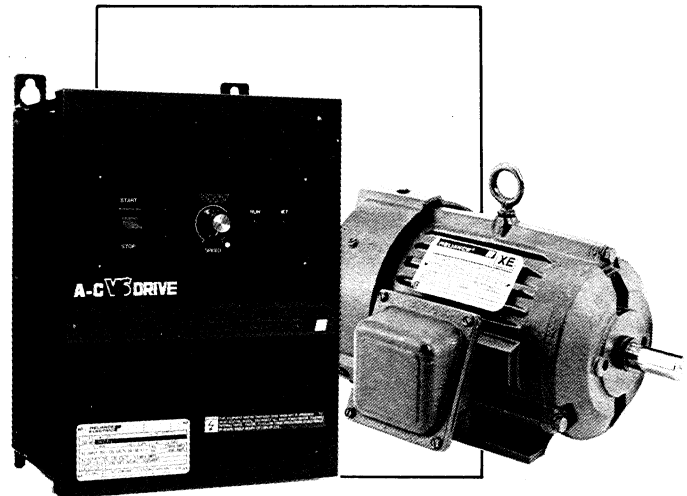


**Installing, Operating
and Maintaining
Single-Phase Input
Three-Phase Output
General Purpose GP-800
A-C V*S Drives**



**200, 208, 220, 230 VAC
1HP**

V*S[®] Reliance
Electric

DRIVES

Instruction Manual D2-3082-1

June 1987

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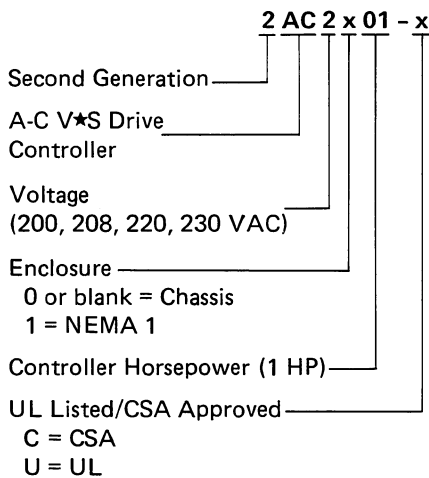
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1 : Receive and Accept the Controller

Identify the Controller

Each Reliance Electric GP-800 A-C V★S® Controller can be positively identified by its model number (standard controller) or sales order number (customer specified controller). This number appears on the shipping label and is stamped on the controller nameplate. Refer to this number whenever discussing the equipment with Reliance Electric personnel.

The standard model number describes the controller as follows:



The sales order number is a six-digit number following a plant code that uniquely describes a controller manufactured to customer specifications.

Receive and Accept the Shipment

Reliance Electric's terms of sales, in all instances, are F.O.B. point of origin. The user is responsible for thoroughly inspecting the equipment before accepting shipment from the transportation company.

If all the items called for on the bill of lading or on the express receipt are not included or if any items are obviously damaged, **do not** accept the shipment until the freight or express agent makes an appropriate notation on your freight bill or express receipt.

If any concealed loss or damage is discovered later, notify your freight or express agent within 15 days of receipt and request that he make an inspection of the shipment. Keep the entire shipment intact in its original shipping container.

The Consignee is responsible for making claim against the Carrier for any shortage or damage occurring in transit. Claims for loss or damage in shipment must not be deducted from the Reliance Electric invoice, nor should payment of the Reliance® invoice be withheld while awaiting adjustment of such claims since the Carrier guarantees safe delivery.

If considerable damage has been incurred and the situation is urgent, contact the nearest Reliance Electric Sales Office for assistance.

Store the Controller until Installation

After receipt inspection, repack the GP-800 A-C V★S Controller in its shipping container until installation. If a period of storage is expected, store in the original shipping container with its internal packing.

To ensure satisfactory drive operation at startup and to maintain warranty coverage, store the equipment:

- in its original shipping container in a clean, dry, safe place.
- within an ambient temperature range of -40° to 65°C (-40° to 149°F).
- within a relative humidity range of 5 to 95% without condensation.
- away from a highly corrosive atmosphere. In harsh environments, cover the shipping/storage container.
- away from construction areas.

File a Return Request

1. To return equipment, send a written request to Reliance Electric within ten days of receipt.
2. Do not return equipment without a numbered authorization form (ERA form) from Reliance Electric.
3. Reliance Electric reserves the right to inspect the equipment on site.

2 : Know the Controller

Terminology Used in This Manual

Definitions and Abbreviations

CCW: The abbreviation for counter-clockwise.

Controller: The term substituted throughout this manual for "GP-800 A-C V★S Drive Controller" to make the manual easier to read and understand.

CW: The abbreviation for clockwise.

Drive: The reference to the controller and the motor combined as one system.

GP-800 A-C V★S Drive Controller: See "controller."

IET: The abbreviation for instantaneous electronic trip.

NEC: The abbreviation for the National Electrical Code.

Pot: The shortened reference for potentiometer.

PS Transformer: The shortened reference to the power supply transformer.

PWM: The abbreviation for Pulse Width Modulation.

Dangers, Warnings, and Cautions

Dangers, warnings, and cautions point out potential trouble areas. All three of these forms are enclosed in a box to call attention to them.

- A **danger** alerts a person that high voltage is present which could result in severe bodily injury or loss of life.
- A **warning** alerts a person of potential bodily injury if procedures are not followed.
- A **caution** alerts a person that, if procedures are not followed, damage to, or destruction of, equipment could result.

Related Publications

For more information about the application and operation of this controller and related equipment and service, refer to these publications:

- "Long Term Storage for Control Cabinets" (D-8079)
- "GP-800 Data Sheet" (D-2752)
- "Selection and Application of A-C V★S Drives" (D-9084)
- "A-C Motor Efficiency" (B-7087)
- "Duty Master Energy Efficient XE A-C Motors" (B-2639)
- "Installation, Operation and Care of Reliance Standard Integral Horsepower Induction Motors" (B-3620)

These publications are available through your Reliance Electric Sales Office.

Drive Components

The Reliance Electric drive consists of a controller with local operator controls and a three-phase A-C motor. When purchased as a drive system, the GP-800 Controller is performance-matched with a Reliance Duty Master® XE Motor. See Figure 2-1. The controller and/or motor can be purchased separately.

Operator: Control Devices. The enclosed controller is equipped with a Standard Function Local Operator's Control Station mounted on the front of the enclosure (Figure 2-1). This station provides a Speed pot and a Start/Stop switch and includes a provision for an optional Forward/Reverse switch. The chassis controller option is provided with a Blank Local Operator's Control Station. Both of these stations include two LEDs: RUN and IET.

Duty Master is a registered trademark of Reliance Electric Company.

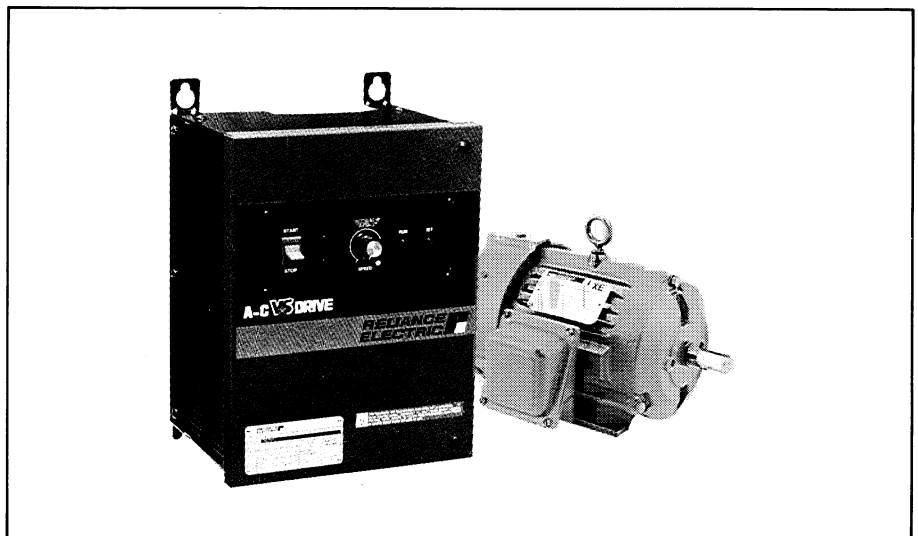


Figure 2-1. Typical A-C V★S Drive Package.

Locate Important Controller Components

The following list of components are important to the installation and startup of the controller. They are located on the controller in Figure 2-2.

- 1P (maximum hertz pot)
- 2P (acceleration/deceleration pot)
- 3P (torque boost pot)
- Bus Charge LED
- Chassis Ground
- Control Fuse (3FU)
- D-C Bus Voltage Check Terminals (+147, -45)
- Input Fuses (1FU, 2FU)
- Input Terminals (181, 182)
- Output Terminals (601, 602, 603)
- Regulator Board
- Remote Operator's Control Station Terminal Board (2TB)
- Voltage Select Fast-ons

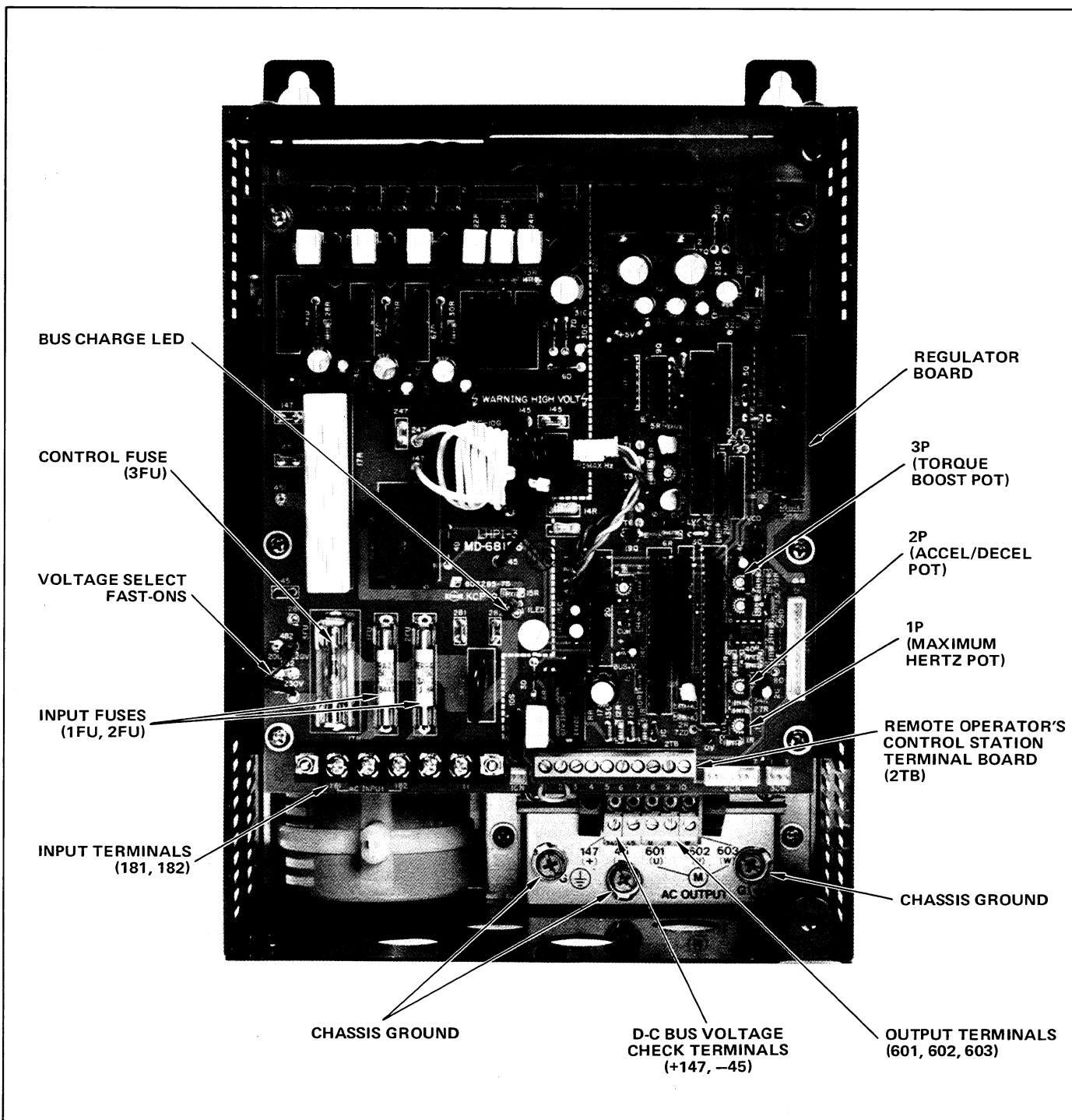


Figure 2-2. Locating Important Controller Components.

Controller Features

- Two LEDs, located on the Local Operator's Control Station, indicate the drive status (RUN) and a fault condition (IET).
- A Bus Charge LED, located on the regulator, provides status of the D-C bus capacitor voltage.
- Line transient protection prevents power line transients from harming the controller.
- Line-to-line and line-to-ground output short circuit protection.
- Standard fuses for easy replacement.
- IET on high D-C bus voltage, high motor current, high or low input A-C line, or function loss input.
- Isolated start/stop and function loss circuitry.
- Local devices (standard) for speed and start/stop control. Refer to Table 2-1 for available control options.
- Coast-to-rest on Stop.
- Torque boost for increased starting torque.
- Single board, hybrid-based regulator.
- Adjustment pots for maximum hertz (1P), acceleration/deceleration (2P), and torque boost (3P).
- NEMA 1 enclosure (standard); chassis available as an option.
- Operates with standard off-the-shelf NEMA B and synchronous motors.
- Other features available; contact your Reliance Electric Sales Office for information.

Available Controller Options

This controller is designed to accept the pre-engineered options listed in Table 2-1. The options can be added either at the factory or in the field. Each option is packaged separately and has its own model number identification. Installation instructions are provided with each option.

Operator's Control Stations

There are three NEMA 1 control stations available:

- **Standard Function Local Operator's Control Station**, which includes a Start/Stop switch, a Speed pot, a RUN LED, an IET LED, and a provision for the Forward/Reverse switch. This station is shipped with the enclosed controller.
- **Blank Local Operator's Control Station**, which includes a RUN LED and an IET LED. This station is shipped with the chassis controller.
- **Remote Operator's Control Station**, which includes a Start/Stop switch, a Speed pot, and a provision for the Forward/Reverse switch. Whenever a remote station is used, a Blank Local Operator's Control Station must be installed on the enclosed controller.

Forward/Reverse Switch

This option includes a Forward/Reverse switch and a PC board. The switch mounts on the Standard Function Local Operator's Control Station or on the Remote Operator's Control Station. The PC board has a connector that connects to the regulator.

Voltmeter

The voltmeter connects directly to the output of the controller. It measures 0 to 250 VAC.

Ammeter

The ammeter, using a current transformer as its input, measures current in one of the output lines of the controller. The ampere scale depends on the controller rating.

Frequency Meter (Analog)

The frequency meter monitors the controller output terminals. It indicates actual output frequency of the controller.

Controller Specifications

Controller Ratings

- Horsepower rating: 1 HP
- Operates at 50 Hz or 60 Hz line frequency
- Operates on single-phase, 230 A-C line voltage (factory set) or 200, 208, and 220 VAC by changing a fast-on on the regulator.

The controller provides the following output:

- Three-phase power
- Variable voltage from 0 to 230 VAC (or 0 to 200, 208, and 220 VAC)
- Variable frequency from 3 to 60 Hz

Table 2-1. Standard Kit Options.

Description	Model Number	Instruction Sheet
Local Operator's Control Station Kit • Blank • Standard Function	1LS2008 1LS2009	D2-3091 D2-3091
Remote Operator's Control Station NEMA 1 Start/Stop, Speed Pot	1RS2001	D2-3091
Forward/Reverse Selection Kit	1FR2000	D2-3091
Voltmeter	1VM2000	D2-3071
Ammeter	1AM2002	D2-3073
Frequency Meter	1FM2000	D2-3072

Service Conditions

- Ambient temperature: 0° to 40° C (32° to 104° F) for enclosed controllers and 0° to 55° C (32° to 131° F) for chassis controllers.
- Storage temperature: -40° to 65° C (-40° to 149° F)
- Atmosphere: 0 to 95% non-condensing relative humidity
- Elevation: To 3300 feet (1000 meters) above sea level without derating. For every 300 feet (91.4 meters) above 3300 feet, derate the current rating by 1%. Consult your Reliance Electric Sales Office for operation above 10,000 feet.
- Line frequency: 50/60 Hz $\pm$ 2 Hz
- Line voltage variation: -5% to +10%
- A-C line distribution system capacity (maximum): 500 KVA, three-phase with 25,000 amps symmetrical fault current capacity (289 KVA, single-phase).
- Controller efficiency data: Refer to Table 2-2.

Controller Application Data

Pulse Width Modulation (PWM): sine wave

Service Factor: 1.0

Displacement Power Factor: 0.96

Maximum Load: 150% for one minute

Volts/Hz (60 Hz base): 3.83 V/Hz

IET: 175% load

Speed reference to output frequency (linearity): $\pm$ 1%

Maximum Frequency: 15 to 90 Hz

Minimum Frequency: 3 Hz

Acceleration/Deceleration Adjustment: 2 to 60 seconds

Voltage Offset (RMS): 0 to 40 volts

The controller and motor must be sized for the specific application load and speed requirements. Refer to "Selection and Application of A-C V*S Drives" (D-9084) for assistance.

Controller Input KVA: 2.4

Max Input Amps:
200, 208, 220 VAC: 12.1
230 VAC: 10.6

Max Controller Output KVA: 1.8

Max Motor Sine Wave Amps: 4.1⁽¹⁾

Max Controller Output Amps (including harmonics): 4.5

- (1) To obtain motor nameplate horsepower, the controller's sine wave output ampere rating should be equal to or greater than the motor nameplate current. If the motor nameplate amperes are higher than the controller sine wave rating, the motor horsepower should be derated by the ratio of the controller sine wave ampere rating to the motor nameplate current.

Multi-motor Applications

One controller can run two or more motors. Adhere to the following requirements to assure correct drive operation:

When all the motors connected to the output of the controller are to start and stop at the same time, the sum of the sine wave currents of all the motors must be less than or equal to the maximum motor sine wave current rating of the controller.

When one or more of the motors connected to the output of the controller are to start and stop independently,

- Any motor that starts or stops while the controller is running must have a current rating less than 10% of the maximum motor sine wave current rating of the controller.
- The sum of the sine wave currents of all the motors connected continuously on the output of the controller and the locked rotor sine wave current of any motor which is to start and stop independently must be less than or equal to the maximum motor sine wave current rating of the controller.

Table 2-2. Typical Controller Efficiencies.

HP	Frequency (Hz)	Torque (%)	A-C V*S Drive Controller	A-C V*S Drive Controller with XE Motor
1	30	25	76.8	40.2
		50	82.5	56.3
		75	86.8	64.5
	45	50	85.2	62.8
		75	88.6	69.6
		100	89.5	70.9
	60	50	86.5	66.1
		75	90.0	72.5
		100	90.6	73.7

3 : Install the Drive

DANGER

ONLY QUALIFIED ELECTRICAL PERSONNEL FAMILIAR WITH THE CONSTRUCTION AND OPERATION OF THIS EQUIPMENT AND THE HAZARDS INVOLVED SHOULD INSTALL THIS EQUIPMENT. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

DANGER

THE USER IS RESPONSIBLE FOR CONFORMING TO THE NEC AND ALL OTHER APPLICABLE LOCAL CODES WITH RESPECT TO WIRING, GROUNDING, DISCONNECTS, AND OVERCURRENT PROTECTION. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

Plan and Complete the Installation

Read and understand this chapter in its entirety before beginning the actual installation. Follow these guidelines and procedures to minimize both installation and operating problems.

The controller is shipped standard as an enclosed unit, fully assembled in its own NEMA 1 enclosure. The chassis controller is shipped fully assembled for mounting in a NEMA 1 enclosure.

Select the Controller Enclosure Location

1. Verify that the controller can be kept clean, cool, and dry.
2. Check that the enclosure is away from oil, coolant, and other airborne contaminants.
3. Check that temperatures in the controller vicinity are between 0° to 40°C (32° to 104°F) for enclosed controllers and 0° to 55°C (32° to 131°F) for chassis controllers.
4. Check that relative humidity is between 5 and 95% (non-condensing).
5. Do not install above 3300 feet (1000 meters) without derating. For every 300 feet (91.4 meters) above 3300 feet, derate the current rating 1%. Consult your Reliance Electric Sales Office for operation above 10,000 feet.

Install the Controller

Enclosed Controller

1. In the location selected, mount the enclosed controller vertically with the input/output terminals at the bottom.
2. Make sure the door or other components do not hinder service access. See Figure 3-1 for mounting dimensions.
3. Provide adequate clearance for air ventilation:
 - At least 2 inches from the sides and 4 inches from the top and bottom of the controller to adjacent non-heat producing equipment, such as a cabinet wall.
 - At least 2 inches from the sides and 10 inches from the top and bottom of adjacent controllers. For the best air movement with three or more controllers, do not mount the controllers in a vertical stack; offset the controllers.

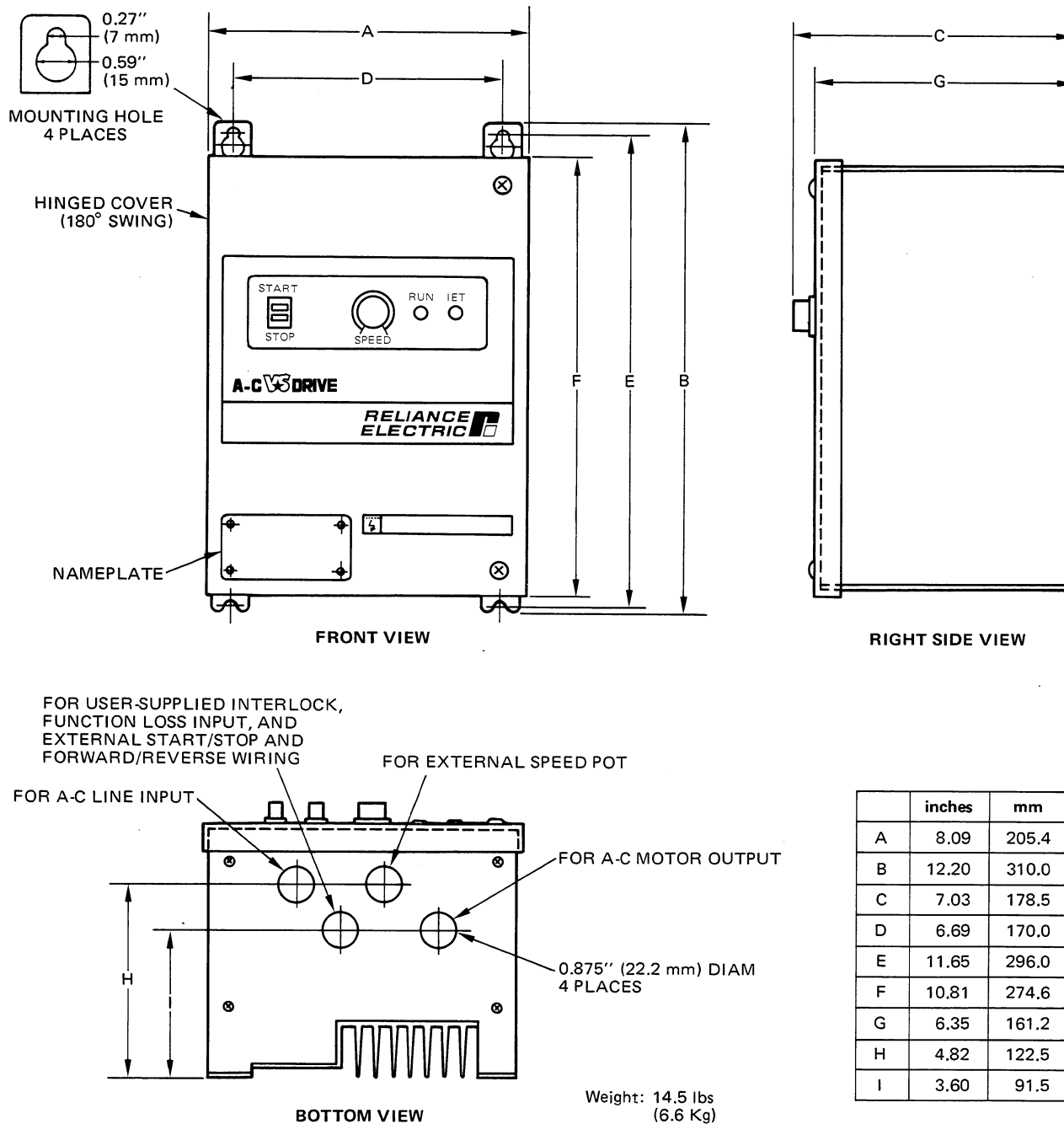


Figure 3-1. Physical Dimensions and Weights for Controller in NEMA 1 Enclosure.

Chassis Controller

CAUTION: Complete all drilling, cutting, welding, etc., before mounting the chassis in the metal enclosure. During installation protect the chassis from metal chips, weld splatters and other debris. Failure to observe these precautions could result in damage to, or destruction of, the equipment.

1. In the location selected, mount the metal enclosure in which the chassis will be mounted. If the enclosure is totally enclosed, size the metal enclosure using the following equation along with Table 3-1:

$$S = S_s + \frac{4}{3}S_t + \frac{2}{3}S_b \quad (1)$$

where:

S_s = Area of enclosure's four side surfaces

S_t = Area of enclosure's ceiling surface

S_b = Area of enclosure's bottom surface

- (1) If a surface does not have at least a 1/2" layer of air beside it, it does not have any cooling effect. Use a zero area in the equation for any such surface.

For example, if you want to enclose a chassis in an enclosure that is 30" high by 20" wide by 16" deep and the back side is 1/2" off the mounting wall, solve the equation and verify the answer with the Table 3-1 specifications.

$$\begin{aligned} S &= 2(30 \times 20) + 2(30 \times 16) + \\ &\quad \frac{4}{3}(320) + \frac{2}{3}(320) \\ &= 2800 \text{ sq. in.} \end{aligned}$$

Referring to Table 3-1, note that one controller requires 2.8 times 10^3 or 2800 sq. in. of surface area. The example enclosure meets the size requirements.

2. Mount the chassis directly to the enclosure mounting panel. Stand-off hardware is not necessary. See Figure 3-2 for mounting dimensions.

3. Provide adequate clearance for air ventilation within the enclosure:
 - At least 2 inches from the sides and 4 inches from the top and bottom of the controller to adjacent non-heat producing equipment, such as a cabinet wall.

- At least 2 inches from the sides and 10 inches from the top and bottom of adjacent controllers. For the best air movement with three or more controllers, do not mount the controllers in a vertical stack; offset the controllers.

Table 3-1. Sizing the Metal Enclosure That Will House the Chassis.

Controller Quantity	Power Loss (Watts)	Effective Surface (S) Area	
		sq. cm	sq. in.
1	100	1.8×10^4	2.8×10^3
2	200	3.6×10^4	5.6×10^3
4	400	7.2×10^4	11.2×10^3

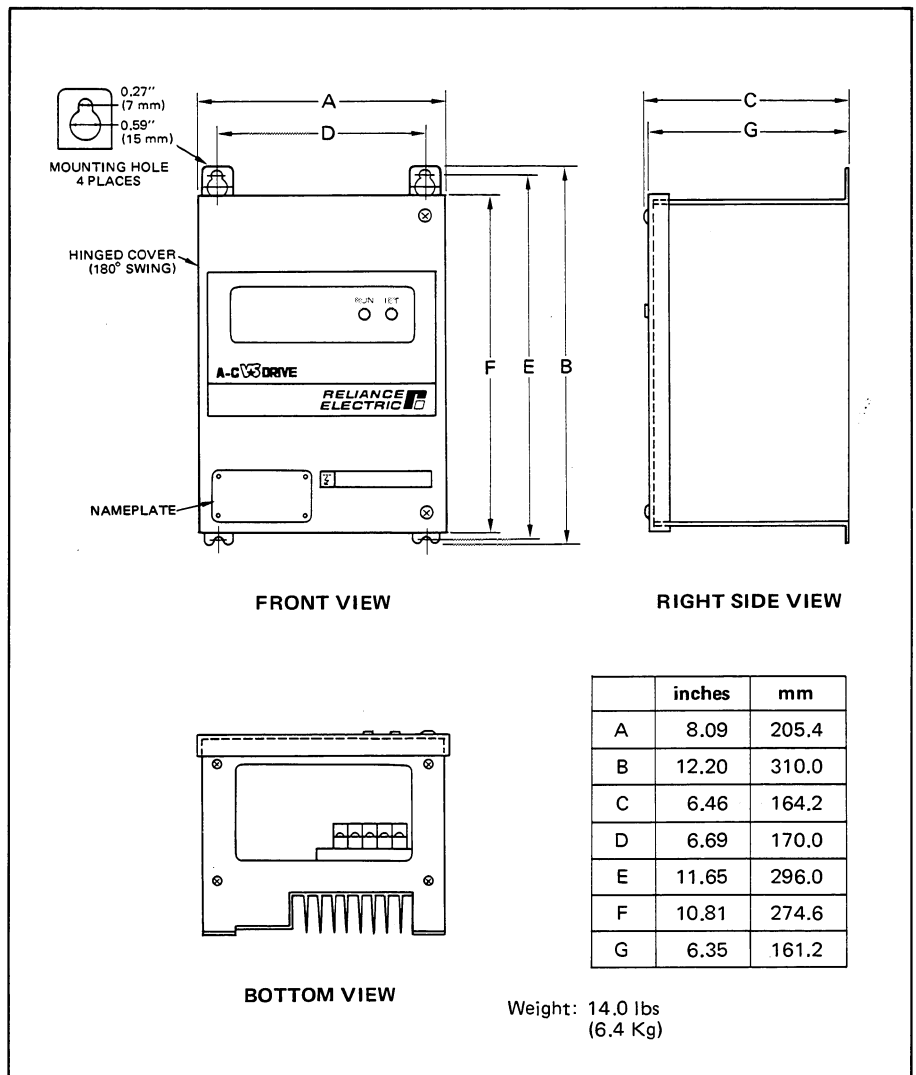


Figure 3-2. Physical Dimensions and Weights for Chassis Controller.

Install a Transformer (if needed)

In all applications requiring the use of an **output transformer**, contact your Reliance Electric Sales Office for assistance.

Input transformers step up or step down input voltage and can be either auto-transformers or isolation transformers. Isolation transformers help eliminate

- Damaging A-C line voltage transients from reaching the controller.
- Damaging currents, which could develop if a point inside the controller becomes grounded.

CAUTION: If an input transformer is installed ahead of the controller, a power disconnecting device must be installed between the power line and the primary of the transformer. If this power disconnecting device is a circuit breaker, the circuit breaker trip rating must be coordinated with the inrush current (10 to 12 times full-load current) of the input transformer. Do not connect an input transformer rated at more than 500 KVA to the controller. Distribution system capacity above the 500 KVA requires using an isolation transformer, a line reactor, or other means of adding similar impedance. Failure to observe these precautions could result in damage to, or destruction of, the equipment.

Install an Input Disconnect

DANGER
THE NEC REQUIRES THAT AN INPUT DISCONNECT BE PROVIDED IN THE INCOMING POWER LINE AND EITHER BE LOCATED WITHIN SIGHT OF THE CONTROLLER OR BE LOCKABLE. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

1. Install an input disconnect in the incoming power line according to the NEC. It must either be located within sight of the controller or be lockable.
2. Size the disconnect to handle the transformer primary as well as any additional loads the disconnect may supply.
3. Wire this disconnect in the primary circuit of the controller isolation transformer (if used).

Install the Motor

1. Verify the motor is the appropriate size to use with the controller.

Derate the A-C motor to compensate for additional heating in the motor caused by harmonics. Refer to D-9084 "Selection and Application of A-C V★S Drives" for application guidelines for constant torque loads. Refer to Table 3-2 for motor derating values for centrifugal loads.

2. Install the A-C motor according to its instruction manual.

3. According to NEC requirements, install an overload protection device responsive to motor current in each power line of the motor (motor overload relay) or verify that a thermal protection device responsive to motor heat is built into or connected to the motor windings.

If the motor will be operated at speeds below one half the motor's rated speed, use the thermal responsive type of protection device because it monitors the actual temperature of the motor windings. The motor overload relay may not protect the motor because of the reduction in motor cooling action due to the reduced speed.

4. Make sure the motor is properly aligned with the driven machine to minimize unnecessary motor loading from shaft misalignment.
5. If the motor is accessible while it is running, install a protective guard around all exposed rotating parts.

Table 3-2. Motor Derating Data for Centrifugal Loads.

Motor Insulation Class	Motor Service Factor	Motor Derating Percentage of Nameplate HP
B	1.0	15%
B	1.15	10%
F	1.0	5%
F	1.15	0%

Ground the Controller and Enclosure, Motor, Remote Operator's Control Station, and Transformer

DANGER
THE USER IS RESPONSIBLE TO MEET ALL CODE REQUIREMENTS WITH RESPECT TO GROUNDING ALL EQUIPMENT. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

1. Open the enclosure door by loosening the two screws.
2. Run a suitable equipment grounding conductor or bonding jumper **unbroken** from the chassis GND terminal (Figure 2-2) to the grounding electrode conductor (earth ground).
3. Connect a suitable equipment grounding conductor or bonding jumper to the motor frame, the remote operator's control station (if used), the power transformer (if used), and the controller enclosure. Run this conductor or jumper **unbroken** to the grounding electrode conductor (earth ground).
4. If the secondary of the PS transformer needs to be grounded, connect a grounding conductor to terminal 1TB-11. See Figure 6-9.

Suppress Electrical Noise

Electrical noise from nearby relays, solenoids, or brake coils can cause erratic drive behavior. To keep this from happening, add an R-C suppressor, such as Reliance part 600686-33A, across the coils of these devices. If the circuit is 115–230 VAC, a 220-ohm, 0.5 watt resistor in series with a 0.5 microfarad, 600-volt capacitor can be used as the suppressor.

Wire the Drive

1. Verify that the input power to the controller corresponds to the controller nameplate voltage and frequency and that the plant supply is of sufficient ampacity to support the input current requirements of the controller.
2. Verify the voltage select fast-on on the regulator is in the correct position:
 - 230 VAC (factory set): 382 (common) to 582
 - 200, 208, 220 VAC: 382 (common) to 482

CAUTION: If the voltage select fast-on position does not correspond to the input line voltage, the incorrect voltage is applied to the PS transformer and an IET could result from a variation in line voltage within the +10% and –5% range. Failure to observe this precaution could result in damage to, or destruction of, the controller.

3. Provide a transformer between the plant power supply and the controller if the correct input line voltage is not available. Refer to "Provide a Transformer" in this chapter.
4. Use a tightening torque of 9 to 11 in-lbs for wire connections to input terminals, 8 in-lbs to output terminals, in the controller.

Power Wiring

Size and install all wiring in conformance with the NEC and all other applicable local codes.

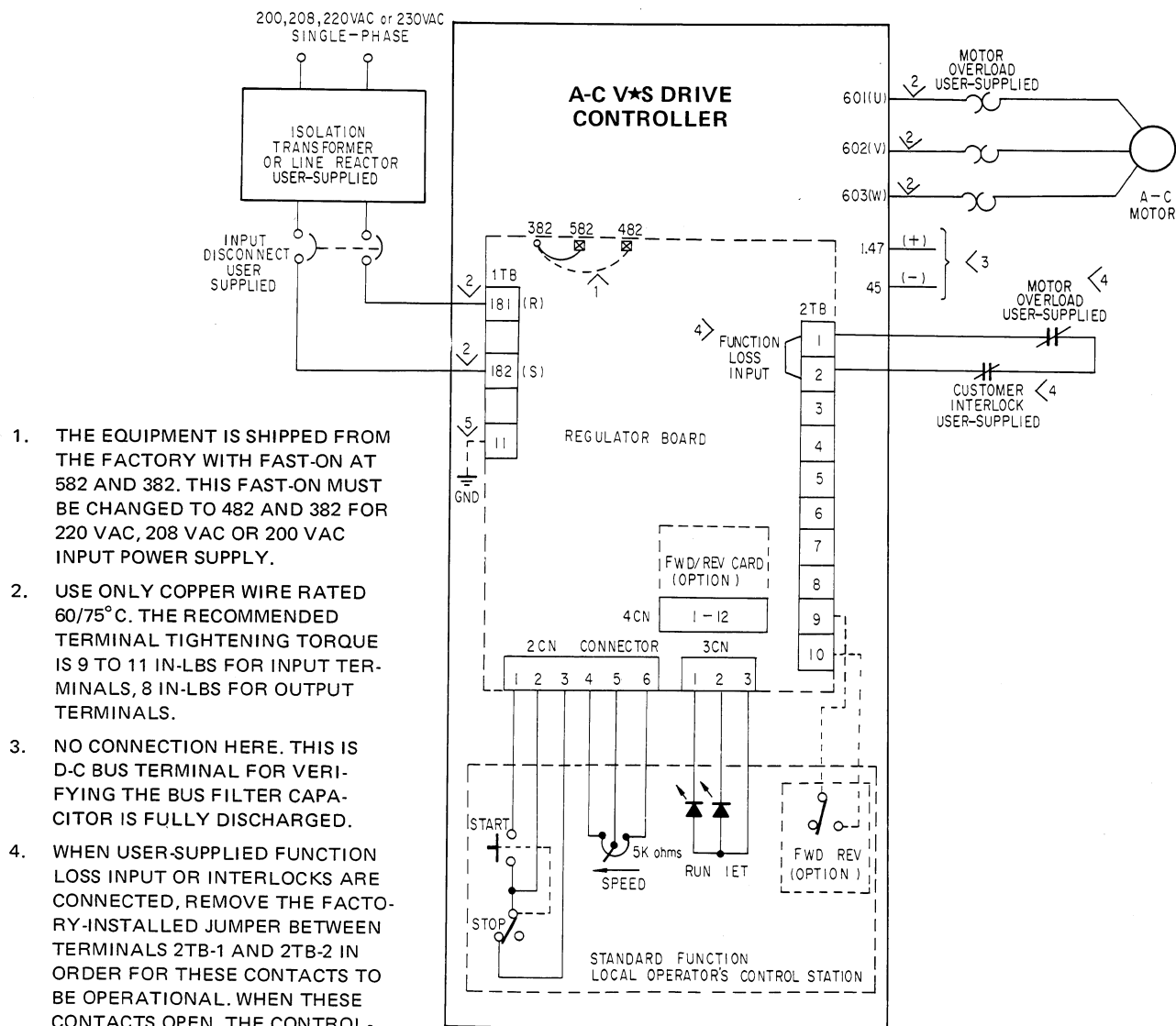
1. Use only copper wire rated 60/75°C.
2. Size input and output power wiring, according to applicable codes, to handle the maximum controller current as listed under "Controller Current Information" in Chapter 2.
3. Install the power wiring according to the interconnection diagram (Figure 3-3 or 3-4).
4. Route A-C input leads through the bottom left front opening of the controller (Figure 3-1) to terminals 181 and 182.
5. Route motor leads through the bottom right rear opening of the controller (Figure 3-1) to terminals 601, 602, and 603.

Control and Signal Wiring

Size and install all wiring in conformance with the NEC and all other applicable local codes.

1. Use twisted wire having two to three twists per inch. If you use shielded wire rather than twisted wire, the shields should not attach to any ground point; they should "float."
2. For distances of less than 150 feet, use a minimum of #22 AWG. For distances of more than 150 feet and less than 300 feet, use a minimum of #16 AWG. For distances of more than 300 feet, contact your Reliance Electric Sales Office.
3. If a separately mounted operator's control station or a Remote Operator's Control Station is required, disconnect the control devices from the Standard Function Local Operator's Control Station. Remove this control station panel and replace it with the Blank Local Operator's Control Station. Connect the LED connector (3CN) on this blank control station panel to 3CN on the regulator.
4. Wire control and signal wiring according to the interconnection diagram. Use Figure 3-3 (controller with a Standard Function Local Operator's Control Station) or Figure 3-4 (controller with a Remote Operator's Control Station).
5. Route user-supplied interlock and function loss input wiring (if any) through the left rear opening in the bottom of the controller. See Figure 3-1. Remove the factory-installed jumper between terminals 2TB-1 and 2TB-2.

WARNING
IF THE FACTORY-INSTALLED JUMPER IS NOT REMOVED WHEN FUNCTION LOSS INPUT OR INTERLOCKS ARE USED, THESE CONTACTS WILL NOT OPEN TO STOP THE CONTROLLER ON AN IET. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.



WARNING
IF THE FACTORY-INSTALLED JUMPER IS NOT REMOVED WHEN FUNCTION LOSS INPUT OR INTERLOCKS ARE USED, THESE CONTACTS WILL NOT OPEN TO STOP THE CONTROLLER ON AN IET. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

5. THIS IS AN OPTIONAL GROUNDING CONNECTION FOR THE PS TRANSFORMER. IF REQUIRED, CONNECT GROUND WIRE TO TERMINAL 1TB-11.

Figure 3-3. Interconnection Diagram of Controller with Standard Function Local Operator's Control Station.

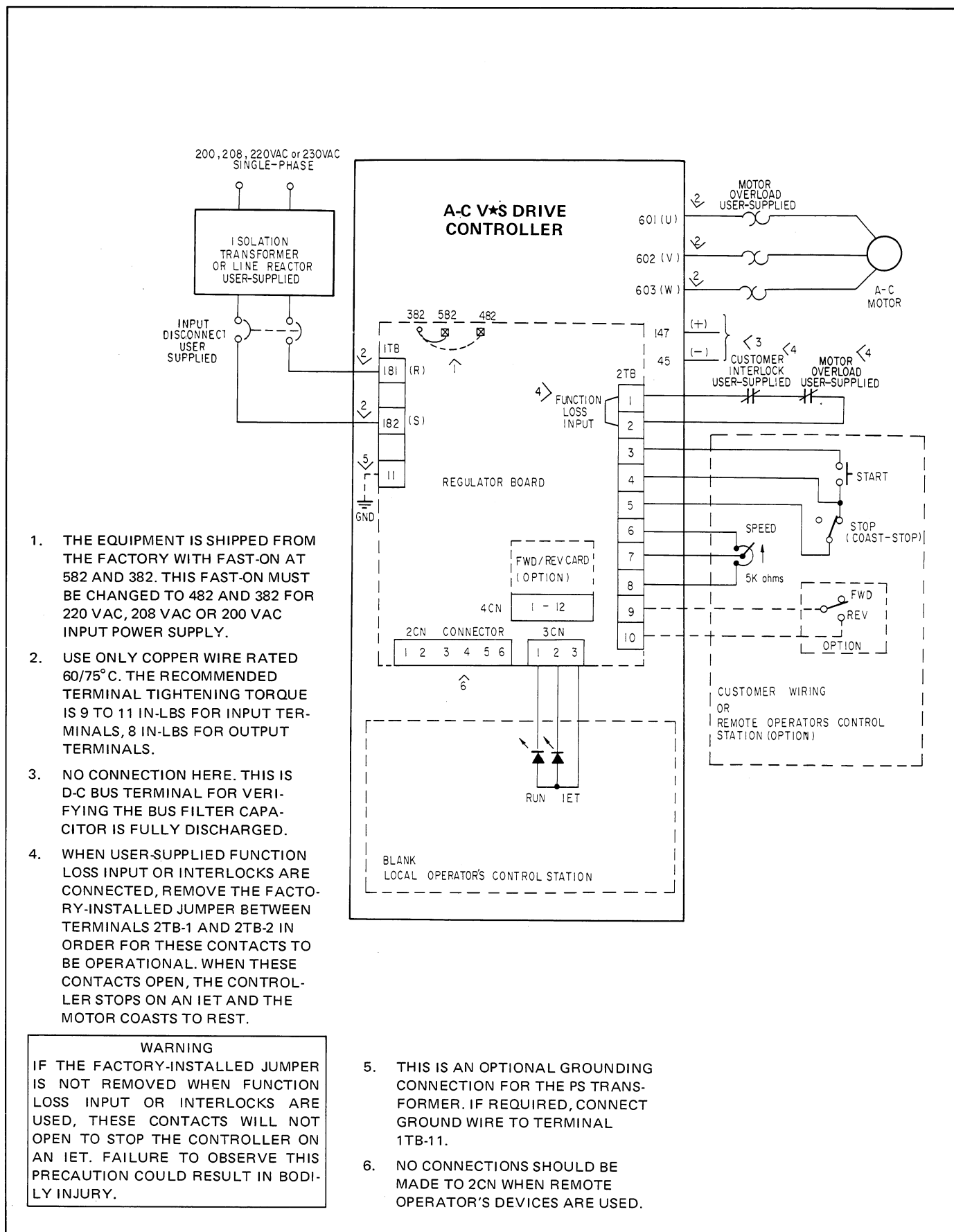


Figure 3-4. Interconnection Diagram of Controller with Remote Operator's Control Station.

6. Route external start/stop and forward/reverse control wiring (isolated from the logic circuit) through the left rear opening in the bottom of the controller in separate steel conduit to eliminate electrical noise pick-up. The conduit can be rigid steel or flexible armored steel. See Figure 3-1.
7. Route external speed pot wiring (not isolated from the logic circuit) through the right front opening in the bottom of the controller in a separate steel conduit to eliminate electrical noise pick-up. The conduit can be rigid steel or flexible armored steel. See Figure 3-1. Note that the Speed pot must be 5K ohms and 0.5 watt minimum.
8. Do not route signal wire through junction or terminal boxes that contain power or control wire.
9. Do not route signal wire in close proximity to devices producing external magnetic fields.

WARNING
THE USER IS RESPONSIBLE FOR ENSURING THAT DRIVEN MACHINERY, ALL DRIVE-TRAIN MECHANISMS, AND PROCESS LINE MATERIAL ARE CAPABLE OF SAFE OPERATION AT AN APPLIED FREQUENCY OF 90 HZ TO THE A-C MOTOR. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

10. To increase the minimum hertz above 3 Hz, add a resistor in series with the Speed pot as shown in Figure 3-5. Determine the value of the resistor using Figure 3-6. Note that minimum hertz depends on the setting of the 1P (maximum hertz) pot as well as the value of this additional resistor.
11. Close and secure the enclosure door if you will not be proceeding to the startup procedures at this time.

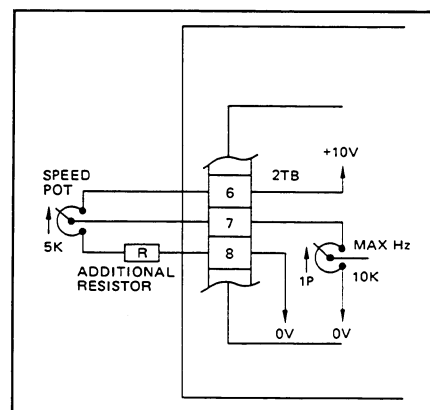


Figure 3-5. Modification for Minimum Hertz.

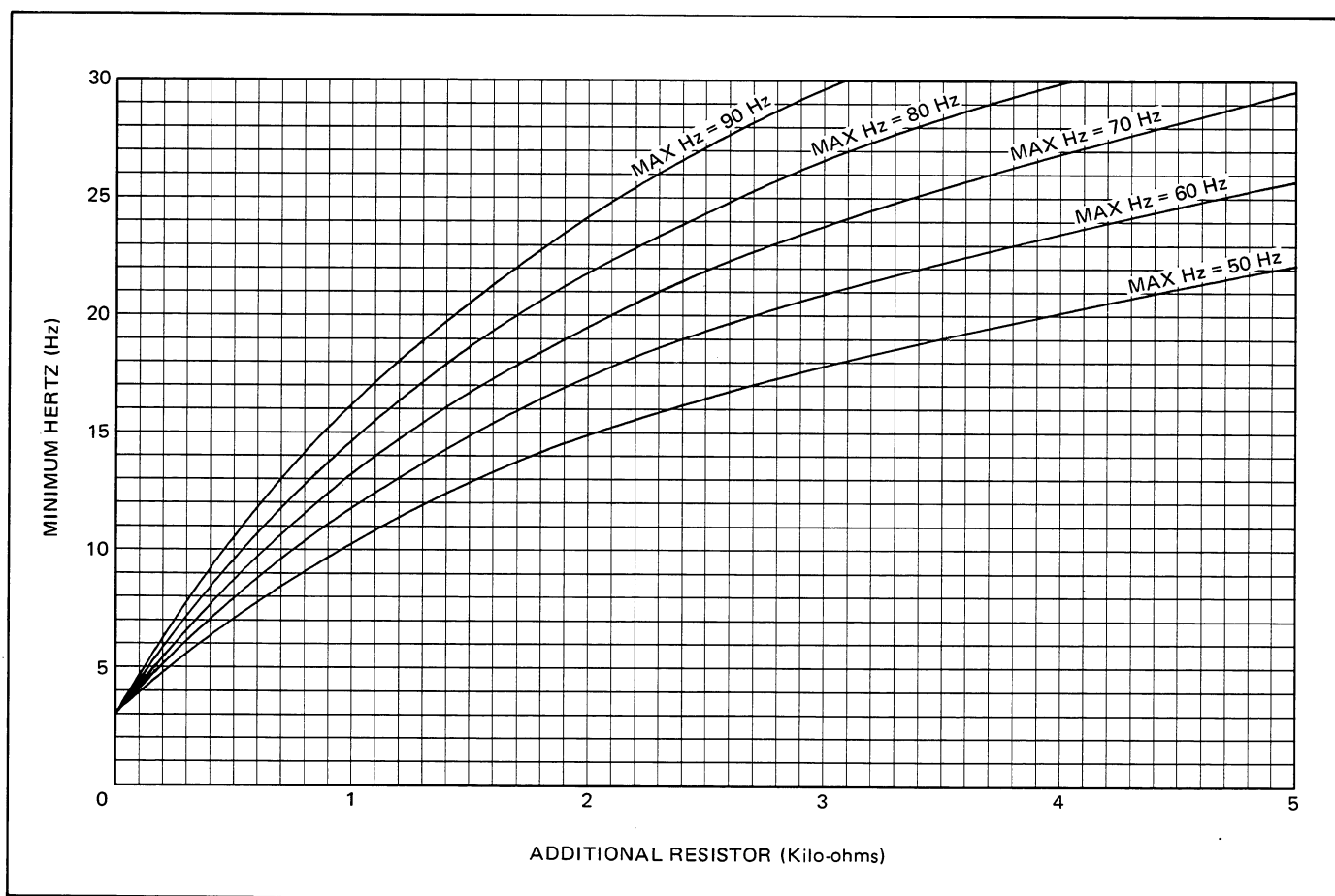


Figure 3-6. Minimum Hertz vs Additional Resistor

4 : Start and Adjust the Drive

DANGER
ONLY QUALIFIED ELECTRICAL PERSONNEL FAMILIAR WITH THE CONSTRUCTION AND OPERATION OF THIS EQUIPMENT AND THE HAZARDS INVOLVED SHOULD START AND ADJUST THIS EQUIPMENT. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

Test Equipment Needed

CAUTION: Do not use a megger to perform continuity checks in the drive equipment. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

1. Two volt-ohmmeters each having a sensitivity of 20,000 ohms-per-volt, such as a Triplet Model 630.
2. A volt-ohmmeter with a 10 meg ohm input impedance on all ranges, such as a Fluke 8022B. (This unit provides an accuracy of $\pm 15\%$ when measuring controller output voltage at terminals 601, 602, and 603.)

The most common voltmeters in use are digital and analog voltmeters. However, these two voltmeters use several different methods of measuring the RMS voltage of a waveform, thus producing a wide range of RMS readings for a particular PWM waveform.

A fundamental voltmeter is best suited for measuring output voltage of PWM waveforms because it filters out unwanted harmonics. An accurate measurement is important since the fundamental waveform is the main contributor to the power conducted to the motor. Therefore, in this manual, voltages given are fundamental voltages.

In comparison testing, the Fluke 8022B provides an RMS measurement nearly equivalent to that of the fundamental voltmeter; the Triplet 630 provides an RMS measurement that is 20 volts higher than that of the fundamental voltmeter.

Follow these guidelines when measuring the output voltage of this PWM controller:

- Keep voltmeter lead lengths as short as possible.
- When using an analog voltmeter, use the 250–300 VAC scale.
- When using a digital voltmeter, use the 200 VAC scale for measuring output voltages up to 200 VAC and the 750 VAC scale for measuring output voltages above 200 VAC.
- When using a Triplet 630 voltmeter, subtract 20 volts from the reading to determine the fundamental output voltage.
- When using a Fluke 8022B voltmeter, the meter reading can be used as an approximate fundamental voltage.

Check the Installation

DANGER
THIS EQUIPMENT IS AT LINE VOLTAGE WHEN A-C POWER IS CONNECTED TO THE CONTROLLER. DISCONNECT ALL UN-GROUNDED CONDUCTORS OF THE A-C POWER LINE FROM THE CONTROLLER. AFTER POWER IS REMOVED, VERIFY WITH A VOLT-METER AT TERMINALS 147(+) AND 45(–) THAT THE D-C BUS CAPACITORS ARE DISCHARGED BEFORE TOUCHING ANY INTERNAL PARTS OF THE CONTROLLER. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

1. Make sure the input disconnect is in the OFF position (power OFF).
2. Make sure the drive shutdown interlocks, such as safety switches installed around the driven machine, are operational. When activated, they should shut down the drive.

CAUTION: Make sure electrical commons are not intermixed when monitoring voltage and current points in the controller. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

Check the Motor

1. Verify that motor nameplate data corresponds to the controller output ratings:
 - Voltage: 200, 208, 220 VAC or 230 VAC; three-phase. If the motor has dual voltage capability, verify that it is connected for the voltage corresponding to the input voltage.
 - Current: Verify that full-load current does not exceed the controller's motor sine wave current rating. If the motor is over-framed, verify that the motor operating current does not exceed the controller's rated current and the motor horsepower rating is not more than one size larger than the controller's horsepower rating.
 - Frequency: 60 or 50 hertz or other frequency consistent with the controller output frequency.

For synchronous motor applications, consult your Reliance Electric Sales Office.

2. Check that the motor is installed according to the motor instruction manual.
3. Disconnect any power factor correction capacitors connected to the motor.
4. If possible, uncouple the motor from the driven machinery.
5. Rotate the motor shaft by hand to check that the motor is free from any binding or mechanical load problem.
6. Check that no loose items, such as shaft keys, couplings, etc., are present.
7. Check all connections for tightness and proper insulation.

8. Check that the any motor thermal switch or overload device is wired according to the interconnection diagram (Figure 3-3 or 3-4).

Motor Overspeed

WARNING

THE USER IS RESPONSIBLE FOR ENSURING THAT DRIVEN MACHINERY, ALL DRIVE-TRAIN MECHANISMS, AND PROCESS LINE MATERIAL ARE CAPABLE OF SAFE OPERATION AT AN APPLIED FREQUENCY OF 90 HZ TO THE A-C MOTOR. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

Check the Transformer (if used)

1. Check that the rating of the transformer (if used) matches the controller requirements. Refer to "Install a Transformer" in Chapter 3.
2. Check that the transformer is connected for the proper voltages.

Check the Controller and Enclosure

1. Open the controller enclosure door, if not already open.
2. Look for physical damage, remaining installation debris, wire strands, etc.
3. Use clean, dry, low pressure air (below 25 PSI) for removing debris from the controller.
4. Check that there is adequate clearance around the controller for air flow.
5. Check that the controller is wired according to the interconnection diagram (Figure 3-3 or 3-4).
6. Make sure the input power voltage is selected as desired: fast-on 382 to 582 for 230 VAC (factory set); or fast-on 382 to 482 for 200, 208, or 220 VAC.

7. Using a voltmeter, check that the selected power is available on the incoming line side of the input disconnect.
8. Check that all control and power terminal connections are tight (9 to 11 in-lbs torque for input terminal connections, 20 in-lbs torque for output connections).
9. Check that all fuses are in place and properly seated in the fuseholders.
10. Check the continuity of all fuses. If any fuse reads open, replace the defective fuse. Refer to Table 6-2 for fuse data.

Check Settings of Adjustment Pots

1. Make sure power is OFF.
2. Verify that the adjustment pots on the regulator are as listed in Table 4-1. The location of these pots are shown in Figure 4-1.
3. Do not adjust pots 4P, 5P, 6P, 7P, and 8P. They are factory set and sealed; any readjustment could degrade the performance of the controller.

Check the Grounding

DANGER

THE USER IS RESPONSIBLE TO MEET ALL CODE REQUIREMENTS WITH RESPECT TO GROUNDING ALL EQUIPMENT. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

1. Verify that a properly sized ground wire is installed between the chassis ground terminal, the controller enclosure, and a suitable earth ground and that the connections are tight.
2. With an ohmmeter, check for and eliminate any grounds between the input power leads to the chassis ground and between the output power leads to the chassis ground.
3. Verify that a properly sized ground wire is installed between the motor frame and a suitable earth ground and that the connections are tight.
4. With an ohmmeter, check for and eliminate any grounds between the motor frame and the motor power leads.
5. Verify that a properly sized ground wire is installed between the transformer (if used) and a suitable earth ground and that the connections are tight.
6. Verify the above ground wires are run **unbroken**.

Table 4-1. Controller Pot Adjustments.

Adjustment			Functional Description	Control Range	Initial Factory Setting
Name	Abbreviation	Pot			
Maximum Hertz	MAX HZ	1P	Sets maximum output frequency when Speed pot is fully clockwise.	15 to 90 Hertz	60 Hz
Acceleration Deceleration Rate	ACC/DEC	2P	Sets rate to accelerate from 3 Hz to maximum Hz and to decelerate from maximum Hz to 3 Hz.	2 to 60 seconds	20 sec
Torque Boost	T.BST	3P	Increases voltage at low frequency in order to increase motor starting torque. (1)	0 to 40 VAC	10 VAC

- (1) In most cases, adjustment is not necessary. Should the application require adjustment, turn the 3P pot slightly and check the performance of the controller over the entire normal load range. Remember that motor current cannot exceed 6.75 amps for more than one minute.

Start the Controller Purchased as Drive Package

Use this simplified procedure **only** when the controller and motor are purchased together as a drive package; otherwise, proceed to "Start the Controller Purchased Separately."

The controller is shipped with a NEMA B induction motor sized to the controller's horsepower rating and is pre-adjusted to operate this motor. In most cases, this startup procedure will locate any shipping damage, verify proper installation and field wiring, provide a second check of adjustments, and successfully start the controller.

1. Follow all of the "Check the Installation" procedures if not already performed.
2. Make sure all power is OFF.
3. Set a voltmeter on the 500 VDC scale or a similar high voltage scale. Connect the voltmeter to terminals 147(+) and 45(-).

Read this voltmeter every time you turn power OFF to verify the D-C bus capacitor is fully discharged. Within one minute after power is turned OFF, the bus voltage should measure about 50 VDC. The Bus Charge LED (red) on the regulator will gradually fade out as the voltage decreases to zero.

4. If the controller has been stored for less than six months, proceed to Step 5. If the controller has been stored for over six months, form the capacitor as follows:

DANGER

THE REMAINING STEPS TO FORM THE CAPACITOR ARE MADE WITH POWER ON. HAZARDOUS VOLTAGE EXISTS. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

- Turn the Speed pot fully CCW. Turn the power ON.
- Observe that the voltmeter reading gives the following D-C bus voltage with respect to the appropriate A-C input voltage:

A-C Input Voltage	D-C Bus Voltage
200 VAC	270 VDC
208 VAC	280 VDC
220 VAC	297 VDC
230 VAC	310 VDC

- Let the controller sit undisturbed for fifteen minutes while the capacitor charges. **Put a tag on the controller that power is ON and hazardous voltage exists.**
- Turn the power OFF. Verify the D-C bus voltage is zero (read the voltmeter).

5. With power OFF, connect the motor power leads, if not already connected, to the controller. Couple the driven equipment to the motor, if not already coupled.

DANGER

THE REMAINING STEPS ARE MADE WITH POWER ON. HAZARDOUS VOLTAGE EXISTS. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

6. Turn the Speed pot fully CCW. Turn the power ON.
7. Press the Start switch. Note: Do not press the Start switch while the motor is rotating. An IET trip will occur (The IET LED will light and the drive will stop.). Always wait for the motor to completely stop. To reset the controller after an IET, press the Stop switch and wait for the motor to completely stop.

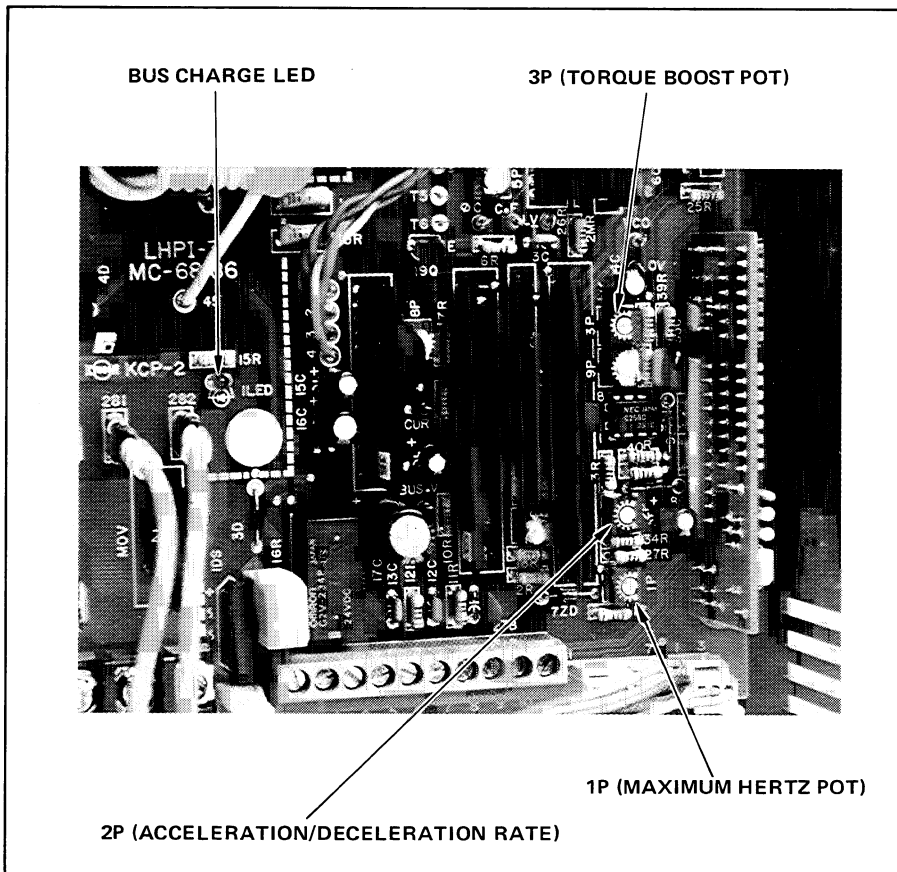


Figure 4-1. Regulator Pots and LEDs.

8. Turn the Speed pot slowly CW to check the motor shaft rotation. If shaft rotation is correct, go to Step 9. If shaft rotation is incorrect, change the motor shaft rotation direction as follows:

- Press the Stop switch and wait until the motor has completely stopped.
- Turn the power OFF.
- After verifying the D-C bus voltage is zero, reverse any two of the three motor power leads.
- Turn power ON and press the Start switch.

9. Run the drive across the speed range under load. If the drive operates satisfactorily, startup is complete.

If the motor draws unnecessarily high current, operation is unstable, or the motor does not break away when starting; proceed to "Start the Controller Purchased Separately" for more detailed startup instructions.

Minor user adjustments may be necessary for satisfactory operation. Refer to Steps 12 and 19 through 24 in "Start the Controller Purchased Separately" and Table 4-1.

10. Press the Stop switch.
11. Turn the input power OFF. After verifying the D-C bus voltage is zero, remove the voltmeter and any other instrumentation connected during startup.
12. Close and secure the controller enclosure door.

Start the Controller Purchased Separately

Use this startup procedure when you purchase the controller separately to use with an existing motor or a separately ordered motor. If any of the following steps cannot be made because of a controller problem, go to "Section 6, Troubleshooting," in this manual.

1. Follow all of the "Check the Installation" procedures if not already performed.
2. Make sure all power is OFF.
3. Set a voltmeter on the 500 VDC scale or a similar high voltage scale. Connect the voltmeter to terminals 147(+) and 45(−).

Read this voltmeter every time you turn power OFF to verify the D-C bus capacitor is fully discharged. Within one minute after power is turned OFF, the bus voltage should measure about 50 VDC. The Bus Charge LED (red) on the regulator will gradually fade out as the voltage decreases to zero.

4. Disconnect the motor power leads from the controller, if connected.
5. If the controller has been stored for less than six months, proceed to Step 6. If the controller has been stored for over six months, form the capacitor as follows:

DANGER
THE REMAINING STEPS TO FORM THE CAPACITOR ARE MADE WITH POWER ON. HAZARDOUS VOLTAGE EXISTS. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

- Turn the Speed pot fully CCW. Turn the power ON.

- Observe that the voltmeter reading gives the following D-C bus voltage with respect to the appropriate A-C input voltage:

A-C Input Voltage	D-C Bus Voltage
200 VAC	270 VDC
208 VAC	280 VDC
220 VAC	297 VDC
230 VAC	310 VDC

- Let the controller sit undisturbed for fifteen minutes while the capacitor charges: **Put a tag on the controller that power is ON and hazardous voltage exists.**
 - Turn the power OFF. Verify the D-C bus voltage is zero (read the voltmeter).
6. With power OFF, set a second voltmeter on the 500 VAC scale. Connect this voltmeter to any two of the three output power terminals (601, 602, and 603).
 7. With the Speed pot fully CCW, turn the power ON.
 8. Press the Start switch. The green RUN LED (Figure 4-1) should light. The controller output frequency is 3 Hz (fixed minimum). The second voltmeter should read about 10 VAC (fundamental output voltage preset with 3P).
 9. Gradually turn the Speed pot CW while reading the voltmeter. As the speed increases, the voltage increases. When the Speed pot reaches fully CW, the output voltage should about equal the input voltage. Output frequency should be 60 Hz. (If a resistor was added, see Figure 3-6.) Note: The output voltage of the PWM controller equals the fundamental voltage plus the harmonics.
 10. Quickly turn the Speed pot fully CCW. The voltage and frequency will decrease to 10 VAC and 3 Hz in about 20 seconds. (If a resistor was added, see Figure 3-6.)
 11. Quickly turn the Speed pot fully CW. The voltage and frequency will increase to the rated voltage and 60 Hz in about 20 seconds. (If a resistor was added, see Figure 3-6.)

12. If you need to change maximum hertz, adjust the Max Hz 1P pot (Figure 4-1). Figure 4-2 shows what pot setting is necessary to obtain a specific maximum hertz. The pot has an accuracy of $\pm 10\%$. After the load is connected, the maximum hertz may require additional adjustment.

Note: You can obtain a precise reading of the output frequency by connecting a frequency counter having an input impedance of more than 1 megohm between checkpins VCO and 0 V (common) on the regulator. It should measure 256 times the controller output frequency.

13. Turn the Speed pot fully CCW and press the Stop switch.
14. Turn the power OFF. Verify the D-C bus voltage is zero (read the first voltmeter).
15. With power OFF, connect the motor power leads to the controller and couple the driven machinery to the motor, if not already coupled.

DANGER
THE REMAINING STEPS ARE MADE WITH POWER ON. HAZARDOUS VOLTAGE EXISTS. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

16. With the Speed pot fully CCW, turn the power ON.
17. Press the Start switch.
18. Turn the Speed pot slowly CW to check the motor shaft rotation. If shaft rotation is correct, go to Step 19. If shaft rotation is incorrect, change the motor shaft rotation direction as follows:

Note: Do not press the Start switch while the motor is rotating. An IET trip will occur (The IET LED will light and the drive will stop.). Always wait for the motor to completely stop. To reset the controller after an IET, press the Stop switch and wait for the motor to completely stop.

- Press the Stop switch and wait until the motor has completely stopped.
- Turn the power OFF.

- After verifying the D-C bus voltage is zero, reverse any two of the three motor power leads.
- Turn power ON and press the Start switch.

19. If motor starting torque is not high enough to break away or accelerate the load, turn the Torque Boost 3P pot (Figure 4-1) slowly CW until the motor performs properly. See Figure 4-3.

Remember that the controller is designed to supply 150% of the current rating for not more than one minute; an IET will occur should current reach 175%. If satisfactory adjustment cannot be reached, contact your Reliance Electric Sales Office.

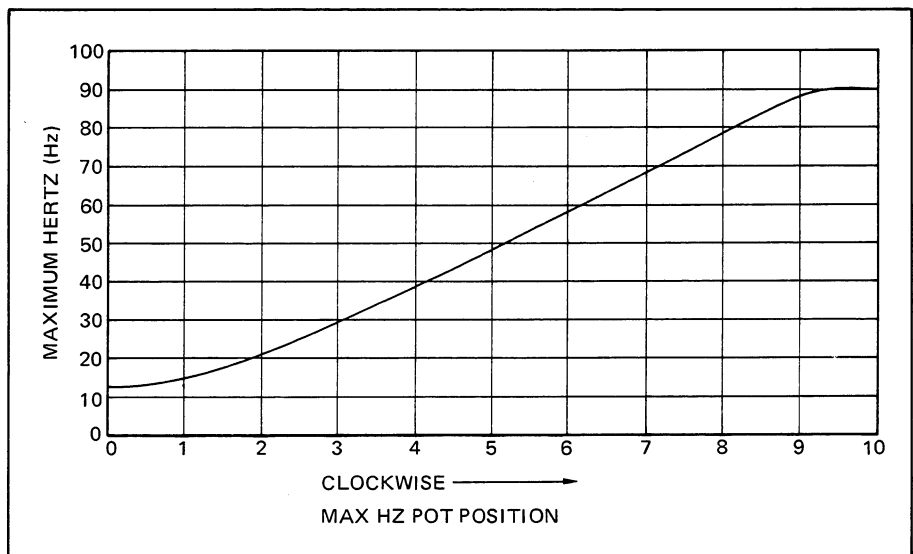


Figure 4-2. MAX HZ Pot Adjustable Range.

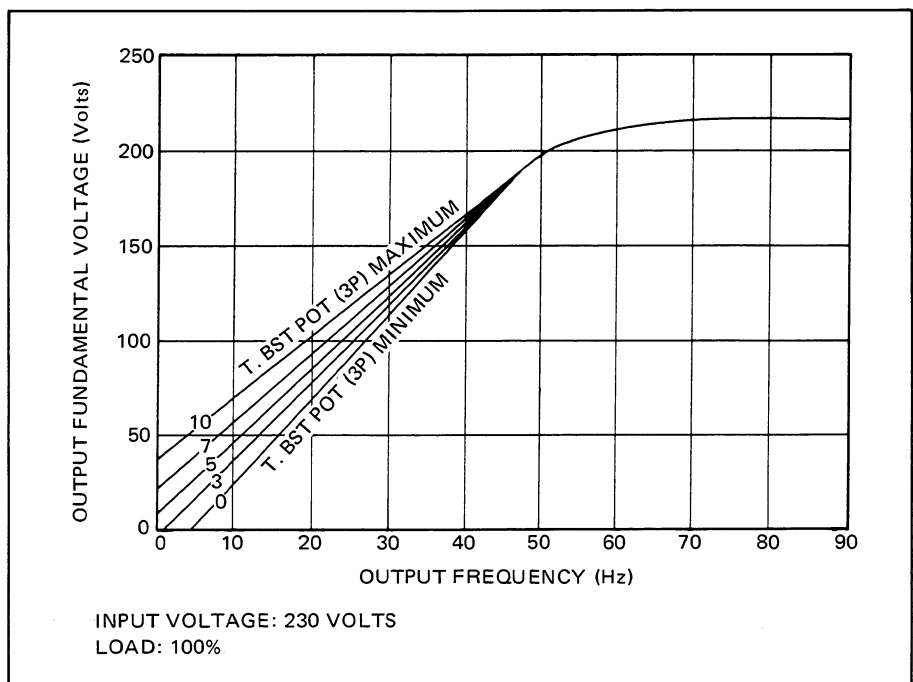


Figure 4-3. Volts/Hertz Characteristics and T. BST Pot Adjustable Region.

20. Turn the Speed pot fully CW. In the time set with the Acceleration/Deceleration 2P pot (Figure 4-1), the motor will accelerate to the maximum speed.

Turn the Speed pot fully CCW. In the time set with the 2P pot, the motor will decelerate to minimum speed.

Note that acceleration and deceleration will be at the same rate because the 2P pot sets the rate for both.

21. With the Speed pot fully CCW, quickly turn the Speed pot fully CW. If the acceleration time is too long, turn the 2P pot slightly CW to decrease the acceleration time. Quickly turn the Speed pot fully CCW. If the deceleration time is too long, turn the 2P pot slightly CW. Repeat this motor acceleration/deceleration process until the desired time is achieved.

The shortest acceleration/deceleration time is at the point when no IET occurs. If an IET occurs, turn the 2P pot slightly CCW to extend the time. If satisfactory adjustment cannot be reached, contact your Reliance Electric Sales Office.

22. Press the Stop switch.
23. Turn the input power OFF. After verifying the D-C bus voltage is zero, remove the two voltmeters and any other instrumentation connected during startup.
24. Close and secure the controller enclosure door.

5 : How the Controller Operates

Fundamentals of Variable Voltage, Variable Frequency Controllers

An A-C motor is a fixed-speed machine operating from a constant voltage, constant frequency source, such as 230 VAC and 60 Hz. To vary the speed of the motor, the voltage and frequency of the source to the motor must be variable. A controller provides this source. The controller transforms its input (single-phase, constant A-C voltage, constant frequency) into an output compatible with the A-C adjustable speed requirement of the A-C motor (three-phase, variable voltage, variable frequency).

The operating frequency of the controller, along with the basic design of the motor, determines the operating speed (rpm) of the motor. The output voltage of the controller establishes the magnetic flux level within the motor to meet the torque demands of the load over the entire speed range. The basic equation to determine motor synchronous speed is:

$$\text{Synchronous RPM} = \frac{\text{Controller Output Frequency} \times 120}{\text{Number of A-C Motor Poles}}$$

The relationship between output voltage and operating frequency is the "Volts per Hertz" ratio (V/Hz). Except at low speed, this ratio is usually a constant determined by this equation:

$$\text{V/Hz} = \frac{\text{Motor Nameplate Voltage}}{\text{Motor Nameplate Frequency}}$$

The two major sections of a controller are the power circuit and the regulator. The power circuit consists of a diode bridge that converts A-C to D-C voltage and a solid state transistor module that transforms the constant voltage, constant frequency input power into variable voltage, variable frequency output power. The regulator controls when the solid state transistor module switches in the power circuit turn ON or OFF.

Power Circuit Operation

Figure 5-1 locates many of the power circuit components, and Figure 5-2 shows the power circuit schematic divided into three sections. Many of the power circuit components are on the regulator.

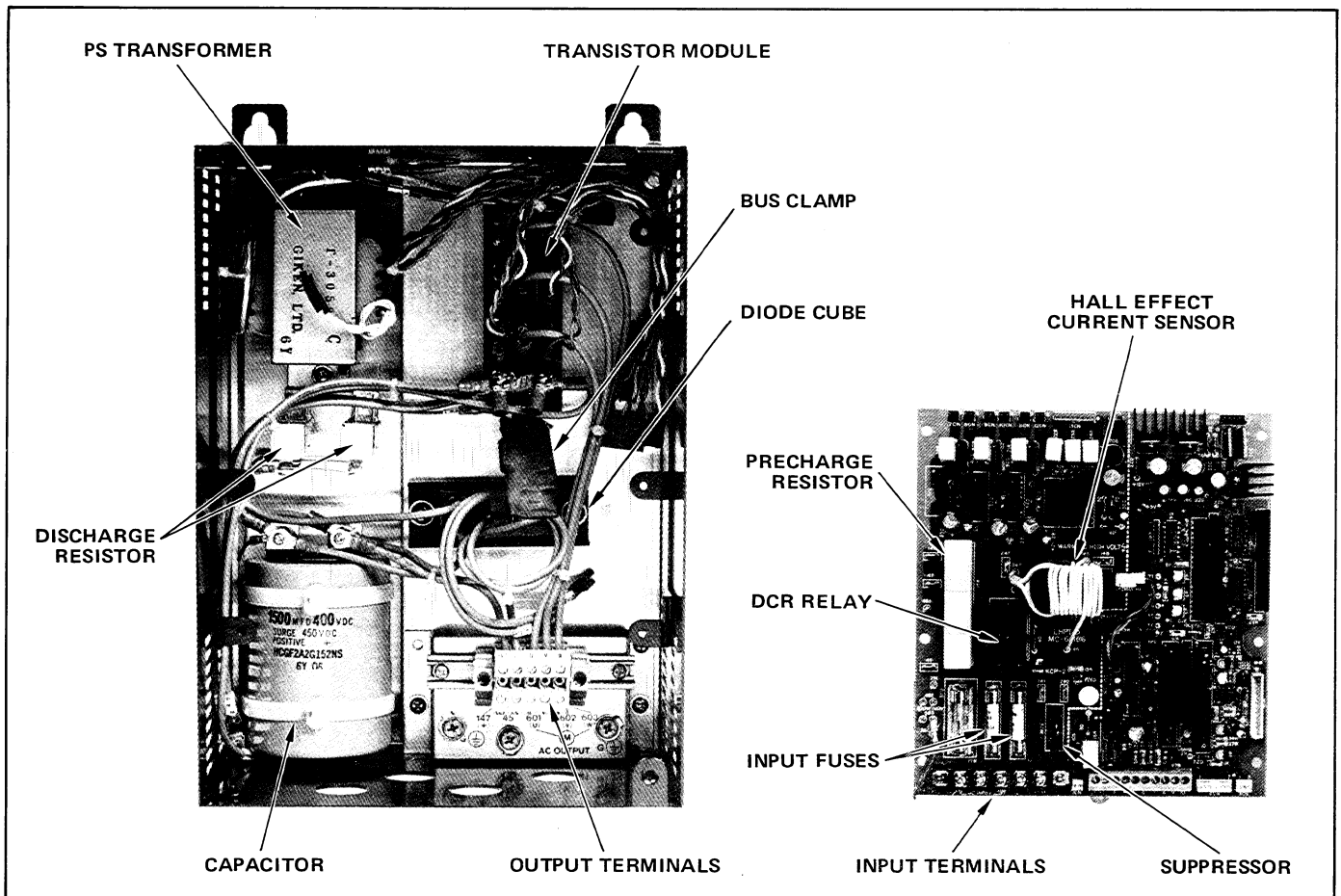


Figure 5-1. Power Circuit Components.

The first section is the **input rectifier**. A-C power is applied to terminals 181 and 182 and is full-wave rectified by the diode cube to constant D-C voltage. This voltage is approximately 310 VDC. Two input fuses (1FU, 2FU) protect the power circuit from any ground faults. A suppressor (MOV) limits voltage transients within the maximum voltage rating of the diodes.

The rectified voltage is then filtered by the **D-C bus filter**. The capacitor is charged through a precharge resistor to limit the charging current. Relay DCR is energized and shorts out the precharge resistor when the bus filter capacitor voltage reaches approximately 90% of the rated bus voltage. Two discharge resistors discharge the bus voltage when the input power is removed.

The positive and negative D-C bus voltage lines run through the ring on the Hall Effect Current Sensor to detect D-C bus current. The D-C bus current feedback protects against an overload or a short circuit in the output inverter section.

The filtered D-C bus voltage is fed into the **output inverter** section. This section transforms D-C bus voltage into three-phase A-C variable voltage, variable frequency by switching transistors in the transistor module. The transistor module, consisting of six transistors with anti-parallel diodes around them, provides a path for reactive motor current.

In summary, constant D-C voltage is produced by rectifying and filtering the incoming A-C power line. Variable voltage, variable frequency is produced by six output transistors inverting the constant D-C voltage to a PWM voltage waveform.

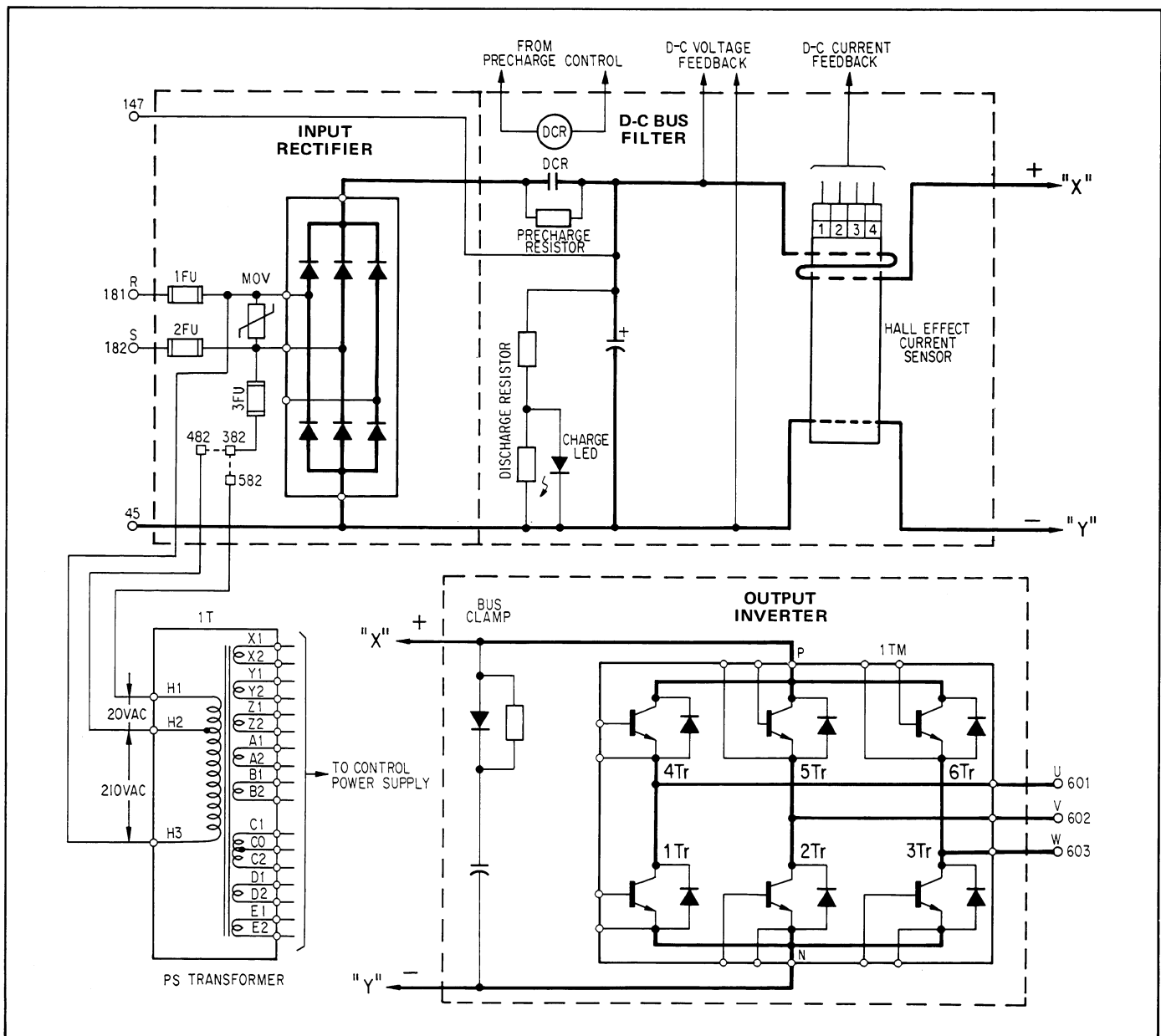


Figure 5-2. Power Circuit Schematic.

Controller Regulator Operation

The regulator is a printed circuit board. Figure 5-3 shows the regulator block diagram divided into seven sections as described below.

The speed reference signal is the input to the **input signal conditioner**. The first conditioning that is done on the input is to set maximum hertz with the Max Hz 1P pot; minimum hertz is fixed. This adjustment causes the reference signal never to exceed the maximum hertz.

The reference signal goes into the ramp control, which controls the length of time the motor takes to accelerate to full speed and decelerate to zero speed. The length of time can be adjusted from 2 to 60 seconds using the Acceleration/Deceleration 2P pot. Typical voltage output of the ramp control is 4.5 volts equal to 60 hertz.

The timed reference provides the reference for the **inverter control** section. The reference signal goes to the signal

conditioner, which defines the V/Hz ratio and torque boost, and the voltage-to-frequency converter. The torque boost is required to offset the IR drop of the A-C motor at a low speed to produce a constant torque capability. The inverter control determines the output frequency of the controller.

The **PWM** generates the sine wave pulse-width modulation signal corresponding to the V/Hz and frequency signals. Figure 5-4 illustrates the principle of generating the PWM sine wave.

The **base driver** section is an amplifier for switching the six inverter transistors to produce the required pulse widths. The signal from the regulator is isolated by an optical coupler. The output of the optical coupler is current amplified by a driver transistor, which supplies the required base driver to the power transistor. These base drivers require an isolated power supply that is supplied by additional secondaries of the PS transformer.

The **controller fault** section monitors selected signals within the controller and generates an IET fault signal whenever the following signals exceed preset limits:

- D-C bus voltage (310 VDC nominal) exceeds 420 volts.
- D-C bus current exceeds 175% of full-load current.
- Regulator A-C input voltage (30 VAC nominal) is not within +11%, -15%.
- Function Loss input is open.

The output of the IET circuit turns OFF the regulator in a controlled manner by turning off the sequencing control, the ramp control, and the PWM modulator. This redundancy assures the controller turns OFF when a fault occurs. The controller can only be reset by pressing the Stop switch and then the Start switch or turning power OFF and then ON again.

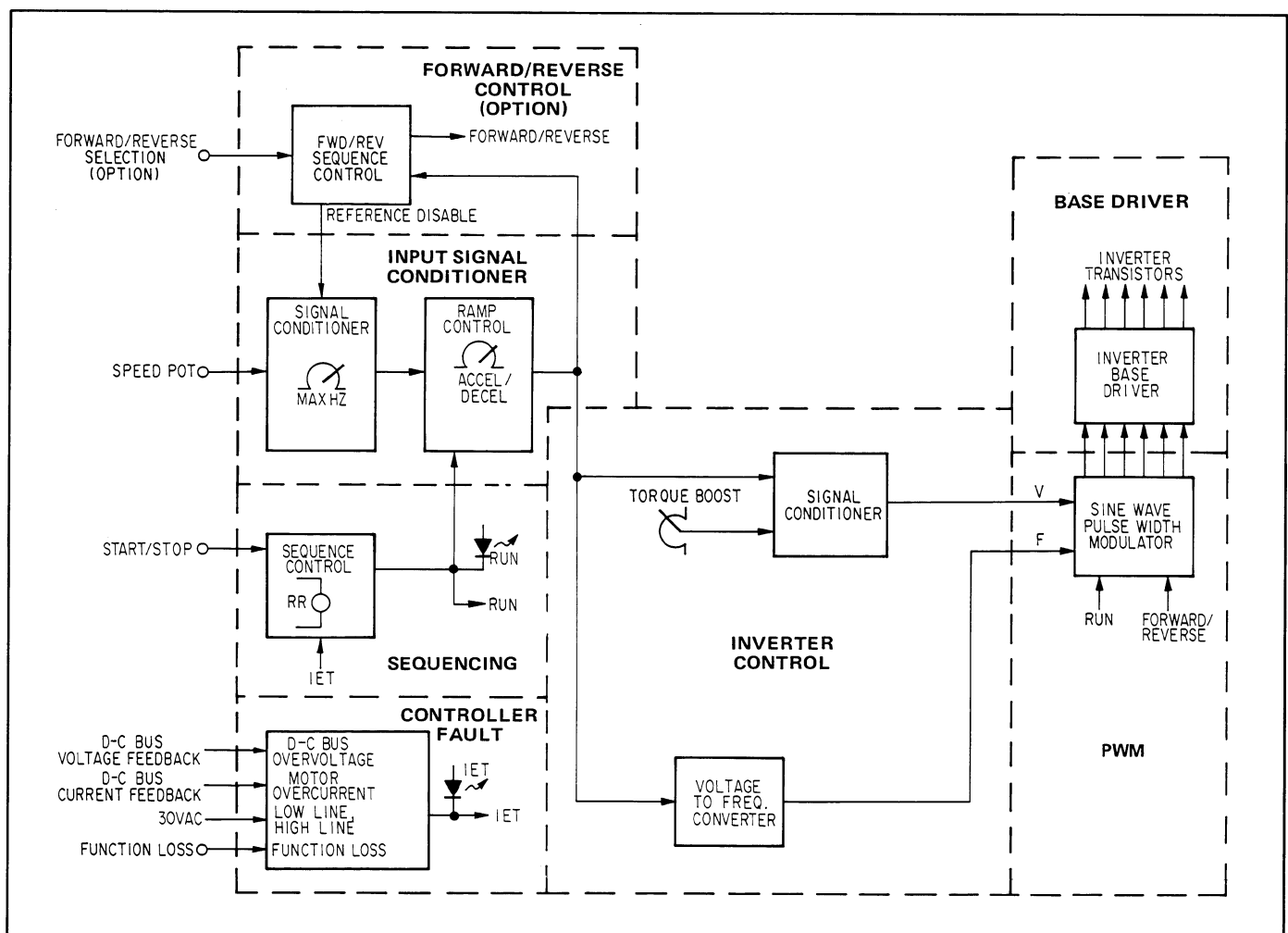


Figure 5-3. Controller Regulator Block Diagram.

The **sequencing** section is the interface between the regulator and the Start/Stop inputs from the operator's control devices. The Start/Stop switch picks up the RR relay. Contacts from the RR relay are connected to the sequence logic as a start/stop input.

The stop function instantly turns OFF the controller and the motor coasts to a rest. If the controller is restarted while the motor is still in motion, an IET may occur due to high D-C bus voltage caused by regeneration.

Opening the function loss input causes an IET, which instantly turns OFF the controller causing the motor to coast to a rest. To restart, the Stop switch must be pressed to reset the IET, and the motor must be completely stopped. Then the Start switch is pressed to start the controller.

The optional **Forward/Reverse control input** section selects the phase rotation of the inverter control section. This can be changed at any motor speed. When the direction is changed, the sequencing control automatically causes the ramp control to go to zero at the deceleration setting (2P pot). Near zero, the frequency of the inverter control reverses, after which the sequencing releases the ramp control and the motor ramps to the speed reference at the acceleration rate setting (2P pot).

Fundamentals of Controller Operator's Controls

Start/Stop Control

With power ON, pressing the Start switch causes the motor to accelerate to the speed determined by the speed reference. The length of time for the motor to accelerate to this speed depends on the time set with the Acceleration/Deceleration 2P pot.

Pressing the Stop switch causes the motor to coast to a rest. The controller will be energized in this STOP mode because power is ON.

If the controller is stopped because of an IET, restart by pressing the Stop switch, waiting for the motor to completely stop, and pressing the Start switch.

Speed Control

WARNING

THIS CONTROLLER CAN BE ADJUSTED DOWN TO ZERO SPEED. DO NOT USE THIS ZERO SPEED SETTING TO STOP DRIVEN EQUIPMENT. CHANGING CONDITIONS COULD RESULT IN UNEXPECTED ROTATION. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

The speed reference, which controls the speed of the motor, is determined by the Speed pot setting. When the controller is ON and the Start switch is pressed, the motor will accelerate to the speed set with the Speed pot. While the motor is running, the speed can be increased or decreased by turning the Speed pot CW or CCW, respectively. The length of time for the motor to accelerate or decelerate to the set speed depends on the time set with the Acceleration/Deceleration 2P pot.

Forward/Reverse Control (optional)

Motor rotation can be changed by interchanging any two motor leads. The Forward/Reverse switch electronically changes the direction of motor rotation. While the motor is rotating at the set speed in the forward direction, pressing the Reverse switch will cause the motor to ramp to rest and then accelerate in the opposite direction to the set speed.

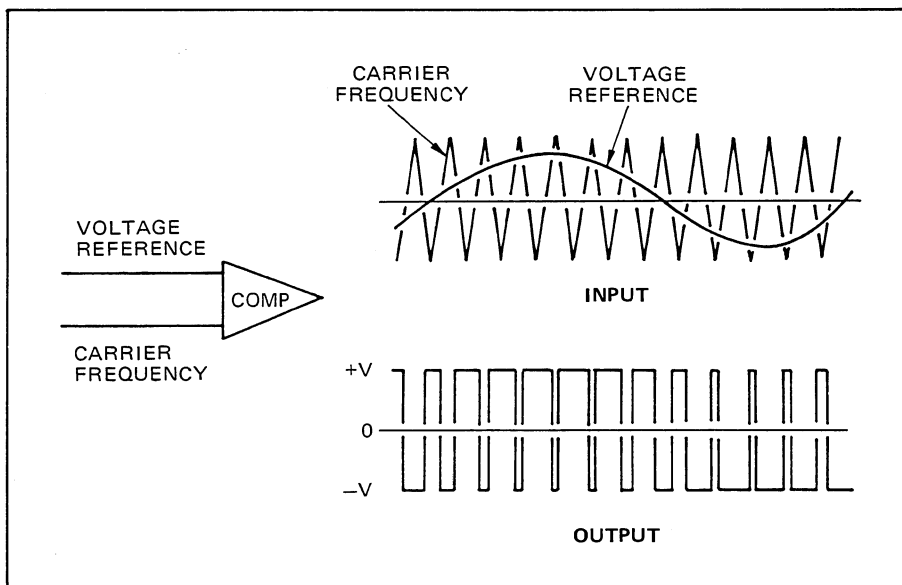


Figure 5-4. Theory of Generating PWM.

6 : Troubleshoot the Controller

DANGER
ONLY QUALIFIED ELECTRICAL PERSONNEL FAMILIAR WITH THE CONSTRUCTION AND OPERATION OF THIS EQUIPMENT AND THE HAZARDS INVOLVED SHOULD SERVICE THIS EQUIPMENT. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

Controller LEDs

- The controller has 3 LED indicators:
 - RUN (green) – normally ON
 - IET (red) – OFF; ON when fault occurs
 - Bus Charge (red) – ON while D-C bus capacitor is charged
- A lit IET LED indicates a fault has occurred. Refer to Table 6-1 for possible causes of an IET occurrence.
 - Clear the fault.
 - Reset the controller by pressing the Stop switch, waiting for the motor to completely stop, and pressing the Start switch. Note that the controller cannot start until the fault is cleared and the controller is reset.

Table 6-1. Possible Causes of IET Trips.

Type of IET	Possible Cause
Overcurrent	Output line-to-ground or line-to-line short
	Motor current higher than 175% of the controller sine wave current rating
	Acceleration time too short
	Hall effect amplifier card is faulty
Overvoltage	Input voltage too high
	Deceleration time too short
Low Line	Input voltage too low
	Momentary power drop
Function Loss	Function loss input (2TB 1-2) is open.

Test Equipment Needed

CAUTION: Do not use a megger to perform continuity checks in the drive equipment. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

- Two volt-ohmmeters each having a sensitivity of 20,000 ohms-per-volt, such as a Triplet Model 630.
- A volt-ohmmeter with a 10 meg-ohm input impedance on all ranges, such as a Fluke 8022B. (This unit provides an accuracy of $\pm 15\%$ when measuring controller output voltage at terminals 601, 602, and 603.)

The most common voltmeters in use are digital and analog voltmeters. However, these two voltmeters use several different methods of measuring the RMS voltage of a waveform, thus producing a wide range of RMS readings for a particular PWM waveform.

A fundamental voltmeter is best suited for measuring output voltage of PWM waveforms because it filters out unwanted harmonics. An accurate measurement is important since the fundamental waveform is the main contributor to the power conducted to the motor. Therefore, in this manual, voltages given are fundamental voltages.

In comparison testing, the Fluke 8022B provides an RMS measurement nearly equivalent to that of the fundamental voltmeter; the Triplet 630 provides an RMS measurement that is 20 volts higher than that of the fundamental voltmeter.

Follow these guidelines when measuring the output voltage of this PWM controller:

- Keep voltmeter lead lengths as short as possible.
- When using an analog voltmeter, use the 250–300 VAC scale.
- When using a digital voltmeter, use the 200 VAC scale for measuring output voltages up to 200 VAC and the 750 VAC scale for measuring output voltages above 200 VAC.

- When using a Triplet 630 voltmeter, subtract 20 volts from the reading to determine the fundamental output voltage.
- When using a Fluke 8022B voltmeter, the meter reading can be used as an approximate fundamental voltage.

General Troubleshooting Procedure

1. Verify that an IET has not occurred; the IET LED will be lit and the drive shut down. If an IET has occurred, refer to Table 6-1 for possible causes of an IET occurrence.
 - Clear the fault.
 - Reset the controller by pressing the Stop switch, waiting for the motor to completely stop, and pressing the Start switch. Note that the controller cannot start until the fault is cleared and the controller is reset.
2. Open the enclosure door.
3. With power OFF, make a complete physical inspection of all control and motor wiring for correct and tight connections. Be sure that connectors on the regulator are correctly positioned and tight.
4. Verify that the input power voltage corresponds with the voltage select fast-on. If not, change the fast-on and/or add a transformer between the plant power supply and the controller.
5. Verify that the input power voltage is in the +10%, -5% tolerance range.
6. Check for and correct poor wiring conditions:
 - Input and output leads routed through the same conduit.
 - Input or output leads running parallel or in the same conduit with control signal wiring.
 - Control signal wire that is not twisted.
7. Make sure that all nearby relays, solenoids, or brake coils are suppressed.
8. Check that the ambient temperature does not exceed 40°C (104°F) for enclosed controllers or 55°C (131°F) for chassis controllers.

9. The Torque Boost 3P pot may need adjustment if the following conditions are true:

- Too much torque boost caused high no-load and full-load motor current, causing excessive heating in the motor and overloading of the controller.
- Not enough torque boost resulted in abnormally high current during hard starting, fast acceleration, and/or transient load operations.

Readjust the 3P pot as needed. Note that the controller is designed to supply 150% of the current rating for not more than one minute; an IET will occur should current reach 175%.

Fault Symptom Troubleshooting Flow Charts

Identify the fault symptom from the following list. Then turn to the flow chart having the figure number corresponding to the symptom. If a part needs to be replaced, refer to Table 6-2 and Figure 6-6. Figures 6-7 through 6-9 provide detailed wiring diagrams, and Figure 6-10 locates components of the regulator board.

1. Motor will not run, which includes the following symptoms:
 - Controller will not start.
 - Input fuses are blown.
 - IET trip occurs when the controller is started.
2. Motor will not reach maximum speed, which includes the following symptoms:
 - Controller starts but motor stays at low speed.
 - Controller IET occurs during acceleration.
3. Controller IET occurs during controlled deceleration.
4. Controller IET occurs occasionally while running but can be restarted.
5. Motor overheats above allowable temperature.

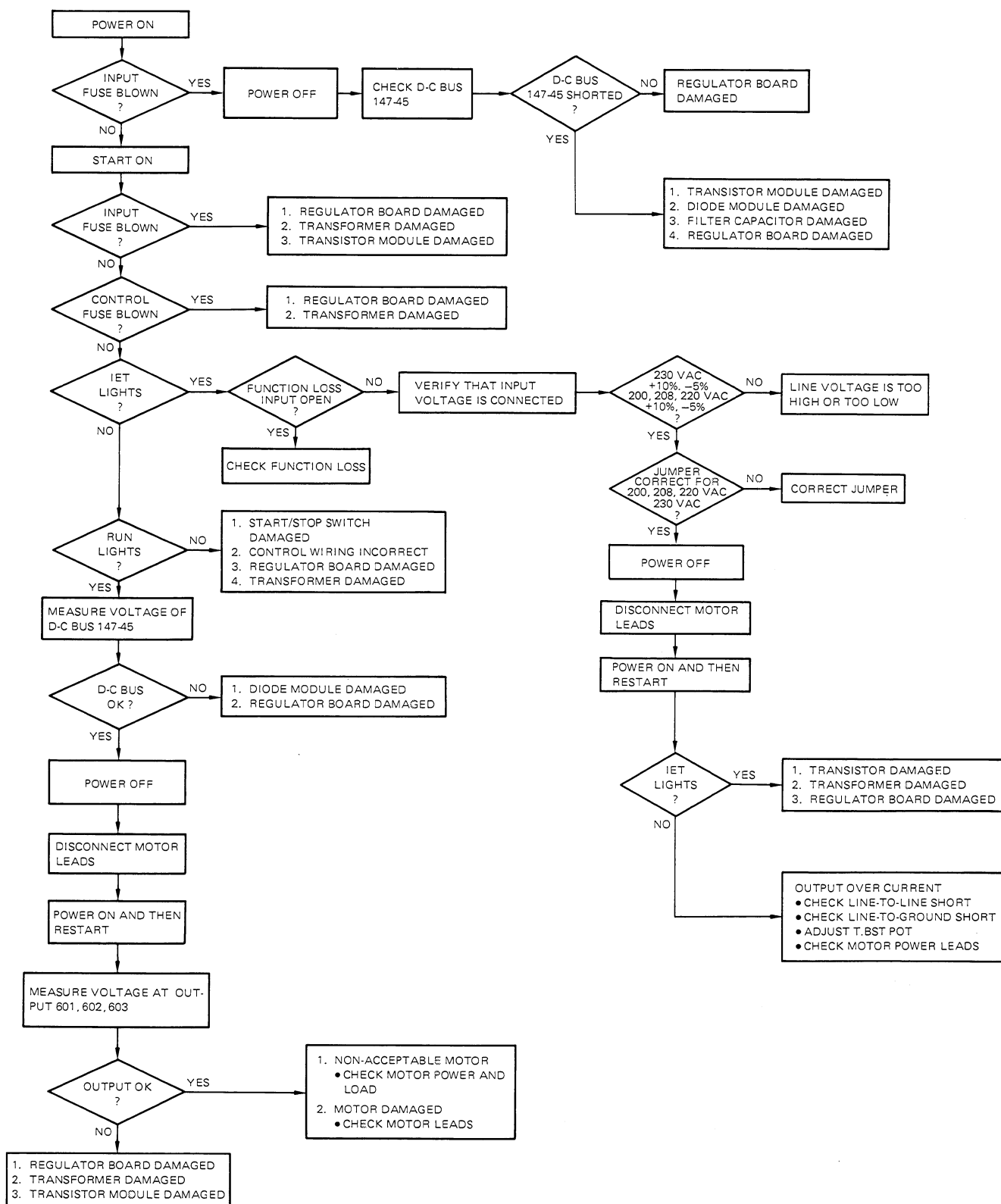


Figure 6-1. Motor will not run.

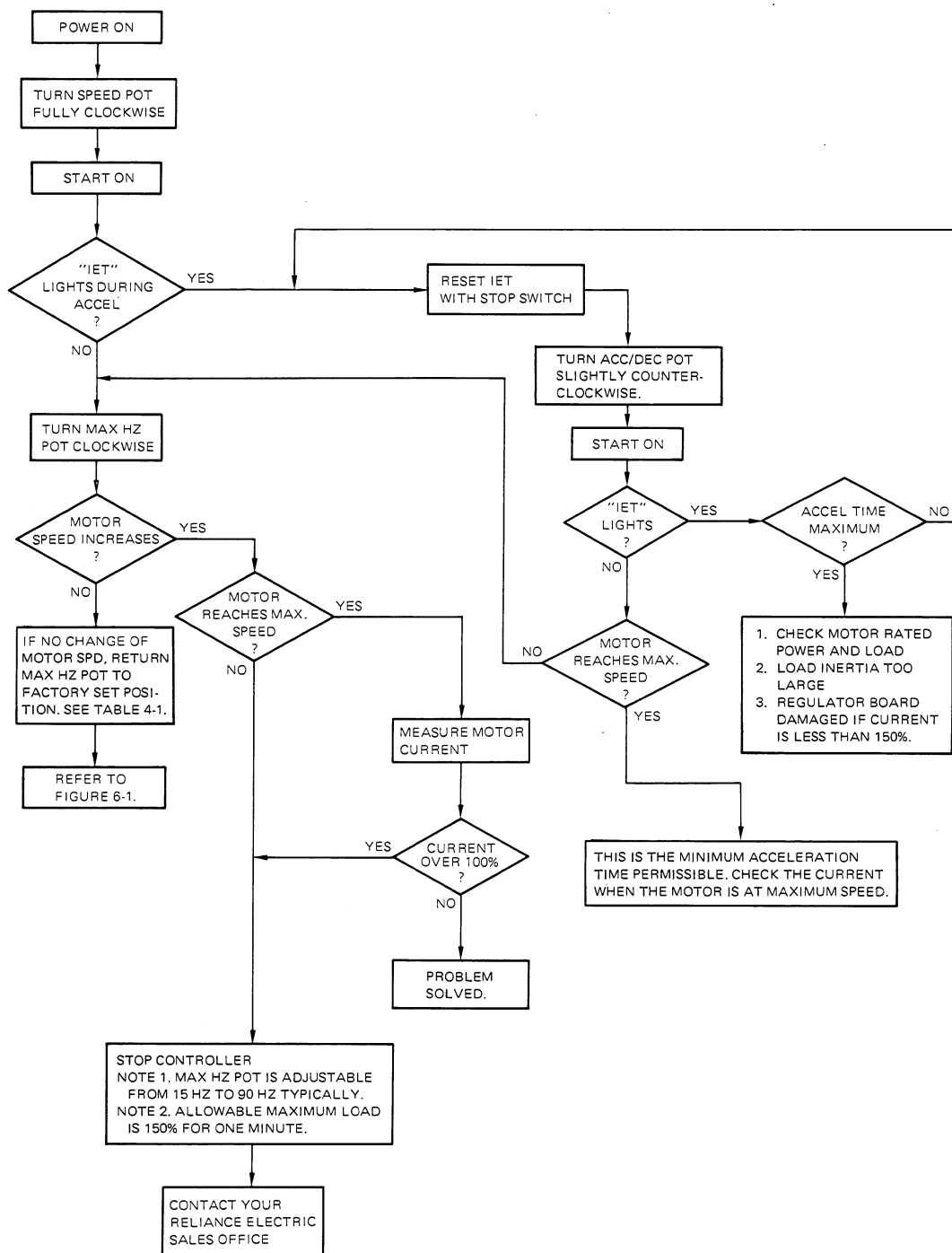


Figure 6-2. Motor will not reach maximum speed.

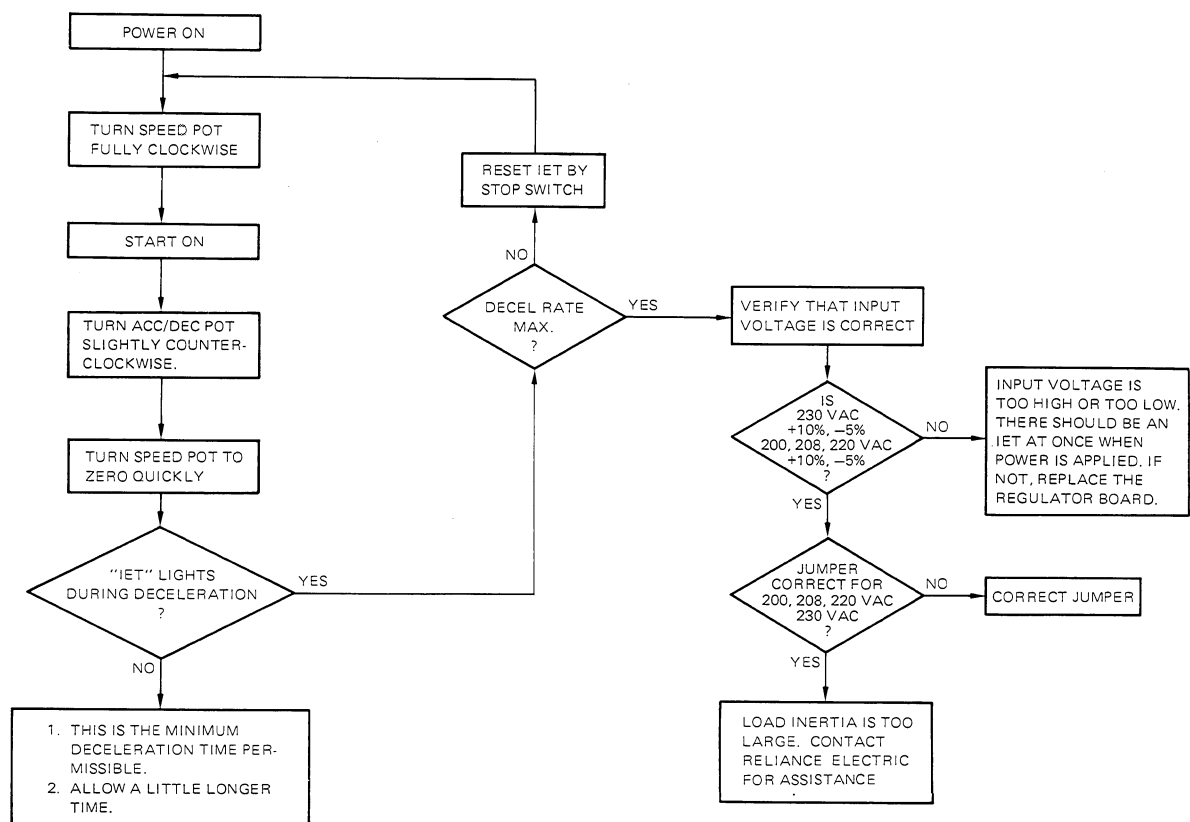


Figure 6-3. Controller IET during controlled deceleration.

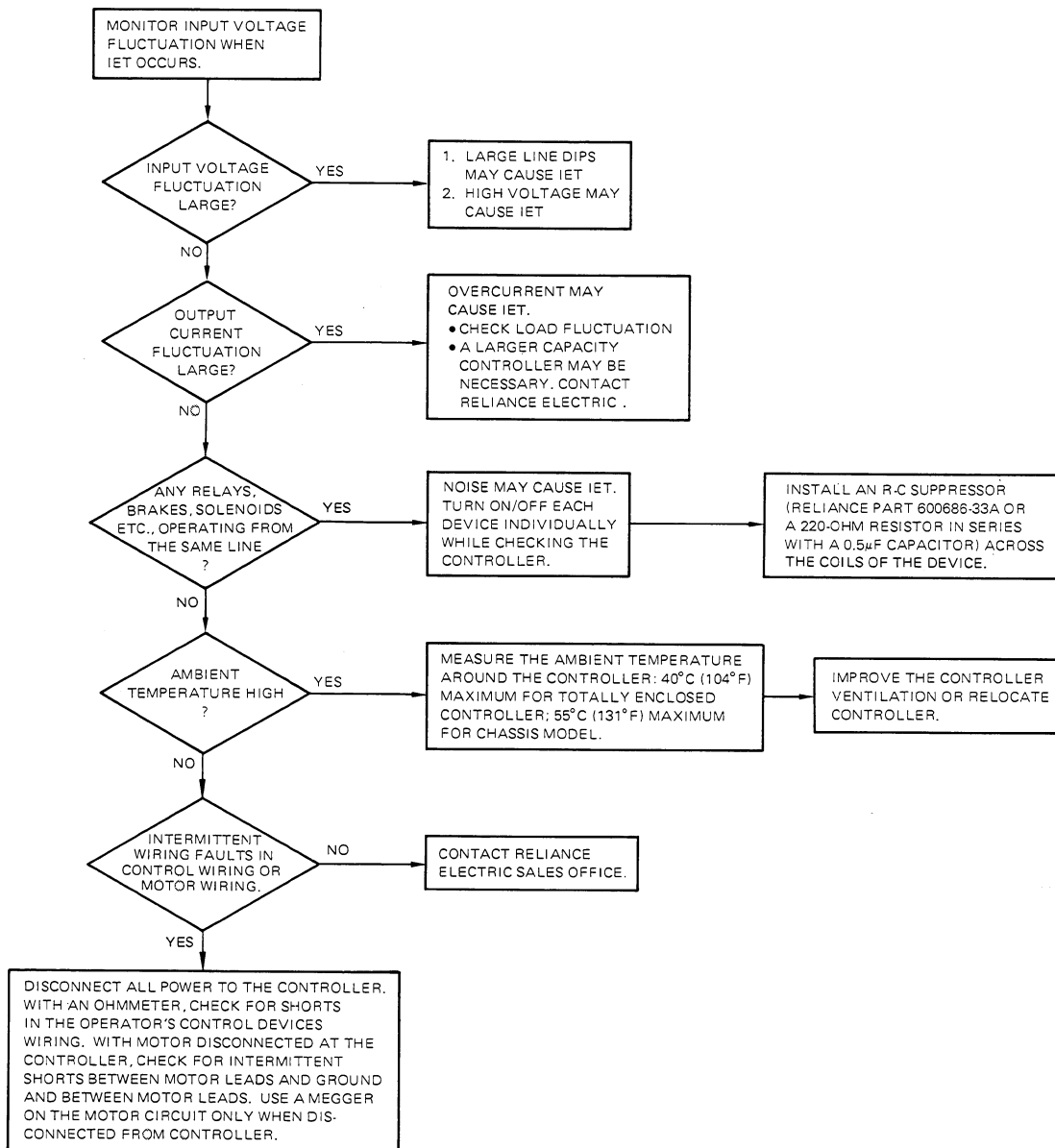


Figure 6-4. Occasional IET while running but can be restarted.

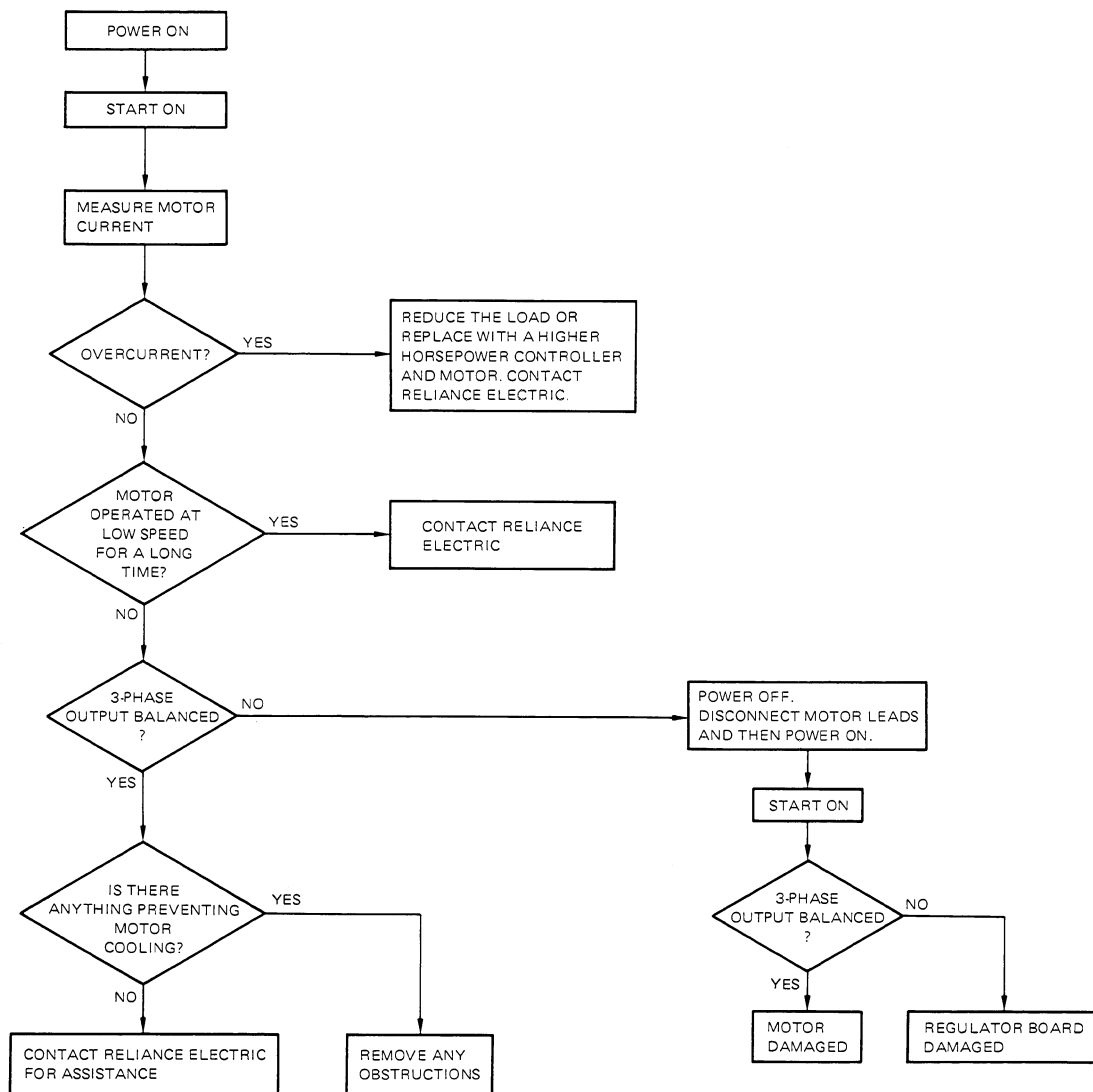


Figure 6-5. Motor overheats above allowable temperature.

Table 6-2. Replacement Parts List.

Description	Qty. Per Drive	Reliance Part Number
Diode Cube	1	701819-40AG
Transistor Module	1	602909-236AA
Capacitor	1	600442-21C
Bus Clamp Assembly	1	803422-4
Regulator PC Board	1	802285-75
PS Transformer	1	411027-201C
Input Fuse 20A, 250V, Type: SA16A Mfr: FERRAZ	2	402410-502U
Control Fuse 0.3A, 250V, Type: GDL Mfr: NAGASAWA/ GOULD	1	64676-22J

Table 6-3. Recommended Spare Parts for 6 Controllers.

Description	Qty.	Reliance Part Number
Diode Cube	1	701819-40AG
Transistor Module	1	602909-236AA
Regulator PC Board	1	802285-75
PS Transformer	1	411027-201C
Input Fuse 20A, 250V, Type: SA16A Mfr: FERRAZ	6	402410-502U
Control Fuse 0.3A, 250V, Type: GDL Mfr: NAGASAWA/ GOULD	3	64676-22J

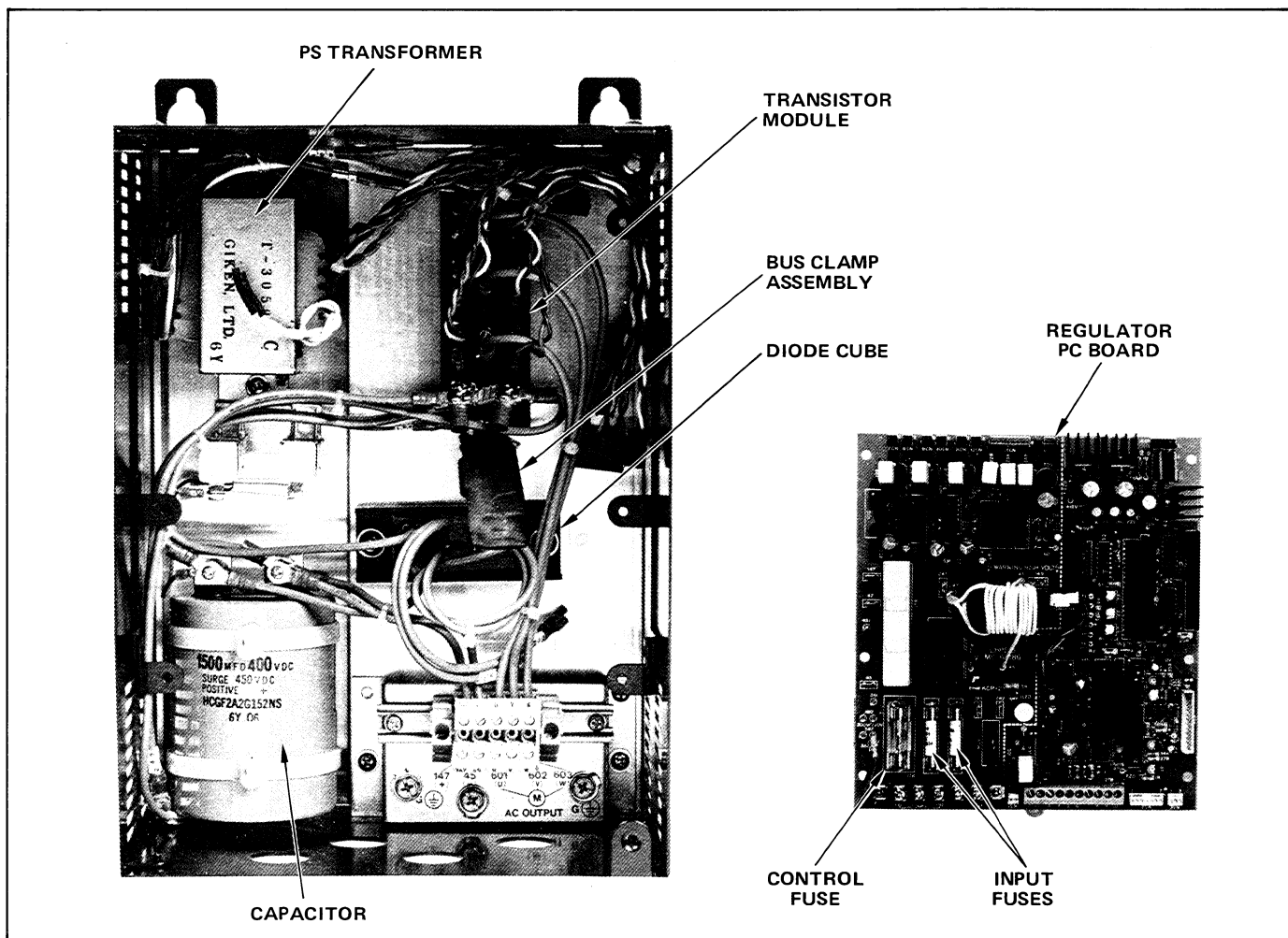


Figure 6-6. Replacement Component Identification.

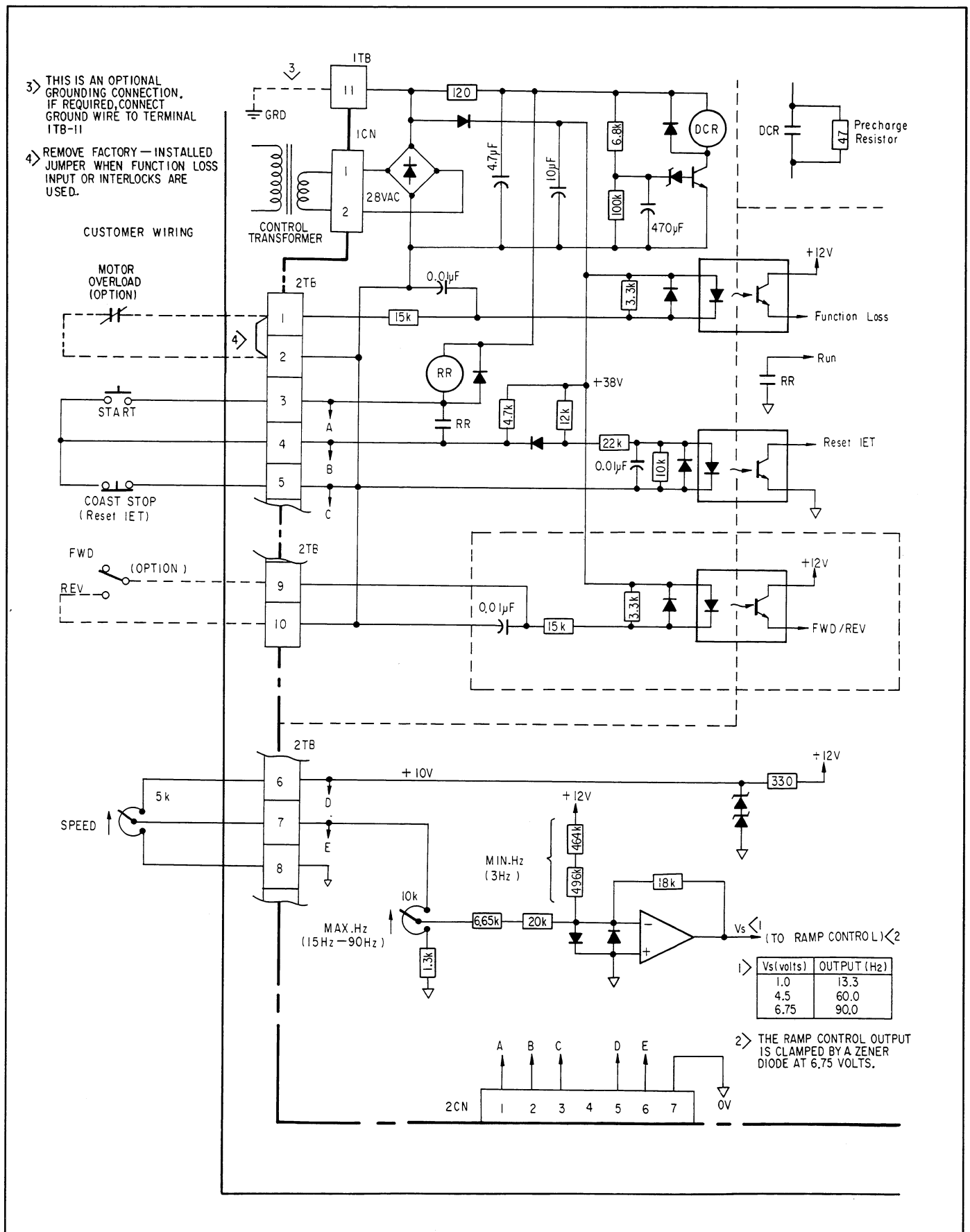


Figure 6-9. Input Circuit for Control Signals.

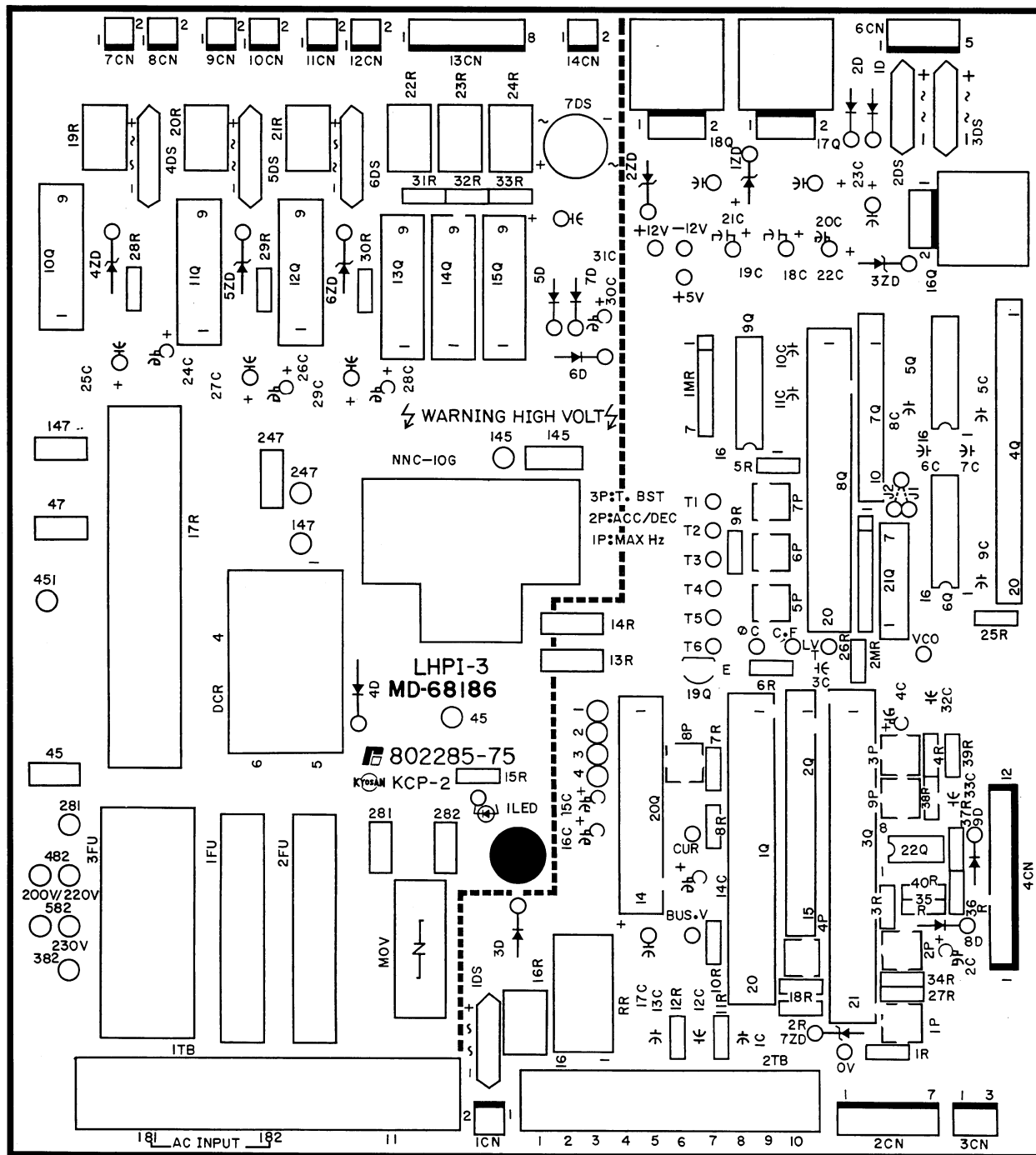


Figure 6-10. Typical Component Layout of Regulator Board.

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