# SERIES 2400/2450 MK II SINGLE-PHASE ADJUSTABLE-SPEED DC MOTOR CONTROLLERS

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# GENERAL INFORMATION

## INTRODUCTION

This manual contains installation, operation, and maintenance instructions for Fincor Series 2400/2450 MKII Single-Phase Adjustable-Speed DC Motor Controllers. A parts list and illustrations are also included.

## GENERAL DESCRIPTION

Fincor Series 2400/2450 MKII Controllers are general purpose units which statically rectify single-phase AC line power to regulated DC for adjustable speed armature control of DC motors.

Series 2400/2450 MKII Controllers comply with applicable standards established by the National Electrical Code and NEMA for industrial motor and control equipment. Each controller is Underwriters Laboratories Listed. Series 2450 MKII Controllers are CSA approved, while 2400 MKII Controllers require Option 1116 for CSA approval.

## 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 3 for motor ratings.

## MODEL TYPES

### Series 2400 MKII

Series 2400 MKII Controllers are cataloged in three functional groups comprising twelve basic model types, as shown in Table 1.

1. **Basic Units** - The 2401 and 2402 Controllers are basic units from which all other models are formed by the addition of standardized component assemblies.

2. **Local Control Models** - Local control models have an integral operator control panel, mounted in the enclosure cover. This panel has RUN and STOP pushbuttons and a MOTOR SPEED potentiometer. Reversing models also have a FWD/REV toggle switch. Three predrilled holes with removable inserts are provided for an optional JOG SPEED potentiometer, RUN/JOG toggle switch, and other optional operator controls.

3. **Remote Control Models** - Remote control models have a blank cover, which replaces the operator control panel on local control models. The operator control panel is then either mounted in a control station or flush-mounted within a user's operator control station. Table 2 lists the standard Fincor remote control stations.

### Series 2450 MKII

Series 2450 MKII Controllers are basic unenclosed, chassis-mount controllers. The controllers are a complete, self-contained, functional package which include power conversion and regulator electronics, AC line and DC loop overload protection and a motor contactor.

Series 2450 MKII Controllers are cataloged in three functional groups comprising nine basic model types, as shown in Table 1.

Models 2451, 2452, and 2453 are basic controllers from which the other models are derived. The letter A suffix indicates the addition of dynamic braking; letter B indicates reversing capabilities.

Series 2450 MKII Controllers require operator controls which may be user supplied or Fincor supplied. Table 2 lists Fincor companion remote operator control stations for use with Series 2450 MKII Controllers.

**TABLE 1. SERIES 2400/2450 MKII MODEL MATRIX**

| MODEL | FUNCTION | | | OPERATOR CONTROLS | |
|---|---|---|---|---|---|
| | Run-Stop | Run-Stop (DB) | Run-Stop (DB)–Fwd-Rev | Local | Remote |
| 2401, 2402 | X | | | X | |
| 2401A, 2402A, 2451, 2452, 2453 | X | | | | X |
| 2401B, 2402B | | X | | X | |
| 2401C, 2402C, 2451A, 2452A, 2453A | | X | | | X |
| 2401D, 2402D | | | X | X | |
| 2401E, 2402E 2451B, 2452B, 2453B | | | X | | X |
| 2401, 2451 | 1/6-1 HP, 115V Single-Phase, 50 or 60 Hz | | | | |
| 2402, 2452 | 1/2-3 HP, 230V Single-Phase, 50 or 60 Hz | | | | |
| 2453 | 5 HP, 230V Single-Phase, 50 or 60 Hz | | | | |

## OPERATOR CONTROLS

Table 2 lists the standard operator control stations for use with the Series 2400/2450 MKII Controllers. All remote control stations are NEMA Type 1 TENV with industrial rated components.

**TABLE 2. REMOTE CONTROL STATIONS**

| MODEL NO. | USE WITH CONTROLLER MODELS | CONTROL ELEMENTS | | |
|---|---|---|---|---|
| | | Push-buttons | Toggle Switch | Potentiometer |
| SCS161 | 2401A, 2402A, 2401C, 2402C, 2451, 2452, 2453, 2451A, 2452A, 2453A | Run, Stop | — | Motor Speed |
| SCS162 | 2401E, 2402E, 2451B, 2452B, 2453B | Run, Stop | Fwd-Rev | Motor Speed |
| SCS163 | 2401A, 2402A, 2401C, 2402C, 2451, 2452, 2453, 2451A, 2452A, 2453A | Run, Stop | Run-Jog | Motor Speed Jog Speed |
| SCS164 | 2401E, 2402E, 2451B, 2452B, 2453B | Run, Stop | Run-Jog Fwd-Rev | Motor Speed Jog Speed |
| 104200001 | 2401, 2402, 2401B, 2402B, 2401D, 2402D | Operator station housing with blank cover for converting local control models to remote control. | | |

## CONTROLLER IDENTIFICATION

Each controller has a data label which identifies the controller, maximum wire size, controller ratings, operation notes, and applicable options.

## RATINGS

1. **Horsepower Range** ..... 1/6-5 HP
2. **Power Source**
   a. 1/6-1 HP ..... 115 VAC, 1-phase, 50 or 60 Hertz
   b. 1/2-5 HP ..... 230 VAC, 1-phase, 50 or 60 Hertz
3. **115V Unit Output Voltage** (1/6-1 HP)
   a. Armature ..... 0-90 VDC
   b. Field ..... 50 VDC
4. **230V Unit Output Voltage** (1/2-5 HP)
   a. Armature ..... 0-180 VDC
   b. Field ..... 100 VDC
5. **Service Factor** ..... 1.0
6. **Duty** ..... Continuous
7. **Overload Capacity** ..... 150% for 1 minute (armature circuit)
8. **Circuit Breaker Interrupting Capacity** ..... 5000 amperes
9. **Reference Power Supply** ..... +10 VDC
10. **Motor Speed Potentiometer** ..... 5K, ½ W

TABLE 3. TYPICAL APPLICATION DATA

| COMPONENT | | | RATINGS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RATED HORSEPOWER (HP) | | | 1/6 | 1/4 | 1/3 | 1/2 | 3/4 | 1 | 1-1/2 | 2 | 3 | 5 |
| RATED KILOWATTS (kW) | | | 0.124 | 0.187 | 0.249 | 0.373 | 0.560 | 0.746 | 1.120 | 1.492 | 2.238 | 3.730 |
| 1-PHASE AC INPUT (FULL-LOAD) | Line Amps | 115V Unit | 3.3 | 5.0 | 6.0 | 9.0 | 13.0 | 14.5 | — | — | — | — |
| | | 230V Unit | — | — | — | 4.5 | 6.5 | 7.2 | 10.0 | 15.0 | 22.0 | 38.0 |
| | KVA | | .38 | .58 | .68 | 1.04 | 1.50 | 1.70 | 2.30 | 3.45 | 5.06 | 8.74 |
| DC OUTPUT (FULL-LOAD) | Motor Armature Amps | 90V | 2.0 | 2.8 | 3.5 | 5.4 | 8.1 | 10.5 | — | — | — | — |
| | | 180V | — | — | — | 2.7 | 4.0 | 5.5 | 8.2 | 11.6 | 14.4 | 25.0 |
| | Motor[1] Field Amps | 50V | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | — | — | — | — |
| | | 100V | — | — | — | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| FULL-LOAD TORQUE (lb-ft) with 1750 RPM Base Speed Motors | | | 0.5 | 0.75 | 1.0 | 1.5 | 2.2 | 3.0 | 4.5 | 6.0 | 9.0 | 15.0 |
| MINIMUM TRANSFORMER KVA FOR VOLTAGE MATCHING OR ISOLATION | | | 0.5 | 0.75 | 0.75 | 1.0 | 1.5 | 2.0 | 3.0 | 5.0 | 7.5 | 15.0 |
| CONTROLLER WEIGHT in pounds (Kgs) | Series 2400 MKII | | 11.2 lbs. (5.09 kg) | | | | | | | | | — |
| | Series 2450 MKII | | 6.5 lbs. (2.95 kg) | | | | | | | | | 11.0 (4.95) |

NOTE: [1]Does not apply to permanent-magnetic motors.

## OPERATION CONDITIONS

1. **Line Voltage Variation**..... ± 10% of rated
2. **Line Frequency Variation**..... ± 2 Hertz of rated
3. **Ambient Temperature**[1]..... 0 to 40° C (32° F to 104° F)
4. **Altitude** (Standard) ..... 1000 Meters (3300 feet) maximum

NOTE: (1) Series 2450 MKII controllers are designed for panel mounting within an enclosure where the internal temperature does not exceed 55°C (131°F).

## PERFORMANCE CHARACTERISTICS

1. **Speed Range** (Controlled) ..... 0 to motor base speed
2. **Efficiency** (Rated Speed & Rated Load)
   a. Controller..... 99%
   b. Complete drive (controller with motor, typical)..... 85%
3. **Displacement Power Factor** (Rated Speed & Rated Load)..... 87%
4. **Acceleration** (Standard) ..... By current limit
5. **Speed Regulation** (See Table 4)—Regulation percentages are of motor base speed under steady-state conditions.

TABLE 4. SPEED REGULATION CHARACTERISTICS

| REGULATION METHOD | VARIABLE | | | | |
|---|---|---|---|---|---|
| | Load Change 95% | Line Voltage ±10% (1) | 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 (1061C) with Sigmation or 5 PY DC Tach | 0.5% | ± 1% | 0.2% | ± 2% | 200:1 |

NOTE: (1) With Precision Reference (Option 1059) Regulation due to ± 10% Line Voltage Change is ±0.1%.

## STANDARD FEATURES

1. **Construction**
   (a) **Series 2400 MKII** – Totally enclosed, nonventilated, constructed of rugged die-cast aluminum alloy. Hinged cover includes a draw latch that tightly compresses the gasket to exclude contaminants. Conduit entry is provided by four ¾-14 NPT tapped holes on three sides. Standard unit is easily and inexpensively convertible to NEMA Type 3, 4 or 12. Back surface is deeply finned for maximum heat transfer.
   (b) **Series 2450 MKII**– Open chassis with a dead back and front construction. Front access is provided to all components by a hinged, latched front cover which forms a mounting surface for the main control circuit board. The entire base is a finned alloy extrusion for maximum heat transfer.
2. **Power Conversion** – NEMA Code K semiconverter power bridge consisting of 2 SCR's, 2 diodes and a freewheeling diode. Power bridge is an integrated, encapsulated component.
3. **Feedback** – Counter EMF voltage with adjustable IR compensation.
4. **Control Transformer** – 24 VAC secondary isolates magnetic control logic from the AC power source for operator protection.
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.
6. **Motor Overload** – Positive motor protection by an electronic nonadjustable current (load) monitor. The circuit shuts down the drive when the motor armature current exceeds 120% for 80 seconds. An optional current (load) monitor (Option 1081B) is available which provides an adjustable trip range and an adjustable time delay range. Option 1081B provides a relay with one set of Form C, 2 ampere, 120 VAC or 28 VDC rated 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. An optional two-pole circuit breaker (Option 1010) is available which opens both lines of the input supply.
8. **Line Transient Protection** – Provided by a metal oxide suppressor (varistor) across the AC input line.
9. **UL Listed.**

## ADJUSTMENTS

The following adjustment potentiometers are located on the standard circuit boards in the controller.

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 Series 2400/2450 MKII Controllers at additional costs. See Section V for option listings.

## MOUNTING INSTRUCTIONS

1. Wall mount the controller in an upright position using the mounting holes or slots provided. See Figure 1, 2, 3, or 4, as applicable, for mounting dimensions.

2. Install the controller in a dry location. The standard 2400 MKII enclosure should not be used where a water-tight or weather-proof or explosion proof enclosure is required.

3. Allow 4 inches minimum clearance on all sides for maximum cooling efficiency.

**CAUTION** — **NEVER MOUNT THE CONTROLLER IMMEDIATELY BESIDE OR ABOVE HEAT-GENERATING EQUIPMENT OR DIRECTLY BELOW WATER AND STEAM PIPES.**

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

5. If the controller is to be enclosed by the user, allow for adequate ventilation. Air passages into the bottom, with exit openings near the top, form an adequate configuration. If a small enclosure is used, a ventilation fan may be required. Ambient temperature inside an enclosure must not exceed 55°C (131°F) or controller damage may occur.

6. If the controller is factory installed in an enclosure, position the enclosure upright in a dry location. Allow the enclosure door to open fully for ease of maintenance. A minimum swing of 90 degrees is required for access. The NEMA Type 1 enclosure supplied with Option 1139B (W3) or Option 1139C (W4) is designed for wall mounting. See Figure 3 for enclosure dimensions.

**CAUTION** — **DO NOT RESTRICT THE FLOW OF AIR TO AND FROM THE ENCLOSURE LOUVERS.**

7. Fincor's Series SCS160 standard operator control stations can be wall mounted using the two holes in the back of the enclosure. See Figure 5 for mounting dimensions.

8. 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 may occur.**

## WIRING INSTRUCTIONS

### General

**CAUTION** — **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 CURRENT PROTECTION.**

Be sure the input line voltage and frequency agree with the ratings on the controller data label. The controller is protected 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 between the transformer secondary and the controller. See Table 3 for minimum transformer KVA.

**CAUTION**

1. **NEVER MAKE OR BREAK POWER IN THE TRANSFORMER PRIMARY. Transients may be generated which can damage the controller.**
2. **THE MAXIMUM AVAILABLE SHORT-CIRCUIT CURRENT OF THE SUPPLY LINE MUST BE LESS THAN 5000 AMPERES SYMMETRICAL OR CONTROLLER DAMAGE MAY OCCUR. Short-circuit current can be limited by sizing the input supply transformer at 50 KVA or less, or by using correctly sized current-limiting fuses in the supply line to the controller. Do not size the transformer less than the minimum transformer KVA listed in Table 3.**

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

**CAUTION** — **NEVER USE POWER FACTOR CORRECTION CAPACITORS ON THE SUPPLY LINE TO THE CONTROLLER WITHOUT CONSULTING FINCOR. These capacitors can damage the solid-state components.**

Size the power wiring (AC line and motor) for the rated currents listed in Table 3 and the controller data label. Do not use wire larger than #12 AWG for controllers rated 1/6 through 3 HP nor larger than #8 AWG for 5 HP controllers. Use stranded wire for all wiring.

**CAUTION**

1. **NEVER USE SOLID WIRE. Intermittent and broken connections may occur if solid wire is used.**
2. **OVERSIZED OR SOLID WIRE, AS WELL AS THE USE OF LARGE SCREWDRIVERS FOR ELECTRICAL CONNECTIONS, CAN BREAK TERMINAL BOARD BARRIERS.**

Run all external low voltage signal wiring (e.g., wiring for potentiometers, transducers, tachometer generators) in separate conduit from all other wiring. Use multiconductor twisted cable (Alpha 5630B1801 or equal) for all signal wiring. Maintain a separation of signal wiring from all other wiring in an enclosure by at least 2 inches.

**CAUTION** — **ELECTRICAL NOISE PICKUP ON THE SIGNAL WIRING CAN CAUSE ERRATIC OPERATION AND CONTROLLER DAMAGE.**

If shielded cable is used for the signal wiring, the shield must not be connected to any ground point, or controller damage may occur.

The control wiring (e.g., wiring for operator controls, magnetic control logic) may be run in the same bundle with the power wiring (AC line and motor), but not in the same bundle with the signal wiring.

Use the ¾-14NPT tapped conduit holes in the standard 2400 MKII enclosure to facilitate wiring.

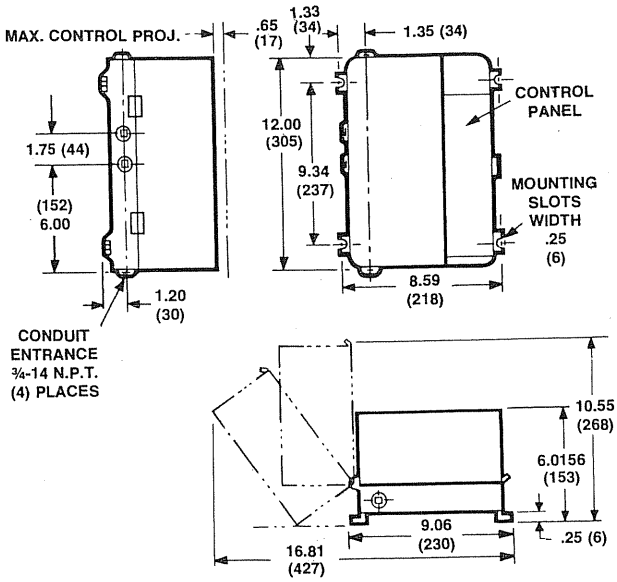
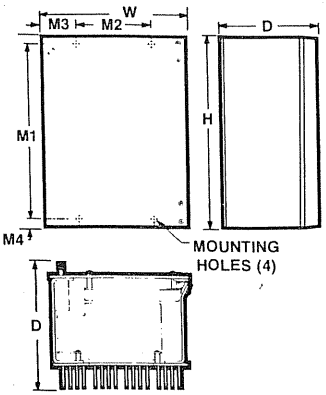
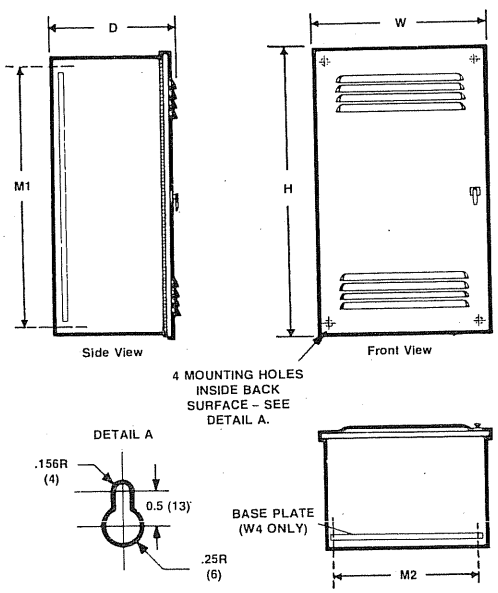



FIGURE 1. SERIES 2400 MKII DIMENSIONS




| MODELS | HP | DIMENSIONS inches, (mm) | | | MOUNTING DIMENSIONS inches, (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | H | W | D | M1 | M2 | M3 | M4 | Hole Dia. |
| 2451, 2452 | 1/6-3 | 11.0 (279) | 7.0 (178) | 6.25 (159) | 10.25 (260) | 3.25 (83) | 1.75 (45) | .38 (10) | .218 (6) |
| 2453 | 5 | 11.0 (279) | 9.88 (251) | 6.38 (162) | 6.00 (152) | 9.50 (241) | .19 (5) | 2.50 (64) | .218 (6) |

FIGURE 2. SERIES 2450 MKII DIMENSIONS




| ENCLOSURE | | DIMENSIONS inches, (mm) | | | MOUNTING DIMENSIONS inches, (mm) | | BASE PLATE DIMENSIONS inches, (mm) | | DOOR SWING |
|---|---|---|---|---|---|---|---|---|---|
| Model | Drawing | H | W | D | M1 | M2 | Height | Width | |
| W3 (Option 1139B) | C104311101 | 15.38 (391) | 12.50 (318) | 8.38 (213) | 12.50 (318) | 7.00 (178) | — | — | 175° |
| W4 (Option 1139C) | C1041559 | 24.38 (619) | 16.50 (419) | 11.38 (289) | 21.50 (546) | 11.00 (279) | 20.00 (508) | 15.00 (381) | 175° |

FIGURE 3. OPTIONAL NEMA TYPE 1 ENCLOSURES FOR SERIES 2450 MKII

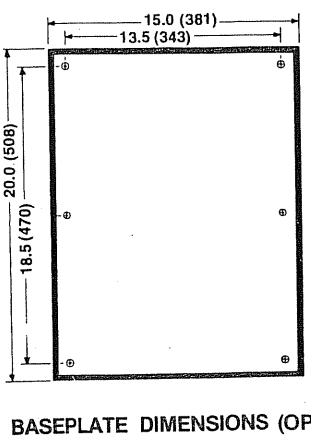



FIGURE 4. W4 BASEPLATE DIMENSIONS (OPTION 1138)

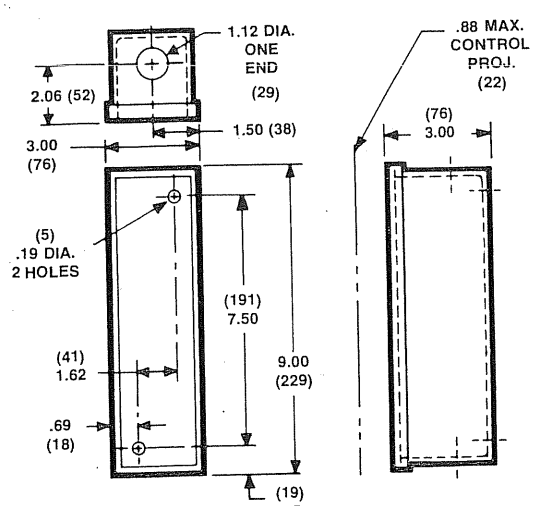



FIGURE 5. OPERATOR CONTROL STATION DIMENSIONS (OPTION 1120)

### AC Power Connections

**CAUTION**

**METAL CHIPS FROM DRILLED CONDUIT HOLES IN AN ENCLOSURE CAN CAUSE SHORT CIRCUITS AND/OR GROUNDS WHICH CAN DAMAGE THE CONTROLLER.**

Connect the AC input power wires to controller Terminals L1 and L2 on Terminal Board TB1. See Figure 19, 20 or 21.

If one of the power wires is a neutral wire (ground potential), connect it to Terminal L2, and connect the hot wire (H) to Terminal L1.

**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.**

Connect the controller to an earth ground according to applicable electrical codes. A ground connection terminal is provided in the controller. (See Figure 19, 20 or 21.)

### Motor Connections

Check the motor data plate and be sure the HP, voltage, and current ratings are compatible with the ratings on the controller data label.

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. (See Figure 19, 20 or 21.) Be sure to remove the jumper wire from Terminals 2 and 3 if a thermal guard is used.

### Remote Opeator Control Station Connections

Connect remote operator controls, if used, to controller Terminal Board TB2, as follows:

If a Fincor Series SCS160 remote operator control station (Option 1120) is used, see Figure 6, 7, 8 or 9, as applicable.

For operation functions with external relay logic (user supplied), see Figure 10, 11, 12, 13 or 14, as applicable.

For basic operation functions, see Figure 15, 16, 17 or 18, as applicable.

**CAUTION**

**FAILURE TO CONNECT THE OPERATOR CONTROLS AS SHOWN CAN RESULT IN CONTROLLER DAMAGE.**

If the controller has an input board other than standard (60211), refer to the instruction sheet supplied with the input board for connection drawing.

When connecting remote operator controls for reversing operations, be sure the controls initiate a Stop function before changing the direction of motor rotation. Failure to do this could damage the reversing logic. When a Stop function is initiated, an antiplug circuit prevents the motor from being restarted while the motor is braking until a safe speed for reversing is attained.

If a remote switch is used to select the direction of motor rotation, it should contain a center position interlock, which requires a momentary relaxation of pressure before reverse position can be engaged. This center position initiates a Stop function.

If more than three 5000 ohm motor speed potentiometers are required, use switching to ensure that no more than three potentiometers connect to the controller input board (Terminal TB3-4) at a time.

**CAUTION**

**FOUR OR MORE 5K SPEED CONTROL POTENTIOMETERS WILL OVERLOAD THE CONTROLLER REFERENCE POWER SUPPLY.**

## INITIAL STARTUP

Before energizing the controller for the first time, be familiar with all applicable 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. Be sure the correct resistance wires are removed (cut out) from the power board in controllers 1/6 through 3 HP. See Table 5 and Figures 19 and 20. Model 2453 Controllers (5 HP) do not have resistance wires.
3. For 50 Hertz operation, be sure the 60 Hz jumper wire is removed (cut out) from the control board. (See Figure 19, 20 or 21.)
4. Close and latch the controller cover.

**TABLE 5. RESISTANCE WIRES**

| HP RATING | | RESISTANCE WIRE |
|---|---|---|
| 115V | 230V | Remove |
| 1/6 | — | R2 thru R9 |
| 1/4 | 1/2 | R3 thru R9 |
| 1/3 | 3/4 | R3 thru R9 |
| 1/2 | 1 | R4 thru R9 |
| 3/4 | 1-1/2 | R6 thru R9 |
| 1 | 2 | R8, R9 |
| — | 3 | None |

5. Turn the motor speed potentiometer fully counterclockwise.
6. If supplied, place the RUN/JOG switch in RUN position and the FWD/REV switch in FWD position.
7. Couple the motor to the machine (load).
8. Turn-on the AC input power and the AC POWER ON/OFF switch.
9. Initiate a Run function, and slowly turn the motor speed potentiometer clockwise until the motor rotates. If motor rotation is opposite to that desired, stop the motor, turn-off the AC POWER ON/OFF switch and the AC input power, and interchange the motor armature leads at the motor connection box.
10. Turn the motor speed potentiometer fully clockwise. The motor should run at its rated (base) speed.
11. Turn the motor speed potentiometer fully counterclockwise and stop the motor.

# 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.

**WARNING**

**IF LINE TERMINAL L2 IS NOT GROUNDED, THE CONTROLLER REMAINS ELECTRICALLY "HOT" WHEN THE AC POWER ON/OFF SWITCH IS TURNED-OFF.**

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 (short or ground) is indicated which must be corrected. See the troubleshooting table in Section IV.

**CAUTION** — **CONTINUAL RESETTING OF THE CIRCUIT BREAKER MAY DAMAGE THE CONTROLLER.**

## RUN

To start the motor, initiate a Run function, and the motor will accelerate to the setting of the motor speed potentiometer.

## STOP

To stop the motor, initiate a Stop function, and the motor will stop at a rate proportional to the motor load.

If the controller has dynamic braking (Option 1039), 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 the kinetic energy of its armature 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 torque as shown in Table 6.

**TABLE 6. DYNAMIC BRAKING CHARACTERISTICS**

| COMPONENT | UNIT | RATED HORSEPOWER | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1/6 | 1/4 | 1/3 | 1/2 | 3/4 | 1 | 1½ | 2 | 3 | 5 |
| Braking Torque % | 115V | 300 | 215 | 170 | 110 | 75 | 60 | — | — | — | — |
| | 230V | — | — | — | 400 | 320 | 220 | 145 | 105 | 85 | 96 |
| Stops Per Minute | 115V | 9 | 6 | 5 | 5 | 4 | 4 | — | — | — | — |
| | 230V | — | — | — | 5 | 4 | 4 | 3 | 3 | 2 | 2 |

**CAUTION** — **HIGH INERTIA LOADS MAY EXTEND BRAKING TIME BEYOND THE WATTAGE RATING OF THE RESISTOR.**

Option 1039 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.

## REVERSE

To reverse motor rotation on controllers with reversing capabilities, initiate a Stop function, then initiate a reversing function. The motor will accelerate to the setting of the motor speed potentiometer. Forward and reverse speeds are identical.

The FWD/REV switch on Model 2401D, 2402D, 2401E and 2402E Controllers has 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 stopping until a safe speed for reversing is attained.

## JOG

To jog the motor on controllers with Jog Option 1022, place the RUN/JOG switch in JOG position and jog the motor with the RUN button. With Jog Option 1019, jog the motor with the JOG button. Jog is momentary, causing motor rotation only while the button is depressed. Release the button to stop the motor.

Options 1022 and 1019 provide a separate JOG SPEED potentiometer, adjustable from 0 to approximately 50% of motor base speed.

## INOPERATIVE MOTOR

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 shut off the drive. The standard current monitor will shut off the controller and motor if the motor armature current exceeds 120% of rated for 80 seconds of continuous operation. To reset the controller, initiate a Stop function, remove the overload, and initiate a Run function to restart. Repeated shutoff indicates a continual overload (mechanical or electrical) which must be removed. See the troubleshooting table in Section IV.

# SECTION IV
# MAINTENANCE

**WARNING**

1. **SERIES 2400/2450 MKII 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 AC POWER ON/OFF SWITCH IS TURNED-OFF, COMPONENTS WITHIN THE CONTROLLER REMAIN AT LINE POTENTIAL UNTIL THE AC INPUT POWER IS TURNED-OFF.**

## GENERAL

Series 2400/2450 MKII 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

Series 2400/2450 MKII Controllers are 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.

Refer to Figure 19, 20 or 21 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 of operation from a cold start.
2. If the motor has a shunt field, check the 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. Initiate a Run function, 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. Initiate a Run function, 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.

## IR Compensation

IR compensation is factory adjusted and sealed for a 2.0% 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, IR compensation can be readjusted.

1. An adjustable load (dynamometer) that can be applied and removed while the motor is running.
2. A close reading tachometer to record speed changes.

If, during this adjustment procedure, motor speed becomes unstable or oscillates (hunts), slowly turn the 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 initiate a Run function.
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 3 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, it should not be readjusted 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 3 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. Initiate a Run function, and slowly turn CURRENT LIMIT Potentiometer R12 clockwise while the motor is accelerating until the ammeter records the desired armature current.

**CAUTION**

**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 ON 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 7. TROUBLESHOOTING

| INDICATION | POSSIBLE CAUSE | CORRECTIVE ACTION |
|---|---|---|
| 1. AC POWER ON/OFF switch trips immediately when turned-on | Wiring faulty or incorrect | Check all external wiring terminating in the controller. Correct accordingly. |
| | Circuit, component, or wiring grounded | Remove unwanted ground. |
| | Power Bridge BR1 shorted | Replace BR1. |
| | Power board failure | Replace power board. |
| | Control board failure | Replace control board. |
| | Shunt field shorted or grounded | Repair or replace motor. |
| 2. AC POWER ON/OFF switch trips when a Start function is initiated | Power Bridge BR1 shorted | Replace BR1. |
| | Motor shorted or grounded | Repair or replace motor. |
| | Control board failure causing SCR's to turn-on fully | Replace control board. |

TABLE 7. TROUBLESHOOTING ( Cont'd )

| INDICATION | POSSIBLE CAUSE | CORRECTIVE ACTION |
|---|---|---|
| 3. AC POWER ON/OFF switch trips 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 shorted armature. Correct accordingly. |
| | Loose or corroded connection. Wiring faulty, incorrect, or grounded | Check AC POWER ON/OFF switch terminals and all terminals, connections, and wiring between the line, controller, and motor. |
| | Motor shorted or grounded | Repair or replace motor. |
| | SCR and/or diode breaking down (shorting intermittently) in Power Bridge BR1 | Replace BR1. |
| | Control board failure causing SCR false firing or misfiring | Replace control board. |
| 4. AC POWER ON/OFF switch not tripped, but motor won't run | AC line open | Be sure external disconnect switch or circuit breaker is turned-on and rated AC power is applied to controller. |
| | Operator controls or relay logic inoperative or connected incorrectly | Repair accordingly. |
| | Motor speed potentiometer failure | Replace potentiometer. |
| | Motor failure | Repair or replace motor. |
| | Control, input, or power board failure | Replace faulty board. |
| 5. Minimum speed excessive | MIN SPEED Potentiometer R1 misadjusted | See "Adjustment Instructions." |
| | Control or input board failure | Replace faulty board. |
| 6. Motor won't reach top speed | Low line voltage | Check for rated line voltage, ±10%, on controller AC 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 shorted armature. Correct accordingly. |
| | Motor speed potentiometer failure | Replace potentiometer. |
| | MAX SPEED Potentiometer R59 misadjusted | See "Adjustment Instructions." |
| | CURRENT LIMIT Potentiometer R12 misadjusted | See "Adjustment Instructions." |
| | Control or input board failure | Replace faulty board. |
| | Power Bridge BR1 failure | Replace BR1. |
| 7. Motor runs at fast speed only | Control board failure | Replace control board. |
| | Feedback circuit open | Check for faulty feedback board. Repair accordingly. |
| 8. Unstable speed (Cont'd on next page) | AC line voltage oscillating | Observe line voltage with voltmeter or oscilloscope. If oscillations occur, contact an electrician or the local electric utility company. |
| | Oscillating load connected to the motor | Correct condition accordingly. Turning IR COMP Potentiometer R9 counterclockwise may minimize condition. See "Adjustment Instructions." |

| INDICATION | POSSIBLE CAUSE | CORRECTIVE ACTION |
|---|---|---|
| 8. Unstable speed (Cont'd) | Motor failure | Check motor brushes, replace if needed. Repair or replace motor. |
| | IR compensator misadjusted | See "Adjustment Instructions." |
| | SCR(s) misfiring or false firing | Replace Power Bridge BR1 and/or control board. |
| 9. High, unstable speed, low torque | Armature and field connections interchanged[1] | Check controller-to-motor wiring. |
| | Power Bridge BR1 failure | Replace BR1. |
| 10. Top speed only 1/2 (approximately) of motor base speed (possible half-waving) | Power Bridge BR1 failure | Replace BR1. |
| | Control board failure | Replace control board. |
| 11. Motor surges when starting | Open or faulty K1 Relay contact | Replace Relay K1 or the power board. Contact must close between starts. |
| | Power Bridge BR1 breaking down (shorting intermittently) | Replace BR1. |
| | Control board failure | Replace control board. |
| 12. Line and 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 shorted armature. Correct accordingly. |
| 13. Shunt field current insufficient[1] | Open shunt field winding or wiring to the shunt field | Check motor shunt field and associated circuitry for loose connection or broken wire. Repair accordingly. |
| | Power Bridge BR1 failure | Replace BR1. |
| 14. Shunt field current excessive[1] | Power Bridge BR1 failure | Replace BR1. |
| | Shunt field windings shorted | Measure shunt field resistance and compare with motor rating. Repair or replace motor. |
| 15. Motor thermal guard open (if used) | Ventilation insufficient | Free the motor intake and exhaust screens from dirt, dust, and debris. |
| | Line and motor armature current excessive | See Indication 12. |
| | Motor overheating from friction | Check for misalignment. Realign motor. |
| | Shorted motor windings or faulty bearings | Repair motor. |

NOTE: [1]Does not apply to permanent-magnet motors.

# SECTION V
# OPTIONS

Optional features are available for Series 2400/2450 MKII Controllers which increase the functional use of the basic controller. Table 8 lists all available options.

Options can be added to the basic controller at any time. Each option consists of all required components, mounting hardware and wiring harness (if used). Also included are installation instructions and applicable drawings.

Options 1004A (reversing), 1022 (jog), and 1039 (dynamic braking), the most commonly selected options, are shown schematically on Figures 16 and 18.

## TABLE 8. ALLOWABLE OPTION COMBINATIONS

| OPTION GROUP | OPTION NUMBER | OPTION | 2401 2402 | 2401A 2402A 2451 2452 2453 | 2401B 2402B | 2401C 2402C 2451A 2452A 2453A | 2401D 2402D | 2401E 2402E 2451B 2452B 2453B | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| A(1) | 1037 | Feedback, Adapter Interface Board | XK | XK | XK | XK | XK | XK | Feedback Options: Choice of one within this group unless Option 1037 is selected. Can be combined with options selected from all groups except Group C.<br>NOTE: (a) May not be used with Group D options or Option 1057A and Option 1047 from Group B. |
| | 1061C | Feedback, Tachometer AC or DC | XK | XK | XK | XK | XK | XK | |
| | 1062A(a) | Feedback, Digital Pulse Generator | XK | XK | XK | XK | XK | XK | |
| | 1054 | Torque (Current) Limit Control | XK | XK | XK | XK | XK | XK | |
| | 1190 | Torque Taper | XK | XK | XK | XK | XK | XK | |
| B(1) | 1034 | Acceleration-Deceleration Linear | XK | XK | XK | XK | XK | XK | Input Options: Choice of one within this group unless Option 1037 is selected. Can be combined with options selected from all groups except Group C.<br>NOTES: (a) May not be used with Option 1022 from Group G or Operator Control Station SCS 163, SCS 164.<br>(b) Can only be mounted externally on 2451, 2451A, 2451B, 2452, 2452A and 2452B models.<br>(c) May not be used with Group D options or Option 1062A from Group A. |
| | 1037 | Input, Interface Board | XK | XK | XK | XK | XK | XK | |
| | 1049(a) | Follower, External DC Signal | XK | XK | XK | XK | XK | XK | |
| | 1050 | Follower, External AC Signal | XK | XK | XK | XK | XK | XK | |
| | 1050A(a) | Follower, AC Current Transducer | XK | XK | XK | XK | XK | XK | |
| | 1051(a) | Follower, MIRC | XK | XK | XK | XK | XK | XK | |
| | 1052(a) | Follower, Process Instrument Controller | XK | XK | XK | XK | XK | XK | |
| | 1055(a) | Follower, Tachometer AC or DC Gen | XK | XK | XK | XK | XK | XK | |
| | 1057A(a)(b)(c) | Follower, Digital Pulse Generator | XK | XK | XK | XK | XK | XK | |
| | 1059 | Reference, Precision | XK | XK | XK | XK | XK | XK | |
| | 1065 | Isolator, Speed Potentiometer | XK | XK | XK | XK | XK | XK | |
| C(1) | 1064A | Follower, Current Regulator | XK | XK | XK | XK | XK | XK | Input and Feedback Options: Can be combined with options selected from all groups except Group A and B. |
| | 1191 | Centerwind Torque Control | XK | XK | XK | XK | XK | XK | |
| | 1220 | Constant Velocity Winder | | | | | | | |
| D(2) | 1015 | Magnetic Control Interface (115V) | XK | XK | XK | XK | XK | XK | Special Options: Choice of one within this group. May not be used with Option 1062A from Group A or Option 1057A and 1047 from Group B. These options can only be mounted externally on 2451, 2451A, 2451B, 2452, 2452A and 2452B models. |
| | 1026A | Field Supply, Full-wave | XK | XK | XK | XK | XK | XK | |
| | 1047 | Controlled (Ramp) Stop | XK | XK | XK | XK | XK | XK | |
| | 1072A | Auxiliary Contacts | XK | XK | XK | XK | XK | XK | |
| | 1081B(a) | Current (Torque) Monitor | XK | XK | XK | XK | XK | XK | |
| E(2) | 1004A | Reversing, (Armature) Switch | XK | XK | NA | NA | STD | STD | Reversing and Dynamic Braking Options: Choice of one option within this group. Can be combined with options selected from all groups. |
| | 1004B | Reversing, (Armature), PB LS Magnetic | K | K | NA | NA | NA | NA | |
| | 1039 | Dynamic Braking | XK | XK | STD | STD | STD | STD | |
| F(3) | 1138(a) | Baseplate | NA | X(c) | NA | X(c) | NA | X(c) | Custom Options: Choice of one or all options within this group. Can be combined with options selected from all groups.<br>NOTES: (a) Can only select 1138 or 1139B or 1139C not all. Option 1139C includes Option 1138.<br>(b) Applies to 2453, 2453A, and 2453B only.<br>(c) Applies only to Series 2450 MKII models if additional panel space is required. |
| | 1139B(a) | Enclosure W3 | NA | X(b) | NA | X(b) | NA | X(b) | |
| | 1139C(a) | Enclosure W4 | NA | X(c) | NA | X(c) | NA | X(c) | |
| G | 1010 | Circuit Breaker, Two-Pole | XK | XK | XK | XK | XK | XK | External Options: Choice of one or all options within this group. Can be combined with options selected from all groups.<br>NOTES: (a) Can only select 1022 or 1058A not both.<br>(b) Applies to Series 2400 MKII only. Series 2450 MKII controllers are CSA Approved as standard.<br>(c) Models 2401, 2402, 2401B, 2402B, 2401D, 2402D which include local operator controls, only require 104200001 which is the operator control station with a blank cover to convert models for remote control station operation.<br>(d) Applies to Series 2400 MKII only. |
| | 1022 | Jog, Toggle Switch Selector | XK | K | XK | K | XK(a) | K(a) | |
| | 1037A | Input, Feedback Adapter, 1-Position | K | K | K | K | K | K | |
| | 1037B | Input, Feedback Adapter, 2-Position | K | K | K | K | K | K | |
| | 1058A | Follower Manual Mode Select | XK | K | XK | K | XK(a) | K(a) | |
| | 1116 | CSA Approval (b) | X | X | X | X | X | X | |
| | 1120 | Control Station (c) | K | K | K | K | K | K | |
| | 1120B | Potentiometer, Single-Turn MSA | K | K | K | K | K | K | |
| | 1120A | Potentiometer, Ten-Turn Motor Speed (Analog Dial) | XK | K | XK | K | XK | K | |
| | 1120C | Potentiometer, Ten-Turn Motor Speed (Digital Dial) | XK | K | XK | K | XK | K | |
| | 1166 | Manuals, Instruction | K | K | K | K | K | K | |

NOTES
(1) Options in Groups A, B and C are simple plug-in additions
(2) Options in Group D and E are internal pre-wired options (excluding 1004B)
(3) Options in Group F are Custom Options which may require engineering

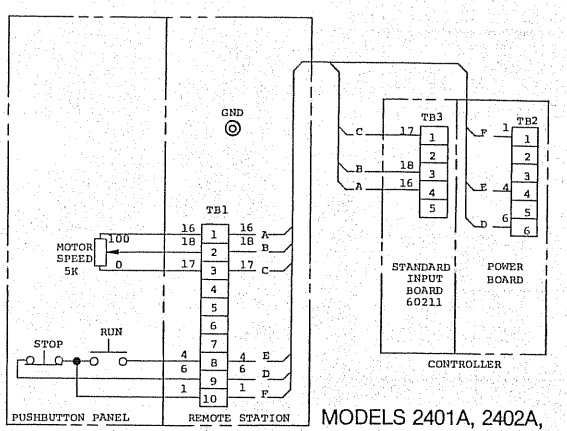
CODE:
X – Factory Installed
K – Field Kit
XK – Factory or Field Kit
STD – Standard
NA – Not Available

# SECTION V
# PARTS LIST

## TABLE 9. PARTS LIST, SERIES 2400/2450 MKII CONTROLLERS

| COMPONENT DESIGNATION | PART DESCRIPTION | FINCOR PART NUMBER[1] | | |
|---|---|---|---|---|
| | | 115 VAC | 230 VAC | |
| | | 1/6-1 HP | 1/2-3 HP | 5 HP |
| C1 | Capacitor | 3402062 | 3402062 | 3402062 |
| C2, C3 | Capacitor | 3402064 | 3402064 | 3402064 |
| CB1 | Circuit Breaker | 1045826 | 1045826 | 1047532 |
| MF | Contactor | 3022162 | 3022162 | 3022176 |
| MR | Contactor[2] | 3022164 | 3022164 | 3022176 |
| — | Control Board[3] | 266020801 | 266020801 | 266020801 |
| D1-D9 | Diode | 3303073 | 3303073 | 3303073 |
| — | Feedback Board[3] | 2660212 | 2660212 | 2660212 |
| — | Input Board[3] | 266021101 | 266021101 | 266021101 |
| — | Knob, SPEED Pots[2] | 3014081 | 3014081 | 3014081 |
| — | Operator Control Panel w/Controls[2] | 2660158 | 2660158 | ——— |
| — | Pot, JOG SPEED[4] | 3620229 | 3620229 | 3620229 |
| — | Pot, MOTOR SPEED[2] | 3620229 | 3620229 | 3620229 |
| — | Power Board[3] | 104714906 | 104714907 | 104299202 |
| BR1 | Power Bridge | 2660229 | 2660228 | 3301056 |
| — | Pushbutton (Green)[2] | 3013122 | 3013122 | ——— |
| — | Pushbutton (Red)[2] | 3013123 | 3013123 | ——— |
| — | Pushbutton Operator & Contact Block[2] | 3008097 | 3008097 | ——— |
| APR | Relay[2] | 3022165 | 3022165 | 3022165 |
| K1 | Relay | 3022163 | 3022163 | 3022183 |
| DB | Resistor[2] | 3538016 | 3538016 | 3538016 |
| — | Switch, FWD/REV[2] | 3004068 | 3004068 | ——— |
| — | Switch, RUN/JOG[4] | 3004069 | 3004069 | ——— |
| T1 | Transformer | 1041540 | 1041540 | 1041540 |
| RV1 | Varistor | 3318070 | 3318071 | 3318071 |

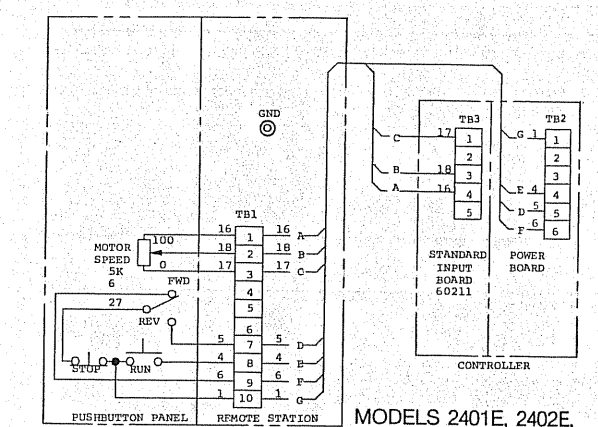
NOTES: 1 Substitution of parts will void UL Listing. 2 Not supplied with all model controllers. 3 Complete with all components.
4 Optional component. Not supplied with basic controllers.




MODELS 2401A, 2402A, 2401C, 2402C, 2451, 2452, 2453, 2451A, 2452A, & 2453A

NOTES:
1. Add Wires A thru F from remote station to TB-2 & TB-3 in controller.
2. Wires A, B, & C must be multiconductor twisted cable—such as Alpha 5630B1801.

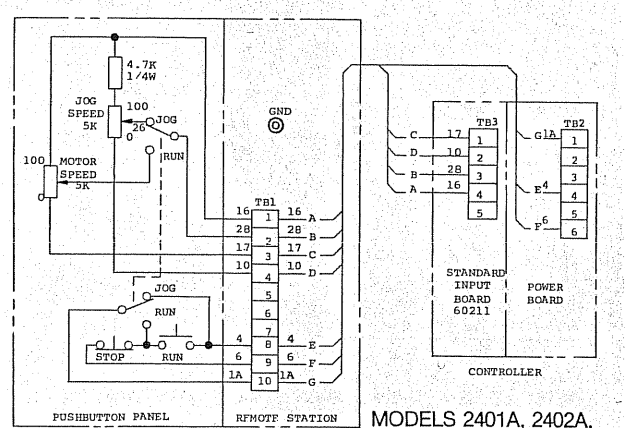
**FIGURE 6. CONNECTION DIAGRAM, RUN/STOP W/SCS 161 REMOTE STATION**




MODELS 2401E, 2402E, 2451B, 2452B, & 2453B

NOTES:
1. Add Wires A thru G from remote station to TB-2 & TB-3 in controller.
2. Wires A, B, & C must be multiconductor twisted cable — such as Alpha 5630B1801.

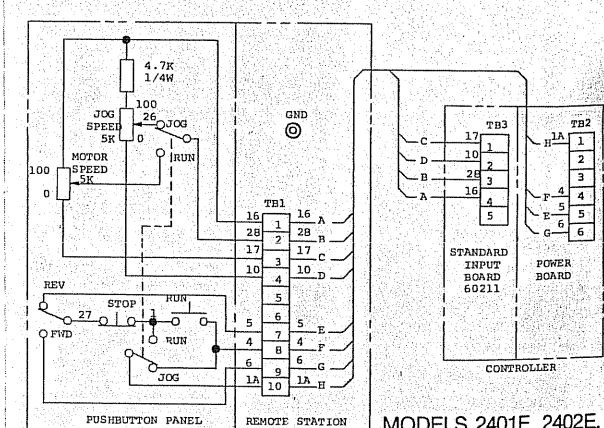
**FIGURE 7. CONNECTION DIAGRAM, FWD/STOP/REV W/SCS 162 REMOTE STATION**




MODELS 2401A, 2402A, 2401C, 2402C, 2451, 2452, 2453, 2451A, 2452A, & 2453A W/JOG OPTION 1022

NOTES:
1. Add Wires A thru G from remote station to TB-2 & TB-3 in controller.
2. Wires A thru D must be multiconductor twisted cable — such as Alpha 5630B1801.

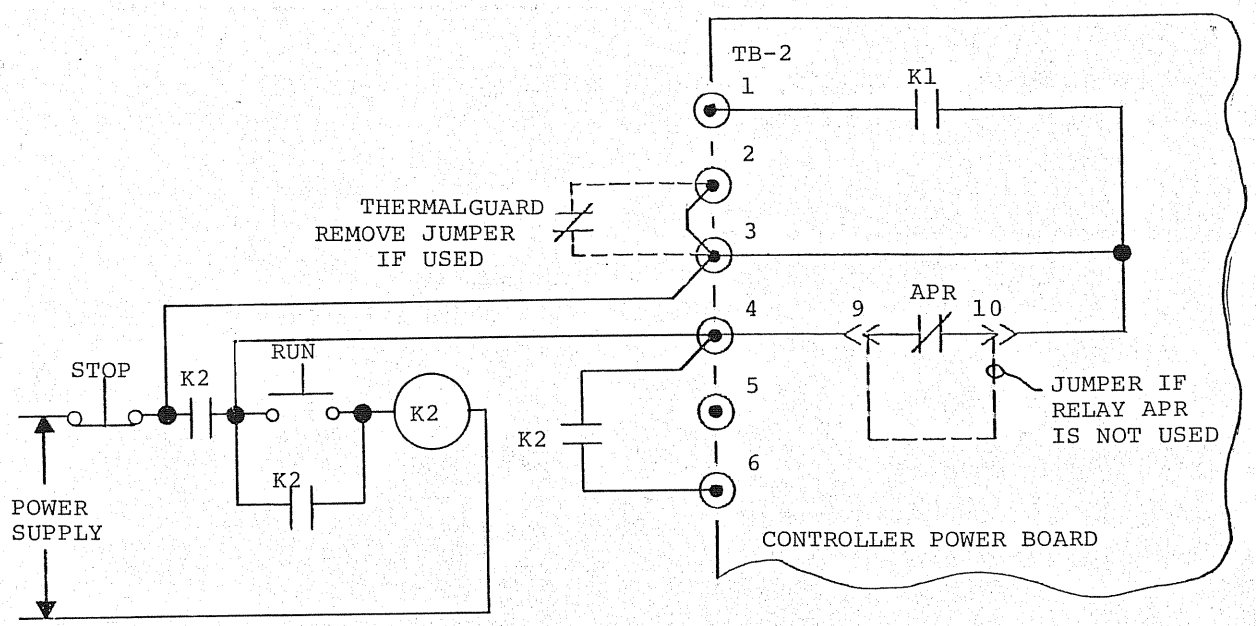
**FIGURE 8. CONNECTION DIAGRAM, RUN/STOP/JOG W/SCS 163 REMOTE STATION**




MODELS 2401E, 2402E, 2451B, 2452B, & 2453B W/JOG OPTION 1022 AND REVERSE OPTION 1004A

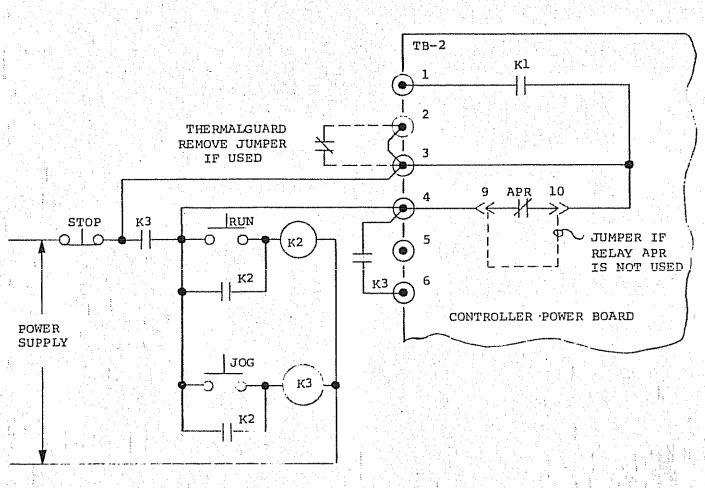
NOTES:
1. Add Wires A thru H from remote station to TB-2 & TB-3 in controller.
2. Wires A thru D must be multiconductor twisted cable — such as Alpha 5630B1801.

**FIGURE 9. CONNECTION DIAGRAM, FWD/STOP/REV/JOG W/SCS 164 REMOTE STATION**

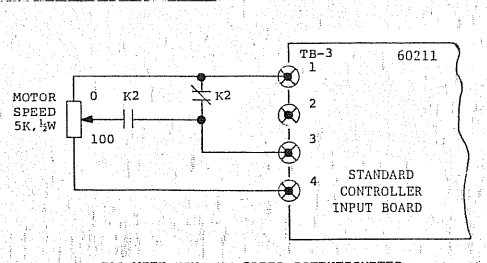



NOTES:
1. Relay and push buttons are user supplied.
2. Suggested relay – P & B KUP14A15.
3. Connect motor spd pot as shown in Figure 15 or 17.

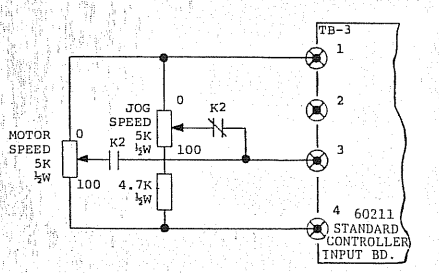
**FIGURE 10. CONNECTION DIAGRAM, RUN/STOP W/EXTERNAL RELAY LOGIC**




NOTES:
1. Relays, push buttons and pot are user supplied.
2. Suggested relays – P & B KUP14A15.
3. Motor speed and jog speed pot wires must be multiconductor twisted cable — such as Alpha 5630B1801.

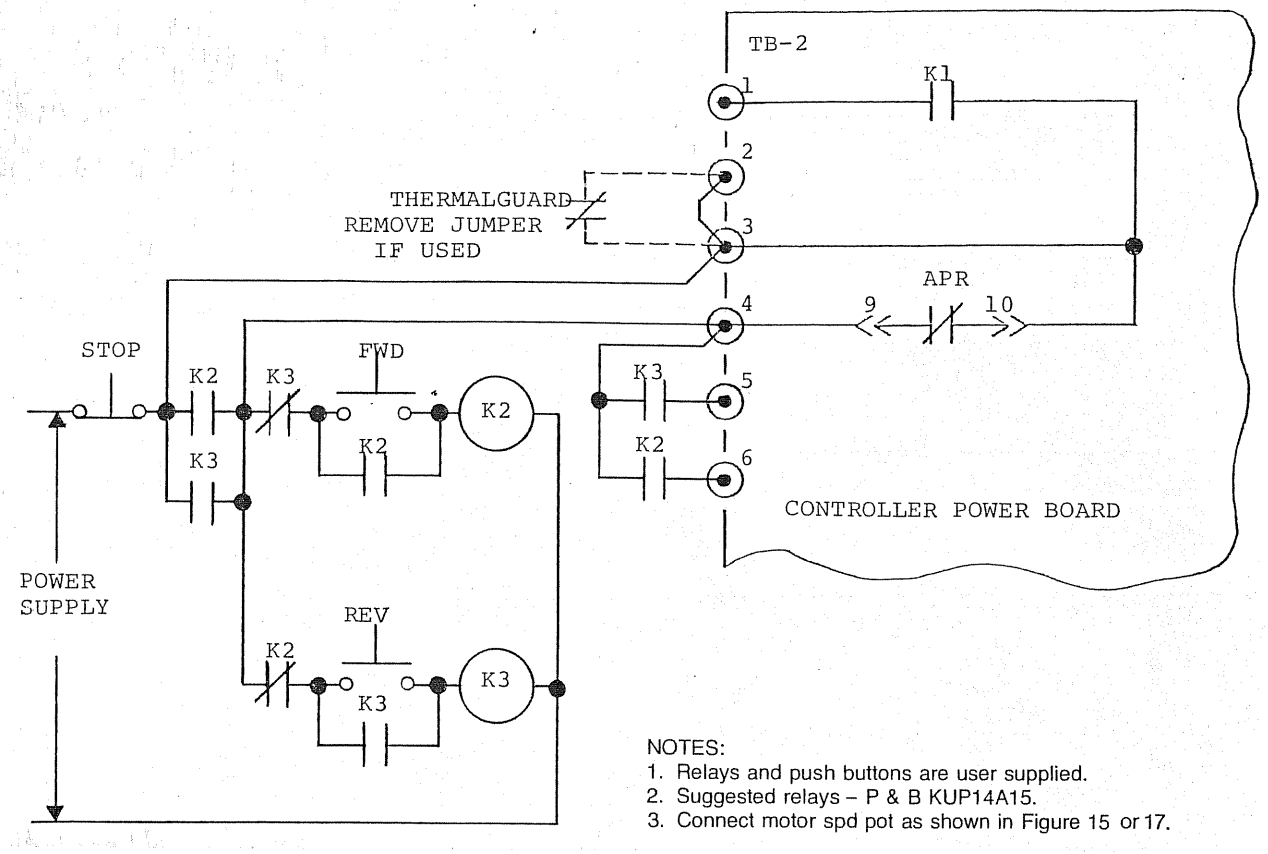



JOG WITH MINIMUM SPEED POTENTIOMETER



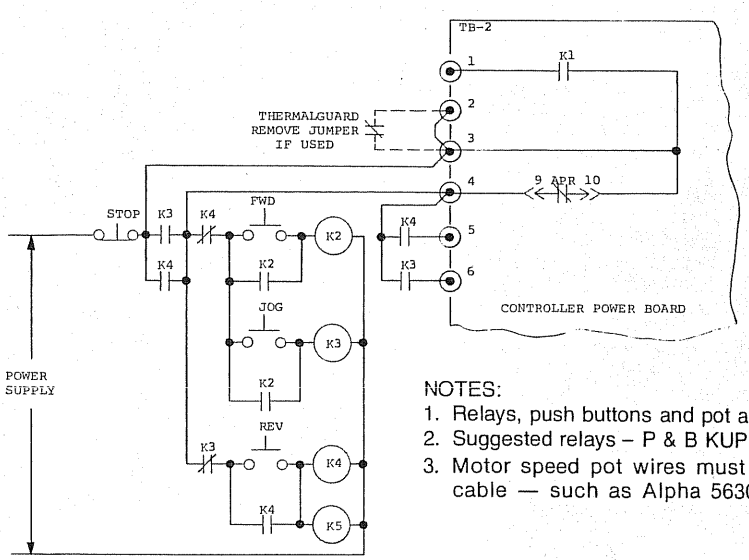

JOG WITH EXTERNAL JOG SPEED POTENTIOMETER

**FIGURE 11. CONNECTION DIAGRAM, RUN/STOP/JOG W/EXTERNAL RELAY LOGIC**

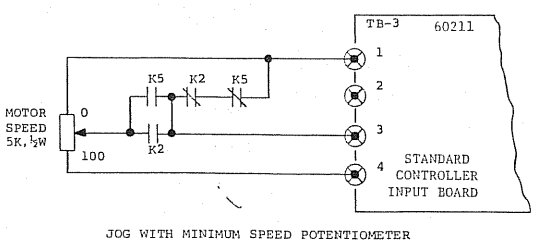



NOTES:
1. Relays and push buttons are user supplied.
2. Suggested relays – P & B KUP14A15.
3. Connect motor spd pot as shown in Figure 15 or 17.

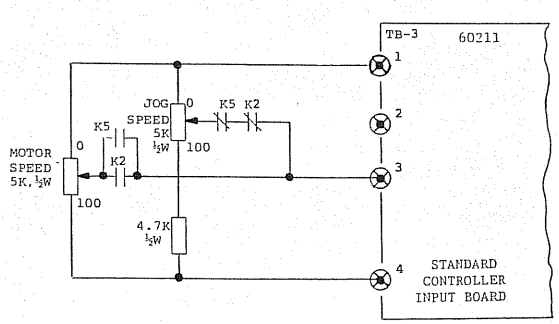
**FIGURE 12. CONNECTION DIAGRAM, FWD/STOP/REV W/EXTERNAL RELAY LOGIC**




NOTES:
1. Relays, push buttons and pot are user supplied.
2. Suggested relays – P & B KUP14A15.
3. Motor speed pot wires must be multiconductor twisted cable — such as Alpha 5630B1801.




JOG WITH MINIMUM SPEED POTENTIOMETER




JOG WITH EXTERNAL JOG SPEED POTENTIOMETER

**FIGURE 13. CONNECTION DIAGRAM, FWD/STOP/REV/JOG FWD W/EXTERNAL RELAY LOGIC**

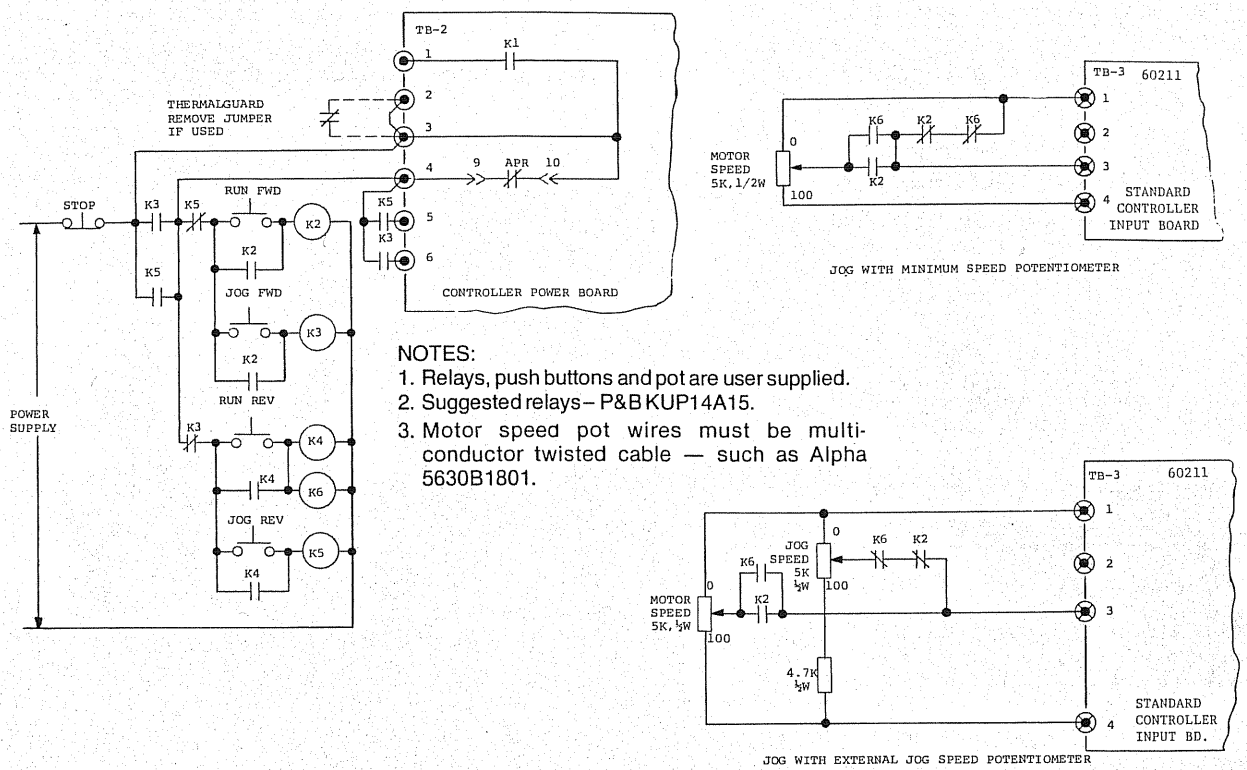



**FIGURE 14. CONNECTION DIAGRAM, FWD/STOP/REV/JOG FWD/JOG REV W/EXTERNAL RELAY LOGIC**

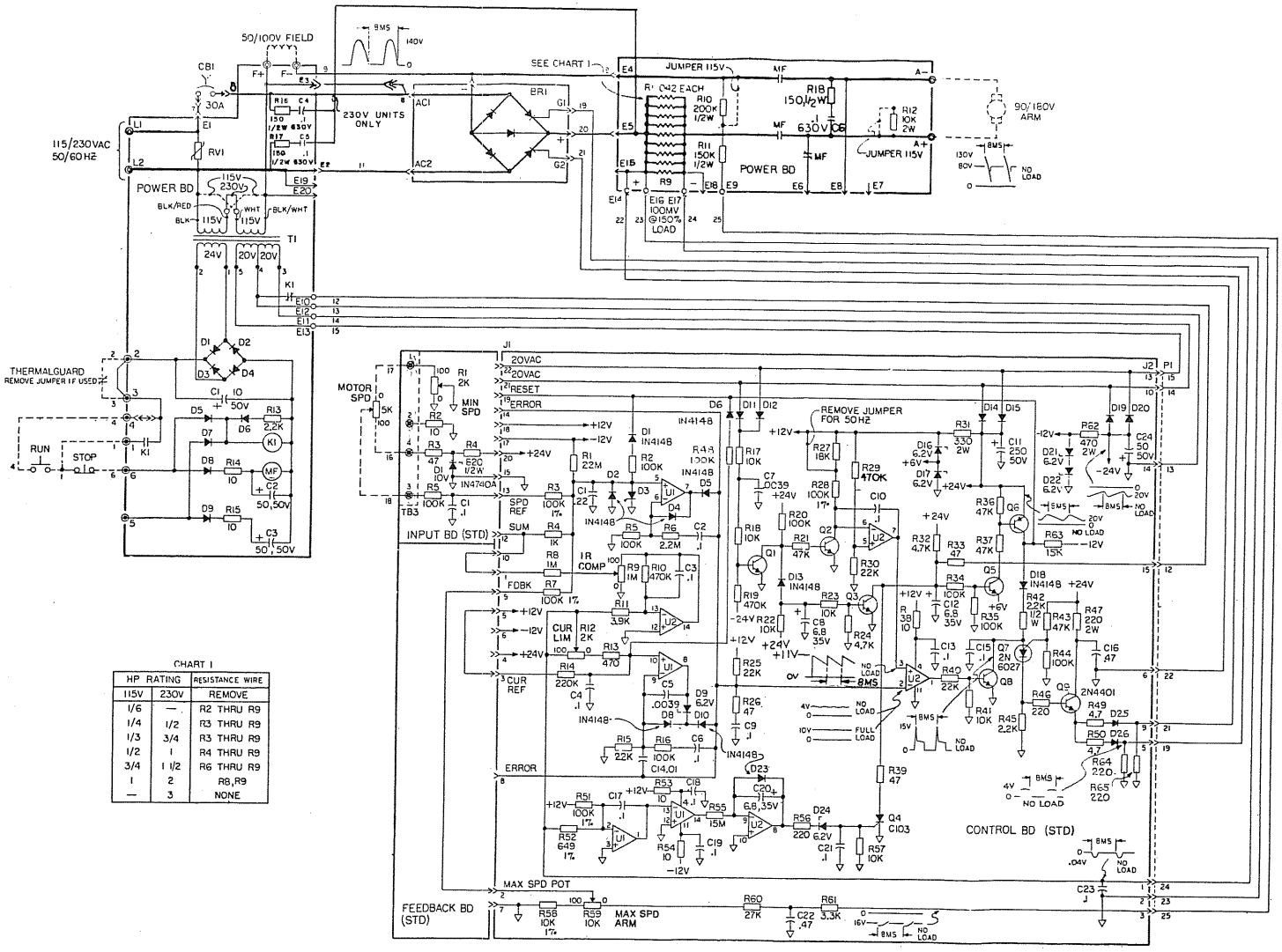



CHART I

| HP RATING | | RESISTANCE WIRE |
|---|---|---|
| 115V | 230V | REMOVE |
| 1/6 | — | R2 THRU R9 |
| 1/4 | 1/2 | R3 THRU R9 |
| 1/3 | 3/4 | R3 THRU R9 |
| 1/2 | 1 | R4 THRU R9 |
| 3/4 | 1 1/2 | R6 THRU R9 |
| 1 | 2 | R8,R9 |
| — | 3 | NONE |

NOTES

1. MOTOR SPD POT WIRES MUST BE MULTICONDUCTOR TWISTED CABLE — SUCH AS ALPHA 5630B1801
2. UNLESS OTHERWISE SPECIFIED:
   ALL RESISTORS ¼ W 5%
   ALL DIODES IN5393
   ALL TRANSISTORS NPN MPS6513
   ALL TRANSISTORS PNP MPS6517
   ALL POTENTIOMETERS ½ W 10%
   ALL CAPACITORS 100V 10%
   ALL CAPACITOR VALUES IN MICROFARADS
   ALL RESISTOR VALUES IN OHMS
   U1, U2, LM324
   ZENER DIODES D9, D16, D17, D21, D22, D24 – 1N4735A

◎ TB1
◉ TB2
⊗ TB3

C1041541 Rev E

**FIGURE 15. SCHEMATIC, SERIES 2400 MKII & MODELS 2451 & 2452 W/RUN-STOP LOGIC (1/6 - 3 HP)**

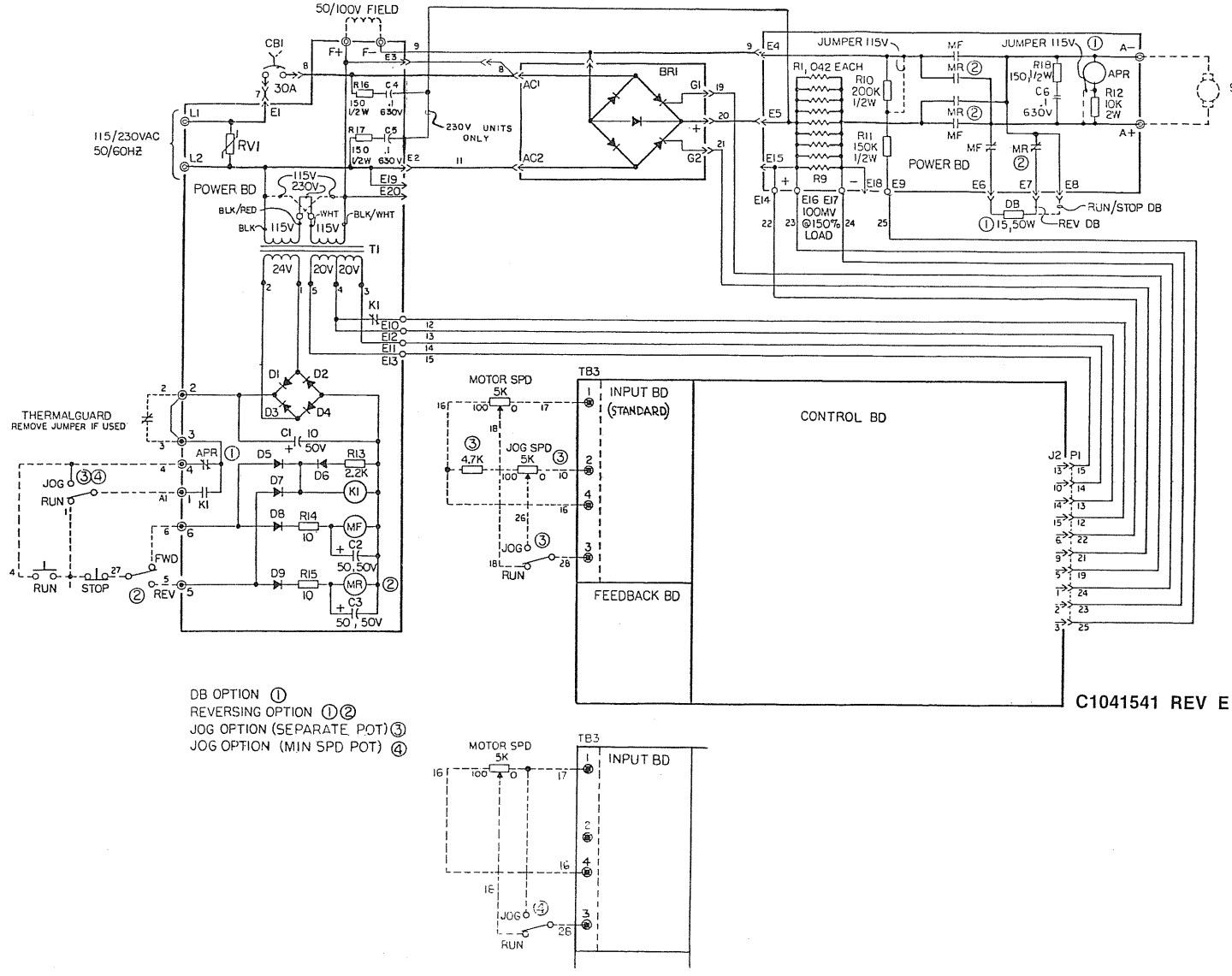
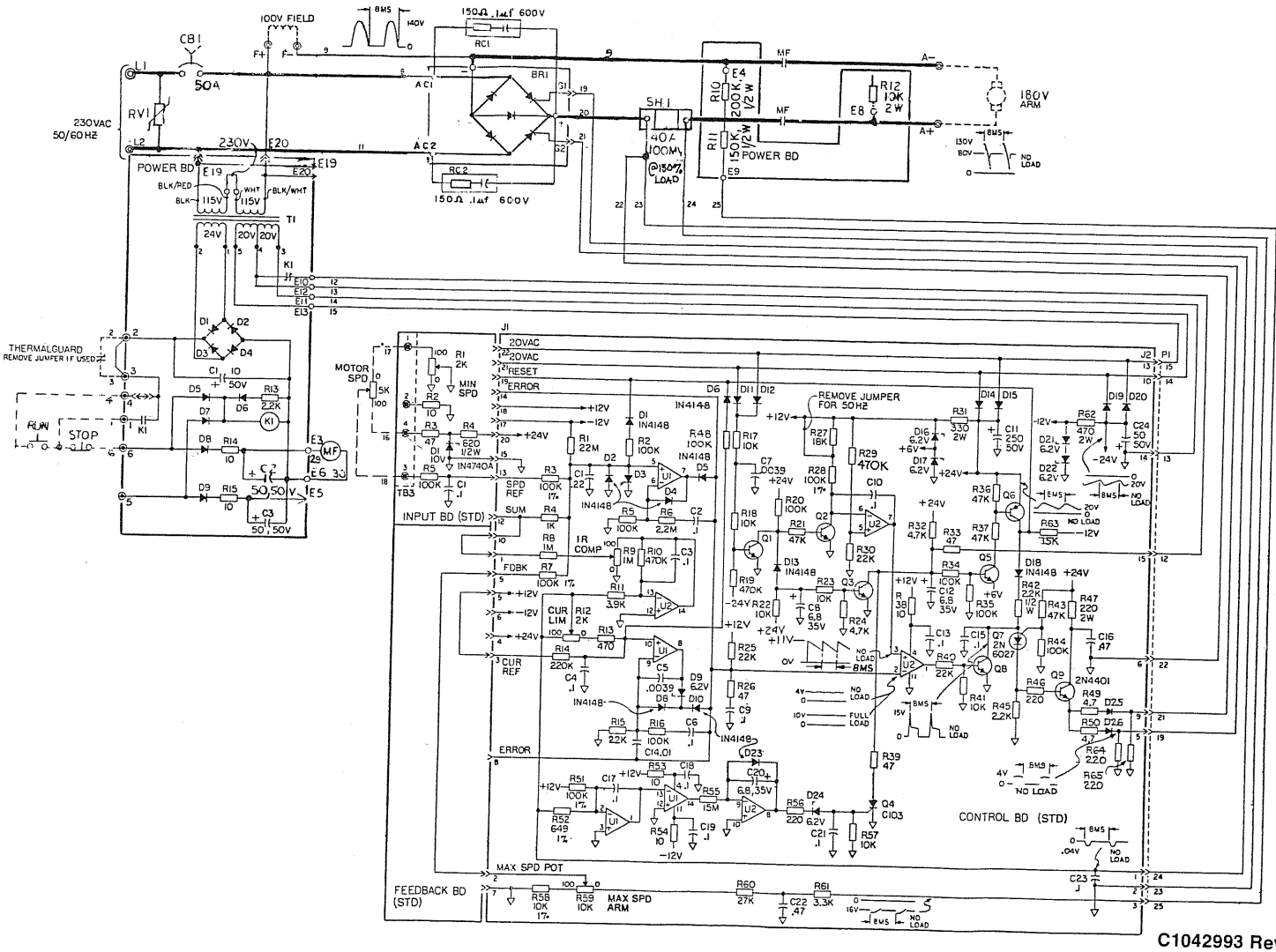



**FIGURE 16. SCHEMATIC, SERIES 2400 MKII & MODELS 2451B & 2452B W/DB-REVERSE-JOG OPTIONS (1/6 - 3 HP)**




NOTES

1. MOTOR SPD POT WIRES MUST BE MULTICONDUCTOR TWISTED CABLE — SUCH AS ALPHA 5630B1801
2. UNLESS OTHERWISE SPECIFIED:
   ALL RESISTORS ¼ W 5%
   ALL DIODES IN5393
   ALL TRANSISTORS NPN MPS6513
   ALL TRANSISTORS PNP MPS6517
   ALL POTENTIOMETERS ½ W 10%
   ALL CAPACITORS 100V 10%
   ALL CAPACITOR VALUES IN MICROFARADS
   ALL RESISTOR VALUES IN OHMS
   U1, U2, LM324
   ZENER DIODES D9, D16, D17, D21, D22, D24 – 1N4735A

◎ TB1
◉ TB2
⊛ TB3

C1042993 Rev B

**FIGURE 17. SCHEMATIC, MODEL 2453 W/RUN-STOP LOGIC (5 HP)**

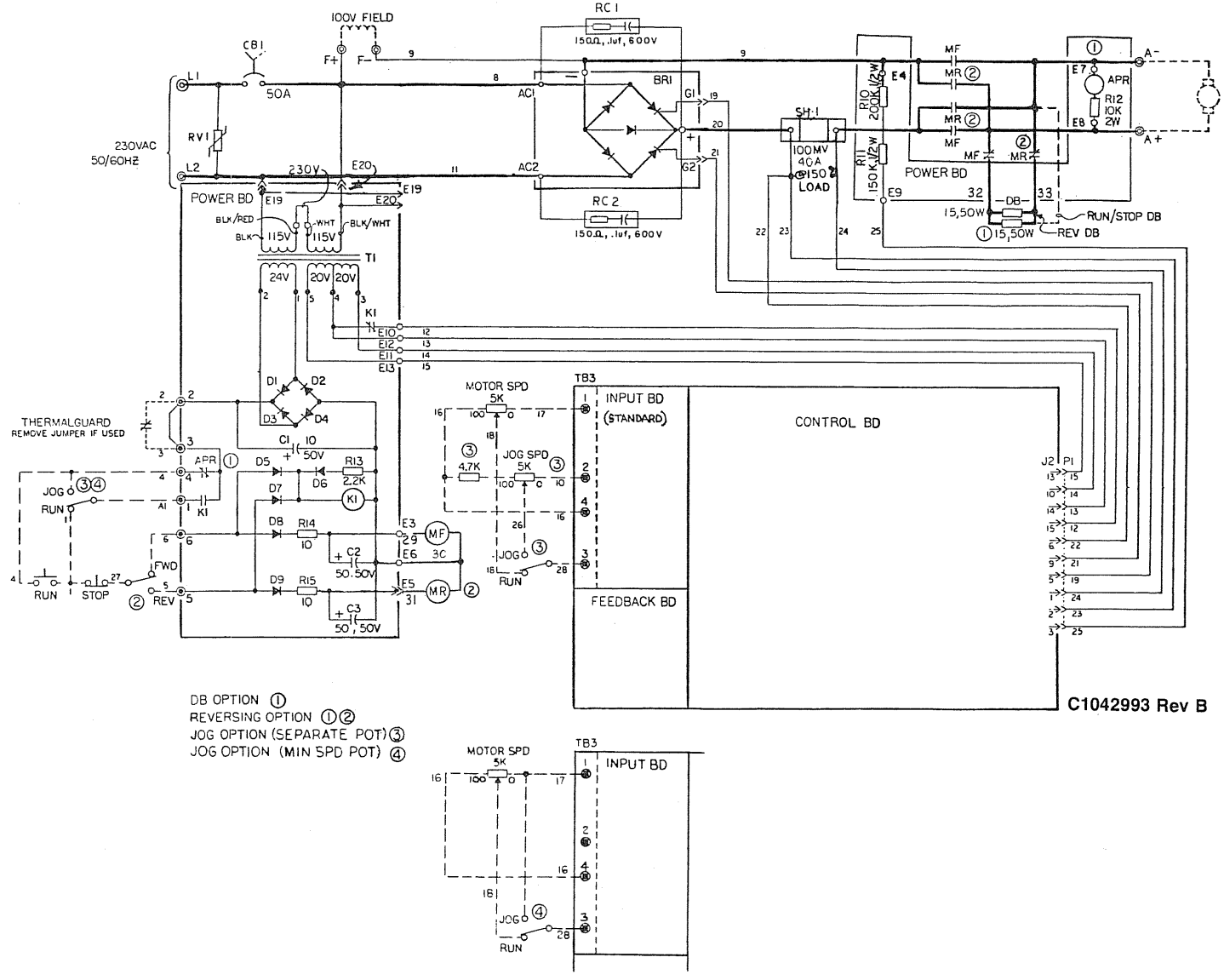



FIGURE 18. SCHEMATIC, MODEL 2453B W/DB-REVERSE-JOG OPTIONS (5 HP)

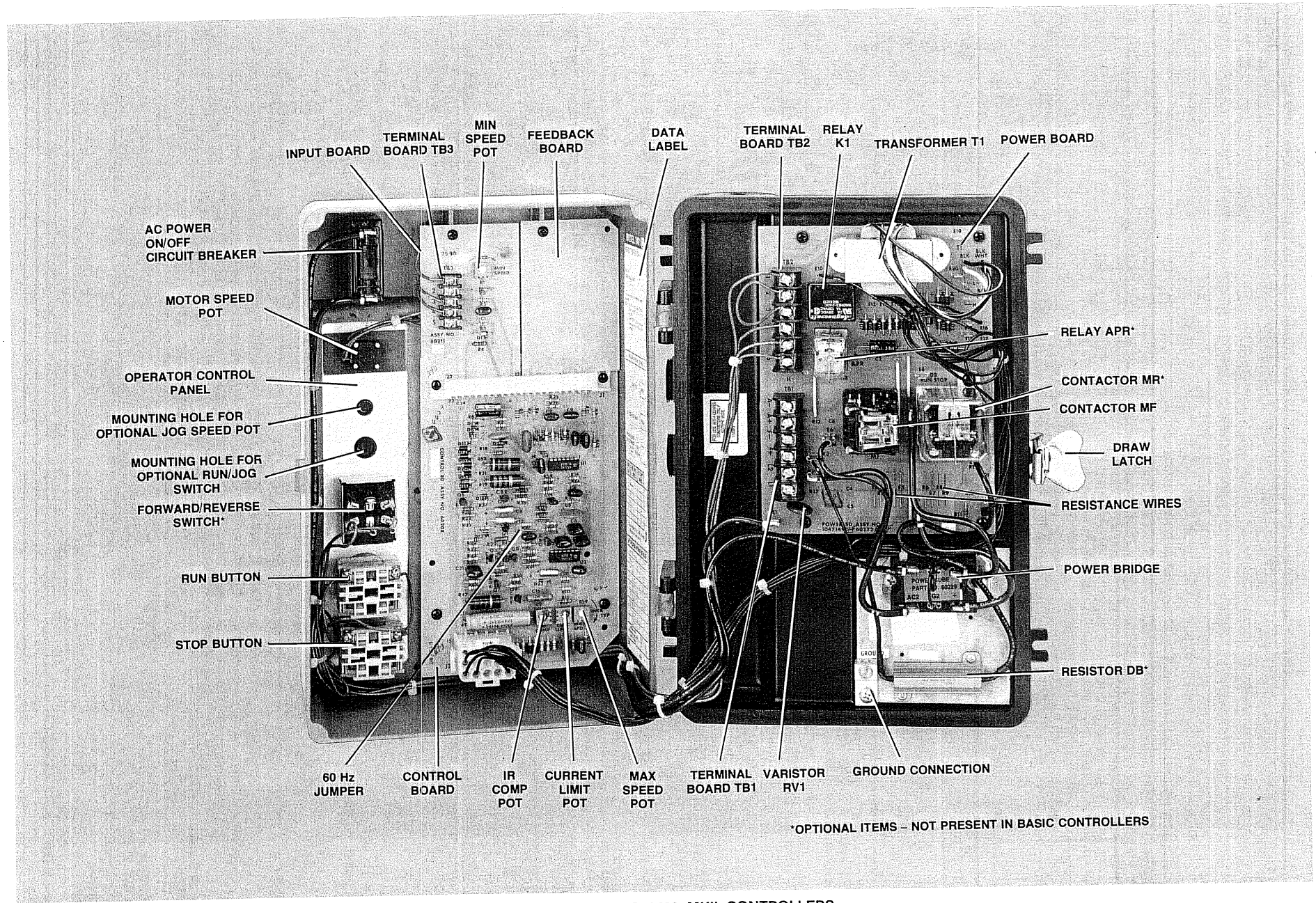



FIGURE 19. SERIES 2400 MKII CONTROLLERS

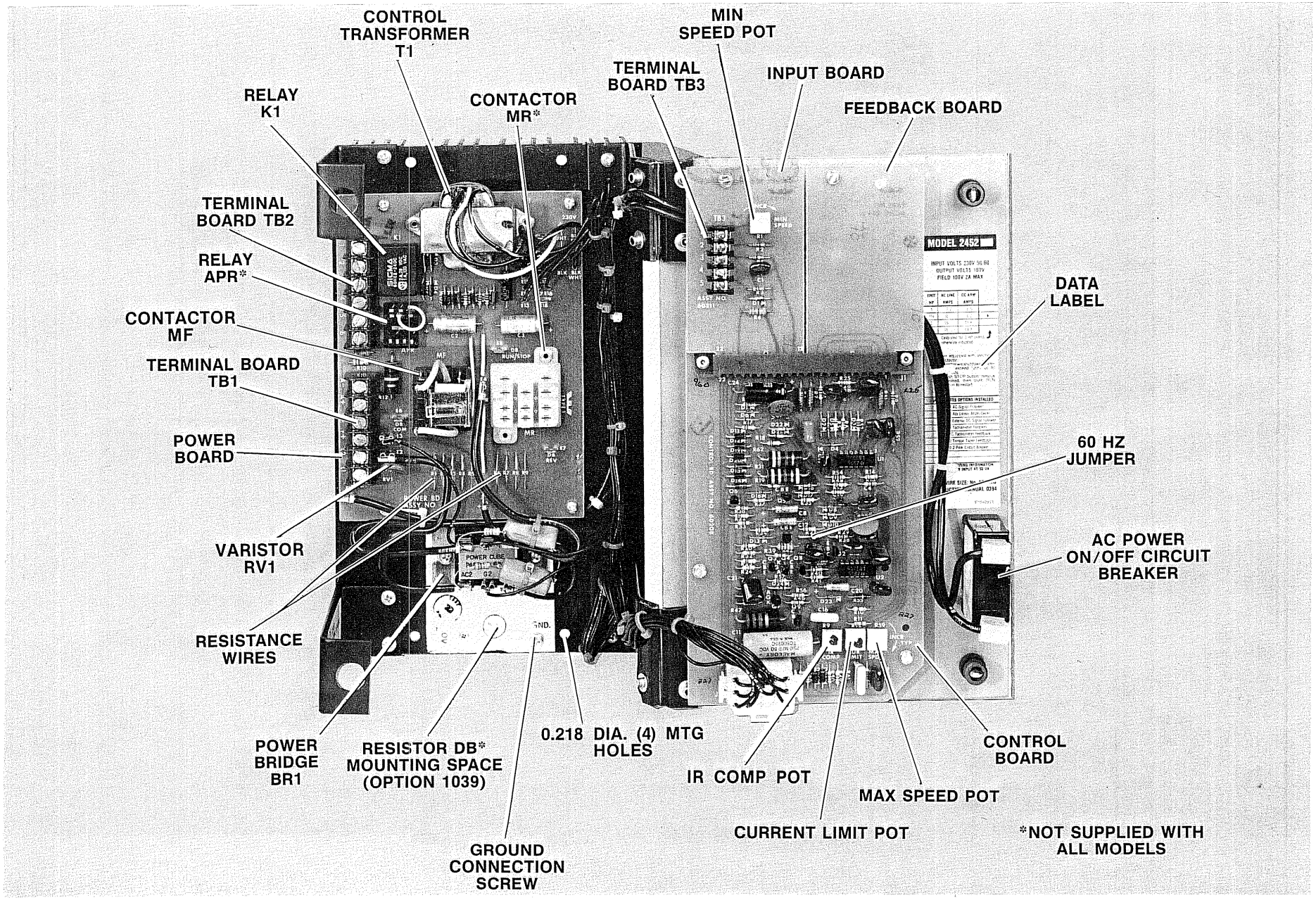



FIGURE 20. SERIES 2450 MKII CONTROLLERS, 1/6 - 3 HP

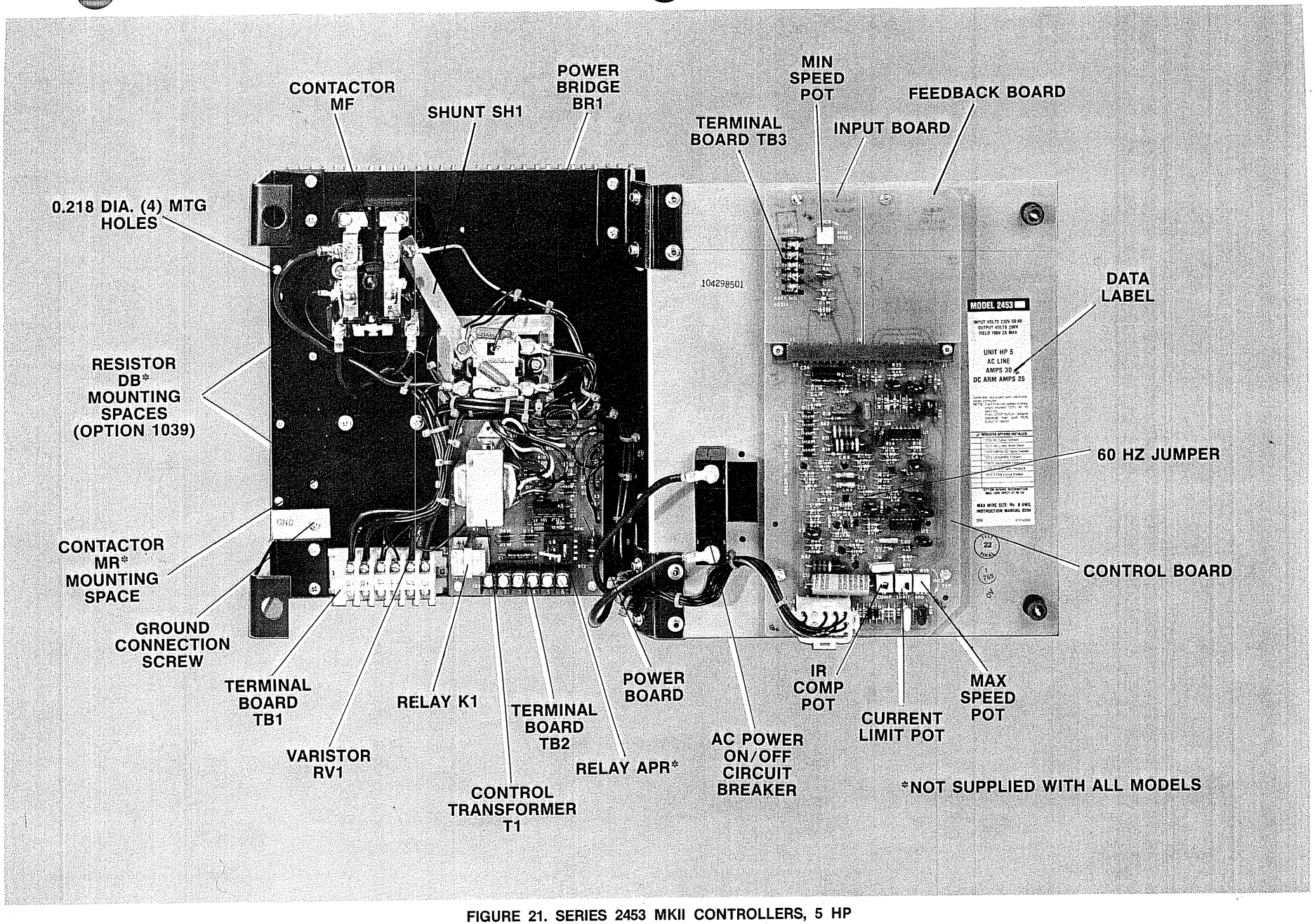



FIGURE 21. SERIES 2453 MKII CONTROLLERS, 5 HP