

Boston Gear[®]

RB Series DC Motor Speed Control

Installation and Operation

Doc. No. 19025

RB1, B, S, R
RB2, B, S, R
RB3, B, R



An Altra Industrial Motion Company

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GENERAL INFORMATION

Description

Ratiotrol Beta controllers statically convert single-phase AC line power to regulated DC for adjustable-speed armature control of shunt-wound and permanent-magnet motors. The controllers are Underwriters Laboratories Listed. (File No. 71E60208)

Enclosure

Totally enclosed, non-ventilated, constructed of rugged die-cast aluminum alloy. Gasketed, screw fixed cover excludes contaminants. Provision for conduit entry is included top and bottom by two (2) 3/4-14 NPT tapped holes. Standard unit is easily and inexpensively convertible to NEMA Type 3, 4 or 12.

Model Types

Table 1. Ratiotrol Beta Model Matrix

Model	Function			Configuration		Operator Controls		Power Source And Horsepower Range	
	Unidirectional Run-Stop	Armature Switch Reversing	Armature Contactor Reversing and D.B.	Open Chassis	Enclosed	Local (Integral)	Remote (*)	115VAC	230VAC
								50/60 Hz	50/60 Hz
RB1	X			X			X	1/12 - 1HP	N/A
RB1B	X				X		X		
RB1S	X				X	X			
RB1R		X			X	X			
RB2	X			X			X	Reconnectable Units	
RB2B	X				X		X		
RB2S	X				X	X		115VAC	230VAC
RB2R		X			X	X		50/60 Hz	50/60 Hz
RB3			X	X			X	1/12 - 1HP	1/2 - 2HP
RB3B			X		X		X		
RB3R			X		X	X			

* Operator controls provided by user

OPERATOR CONTROLS

Table 2. Operator Controls

Controller Suffix	Operator Controls
B or no Suffix	None
S	<ol style="list-style-type: none"> Run/Stop Switch - 2 maintained positions Motor Speed Pot - 5K ohm, 1/2 watt
R (RB1, 2)	<ol style="list-style-type: none"> Run/Stop Switch - maintained positions Fwd/Rev Switch - 3 maintained positions with center detent position for antiplug protection Motor Speed Pot - 5K ohm, 1/2 watt
R (RB3 only)	<ol style="list-style-type: none"> Run/Stop Switch - 2 maintained positions Rwd/Rev Switch - 2 momentary positions with return to center Motor Speed Pot - 5K ohm, 1/2 watt

RATINGS

- Service Factor1.0
- DutyContinuous
- Overload Capacity150% for 1 minute
- AC Line Fuse Interrupting Capacity5000 amperes

Table 3. Ratings

Component			Rated Horsepower								
			1/12	1/6	1/4	1/3	1/2	3/4	1	1 1/2	2
1-Phase 50 or 60 Hz AC Input (Full Load)	Line Amps	115VAC Unit	2.0	3.9	5.0	6.0	8.7	12.4	15.0	----	----
		230VAC Unit	----	----	----	----	4.2	5.9	8.8	12.6	15.8
	KVA		.30	.48	.58	.71	1.0	1.4	2.0	3.0	4.0
DC Output (Full Load)	Motor Armature Amps	90V	0.9	2.0	2.8	3.5	5.4	8.1	10.5	----	----
		180V	----	----	----	----	2.6	3.8	5.5	8.2	11.6
	Motor Field Amps	50V	----	1.0	1.0	1.0	1.0	1.0	1.0	----	----
		100V	----	----	----	----	1.0	1.0	1.0	1.0	1.0
Full Load Torque (LB. FT.) With 1750 RPM Base Speed Motors			.25	0.5	0.75	1.0	1.5	2.2	3.0	4.5	6.0
Weight LBS. (kg)	RB1, RB2		3.25 (1.48 kg)								
	RB3		3.8 (1.73 kg)								
	RB1B, RB1S RB2B, RB2S RB1R, RB2R		5.5 (2.5 kg)								
	RB3B, RB3R		6.05 (2.75 kg)								

OPERATING CONDITIONS

1. Line Voltage Variation ± 10% of rated
2. Line Frequency Variation ± 2 Hz
3. Ambient Temperature (*) 0°C to 40°C (32°F to 104°F)
4. Altitude (standard) 3300 feet (1000 meters) maximum
 * 55°C (131°F) maximum in enclosed areas where RB1, RB2 or RB3 open chassis units are mounted.

PERFORMANCE CHARACTERISTICS

1. Controlled Speed Range 0 to motor base speed
2. Speed Regulation (See Table 4) - Regulation percentages are of motor base speed under steady-state conditions
3. Efficiency (at maximum speed)
 - a. Controller 99%
 - b. Controller with motor 85%
4. Displacement Power Factor (Rated Speed/Rated Load) 87%
5. Acceleration (non-adjustable) By fixed ramp with current limit override
6. Current Limit (non-adjustable) 150% full-load torque (typical)

Table 4. Speed Regulation Characteristics

Regulation Method	Load Change 95%	Line Voltage ± 10%	Variable Field Heating (1) Cold/Normal	Temperature ± 10°C	Speed Range
Standard Voltage Feedback with IR Compensation	2%	± 1%	5-12%	± 2%	50:1
Optional Speed (Tach) Feedback (2)	0.5%	± 1%	0.2%	± 2%	100:1

- (1) Does not apply to Permanent-Magnet Motors
 (2) Unidirectional Models Only

PERFORMANCE CHARACTERISTICS (Con't)



Figure 1. Typical Beta Enclosed Controller

7. Dynamic Braking - Supplied in Models RB3, RB3B and RB3R. Provides initial braking torque and stops per minute as shown in Table 5. The dynamic braking resistor is rated for stopping a typical load when the motor load inertia does not exceed the motor armature inertia.

HIGHER INERTIA LOADS AND/OR ARMATURE VOLTAGE HIGHER THAN RATED MAY EXTEND BRAKING TIME BEYOND THE WATTAGE RATING OF THE DYNAMIC BRAKING RESISTOR.

Table 5. Dynamic Braking Characteristics

Component	Unit	Rated Horsepower								
		1/12	1/6	1/4	1/3	1/2	3/4	1	1-1/2	2
Braking Torque %	115V	200	180	129	103	66	44	34	---	---
	230V	---	---	---	---	278	190	130	88	62
Stops Per Minute	115V	20	15	12	11	8	6	2	---	---
	230V	---	---	---	---	8	6	1	1	1

INSTALLATION AND WIRING

BE SURE TO READ ALL THE FOLLOWING INSTALLATION AND WIRING INSTRUCTIONS BEFORE INSTALLING THE CONTROLLER.

1. Unpack the controller.
2. Remove the controller front cover (if applicable) and check components in the controller. Report shipping damage to the carrier.

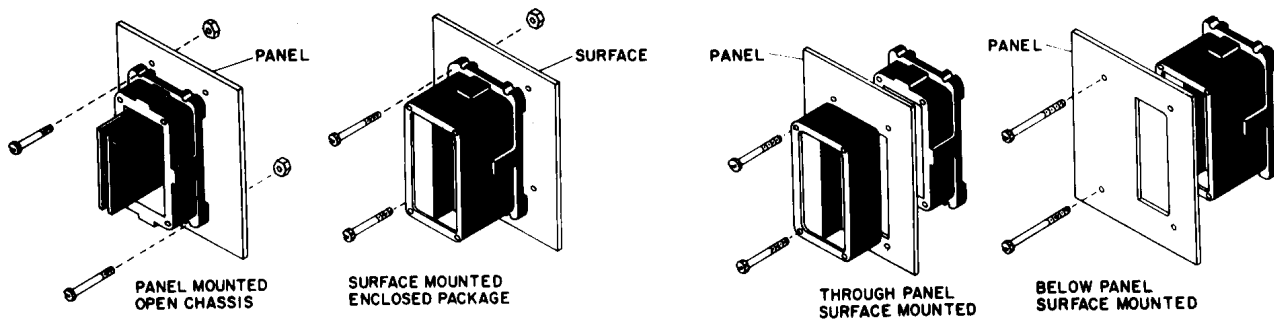


Figure 2. Series Beta Mounting Configurations

3. The controller can be mounted in any of four configurations, as shown in Figure 2.
4. Conduit entry is made by driving a 5/8" diameter pipe nipple, socket or similar rigid object through the conduit opening. On all models install a 3/4" x 14 conduit fitting or pipe.
NOTE: DO NOT USE A PUNCH SINCE THIS WILL LEAVE SHARP PROTRUSIONS AROUND THE OPENING. To prevent component damage from knockout fragments, apply masking tape to the inside of the knockout before removing it.
5. Remove the proper calibration wire(s) from the controller main board with a wire cutter, as shown in Table 6 and Figure 3.
6. Be sure the main board is connected for the correct voltage. Figure 3 shows the main board connected for 230 volt operation. For 115 volt operation, the yellow and white leads on Transformer T1 connect to the 115V tabs, and the feedback jumper connects to the 90V ARM tab.
NOTE: Model RB1 Controllers are designed for 115 volt operation only.
7. Replace the front cover (if applicable) on the chassis.
8. Mount the controller. If the controller is subjected to vibrations, it must be shock mounted.
NOTE: Never mount the controller immediately beside or above the heat-generating equipment, or directly below water or steam pipes. If the controller is mounted in an enclosure, be sure the temperature in the enclosure does not exceed 550.
9. Prepare for wiring by removing the front cover (if applicable) and attaching it to the chassis as shown in Figure 4.

INSTALLATION AND WIRING (Con't)

Motor Horsepower		Remove Wires
90 VDC	180 VDC	
1/12	1/6	R9 Thru R14
1/8	1/4	R9 Thru R14
1/6	1/3	R9 Thru R14
1/4	1/2	R10 Thru R14
1/3	3/4	R10 Thru R14
1/2	1	R11 Thru R14
3/4	1 1/2	R13 Thru R14
1	2	None

Table 6. Series Calibration Wires

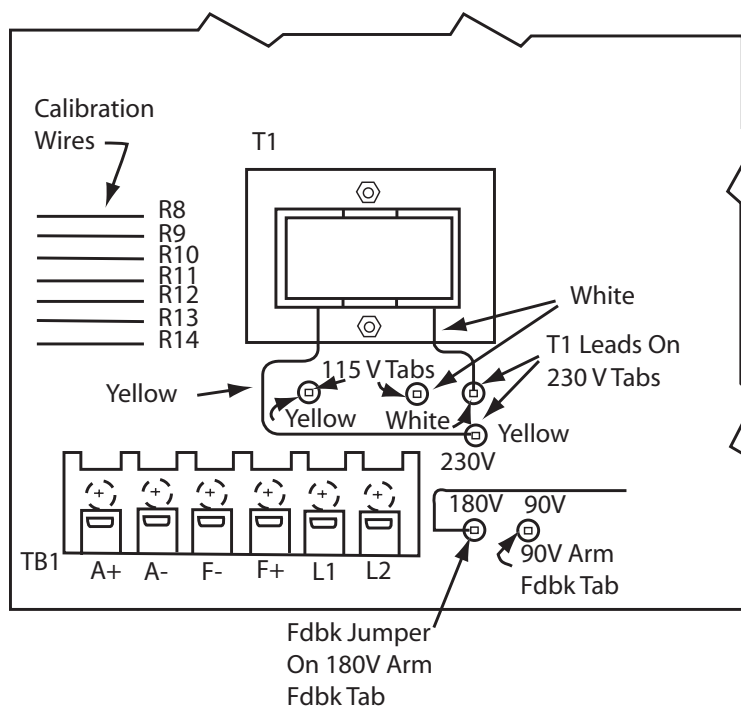


Figure 3. Main Board Connections

INSTALLATION AND WIRING (Con't)

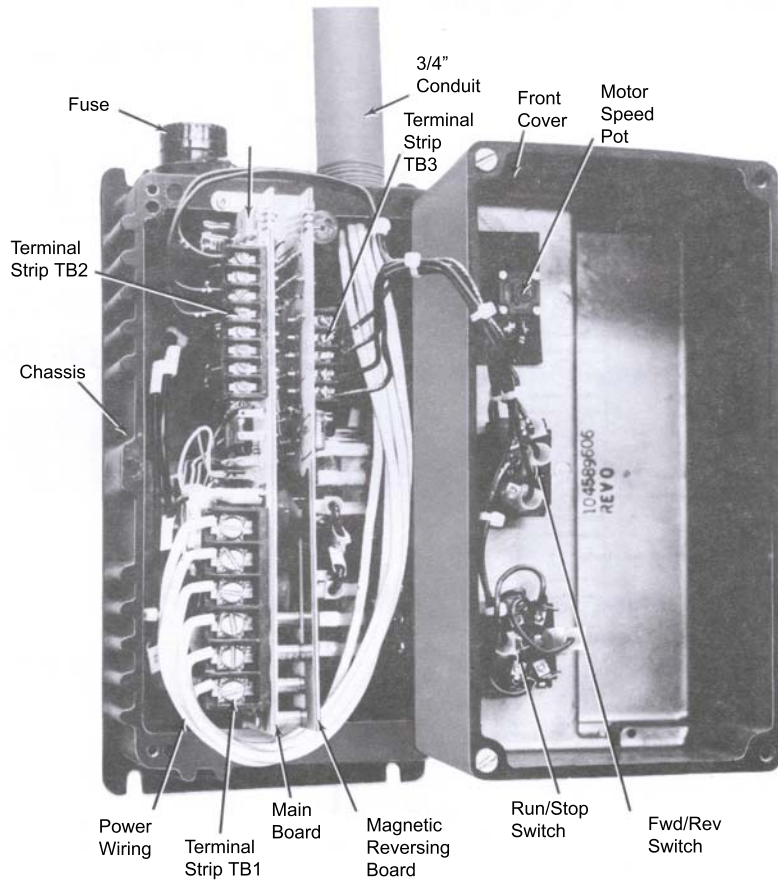


Figure 4. Internal View Beta Controller

CAUTION

- a. SEPARATE OVERCURRENT PROTECTION IS REQUIRED BY THE NATIONAL ELECTRICAL CODE. THE USER IS RESPONSIBLE FOR CONFORMING WITH THE NATIONAL ELECTRICAL CODE AND ALL APPLICABLE LOCAL CODES WHICH GOVERN SUCH PRACTICES AS WIRING PROTECTION, GROUNDING DISCONNECTS AND OTHER PROTECTION.
- b. THE AVAILABLE SHORT-CIRCUIT CURRENT OF THE INPUT SUPPLY MUST BE LESS THAN 5,000 AMPERES SYMMETRICAL OR CONTROLLER DAMAGE MAY RESULT. Short circuit current can be limited by sizing the input supply transformer at 50KVA or less, or by using correctly sized current limiting fuses in the input supply to the controller.
- c. NEVER USE POWER FACTOR CORRECTION CAPACITORS ON THE INPUT LINE TO THE CONTROLLER. These capacitors can damage the solid-state components.

INSTALLATION AND WIRING (Con't)

10. Use #14AWG stranded wire and connect the line and motor wiring to Terminal Strip TB1 as shown in Figure 5. Route the wiring as shown in Figure 4.

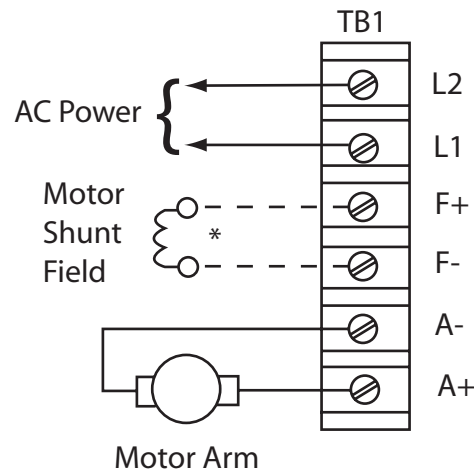


Figure 5. AC Power And Motor Connections

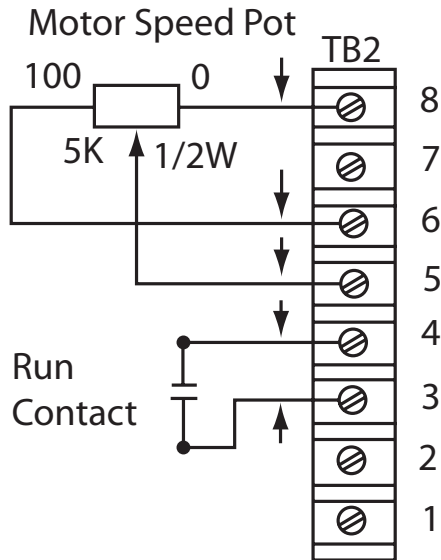
NOTE: Connections shown in Figure 5 do not provide positive disconnect of power from the motor on Models RB1 and RB2. Model RB1 should only be connected to 115VAC power. Models RB2 and RB3 are shipped for connection to 230VAC power, but they are reconnectable for 115VAC power per Figure.

11. Connect ground to a controller mounting screw. Be sure to remove the paint where the ground screw contacts the controller.
12. Do not close the controller until “startup” is complete.

Models RB1, RB1B, RB2, RB2R, RB3 And RB3B

13. Use Alpha No. 1898 or equal twisted cable and connect the operator controls to the controller as shown in Figure 6 or 7. Maintain separation between the power wiring (Figure 5) and the operator control wiring by 2” minimum.

MODELS RB1, RB1B, RB2, RB2R, RB3 AND RB3B (Con't)



NOTES:

1. Contacts and motor speed pot are user supplied.
2. Contacts must be rated at 4 ma DC minimum
3. Symbol "↓" means twisted wire.

Figure 6. Connections Models RB1 & RB2

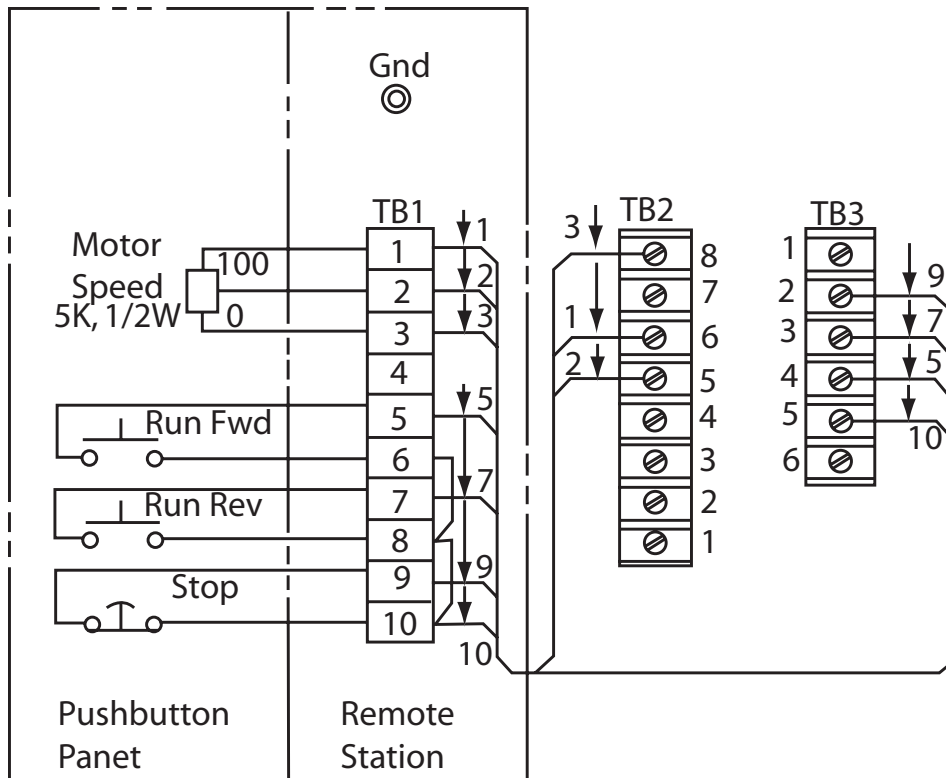


Figure 7. Connections Models RB3 & RB3B

MODELS RB1, RB1B, RB2, RB2R, RB3 AND RB3B (Con't)

Startup And Operation

1. Be sure all operator switches are in STOP or in neutral center position.
2. Turn the MOTOR SPEED control pot to zero on its dial.
3. Apply AC power to the controller.

Models RB1, RB2, RB1B And RB2B

4. Close the run contact between Terminals 3 and 4.
5. Turn the MOTOR SPEED control pot until the motor rotates.

Models RB3 And RB3B

4. Push the RUN FWD button.
5. Turn the MOTOR SPEED control pot until the motor rotates.
6. Reverse Operation - Push the STOP button and then push the RUN / REV button. The motor will dynamically brake to a stop and then accelerate in the opposite direction. Do not exceed the braking capabilities listed in Table 5, page 7.

Models RB1S And RB2S

4. Place the RUN/STOP switch in RUN position.
5. Turn the MOTOR SPEED pot until the motor rotates.

Models RB1R And RB2R

4. Place the RUN/STOP switch in RUN position.
5. Place the FWD/REV switch in FWD position.
6. Turn the MOTOR SPEED pot until the motor rotates.
7. Reverse Operation - Place the FWD/REV switch in REV position. If the motor load inertia exceeds the motor inertia, place the RUN/STOP switch in STOP position before changing the FWD/REV switch.

Model RB3R

4. Place the RUN/STOP switch in RUN position.
5. Push the FWD/REV switch into FWD position. This position is momentary. When the switch is released, it returns to the center position.
6. Turn the MOTOR SPEED pot until the motor rotates.
7. Reverse Operation - Place the RUN/STOP switch in STOP position and then return it to RUN position. Next, push the FWD/REV switch into REV position. This position is momentary. When the switch is released, it returns to the center position. The motor will dynamically brake to a stop and then accelerate in the opposite direction. Do not exceed the braking capabilities listed in Table 5.

- Notes:**
1. If motor rotation is opposite to that desired, stop the motor, turn-off the AC supply, and interchange the motor armature leads.
 2. Turn the MOTOR SPEED pot to zero on its dial and check minimum speed, which is normally set for zero. To readjust minimum speed, turn the MIN SPD pot on the main board. See Figure 4.
 3. The MOTOR SPEED pot controls forward, reverse and jog speeds from minimum speed to maximum speed.
 4. Whenever the AC input power is interrupted (turned-off), the controller must be reset after the AC power is restored by initiating a Stop function and then a Run function. This feature prevents accidental restarts.

MAINTENANCE

Maintenance consists of keeping the controller clean and dry. Refer to maintenance instructions supplied by the motor manufacturer. If the motor does rotate, check the fuse on top of the controller. The fuse type is shown on the controller data label.

CAUTION

SUBSTITUTE FUSES CAN CAUSE CONTROLLER DAMAGE.

WARNING

BE SURE THE AC INPUT POWER IS REMOVED BEFORE WORKING ON THE CONTROLLER. High voltage within the controller can cause electric shock resulting in personal injury or loss of life.

Beta Modifications

Full Wave Field

The standard half wave field supply may be converted to a full wave field supply. This modification doubles the field voltage that would otherwise be available. The table below shows the relationship.

AC Line Volts	Standard Half Wave Field Voltage	Full Wave Field Voltage After Modification
115 VAC	50 VDC	100 VDC
230 VAC	100 VDC	200 VDC

Table 7.

In order to obtain the increased field voltage, two diodes must be installed in the PC board. These diodes together with the two diodes in the power bridge form a full wave rectifier circuit.

Figure 8 shows the location of the diodes. Observe the orientation of the band marking on the devices when installing them. Use IN5399 diodes or similar 1.5A, 1000V diodes. Remove the existing jumper as shown in Figure 8 and install #20 insulated wire between the holes connected by the dotted line.

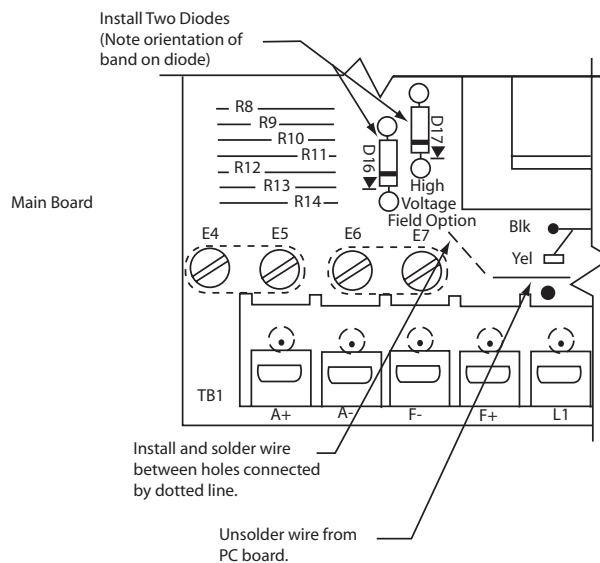


Figure 8. Full Wave Field

HALF VOLTAGE OUTPUT

When the Beta controller is calibrated for 230 VAC, the armature voltage is adjustable from 0 to 180 VDC. It is possible to reduce this range to 0 to 90 VDC by moving the feedback jumper on the main board from its 180V position to the 90V position. This effectively doubles the armature feedback signal to the controller's error amplifier, thus reducing the armature voltage by half. Although the armature voltage is reduced, the field voltage remains at 100 VDC. Furthermore, the controller must now be calibrated for horsepower as if it were a 115 VAC unit.

Because the armature voltage is reduced by half, the gain of the system has doubled. This may cause instability at certain loads or speeds. Another consideration is the controller/motor form factor. The form factor is much higher when obtaining 90 VDC from a 230 VAC controller than it would be if the 90 VDC were obtained from 115 VAC. This will increase motor heating to some extent and may cause commutation difficulties. Therefore, the suitability of this mode of operation should be confirmed by testing or consulting the motor manufacturer.

INCREASED ACCELERATION TIME

The time it takes the Beta controller to bring the motor to full speed may be increased from the standard 0.3 second time to a maximum of 2.5 minutes. This is done by installing a 25V, axial lead electrolytic capacitor on the PC board. The value of the capacitor in microfarads determines the time the motor will take to reach full speed. The following table shows standard values of capacitors and the acceleration time obtained with each. The time listed is approximate due to the tolerance of the capacitor and is specified at the point the armature voltage reaches 95% of its final value. Although values larger than 1000 MFD may be used, it is not recommended. Larger values may prohibit the controller from reaching full speed.

<u>Capacitance (MFD)</u>	<u>Time (SEC.)</u>
30	5
50	8
100	15
150	23
200*	30
1000*	2.5 min.

*These caps may not fit into the space provided on the PC board. In this case the caps leads may be insulated and bent so that they reach the holes provided.

Table 8. Capacitor Values/Acceleration

Capacitor values for other acceleration times may be obtained by using the following formula:

$$(6.66 \times \text{Time})^{-2} \text{ is approximate equal to capacitance in MFD}$$

Select a standard capacitor value which is close to the calculated result.

Example: Compute the value of capacitance required for an acceleration time of two seconds:
 $(6.66 \times 2)^{-2} = 11.3$ Microfarads
Therefore, a 10 MFD capacitor would be installed on the Beta controller's main board.

INCREASED ACCELERATION TIME (Con't)

Figure 9 shows the location of the acceleration capacitor. Observe the polarity when installing it.

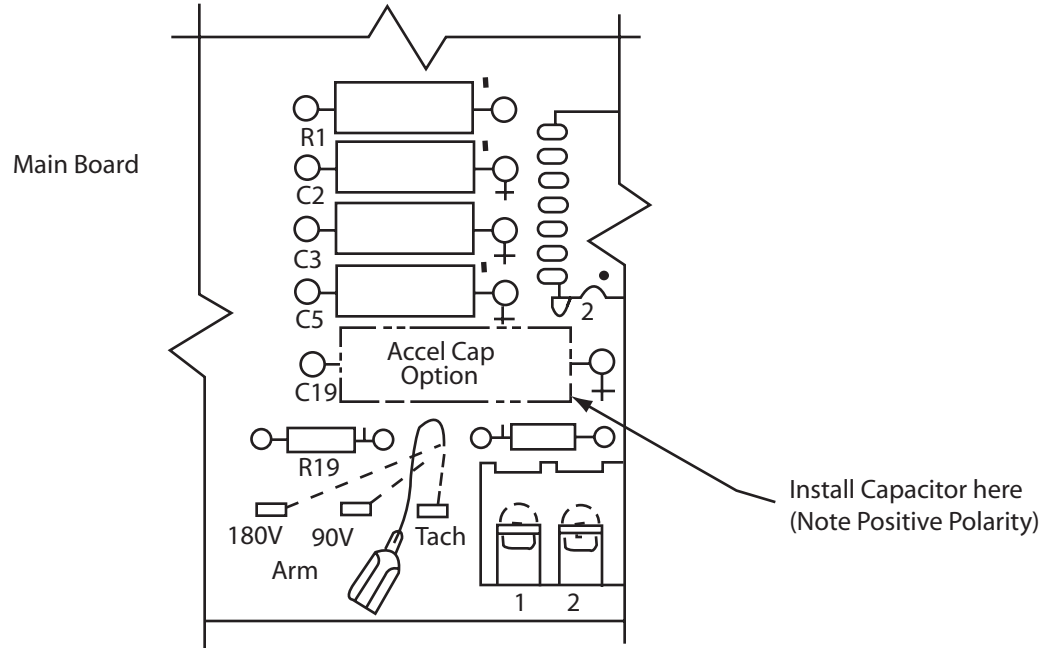


Figure 9.

LIMIT SWITCH REVERSING

Limit switch reversing controls the direction of motor rotation by the use of limit switches. The process starts by pressing a forward or reverse pushbutton. Typically the motor runs one direction performing a process until the machine encounters a limit switch. The switch then causes the motor to reverse direction. Finally, the limit switch at the beginning of the process is activated, reversing the motor direction again. This action continues until a stop button is pressed.

The RB3 controller is the only model controller capable of performing this function. In fact, no additional electronics are required when using the RB3 controller. It can be mounted in an existing enclosure or a blank cover can be added, enclosing the controller for convenient mounting.

The "R" cover cannot be used for this application. Either an RCS6 remote station (Figure 11) or a custom station, with the controls shown in Figure 11, is required.

A jumper wire (J1) on the RB3 magnetic reversing board must be cut to break the on-board connection between TB3 terminals 5 and 6 in order to use limit switch reversing. This is shown in Figure 10.

LIMIT SWITCH REVERSING (Con't)

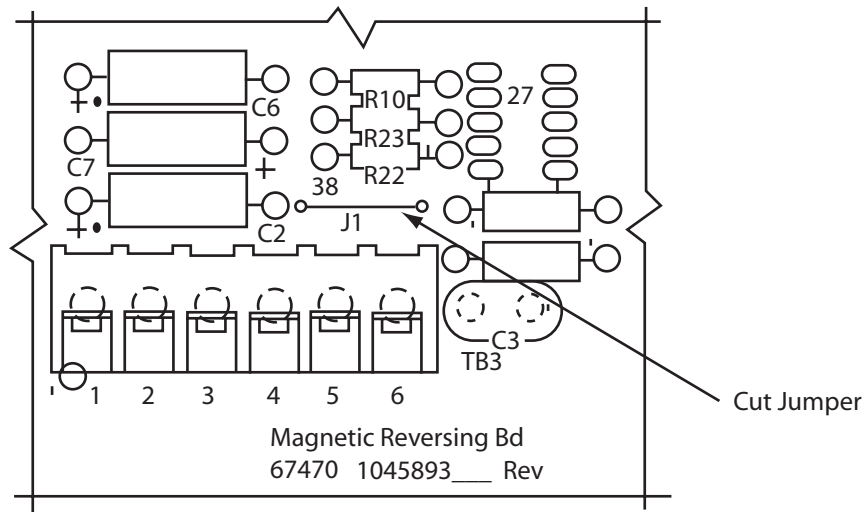


Figure 10. Location of J1 Jumper

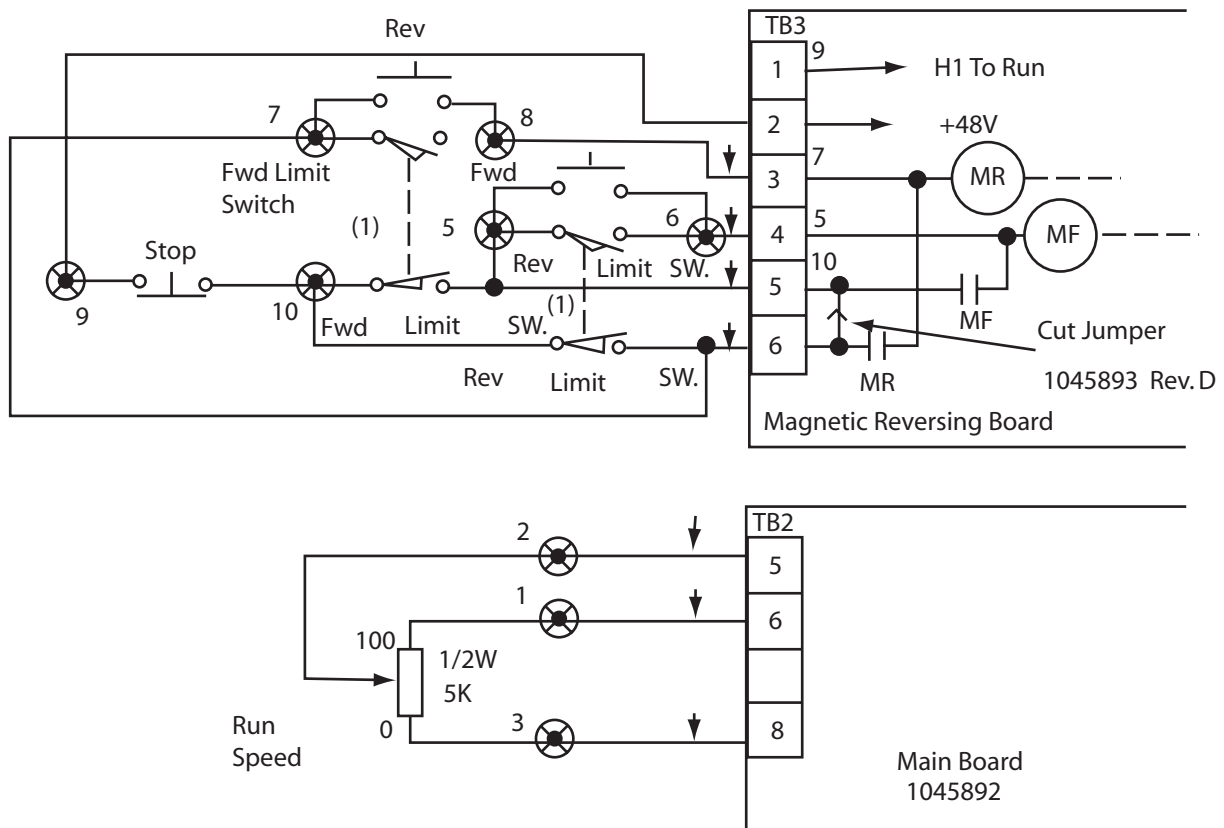


Figure 11. Limit switch Reversing Using RCS6 Remote Control Station

NOTES:

1. Wires connected to TB2 and TB3 must be twisted cable - such as Alpha 1893/3.
2. Symbol "⊗" are terminals located on RCS6 remote control station.

TORQUE CONTROL

The standard mode of operation of the Beta controller is that of a speed controller with current limit. This means that the controller will regulate speed until the current reaches 100-120% of the motor's rated armature current. As the load increases beyond 120%, the controller's voltage will reduce until the motor has stopped rotating at 15% of rated current. Because the controller is regulating speed, the current or torque of the motor is allowed to vary up to 100% as required by the mechanical load.

Some applications require the opposite mode of operation. The controller in this case controls the torque of the motor, allowing the speed to vary between zero RPM and base speed. Actually, the speed of the torque controlled motor is set by the speed of the material or system the torque controlled motor is pulling against.

For Example:

A torque controller is used to power a motor connected to a spool winding up scrap metal. The metal is being extruded from the process at a given rate. If a speed controller were used, the speed of the winder would have to match the speed of the material; otherwise, the material would go slack or become taut. It would be expensive and undesirably complicated to try to match the speed. However, with torque control, the process speed can vary and the controller will continue to regulate torque, disregarding any process speed changes. Because the material is always in tension, the speed of the torque motor will necessarily have to be proportional to the process speed. But, what happens when the material breaks:"

If the torque controlled motor doesn't have a process to exert its torque against, the motor will run at maximum speed. This should be taken into consideration when planning the installation. Make sure that the appropriate safety precautions are taken in the event of a material breakage, causing the winder to run at maximum speed.

In order to use the torque control mode of operation either a 5K, 1/2W pot is required or an "S" or "R" cover assembly. The speed pot in these cover assemblies can easily be converted to a torque pot by moving the wire on TB2-5 to TB2-7, then cut the jumper as shown in Figure 12. A #20 AWL insulated jumper is also required between TB2-6 and TB2-5.

TORQUE CONTROL (Con't)

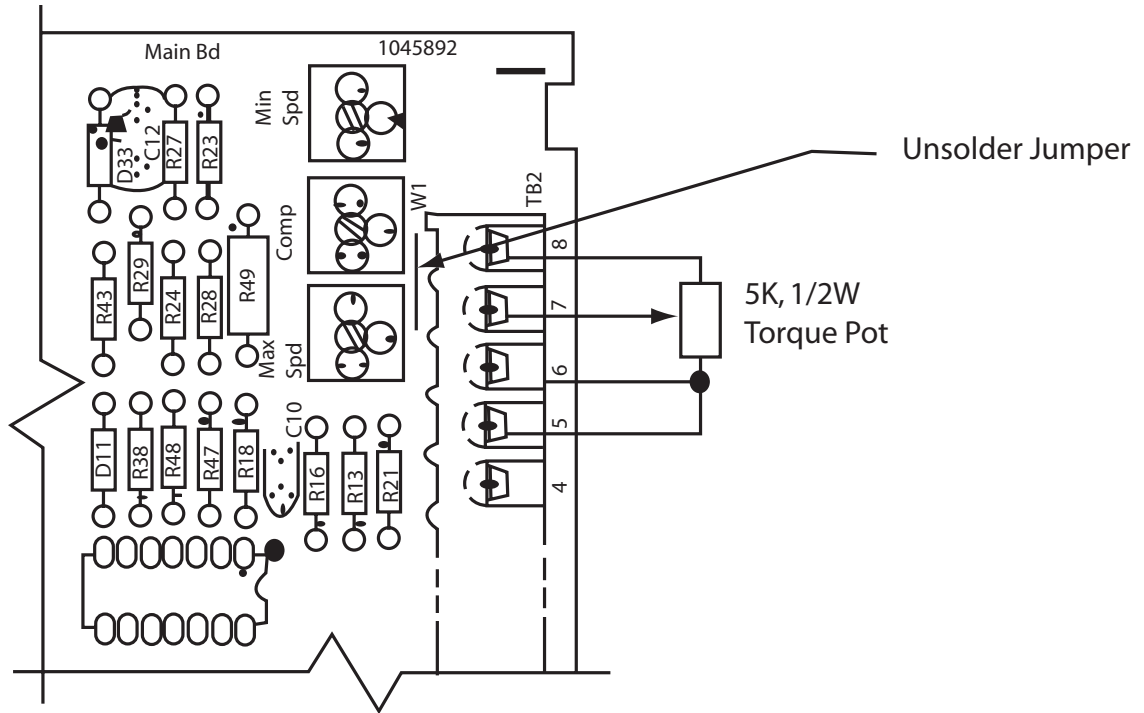


Figure 12.

The modifications made in Figure 12 allow the controller to run at maximum speed in the event of material breakage. If the torque controller, during its normal winding process, never reaches maximum speed, it may be desirable to limit the speed in the event of a material break. This is possible by adding the speed pot as shown in Figure 13. It should be noted that if the speed pot is set below the maximum process speed, that the torque controlled motor will be unable to keep up with the process, causing a sag in the material.

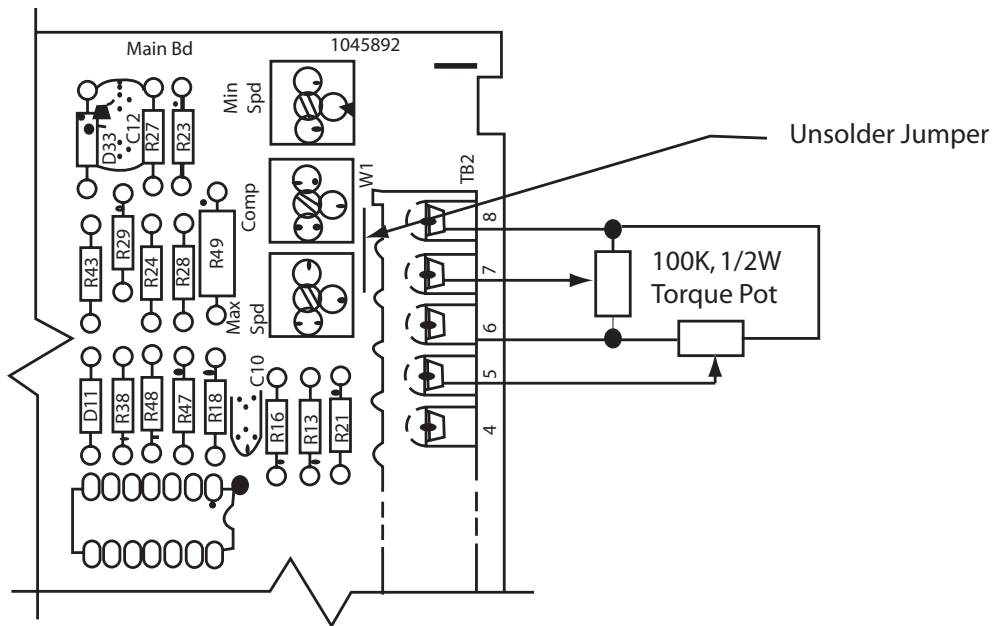


Figure 13.

TACHOMETER FEEDBACK

The RB1 and RB2 unidirectional controllers have provisions for tachometer feedback built into their main PC board. Since the controller requires the proper polarity tach voltage, tach feedback cannot be used with Beta controllers which permit the motor rotation to be reversed.

The electronics are designed so that a 35 VDC/1000 RPM to a 50 VDC/1000 RPM tach can be used without circuit board modification. A 7 VDC/1000 RPM tach can be used by replacing R20 with a #20 AWG jumper wire. Refer to Figure 14 for the location of the resistor.

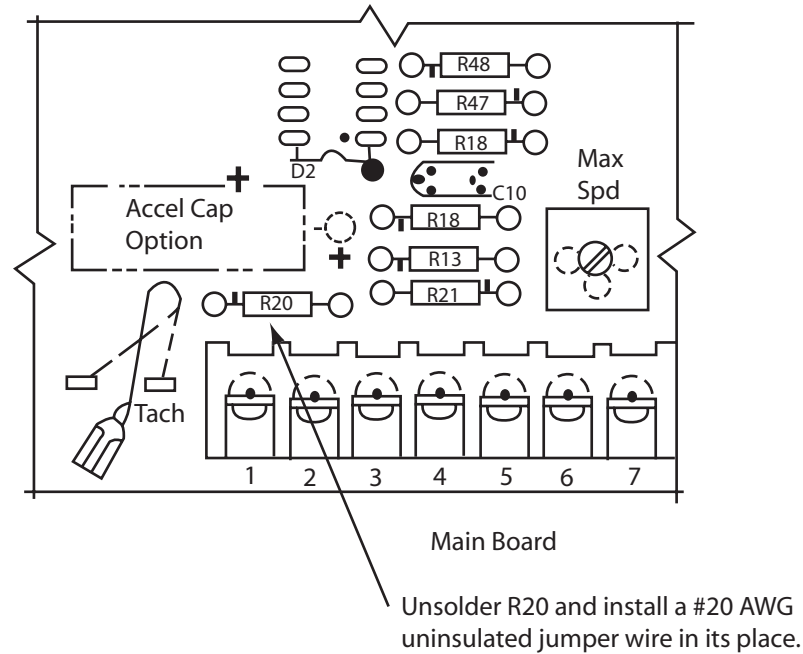


Figure 14.

In order to use tachometer feedback connect the DC tachometer wires to the main boards TB2-1 and TB2-2 (observe polarity) and move the jumper from either the 90V or the 180V position to the tach position. See Figure 15. Moving the jumper breaks the armature feedback circuit and connects the tachometer signal through scaling resistors to the error amplifier's summing point.*

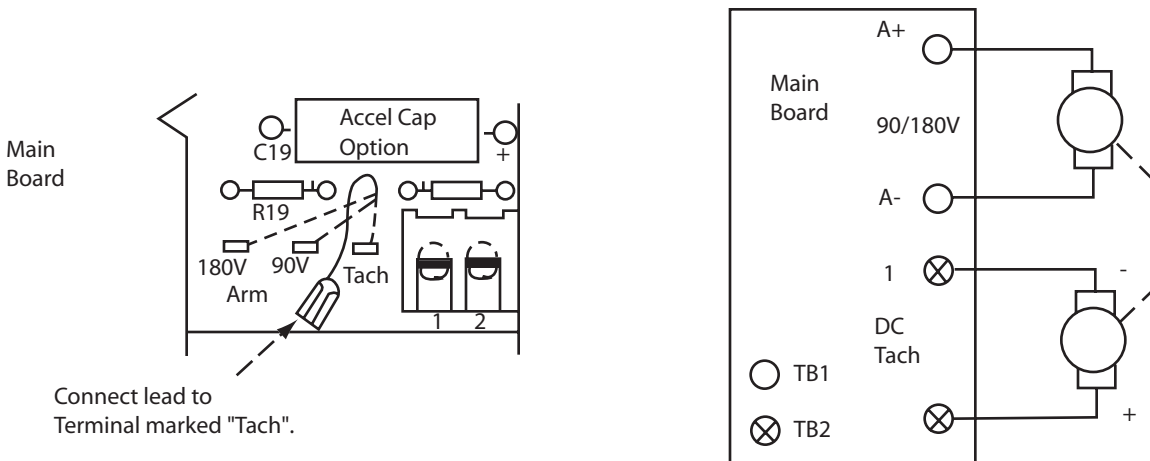


Figure 15.

*Broken tach wires or tach coupling may cause the motor to run at a dangerously high speed.

TACHOMETER FEEDBACK (Con't)

In order to calibrate the maximum speed of the controller, follow this procedure:

1. Connect a DC voltmeter (adjusted to read 90 VDC or 180 VDC) to the A+ and A- terminals of the controller.
2. Turn the max. speed pot counterclockwise.
3. Turn the speed pot counterclockwise.
4. Turn the IR COMP pot fully counterclockwise. (IR COMP set clockwise may cause instability.)
5. Apply power and initiate a run command.
6. Turn the speed pot clockwise slowly. If the Voltmeter reading reaches or exceeds rated armature voltage, with no adjustment from the motor speed pot, shut down the controller and switch the tachometer wires on TB2-1 and TB2-2.
7. Adjust the speed pot fully clockwise.
8. Turn the max. speed pot clockwise until the voltmeter reads rated armature voltage (90 or 180V).

The controller's maximum speed pot is now calibrated so that no further adjustment is necessary.

LINE STARTING

The standard Beta controller contains control logic which prevents the controller from restarting automatically if the AC line is interrupted and then reapplied. This is a safety feature which requires the controller be manually restarted after power loss.

In some applications it may be desirable to start and stop the controller by applying or removing the AC power. This would typically be done with a contactor installed in the AC line. The logic which requires a manual restart after power loss may be defeated to accommodate a line starting application on the RB1 or RB2 chassis mount controllers. The RB3 is not a desirable controller to receive this modification due to its contactor reversing feature.

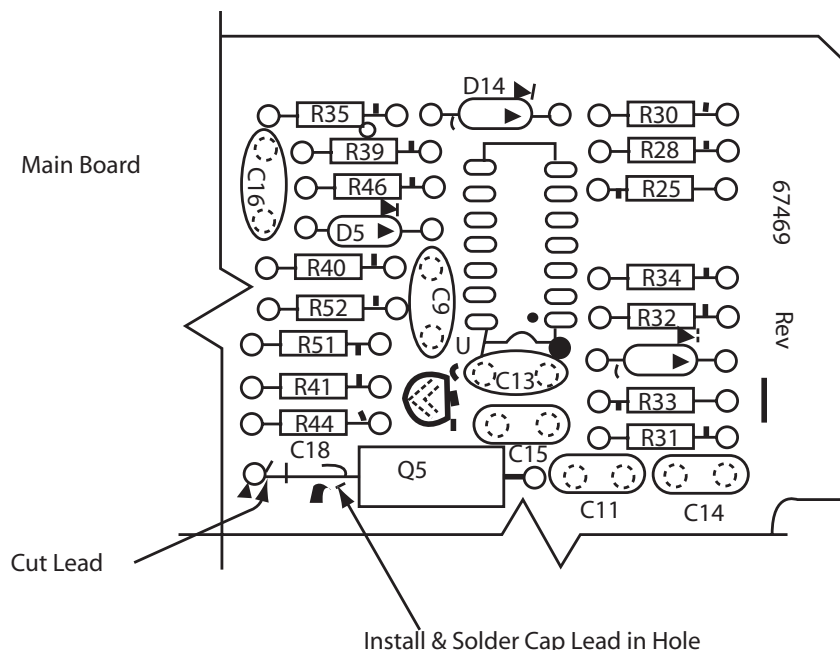


Figure 16.

LINE STARTING (Con't)

In order to allow the controller to run, place a jumper between TB2-3 and TB2-4 on the main board (refer to Figure 17). At this time, the motor will run as soon as power is applied to the controller.

Figure 17 also shows how a contactor is used to start and stop the motor. The table on page 21 shows the size of the contactor required for various horsepower controllers.

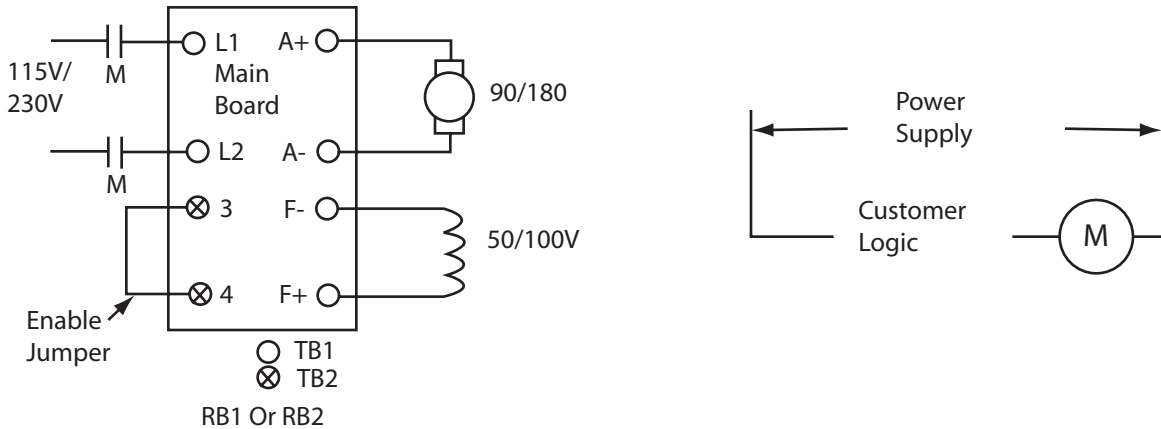


Figure 17.

Table 9. Contactor Selection Table

Controller Horsepower	AC Contactor Size	
	115 VAC	230 VAC
2 HP	---	0
1 HP	0	00

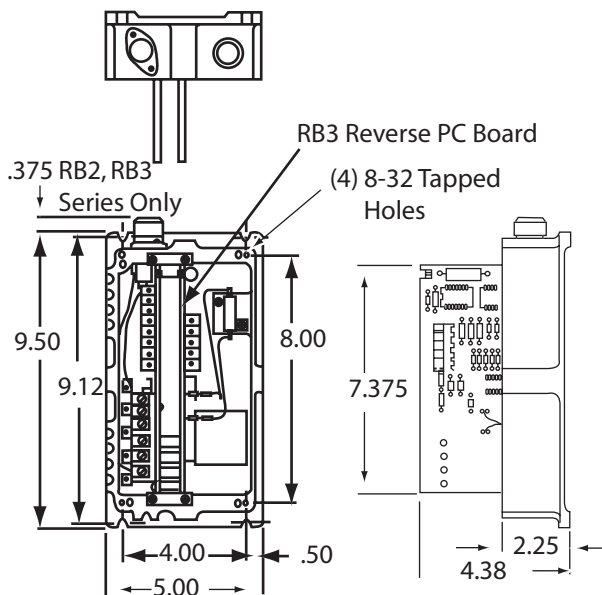


Figure 18. RB1, RB2 & RB3 Mounting Dimensions

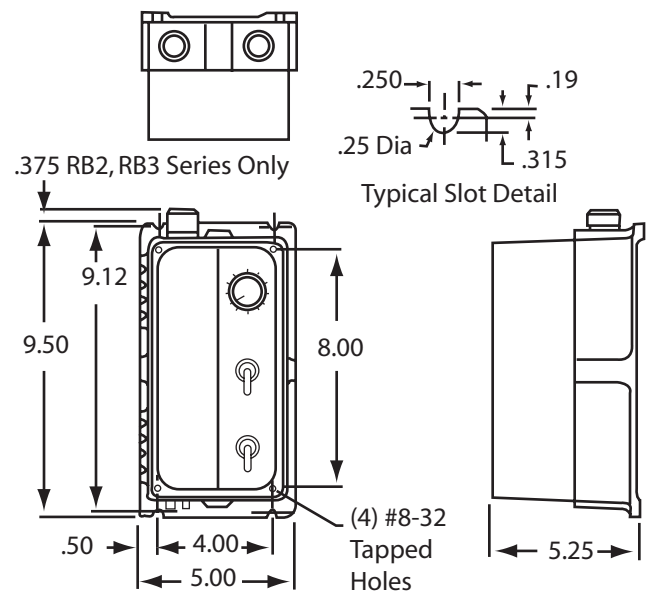


Figure 19. RB1, RB2, RB3 (Types B, S, R) Mounting Dimensions

Table 10. Troubleshooting

Indication	Possible Cause	Corrective Action
1. Controller fuse F1 blows when controller is turned on.	Wiring faulty, incorrect or grounded.	Check all external wiring terminating in the controller.
	Motor shunt field shorted or grounded.	Repair or replace motor.
	Controller shorted.	Repair or replace controller.
2. Controller fuse F1 blows when motor starts to turn.	Motor armature shorted or grounded	Repair or replace motor
	Shorted SCR, SCR1 or SCR2, or circuit board faulty.	Replace circuit board or shorted SCR.
3. Controller Fuse F1 blows while motor is running.	Loose or corroded connection, or wiring faulty, incorrect or grounded.	Check all terminal connections and wiring between the line, controller, and motor.
	Overload.	Check motor armature current. If current exceeds controller rating, check for a mechanical overload or faulty motor. Also check shunt field current. Low shunt field current causes excessive armature current.
	Circuit board faulty.	Replace circuit board.
4. Motor does not rotate.	Wiring faulty, incorrect or grounded.	Check all external wiring terminating in the controller.
	Fuse F1 blown.	Replace F1 with exact replacement.
	Motor Speed pot faulty.	Replace pot.
	Run/Stop or Forward/Stop/Reverse switch faulty.	Replace switch.
	Controller faulty.	Repair or replace controller.
5. Minimum speed excessive.	High line voltage.	Check for rated line voltage $\pm 10\%$.
	Shorted SCR, SCR1 or SCR2, or circuit board faulty.	Replace circuit board or shorted SCR.

Table 10. Troubleshooting (Con't)

Indication	Possible Cause	Corrective Action
6. Motor does not reach top speed.	Low line voltage.	Check for rated line voltage $\pm 10\%$.
	Overload.	See Indication 3.
	Circuit board faulty.	Replace circuit board.
7. Unstable speed, inadequate regulation, or low torque.	Wrong calibration wire (s) removed.	See Table 6 and Figure 3.
	Motor faulty.	Check motor commutator and brushes. Refer to motor manufacturer's instructions.
	Circuit Board Faulty.	Replace circuit board.

PARTS LIST

1.	Power Device Kit (SCR's and power diodes)	.67482
2.	Main Board	.67469
3.	Reverse Board, RB3 only	.67470
4.	NEMA Kit (NEMA 3, 3, 12, 13)	.67474
5.	Run-Stop Switch, RB1 and RB2	.67476
6.	Run-Stop Switch, RB3	.67477
7.	Reverse Switch, RB1 and RB2	.67478
8.	Reverse Switch, RB3	.67479
9.	Run Speed Potentiometer	.60246
10.	Fuse, ABC15, RB1	.67481
11.	Fuse, KTK20,, RB2 and RB3	.67480
12.	Run Speed Knob	.60245
13.	SCR's (two per unit)	.67492
14.	Power Diodes (three per unit)	.50395

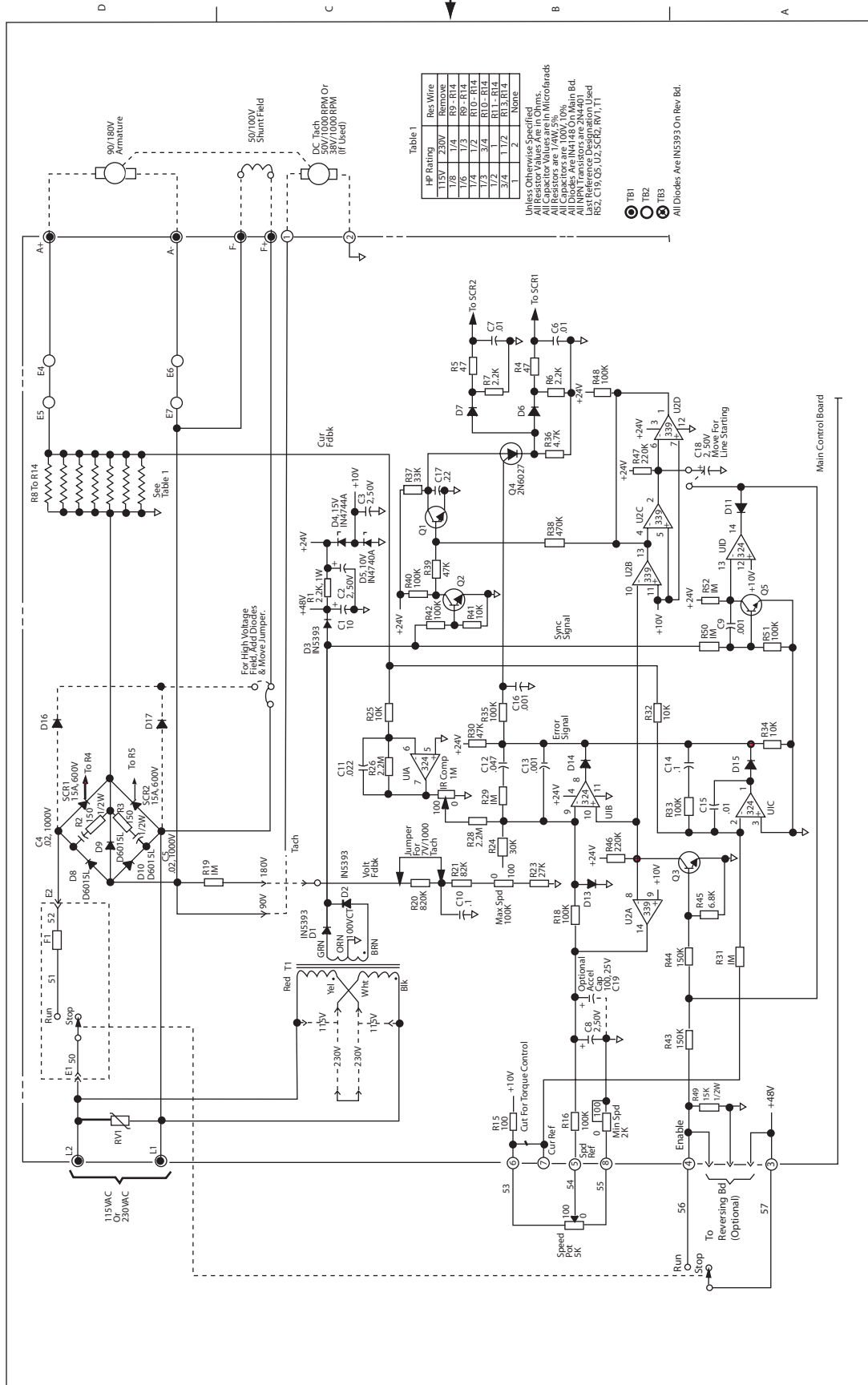


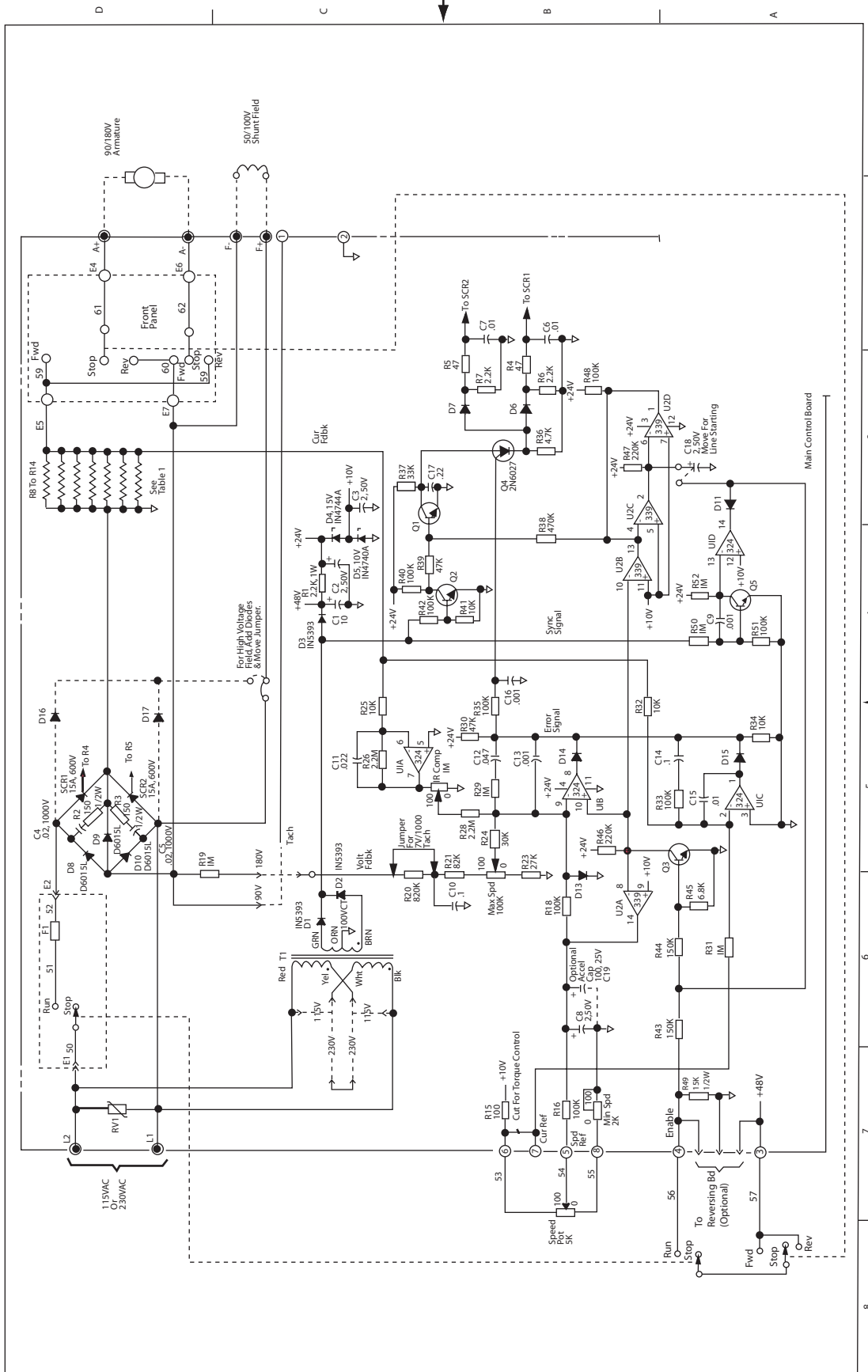
Table 1

HP Rating	Res Wire
1/8	Remove
1/4	RS - R1.4
3/4	RSF - R1.4
1	R10 - R1.4
1 1/2	R11 - R1.4
2	R12 - R1.4
3	R13 - R1.4
4	R14 - R1.4
5	None

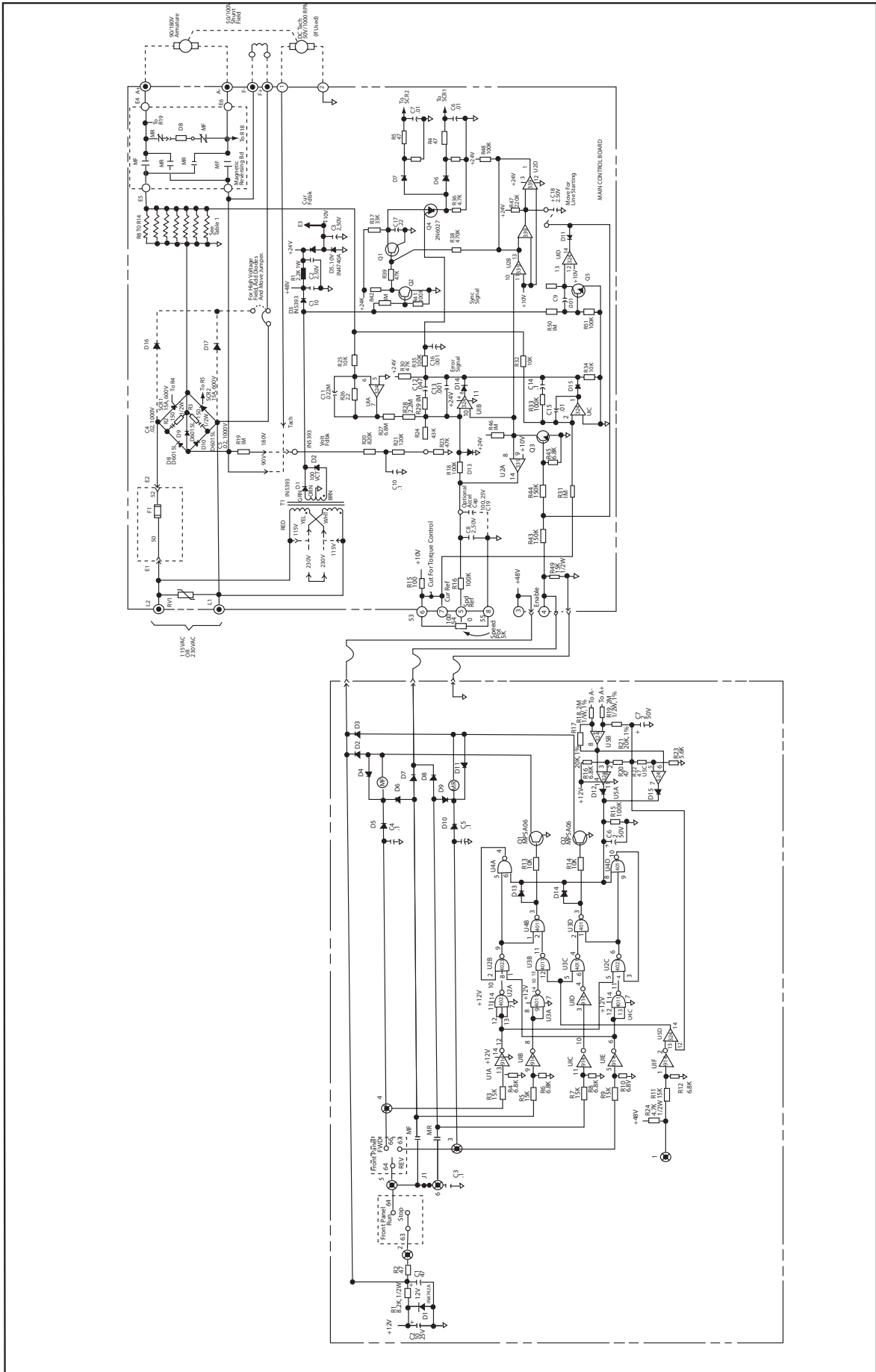
Unless Otherwise Specified
 All Resistors are 1/4W, 5%
 All Capacitors are in Microfarads
 All Diodes are 1N4148 On Main Bd.
 All NPN Transistors are 2N4401
 All PNP Transistors are 2N2907
 R52, C19, Q2, U2, SCR2, RV1, T1

- ⊙ T1
 - ⊙ T2
 - ⊙ T3
- All Diodes Are 1N5393 On Rev Bd.

Run/Stop



Switch Reverse



Switch Reverse

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