high (1)	Shunt field connected for incorrect voltage	Check motor rotating and refer to Table 13, page 29.
	Shunt field windings shorted	Measure the shunt field resistance and compare with the motor rating. Repair or replace the motor.
12. Motor thermal guard tripped (if used)	Ventilation insufficient	Free the motor intake and exhaust screens from dirt, dust, and debris.
	Excessive motor load at low speed	Reduce the load or increase the speed.
	Line and motor armature current excessive	See Indication 9.
	Motor overheating from friction	Check for misalignment. Realign the motor.
	Shorted motor windings or faulty bearings.	Repair or replace the motor.

(1) Does not apply to permanent-magnet motors.

(2) Does not apply to shunt-wound motors.

Section V – Options

Options are available for VEplus Controllers which increase the functional use of the basic controller. Table 6 lists all available options and allowable option combinations.

Options can be added to the basic controller at any time. Each option consists of all required components, mounting, hardware, and instruction sheet.

TABLE 6. ALLOWABLE OPTION COMBINATIONS

Option Type	Option Group	Option Number	Option Code*	Option
Power Options	C	30	XK	Circuit Breaker – Two Pole (VES3 Only)
	C	LD	XK	AC Line Switch (VES5 Only)
	C	M	XK	Armature Contactor Reversing with Dynamic Braking (May Be Combined with All Options in this Group)
Input Signal Options – Choice of one within this group. May be combined with options from any other groups except Group F. Option IAB is required for all options in this group.	D	IAB	XK	Interface Adaptor Board
	D	25	XK, P	Follower, External DC Signal
	D	14	XK, P	Follower, External AC Signal
	D	25C	XK, P	Follower, AC current Transducer
	D	35	XK, P	Follower, MIRC
	D	22A	XK, P	Follower, AC or DC Tach Generator
	D	22B	XK, P	Follower, Digital Pulse Generator
	D	47	XK, P	Precision Reference
Feedback Options – Choice of one within this group. May be combined with options from any other groups except Group F. Option IAB is required for all options in this group.	E	IAB	XK	Interface, Adaptor Board
	E	24A	XK, P	Feedback, AC or DC Tachometer Generator
	E	24B	XK, P	Feedback, Digital Pulse Generator
	E	18A	XK, P	Torque Taper
	E	18B	XK, P	Torque (Current) Limit Control
Input and Feedback Options – May be combined with options from any other groups except Groups D and E.	F	18C	XK, P	Follower, Current Regulator
	F	36A	XK, P	Centerwind Torque Control
	F	36B	XK, P	Constant Velocity Winder
External Options – Choice of any or all within this group.	G	21A	K	Motor Speed Potentiometer, Ten-Turn with Analog Dial
	G	21	K	Motor Speed Potentiometer, One-Turn
	G	21B	K	Motor Speed Potentiometer, Ten-Turn with Digital Dial
	G	9A	K	Jog, Toggle Switch Selection
	G	38	K	Follower/Manual Mode Select Switch
Miscellaneous Options	H	31	XK, P	Current (Torque) Monitor
	H	50	XK	Hinge Kit

*XK = Factory Installed or Field Kit K = Field Kit P = Plug-In Option

Section VI – Parts List

TABLE 7. PARTS LIST, VEplus CONTROLLERS

PART	RATING	BOSTON PART NUMBER	
		VES3	VES5
Control Board	N/A	64979	64988
Fuse, Line	30A, 600V (ATM-30)	64991	N/A
	60A, 300V (SC-60)	N/A	64992
SCR	55A, 800V	64994	N/A
	65A, 600V	N/A	64995
Silicon Rectifier (Freewheeling Diode)	24A, 600V	64990	64990
Run Speed or Current Reference Potentiometer	5KΩ, 1/2 W	60246	60246
Speed or Current Potentiometer Knob	N/A	60245	60245
Run-Stop-Jog Switch	N/A	50457	50457
FWD-REV Switch (VES3MR, VES5MR)	N/A	67479	67479
Reversing Board (“M” Suffix)	N/A	64905	64906
Unidirectional Board (“U” Suffix)	N/A	57891	57893

Section VII – Ratings and Specifications

RATINGS

1. Current/Torque Reference Potentiometer ..... 5K Ohms, 1/2 W
2. Duty ..... Continuous
3. Horsepower Range ..... 1/6 - 5 HP (See Table 1, Page 5)
4. Line Fuse Interrupting Capacity ..... 100,000 Amperes
5. Line Power ..... 115V Or 230V, Single-Phase, 50 Or 60 Hz
6. Motor Speed Potentiometer ..... 5K Ohms, 1/2 W
7. Overload Capacity, Armature Circuit ..... 150% For 1 Minute
8. Service Factor 1.0

TABLE 8. TYPICAL APPLICATION DATA

COMPONENT			RATINGS									
RATED HORSEPOWER (HP)			**1/6**	**1/4**	**1/3**	**1/2**	**3/4**	**1**	**1-1/2**	**2**	**3**	**5**
RATED KILOWATTS (kW)			**0.124**	**0.187**	**0.249**	**0.373**	**0.560**	**0.746**	**1.120**	**1.492**	**2.238**	**3.730**
1-Phase AC Input (Full-Load)	Line Amps	115V Unit	3.9	5.0	6.0	8.7	12.4	15.8	–	–	–	–
		230V Unit	–	–	–	4.2	5.9	8.8	12.6	15.8	22.0	32.0
	KVA		0.48	0.58	0.71	1.00	1.40	2.00	3.00	4.00	5.00	8.00
DC Output (Full-Load)	Motor Armature Amps	90V	2.0	2.8	3.5	5.4	8.1	10.5	–	–	–	–
		180V	–	–	–	2.6	3.8	5.5	8.2	11.6	15.1	25.0
	Motor Field Amps (Max.)	All	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Full-Load Torque (Lb-Ft) with 1750 RPM Base Speed Motors			0.5	0.75	1.0	1.5	2.2	3.0	4.5	6.0	9.0	15.0
Minimum Transformer KVA for Voltage Matching or Isolation			0.5	0.75	0.75	1.0	1.5	2.0	3.0	5.0	7.5	10.0

TABLE 9. OPERATING VOLTAGES AND SIGNALS

POWER SOURCE (SINGLE-PHASE)	OUTPUT VDC		SPEED REFERENCE SIGNAL*	MAGNETIC CONTROL VOLTAGE*	TACHOMETER FEEDBACK VOLTAGE**
	ARMATURE	FIELD			
115V, 50 or 60 Hz	0-90	50/100	0-5 VDC 0-10 VDC or 4-20 mA	24 VDC	8-175 VDC
230V, 50 or 60 Hz	0-180	100/200			

*Grounded or ungrounded.

**At maximum motor speed.

RATINGS (continued)

TABLE 10. CONTROLLER WEIGHTS

CONTROLLER MODEL	WEIGHT – LBS (KG)
VES3	7.70 (3.50)
VES5	8.60 (3.90)
VES3M, U	8.50 (3.85)
VES5M, U	9.30 (4.20)
VES3B, S	11.60 (5.27)
VES5B, S	12.50 (5.68)
VES3MB, MR, UB, US	12.40 (5.64)
VES5MB, MR, UB, US	13.20 (6.00)

OPERATING CONDITIONS

1. Altitude, Standard ..... 1000 Meters (3300 Feet) Maximum(1)

2. Ambient Temperature(2) ..... 0-40°C (32°F - 104°F)

3. Line Frequency Variation..... ± 2 Hz of Rated

4. Line Voltage Variation ..... ±10% of Rated

5. Relative Humidity..... 95% Noncondensing

(1) Controller can be derated by 1% per 100 meters to operate at higher altitudes.
(2) 55°C(131°F) maximum in enclosed areas where open-chassis controllers are mounted.

PERFORMANCE CHARACTERISTICS

1. Controlled Speed Range..... 0 to Motor Base Speed

2. Efficiency (Rated Speed/Rated Load)

a. Controller Only..... 98%

b. Controller With Motor, Typical 85%

3. Speed Regulation ..... Regulation percentages are of motor base speed under steady-state conditions.

TABLE 11. SPEED REGULATION CHARACTERISTICS

Regulation Method	Variable				
	Load Change (95%)	Line Voltage (±10%)*	Field Heating (Cold/Normal)	Temperature (±10˚C)	Speed Range
Standard Voltage Feedback with IR Compensation	2%	±1%	5 - 12%	±2%	50:1
Optional Speed (Tach) Feedback†	0.5%	±1%	0.2%	±2%	200:1

*With Precision Reference (Option 47), regulation due to ±10% line voltage change is ±0.1%.
†Unidirectional Models only.

ADJUSTMENTS

1. Acceleration, Linear ..... 0.2 - 30 Seconds
2. Deceleration, Linear ..... 0.2 - 30 Seconds
3. IR (Load) Compensation ..... 0 - 10% Boost
4. Jog Speed ..... 0 - 100% Of Motor Base Speed
5. Maximum Speed ..... 50% - 100% Of Motor Base Speed
6. Minimum Speed ..... 0 - 40% Of Motor Base Speed
7. Torque (Current) Limit ..... 0 - 150% Of Full-Load Torque

SPECIFICATIONS

1. **AC LINE PROTECTION** – A 100,000 ampere interrupting capacity AC line fuse provides instantaneous protection from peak loads and fault currents. This line fuse is located inside the controller. A molded-case, magnetic-trip circuit breaker (Option 30) is available for VES3 Controllers only, which provides a manual disconnection to the controller, and also provides automatic instantaneous trip protection from a peak load.

2. **AUXILIARY CONTACT** – A normally-open Form A relay contact, rated 5 ampere @ 115 VAC and 30 VDC, is available for external use. The relay energizes when a RUN command is initiated, and de-energizes when a Normal STOP command is initiated, the overload monitor trips, or the anti-restart circuit is activated.

3. **CONTROL VOLTAGE –** A transformer coupled 24 VDC power supply isolates all magnetic control logic and operator controls from the AC power source for operator protection.

4. **DIP SWITCH SETTINGS** – A 7-position DIP Switch (S3) is used to program the controller for various applications as shown in Table 12.

5. **FEEDBACK –** Two selectable modes of analog feedback are provided, as follows. See Table 11 (page 27) for speed regulation characteristics.

   a. ARMATURE FEEDBACK – Counter EMF voltage feedback with IR compensation, adjustable for individual motor characteristics.

   b. DC TACHOMETER FEEDBACK – The controller provides voltage scaling, and terminals for accepting the output of a DC tachometer generator, mechanically coupled to the drive motor armature. The controller will automatically transfer to armature feedback if the tachometer signal is lost. Tachometer generators with an output of 8 to 175 VDC at maximum speed may be used.

6. **FIELD SUPPLY –** A half-wave or full-wave shunt field supply is available as shown in Table 13.

7. **ISOLATED REGULATOR** – The internal DC circuits are isolated from the AC power source for operator and equipment safety, and for simplified application. The common of the input speed reference signal may be grounded or connected without additional isolation to other drive controllers or grounded external signal sources. This isolation eliminates line voltage to ground potentials on the motor speed potentiometer.

8. **MOTOR CONTACTOR** – Controller model numbers with an ‘M’ or ‘U’ in the suffix, e.g. VES3MR, VES5U, have a DC magnetic armature contactor, which disconnects both motor armature leads from the controller. An antiplug circuit ensures that the contactor does not make or break DC.

9. **MOTOR OVERLOAD** – A nonadjustable inverse time overload circuit continuously monitors motor armature current and shuts down the controller whenever the current exceeds 120% of rated for a length of time of continuous operation. The length of time is determined by the amount of overload.

SPECIFICATIONS (continued)

TABLE 12. DIP SWITCH S3 SETTINGS

Segment	Segment Position		Description
	ON (Closed)	OFF (Open)	
1	X		Low voltage tachometer generator signal (8 - 30 VDC at max. motor speed)
		X	High voltage tachometer generator signal (31 - 175 VDC at max. motor speed)
2	X		Armature feedback
		X	Tachometer feedback with armature feedback backup
3	X		Armature feedback
		X	Tachometer feedback with armature feedback backup
4	X		4 - 20 mA input speed reference signal
		X	0 - 5 VDC input speed reference signal
5	X		Enables the internal current limit circuit, adjustable with the CUR LIM potentiometer.
		X	Enables the use of an external current (torque) limit potentiometer (5K ohm, 1/2W)
6	X		Selects the MIN SPD potentiometer as a minimum speed adjustment
		X	Selects the MIN SPD potentiometer as an offset adjustment for a 4 - 20 mA input speed reference signal
7	X		Enables anti-restart. Prevents the controller from restarting automatically after an AC power interruption
		X	Line starting. Disables anti-restart

TABLE 13. SHUNT FIELD DATA

Controller Rating (VAC)	Shunt Field Voltage (VDC)		Motor Shunt Field Lead Connections	
	Half-Wave	Full-Wave*	F1	F2
115	50		F+	F/2
		100	F+	F-
230	100		F+	F/2
		200	F+	F-

*Low inductance motors require a full-wave field to prevent current instability.

SPECIFICATIONS (continued)

10. **POWER CONVERSION** -The DC power bridge consists of four SCR's and a freewheeling diode. Each device is rated at least 600 PIV. The controller base forms an integral heat sink, with the power devices electrically isolated from the base.

11. **SELECTABLE CAPABILITIES** - The DIP Switch (S3) allows the user to select various modes of operation, as follows:

    a. EXTERNAL DC SIGNAL FOLLOWER - The controller will operate with an external 0 - 5 VDC, 0 - 10 VDC, or 4 - 20 mA speed reference signal. The signal may be grounded or not grounded, isolated or not isolated. Motor speed will be proportional to the signal.

    0 - 5 VDC - Place S3-4 in OFF (Open) position, and connect the signal to TB2-6.

    0 - 10 VDC - Place S3-4 and S3-6 in ON (Closed) position, and connect the signal to TB2-2.

    4 - 20 mA - Place S3-4 in ON (Closed) position, and connect the signal to TB2-6 (+) and TB2-5 (-). To use the MIN SPD potentiometer as a 4 mA offset adjustment, place S3-6 in OFF (Open) position, and jumper TB2-1 to TB2-3.

    b. LINE STARTING - By placing S3-7 in OFF (Open) position, the 'anti-restart' feature will be disabled, and the controller may be started and stopped with an external AC line contactor. In addition, a wire jumper must be connected between TB2-8 and TB2-9. If full speed operation is desired, connect another wire jumper between TB2-2 and TB2-3.

    c. TACHOMETER FEEDBACK - To select tachometer feedback with armature feedback backup, place S3-2 and S3-3 in OFF (Open) position, and connect the tachometer generator signal to TB2-7 (-) and TB2-5 (+). Select the tachometer generator voltage range with S3-1, as follows:

    8 - 30 VDC at maximum speed, place S3-1 in ON (Closed) position.

    31 - 175 VDC at maximum speed, place S3-1 in OFF (Open) position.

    d. TORQUE REGULATOR - The controller will function as a torque regulator when S3-5 is set to OFF (Open) position. This allows an external potentiometer to set maximum motor torque (0 - 150% of rated).

12. **STATUS INDICATOR** - A bicolor LED glows red when motor armature current is being limited by the controller current limit, and glows green when armature current is not being limited.

13. **VOLTAGE TRANSIENT PROTECTION** - A metal oxide suppressor (varistor) across the AC line is combined with RC snubbers across the power bridge to limit potentially damaging high voltage spikes from the AC power source.

Section VIII – Drawings

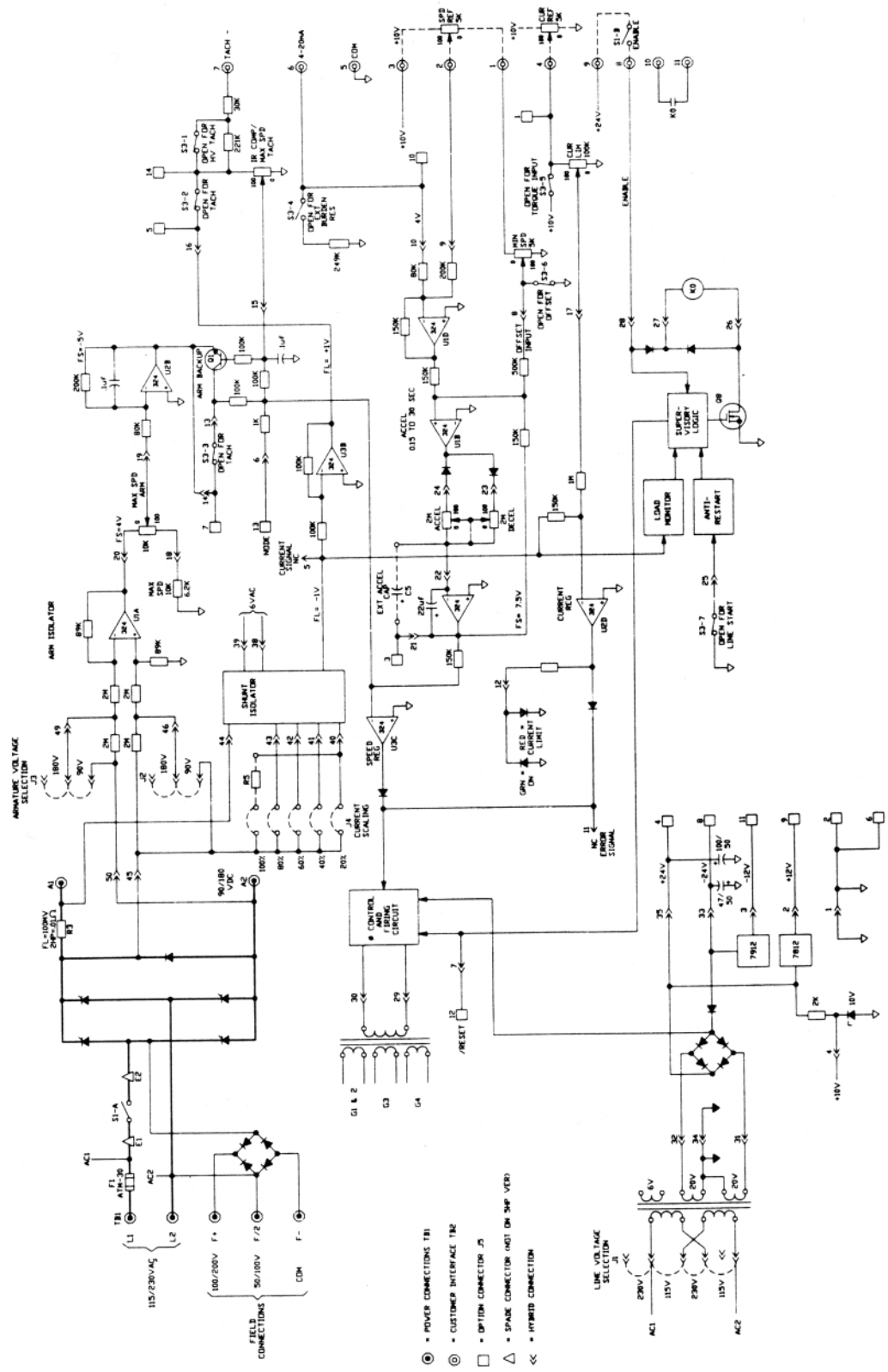


FIGURE 16. FUNCTIONAL SCHEMATIC, VEplus

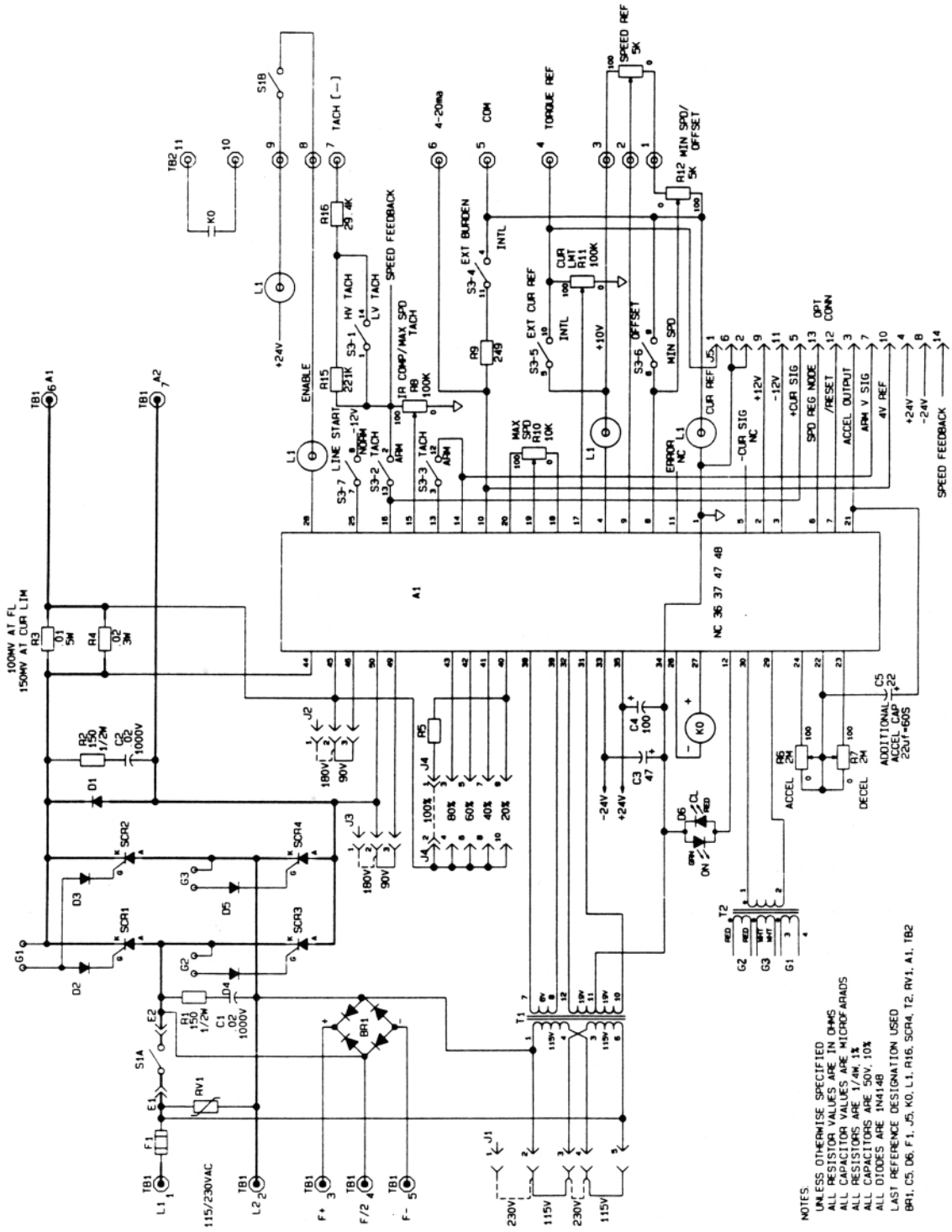


FIGURE 17. SCHEMATIC, VEplus 1/6 - 3 HP

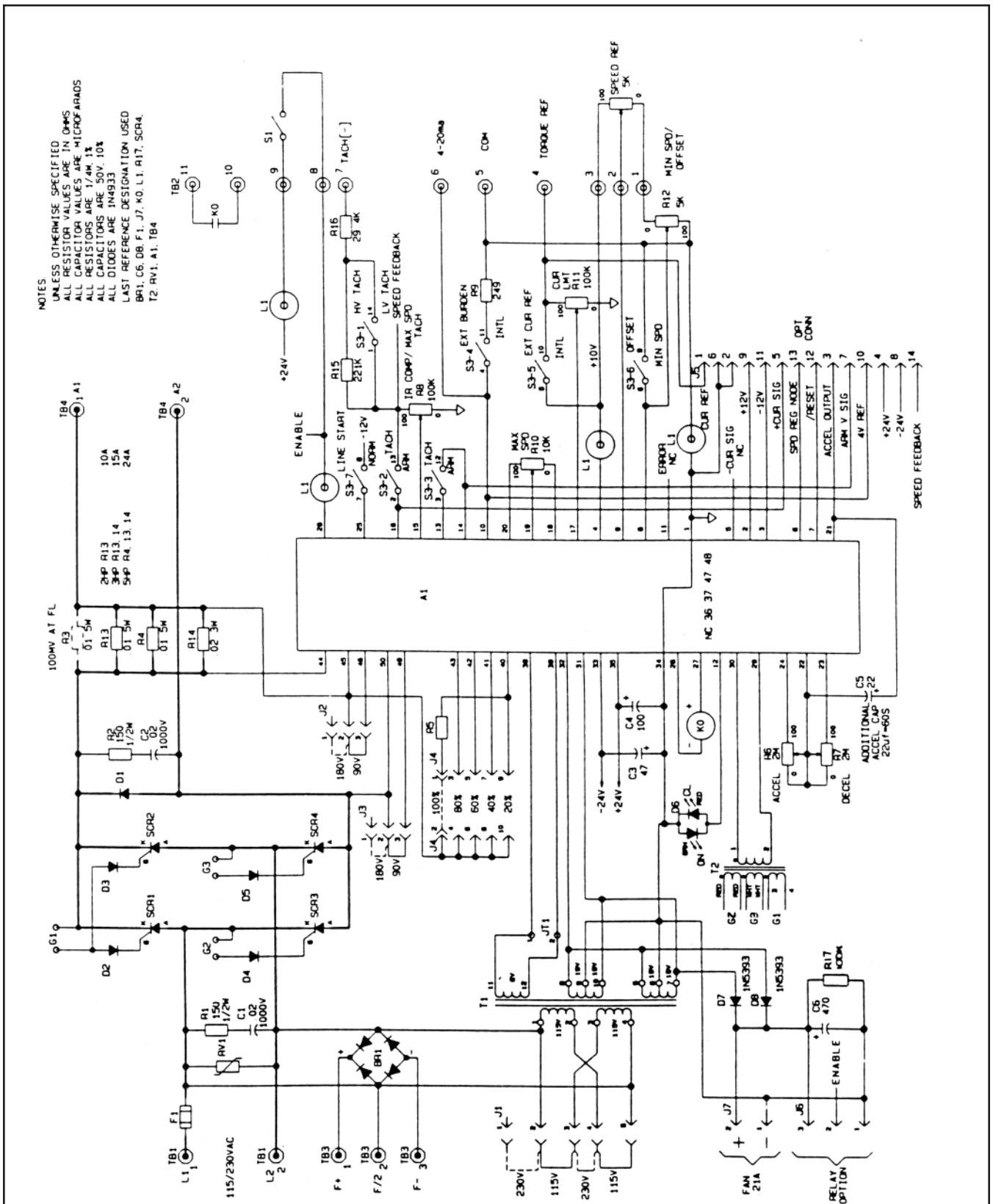


FIGURE 18. VEplus SCHEMATIC, 5 HP

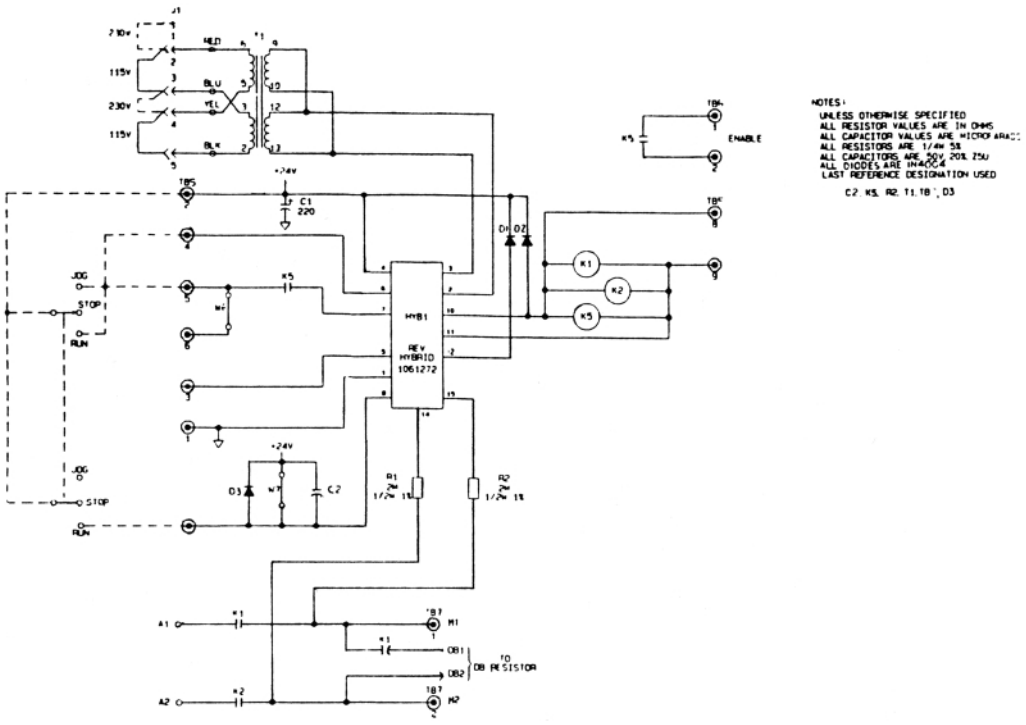


FIGURE 18A. SCHEMATIC, UNIDIRECTIONAL ARMATURE CONTACTOR BOARD

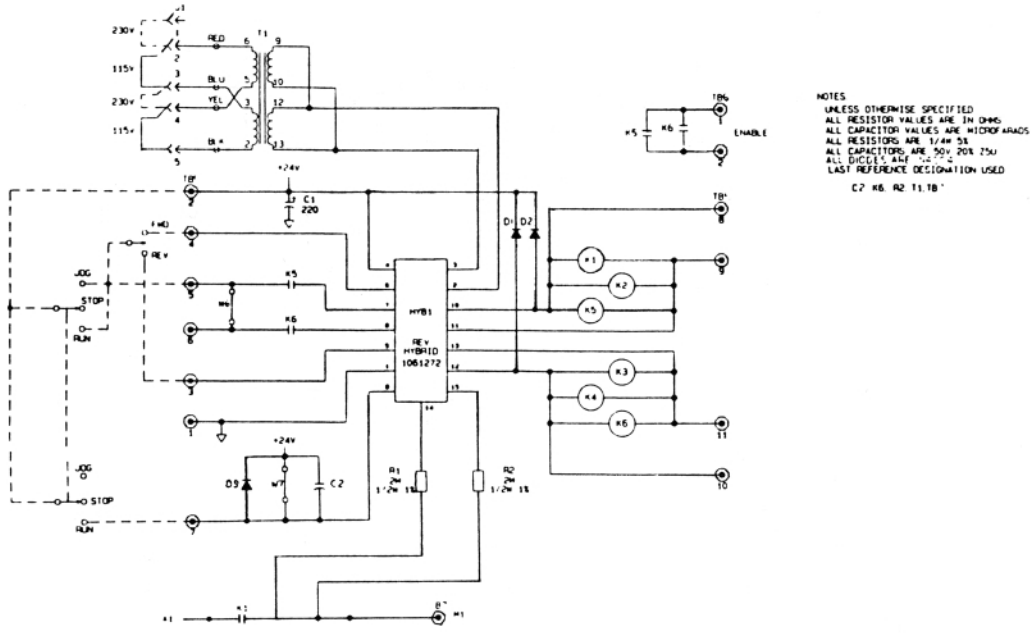


FIGURE 18B. SCHEMATIC, REVERSING ARMATURE CONTACTOR BOARD

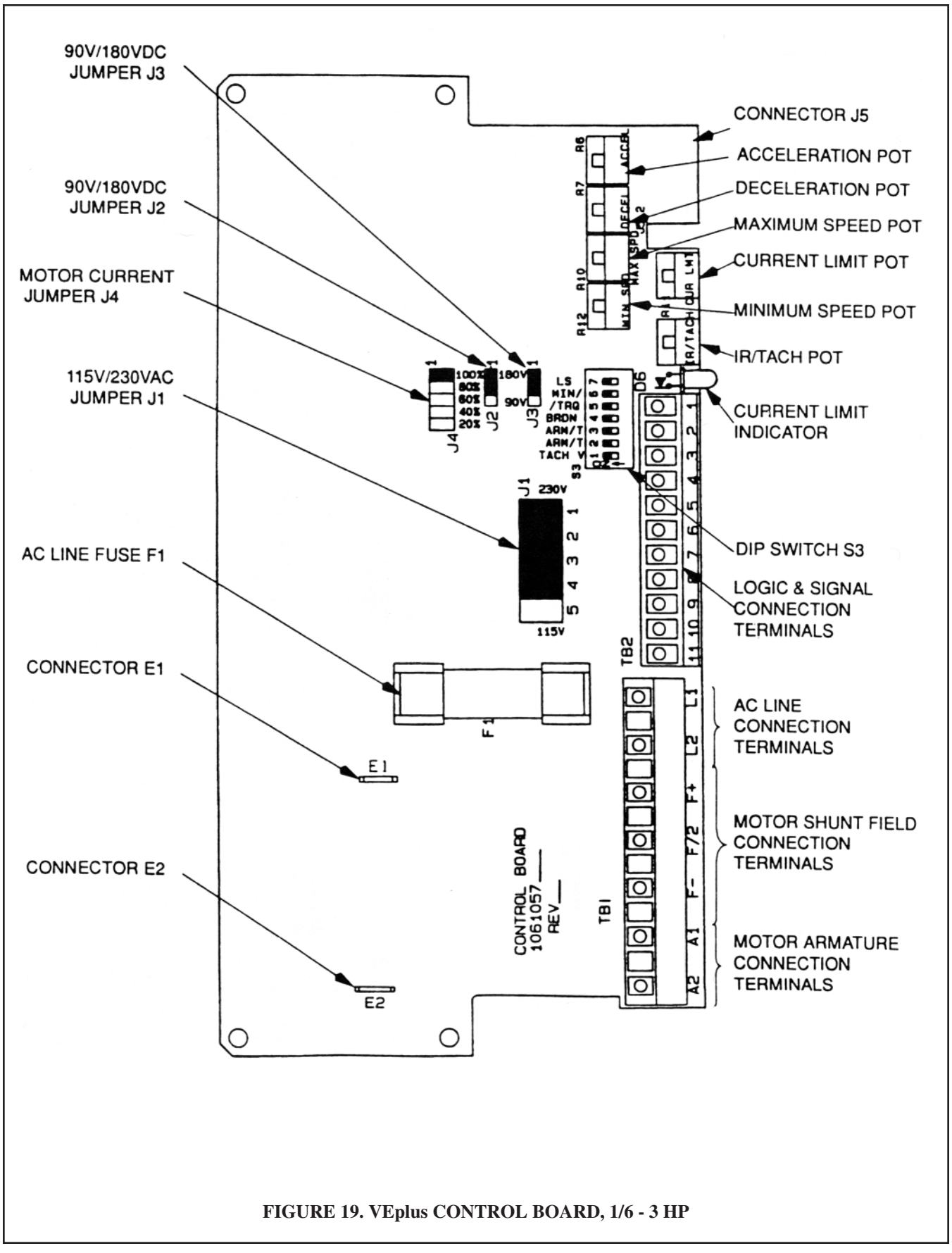


FIGURE 19. VEplus CONTROL BOARD, 1/6 - 3 HP

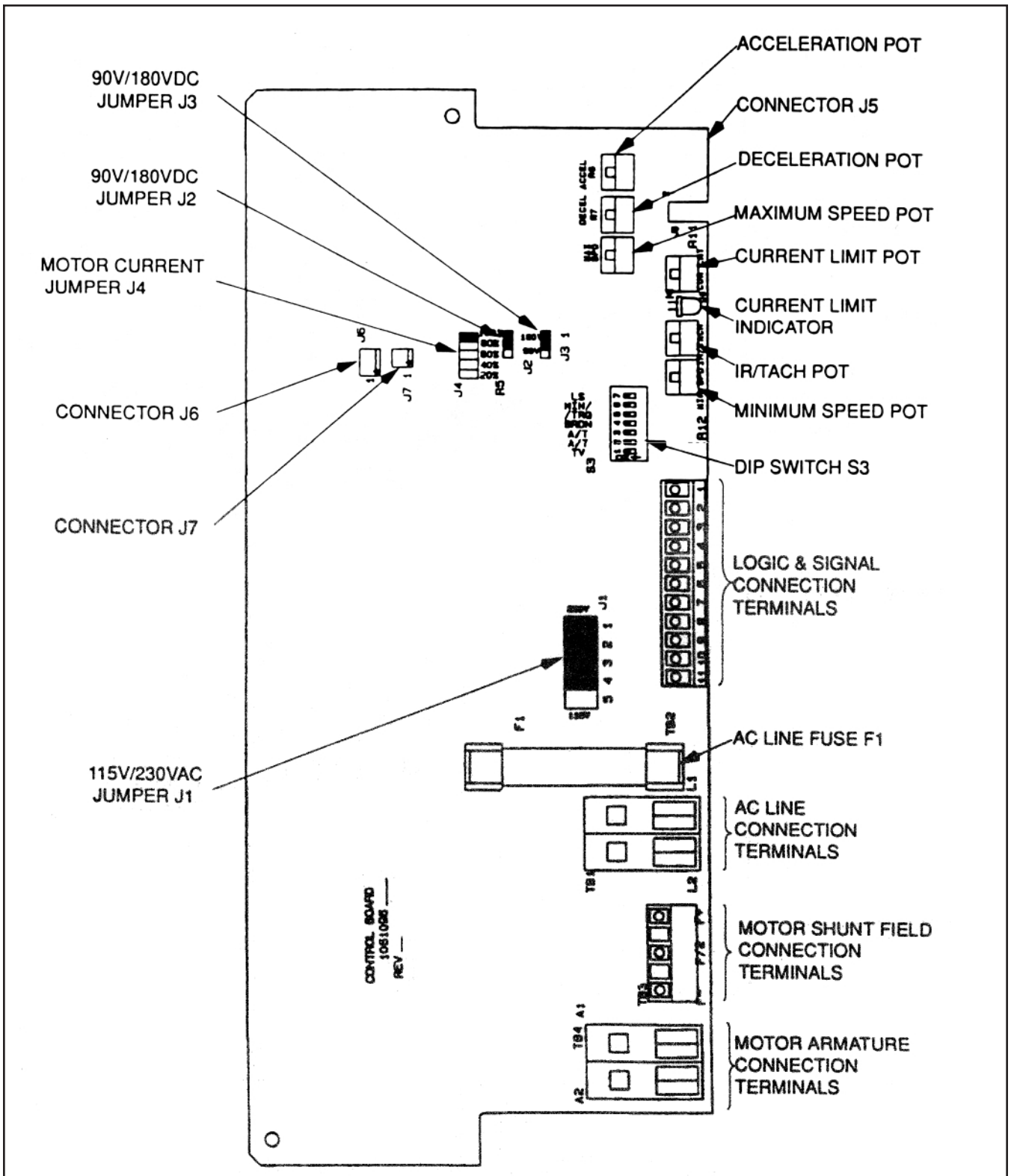


FIGURE 20. VEplus CONTROL BOARD, 5 HP

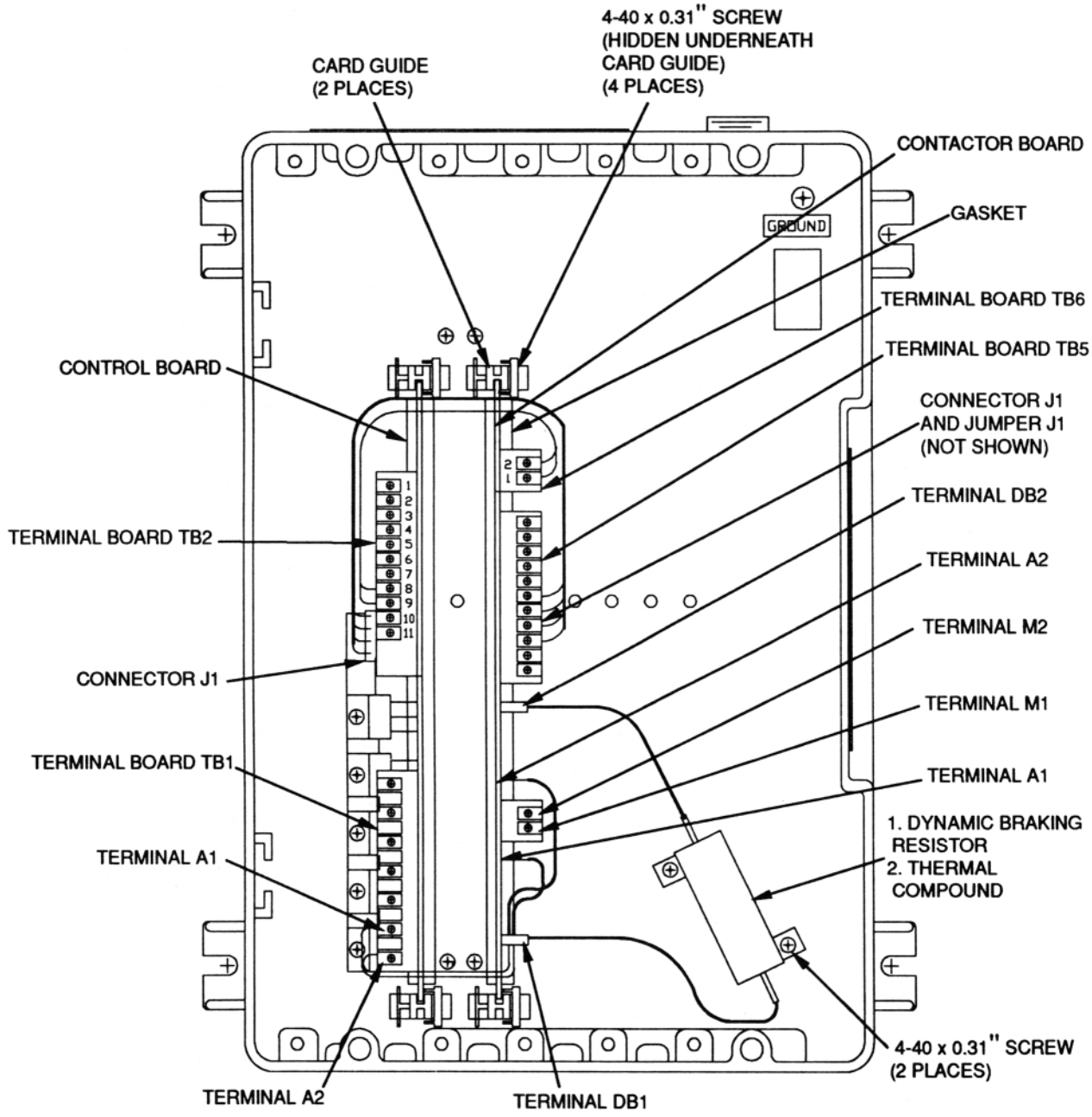


FIGURE 21. BOARD LAYOUT DRAWING, 1/6 - 3 HP

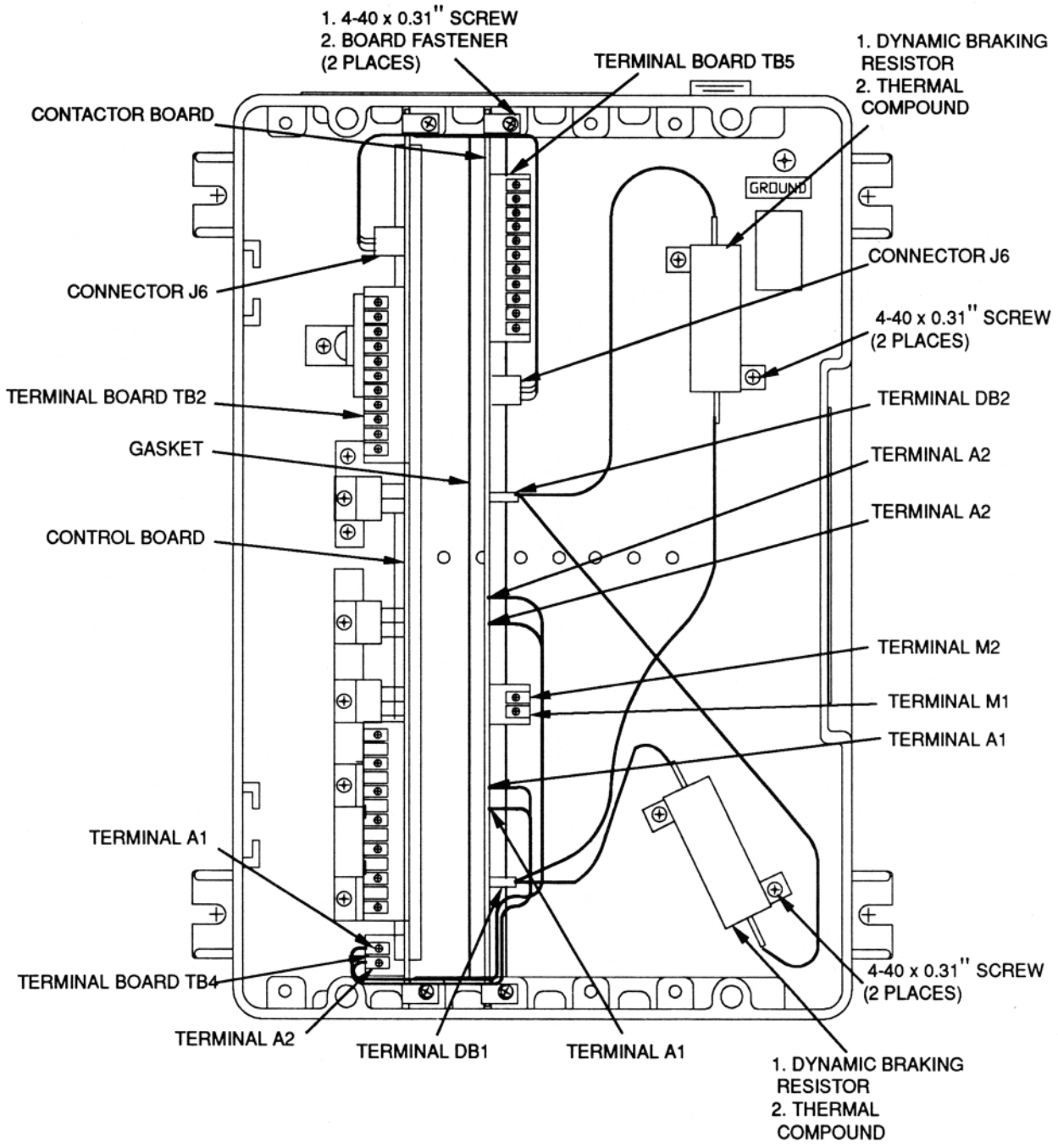
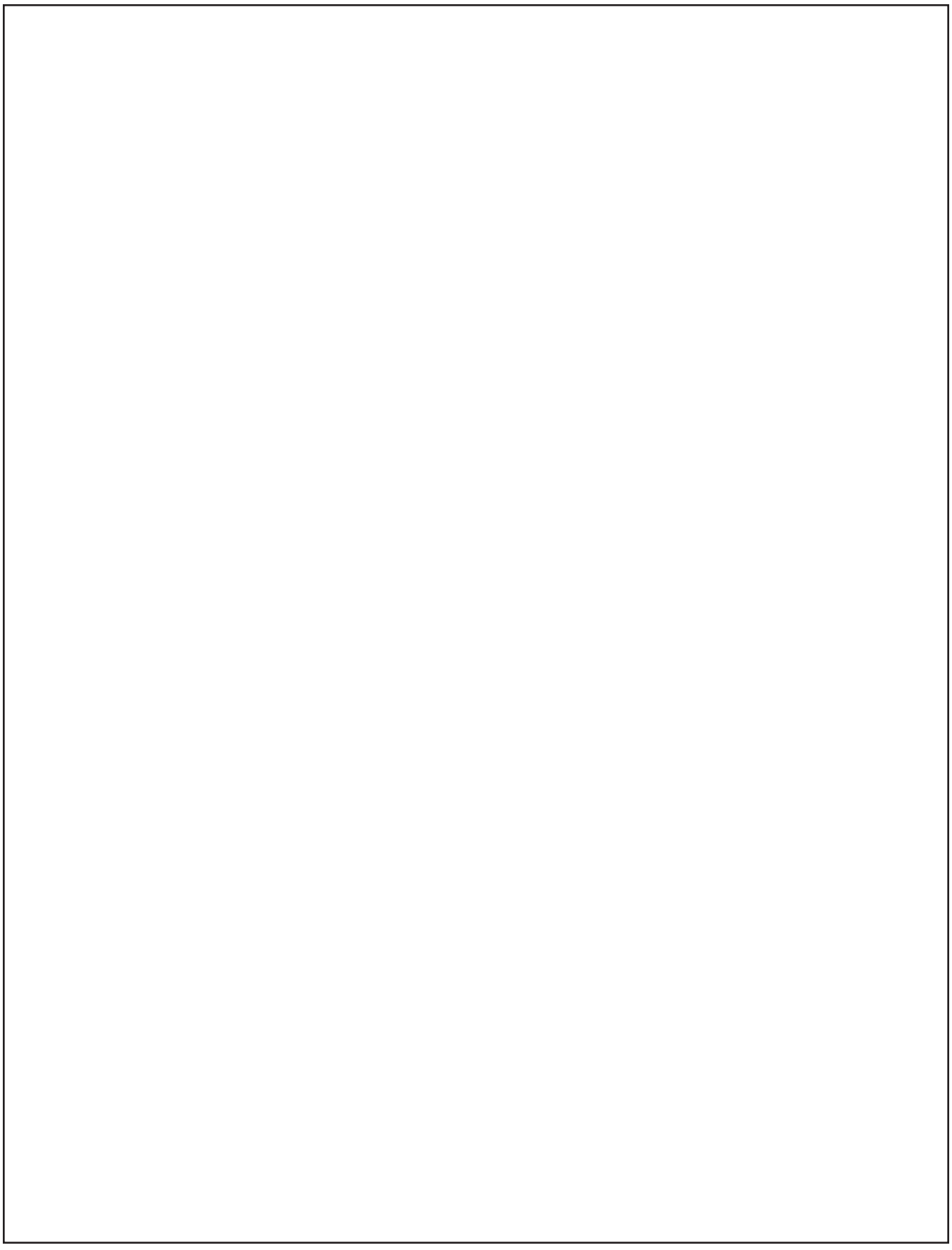


FIGURE 22. BOARD LAYOUT DRAWING, 5 HP



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