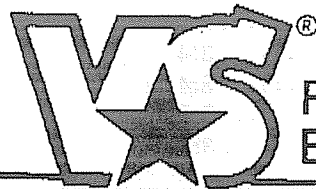


Installing, Operating
and Maintaining the
Three-Phase Input
Three-Phase Output
FlexPak™
A-C V*_S Drive

460 VAC, 60HZ INPUT
15 thru 40 HP



Reliance
Electric

DRIVES

Instruction Manual
D2-3132

June, 1988

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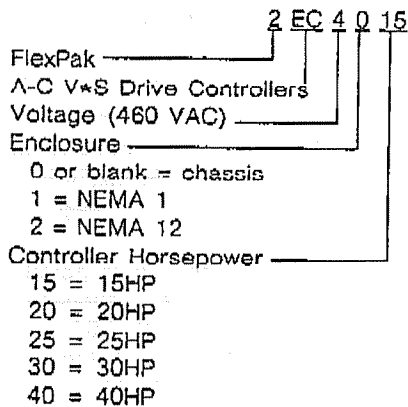
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1: Receive and Accept the Controller

Identify the Controller

Each Reliance Electric FlexPak A-C V*S® Drive Controller can be positively identified by its nameplate information. The nameplate for the chassis controller is located on the panel adjacent to the input fuse terminals. The nameplate for the enclosed controller is located on the sidewall of the cabinet. Refer to this information whenever discussing the equipment with Reliance Electric personnel.

The model number describes the controller as follows:



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.

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.

Store the Controller until Installation

After receipt inspection, repack the FlexPak A-C V*S Drive Controller in its shipping container until installation. If a short period of storage is expected, store in the original shipping container with its internal packing. Indoor storage is required.

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

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

For storage longer than 5 months, contact Reliance for long-term storage instructions.

2: Know the Controller

Terminology Used in This Manual

Definitions and Abbreviations

CCW: The abbreviation for counterclockwise.

Controller: The term substituted throughout this manual for "FlexPak 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.

FlexPak A-C VS* 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.

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)
- FlexPak Data Sheet" (D-2799)
- "Selection and Application of A-C V**S* Drives" (D-9084)
- "A-G 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 and a three-phase A-C motor. The controller and/or motor can be purchased separately, or the controller with a performance-matched Duty Master® XE or RPM AC® motor can be purchased as a drive package.

Operator Control Devices must be connected to the controller. These devices for local or remote mounting may be supplied by the user or Reliance. Standard Reliance Electric Remote Operator Control Stations include functions as outlined in Table 2-1. These devices can also be mounted in the cabinet door of the enclosed controller.

Table 2-1. Operator's Control Station Functions.

Model 9C45 Functions	Model 9C46 Functions
Start/Stop Speed Setting Jog Control	Start/Stop Speed Setting Jog Control Forward/Reverse
Model 34C800	34C801
Full Function Speed Pot Run/IET Leds Digital Meter	Digital Meter (amps, volts, Hz) Run/IET Leds

Controller Features

Standard Features

- Controller speed range of 0 to 60 Hz with capability of 240 Hz
- Near unity power factor throughout the speed range
- Input fused internally with standard fuses for easy replacement
- Input line reactor to permit operation on a distribution system up to 100,000 amp fault current capability without an isolation transformer
- Insensitive to incoming power phase sequence
- Line transient protection to prevent power line transients from harming the controller
- Line-to-line and line-to-ground output short circuit protection
- Single board, LSI-based regulator for increased reliability
- Electronic reversing from any speed
- Start-stop and speed selection with coast-to-rest as standard or ramp-to-rest on "stop" as a modification
- Motoring current limit
- Standard adjustments:

Acceleration	Current Limit
Deceleration	Volts per Hertz
Minimum Hertz	Voltage Boost
Maximum Hertz	Stability
Automatic Voltage Boost	

- Fault reset pushbutton
 - Automatic voltage boost compensation when voltage boost adjustment is selected to provide optimal running amps
 - Three-phase output voltage regulated to $\pm 1\%$ of selected voltage within +10% to -10% variations in plant power
 - Input power contactor
 - Automatic shutdown with first fault indication (via regulator LEDs) under any of the following conditions:

Undervoltage	D-C Bus fault
Overcurrent	Ground fault
Overvoltage	Overtemperature
 - Relay contacts for external indication of drive run and drive fault
 - Provisions for RUN and READY pilot lights
 - 24 VDC isolated operator's control for increased safety
 - 0-10 VDC, 4-20 mA, and 0-20 mA input signal capability
 - 0-10 VDC output signals proportional to voltage, frequency, and current
 - Switching technique that reduces the fifth and seventh current harmonics from 20% and 14% of the fundamental to 6% each to reduce motor heating
 - 15 and 20 HP available as chassis or in NEMA 12 enclosure
 - 25 through 40 HP available as chassis or NEMA 1 enclosure
- Optional Features**
- Portable tester with digital readout, trending indicator, and provisions for manual speed control
 - Cabinet-mounted or remote-mounted meters:
 - Output Voltmeter
 - Output Ammeter
 - Output Frequency Meter
 - Dynamic braking
 - Input disconnect
 - 115 VAC operator's control voltage
 - Remote Reset
 - Motor overload
 - Motor Blower Power Supply
 - Other features available; contact your Reliance Electric Sales Office for information.

Controller Specifications

DESCRIPTION	HORSEPOWER RATING				
	15	20	25	30	40
Input KVA	20.2	23.6	28.9	36.8	43.8
Maximum Continuous Input AMPS	25.3	29.7	36.3	46.2	55
Maximum Continuous Output AMPS	23	27	33	42	50

<p>Service Conditions Elevation: to 3300ft (1000m) Temperature Range: • Cabinet: 0° to 40°C (32°F to 104°F) • Chassis: 0° to 55°C (32°F to 131°F) Atmosphere: Non-condensing relative humidity to 95% A-C Line Voltage: 3 Phase, 460V ± 10% A-C Line Frequency: 60HZ ± 2HZ Displacement Power Factor: 0.96 Maximum A-C Line Distribution System Capacity: 100,000 AMP Symmetrical Fault Current Storage Temperature: -40°C to 65°C (-40°F to 149°F)</p> <p>Application Data Service Factor: 1.0 Maximum Load: .. 150% of continuous output amp rating for 1 minute Output Voltage: 0 to 460VAC Output Voltage Waveform: ... Sine Wave Pulse Width Modulation (PWM) Output Regulation: Voltage: 1% Frequency Stability: 0.5% (0° to 40°C) Continuous Speed Range (1): 3 to 60HZ</p> <p>Adjustments (Nominal Values) Minimum Speed (1): 2.4 to 50HZ Maximum Speed (1): 36 to 72HZ Volts per Hertz (2): 3.1 to 27.0 V/HZ Voltage Offset: 0 to 18V Auto Voltage Boost: ... 0 to 100% of rated amps Acceleration Rate (3): 4 to 140 seconds Deceleration Rate (3): 4 to 140 seconds Current Limit: 50 to 150% rated amps</p>	<p>Fuse Data 3 Input Fuses (FERRAZ Type gl, 660V or equivalent) 15-20HP 40AMP 25HP 63AMP 30-40HP 80AMP</p> <p>1 D-C Bus Fuse (FERRAZ Type URD, 660V or equivalent) 15-20HP 63AMP</p> <p>1 D-C Bus Fuse (Bussman Type 170L, 550V or equivalent) 25HP 80AMP 30-40HP 125AMP</p> <p>3 Control Fuses (FERRAZ Type aM, 500V or equivalent) 15-40HP 1AMP</p> <p>1 VFC Regulator Fuse (Bussman Type GDC, 250V or equivalent) 15-40HP 1AMP</p> <p>Product Publications Data Sheet D-2799 Application Manual D-9084 Wiring Diagrams 15-20HP W/D 30360-1 25-40HP W/D 30360-2</p>
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(1) Range shown is for factory standard setting. Max speed above standard will change range.
 (2) This parameter only adjustable with the V/HZ jumper in the adjustable position.
 (3) Range can be changed by jumper selection on the VFC Board.

Customer Interlocks, Proportional Signals, Speed Pot, Control Voltage

- Frequency: 0-10 volts $\pm 2\%$ impedance isolated proportional to maximum frequency setting at terminals 553, 550 (COM)
- Current: 0-10 volts $\pm 2\%$ impedance isolated proportional to controller continuous current rating at terminals 552, 550 (COM)
- Voltage: 0-10 volts $\pm 2\%$ impedance isolated proportional to motor voltage at terminals 551, 550 (COM)
Maximum loading: 3 mA each with three outputs used; 5 mA each with one or two outputs used
- RUN contact
D-C Rating 120 watts maximum with a maximum voltage of 30 VDC or a maximum current of 5 amps resistive
A-C Rating 920 VA maximum with a maximum voltage of 240 VAC or a maximum current of 5 amps resistive
- FAULT contact
D-C Rating 120 watts maximum with a maximum voltage of 30 VDC or a maximum current of 5 amps resistive
A-C Rating 920 VA maximum with a maximum voltage of 240 VAC or a maximum current of 5 amps resistive
- Speed pot: 10 VDC, maximum loading 6 mA; recommend a 5K ohm, 1/2 watt speed pot
- Logic inputs: 24 VDC, maximum loading 280 mA total, 40 mA maximum per input

LED Indications on Regulator VFC Board

Green LEDs

- SOK Power supply voltage okay
-  Drive ready to run

Red LEDs

- >I Overcurrent: instantaneous peak current greater than 150% of controller continuous rating
- >U Overvoltage: bus voltage greater than 800 VDC or input voltage greater than 560 VAC
- <U Undervoltage: bus voltage less than 300 VDC or input voltage less than 320 VAC
- >IE Ground fault at output
- <C D-C bus fault
- >T Controller overtemperature: internal heat sink temperature greater than 96°C

Single-Motor Applications

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

If the motor is overframed, the motor operating current must not exceed the controller's rated output current and the motor horsepower must not be more than one size larger than the controller's horsepower rating. The NEC requires that a motor overload relay, sized to be equal to or less than the controller output current rating, be

connected between the motor and the controller output.

If the motor will be operated at speeds below one half the motor's rated speed, the motor overload relay may not protect the motor because of the reduction in motor cooling action due to the reduced speed. A motor thermostat built into or connected to the motor windings should be installed because it monitors the actual temperature of the motor windings.

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 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 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(s) which is(are) to start and stop independently must be less than or equal to the maximum current rating of the controller.

3: Install the Drive

DANGER
 ONLY QUALIFIED ELECTRICAL PERSONNEL FAMILIAR WITH THE CONSTRUCTION AND OPERATION OF THIS EQUIPMENT AND THE HAZARDS INVOLVED SHOULD INSTALL, ADJUST, OPERATE AND/OR SERVICE THIS EQUIPMENT. READ AND UNDERSTAND THIS MANUAL IN ITS ENTIRETY BEFORE PROCEEDING. 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.

WARNING
 THIS EQUIPMENT GENERATES, USES, AND CAN RADIATE RADIO FREQUENCY ENERGY, AND, IF NOT INSTALLED AND USED IN ACCORDANCE WITH THE INSTRUCTION MANUAL, MAY CAUSE INTERFERENCE TO RADIO COMMUNICATIONS AS TEMPORARILY PERMITTED BY REGULATION. IT HAS NOT BEEN TESTED FOR COMPLIANCE WITH THE LIMITS FOR CLASS A COMPUTING DEVICES PURSUANT TO SUBPART J OF PART 15 OF FCC RULES, WHICH ARE DESIGNED TO PROVIDE REASONABLE PROTECTION AGAINST SUCH INTERFERENCE. OPERATION OF THIS EQUIPMENT IN A RESIDENTIAL AREA IS LIKELY TO CAUSE INTERFERENCE IN WHICH CASE THE USER AT HIS OWN EXPENSE WILL BE REQUIRED TO TAKE WHATEVER MEASURES MAY BE REQUIRED TO CORRECT THE INTERFERENCE.

Plan and Perform 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 comes standard in two configurations: enclosed or chassis. The enclosed controller is shipped as an enclosed unit, fully assembled in its own enclosure. The chassis controller is shipped fully assembled for mounting in an enclosure.

Chassis Controller

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

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°C to 40°C (32°F to 104°F) for enclosed 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 1000 feet above 3300 feet, derate the current rating 4%. Contact your Reliance Electric Sales Office for installations above 5000 feet.

1. Refer to Figures 3-1 and 3-2 for mounting dimensions of the chassis controller
2. Make sure the controller has at least 4 inches clearance from the top and bottom of the controller to adjacent non-heat producing equipment for air ventilation. Note that the regulator panel swings to the right 90 degrees.
3. Make sure the internal cabinet temperature is kept below 55°C. Make sure that service access will not be hindered. When designing the ventilating system or when sizing a non-ventilated enclosure in which the controller is to be mounted, the energy dissipation of all components within the cabinet should be considered. The heat dissipation of each controller and the required minimum vertical area is listed in Table 3-1 to aid in the sizing of enclosures.

Install the Controller

Enclosed Controller

1. Refer to Figures 3-1 and 3-2 for mounting dimensions of the enclosed controller. Note that the enclosure door swings to the left 90 degrees.
2. Allow at least 4 inches clearance from the top and bottom of the controller to adjacent non-heat producing equipment for air ventilation.
3. Make sure the door or other components will not hinder service access.
4. In the location selected, mount the enclosed controller vertically with the input/output terminals at the bottom.

Table 3-1. Heat Dissipation and Minimum Surface Area

HP	Power Loss (watts)	Minimum Vertical Surface (S) Area	
		sq cm	sq in.
15	550	30,000	4700
20	625	36,000	5500
25	700	41,000	6400
30	800	48,000	7500
40	900	55,000	8600

4. With the input/output terminals at the bottom, vertically mount the chassis directly to the cabinet back wall or building wall. Standoff hardware is not necessary.

Install a Transformer (if needed)
 In all applications requiring the use of an output transformer, contact your Reliance Electric Sales Office for assistance.

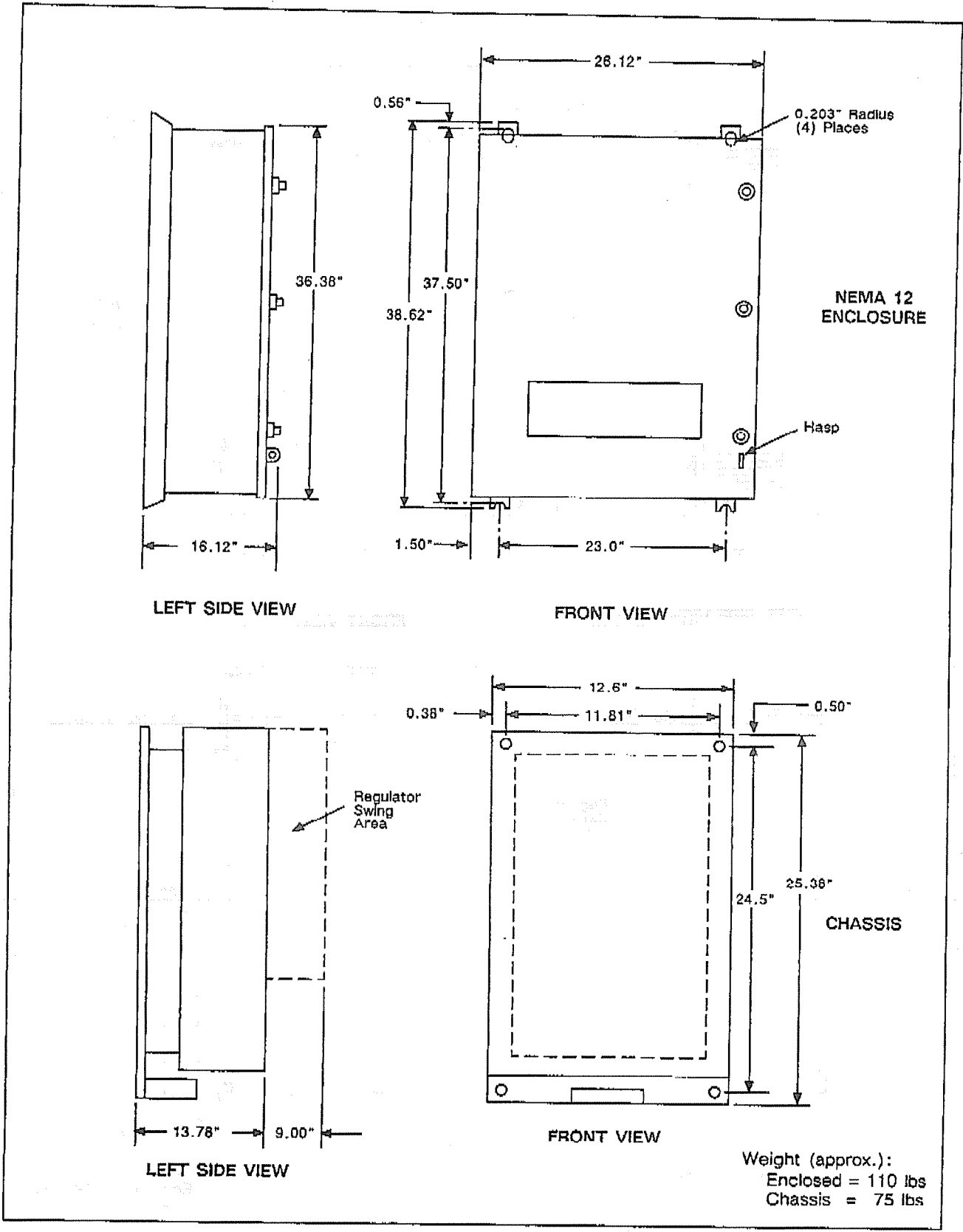


Figure 3-1. Physical Dimensions of 15 and 20 horsepower controllers.

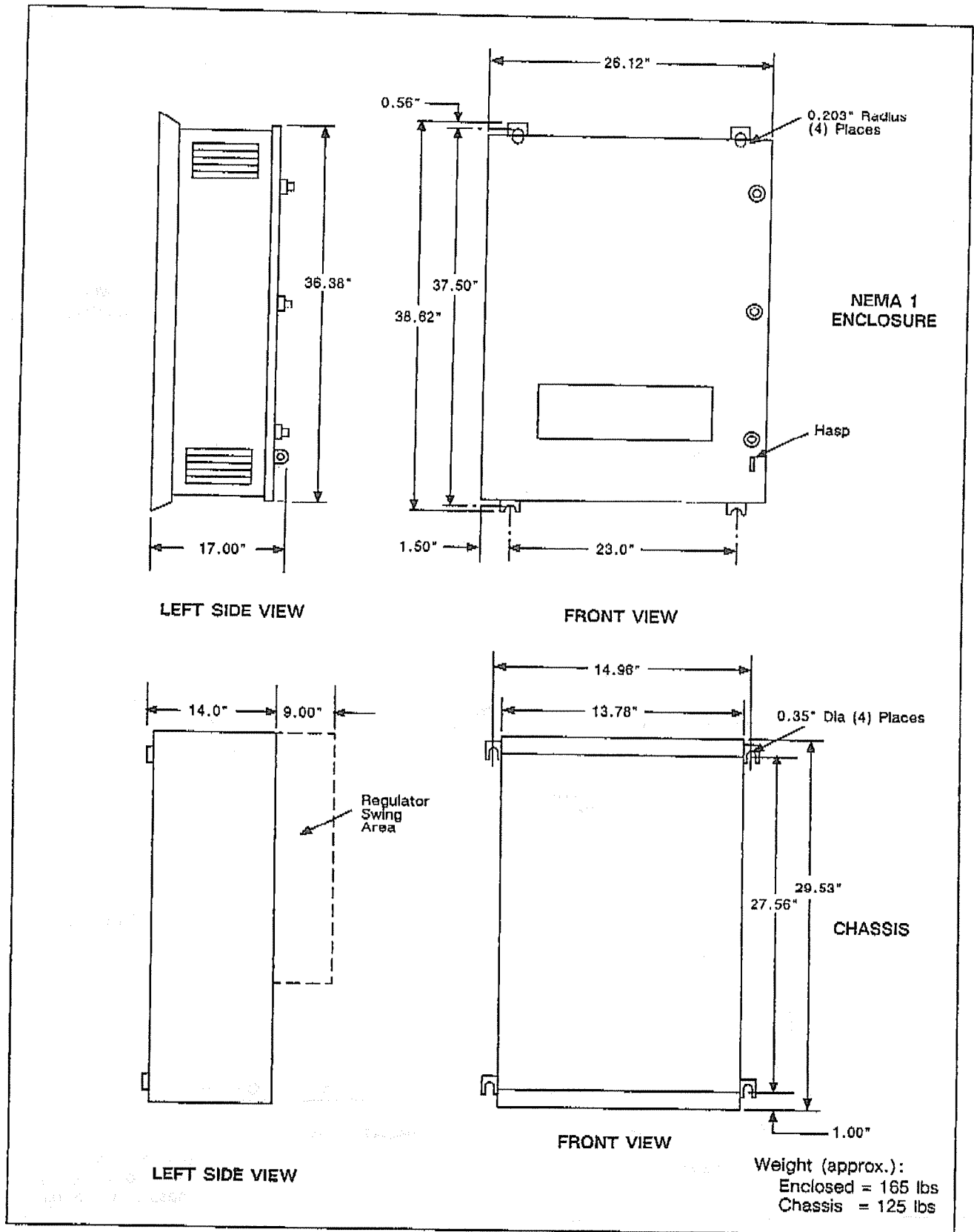


Figure 3-2. Physical Dimensions of 25 thru 40 horsepower controllers.

Input transformers step up or step down input voltage and can be either autotransformers 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 with more than 100,000 amperes fault current capability to the controller. Distribution system capacity above 100,000 amperes fault current capability 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 FOR 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.

Note that the fuseholder for fuses F1, F2 and F3 is not rated as a disconnect.

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.

The standard enclosed controller includes a mounting panel on the right side. If an input disconnect is not supplied mounted and wired by Reliance Electric, a user-supplied input disconnect can be mounted on this panel with a through-the-door handle. With this configuration, the enclosure door cannot be normally opened without first turning the input disconnect OFF.

Drill mounting holes in the panel according to the drilling plan supplied with your device.

CAUTION: During installation, protect the chassis from metal chips, weld splatters, and other debris. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

2. If an input transformer is used, size the disconnect to handle the transformer primary as well as any additional loads the disconnect may supply.
3. If an input transformer is not used, wire the load side of the disconnect to terminals 181, 182, and 183 in the controller.

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.

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

Motor Insulation Class	Motor Service Factor	Motor Derating Percentage of Nameplate HP
B	1.00	15%
B	1.15	10%
F	1.00	5%
F	1.15	0%

2. Install the A-C motor according to its instruction manual.
3. Make sure the motor is properly aligned with the driven machine to minimize unnecessary motor loading from shaft misalignment.
4. 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 is overframed, verify that the motor operating current does not exceed the controller's output current and the motor horsepower is not more than one size larger than the controller's horsepower rating. Then connect a motor overload relay, sized to be equal to or less than the controller output current rating.

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.

- Mount the motor overload relay next to the chassis controller or on the provided mounting panel on the right side of the standard enclosed controller. Drill mounting holes in this panel according to the drilling plan supplied with your device.

CAUTION: During installation, protect the chassis from metal chips, weld splatters, and other debris. Failure to observe this precaution can result in damage to, or destruction of, the equipment.

- Connect the motor overload relay to terminals 601, 602 and 603 of the right-hand terminal block at the bottom of the controller.

WARNING

IF THE FACTORY-INSTALLED JUMPER ACROSS TERMINALS 21 AND 22 IS NOT REMOVED WHEN FUNCTION LOSS INPUT OR INTERLOCKS ARE USED, THESE CONTACTS WILL NOT STOP THE CONTROLLER ON AN IET WHEN OPENED. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

- Remove the factory-installed jumper between terminals 21 and 22 of the left-hand terminal block at the bottom of the controller. Connect the normally closed auxiliary contact of the motor overload relay into the emergency stop circuit at terminals 21 and 22. See Figure 3-6.
- 5. If the motor is accessible while it is running, install a protective guard around all exposed rotating parts.

Suppress Electrical Noise

1. Suppress switched inductive devices or their wiring (solenoids, relay coils, starter coils, etc.) within the vicinity of the controller with RC suppression devices, such as Reliance part 600686-33A, to avoid transient voltages that could disturb electronic circuits. If the circuit is 115 to 230 VAC, a 220-ohm, 1/2 watt resistor in series with a 1/2 microfarad, 600-volt capacitor can be used as the suppressor.
2. Physically separate the wiring of the switching devices in Step 1 above from low level signal circuits.

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. 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.
3. Throughout the wiring procedures, refer to Figure 3-3 thru 3-6 for wiring locations.

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

1. Make sure that the A-C input line and the motor frame are connected to GND terminals, at the right-hand terminal block at the bottom of the chassis controller. (The GND terminals are located near the top conduit entrances for Type 1 and 12 enclosures.) Note that the GND terminals are connected to the controller chassis ground.
2. Connect a suitable equipment grounding conductor unbroken to the motor frame, the remote operator's control station (if used), the transformer (if required), and the controller enclosure. Run this conductor unbroken to the grounding electrode conductor (earth ground).

Power Wiring

1. Size and select input and output wire according to all applicable codes so that it is adequate for the voltages and currents to which it will be subjected.

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.

2. Install input and output power wiring using Figure 3-5. Connect A-C input leads (181, 182, and 183) to the line side of the input disconnect or directly to terminals 181, 182, and 183, respectively, in the controller. Connect the motor leads to the motor overload relay, if installed, or directly to terminals 601, 602 and 603 of the right-hand terminal block at the bottom of the controller.

Control and Signal Wiring

Note that the green terminal blocks on the regulator detach for easy wire installation.

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."

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.

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 Reliance Electric.
3. Install control and signal wiring, rated at 600 volts or greater, using Figure 3-6.

CAUTION: It is important to use wire rated at 600 volts or greater because this wiring may make contact with uninsulated (460 VAC) components. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

4. User-supplied interlock and function loss input wiring connect between terminals 21 and 22 at the left-hand terminal block at the bottom of the controller. The controller is shipped with a jumper across terminals 21 and 22.

WARNING
 IF THE FACTORY-INSTALLED JUMPER ACROSS TERMINALS 21 AND 22 IS NOT REMOVED WHEN FUNCTION LOSS INPUT OR INTERLOCKS ARE USED, THESE CONTACTS WILL NOT STOP THE CONTROLLER ON AN IET WHEN OPENED. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

external power wiring. (Reliance normally uses yellow wire.) Provide a means to disconnect this external wiring.

6. Do not route signal wire through junction or terminal boxes that contain power or control wire.
7. Do not route signal wire in close proximity to devices producing external magnetic fields.

DANGER
 EXTERNAL POWER WIRING MAY REMAIN ENERGIZED WHEN THE MAIN A-C POWER IS DISCONNECTED. IDENTIFY ALL SUCH EXTERNAL WIRING. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

Controller Regulator Modifications

Blue jumpers on the VFC board are provided to modify the controller to the desired application. Refer to Figures 3-3 and 3-4 to locate the jumpers and Table 3-3 for the application of each jumper function. A brief description of each modification follows.

CAUTION: Do not alter any red jumper not discussed. These jumpers are factory-installed for specific design parameters. Failure to observe this precaution could result in damage to, or destruction of, this equipment.

5. If required, user-supplied RUN and FAULT contacts are available at terminals 192-193 and 190-191, respectively, on the VFC board. Identify this as

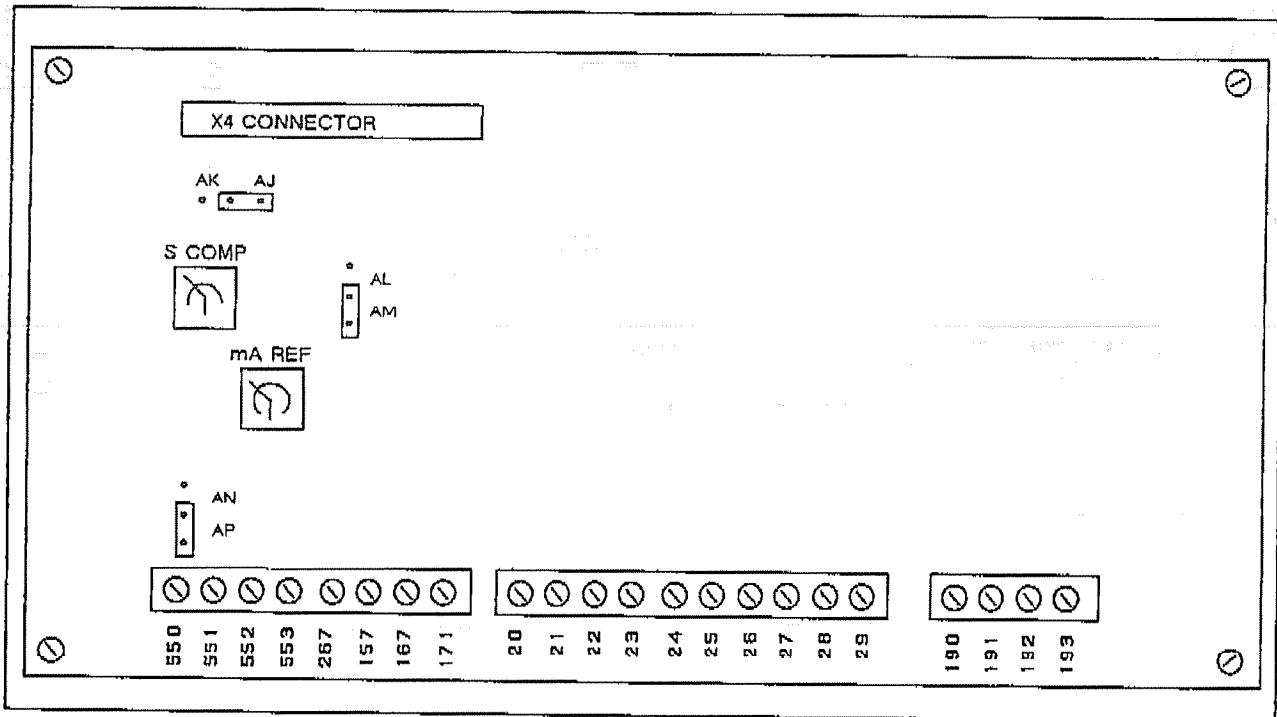


Figure 3-3. CIC Regulator Board Blue Jumper, Potentiometer and Terminal Board Locations.

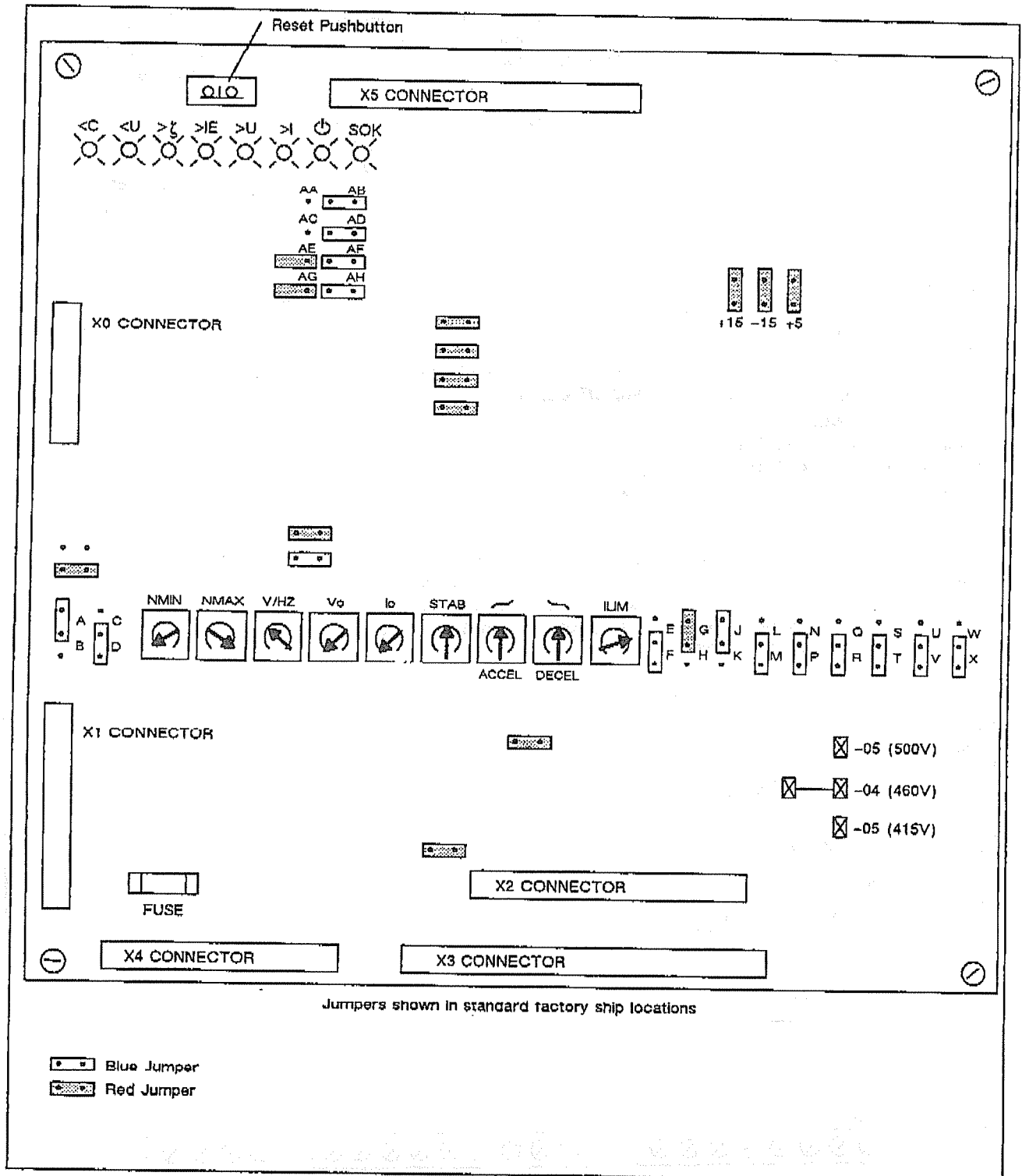


Figure 3-4. VFC Regulator Board Blue Jumpers, Red Jumpers, Potentiometer and Connector Locations.

WARNING
IF THE FACTORY-INSTALLED JUMPER IS NOT REMOVED BETWEEN 21 AND 22 WHEN FUNCTION LOSS INPUT OR INTERLOCKS ARE USED, THESE CONTACTS WILL NOT STOP THE CONTROLLER WHEN OPENED. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

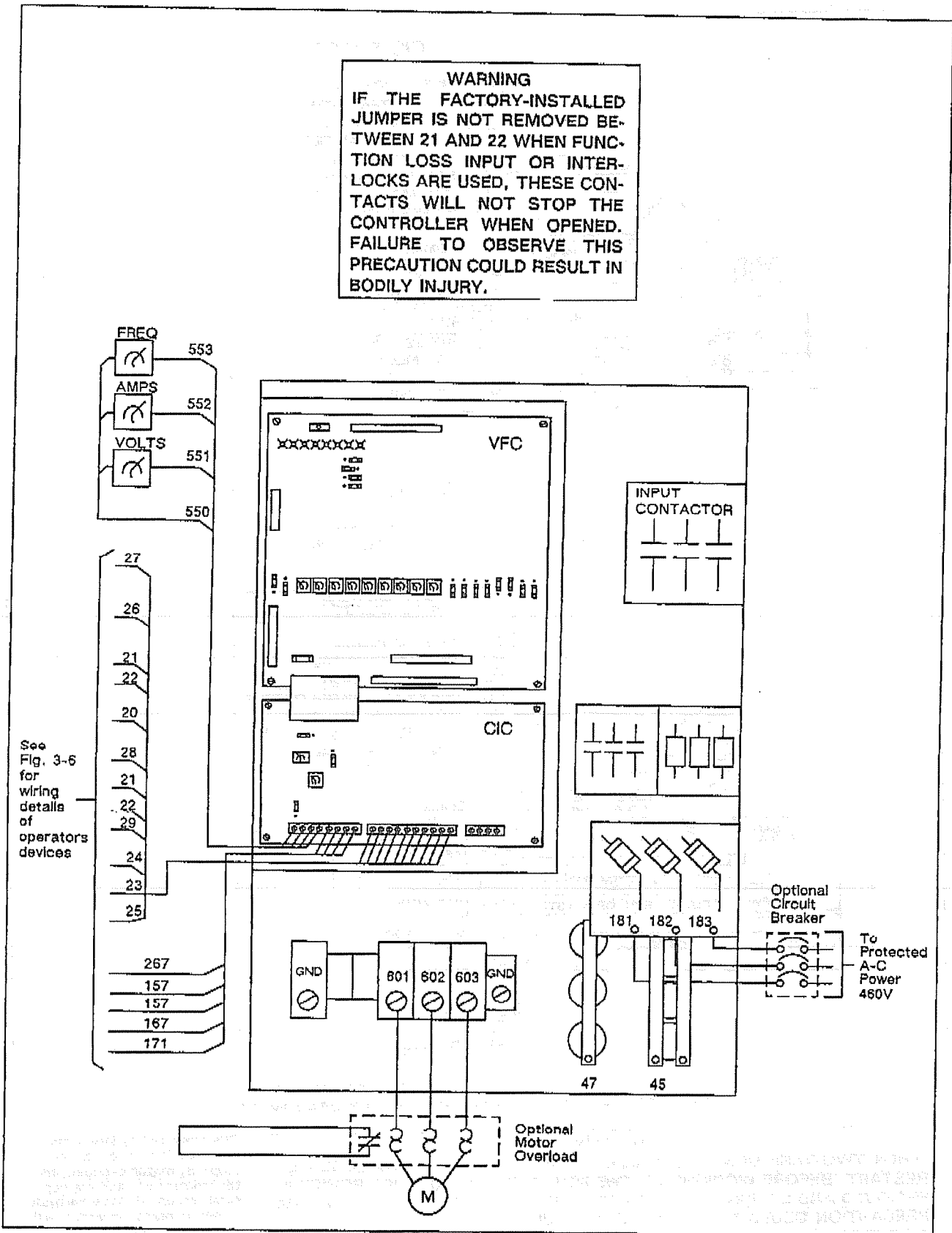
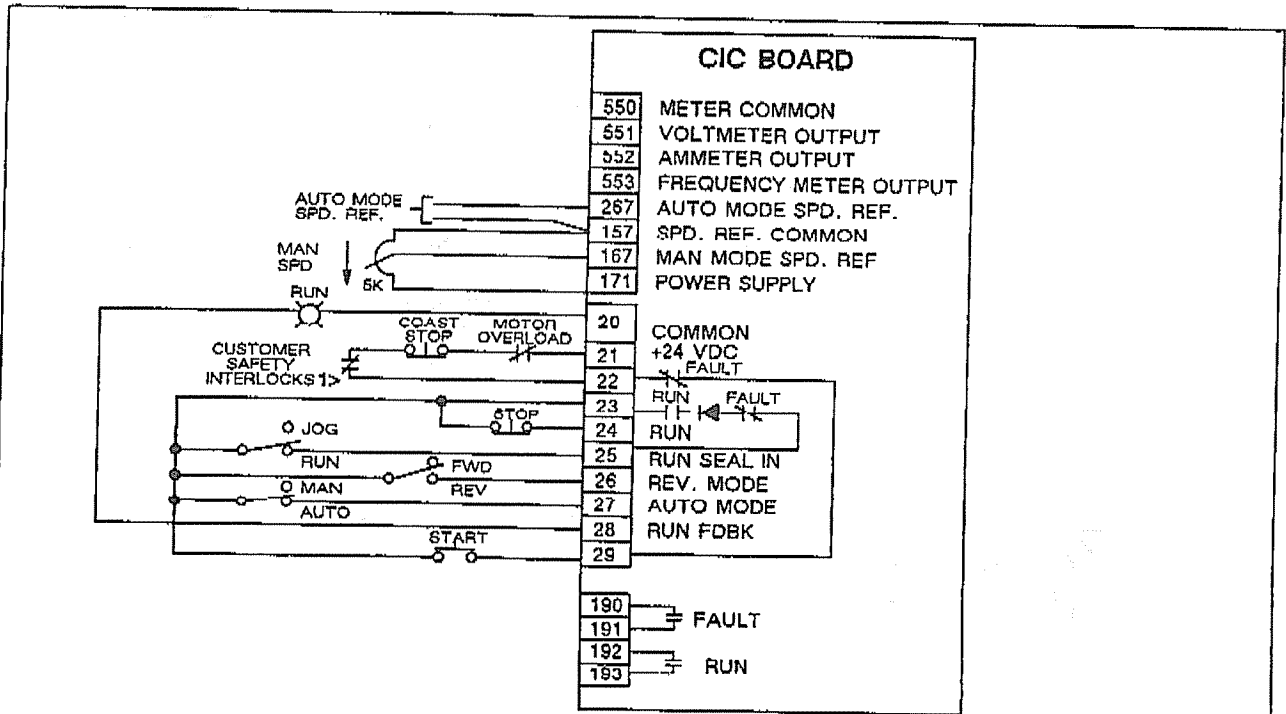
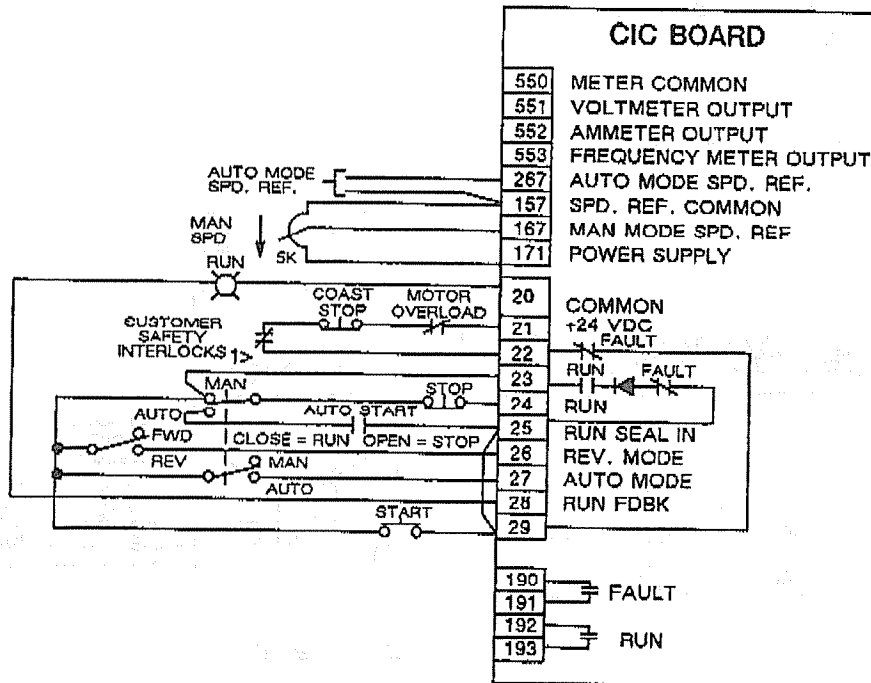


Figure 3-5. Typical Connection Diagram.



SPEED REF SELECT VIA AUTO-MAN SWITCH



START/STOP AND SPEED REF SELECT VIA AUTO-MAN SWITCH

WARNING
 WHEN TWO-WIRE CONTROL IS USED, THE DRIVE MAY AUTOMATICALLY RESTART. BEFORE WORKING ON THE EQUIPMENT, MAKE SURE POWER IS REMOVED AND LOCKED OUT FROM THE DRIVE. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

1> Customer safety interlocks include devices such as coast stop PB, motor overload, motor thermostats and are separately mounted. Wire normally closed contacts in series with terminals 21 and 22.

Figure 3-6. Wiring Detail For Operators Devices.

Table 3-3. Regulator Jumper Modifications.

Function	Application	As Shipped	Blue Jumper Open	Jumper Location Card Name
Auto Reference Input	4-20mA	X	AM and AP	CIC
	0-10VDC		AL and AN	
	0-20mA		AL and AP	
Accel/Decel Ramp Time	1-35 sec		AK	CIC
			K	VFC
	2-70 sec		AJ	CIC
			K	VFC
	4-140 sec	X	AJ	CIC
X		J	VFC	
Base Speed Frequency	60HZ	X	A	VFC
	50HZ		B	
Motor Inertia	Less Than 3 Times Motor Inertia		C	VFC
	Greater Than 3 Times Motor Inertia	X	D	
Reactive Current Compensator	Motor With High Copper Losses		E	VFC
	Motor With Normal Copper Losses	X	F	
Load Profile	Variable Torque		L	VFC
	Constant Torque	X	M	
V/HZ	Adjustable V/HZ		N	VFC
	Fixed V/HZ	X	P	
Auto Torque Boost Circuit	Active		Q	VFC
	Inactive	X	R	
Frequency Range (Frequency stated for Jumper Position "A")	60 HZ Base Min HZ Range 2.4-43 HZ Max HZ Range 25-72 HZ	X	A, T, V, AF, AH	VFC
	120 HZ Base Min HZ Range 6-86 HZ Max HZ Range 50-144 HZ		A, S, V, AF, AG	
	240 HZ Base Min HZ Range 12-172 HZ Max HZ Range 100-288 HZ		A, T, U, AE, AG	
Motor Voltage	460V	X	X Wire Wrap pin to FM125 - 04	VFC
	380V		W Wire Wrap pin to FQ125 - 03	
	415V		X Wire Wrap pin to FQ125 - 03	
Stopping Mode	Ramp To Stop		AA	VFC
	Coast To Stop	X	AB	
Reset After Input Line Fault	Auto Reset		AC	VFC
	Manual Reset	X	AD	

Auto Reference Input

The controller will accept grounded or ungrounded auto speed reference signals (0 to 10 VDC, 0 to 20 mA, or 4 to 20 mA) at terminals 267(+) and 157 (COM). Voltage or current reference selection is made by the jumper position. The input impedance is 500 ohms for a current signal. Voltage reference must be capable of sourcing 0.50mA maximum.

This input may be switched by means of an Auto/Manual selector switch if a manual Speed reference is also used.

Motor Voltage

The controller is shipped with 460-volt output at 60 Hz. A 380V or 415-volt maximum output is available by jumper selection. Consult Reliance Electric for application assistance.

Extended Accel and Decel Times

The controller is factory set to provide an acceleration and deceleration time between 4 and 140 seconds. This can be reduced to 1 to 35 seconds or 2 to 70 seconds by jumper selection. Note that the actual acceleration and deceleration times will be determined by the load inertia and the torque capability of the controller/motor combination.

Base Speed

The controller is shipped with an output frequency of 60HZ when the controller is given a full reference. An output frequency of 50HZ at full reference can be selected by jumper selection.

Inertia Compensation

Inertia compensation is factory set for a load inertia reflected to the motor shaft that is greater than three times motor inertia. If the load inertia is less than the motor inertia, the appropriate jumper position can be changed.

Reactive Current Compensator

The Controller regulator has a Reactive Current Compensator Circuit which will increase performance for some types of motors. The controller is shipped with the regulator jumped for operation of motors with normal copper losses. To improve operation of motors with large copper losses, the appropriate jumper must be selected.

Load Profile

The controller is suitable for running constant torque loads or variable torque loads. The controller is shipped jumpered for constant torque applications. To optimize operation on variable torque loads, select the variable torque jumper.

Volts/Hertz

The controller is factory set to provide a fixed V/Hz characteristic providing 460 volts at the selected maximum frequency as shown in Figure 3-7. An adjustable V/Hz, from 2.2 to 28.8 with a 60 Hz base, may be obtained by jumper selection. The range of adjustments also is shown in Figure 3-7.

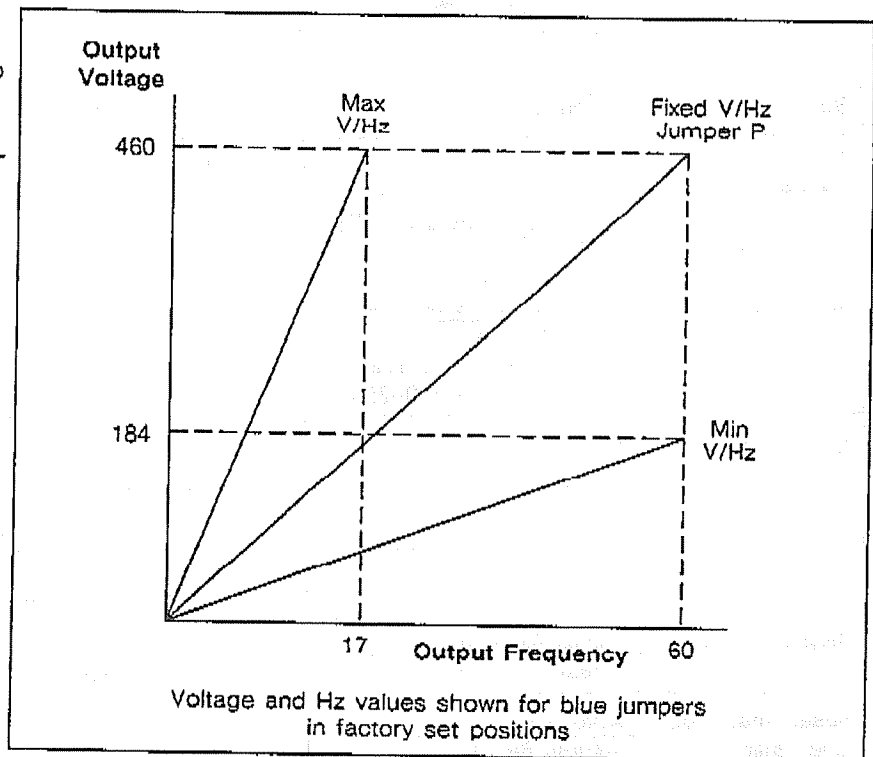


Figure 3-7. Volts/Hertz Adjustment Range.

Auto Voltage Boost

The controller includes a voltage boost adjustment pot and an automatic voltage boost compensating circuit to optimize the applied voltage for the required running torque based on a determination of the real torque-producing current and the magnetizing current. The controller is shipped with the boost adjustment inactive.

If this feature is required, the voltage boost adjustment should be set to just overcome the motor stator resistance. This can be done by observing the load and increasing the boost until the motor begins to rotate. It is desirable to keep this adjustment as low as possible because, if set too high, high currents will result which can cause motor overheating.

Maximum Frequency

The controller is factory set to provide a maximum frequency of 60 Hz. If operation above 60 Hz is required, a maximum frequency of 120 Hz or 240 Hz is available by jumper selection. When operation above 60 Hz is required, contact Reliance Electric for application

assistance and instructions for the modification.

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 100% OF THE MAXIMUM SELECTED BASE FREQUENCY TO THE A-C MOTOR. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

Under most fault conditions, the controller is designed so that, regardless of the maximum frequency selected (60 Hz, 120 Hz or 240 Hz), the maximum output frequency to the motor will be limited to the maximum frequency selected (60 Hz, 120 Hz or 240 Hz, respectively).

Stop Mode

The controller is factory set to provide a coast-to-rest stop when the normal Stop button is operated. Ramp-to-rest, available by jumper selection, will decelerate

the load by following the deceleration rate.

WARNING

THE RAMP-TO-REST FUNCTION REQUIRES PROPER OPERATION OF REGULATOR ELECTRONICS AND IS NOT FAIL-SAFE. WHEN THE RAMP-TO-REST STOP FUNCTION IS REQUIRED, A COAST-STOP PUSHBUTTON IS REQUIRED. THE COAST-STOP PUSH-BUTTON DISABLES THE REGULATOR AND ALLOWS THE MOTOR TO COAST-TO-REST. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

When ramp-to-rest is selected, a coast-stop pushbutton must be wired to the input terminals 21 and 22 on the CIC board. (Figure 3.6)

Reset After Input Line Faults

The controller requires a manual reset utilizing the regulator mounted reset pushbutton when the controller is in an IET condition. If input power line faults cause nuisance tripping the controller can be automatically reset by the appropriate jumper selection.

4: Start and Adjust the Controller

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.

- The following meters or their equivalent are recommended (Having two devices available is convenient.):

- An analog volt-ohmmeter having a sensitivity of 20,000 ohms-per-volt, such as a Triplott Model 630.

- A digital volt-ohmmeter with a 10 megohm input impedance on all ranges, such as a Fluke 8022B.
- The optional portable diagnostic tester may be used in lieu of the above measuring devices. This manual assumes the tester is not used. Filtered outputs are provided on the regulator VFC board for the key parameters summarized below in Table 4-1. If these outputs are used for meters or other devices, they must be disconnected before beginning the startup adjustments.

Check the Installation

- Verify that the input disconnect is in the OFF position (power OFF).
- 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.

- Verify that the motor overload relay, if one is required, is installed according to its instructions and that it is sized for the rated motor current.
- Visually check the controller for mechanical damage and remaining installation debris, wire strands, etc.
- Verify that all coils connected to the controller or located in the controller vicinity are suppressed: A-C coils with RC suppression and D-C coils with diodes in a non-conducting direction.

Check the Motor

- Verify that motor nameplate data corresponds to the controller output ratings:
 - Voltage: 460 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 current rating. If the motor is overframed, 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 Hz.

Table 4-1. CIC (0-10 VDC) Output Signals

Parameter	Terminals	Calibration	
Output Voltage	551(+) 550(COM)	10.0 VDC \pm 2% = 460 volt fundamental output with 460 Volt Input (1.0 VDC/46 VAC Output)	
Output Current	552(-) 550(COM)	HP Rating	100% Controller's Output Current Rating
		15	5.68VDC
		20	6.67VDC
		25	6.67VDC
		30	5.60VDC
40	6.67VDC		
Output Frequency	553(+) 550(COM)	10.0 VDC \pm 1% = maximum frequency (.17 VDC/Hz for 60 Hz max; .08 VDC/Hz for 120 Hz max; .0417VDC/HZ for 240HZ max)	

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

2. Verify that the motor is installed according to its 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 any motor thermal switch or overload device is wired according to Figures 3-5 and 3-6.

2. Check that signal leads are shielded and separated from electromagnetic fields.
3. Verify that A-C line voltage to the controller is three-phase, 460 VAC. Verify that the A-C line frequency is 60 Hz.

Check that Application Limitations Are not Exceeded

If the controller will control more than one motor, verify the following:

- If no motor will be switched on during operation, the sum of the rated motor currents is equal to or less than the rated controller current.
- If motors are switched on while the controller is running, the sum of the rated motor currents of all the motors connected continuously and the locked rotor current of any motor which is to start is equal to or less than the rated controller current.

WARNING

DO NOT ADJUST THE MINIMUM SPEED SETTING BELOW THE POINT THAT WILL ENSURE THAT THE MOTOR WILL CONTINUE TO ROTATE WHEN THE OPERATOR'S SPEED CONTROL POTENTIOMETER IS SET AT ZERO. NOISE, IMPROPER WIRING, POWER LINE DISTURBANCES, MALFUNCTION, OR MECHANICAL BINDING MAY CAUSE THE DRIVE TO RESTART UNEXPECTEDLY. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

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 1000 VDC scale or a similar high voltage scale. Connect the voltmeter to terminals 47(+) and 45(-).

Read this voltmeter every time you turn power OFF to verify the D-C bus capacitors are fully discharged. Within one minute after power is turned OFF, the bus voltage should measure about 50 VDC.

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 100% OF THE MAXIMUM SELECTED BASE FREQUENCY TO THE A-C MOTOR. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

Check the Wiring

1. Check that the controller is wired according to Figure 3-5 and that all connections are tight.

Start the Controller



Simplified Procedure

The controller is set up to operate a typical NEMA Design B motor with nameplate current less than or equal to the controller output rating. Review the "as shipped" settings listed in Table 3-2. If these settings meet the application requirements and the initial pot adjustment settings listed in Table 4-2 are acceptable, perform the following simplified procedure; otherwise, proceed to "Detailed Procedure."

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 VOLTMETER AT TERMINALS 45(-) AND 47(+) 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.

Table 4-1. Regulator Board Initial Pot Settings.

VFC Board			
Pot Function	Symbol	Setting	Factory Setting
Minimum Speed	NMIN	3.0HZ	90%
Maximum Speed	NMAX	60HZ	Approx. 90%
Volts per Hertz	V/HZ	460V at 60HZ, Fixed	No Effect (Factory set @ 25%)
Voltage Offset	Uo	0V	Fully CCW
Auto Voltage Boost	Io	0V	Fully CCW
Stability	STAB	Normal	Mid Range
Acceleration Rate		Approx. 70 seconds	Mid Range
Deceleration Rate		Approx. 70 seconds	Mid Range
Current Limit	ILIM	150% of Controller Rating	Varies with HP
CIC Board			
Pot Function	Symbol	Setting	Approximate Setting
Milliamp Ref. Bias	mA REF	No Effect	4mA - Min Speed 20mA = Max Speed
Slip Comp	S COMP	No Effect	Fully CCW

DANGER

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

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 capacitors as follows:

- Disconnect the motor by removing the motor leads from the terminal board or overload if provided.
- Put the Run/Jog switch, if used, in the RUN position.
- Turn the Speed pot fully CCW. Turn the power ON. Push the start button.
- Observe that the voltmeter reading is approximately 650 VDC with respect to 460 VAC input.

- Let the controller sit undisturbed for fifteen minutes while the capacitors charge. 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.

- 6. Turn the Speed pot fully CCW. Turn the power ON. Both green LEDs on the VFC board will be lit.
- 7. Press the Start switch. [Terminal 28(+) to 20(-) will have 24 VDC present or the RUN pilot light, if used, will be lit.]
- 8. 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.

Monitor CIC terminals 551, 552, 553 and 550 (com) with digital voltmeter (20V scale). Turn speed pot to mid range. The voltage on terminals 551 and 553 should be approximately equal to 5.0 VDC. The voltage at 552 must be equal to or less than the full load values in Table 4-1. Turn speed pot to full CW. The voltage on 551 and 553 should equal 10.0 VDC $\pm 2\%$ and 552 should be less than or equal to the full load current values shown in Table 4-1.

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

Minor user adjustments may be necessary for satisfactory operation. Refer to Steps 24 through 35 in "Detailed Startup Procedure."

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.

Detailed Startup Procedure

Use this startup procedure when the simplified startup does not result in satisfactory operation. 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. Make sure the regulator adjustment pots are set per Table 4-1.
4. Set a voltmeter on the 1000 VDC scale or a similar high voltage scale. Connect the voltmeter to terminals 47(+) and 45(-).

Read this voltmeter every time you turn power OFF to verify the D-C bus capacitors are fully discharged. Within one minute after power is turned OFF, the bus voltage should measure about 50 VDC.

4:4

DANGER

THIS EQUIPMENT IS AT LINE VOLTAGE WHEN A-C POWER IS CONNECTED TO THE CONTROLLER. DISCONNECT ALL UNGROUNDED CONDUCTORS OF THE A-C POWER LINE FROM THE CONTROLLER. AFTER POWER IS REMOVED, VERIFY WITH A VOLTMETER AT TERMINALS 45(-) AND 47(+) 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.

5. Disconnect the motor power leads from the controller, if connected.
6. If the controller has been stored for less than six months, proceed to Step 7. If the controller has been stored for over six months, form the capacitors as follows:

DANGER

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

- Put the Run/Jog switch, if used, in the RUN position.
- Turn the Speed pot fully CCW. Turn the power ON. Push the start button.
- Observe that the voltmeter reading is 650 VDC with respect to 460 VAC input.
- Let the controller sit undisturbed for fifteen minutes while the capacitors charge. 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).

7. With power OFF, connect a digital voltmeter (20 VDC scale) with (-) lead connected continuously to terminal 550 (CIC pcb) and (+) to either 551, 552, 553 which represents output fundamental voltage, output RMS current, and output frequency respectively. See Table 4-1 for range information.
8. With the Speed pot fully CCW, turn the power ON.
9. Press the START switch. (Fig. 3-6) The green RUN LED should turn "ON" and the input contactor should pick up. The voltage on CIC terminal 553 is 0.5 VDC (3 HZ). The voltage at 551 is 0.5 VDC (23 VAC).
10. Gradually turn the Speed pot CW direction. Notice that the voltage at 553 and 551 increase gradually also. With the Speed pot at mid-range, 553 and 551 is equal to 5.0 VDC. Turn the Speed pot to full CW. The voltage at 552 and 551 is equal 10.0 VDC. The voltage at 552 should be less than or equal to the values shown in Table 4-1.
11. Quickly turn the Speed pot fully CCW. The voltage and frequency will decrease to 0.5 VDC (23 VAC) and 0.5 VDC (3HZ) at the time determined by the deceleration setting.
12. Quickly turn the Speed pot fully CW. The voltage and frequency will increase to the rated voltage and 60 Hz at the rate determined by the acceleration setting.
13. Note that the V/Hz pot is not operative as shipped. V/Hz is fixed to provide 460 VAC at 60 Hz output. The factory adjustment will maintain the required 7.6 V/Hz characteristic over the speed range.

Do not adjust the V/Hz unless your application requires a different voltage at 60 Hz.

If a different volts/hertz ratio is required (See Figure 3-7.), select the appropriate jumper position and adjust the V/Hz pot as follows:

- Make sure the motor is disconnected.
- Determine the required V/Hz slope. This can range from 28.8 (14.4) V/Hz to 2.2 (1.1) V/Hz for a maximum frequency selection of 60 (120). Note the limits of the setting as discussed in "Controller Regulator Modifications" in Section 3.
- Determine the required voltage at 16 (32) Hz. For example, the required voltage for 24.0 (12.0) V/Hz at 16 (32) Hz is $24.0 (12.0) \times 16 (32) = 384 (384)$ volts.
- See Figure 3-4.
- Turn the Uo pot fully CCW.
- Measure the voltage at terminals 553(+), 550 (COM). (CIC PCB)
- With the Speed pot fully CCW, press the Start switch.
- Turn the Speed pot CW until 16 (32) Hz output is reached. Read approximately 2.7 volts at terminals 553 to 550.
- Connect a second voltmeter to terminals 551(+), 550(-).
- While reading the second voltmeter, adjust the V/Hz pot until the voltage reads approximately the required voltage at 16 (32) Hz divided by 46.0. For example, 384 divided by 46.0 is approximately 8.4 volts at 551. Check a second point to determine that the V/Hz is properly set.

DANGER

DO NOT ADJUST THE MINIMUM SPEED SETTING BELOW THE POINT THAT WILL ENSURE THAT THE MOTOR WILL CONTINUE TO ROTATE WHEN THE OPERATOR'S SPEED CONTROL POTENTIOMETER IS SET AT ZERO. NOISE, IMPROPER WIRING, POWER LINE DISTURBANCES, MALFUNCTION, OR MECHANICAL BINDING MAY CAUSE THE DRIVE TO RESTART UNEXPECTEDLY. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

14. If a minimum frequency other than 3.0 Hz is required, adjust the NMIN pot as follows:

- Turn the NMIN pot fully CCW.
- Turn the Speed pot fully CCW.
- Place the Auto/Man switch (if used) in the Man mode.
- Connect the voltmeter to terminals 553 (+), 550 (COM).
- Determine the minimum frequency required and the corresponding reading at terminals 553, 550. For example, the required reading for 25 Hz minimum would be $25 \text{ Hz} \times 0.17 = 4.2 \text{ VDC}$ for a maximum frequency selection of 60 Hz. For a maximum frequency selection of 120 Hz, the reading would be $25 \text{ Hz} \times 0.08 = 2.0 \text{ VDC}$.
- While observing the voltage at terminals 553 and 550, adjust the NMIN pot until the required voltage level is reached.
- Place the Auto/Man switch (if used) in the Auto mode. Verify the blue jumper is properly set for the type of

signal to be followed i.e., 0-10VDC, 4-20mA or 0-20mA. Reduce this automatic signal to the minimum value.

- The controller is shipped adjusted to follow a 4-20mA signal. If less than 4mA is being received at the speed reference input terminals (267-157) adjust "mA REF" potentiometer on the CIC board.
- Verify that approximately the same voltage levels are present at terminals 553 and 550 in both Auto and Man modes.

If equal voltage levels are desired, additional circuitry may need to be added.

15. If a maximum frequency other than 60 (120, 240) Hz is required, adjust the NMAX pot as follows (Note that the NMIN pot must always be adjusted before adjusting the NMAX pot, and the maximum hertz will start where the NMAX is set if set above 50%.):

- Turn the NMAX pot fully CCW.
- Turn the Speed pot fully CW.
- Determine the maximum frequency required and the corresponding reading at terminals 553(+), 550 (COM). For example, for a maximum frequency selection of 60 Hz and a desired NMAX of 50 Hz, $50 \text{ Hz} \times 0.17$ at 553 is approximately 8.5 volts. For a maximum frequency selection of 120 Hz and a desired NMAX of 50 Hz, $50 \text{ Hz} \times 0.08$ is approximately 4.3 volts.
- While observing the voltage at terminals 553 and 550, adjust the NMAX pot until the required voltage is reached.

16. Note the reading on the volt-meter connected to 553. Put the Forward/Reverse switch, if applicable, in the REV position. The reading should decrease to zero and then return to the original reading. Return the Forward/Reverse switch to the FWD position.
17. Put the Auto/Man switch, if applicable, in the AUTO position. The Speed pot is now ineffective; speed is controlled by a process control reference signal of 4 to 20 mA, 0 to 20 mA, or 0 to 10 VDC. Return the Auto/Man switch to the MAN position.
18. Turn the Speed pot fully CCW and press the Stop switch.
19. Turn the power OFF. Verify the D-C bus voltage is zero (read the first voltmeter).
20. With power OFF, connect the motor power leads to the controller and couple the driven machinery to the motor, if not already coupled.
21. With the Speed pot fully CCW, turn the power ON.
22. Press the Start switch.
23. Check the motor shaft rotation. If shaft rotation is correct, go to Step 24. 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 the Speed pot fully CCW.
24. Note that U_o pot is factory set to produce zero offset volts. Turn power ON and press the Start switch. Observe the driven equipment and the motor. The motor should begin rotation and increase speed as the Speed pot is slowly turned CW. If the motor does not begin rotation, adjust the U_o pot as follows:
- With the drive coupled to the machine, the voltage boost may not be high enough to break away or accelerate the load within the current limit of the drive.
 - Connect the voltmeter to terminals 552(-), 550 (COM) to monitor the output current. The controller will be at 100% rated current when the voltmeter reads the voltages listed in Table 4-1. (150% is 1.5 times the values shown in Table 4-1.)
 - Start the controller and slowly turn the Speed pot in the CW direction while observing the voltmeter.
 - Adjust the U_o pot, if required, until the motor just begins rotation.
 - If the load will not start rotation, the controller may be undersized.
25. The current limit adjustment ranges from approximately 50 to 150% of the controller continuous ampere rating with 50% corresponding to full CCW and 150% to approximately 75 to 100% CW rotation. (See Fig. 3-4) Actual output current can be monitored by connecting a voltmeter to terminals 552(-) and 550 (COM) on the CIC board.
26. Operate the controller at the minimum speed setting and at several points in the speed range while observing the voltage at terminals 552(-) and 550 (COM). If the voltage signal appears to oscillate, adjust the Stability pot until the oscillation is minimized. (See Fig. 3-4)
27. Turn the Speed pot to the maximum CW position and the motor will accelerate to the maximum speed setting. Maximum speed may not be reached due to current limit. (Factory set at 150% full load current) The controller is not designed to supply 150% of the current rating for more than one minute. If satisfactory adjustment cannot be reached, contact your Reliance Electric Sales Office.
28. Turn the Speed pot fully CCW and the motor will decelerate to the minimum speed set with the NMIN pot.
29. With the Speed pot fully CCW, quickly turn the Speed pot fully CW. If the acceleration time is too long, turn the Acceleration pot (↗) a quarter turn CW and accelerate the motor again. Repeat the motor acceleration process until the desired acceleration time is achieved.
- Note: The shortest acceleration time is limited by the current limit circuit. When the Acceleration pot no longer has any effect, the acceleration rate is at its maximum for the application. When the motor is in acceleration while the current is limited, the acceleration will not be smooth. To smooth the acceleration, turn the Acceleration pot slightly CCW.
30. Turn the Speed pot fully CW and wait until the motor reaches top speed. Quickly turn the Speed pot fully CCW. If the deceleration time is too long, turn the Deceleration pot (↘) a 10% turn CW and decelerate the motor again. Repeat the motor deceleration process until the desired deceleration time is achieved.

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.

Note: The shortest deceleration time is limited by the voltage limit circuit. When the Deceleration pot no longer has any effect or the controller trips off, the deceleration rate is at its maximum for the application. When the motor is in deceleration while the D-C bus voltage is limited, the deceleration will not be smooth. To smooth the deceleration, turn the Deceleration pot slightly CCW.

31. Turn the Speed pot CCW and wait until the motor completely stops. Then put the Run/Jog switch, if used, in the JOG position.
32. Turn the Speed pot a quarter turn CW and press the Start switch. The motor will rotate while the Start switch is held in the START position. The speed depends on the Speed pot setting.
33. Put the Run/Jog switch in the RUN position. Press the Stop switch.
34. Turn the speed pot CW and press the Start switch. The motor will accelerate to full speed. Run the motor at no load and at full load conditions. If motor slip at these operating points is required to be reduced; adjust the S Comp pot (See Fig. 3-3) as follows:
 - Turn the S Comp pot a 10% turn CW.
 - Load and unload the motor while noting slip.
 - Increase the S Comp pot until slip is reduced to a satisfactory level.
 - Press the stop switch and wait for the machine to come to a rest.
 - Press the start switch.
 - If the controller trips off with the new S Comp setting, the accel/decel ramps must be extended.
35. Turn the Speed pot CCW to the machine's minimum operating speed. Run the motor at no load and full load conditions if applicable. If motor slip at this operating point must be reduced; adjust the Io pot (See Fig. 3-4) as follows:
 - Turn power off and verify that bus caps are discharged.
 - Activate the Auto Torque Boost Circuit by placing the blue jumper from position R to Q.
 - Increase the Io pot until slip is reduced to a satisfactory level.
36. Turn the power OFF. After verifying the D-C bus voltage is zero, remove the voltmeters and any other instrumentation connected during startup.
37. 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 when operating from a constant voltage, constant frequency source, such as 460 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 (three-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

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

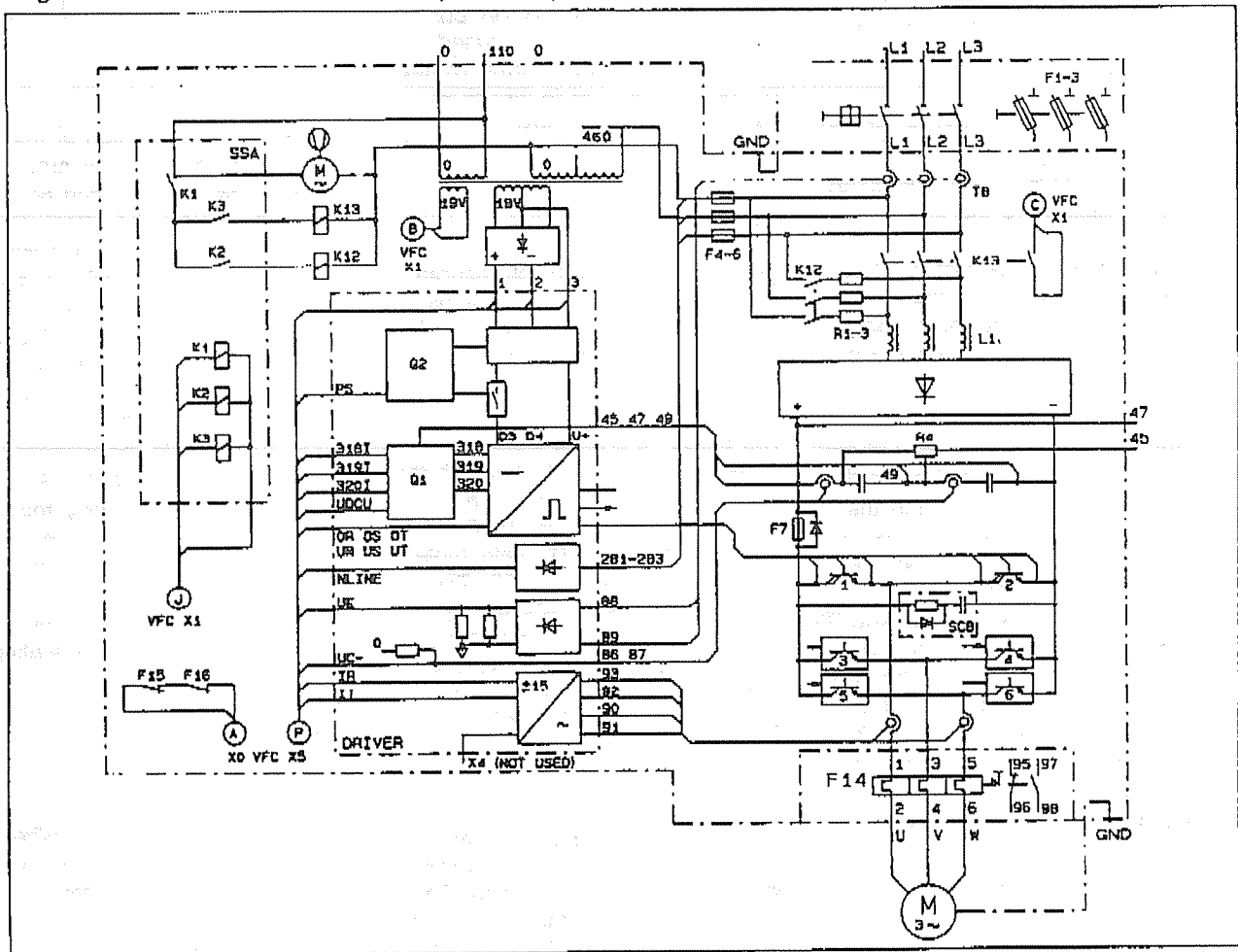
The relationship between output voltage and operating frequency is the "volts per hertz" ratio (V/Hz).

Except at low speed, this ratio is usually a constant determined by this equation:

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

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 based inverter that transforms the constant voltage, constant frequency input power into variable voltage, variable frequency output power. The regulator controls when the transistor switches in the power circuit turn ON or OFF.

Figure 5-1. Controller Power Circuit (25-40 HP).



Power Circuit and Power Circuit Sequencing

Figure 5-1 shows the controller power circuit. Three-phase, 60 hertz, 460-volt power is applied to terminals 181, 182, and 183. Power is applied to the precharge circuit through the standard input fuses. Current transformer T8 senses ground fault currents. With input power applied to the precharge circuit, the green SOK LED on the VFC board will be lit if the power supply voltages are correct; the green READY LED will be lit if there are no faults present (The faults are summarized under "Controller Specifications" in Section 2 of this manual.); and relay K1 will be picked up. Output terminals 29(+) and 20(-) are available for pilot light indication of READY. When ready, 24 VDC will be present at terminal 29. These indications must be ON before the controller will start.

Input power is also supplied ahead of the precharge circuit to the control transformer which supplies control voltages to the power supply diode rectifier, relays K2 and K11 and interlock terminals 21 and 22. Terminals 21 to 22 are available for external interlocks and must be closed for the controller to operate.

When the Start command is given and READY and SOK LEDs are lit, the precharge relay K12 and the run relay K5 will close. (Contacts for run indication are available at terminals 192 to 193.) The precharge resistors R1, R2, and R3 switch in to limit the D-C bus capacitor charging current. After the D-C bus voltage reaches 95% of rated voltage (approximately 620 VDC), relay K3 will close, picking up contactor K13, and the precharge relay K12 will drop out.

The input line reactor L1 limits the rate of change of input current seen on the input power line and

permits the drive to be operated on any size transformer up to the fault current rating of the fuses.

The diode bridge rectifies the three-phase, 60 hertz, 460 VAC input power to approximately 650 VDC. This voltage is filtered by the D-C bus filter capacitors. A D-C bus capacitor discharge resistor R4 is sized to discharge the capacitors to 50 VDC within approximately 1 minute after power is removed from the capacitors either by a Stop command or opening the input disconnect. The green READY LED signals when it is okay to restart.

The rectified, filtered D-C voltage is fed to the transistorized inverter section which is operated to produce variable voltage, variable frequency output to the motor. The inverter phase transistors are switched by the base driver board and the inverter phase is fused by F7. Two Hall Effect devices T5 and T6 provide current feedback to the regulator VFC board.

Regulator

Figure 5-2 shows a block diagram of the regulator. All connections to the regulator are made using pull-apart terminals located on the VFC board.

The speed reference signal is either a manual Speed pot with the input at terminal 167 or an automatic speed reference (0-20 mA, 4-20 mA, or 0-10 VDC selectable by jumper) at terminal 267. The speed reference is selected by use of an Auto/Manual selector switch at terminal 27 (24 VDC at terminal 27 selects the manual speed reference). The switch operates relay K4.

The speed reference signal is applied to the minimum and maximum hertz as determined by the NMIN and NMAX pot settings. This signal then goes to the rate circuit (LVTU) which determines the ac-

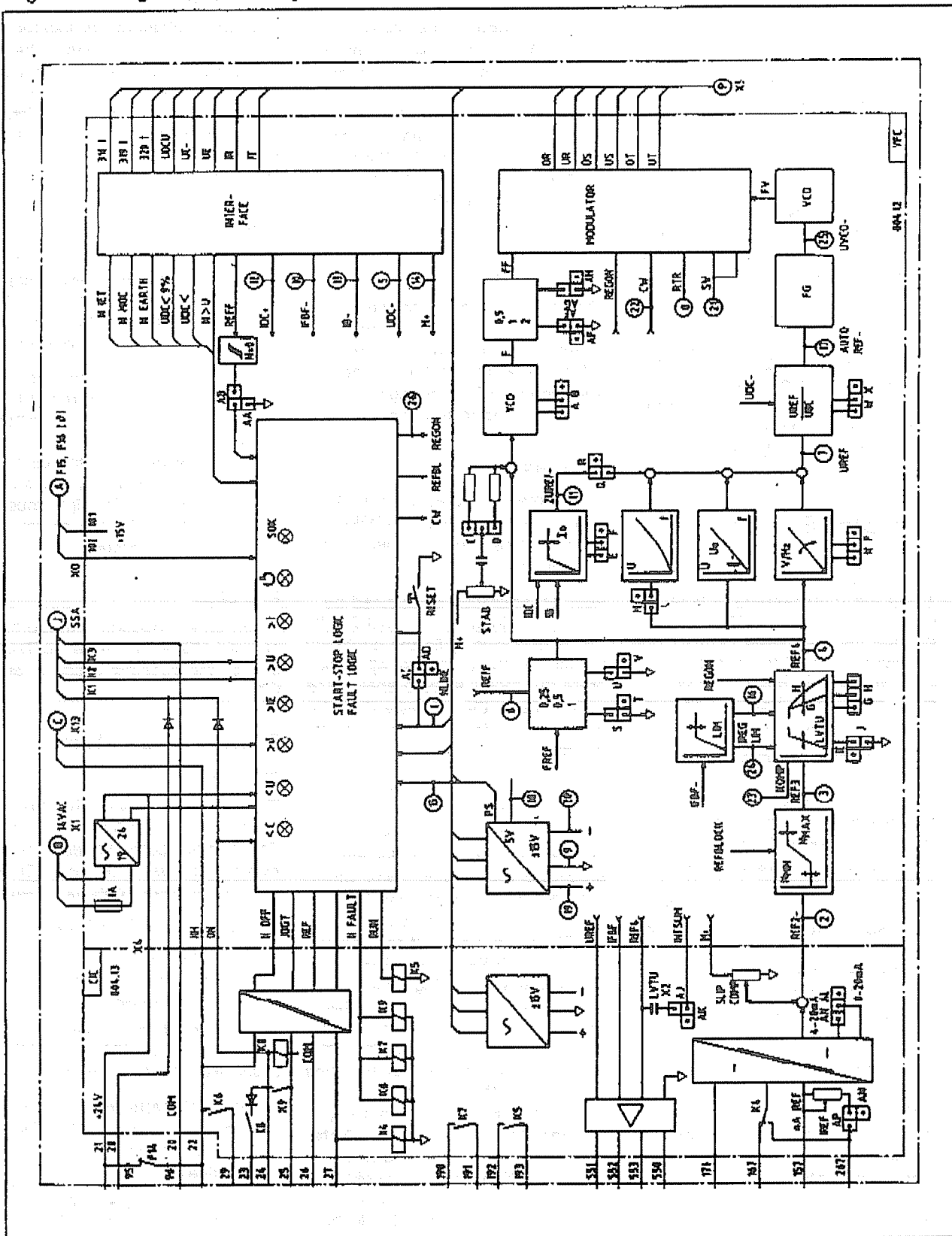
celeration and deceleration rates as determined by the Accel and Decel pot settings. The rate circuit (LVTU) also has inputs from the current limit circuit and the over-voltage limiting circuit. The current limit setting is determined by the ILIM pot and the circuit compares the current limit setting to the current feedback signal. If the control goes into current limit, the frequency is reduced or the accel or decel rate is extended to keep the current within required limits.

The timed reference circuit provides the reference for the volts/hertz circuitry. The volts/hertz is determined by the V/Hz pot setting and may be fixed or adjustable by jumper selection. When fixed, the voltage will be 460 volts at 60 hertz. If the motor will not rotate at low speed, increase the voltage offset pot (Uo) until the motor begins to rotate.

If the Auto Voltage Boost Circuit is selected (by the position of the jumper [position Q]), the Auto Voltage Boost pot (Io) can be used to determine the offset voltage applied at 1.4 Hz to provide starting torque up to 150% of the controller current rating. When this function is selected, it includes an automatic boost compensating circuit that senses motor reactive current and applies the proper voltage to maintain the magnetizing current at the proper level. It is important to avoid applying too much voltage boost because high motor currents and motor overheating can occur. When adjusting the Auto Voltage Boost pot (Io), the controller should be operating a motor at 30Hz. Monitor the motor current and adjust Io until the current level is minimized.

The rate circuit also feeds the ramp-to-rest stop circuitry. When ramp-to-rest is selected, the input contactor is held in until the rate circuit decreases to zero. This is selectable by jumper.

Figure 5-2. Regulator Block Diagram.



The output of the rate circuits inputs to the VCO (voltage controlled oscillator), which controls the switching of the transistors through the base drive circuits. Maximum frequency selections of 60, 120, and 240 hertz are available by jumper selection.

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 100% OF THE MAXIMUM SELECTED BASE FREQUENCY TO THE A-C MOTOR. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

Operator Sequencing

Start/Stop

When the Start command is given at terminal 24, the control will sequence the precharge circuitry and accelerate the motor to the applied speed reference. In order to start, both green READY and SOK indicators must be lit.

Stopping may be either coast stop or ramp-to-rest selectable by jumper. When coast stop is used, the regulator is sequenced off, the input contactor is opened, and the motor coasts to a rest. If the ramp-to-rest stop mode is used, the motor will decelerate to minimum speed according to the rate on the Decel pot or as determined by the overvoltage control circuitry. The controller can be re-started at any time during or after the deceleration time.

Coast stop may be achieved by opening terminal 21. This immediately drops out the input contactor, bypasses the normal regulator sequencing, and results in a coast stop. The controller cannot be re-started until the READY light comes on again. Under normal operation, stop should be done by opening terminal 24.

5:4

Run/Jog

In the run mode, input 25 is closed. When the Start command is given, the drive will accelerate to the speed set by the speed reference and will run. In the jog mode, input 25 is open. The motor will rotate only while the Start pushbutton is closed and will stop when the Start pushbutton is opened.

Auto/Manual

The manual mode is selected by opening the input to 27. This switches in the manual Speed pot reference at terminal 167. The auto speed reference signal is selected by closing terminal 27.

Forward/Reverse

In the forward mode, terminal 26 is open. If the opposite rotation is required, any two motor leads can be switched on the output.

Reverse operation is obtained by closing the input to terminal 26. If this is operated while the controller is running, the controller will decelerate the motor to zero speed and accelerate in the opposite direction to the speed set by the speed reference.

Status and Fault Indication

The controller monitors selected signals within the controller and generates an IET fault signal whenever one of the conditions listed in Table 5-1 occurs. 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 VCO. This redundancy assures the controller turns off when a fault occurs. The controller can be reset by pressing the Reset button located on the VFC board, or remotely by using the Remote Reset Kit option. Note that, in addition to the indicated faults, an IET might be caused by a customer-supplied interlock between terminals 21 and 22. If this is open, the READY LED will not come on.

LED Indicators

The LED indicators are located at the top of the VFC board. The two green LEDs indicate drive status. The red LEDs provide first fault indication and latch after the first fault. The status is maintained until the controller is reset or power is removed.

Green LEDs

SOK This LED indicates the regulator power supply voltage is correct. This light must be lit for the controller to operate.



This LED indicates the controller is ready to run: the control voltage is correct, there is no external E-stop command, and there are no faults. This light must be lit for the controller to operate.

Red LEDs

When an IET occurs, the appropriate red LED lights. Refer to Table 5-1 for the possible cause of an IET.

Contact Indicators

RUN Contact

This contact indicates that the regulator is controlling the output. This contact corresponds to relay K5 with voltage at terminals 28 to 20. The following conditions exist:

- Both green LEDs will be lit
- No faults are present
- A start command has been given to the controller.

The RUN contact is connected at terminals 192 to 193 on the VFC board with the following ratings:

- D-C: 120 watts maximum with a maximum voltage of 30 VDC or a maximum current of 5 amps resistive.
- A-C: 920 VA maximum with a maximum voltage of 120 VAC or a maximum current of 5 amps resistive.

Table 5-1. Possible Causes for a Red LED To Light.

LED	Possible Causes
>I	<ul style="list-style-type: none"> • Motor overcurrent • Acceleration rate too fast • Stability adjustment too high • Line transient
>U	<ul style="list-style-type: none"> • Input voltage greater than 560 VAC • Bus voltage greater than 800 VDC because deceleration rate too fast
<C	<ul style="list-style-type: none"> • Short circuit in the D-C bus • Faulty precharge circuit operation • Unbalanced output currents
>IE	<ul style="list-style-type: none"> • Phase-to-ground fault on the output
<U	<ul style="list-style-type: none"> • Input voltage less than 320 VAC (Dip or Continuous) • Power supply voltage low
>ξ	<ul style="list-style-type: none"> • Controller temperature greater than 96°C. (This fault is not indicated by the fault contact. When this fault occurs, the drive decelerates according to the stop mode selected. It can be restarted after the temperature is below 73°C and the Reset button on the VFC board is pressed.)

FAULT Contact

This contact corresponds to relay K7 and indicates that either a controller fault has occurred as defined in Table 5-1 (with the exception of over-temperature) or a customer interlock is open. The FAULT contact is connected at terminals 190 to 191 on the VFC board with the following ratings:

- D-C: 120 watts maximum with a maximum voltage of 30 VDC or a maximum current of 5 amps resistive.
- A-C: 920 VA maximum with a maximum voltage of 120 VAC or a maximum current of 5 amps.

Pilot Light Outputs

Outputs are provided to drive user-supplied pilot lights to indicate "drive RUN" and "drive READY." Each output is rated 24 VDC, 40 mA maximum.

- RUN: This output is available from terminals 28(+) to 20 (-). It can only be lit if the READY output is high and the input contactor is closed. This pilot light indicates that a start command has been applied and the regulator is operating.
- READY: This output is available from terminals 29(+) to 20(-). It indicates that no faults are present and the required control voltage is present.

Relay Functions

The controller has several relays that provide the functions listed in Table 5-2.

Table 5-2. Controller Relay Functions.

Relay	External Contacts	Relay Function
K1	None	Run permissive; no faults and power supplies are okay
K3	None	Input contactor relay
K4	None	Auto/Manual selection
K5	192-193	Run
K6	None	Internal fault contact
K7	190-191	Fault
K12	None	Precharge relay
K13	None	Input contactor

6: Service 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 Indicators

The controller has several LED indicators, fault and run contacts, and provisions for pilot light outputs for "drive READY" and "drive ON."

LED Indicators

The LED indicators are located at the top of the VFC board. The two green LEDs indicate drive status. The red LEDs provide first fault indication and latch after the first fault. The status is maintained until the controller is reset or power is removed.

Green LEDs

- SOK** This LED indicates the regulator power supply voltage is correct. This light must be lit for the controller to operate.
-  This LED indicates the controller is ready to run: the control voltage is correct, there is no external E-stop command, and there are no faults. This light must be lit for the controller to operate.

Red LEDs

When an IET occurs, the appropriate red LED lights. Refer to Table 6-1 for the possible cause of an IET.

Table 6-1. Possible Causes for a Red LED To Light.

LED	Possible Causes
>I	<ul style="list-style-type: none"> • Motor overcurrent • Acceleration rate too fast • Stability adjustment too high • Line transient
>U	<ul style="list-style-type: none"> • Input voltage greater than 560 VAC • Bus voltage greater than 800 VAC because deceleration rate too fast
<C	<ul style="list-style-type: none"> • Short circuit in the D-C bus • Faulty precharge circuit operation • Unbalanced output currents
>IE	<ul style="list-style-type: none"> • Phase-to-ground fault on the output
<U	<ul style="list-style-type: none"> • Input voltage less than 320 VAC (Dip or Continuous) • Power supply voltage low
>Z	<ul style="list-style-type: none"> • Controller temperature greater than 96°C. (This fault is not indicated by the fault contact. When this fault occurs, the drive decelerates according to the stop mode selected. It can be restarted after the temperature is below 73°C and the Reset button on the VFC board is pressed.)

Contact Indicators

RUN Contact

This contact indicates that the regulator is controlling the output. This contact corresponds to relay K5 with voltage at terminals 28 to 20. The following conditions exist:

- Both green LEDs will be lit
 - No faults are present
 - A start command has been given to the controller.
- A RUN contact is connected at terminals 192 to 193 on the VFC board with the following ratings:
- D-C: 120 watts maximum with a maximum voltage of 30 VDC or a maximum current of 5 amps resistive.
 - A-C: 920 VA maximum with a maximum voltage of 120 VAC or a maximum current of 5 amps resistive.

FAULT Contact

This contact corresponds to relay K7 and indicates that either a controller fault has occurred as defined in Table 6-1 (with the exception of overtemperature) or a customer interlock is open. A FAULT contact is connected at terminals 190 to 191 on the VFC board with the following ratings:

- D-C: 120 watts maximum with a maximum voltage of 30 VDC or a maximum current of 5 amps resistive.
- A-C: 920 VA maximum with a maximum voltage of 120 VAC or a maximum current of 5 amps resistive.

Pilot Light Outputs

Outputs are provided to drive user-supplied pilot lights to indicate "drive RUN" and "drive READY." Each output is rated 24 VDC, 40 mA maximum.

- **RUN:** This output is available from terminals 28(+) to 20 (-). It can only be lit if the READY output is high and the input contactor is closed. This pilot light indicates that a start command has been applied and the regulator is operating.
- **READY:** This output is available from terminals 29(+) to 20(-). It indicates that no faults are present and the required control voltage is present.

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. The following meters or their equivalent are recommended (Having two devices available is convenient.):
 - An analog volt-ohmmeter having a sensitivity of 20,000 ohms-per-volt, such as a Triplet Model 630.
 - A digital volt-ohmmeter with a 10 megohm input impedance on all ranges, such as a Fluke 8022B.
2. The optional portable diagnostic tester in lieu of the above measuring devices.

General Troubleshooting Procedure

1. Verify that an IET has occurred by referring to external indica-

tors. Refer to Table 6-1 for possible causes of the IET.

DANGER

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

If external indication is not provided or used, view the IET LED indicators on the VFC board without removing power from the controller. (Removing power from the controller loses the status of the LED.)

- Clear the fault.
- Reset the controller by pressing the red Reset pushbutton on the VFC board adjacent to the LEDs.
- Restart the controller.
- If the controller does not restart, proceed to Step 2.

2. Turn power OFF.

DANGER

THIS EQUIPMENT IS AT LINE VOLTAGE WHEN A-C POWER IS CONNECTED TO THE CONTROLLER. DISCONNECT ALL UNGROUNDED CONDUCTORS OF THE A-C POWER LINE FROM THE CONTROLLER. AFTER POWER IS REMOVED, VERIFY WITH A VOLTMETER AT TERMINALS 45(-) AND 47(+) 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.

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 VFC board are correctly positioned and tight.
4. Verify that the input power voltage is in the $\pm 10\%$ tolerance range. If not, apply the correct input voltage or add a transformer.
5. 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 or shielded.
6. Make sure that all nearby relays, solenoids, or brake coils are suppressed.
7. Check that the ambient temperature does not exceed 40°C (104°F) for enclosed controllers or 55°C (131°F) for chassis controllers.
8. Check that the VFC blue jumpers are in the correct position (Fig. 3-4) for the application, the required jumpers are in place, and external customer interlocks are operating correctly.
9. If the optional tester is available plug the ribbon cable into connector X2 on the VFC board. Using the selector switch to monitor positions 1 through 26 to verify the proper signals are present per table 6-4.
10. If satisfactory operation still cannot be obtained, proceed to Tables 6-2 and 6-3 for troubleshooting suggestions by fault symptoms.

Identifying the Fault Symptom

Before troubleshooting, using Tables 6-2 and 6-3.

- Determine the operating conditions when the fault occurred.
- Determine the fault symptom.
- Proceed through Tables 6-2 and 6-3 step by step in the sequence listed.
- Proceed through the "Power Unit Checks" and "Printed Circuit Board Tests."

- Refer to Table 6-6 for replacement parts data.
- Refer to wiring diagrams, as necessary, beginning with Figure 6-4.

Output voltage, frequency, and current can be measured at VFC board terminals as indicated below:

If satisfactory operation cannot be obtained, contact your Reliance Electric Sales Office for service coordination.

Parameter	Terminals	Calibration	
Output Voltage	551 (+) 550 (COM)	10.0 VDC $\pm 2\%$ = 460 volt fundamental output with 460 Volt Input 1v = 46 volts Output	
Output Current	552 (-) 550 (COM)	HP Rating	100% Controller's Output Current Rating
		15	5.68 VDC
		20	6.67 VDC
		25	6.67 VDC
		30	5.60 VDC
40	6.67 VDC		
Output Frequency	553 (+) 550 (COM)	10.0 VDC $\pm 1\%$ = maximum frequency (.17 VDC/Hz for 80 Hz max; .08 VDC/Hz for 120 Hz max; .0417VDC/HZ for 240HZ max)	

Table 6-2. Input Disconnect Is CLOSED but There Is No START Command.

Symptom	Possible Cause	Test Required	Corrective Action
Both VFC board green LEDs not lit.	No input voltage.	Check for 460 VAC +10% input voltage at 181, 182, 183.	Provide correct input voltage; if necessary add transformer.
		Check input line fuses F1, F2, F3.	Replace fuses if open.
		Check control input fuses F3, F4, F5.	Replace fuses if open.
		Check between 21-22 that customer interlocks are closed or that a jumper is in place.	Add a jumper or correct interlocks.
	Check that cables between the VFC and Base Driver board are in place and secure.	Reconnect and secure the cables.	
	±15-volt power supply voltage missing.	Verify voltages are present on VFC board: See Fig. 3-4.	Follow the "Printed Circuit Board Checks" procedure in this chapter.
Only the green SOK LED lights	Input disconnect closed immediately after being opened or after power line loss.	Check capacitor voltage on the D-C bus (normal is 650 VDC).	Wait for the capacitor voltage to go below 50 VDC (approximately 1 minute).
	Loss of and return of power.		
	24 VDC control voltage not at 21(+), 20(-).	Check fuse on VFC board.	Replace fuse if opened.
	Customer interlock or coast-stop circuit open.	Check that jumper 21-22 is in place or customer interlocks are closed.	Replace jumper or close external interlocks.
Check that coast-stop circuit is closed.		Close the coast-stop circuit.	

Table 6-3. Input Disconnect Is CLOSED and There Is START Command.

Symptom	Possible Cause	Test Required	Corrective Action
>T is lit	Internal control temperature is greater than 93°C.	Check controller ambient temperature. Enclosed controller should be less than 40°C; chassis should be less than 55°C.	Let controller cool to 73°C. Press Reset pushbutton on the VFC board and re-start.
<C is lit	Short circuit in D-C bus.	Make sure D-C bus voltage is at zero. Then check for short circuits between 47-49 and 45-49.	If capacitors are shorted, replace.
		Check transistors as described under "Power Unit Checks" in this chapter.	If transistors are faulty, replace.
<U is lit	Input voltage less than 320 VAC or D-C bus voltage less than 300 VDC.	Check that input voltage at 181, 182, 183 is 460 VAC $\pm 10\%$ or if short power outages have occurred.	Apply correct voltage.
>U is lit	Input voltage too high.	Check that input voltage at 181, 182, 183 is 460 VAC $\pm 10\%$.	Apply correct voltage.
	D-C bus voltage too high due to high input voltage.	Check input voltage.	Correct input voltage.
	D-C bus voltage too high due to decel time too short.	Deceleration time too fast.	Increase the deceleration time by adjusting the Decel pot.
>I is lit.	Overcurrent trip caused by accel time too short.	Acceleration time too fast.	Increase the acceleration time by adjusting the Accel pot.
	Overcurrent trip caused by stability setting too low.	Check the output current described under "Detailed Startup Procedure."	Readjust the Stab pot.
		Check power circuit described under "Power Unit Checks" in this chapter.	Replace defective components.
	Input line transient.	Monitor input power to verify condition.	Solution based on results of monitoring

Table 6-3. Input Disconnect Is CLOSED and There Is START Command. (continued)

Symptom	Possible Cause	Test Required	Corrective Action
>I is lit. (continued)	Overcurrent trip caused by motor short circuit or output short circuit.	Check output and motor connections for short circuit.	Remove the short circuit.
		Check power circuit described under "Power Unit Checks" in this chapter.	Replace defective components.
>IE is lit.	Line-to-ground short circuit.	Check the output leads and the motor for line-to-ground short circuit.	Remove the cause of the short circuit.
Both VFC green LEDs are lit.	Stop circuit open; no internal start command.	Check that start circuit is 24 VDC from 23(+) to 20(-). Check that 24 VDC is present between 24(+) and 20(-) with start command closed.	Correct external wiring.
Run pilot light not lit or 24 VDC not present at 28(+) to 20(-) if no light used.	Faulty input contactor or VFC board.	Operate Start command. Input contactor K11 should close after a 200 ms time delay.	Replace defective components
	Auxiliary contact K11 defective.	After the input contactor closes, 24 VDC should be present from 28(+) to 20(-).	Replace auxiliary contact K11 on the input contactor.
Motor does not start.	Wrong reference signal selected.	Voltage at terminal 27 should be 0 V in MAN mode and 24 V for AUTO mode.	Apply correct voltages.
Run pilot light lit or 24 VDC present at 28(+) to 20(-) if no light used.	Speed reference signal at the regulator input missing.	In MAN mode, reference 167(+) to 157(-) should range from +10 VDC to 0 VDC as the Speed pot is changed from max to min position.	Check reference source and wiring.
		In AUTO mode, reference signal at 267(+) and 157(-) should range from 0 to 10 VDC for a voltage follower or 0(4) to 20 mA for a current follower.	
		V/Hz is too low.	Adjust the V/Hz pot as described in "Detailed Startup Procedure."

Table 6-3. Input Disconnect Is CLOSED and There Is START Command. (continued)

Symptom	Possible Cause	Test Required	Corrective Action
Run pilot light lit or 24 VDC present at 28(+) to 20(-) if no light used	Starting torque too low.	Voltage boost set too low.	Adjust the boost (U ₀) pot as described in "Detailed Startup Procedure."
		Current limit set too low.	Adjust the ILIM pot as described in "Detailed Startup Procedure."
		Motor/controller undersized for the load.	Review the required starting torque and motor/controller capability.
Motor rotates in one direction only.	Controller is set up for one direction only.	For FWD direction input 26-20 must be open.	Make sure FWD/REV Switch is wired correctly
Motor rotates in wrong direction.	Motor leads connected in wrong sequence.		Interchange any two output leads to the motor.
Motor does not reach max speed.	Max reference signal not applied.	In MAN mode, 10 VDC should be available at 167(+) to 157(-).	
		In AUTO mode, 10 VDC should be available at 267(+), 157(-) or 20 mA at 267 for max speed.	
	Wrong NMAX pot adjustment.	Apply the required max speed reference signal and measure output frequency as described in "Detailed Startup Procedure."	Readjust the NMAX pot per "Detailed Startup Procedure."
	Controller is in current limit.	Current limit adjustment too low. (Factory set for 150%)	Adjust the ILIM pot as described in "Detailed Startup Procedure."
		V/Hz too low.	Adjust the V/Hz pot as described in "Detailed Startup Procedure."
	Motor undervoltage.	460 VAC not selected.	Review position of Jumper W-X
Motor overload.	The controller/motor may be undersized.	Check the required torque for application over the speed range.	

Table 6-3. Input Disconnect Is CLOSED and There Is START Command. (continued)

Symptom	Possible Cause	Test Required	Corrective Action
Motor too hot.	Motor undervoltage or motor overload.	Apply maximum speed reference of 10 VDC or 20 mA and observe the output voltage.	If too low, check that Jumper W-X is in proper position
			Adjust the V/Hz pot as described in "Detailed Startup Procedure."
		Check motor current.	Motor may be undersized. Review speed torque requirements.
Motor stops; >I lit.	Overcurrent trip caused by acceleration too short.	Check adjustment of Accel pot.	Adjust Accel pot to increase acceleration time.
	Overcurrent trip caused by Stab pot setting too low or too high.	Check stability adjustment as described in "Detailed Startup Procedure."	Adjust the Stab pot as described in "Detailed Startup Procedure."
Motor stopped; >U lit.	Overvoltage on D-C bus caused by deceleration time too short.	Check adjustment of Decel pot.	Increase decel. time
Motor continues to run at constant speed after stop command.	Control command ineffective.	Verify that voltage at terminals 23-20 is zero volt.	Press E-Stop or disconnect the input power. Review Control Wiring

Table 6-4. Tester signals of the FlexPak A-C V \star S Controller.

Selector Position	Signal Name	Voltage range (V)	Description
1	UAC	0V or 6.5V	Input voltage: 6.5V normal, 0V during fault
2	REF2-	0V..-10V	Speed reference after isolation ckt
3	REF3	0V..10V	Reference after NMAX 10V \approx 100% freq.
4	REF4	0V..10V	LVTU output 10V \approx 100% freq. of the selected range
5	UDC-	0V..-9V	DC-ckt voltage: -7.0V at UN = 460V
6	REFF	0V..+10V	Absolute frequency +10V \approx 240 Hz
7	UREF	0V..10V	Voltage reference 10V \approx nom. voltage
8	RTR	0V/+5V	Phase signal, phase R
9	GND	0V	Regulator zero
10	IFBF-	0V..-7.5V	Motor current feedback: -7.5V \approx 125% for 20, 25, 40 HP -6.4V \approx 125% for 15, 30 HP
11	ZUREF	-0.6V..11V	>0V IO regulator active
12	IDC+	0V..2.5V	Active power current 2.3 V/ In
13	IB-	0V..-2.5V	Reactive power current 2.2 V/ In
14	M+	-0.4V..+3.5V	Torque signal 3.5 \approx nom. Torque
15	PS	4V/-15V	Power supply +4V normal, -15V during fault
16	IREG	-6.8..10V	Curr. regul. output active at > -4V
17	AREF-	0V..-10V	Voltage regulator output (Correct.)
18	+5V	+5V	Supply for the LSI's
19	+15V	+15V	Positive supply voltage
20	-15V	-15V	Negative supply voltage
21	SW	5V/0V	5V \approx Synchron / 0V \approx Asynchron
22	CW	0V/+5V	Logic signal 0V \approx cw rotation
23	KOMP	+10V..-10V	Output LVTU-comparator, neg. \approx accel.
24	LIM	-0.6..10V	Dynamic current limit at > 0V
25	UVCO	0V..-12V	Reference for the volt. compar. VCO
26	REGOFF	0V/+5V	+5V \approx regulator disabled, 0V \approx enabled

Power Unit Checks

1. Remove the input voltage. After verifying the D-C bus voltage is zero VDC, disconnect the motor from the controller.
2. Set a volt-ohmmeter on the X1 ohmmeter scale and measure from the transistor collector (+) to the emitter (-) using the terminals defined in Table 6-5. Refer to figures 6-2 and 6-3 for transistor terminal details. The transistors should all read very high resistance. If any read low resistance, they are defective and must be replaced.
3. With the input voltage removed and the motor disconnected from the controller, remove all transistor connections. When removing the transistor connections, mark the connectors for quick reconnection after the test.
4. Set a volt-ohmmeter on the X1 ohmmeter scale and measure the resistance by referring to the labels B, E, and C on the transistor block. See Figure 6-1, 6-2 and 6-3 and refer to Table 6-6.
5. If any transistor is defective, replace the transistor and the corresponding Base Driver Board. Check the D-C Bus fuse and replace if open.
6. Turn input power on. Manually pick up precharge relay with screwdriver. With a voltmeter set on the 1000VDC scale, measure the voltage at terminals 45(-) and 47(+). The voltage should be greater than 580VDC

DANGER

THE FOLLOWING CHECKS ARE MADE WITH INPUT VOLTAGE APPLIED TO THE CONTROLLER. EXERCISE EXTREME CAUTION BECAUSE HAZARDOUS VOLTAGE EXISTS. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

6:10

Table 6-5. Transistor Terminals from Which To Take Readings.

Transistor Number	(+) Terminals		(-) Terminals	
	Location	Terminal	Location	Terminal
1	Plus	47	Output Terminal Block	601
3	D-C	47		602
5	Bus	47		603
2	Output	601	Minus D-C Bus	45
4	Terminal	602		45
6	Block	603		45

Table 6-6. Transistor Resistance Readings.

(+)	(-)	Transistor Okay	Transistor Defective
Base	Emitter	Low Resistance	Open
Base	Collector	Low Resistance	Open
Emitter	Base	Low Resistance	Open
Collector	Base	Open	Low Resistance
Collector	Emitter	Open	Low Resistance
Emitter	Collector	Low Resistance	Open

7. Make sure the controller is in the STOP mode.
8. Measure the voltage between the base-emitter (terminals B and E with the red and white twisted cables on the transistor block) at each transistor. There are two transistors per block. The voltage should read more than -1 volt; otherwise, replace the transistor and the Base Driver Board.
9. With a voltmeter set on the 1000 VDC scale, measure the voltage at bus capacitor terminal 49(+) to 601(-), 602(-) and to 603(-) while manually closing precharge relay K12. Close relay K12 by inserting a small screwdriver in the opening in the top, center of the relay. The voltage should read less than 100 VDC. If the voltage reads higher, replace the Base Driver Board.

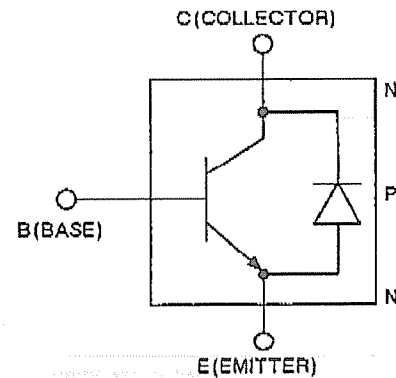
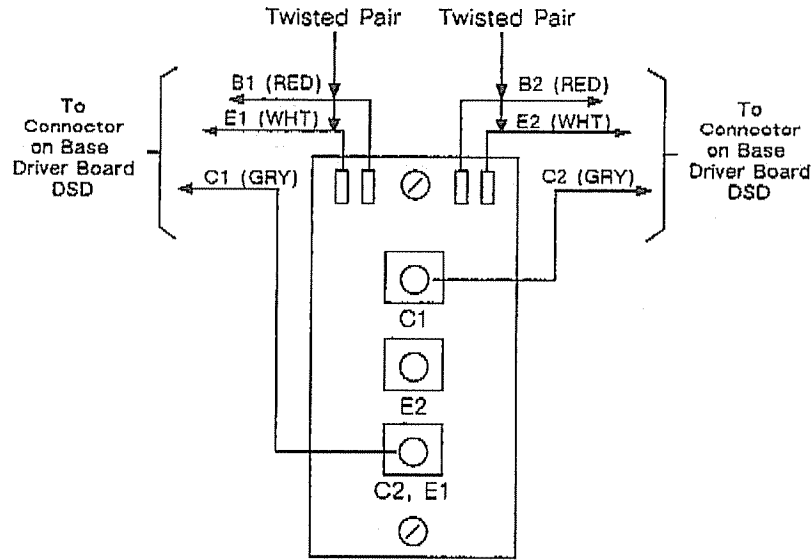


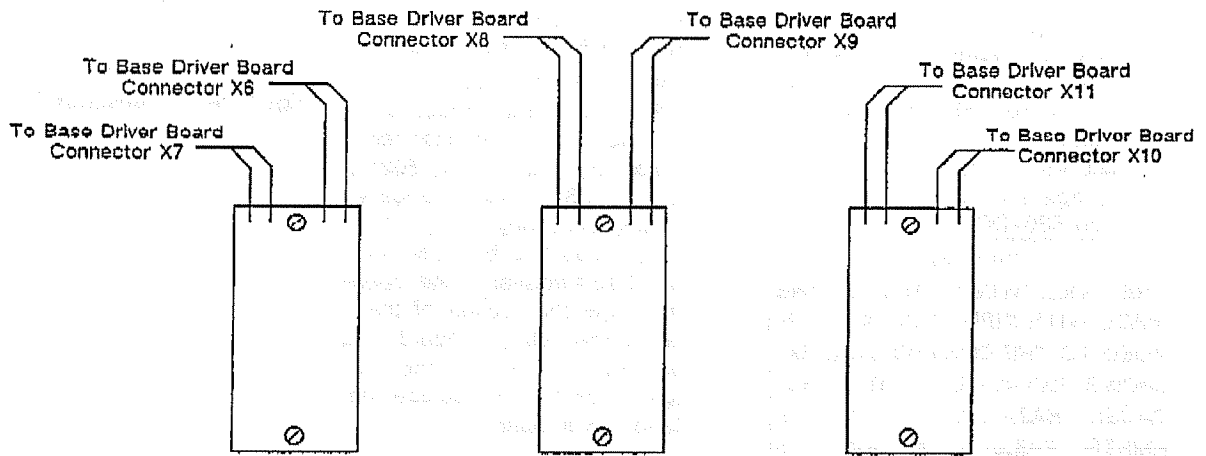
Figure 6-1. Transistor Terminals.



Typical 15-20HP Transistor Wiring

Base Driver Board Connector Position	Wire Position on Connector				
	1	2	3	4	5
X6	WHT	RED	X	X	GRY
X7	WHT	RED	X	X	GRY
X8	GRY	X	X	RED	WHT
X9	GRY	X	X	RED	WHT
X10	WHT	RED	X	X	GRY
X11	WHT	RED	X	X	GRY

Connector Wire Position Detail



Physical Transistor Layout and Connector Positions

Figure 6-2. 15-20HP Power Transistor Detail.

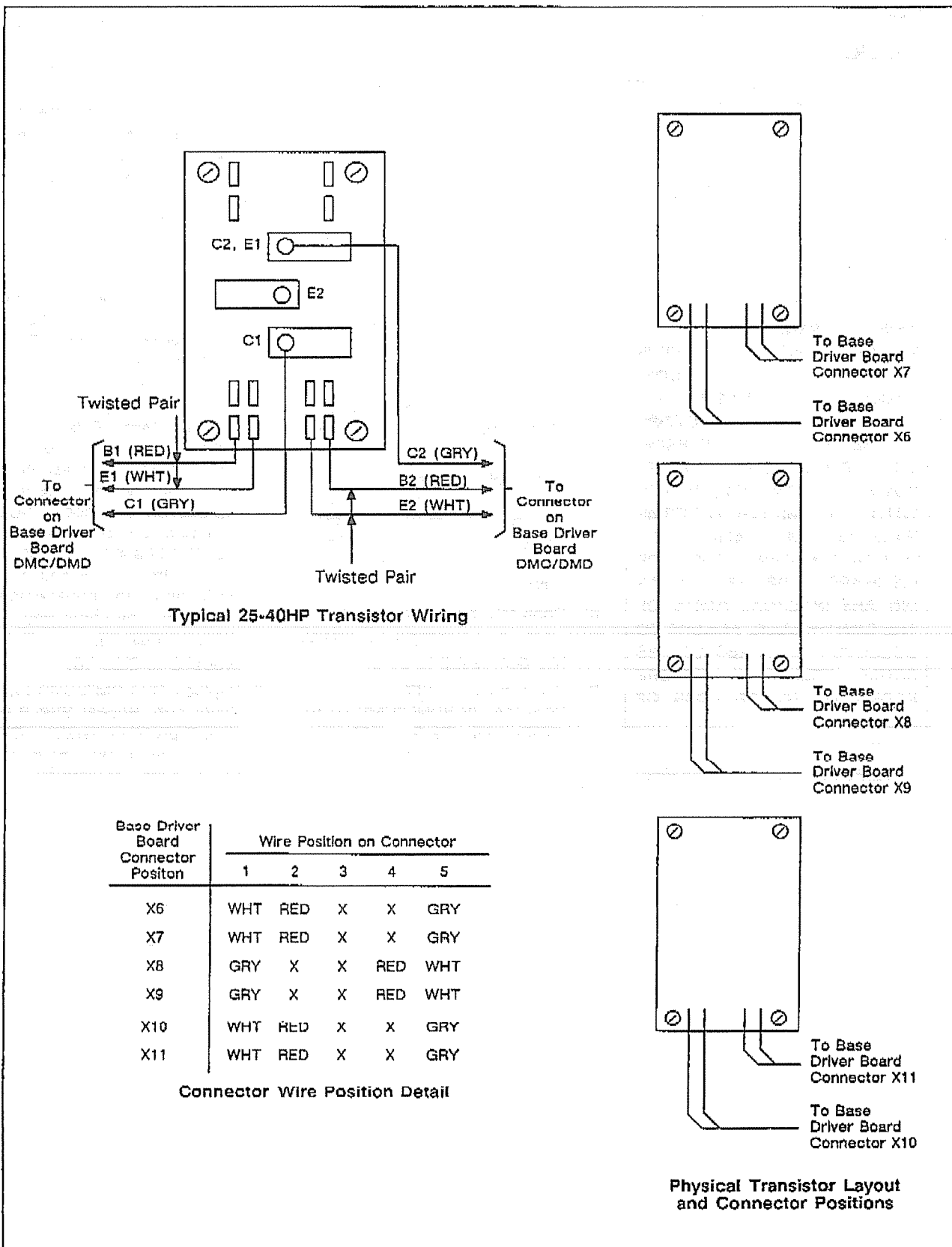


Figure 6-3. 25-40HP Power Transistor Detail.
6:12

Printed Circuit Board Checks

Use this check with Tables 6-2 and 6-3 or whenever the green SOK LED is not lit.

Note that this procedure determines if the supply voltages are correct. It does not check for proper board functioning.

DANGER

THIS EQUIPMENT IS AT LINE VOLTAGE WHEN A-C POWER IS CONNECTED TO THE CONTROLLER. DISCONNECT ALL UNGROUNDED CONDUCTORS OF THE A-C POWER LINE FROM THE CONTROLLER. AFTER POWER IS REMOVED, VERIFY WITH A VOLTMETER AT TERMINALS 45(-) AND 47(+) 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. Verify that the input disconnect

is in the OFF position.

2. Disconnect the motor from the controller by removing motor leads at output terminals 601, 602, and 603.
3. Turn the input disconnect in the ON position.
4. The green SOK LED should light on the VFC board.
5. Using a voltmeter set on the 100 VDC scale, check the following voltages on the VFC board red jumper locations:
 - +30VDC between pin labeled +15 at location CK118(+) and pin labeled -15 at location CK122(-)
 - +20VDC between pin labeled +5 at location CK126 and pin labeled -15 at location CK
 If this voltage is measured, then the board power supplies are operating correctly. If the voltage is less than +15 VDC or is not present, continue to Step 6.
6. Open the input disconnect.
7. Verify that the D-C bus voltage has decreased to zero.
8. Disconnect the VFC board from the DSD/DMC/DMD by removing only the flat cable connector from the DSD/DMC/DMD board.

CAUTION: The DSD/DMC/DMD flat cable connector can be disconnected from the DSD/DMC/DMD with power on. All other connectors on the DSD/DMC/DMD board must remain connected with power on. Failure to observe this precaution could result in damage to, or destruction of the equipment.

9. Using a voltmeter set on the 15 VDC scale, check the following voltage on the DSD/DMC/DMD board:
 - +15 VDC term 91 (x4)
 - 0 VDC term 6 (x4)
 - 15 VDC term 90 (x4)
 If the voltages were not correct when previously measured at Step 5 and are now correct, replace the VFC board. Note all jumper and pot positions on the VFC board being replaced and set the jumper and pot positions on the replacement VFC board the same way. If the problem still persists, proceed to Step 10.
10. Replace DSD/DMC/DMD base driver pcb. Repeat Step 9 except if problem persists. Check input fuses, control fuses and power supply transformer.

Table 6-7. Replacement Parts List.

When ordering spare parts, provide the controller nameplate information along with the required part numbers.

Description	Qty Per Drive	U.S. Part Number	Europe Part Number	Recommended Spares for 1-6 Controllers
Input Power				
Diode Cube				
15-20 HP	3	402421-100AW	124.08.00	2
25-40 HP	1	402421-101AW	135.54.00	2
Power Supply				
Diode Cube				
15-40 HP	1	402421-102W	124.07.04	1
Output Transistor				
15-20 HP	3	402421-200AW	136.04.00	2
25 HP	3	402421-201AW	136.05.00	2
30 40 HP	3	402421-202AW	136.06.00	2
Control Transformer				
15-40 HP	1	402421-300A	254.28.00	-
Ground Fault				
Current Transformer				
15-40HP	1	402421-301A	251.88.21	-
D-C Bus Short Circuit				
Current Transformer				
15-20 HP	1	402421-301B	251.88.08	-
25-40 HP	1	402421-301C	251.88.20	-
D-C Bus Capacitor				
15-20 HP	4	402421-400A	212.74.05	-
25-40 HP	8	402421-400A	212.74.05	-
Input Power Fuse				
15-20 HP	3	402421-500A	553.05.07	3
25 HP	3	402421-501A	553.03.08	3
30-40 HP	3	402421-501B	553.03.09	3
D-C Bus Fuse				
15-20 HP	1	402421-502A	553.41.06	3
25 HP	1	402421-503A	553.27.07	3
30-40 HP	1	402421-503B	553.27.09	3
Control Transformer				
Fuse				
15-40 HP	3	402421-504A	553.40.05	3
VFC Reg. P.S. Fuse				
15-40 HP	1	402421-505A	550.17.00	2
Input Contactor				
15-20 HP	1	402421-600A	605.75.01	-
25 HP	1	402421-600B	605.75.61	-
30-40 HP	1	402421-601A	605.76.61	-
Contactor Coil				
15-25 HP	1	402421-602A	605.93.51	-
30-40 HP	1	402421-603A	605.94.11	-

Table 6-7. Replacement Parts List (Continued)

When ordering spare parts, provide the controller nameplate information along with the required part numbers.

Description	Qty Per Drive	U.S. Part Number	Europe Part Number	Recommended Spares for 1-6 Controllers
Precharge Relay 15-40 HP	1	402421-604A	604.80.01	-
Precharge Resistor 15-20 HP	3	402421-700A	420.14.00	-
25-40 HP	3	402421-701A	425.17.18	-
Input Line Reactor 15-20 HP	1	402421-800A	252.40.02	-
25 HP	1	402421-800B	252.40.03	-
30-40 HP	1	402421-800C	252.40.04	-
Cooling Fan 15-20 HP	1	69739-27X	-	-
25-40 HP	1	402421-900A	921.90.01	-
Heatsink Thermostat 15-20 HP	1	402421-901A	921.06.02	-
30-40 HP	1	402421-901B	921.06.00	-
Regulator (VFC) Board 15-40 HP	1	0-48698-100	804.12.04	1
Base Driver Board 15-20 HP (DSD)	1	0-48698-200	804.15.04	1
25 HP (DMC)	1	0-48698-201	804.24.04	1
30-40 HP (DMD)	1	0-48698-202	804.25.04	1
Customer Interface (CIC) Board 15-40 HP	1	0-48698-500	804.13.00	1
Hall Sensor Printed Circuit Board 15-20 HP	1	0-48698-501	804.37.00	1
25-40 HP	1	0-48698-502	804.35.00	1
Transistor Snubber Board 15-20 HP	3	0-48698-503	804.42.00	-
25-40 HP	3	0-48698-504	804.42.01	-
Relay Card 15-40 HP	1	0-48698-505	804.33.00	1
Regulator Thermostat 15-40 HP	1	402421-901C	921.06.01	-

Table 6-8. Modification Kits

Description	HP	Model Number	Instruction Manual
Auto Reset After Fault	15-40	34C612	D2-3128
115 Control Power	15-40	34C706	D2-3143
Input Disconnect	15-20	34C701	D2-3139
	25-40	34C702	D2-3140
Digital Meter Ammeter, Frequency, Voltmeter	15-40	34C802	(1)
Motor Overload	15-20	37C704	D2-3141
	25-40	37C705	D2-3142
Remote Reset	15-40	34C613	D2-3146
Tester	15-40	34C800	D2-3144
Operator Control Station	15-40	34C801	(1)

(1) Not available at time of printing.

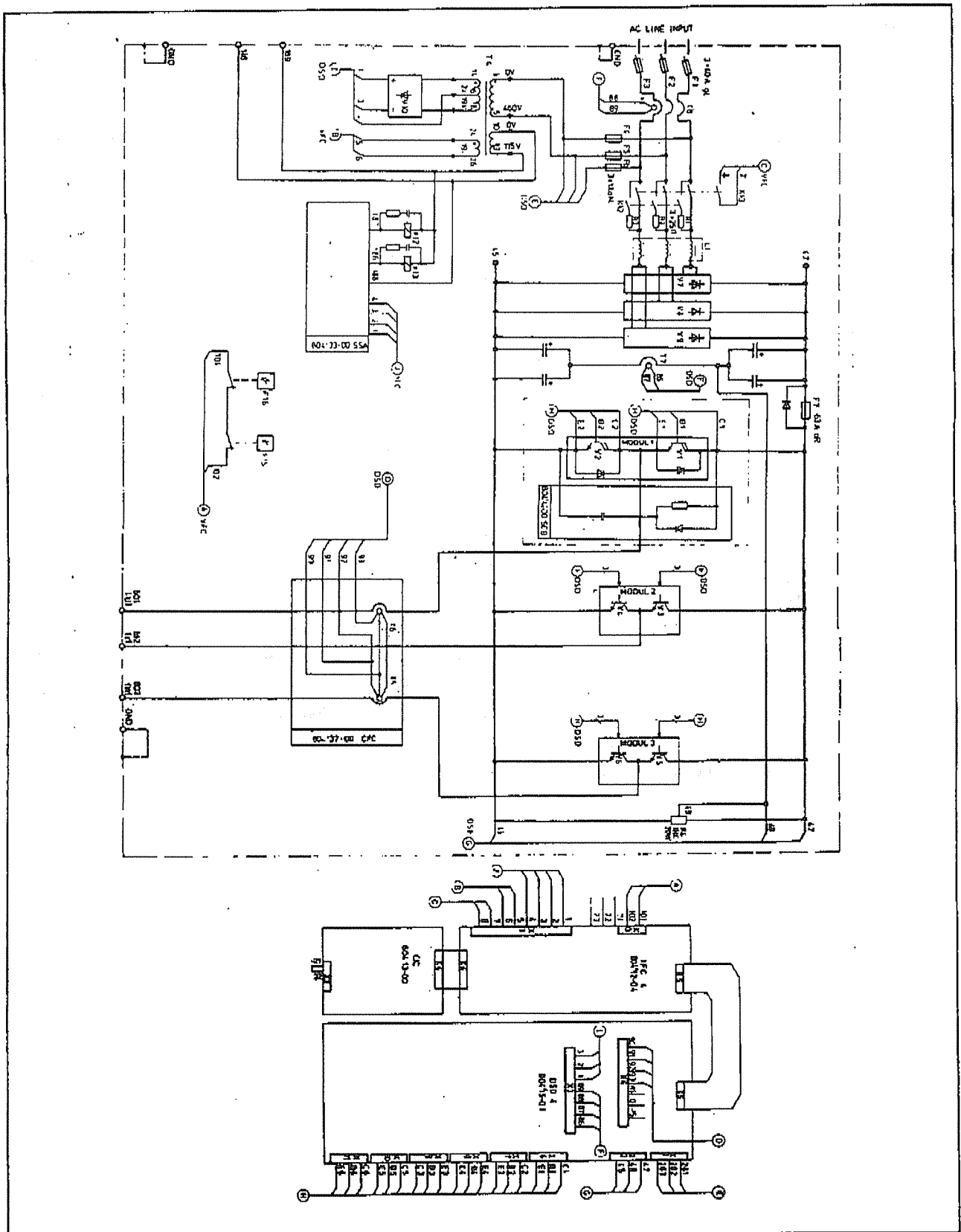


Figure 6-4. Typical Power Circuit Wiring Diagram. (20HP shown)

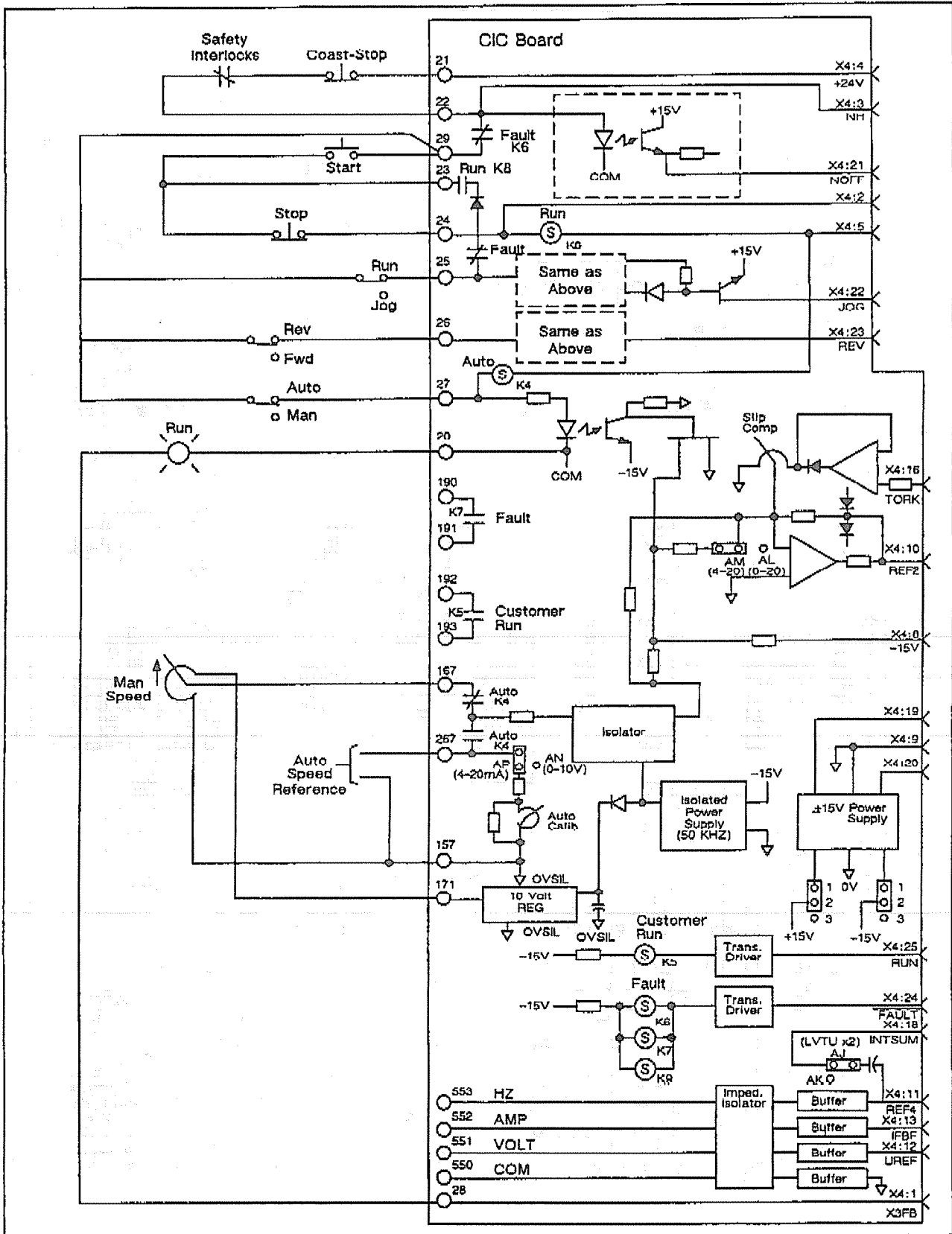


Figure 6-5. Function Block diagram of CIC Boards.

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