Boston Gear®
Ratiotrol®

DC Motor Speed Control

Installation and Operation

Doc. No. 57766

Beta Plus Series
Single Phase
1/6-3 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 THIS CODE REQUIREMENT HAS BEEN MET.**

4. **THE DRIVE EQUIPMENT IS AT AC LINE VOLTAGE 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 AND PERSONAL INJURY.**

8. **ALL DRIVE EQUIPMENT ENCLOSURES, 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.**

Section I – General Information

INTRODUCTION

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

GENERAL DESCRIPTION

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

BETAplus 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).

Table 1. BETAplus MODEL MATRIX

Item Code	Cat. No.	Line Voltage † HP Range		Construction		Function				Operator's Controls	
		115 VAC	230 VAC	Open Chassis	Enclosed	Run/ Stop	Run/ Stop D.B.*	Arm. Switch Rev.	Arm. Cont. Rev. W/D.B.*	Local (Integral)	Remote
64874	RBS2	1/6 - 1	1/2 - 2	X		X					X
64875	RBS2B				X	X					X
64876	RBS2S				X	X				X	
64877	RBS2R				X			X		X	
64878	RBS2M			X			X		X		X
64879	RBS2MB				X		X		X		X
64965	RBS2MS				X		X			X	
64880	RBS2MR				X				X	X	
64881	RBS3	1/6 -1	1/2 - 3	X		X					X
64882	RBS3M			X			X		X		X

* Includes Armature Contactor.
† Units are reconnectable

MOTOR SELECTION

BETAplus 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 for operation from 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 VI) is recommended. The following installation guidelines should be kept in mind when installing the controller.

INSTALLATION GUIDELINES

1. **CONTROLLER MOUNTING** – Controllers may be mounted either vertically or horizontally. 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 side by side, as close to each other as the mounting feet will allow.

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

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

   Controller enclosures are totally enclosed, nonventilated, and comply with NEMA type 3, 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.

   BETAplus enclosure covers are die-cast aluminum alloy.

4. **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 7, 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 7 (page 26) for minimum transformer KVA.

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

   A 12-joule metal oxide varistor (MOV) is connected across the controller terminals. If higher energy transients are present on 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.

5. **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.

6. **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 may occur if the controller, motor, and operator stations are not properly grounded.

7. **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 wiring refers to wiring for potentiometers, tachometer generators, and transducers. Control wiring refers to wiring for operator controls. If nonshielded wire is used for signal and control wiring, it may be run in a common conduit, but not in the same conduit as the power wiring. In an enclosure, nonshielded signal and control wiring must be kept separated from power wiring and only cross at 90 degree angles.

   If shielded wire (such as Alpha 2422 - two conductor, 2423 - three conductor, 2424 - four conductor) is used for the signal and control wiring, it may be run in the same conduit with the power wiring. Connect the shields to chassis ground (ground screw on the controller base) and tape the opposite ends of the shields.

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

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 33).

TABLE 2. JUMPER J4 POSITIONS

JUMPER POSITION	MOTOR ARMATURE CURRENT RATING (AMPERES)*	
	2 HP Maximum	3 HP Maximum
100%	10	15
80%	8	12
60%	6	9
40%	4	6
20%	2	3

*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. For the locations of J1, J2, and J3, see Figure 19 (page 33). 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.

6. The controller may be surfaced mounted or panel mounted as shown in Figure 1, page 9. Mount the controller. Mounting dimensions are shown in Figure 2, page 9.

7. Conduit entry is made by punching out the knockout at the top or bottom of the controller base. To prevent component damage from knockout fragments, apply masking tape to the inside of the knockout before punching.

8. Connect the AC power wiring to Terminals L1 and L2, ground to ground lug, motor armature leads to A1 (+) and A2 (-), and field leads to F + and F -. Be sure to observe Installation Guidelines 4 and 7 on pages 6 and 7. If half-wave shunt field voltage is desired, connect the motor shunt field leads to Terminals F+ and F/2. (Table 12, page 29).

NOTE: Low inductance motors require a full-wave field to prevent instability.

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

10. If remote operator control wiring and/or signal wiring is required, connect the controller as shown in the appropriate connection diagram (Figures 3 through 16). Figures 3 through 8 show operator control connections, and Figures 9 through 16 show signal connections.

11. Set the DIP Switch (S3) as shown in the appropriate connection diagram. See Figure 19 (page 33) for the location of DIP Switch S3. Also refer to Table 11, “DIP Switch Settings,” page 29.

12. Replace the controller cover, if used.

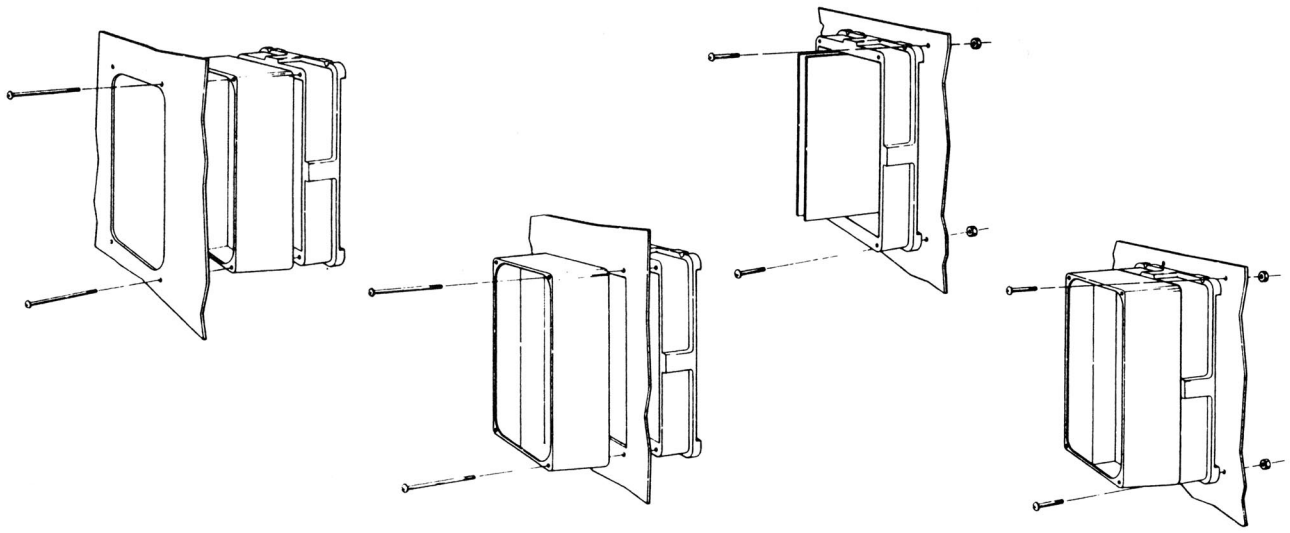

FIGURE 1. BETAplus CONTROLLER MOUNTING CONFIGURATIONS

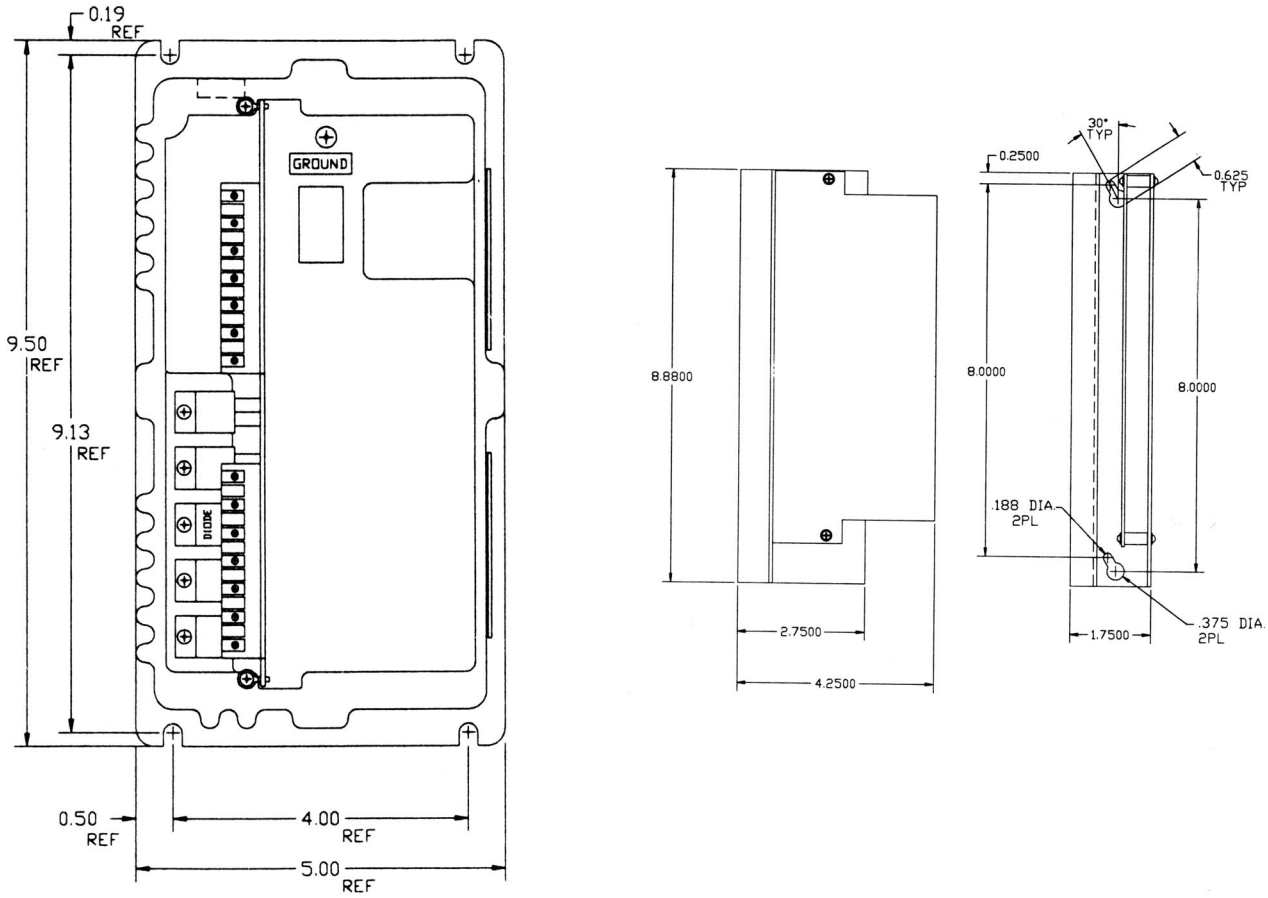

FIGURE 2. MOUNTING DIMENSIONS, BETAplus

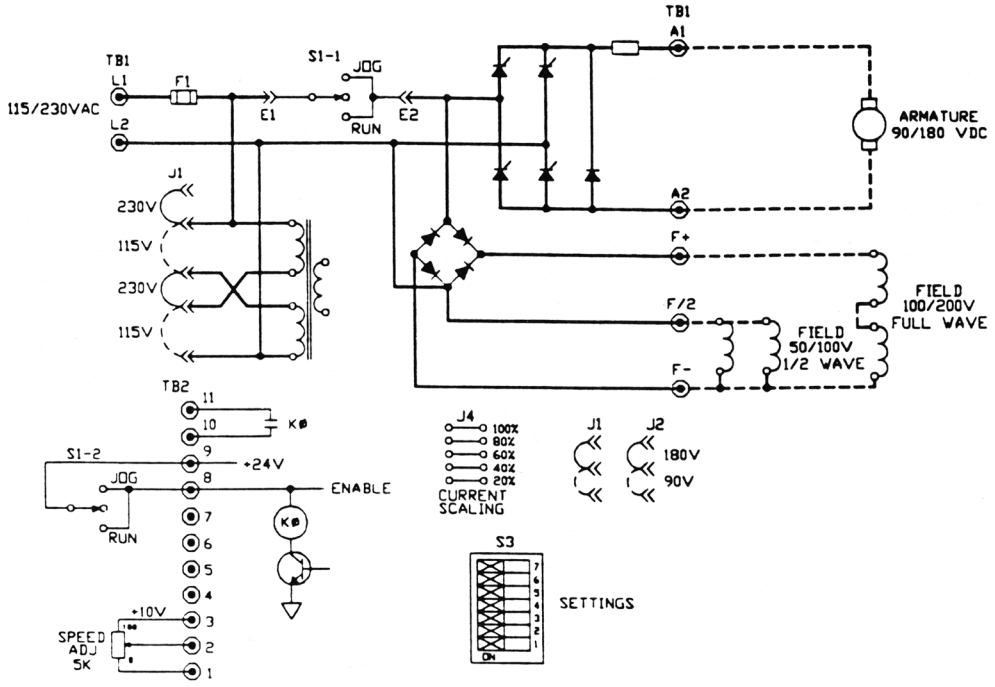

FIGURE 3. LOGIC CONNECTION DIAGRAM, RUN-STOP-JOG SWITCH, 1/6 - 2 HP

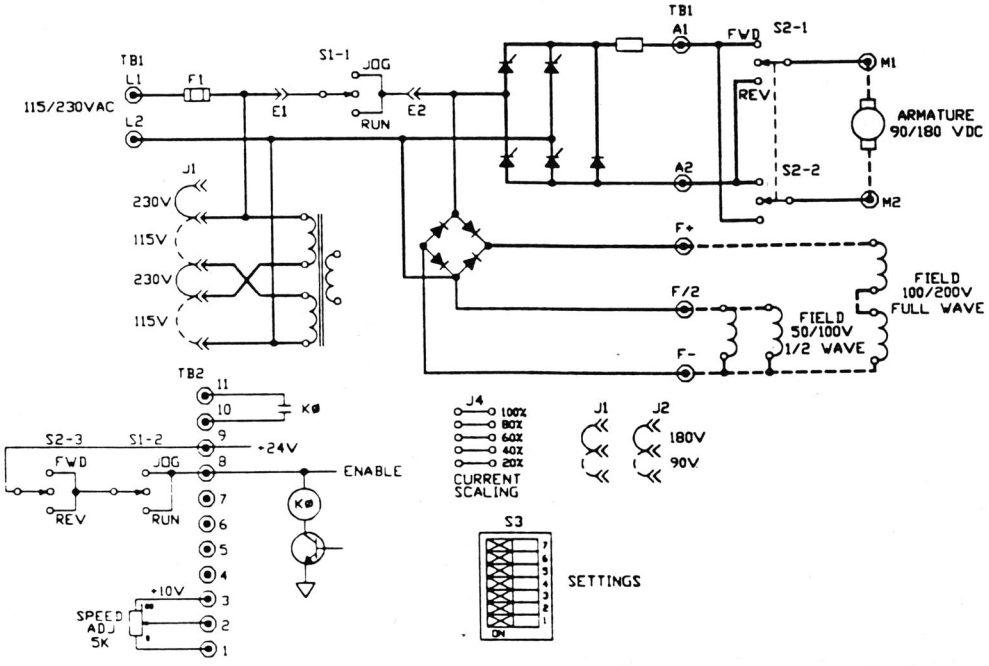

FIGURE 4. LOGIC CONNECTION DIAGRAM, FORWARD-REVERSE SWITCH AND RUN-STOP-JOG SWITCH, 1/6 - 2 HP

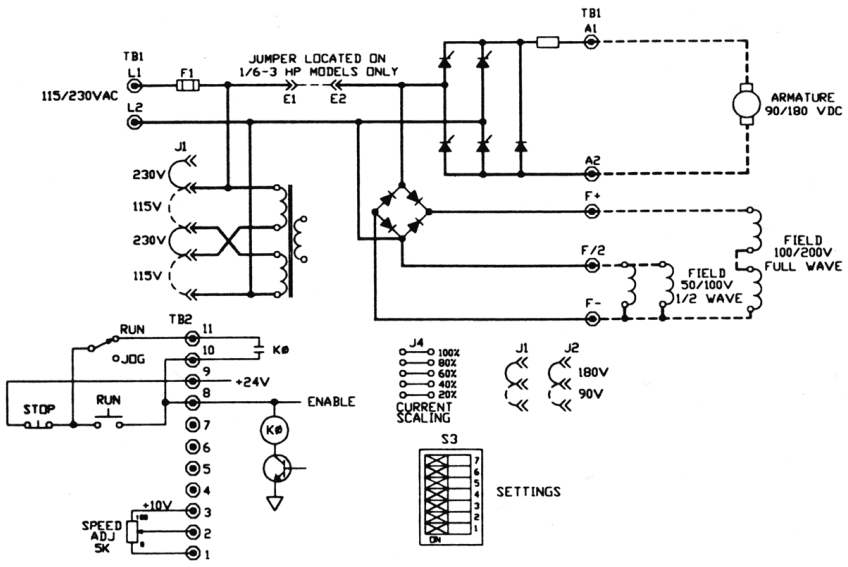

FIGURE 5. LOGIC CONNECTION DIAGRAM, RUN-STOP PUSHBUTTONS AND RUN-JOG SWITCH, 1/6 - 3 HP

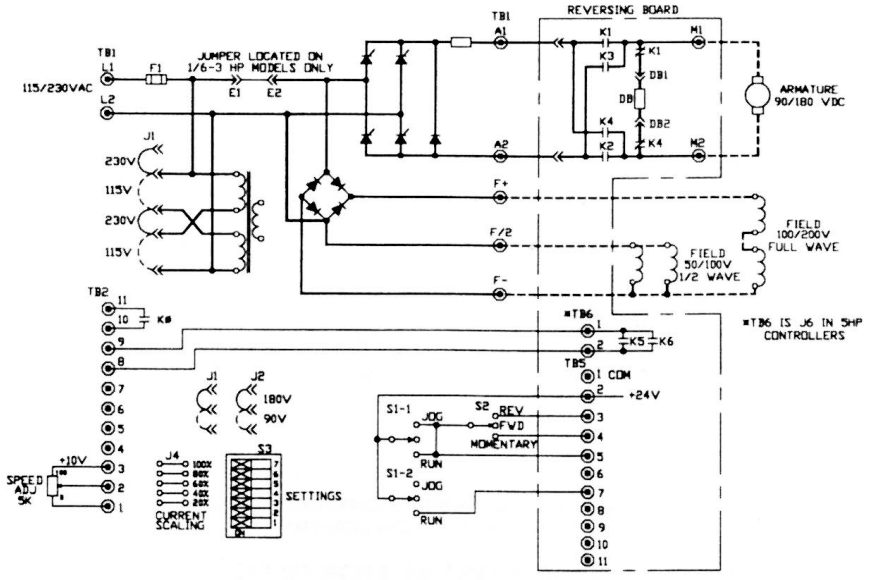

FIGURE 6. LOGIC CONNECTION DIAGRAM, OPTIONAL ARMATURE CONTACTOR REVERSING USING SWITCHES, 1/6 - 3 HP

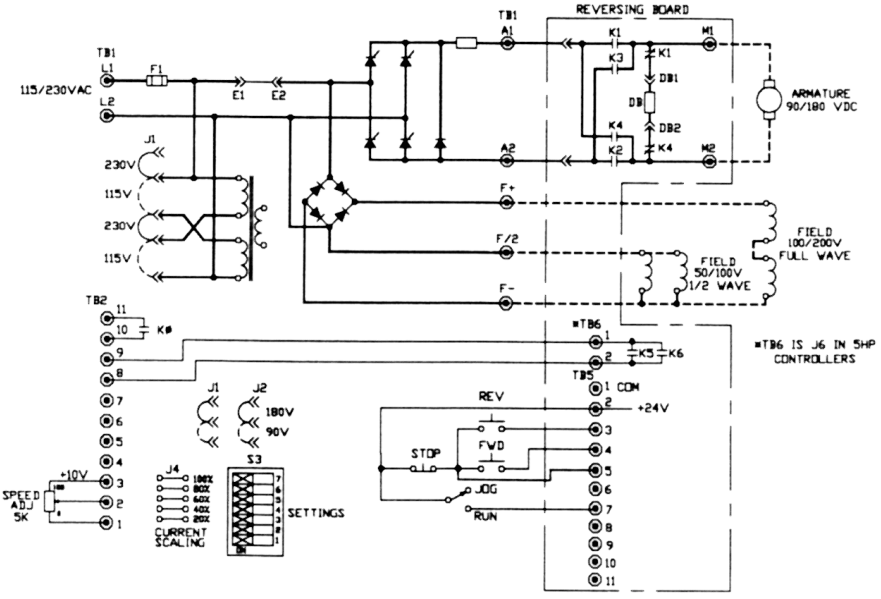

FIGURE 7. LOGIC CONNECTION DIAGRAM, OPTIONAL ARMATURE CONTACTOR REVERSING USING PUSHBUTTONS AND RUN-JOG SWITCH, 1/6 - 3 HP

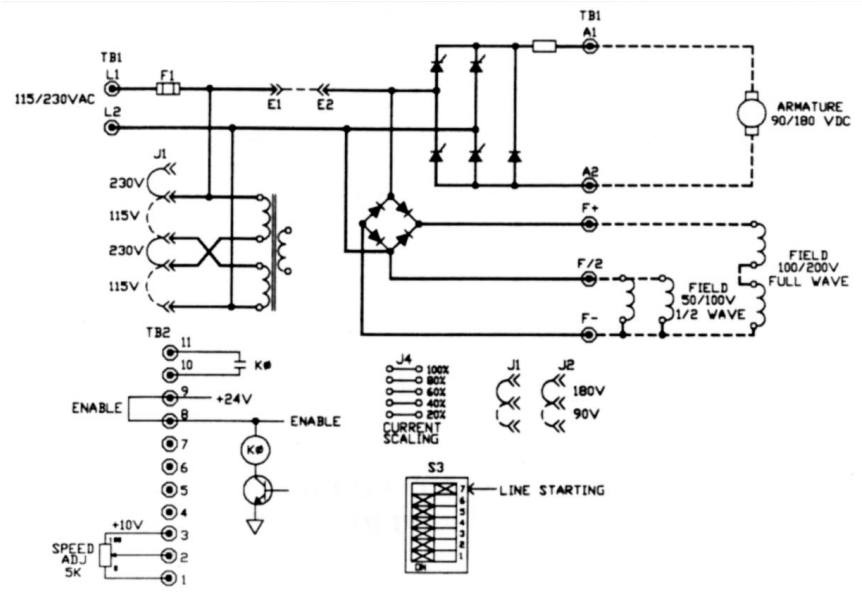

FIGURE 8. LOGIC CONNECTION DIAGRAM, LINE STARTING WITH MOTOR SPEED POTENTIOMETER, 1/6 - 3 HP

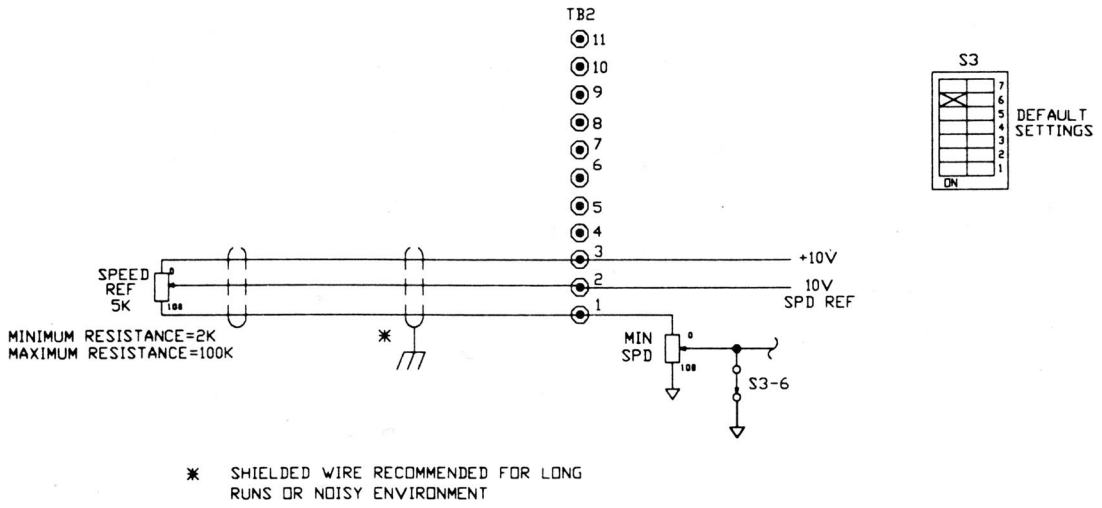

FIGURE 9. SIGNAL CONNECTION DIAGRAM, MOTOR SPEED POTENTIOMETER

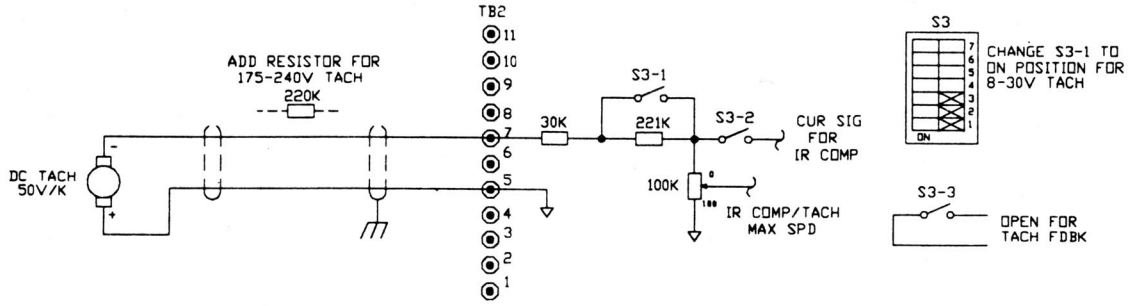

FIGURE 10. SIGNAL CONNECTION DIAGRAM, TACHOMETER FEEDBACK

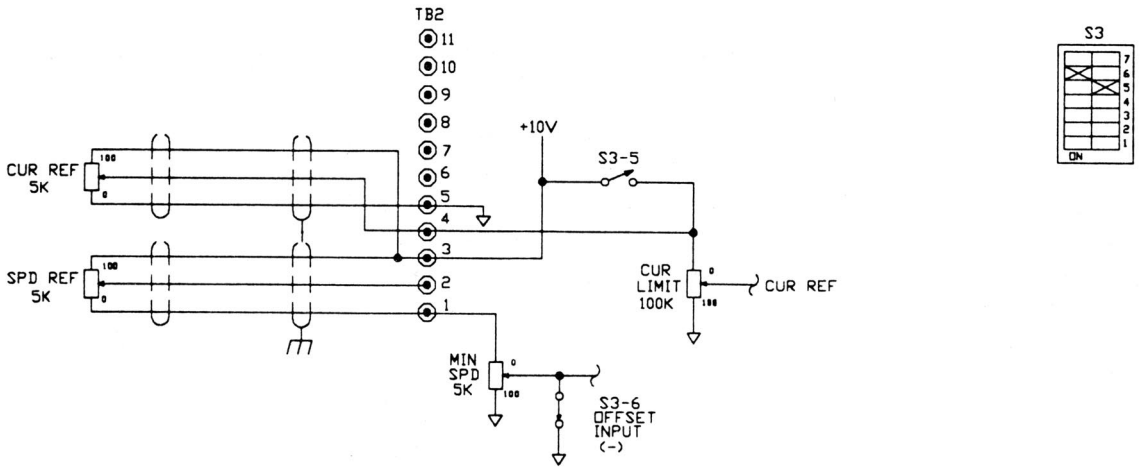

FIGURE 11. SIGNAL CONNECTION DIAGRAM, CURRENT (TORQUE) REFERENCE POTENTIOMETER

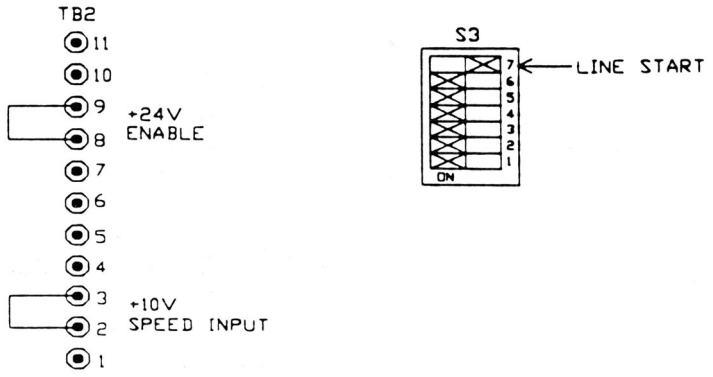

FIGURE 12. SIGNAL CONNECTION DIAGRAM, LINE STARTING WITHOUT A MOTOR SPEED POTENTIOMETER

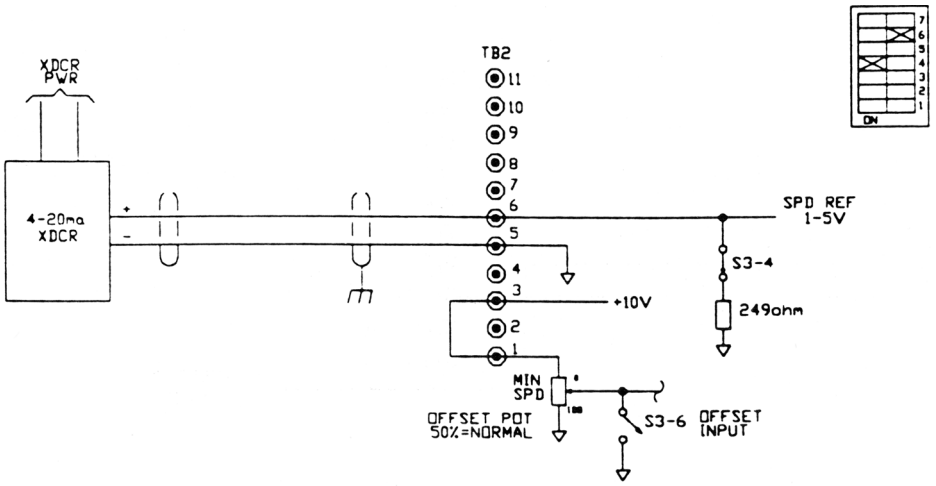

FIGURE 13. SIGNAL CONNECTION DIAGRAM, 4 - 20 mA INTERFACE

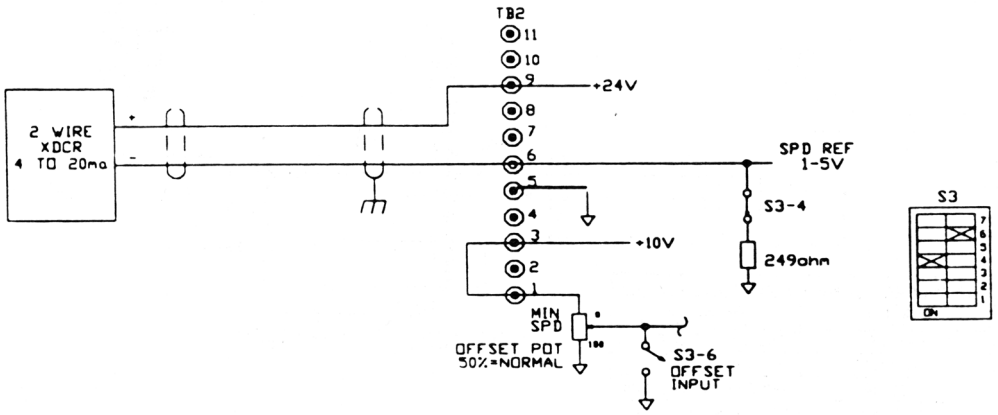

FIGURE 14. SIGNAL CONNECTION DIAGRAM, 2-WIRE TRANSDUCER

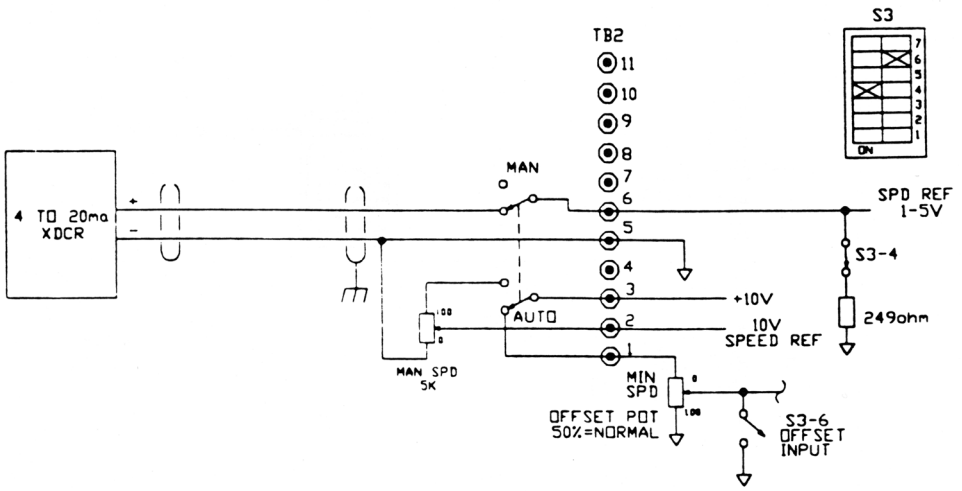

FIGURE 15. SIGNAL CONNECTION DIAGRAM, 4 - 20 mA TRANSDUCER WITH MANUAL/AUTO SWITCH

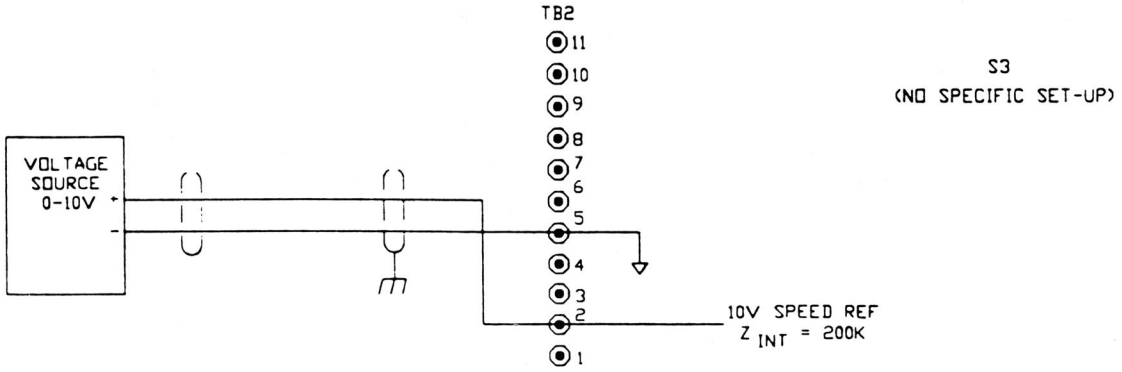

FIGURE 16. SIGNAL CONNECTION DIAGRAM, 0 - 10 VDC EXTERNAL SPEED REFERENCE SIGNAL

INITIAL STARTUP

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

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

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

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

5. 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 19.

TABLE 3. INITIAL POTENTIOMETER SETTINGS

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

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

7. Switch on the AC supply to the controller.

8. 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 is 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 the 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.

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

Section III – Operation

POWER ON/OFF

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

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*

COMPONENT	MODEL	RATED VOLTAGE	RATED HORSEPOWER								
			1/6	1/4	1/3	1/2	3/4	1	1-1/2	2	3
BRAKING TORQUE (%)	RBS2M	115V	180	129	103	66	44	34	-	-	-
		230V	-	-	-	278	190	130	88	62	-
	RBS3M	115V	300	215	170	110	75	60	-	-	-
		230V	-	-	-	400	320	220	145	105	85
STOPS PER MINUTE	RBS2M	115V	15	12	11	8	6	2	-	-	-
		230V	-	-	-	8	6	1	1	1	-
	RBS3M	115V	9	6	5	5	4	4	-	-	-
		230V	-	-	-	5	4	4	3	3	2

*High Intertia 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 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.

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.

Normally, jog speed is at "RUN" speed.

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 anti-plug feature which requires that the motor be stopped before it can be reversed.

INOPERATIVE MOTOR

If the motor stops and/or won’t start, disconnect the 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 33). If the fuse is blown, refer to the Troubleshooting Table (Table 5). Pages 22–24

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. Adjust 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 - 30VDC
OFF (Open)	31 - 175VDC

3. Turn the IR/TACH potentiometer fully counterclockwise (0%). This setting provides maximum motor speed.

4. Be sure the MAX SPD potentiometer has been adjusted correctly.

5. Run the motor at maximum speed, and start turning the IR/TACH potentiometer clockwise until motor speed increases above desired speed. Continue turning the potentiometer clockwise until motor speed decreases to desired 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-l 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 11 on page 13. Segment 5 of DIP Switch S3 must be in OFF (Open) position if an external Current (Torque) Reference potentiometer is desired.

TROUBLESHOOTING

TABLE 5. TROUBLESHOOTING

INDICATION	POSSIBLE CAUSE	CORRECTIVE ACTION
1. Motor won't start (See "Inoperative Motor" page 18.)	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	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 - 20 mA, or 0 - 5 VDC speed reference signal, as applicable.
	Controller not adjusted correctly	Turn the ACCEL and CUR LIM potentiometers fully clockwise (100%).
	DIP switch S3 not set correctly	See Table 11, 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 terminating 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.

(continued)

TROUBLESHOOTING

TABLE 5. TROUBLESHOOTING (continued)

INDICATION	POSSIBLE CAUSE	CORRECTIVE ACTION
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.
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 pages 7 and 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.

(continued)

TROUBLESHOOTING

TABLE 5. TROUBLESHOOTING (continued)

INDICATION	POSSIBLE CAUSE	CORRECTIVE ACTION
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 19.
	Maximum speed not adjusted correctly	See the Maximum Speed (Armature Feedback) adjustment instructions on page 20.
	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.
10. Shunt field current too low (1)	Open shunt field winding or wiring 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 12, 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 rating and refer to Table 12, 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 – Parts List

TABLE 6. PARTS LIST, BETAplus CONTROLLERS

PART	RATING	BOSTON PART NUMBER	
		RBS2	RBS3
Control Board	N/A	64971	64979
Fuse, Line	30A,600V (ATM-30)	64991	64991
SCR	55A, 800V	N/A	64994
	15A, 600V	64993	N/A
Silicon Rectifier (Freewheeling Diode)	15A, 600V	64989	N/A
	24A, 600V	N/A	64990
Run Speed or Current Reference Potentiometer	5 KΩ, 1/2 W	60246	60246
Speed or Current Potentiometer Knob	N/A	60245	60245
Hybrid	N/A	64998	64998
Run-Stop-Jog Switch	N/A	50457	50457
FWD-REV Switch (RBS2M, RBS3M)	N/A	65000	65000
FWD-REV Switch (RBS2R)	N/A	67478	N/A
Reversing Board (RBS2M, RBS3M)	N/A	64908	64905

Section VI – Ratings and Specifications

RATINGS

1. Current/Torque Reference Potentiometer ..... 5K Ohms, 1/2 W

2. Duty ..... Continuous

3. Horsepower Range ..... 1/6 - 3 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 7. TYPICAL APPLICATION DATA

COMPONENT			RATINGS								
RATED HORSEPOWER (HP)			1/6	1/4	1/3	1/2	3/4	1	1-1/2	2	3
RATED KILOWATTS(kW)			0.124	0.187	0.249	0.373	0.560	0.746	1.120	1.492	2.238
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
	KVA		0.48	0.58	0.71	1.00	1.40	2.00	3.00	4.00	5.00
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
	Motor Field Amps (Maximum)	RBS2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-
		RBS3	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
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
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

TABLE 8. OPERATING VOLTAGES AND SIGNALS

POWER SOURCE (Single-phase)	OUTPUT VDC		SPEED REFERENCE SIGNAL*	MAGNETIC CONTROL VOLTAGE
	Armature	Field		
115V, 50 or 60 Hz	0-90	50/100	0-5 VDC, 0-10 VDC or 4-20 mA	24 VDC
230V, 50 or 60 Hz	0-180	100/200		

* Grounded or ungrounded

RATINGS (continued)

TABLE 9. CONTROLLER WEIGHTS

Controller Model	Weight – LBS (KG)
RBS2, RBS3	3.25 (1.48)
RBS2M, RBS3M	3.80 (1.75)
RBS2B, RBS2S, RBS2R	5.50 (2.50)
RBS2MB, RBS2MR	6.05 (2.75)

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. Displacement Power Factor (Rated Speed/Rated Load) 87%

3. Efficiency (Rated Speed/Rated Load)

a. Controller Only 98%

b. Controller With Motor, Typical 85%

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

TABLE 10. 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

*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.
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 11.
5. **FEEDBACK** – Two selectable modes of analog feedback are provided, as follows. See Table 10 (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 12.
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” in the suffix, e.g., RBS2MR, RBS3M, 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 11. DIP SWITCH S3 SETTINGS

Segment	Segment Position		Description
	ON (Closed)	OFF (Open)	
1	X		Low voltage tachometer generator signal (8 - 30 VDC)
		X	High voltage tachometer generator signal (31 - 175 VDC)
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 12. 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 VII – Drawings

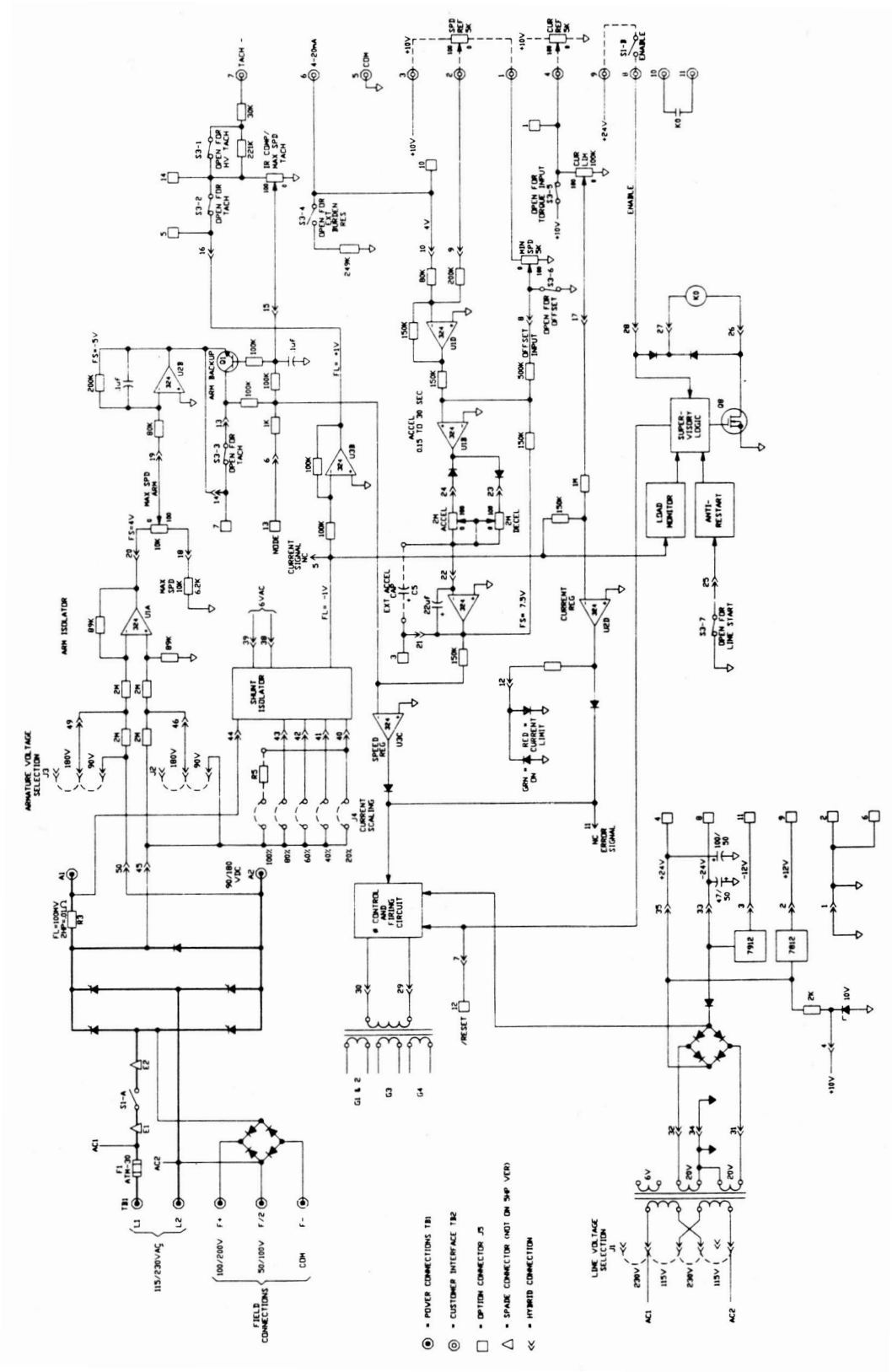

FIGURE 17. FUNCTIONAL SCHEMATIC, BETAplus

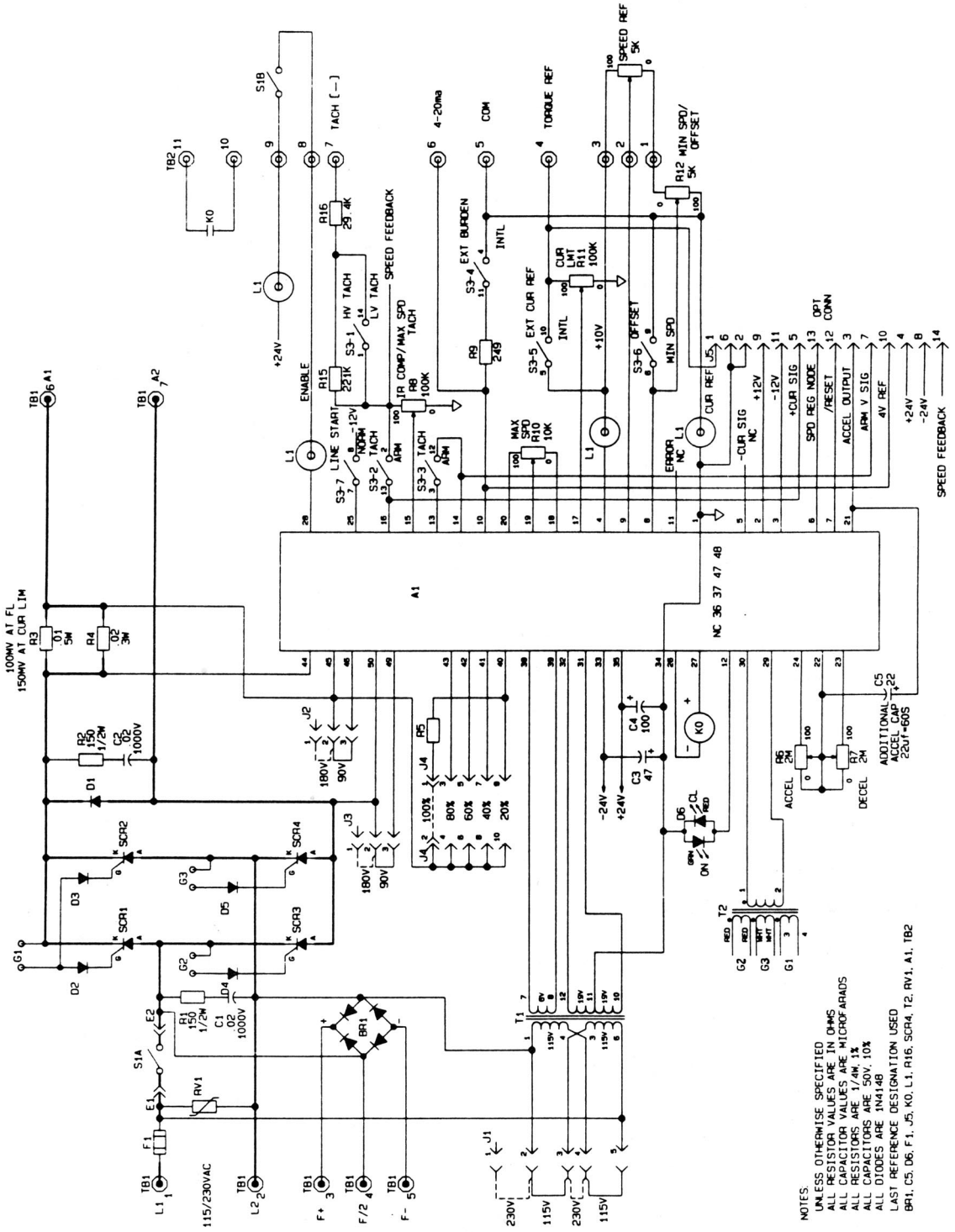

FIGURE 18. SCHEMATIC, BETAplus 1/6 - 3 HP

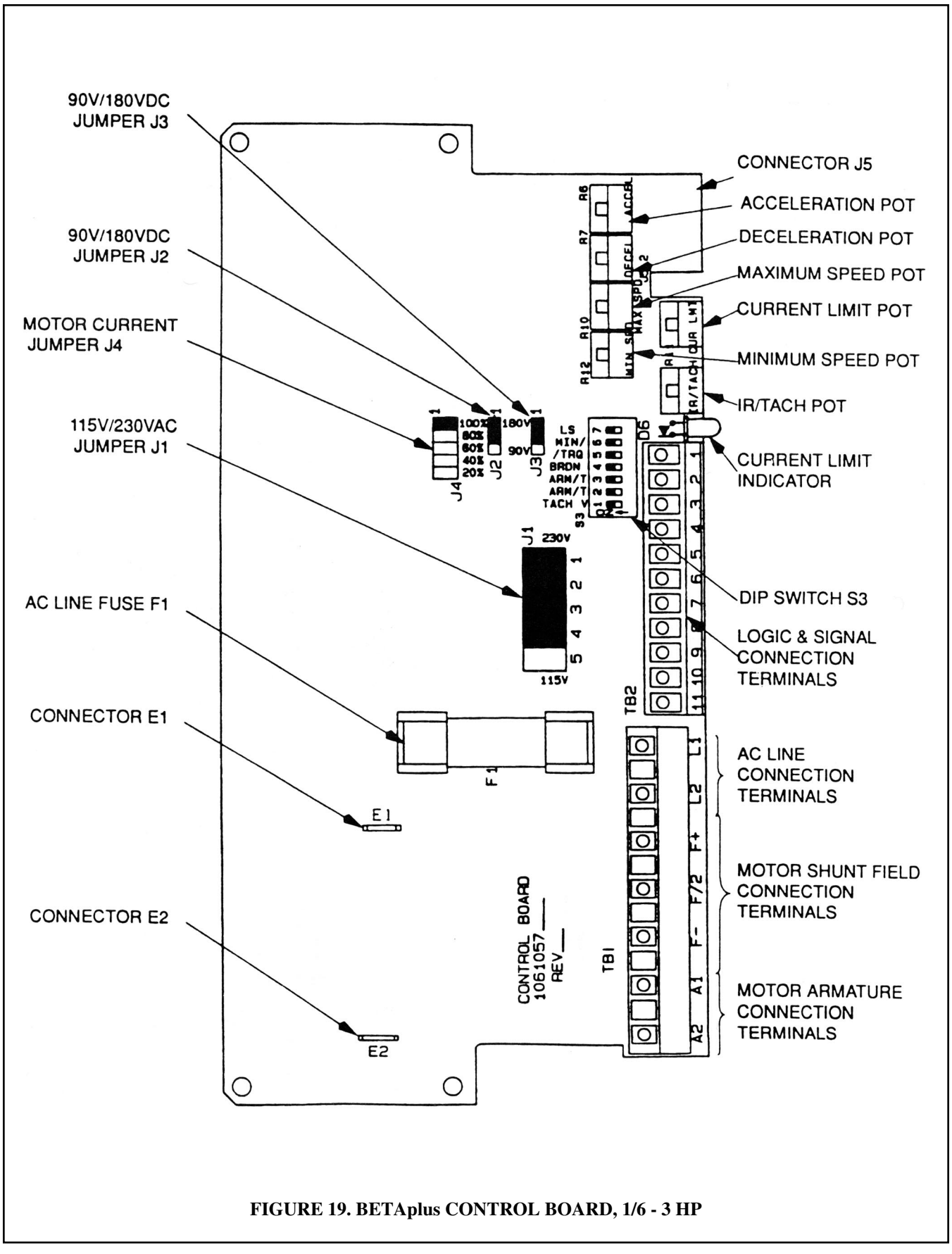

FIGURE 19. BETAplus CONTROL BOARD, 1/6 - 3 HP

(57766)
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