Boston Gear®

Ratiotrol®

DC Motor Speed Control

P-3026-BG

Installation and Operation

Doc. No. 60881

VEL Series 1/6 – 1 HP
VEH Series 1 – 3 HP
Table of Contents

General Information

Section I
General Information ........................................... 3
Introduction ................................................. 3
General Description ......................................... 3
Motors ........................................................... 3
Model Types .................................................... 3
Controller Identification .................................... 3
Ratings .......................................................... 4
Operation Conditions ........................................ 4
Performance Characteristics ............................... 4
Standard Features ............................................ 5
Adjustments .................................................... 5
Options .......................................................... 5

Section II
Installation ..................................................... 6
Mounting Instructions ........................................ 6
Wiring Instructions ............................................ 6
Initial Startup .................................................. 7

Section III
Operation ....................................................... 8
Power On/Off .................................................... 8
Run .............................................................. 8
Stop .............................................................. 8
Speed Control .................................................. 9
Reversing ......................................................... 9
Jogging .......................................................... 9
Inoperative Controller ...................................... 9

Section IV
Maintenance .................................................... 10
General ......................................................... 10
Adjustment Instructions .................................... 10
Troubleshooting .............................................. 12

Section V
Parts List ....................................................... 15

Section VI
Options ........................................................ 16

Section VII
Illustrations .................................................... 17

List of Illustrations
Figure No. 1 Enclosure Dimensions
VEL/H ............................................................. 17
Figure No.2 Enclosure Dimensions
VEH/H-MR ...................................................... 18
Figure No.3 Schematic
Run/Stop Logic ............................................... 19
Figure No.4 Schematic
DB, Reversing, Jog Options ............................... 20
Figure No.5 Internal View,
Controller ..................................................... 21

List of Tables
Table No. 1
Application Data ............................................... 4
Table No. 2
Speed Regulation Characteristics ........................ 5
Table No. 4
Dynamic Braking Characteristics ........................ 8
Table No. 5
Troubleshooting ............................................... 12
Table No. 6
Parts List, Controllers .................................... 15
Table No. 7
Option Combinations ....................................... 16
Introduction
This manual contains installation, operation, and maintenance instructions for the Boston Ratiotrol VEL and VEH Series single-phase Adjustable Speed Motor Controllers. A parts list and illustrations are also included.

General Description
Ratiotrol VEL/H Controllers are general purpose industrial units which statically rectify single-phase AC line power to regulated DC for adjustable speed armature control of DC motors.

Each controller is furnished in a rugged die cast aluminum alloy enclosure with a hinged, gasketed door. A draw latch tightly compresses the door gasket to exclude contaminants.

Motors
Motors may be shunt wound, stabilized shunt wound, or permanent magnet DC types. For maximum efficiency, the motor should be rated for operation from a NEMA Code K power source. See Table 1 for motor ratings.

Model Types
Controllers are available in eleven basic models:
1. VEL16 – VEL100:
   - 115VAC
     - VEL16 – 1/6 HP
     - VEL25 – 1/4 HP
     - VEL33 – 1/3 HP
     - VEL50 – 1/2 HP
     - VEL75 – 3/4 HP
     - VEL100 – 1 HP

2. VEH100 – VEH500:
   - 230VAC
     - VEH100 – 1 HP
     - VEH150 – 1-1/2 HP
     - VEH200 – 2 HP
     - VEH300 – 3 HP

Basic Units
Standard VEL and VEH Controllers are basic RUN/STOP units. Other functional features may be incorporated by adding standardized option kits, available from stock.

Local Control
Each controller contains an integral operator’s control panel mounted in the enclosure cover. This panel contains RUN and STOP pushbuttons and a MOTOR SPEED potentiometer. Three predrilled holes with removable inserts are provided for an optional JOG SPEED potentiometer, RUN/JOG toggle switch, FWD/REV toggle switch, and other optional operator controls.

Remote Control
The remote control station option consists of a die-cast enclosure with installed terminal board and blank cover. This allows the controller operator control panel to be interchanged with the blank cover for remote operation.

Controller Identification
Each controller contains a data label on the inside of the enclosure cover. This label identifies the controller, user connection terminals and maximum wire size, controller ratings, operation notes, and applicable options.
Section I

General Information

Ratings

1. Horsepower Range 1/6 – 3 HP
2. Power Source 1/6 – 1 HP, 115 VAC, 1-phase, 50 or 60 Hz.
   1 – 5 HP, 230VAC, 1-phase, 50 or 60 Hz.
3. 115VAC Unit Output Voltages
   Armature 0-90 VDC
   Field 50 VDC
4. 230VAC Unit Output Voltages
   Armature 0-180 VDC
   Field 100 VDC
5. Service Factor 1.0
6. Duty Continuous
7. Overload Capacity (armature circuit) 150% for 1 minute
   (Armature Circuit)

Note: Internal load monitor provides automatic shut-down if current exceeds 120% for 80 seconds continuously.

Table I Drive Data – Full Load

<table>
<thead>
<tr>
<th>Basic Model</th>
<th>AC Input - 1 Phase</th>
<th>DC Output</th>
<th>Motor - 1750 RPM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HP</td>
<td>Volts</td>
<td>Amps</td>
</tr>
<tr>
<td>VEL16</td>
<td>1/6</td>
<td>115</td>
<td>3.3</td>
</tr>
<tr>
<td>VEL25</td>
<td>1/4</td>
<td>115</td>
<td>5.0</td>
</tr>
<tr>
<td>VEL33</td>
<td>1/3</td>
<td>115</td>
<td>6.0</td>
</tr>
<tr>
<td>VEL50</td>
<td>1/2</td>
<td>115</td>
<td>9.0</td>
</tr>
<tr>
<td>VEL75</td>
<td>3/4</td>
<td>115</td>
<td>13.0</td>
</tr>
<tr>
<td>VEL100</td>
<td>1</td>
<td>115</td>
<td>15.0</td>
</tr>
<tr>
<td>VEH100</td>
<td>1</td>
<td>230</td>
<td>7.2</td>
</tr>
<tr>
<td>VEH150</td>
<td>1-1/2</td>
<td>230</td>
<td>10.0</td>
</tr>
<tr>
<td>VEH200</td>
<td>2</td>
<td>230</td>
<td>15.0</td>
</tr>
<tr>
<td>VEH300</td>
<td>3</td>
<td>230</td>
<td>16.0</td>
</tr>
</tbody>
</table>

Operating Conditions
1. Line Voltage Variation — ±10% of rated
2. Line Frequency Variation — ±2 Hertz of rated
3. Ambient Temperature* — 0 to 50 degrees C
   (32 to 104 degrees F)
4. Altitude (standard) — 1000 meters
   (3300 feet) maximum
   * Temperature inside enclosure in which control is mounted should not exceed 55 degrees C.

Performance Characteristics
1. Speed Range (controlled) – 0 to motor base speed
2. Speed Range At Rated Torque and Regulation – 30:1
3. Efficiency (maximum speed)
   a. Controller SCR regulator – 97%
   b. Complete drive (controller with motor, typical) – 80%
4. Displacement Power Factor (maximum speed) – 86%
5. Acceleration (standard) – By current limit
6. Speed Regulation (see Table 2) – Regulation percentages are of motor base speed under steady-state conditions.

Table 2 – Speed Regulation Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Regulation Method</th>
<th>Load Change</th>
<th>Line Voltage</th>
<th>Field Heating (1)</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard Voltage Feedback with IR</td>
<td>2-3%</td>
<td>2%</td>
<td>5-12%</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>Compensation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Optional Speed (tach) Feedback</td>
<td>0.5%</td>
<td>0.5%</td>
<td>0.5%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

(1) Does Not Apply to Permanent Magnet Motors.

Standard Features

1. Power Conversion — NEMA Code K semiconverter power bridge consisting of two SCR’s, two diodes and a freewheeling diode. Power bridge is an integrated, encapsulated component. (See Figure 5, page 21)

2. Reference Power Supply — +10 VDC regulated, with respect to common.

3. Feedback – CEMF voltage with adjustable IR compensation.

4. Control Transformer – 24 VAC secondary isolates all operator controls and magnetic control logic from the AC power source for operator protection. (See Transformer T1, Figure 5, page 21)

5. Motor Contactor – Provides positive disconnection of motor armature from the controller output, and undervoltage protection. A phase-off circuit ensures that the contactor does not make or break DC. (See Figure 5, page 21)

6. Motor Overload – Positive motor protection by an electronic nonadjustable current (load) monitor. This circuit shuts down the drive when the motor armature current exceeds 120% for 80 seconds. An optional current (load) monitor (Option Kit Cat. No. 60177) is available which provides an adjustable trip range and an adjustable time delay range. This option provides a relay with one set of Form C, 2 ampere (120 VAC – 28 UDC) contacts which can be used to signal audible or visual alarms, or auxiliary control devices, e.g., lubrication pumps, fans, valves.

7. AC Line Disconnect – Provided by a single-pole, magnetic-trip only circuit breaker with a 5000 ampere interruption capacity. (See Figure 5) An optional two-pole circuit breaker (Option 30, Kit Cat. No. 60169) is available which opens both lines of the input supply.

8. Line Transient Protection – Provided by a metal oxide varistor (MOV) suppressor across the AC input line. (See RV1 on Figure 5)

9. UL Listed – File E60208

Adjustments

The following adjustment potentiometers are located on the standard circuit boards in the controller. (See Figure 5)

1. Maximum Speed – 60 to 100% of motor base speed

2. Minimum Speed – 0 to 30% of motor base speed

3. IR (load) Compensation – 0 to 100% of rated load

4. Current Limit – 50 to 150% of full-load torque

Options

Standardized pre-engineered optional equipment can be supplied with Controllers at additional costs. See Section VI for option listing.
Mounting Instructions

See Figures 1 & 2, pages 17 & 18

1. The enclosure is designed for vertical surface mounting in a dry location. It should not be used where a water-tight or weatherproof enclosure is required.

   **CAUTION** Never mount the enclosure immediately beside or above heat-generating equipment, or directly below water and steam pipes.

Comply with the following mounting requirements:

   a. Mount the enclosure in a vertical position, allowing four (4) inches minimum clearance on all sides, for maximum cooling efficiency.

   b. Fasten the enclosure securely on a level surface with the mounting tabs provided. See Figure 1 for enclosure dimensions.

   c. Shock and excessive vibration are detrimental to controller performance and life. Vibration can cause general deterioration of connections, and component damage. Therefore, shock-mount the controller if it is subjected to external vibrations.

2. If the motor is to be foot mounted, bolt the motor to a firm, flat foundation. If the foundation is not flat, use shims to prevent strain when tightening the bolts. If the motor is to be connected directly to a machine, be sure of correct alignment. Pulleys and couplings must slip freely onto the motor shaft.

   **CAUTION** Never hammer the pulleys, couplings, or motor shaft, nor overtighten drive belts or timing chains. Bearing damage could result.

Wiring Instructions

Refer to the data label inside the enclosure cover and be sure the input voltage and frequency to the controller complies with its rating. A surge suppressor (varistor) protects the controller from normal line transients and surges. However, to prevent problems from high-energy transients and large surges, observe the following:

   1. Place the controller on a feeder line separate from that supplying large inductive loads.

   2. If the input power to the controller comes directly from a transformer, always switch power ON and OFF between the transformer secondary and the controller.

   **CAUTION** Never make or break power in the transformer primary. Transients could be generated which could damage the controller.

3. If the controller must be fed from an AC circuit which also supplies highly inductive loads, additional suppression may be required to limit transients or surges to 150% of peak line voltage.

   **CAUTION** Never use power factor correction capacitors on the input line to the controller. These capacitors can damage the solid-state components.

The wire size of the input power and motor wiring can be determined from Table 1 and the controller data label.

   **CAUTION** 1. Do not use wire larger than #12 AWG. Oversize or solid wire, as well as oversize screwdrivers for electrical connections, can break terminal board barriers.

   2. All wiring must comply with the national and local electrical codes.

Use the 3/4-14 NPT tapped conduit holes in the enclosure to facilitate wiring. All external wiring for low voltage signal sources, e.g., potentiometers, tachometer generators, transducers, should be run in separate conduit from all other wiring. Use twisted wire (5 to 6 twists per foot) or shielded cable. Maintain the separation of power and signal wiring within the enclosure.

   **CAUTION** Pickup from unwanted signals can cause erratic operation and/or controller damage.
AC Power Connections

Connect the AC input power wires to controller Terminals L1 and L2 on Terminal Board TB1. (See Figure 5)

If one of the power wires is a neutral wire (grounded potential), connect the hot wire (H) to Terminal L1 and the neutral wire (N) to Terminal L2. Connect the controller Ground Screw (GND) to an earth ground according to applicable electrical codes. Ground Screw (GND) is located near the bottom of the controller enclosure. (See Figure 5)

**WARNING** If the neutral wire (Terminal L2) is not grounded, the controller remains electrically "hot" when the AC power ON/OFF switch is turned off.

Motor Connections

Check the connection diagram supplied on or with the motor. If the motor has dual voltage shunt fields, connect the field terminal straps (or leads) for low field voltage.

Connect the motor field and armature terminals (or leads) to controller Terminals F+, F-, A+, and A-, respectively, on Terminal Board TB1.

**CAUTION** Do not ground the motor wiring. Grounded wiring can cause controller damage.

Connect the motor thermal guard, if applicable, to Terminals 2 and 3 on Terminal Board TB2. Be sure to remove the jumper wire from Terminals 2 and 3 if a thermal overload is used. (See Figure 5)

Initial Startup

Before energizing the controller for the first time, be familiar with any installed options. See the option selection table on the controller data label.

The controller has been factory tested and adjusted with a motor under simulated operating conditions. Therefore, startup adjustments should not be needed. However, the following startup procedure should be performed for proper operation, system compatibility, and safety.

1. Be sure all interconnection wiring is correct, and all wiring terminations are tightened securely. Wiring errors and accidental grounds can cause controller and/or motor damage.

2. For 50 Hertz operation, be sure the 60 Hz jumper wire is removed (cut out) from the control board. (See Figure 5)

3. Close and latch the enclosure cover.

4. Turn the MOTOR SPEED potentiometer fully counterclockwise to zero.

5. If so equipped, place the RUN/JOG switch in RUN position and the FWD/REV switch in FWD position.

6. Couple the motor to the machine (load).

7. Turn on the AC input power and the AC POWER ON/OFF switch.

8. Depress the RUN button, and slowly turn the MOTOR SPEED potentiometer clockwise until the motor rotates. If motor rotation is opposite to that desired, stop the motor with the STOP button, turn off the AC POWER ON/OFF switch and the AC input power, and interchange the motor armature leads.

**CAUTION** Never use line switching to start and stop the motor. Resulting transients may cause controller damage.

9. Turn the MOTOR SPEED potentiometer fully clockwise to 100 and observe motor rotation. The motor should run at its rated (base) speed.

10. Turn the MOTOR SPEED potentiometer fully counterclockwise to zero and depress the STOP button.
Section III

Operation

Power ON/OFF
To energize (turn on) the controller, place the AC POWER ON/OFF switch in ON position. Conversely, to de-energize (turn off) the controller, place the switch in OFF position. The AC POWER ON/OFF switch is a circuit breaker which not only connects and disconnects the AC input power, but also protects the controller and motor from electrical faults. If the circuit breaker trips, reset it by turning it OFF, then ON. If the circuit breaker retrips, an electrical fault is indicated which must be corrected. See the Troubleshooting Table in Section IV.

1. Continual resetting of the circuit breaker could damage the controller.
2. Never use the circuit breaker to start and stop the motor. Controller damage could result.

WARNING If line terminal L2 is not grounded, the controller remains electrically "hot" when the circuit breaker is turned off.

Run
To start the motor, depress the RUN button, and the motor will accelerate to the setting of the MOTOR SPEED potentiometer.

Stop
To stop the motor, depress the STOP button, and the motor will stop at a rate proportional to the motor load. If the controller contains dynamic braking (Option "D", Cat. No. 60159), the motor will dynamically brake to a rapid stop. Dynamic braking provides exponential rate braking of the motor armature, which occurs when the circuit opens between the controller and the motor armature, and a Resistor (DB) connects across the armature. This is accomplished by a contact, interlocked with the normal run contact.

When a Stop (dynamic braking) function is initiated, the motor functions as a DC generator and feeds its counter EMF through Resistor DB where it is dissipated as heat. This opposes motor rotation, thereby stopping the motor. Resistor DB is rated to provide initial braking torques as shown in Table 4.

Table 4 – Dynamic Braking Characteristics

<table>
<thead>
<tr>
<th>Component</th>
<th>Unit</th>
<th>1/6</th>
<th>1/4</th>
<th>1/3</th>
<th>1/2</th>
<th>3/4</th>
<th>1</th>
<th>1-1/2</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Braking Torque %</td>
<td>115V</td>
<td>300</td>
<td>215</td>
<td>170</td>
<td>100</td>
<td>75</td>
<td>60</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>230V</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>220</td>
<td>145</td>
<td>105</td>
<td>85</td>
</tr>
<tr>
<td>Stops Per Minute</td>
<td>115V</td>
<td>9</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>230V</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
High inertia loads may extend braking time beyond the wattage rating of the resistor.

Option "D", Cat. No. 60159 also provides an Antiplug Relay (APR) which picks up immediately after the motor starts and drops out immediately before the motor stops. An APR contact, connected in the run/stop logic, prevents restarting the motor until the braking cycle is complete.

Speed Control
Motor speed is directly proportional to the setting of the MOTOR SPEED potentiometer. This potentiometer may be adjusted while the motor runs or may be preset at any position before the motor is started. The speed range of the controller is limited only by the limitations of the motor.

Reversing
To reverse motor rotation on reversing controllers (Option "R", Kit No. 60160), depress the STOP button, place the FWD/REV switch in the opposite position, and depress the RUN button. The motor will accelerate to the setting of the MOTOR SPEED potentiometer. Forward and reverse speeds are identical.

NOTE:
The FWD/REV switch contains a center position interlock, which requires a momentary relaxation of pressure before the reverse position can be engaged. This center position causes a Stop function, and an antiplug circuit prevents the motor from being restarted while the motor is braking until a safe speed for reversing is attained.

Jogging
To jog the motor on controllers with jog capabilities (Option 9, Kit No. 60166), place the RUN/JOG switch in JOG position and jog the motor with the RUN button. Jog is momentary, causing motor rotation only while the RUN button is held depressed. Release the RUN button to stop the motor.

Inoperative Controller
If the motor stops and/or won’t start, check for a tripped AC POWER ON/OFF switch. If tripped, reset the switch. If the switch retrips, see the Troubleshooting Table in Section IV.

If the switch is not tripped, the internal current monitor may have shutdown the drive. The standard current monitor will shutdown the controller and motor if the motor armature current exceeds 120% of rated for 80 seconds of continuous operation. To reset the controller, depress the STOP button, remove the overload, and depress the RUN button to restart. Repeated shutdown indicates a continual overload (mechanical or electrical) which must be removed. See the Troubleshooting Table in Section IV.
Section IV

Maintenance

WARNING
1. Controllers contain high voltage which can cause electric shock resulting in personal injury or loss of life.
2. Never clean or repair the controller or motor with the AC input power on.
3. When the circuit breaker is turned-off, components within the controller remain at line potential until the AC input power is turned off.

General
VEL/H Controllers require very little maintenance, other than an occasional visual inspection and, if necessary, external cleaning. They must be kept dry and reasonably free from dust, dirt, and debris. No parts require periodic replacement. Maintain the motor according to maintenance instructions supplied by the motor manufacturer.

Visual Inspections
1. Be sure all wires are fastened securely.
2. Check components for damage due to overheating or breakage. All damaged and/or faulty components must be replaced for satisfactory operation.

Adjustment Instructions
All Controllers have been factory tested and adjusted under load. No adjustments should be required for normal operation. However, if circuit boards are replaced, or if factory adjustments are changed, the following adjustments can be made. All adjustments must be made in strict conformance to the instructions given herein. If, during any step of the adjustment procedure, it is not possible to attain the stated result, stop the motor, turn off the AC input power and refer to the Troubleshooting Table (Table 5). Refer to Figure 4 for the location of the internal adjustment potentiometers.

Preliminary
1. Be sure the controller and motor are at operating temperature, usually achieved within 30 minutes from a cold start.
2. Check the motor shunt field voltage on TB1 Terminals F+ and F-. If rated line voltage is 115 VAC, the shunt field voltage should be 50 VDC, ±5 VDC. If rated line voltage is 230 VAC, the shunt field voltage should be 100 VDC, ±10 VDC.

Minimum Speed
1. Turn the MOTOR SPEED potentiometer fully counterclockwise.
2. Depress the RUN button, and slowly turn the MIN SPEED potentiometer (R1) clockwise until the motor starts to turn.
3. Turn MIN SPEED potentiometer (R1) counterclockwise until the motor stops.
4. If desired, minimum speed can be increased to 30% of motor base speed.

Maximum Speed
1. Depress the RUN button, and turn the MOTOR SPEED potentiometer fully clockwise.
2. Turn the MAX SPEED potentiometer (R59) until the motor runs at rated (base) speed. If a tachometer is unavailable, connect a DC voltmeter across the motor armature, and adjust MAX SPEED potentiometer (R59) until the voltmeter records rated armature voltage.
3. If desired, maximum speed can be decreased to 60% of motor base speed.

CAUTION
Do not exceed rated armature voltage or base speed. Overvoltage and resulting overspeed can damage the motor.
**IR Compensation**

IR compensation is factory adjusted and sealed for 3% maximum speed change with a 95% load change throughout the motor speed range. Therefore, readjustment should not normally be necessary. However, if the following facilities are available, readjustment can be performed.

To adequately adjust IR compensation, an adjustable load is required that can be applied and removed while the motor is running. In addition, a close reading tachometer is needed to record speed changes. If these facilities are unavailable, do not readjust IR compensation.

If, during this adjustment procedure, motor speed becomes unstable or oscillates (hunts), slowly turn IR COMP potentiometer (R9) counterclockwise until the hunting stops.

1. Turn IR COMP potentiometer (R9) fully counterclockwise.
2. Remove the load from the motor and depress the RUN button.
3. Turn the MOTOR SPEED potentiometer until the motor runs at the maximum speed of the desired speed range, normally rated motor base speed. Record motor speed.
4. Apply load to the motor until it draws rated armature current. (See Table 1 for motor current ratings.) Note the speed change.
5. Turn IR COMP potentiometer (R9) until the motor returns to the speed recorded in Step 3.
6. Remove the load and repeat Step 3.
7. Repeat Steps 4, 5 and 6 until desired speed regulation is attained.

**Current Limit**

The current limit prevents excessive armature current and resulting excessive line current by limiting armature current at 150% of rated. Since the current limit is factory adjusted and sealed, readjustment should not be performed unless an application requires a lower limit of armature current, e.g., limiting torque or accelerating high inertia loads.

1. Turn off the AC input power and connect a DC ammeter, with a rating of at least twice rated armature current, in series with the armature. Observe correct polarity when connecting the ammeter. (See Table 1 for motor current ratings.)
2. Turn the CURRENT LIMIT potentiometer (R12) fully counterclockwise.
3. Connect maximum load to the motor.
4. Turn on the AC input power and the AC POWER ON/OFF switch.
5. Turn the MOTOR SPEED potentiometer fully clockwise.
6. Depress the RUN button, and slowly turn CURRENT LIMIT potentiometer clockwise (R12) while the motor is accelerating until the ammeter records the desired armature current.

Do not turn potentiometer (R12) past the factory setting in the increase direction. Resulting excessive current could damage the controller and motor.

To obtain a particular percentage of rated output torque, set the armature current at a percentage of rated armature current; e.g., 50% torque is obtained with 50% rated armature current.
**Troubleshooting**

Most electrical failures are caused by incorrect connections, overload, or the accumulation of dirt, dust, or moisture. Dirt and dust deposits limit the transfer of heat from the solid-state components. Moisture, usually caused by either "wash-down" or condensation, can cause insulation failures and short circuits. Be sure the controller is clean and dry before doing troubleshooting.

**WARNING**

Be sure the AC input power is turned-off before working in the controller.

If repeated circuit breaker tripping and/or power bridge failures occur, check the AC input power for transients (high level spikes) or rapid power fluctuations.

If a circuit board fails, check all inputs to the board for proper values before replacing the board.

Use standard troubleshooting procedures, e.g., continuity checks, to detect faults in relay and switching logic and operator controls.

---

**Table 5 – Troubleshooting**

<table>
<thead>
<tr>
<th>Indication</th>
<th>Possible Cause</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. AC POWER ON/OFF switch trips immediately when turned-on</td>
<td>Wiring faulty or incorrect</td>
<td>Check all external wiring terminating in the controller. Correct accordingly.</td>
</tr>
<tr>
<td></td>
<td>Circuit, component, or wiring grounded</td>
<td>Remove unwanted ground.</td>
</tr>
<tr>
<td></td>
<td>Power Bridge BR1 shorted</td>
<td>Replace BR1</td>
</tr>
<tr>
<td></td>
<td>Power board failure</td>
<td>Replace power board.</td>
</tr>
<tr>
<td></td>
<td>Control board failure</td>
<td>Replace control board.</td>
</tr>
<tr>
<td></td>
<td>Shunt field shorted or grounded</td>
<td>Repair or replace motor.</td>
</tr>
<tr>
<td>2. AC POWER ON/OFF switch trips when motor starts to turn</td>
<td>Power Bridge BR1 shorted</td>
<td>Replace BR1.</td>
</tr>
<tr>
<td></td>
<td>Motor shorted or grounded</td>
<td>Repair or replace motor.</td>
</tr>
<tr>
<td></td>
<td>Control board failure causing SCR’s to turn-on fully</td>
<td>Replace control board.</td>
</tr>
<tr>
<td>3. AC POWER ON/OFF trips while motor is running</td>
<td>Overload</td>
<td>Check shunt field current. Insufficient shunt field current causes excessive armature current. If field current is OK, check for mechanical overload. If the unloaded motor shaft does not rotate freely, replace motor bearings. Also check for shorted armature. Correct accordingly.</td>
</tr>
<tr>
<td></td>
<td>Loose or corroded connection.</td>
<td>Check AC POWER ON/OFF switch terminals and all terminals, connections, and wiring between the line, controller and motor.</td>
</tr>
<tr>
<td></td>
<td>Wiring faulty, incorrect or grounded</td>
<td>Repair or replace motor.</td>
</tr>
<tr>
<td></td>
<td>Motor shorted or grounded</td>
<td>Replace BR1.</td>
</tr>
<tr>
<td></td>
<td>SCR and/or diode breaking down (intermittently shorting) in Power Bridge BR1</td>
<td>Replace control board.</td>
</tr>
<tr>
<td></td>
<td>Control board failure causing SCR false firing or misfiring</td>
<td>Replace control board.</td>
</tr>
</tbody>
</table>
## Table 5 – Troubleshooting (con’t)

<table>
<thead>
<tr>
<th>Indication</th>
<th>Possible Cause</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4. AC POWER ON/OFF switch</strong> Tripped, but motor won’t run</td>
<td>AC line open</td>
<td>Be sure external disconnect switch or circuit breaker is turned-on and rated AC power is applied to controller.</td>
</tr>
<tr>
<td></td>
<td>Operator controls or relay logic inoperative</td>
<td>Repair accordingly.</td>
</tr>
<tr>
<td></td>
<td>MOTOR SPEED potentiometer failure</td>
<td>Replace potentiometer.</td>
</tr>
<tr>
<td></td>
<td>Motor failure</td>
<td>Repair or replace motor.</td>
</tr>
<tr>
<td></td>
<td>Control, input or power board failure</td>
<td>Replace faulty board.</td>
</tr>
</tbody>
</table>

**5. Minimum speed excessive**

- High line voltage
  - MIN SPEED potentiometer (R1) misadjusted
  - Power Bridge BR1 shorted
  - Control or input board failure
  - **MAX SPEED potentiometer failure** (R59) misadjusted
  - **CURRENT LIMIT potentiometer** (R12) misadjusted
  - Control or input board failure
  - Power Bridge BR1 failure

- **Check for rated line voltage, ±10%**, on controller AC line terminals.
- See "Adjustment Instructions".
- Replace BR1.
- Replace faulty board.

**6. Motor does not attain top speed**

- Low line voltage
  - Overload
    - Motor failure
      - Check motor brushes, replace if needed. Repair or replace motor.
    - **MOTOR SPEED potentiometer failure**
      - **MAX SPEED potentiometer failure**
        - (R59) misadjusted
        - **CURRENT LIMIT potentiometer**
          - (R12) misadjusted
          - Control or input board failure
          - Power Bridge BR1 failure

**7. Motor runs at fast speed only**

- Power Bridge BR1 failure
  - Control board failure
  - Feedback circuit open
  - **Replace BR1.**
  - **Replace faulty board.**
  - **Check for open Resistance Wire (R1-R9) and feedback board.** Repair accordingly.

**8. Unstable speed**

- AC line voltage oscillating
  - Oscillating load connected to the motor
    - Correct condition accordingly.
      - Turning IR COMP potentiometer (R9) counterclockwise may minimize condition.
  - Motor failure
    - Check motor brushes, replace if needed. Repair or replace motor.
## Table 5 – Troubleshooting (con’t)

<table>
<thead>
<tr>
<th>Indication</th>
<th>Possible Cause</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Unstable Speed (Con’t)</td>
<td>IR compensator misadjusted SCR(s) misfiring or false firing</td>
<td>See &quot;Adjustment Instructions&quot;. Replace Power Bridge BR1 and/or control board.</td>
</tr>
<tr>
<td>10. Top speed only 1/2 (approximately) of motor base speed and motor noisy (possible half-waving)</td>
<td>Power Bridge BR1 failure Faulty control board</td>
<td>Replace BR1. Replace control board.</td>
</tr>
<tr>
<td>11. Motor surges when starting</td>
<td>Open or faulty K1 Relay contact Power Bridge BR1 breaking down (shorting intermittently) Faulty control board</td>
<td>Replace Relay K1 or the power board. Contact must close between starts. Replace BR1. Replace control board.</td>
</tr>
<tr>
<td>12. Line and armature current excessive</td>
<td>Overload</td>
<td>Check shunt field current. Insufficient shunt field current causes excessive armature current. If field current is OK, check for mechanical overload. If unloaded motor shaft does not rotate freely, replace motor bearings. Also check for shorted armature. Correct accordingly.</td>
</tr>
<tr>
<td>13. Shunt field current insufficient</td>
<td>Open shunt field winding or wiring to the shunt field Power Bridge BR1 failure</td>
<td>Check motor shunt field and associated circuitry for loose connection or broken wire. Repair accordingly. Replace BR1.</td>
</tr>
<tr>
<td>14. Shunt field current excessive</td>
<td>Power Bridge BR1 failure Shunt field windings shorted</td>
<td>Replace BR1. Check shunt field current and/or measure shunt field resistance and compare with motor data plate. Repair or replace motor.</td>
</tr>
<tr>
<td>15. Motor thermal switch open (if used)</td>
<td>Ventilation insufficient Motor armature drawing excessive current Motor overheating from friction Shorted motor windings or faulty bearings</td>
<td>Free the motor intake and exhaust screens from dirt, dust and debris. Check shunt field current. Insufficient shunt field current causes excessive armature current. If field current is OK, check for a mechanical overload. Correct accordingly. Motor fields should be connected for low voltage. Check for misalignment. Realign motor. Repair motor.</td>
</tr>
</tbody>
</table>
# Parts List

## VEL-VEH RATIOTROL

### Table 6

<table>
<thead>
<tr>
<th>Dwg Desig</th>
<th>Description</th>
<th>Boston Part No.</th>
<th>Used In</th>
<th>Qty</th>
<th>Typical Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Manufacturer</strong></td>
</tr>
<tr>
<td>CB1</td>
<td>Circuit Breaker</td>
<td>60237</td>
<td>All</td>
<td>1</td>
<td>Airpax</td>
</tr>
<tr>
<td>----</td>
<td>Control Board</td>
<td>60208</td>
<td>All</td>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td>----</td>
<td>Power Board - 115V</td>
<td>60209</td>
<td>VEL16-100</td>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td>----</td>
<td>Power Board - 230V</td>
<td>60210</td>
<td>VEH100-300</td>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td>----</td>
<td>Input Board</td>
<td>60211</td>
<td>All</td>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td>----</td>
<td>Feedback Board</td>
<td>60212</td>
<td>All</td>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td>BR1</td>
<td>Power Bridge - 115V</td>
<td>60229</td>
<td>VEL 16-100</td>
<td>1</td>
<td>Int'1. Rect.</td>
</tr>
<tr>
<td>BR1</td>
<td>Power Bridge - 230V</td>
<td>60228</td>
<td>VEH100-300</td>
<td>1</td>
<td>Int'1. Rect.</td>
</tr>
<tr>
<td>----</td>
<td>Operator's Panel, Complete</td>
<td>60158</td>
<td>All</td>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Pushbutton only, green</td>
<td>60244</td>
<td>All</td>
<td>1</td>
<td>Alco</td>
</tr>
<tr>
<td></td>
<td>Pushbutton only, red</td>
<td>60243</td>
<td>All</td>
<td>1</td>
<td>Alco</td>
</tr>
<tr>
<td></td>
<td>Pushbutton contact block</td>
<td>60242</td>
<td>All</td>
<td>2</td>
<td>Alco</td>
</tr>
<tr>
<td></td>
<td>Pot, Motor Speed</td>
<td>60246</td>
<td>All</td>
<td>1</td>
<td>Allen Bradley</td>
</tr>
<tr>
<td></td>
<td>Pot, Jog Speed</td>
<td>60246</td>
<td>Jog Option No. 9</td>
<td>1</td>
<td>Allen Bradley</td>
</tr>
<tr>
<td></td>
<td>Knob, Pot</td>
<td>60245</td>
<td>All</td>
<td>1</td>
<td>Rogan</td>
</tr>
<tr>
<td>T1</td>
<td>Transformer</td>
<td>60259</td>
<td>All</td>
<td>1</td>
<td>Inelco</td>
</tr>
<tr>
<td>APR</td>
<td>Relay, Anti-Plug</td>
<td>60263</td>
<td>Jog &amp; Reverse Options</td>
<td>1</td>
<td>P &amp; B</td>
</tr>
<tr>
<td>K1</td>
<td>Relay</td>
<td>60262</td>
<td>All</td>
<td>1</td>
<td>P &amp; B</td>
</tr>
<tr>
<td>MF</td>
<td>Contactor, Run or Fwd</td>
<td>60261</td>
<td>All</td>
<td>1</td>
<td>P &amp; B</td>
</tr>
<tr>
<td>D1-D9</td>
<td>Diode</td>
<td>63717</td>
<td>Power Boards</td>
<td>9</td>
<td>Jedeck</td>
</tr>
<tr>
<td>RV1</td>
<td>MOV Suppressor - 115V</td>
<td>60877</td>
<td>60209 Power Board</td>
<td>1</td>
<td>G.E.</td>
</tr>
<tr>
<td>RV1</td>
<td>MOV Suppressor - 230V</td>
<td>60878</td>
<td>60210 Power Board</td>
<td>1</td>
<td>G.E.</td>
</tr>
<tr>
<td>C1</td>
<td>Capacitor</td>
<td>60274</td>
<td>Power Boards</td>
<td>1</td>
<td>Sprague</td>
</tr>
<tr>
<td>C2, C3</td>
<td>Capacitor</td>
<td>60275</td>
<td>Power Boards</td>
<td>2</td>
<td>Sprague</td>
</tr>
<tr>
<td>DB</td>
<td>Resistor, DB 15 ohm 50W</td>
<td>60265</td>
<td>DB Option “D”</td>
<td>1</td>
<td>Dale</td>
</tr>
<tr>
<td>----</td>
<td>Switch, Fwd/Rev</td>
<td>60266</td>
<td>Sel. Switch Rev. Option “R”</td>
<td>1</td>
<td>Cutler-Hammer</td>
</tr>
<tr>
<td>----</td>
<td>Switch, Jog/Run</td>
<td>60268</td>
<td>Jog Option No. 9</td>
<td>1</td>
<td>Alco</td>
</tr>
<tr>
<td>----</td>
<td>Latch</td>
<td>63817</td>
<td>All</td>
<td>1</td>
<td>Simmons</td>
</tr>
<tr>
<td>----</td>
<td>Pipe Plug, Conduit</td>
<td>63818</td>
<td>All</td>
<td>3</td>
<td>----</td>
</tr>
</tbody>
</table>

Note: Substitution of parts will void UL listing.
### Table 7 – Options

Any single controller can have one option from each option group A, B, C and D and any or all of the group E options, except Option No. 36, centerwind torque control, which utilizes both input and feedback circuitry and thus cannot be used with any input options (Group B). All options are available factory installed or as kits for field installation.

<table>
<thead>
<tr>
<th>Option Group</th>
<th>Option No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A – Switching Options</td>
<td>&quot;D&quot;</td>
<td>Dynamic Braking</td>
</tr>
<tr>
<td></td>
<td>&quot;R&quot;</td>
<td>Reversing, Selector Switch*</td>
</tr>
<tr>
<td></td>
<td>MR</td>
<td>Reversing, Auto. magnetic**</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Jog, Selector Switch</td>
</tr>
<tr>
<td>B – Input Options</td>
<td>14</td>
<td>Master Override Board</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>Adj. Linear Accel/Decel</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>Tach. Follower</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>Ext. MA Signal – Isolated</td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>Speed Pot Isolation</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>Follower, Master Isol. Ref.</td>
</tr>
<tr>
<td>C – Feedback Options</td>
<td>18</td>
<td>Torque-Taper</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>Tach. Feedback</td>
</tr>
<tr>
<td></td>
<td>36</td>
<td>Centerwind Torque Control</td>
</tr>
<tr>
<td>D – Miscellaneous</td>
<td>31</td>
<td>Load Monitor</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>Full Wave Field Supply</td>
</tr>
<tr>
<td>E – “Operator’s Options</td>
<td>6</td>
<td>Remote Operator’s Station</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>10-Turn Speed Pot</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>NEMA 3, 4, 12, &amp; 13 Kit</td>
</tr>
</tbody>
</table>

* Includes Option D, Dyn. Braking
** Includes Option D and Option 9, Jog
Ratiotrol D.C. Systems
Figure 1
VEL/VEH Series
1/6-3 Horsepower Dimensions

Max. Control Proj. .65 1.35
Circuit Breaker
Operator Panel
Mounting Slot Width .25
Conduit Entrance 3/4-14 N.P.T. (4) Places

10.55
6.30
9.06
.25
16.81
8.59
12.00
9.34
1.33
1.75
6.00
1.20
.25

Ratiotrol D.C. Systems
Figure 2
VEL/VEH Series
Auto. Magnetic Reversing Models
1/6-3 Horsepower Dimensions

Conduit Entrance
3/4-14 N.P.T.
(6) Places

(8) Mounting Slots
.25 Wide

Approximate Weights
VEL Controls 30 Pounds
VEH Controls 32 Pounds

Figure 2
Ratiotrol D.C. Systems

Figure 3
VEL/VEH Series

Notes:
1. Motor Start Pot Wires Must Be
2. Conductor 16 AWG, Stranded Wire
3. Conductor 22/24 AWG, Stranded Wire
4. Conductor 22/24 AWG, Solid Wire
5. Conductor 14/16 AWG, Solid Wire
6. Conductor 14/16 AWG, Stranded Wire

All Resistors 
1/8 W 10%
All Transistors NPN, PNP, NPN
All Capacitors 100V 10%
All Capacitors 100V 10%
All Capacitors 100V 10%
All Resistors in Ohms

Figure 3
Section VII
Illustrations

Ratiotrol D.C. Systems

Figure 4
Boston Gear warrants that products manufactured or sold by it shall be free from defects in material and workmanship. Any products which shall within two (2) years of delivery, be proved to the Company's satisfaction to have been defective at the time of delivery in these respects will be replaced or repaired by the Company at its option. Freight is the responsibility of the customer. The Company's liability under this limited warranty is limited to such replacement or repair and it shall not be held liable in any form of action for direct or consequential damages to property or person. The foregoing limited warranty is expressly made in lieu of all other warranties whatsoever, express, implied and statutory and including without limitation the implied warranties of merchantability and fitness.

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