IM-530016-8803

Dynamatic

Instruction Manual

Model AF-1500
Adjustable Frequency AC Drives

EATON

AF–1500 SIMPLIFIED START–UP PROCEDURE

This manual contains detailed installation and operating instructions. Personnel installing and operating this equipment are strongly urged to carefully follow these instructions; they are intended to help you obtain safe and reliable operation from this equipment.

The AF-1500 is shipped with its programming and adjustments set for keypad operator control of a standard 3 phase 60 Hz induction motor with the same voltage rating as the AF-1500. The factory set range of control is 0.5 to 60 Hz. The following paragraphs describe how to operate the AF-1500 using only the keypad for operator control. An external operator station is not required, only the following connections need be made. (Refer to section 3 for detailed installation instructions.)

1. Connect three phase input power from a protected source to terminals L1, L2, and L3.
2. Connect a grounding wire to the grounding screw.
3. Connect the motor to terminals T1, T2, T3.

Note that the top three keys on the operator keypad are labelled "Monitor," "Function," and "Enter." The Function and Enter keys are used for changing the factory programming and adjustment settings. Refer to section 3 of this manual for instructions covering the use of these two keys. The Monitor key selects the Monitor Mode of operation which is the mode used for operating the drive.

When power is initially applied to the drive, the drive should display the first line of the Monitor Mode Display as shown below. If the drive displays an "?ERROR" message, refer to section 6 of this manual. The Monitor Mode Display contains 10 lines as shown in below. Each time you press the Monitor key, the display steps to the next line. You can also step through the display by pressing the Increase and Decrease keys. You can jump to the first line of the display by pressing the Function key and then the Monitor key. You may wish to step through the ten lines of the display and familiarize yourself with the Monitor Mode display parameters.

The following is a step by step example which will demonstrate the basic procedure for operating the drive.

1. Press the Function key and then the Monitor key to jump to the first line of the Monitor Mode Display.
2. Press the Monitor key again to step to the second line of the Monitor Mode Display. The second line of the display shows the set frequency (FS). When the drive is shipped. FS is set to 000.0 Hz.
3. Press the Forward key. Note that an "F" appears in front of the frequency readout (FS F000.0 Hz). This indicates that the drive has been called to run in the forward direction.
4. Press the cursor key three times to move the cursor under the 1's place. **Note: The cursor is the underscore which appears under one charactor of the display line. It is easier to see when the display is viewed at an angle below the drive.**
5. Press the Increase key to increase the set frequency to 1 Hz (FS F001.0 Hz). If the motor is not coupled to a load, it should start to rotate. If the motor is coupled to a load, you may need to press the Increase key several times to increase the frequency to 2 or 3 Hz in order to get the motor to start.
6. Press the increase key several times to increase the set frequency to 5 Hz. The operating speed of the motor will increase.
7. Press the Stop key. The motor will stop.
8. Without changing the frequency setting, turn off the power to the drive.
9. After the display goes blank, turn the power on again. The drive displays FM 000.0 Hz.
10. Press the forward key. Note that the motor starts and the display changes to FM 005.0 Hz. The drive retains all keypad settings in memory when the input power is turned off. The drive retained the FS 005.0 Hz setting. When the Forward key was pressed, the drive automatically accelerated the motor frequency (FM) to the set frequency (FS = 5 Hz).

Description of Monitor Mode Display Parameters

Line	Display (Defaults shown)	Description and Adjustment Range
1	FM 000.0 Hz	Motor Frequency (Inverter output frequency) Display only
1	FM▒▒> F030.0 Hz (Display for) (Drive Running)	When the drive is running, frequency is displayed and a bar graph indicates percent of max frequency. ▒ indicates each 20% increment and > indicates 10%. F or R indicates forward or reverse operation.
2	FS 000.0 Hz	Set Frequency -- .1, 1, 10, & 100 Hz steps within limits set in function mode. A bar graph indicates set frequency as % of max. ▒ indicates each 20% increment and > indicates 10%. When the drive is running, F or R indicates direction of operation.
3	F-SET-M Ope.-Key	Frequency Setting Method; Operator keypad or Terminal block input. Changeable only when drive is not running.
4	F/R-SW Ope.-Key	Forward and Reverse Run Command Method; Operator keypad or Terminal block input. Changeable only when drive is not running.
5	RPM 4P 00000rpm	Motor Speed. Enter the number of motor poles.
6	IF----A Im000.0%	IF = Rated Output Current Im = Indicated Output Current Leave IF blank for Im readout in %; fill in drive nameplate current for Im readout in amps.
7	V-Boost Code<31>	Voltage Boost Setting Code -- 0 to 99 (99 = approximately 18% boost.)
8	V-Gain 100%	Voltage Gain Setting (V/Hz) -- 50 to 100%, 1% steps (See Fig. 5-2.)
9	Jogging 01.0 Hz	Jogging Frequency -- .5 to 9.9 Hz; .1 Hz steps
10	#	Fault Diagnostic Message -- See section 6.

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SECTION 1

INTRODUCTION

Congratulations and thank you for purchasing the Dynamatic Model AF-1500 microprocessor based adjustable frequency AC drive. You are now the owner of one of the most powerful and versatile AC drives in today's marketplace. If you have any questions or comments, please feel free to contact us. We at Eaton Corporation are proud to have you as a customer and can assure you that you will have many productive years from your new Dynamatic AF-1500 AC drive.

The Model AF-1500 adjustable frequency AC drives are designed to provide adjustable speed control of three phase motors. These microprocessor based pulse width modulated (PWM) drives have standard features which can be programmed to tailor the drive's performance to suit a wide variety of application needs.

Models rated 200-240 volts, 3 phase, 50/60 Hz are available in 1 to 20 horsepower sizes. Models rated at 380-480 volts, 3 phase, 50/60 Hz are available in 2 to 15 horsepower sizes. The standard enclosure is a NEMA 1 wall mount enclosure with a lift off cover. A cover mounted operator keypad and digital display panel are provided as standard.

Microprocessor based technology results in a less complicated drive, with fewer components and greater product reliability. It also provides accurate, reliable digital control with time saving, convenient features.

CAUTION: Read and heed all danger, warning and caution notices contained in this manual or attached to the equipment.

CAUTION: These instructions should be read and clearly understood before working on the Model AF-1500 AC drive.

This instruction manual covers the handling, maintenance and operation of your AF-1500 AC drive. Please read it thoroughly, before you begin installation or operation of this equipment, and make it available to all operating and maintenance personnel.

Unpacking and Inspection

Although every precaution is taken to ensure that the unit is delivered in good condition, it is essential that a careful inspection be made upon its arrival at your plant. Compare all items received with the packing slip to make sure that the entire order has been received. Check carefully for any damage, especially if there is any evidence of rough handling.

Any discrepancy or damage should be reported immediately to both the carrier and the Eaton sales office or the distributor from whom the drive was purchased. It is important that you file a damage claim with the carrier immediately. This is your responsibility; shipping damages and unreported shortages are not covered by the Company's warranty policy. Failure to file a claim promptly may prevent you from collecting for the damage or loss.

Your AF-1500 AC drive was tested prior to shipment to verify that it functioned properly and will operate over the speed/torque range required. After testing, the AC drives are carefully inspected and packed by approved methods. The carrier, in accepting the shipment, assumes the responsibility for delivering the material in good condition.

Handling

The weights and dimensions of the various AF-1500 models are listed in Section 2 of this manual. The size of the largest model is less than 18" X 13" X 10" and it weighs less than 50 pounds. Special handling equipment is not required.

> **CAUTION:** Handle the AF-1500 carefully to avoid personal injury or damage to the unit.

Storage

If it is necessary to store the AC drive for some period of time before it is actually installed, keep it in the packing material until ready for use. Store it in a clean, dry location protected from sudden temperature changes, shock vibration, corrosive conditions or high humidity. Storage temperatures should not exceed 70°C (158°F) or go below -10°C (14°F).

Installation Location

Select the installation location and environment carefully. The service life of this unit can be reduced by an unsatisfactory operating environment. Section 3 of this manual provides information to help you select a suitable location.

Installation of the AC Drive

Please refer to Section 3 of this instruction manual for installation and wiring instructions for your Model AF-1500 AC drive.

> **WARNING:** This equipment must be installed, adjusted and serviced only by qualified personnel familiar with the construction and operation of the equipment and the hazards involved. Failure to observe this precaution could result in personal injury and/or equipment damage.

WARNING: Equipment is at line voltage when AC power is connected to the input terminals. All ungrounded conductors of the ac power line must be disconnected before it is safe to touch any internal parts of this equipment. After power is removed, use a voltmeter at dc bus terminals marked + and - to verify that the dc bus capacitors are discharged before touching any internal parts of the equipment. Failure to observe these precautions could result in fatal injury.

WARNING: The AF-1500 and all other components of the drive system such as operator control devices, electrical power distribution equipment, the motor and mechanical power transmission equipment must be properly selected and applied to assure a safe and reliable installation. Each individual installation has unique requirements for safety equipment such as emergency stop pushbuttons, motor and power disconnect devices and guards on mechanical power transmission apparatus. The party responsible for the overall design and operation of the facility must make sure that qualified personnel are employed to select and apply all components of the drive system including appropriate safety devices.

Selection of the Ac Motor

Verify that the motor is appropriately sized for the torque and speed range requirements of the driven load. As the speed of the motor is reduced below its 60 Hz base speed, motor cooling becomes less effective because of the reduced speed of the self cooling fan. Because the output of the AF-1500 AC drive is not a pure sine wave, harmonics will be generated that will cause some additional heating in the motor. The motor may need to be oversized and/or the speed range may need to be restricted to assure that the motor will not exceed its operating temperature rating. Refer to the Electric Drive Application Guide in the Eaton Industrial Drives Catalog for additional information.

Motor Installation

Install the ac motor in accordance with its own instruction manual. Refer to Section 3 of this manual for instructions regarding wiring between the motor and the AF-1500.

WARNING: The AF-1500 can be programmed to operate above 60 Hz. Operation above 60 Hz permits the motor to operate above nameplate base speed. Hazard of personal injury or equipment damage exists if motor and driven machine are operated above their rated speed due to misadjustment or electronic failure. Before operating the equipment, make sure that appropriate guards and other safety devices are in place.

SECTION 2

SYSTEM EQUIPMENT DESCRIPTION

This instruction manual contains installation, operation, start-up and trouble-shooting information for the Dynamatic Model AF-1500 adjustable frequency AC Drive. The instructions given apply to the eleven sizes of inverters with ratings from 2 to 15 hp at 480 V and 1 to 20 hp at 240 V. The nameplate data for the standard units are included in Table 2-1. Table 2-2 lists the design and performance specifications. Also available, as a companion to this manual, is an "AF-1500 System Design Guide," No. 053-4037, which provides additional information about features available with this drive.

Standard Ratings — Table 2-1

200-240 Volt Models - Ratings in parentheses are for single phase input power.

Rated Output RMS Amps	Nominal Motor Hp at 240 V	Model Number	Height (In.)	Width (In.)	Depth (In.)	Weight (Lbs.)
5.0 (3.8) A	1/1.5 (.75)	AF-150102-0240	11.8	8.7	5.5	9.9
7.5 (5.6) A	2 (1.5)	AF-150202-0240	11.8	8.7	6.9	11.5
10.5 A	3	AF-150302-0240	11.8	8.7	6.9	13.2
16.5 A	5	AF-150502-0240	11.8	8.7	6.9	14.3
24.0 A	7.5	AF-150702-0240	17.3	9.8	7.7	26.5
32.0 A	10	AF-151002-0240	17.3	9.8	7.7	30.0
46.0 A	15	AF-151502-0240	17.3	9.8	7.7	31.0
64.0 A	20	AF-152002-0240	17.7	12.8	9.5	48.5

380-480 Volt Models

Rated Output RMS Amps	Nominal Motor Hp at 480 V	Model Number	Height (In.)	Width (In.)	Depth (In.)	Weight (Lbs.)
3.8 A	2	AF-150202-0480	11.8	8.7	6.9	16.5
5.3 A	3	AF-150302-0480	11.8	8.7	6.9	16.5
8.6 A	5	AF-150502-0480	11.8	8.7	6.9	16.5
13 A	7.5	AF-150702-0480	17.3	9.8	7.7	32
16 A	10	AF-151002-0480	17.3	9.8	7.7	33
23 A	15	AF-151502-0480	17.7	12.8	9.5	50

The following descriptions apply to all units. In cases where there are exceptions due to size differences or component variations, they will be noted.

PCB Location

The PCB location and its circuit configuration are shown in Figure 2-1.

Circuit Description

The power circuit input is 3 phase ac voltage which is converted to dc voltage by the full wave rectifying diode module DM, and is filtered by capacitor CB. The voltage is then "inverted" to ac voltage by transistor module PM. This

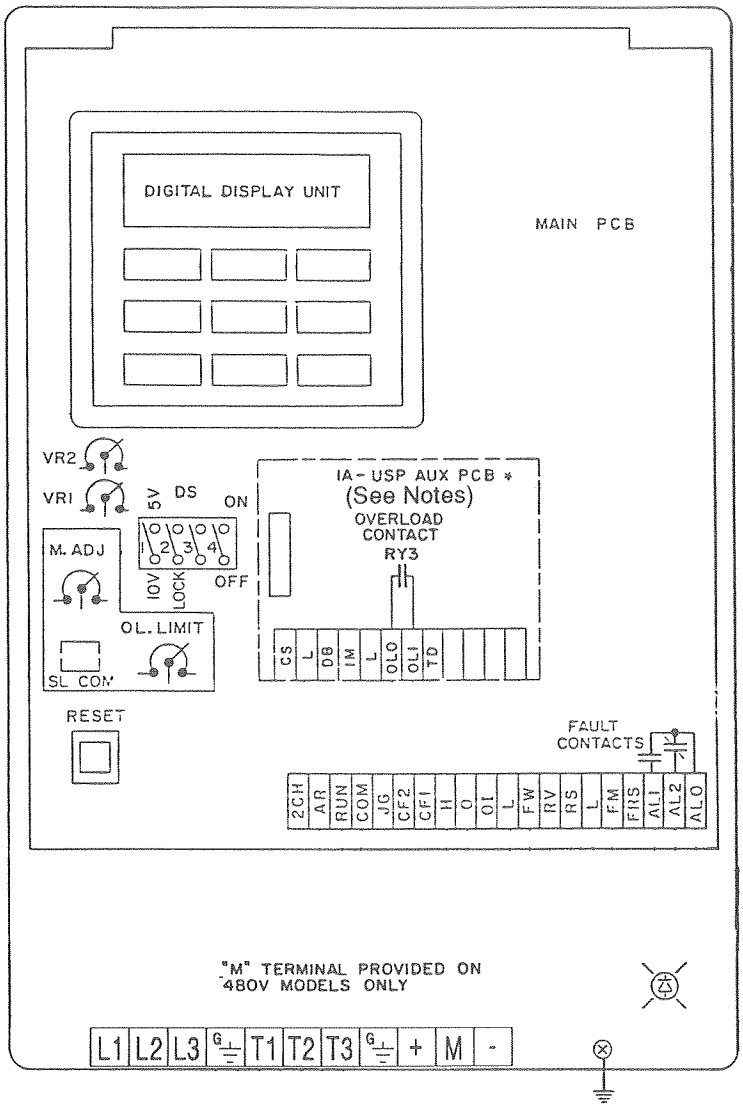
circuit produces sinusoidal current waveforms by changing the pulse width of the output voltage as controlled by the microprocessor logic.

The logic circuitry consists of a CPU, analog module, interface, base drive and digital operation panel. The CPU ensures that the ratio of output voltage to output frequency (V/Hz) conforms to the motor characteristics. This inverter was designed to allow thirty-six primary V/Hz profiles, along with variations

Model AF-1500 AC Drives Specifications Table 2-2

Output Ratings	
Horsepower @ 240 V	1 to 20 Hp
@ 480 V	2 to 15 Hp
Frequency Range	0.5 to 135 Hz
Service Deviation	+/-0.5% of maximum frequency; 15 to 35ºC
Maximum Overload Current	150% 1 minute every 10 minutes
Motor Performance	
Speed Range	Determined by thermal limitations of motor. OL protection limits operating time below 20 Hz.
Speed Regulation	Determined by motor slip (3% typical).
Starting Torque	150% with properly sized drive and optimum adjustment.
Input Power	
Voltage at 60 Hz +/-5%	200-240 V, +5%/-10% 380-480 V, +5%/-10%
Voltage at 50 Hz +/-5%	200-220 V, +/-10% 380-415 V, +/-10%
Displacement Power Factor	Approximately 0.95
Efficiency	Typically greater than 95%
Design Type	
Converter Type	Diode bridge
Inverter Type	Transistor
Waveform	Sine coded PWM
Setup Adjustments and Performance Features	
Linear Accel and Linear Decel	Keypad, 2 Presets 0.1 sec. to 50 minutes
S Curve Accel/Decel	Keypad, 0.1 to 230 seconds
Volts/Hertz	Keypad, 50-100%
Voltage Boost	Keypad
Accel Voltage Boost	Keypad
Current Limit	Potentiometer, 80-150%
Time Constant	Keypad, 0.3 to 30 seconds
Base/Maximum Frequency	Keypad, 9 selections
Maximum Frequency Trim	Keypad, maximum +0 to 15 Hz
Maximum Frequency Limit	Keypad, 0-135 Hz
Minimum Frequency Limit	Keypad, 0-135 Hz
V/Hz "Economy" Adjust	Keypad, 3 selections
Jump Frequency	Keypad, 3 presets
Hysteresis	Fixed, +/-0.3 Hz
Overload Protection FLA	Keypad, 50-100%
Overload Warning	Keypad, 100-150%
DC Brake Frequency	Keypad, 0.5 Hz (15 Hz option)
DC Brake Voltage	Keypad, 0-20 V
DC Brake Time	Keypad, 0-15 seconds
Power Loss Ride Thru	15 ms typ, varies with load
Auto Restart Delay	Keypad, 0.3-30 seconds
Carrier Frequency	Keypad, 19 selections
Freq. at Minimum Reference	Keypad, 0-135 Hz
Freq. at Maximum Reference	Keypad, 0-135 Hz
Start Frequency	Keypad, 0.5-5 Hz
Start Dwell Time	Keypad, 0-15 seconds

Environment	
Operating Temperature	
NEMA 1 or NEMA 12	-10 to 40º C
Chassis	-10 to 50º C
Storage Temperature	-10 to 70º C
Humidity	20-90% noncondensing
Maximum Elevation	1000 m (3300 ft.)
Codes and Standards	
Listings	ETL and CSA
Enclosure	
Standard	NEMA 1/Chassis
Optional	NEMA 12
Protective Features	
Input Line Fuses	External addition
Circuit Breakers	External addition
Contactor	External addition
Output Short Protection	Standard
Ground Fault Protection	Standard
Phase Loss Protection	Relay interlock (380-480 V Models)
Undervoltage	Standard
Overvoltage	Standard
Overload	Inverse time curve trip
Overcurrent	Instantaneous trip: 180 to 220%
Overtemperature	OT switch on models with fan
Ac Line Transients	Meets ANSI/IEEE C62.41-1980
Operator Control and External Interface	
Digital Readout	16 characters, on cover
Speed/Frequency	Rpm or Hz
Load	Percent or Amps
Fault Diagnostics	20 items
Setup Parameters	39 items
Keypad	Membrane, 9 keys
Isolated I/O Circuits	Standard
Speed Setting	Keypad or analog input
Potentiometer	500 to 2000 ohms: 10 V
Analog Voltage	0-5 or 0-10 Vdc (15/30K ohms)
Analog Current	4-20 mAdc (250 ohms)
Direct or Inverse Command Function	Keypad selectable
Preset Speeds	3 plus Maximum, Minimum & Jog
Run/Stop	Keypad or external switch
Auto Restart Power Up	Available
Auto Restart Fault	Keypad selectable
Forward/Reverse	Keypad or external switch
Reset	Ext switch or Power Off
Manual/Automatic	External switch
Preset Speed Select	External switch
Jog Function Select	External switch
Coast Stop	External switch
Preset Accel/Decel	External switch (2 presets)
"Drive Fault" Output	Form C contacts
"At Set Speed" Output	Open collector (relay option)
"Drive Run" Output	Open collector (relay option)
"OL Warning" Output	1 N.O. Contact (option)
Frequency Count Signal	Square wave 1xf standard
Speed Signal	0-10 Vdc = 0-100%
Load Signal	0-4 Vdc = 0-100% (option)



Note:

The 1A-USP AUX PCB (Part No. 13-21-1321) is an optional function board that is offered for sale as a modification kit which can be installed in the drive as shown in this figure. Table 3-7 on page 3-20 describes the inputs and outputs provided by the 1A-USP board. This PCB is also shown in various diagrams and its functions are discussed in various places in this manual.

In addition to the 1A-USP board, the following two optional function PCBs are also available:

The S3OP-PCB (Part No. 13-21-1500) provides the inputs and outputs as listed in Table 3-7 for the 1A-USP board except that the "TD" output is not provided. The S3OP-PCB includes two relay contacts in addition to the OL1 contact. The RN1 contact is closed when the drive is running, and the AR1 contact is closed when the drive is running at the set speed.

The OP-RY PCB (Part No. 13-21-1501) provides only the relay contacts RN1 and AR1 described above. It provides no other functions.

NOTE:
* Revision C of the 1A-USP Aux PCB is shown in this diagram. Revision B of this PCB is shown in Figure 8-1 in the Appendix.

ED-60521-2/B

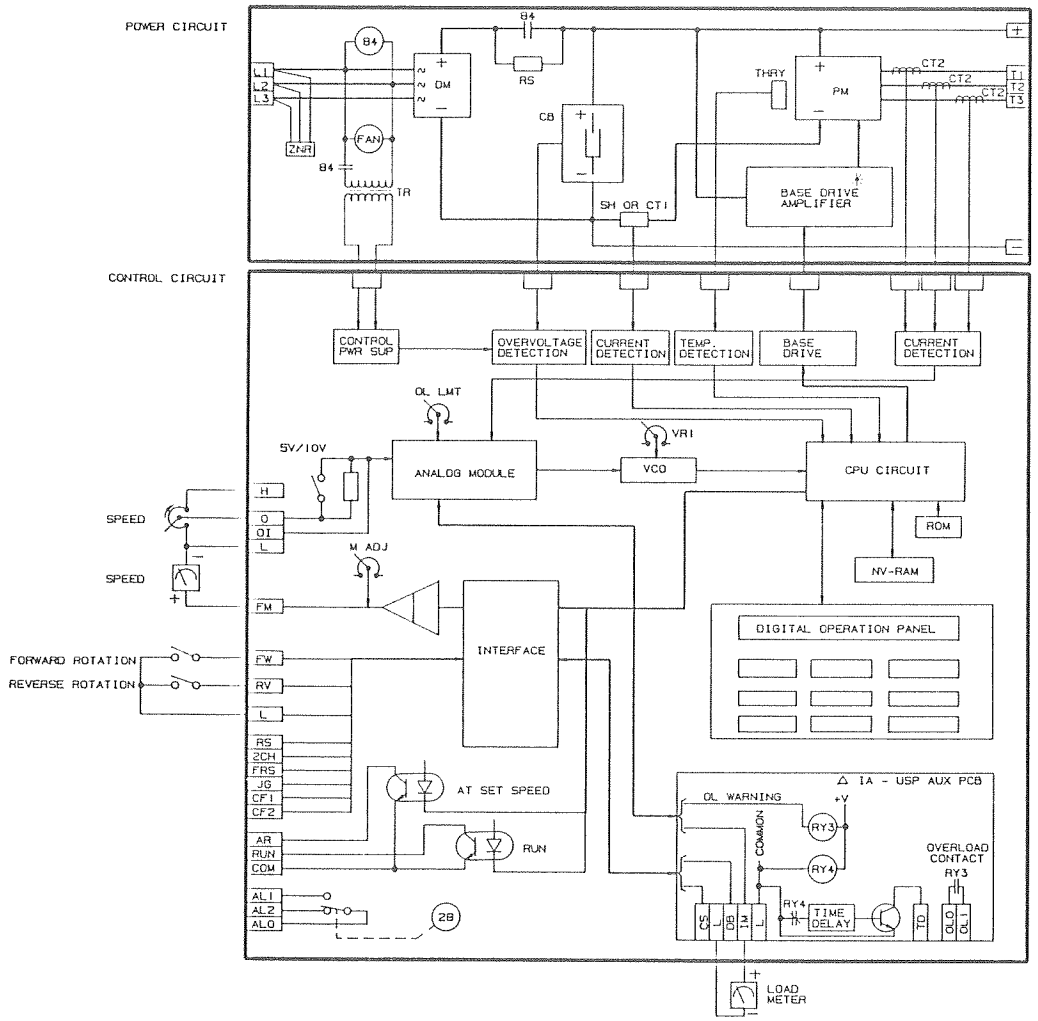
PCB Location

Figure 2-1

to the Boost, Start Frequency, Jumps, etc. Electronic thermal characteristics and overload limiting characteristics are obtained from output current detecting signals. Run/Stop, forward operation, reverse operation and multistage speed commands for execution are received and processed by the CPU. The CPU also commands the display on the digital operation panel. Current limit, I^2T, and instantaneous fault sensing are provided by the logic.

The analog module is an interface circuit for transmitting analog frequency commands and analog detecting signals to the CPU. The interface circuit transmits digital signals to the CPU for various external commands, including Run/Stop commands, multistage speed commands, jogging operation commands and reset commands. The base drive circuit, upon receiving a sine coded PWM signal controlled by the CPU, drives the inverter module. The digital operation panel provides various displays, using a 16 digit LCD, and allows for operator instruction entry via the key pad.

For a description on protection and display contents, refer to Section 6, Troubleshooting, and Table 6-1.



NOTES:

ED-60521-3/B

Revision C of the 1A-USP AUX PCB is shown in this diagram. Revision B of this PCB is shown in Figure 8-1 in the Appendix.

ZNR Surge absorber

DM Diode module(s) (Single module; except 240V, 20Hp model uses three)

RS Current limiting resistor

CB Bus capacitor (240V models have a single capacitor across the bus; except 15 & 20Hp modules have two in parallel. 480V models have two series capacitors across the bus.)

SH Shunt resistor (All models except 240V, 3-20hp and 480V 7.5-15Hp models)

CTI Dc bus current transformer (240V 3-20Hp & 480V 7.5-15Hp models)

TR Transformer (only 480 V models)

THRY Thermal relay (240V, 3-20Hp; two used on 10 & 20Hp models)

PM Power module (Single module; except three used on 240V, 10-20Hp & 480V, 7.7-15Hp)

* Base Drive Amplifier (Used on 240V 7.5-20Hp & 480V 7.5-15Hp)

CT2 3 phase output current transformers (240V 15 & 20 Hp use two overload sensors.)

84 Relay (not used on 240V, 1 & 2Hp models)

FAN (Used on 240V, 3-20Hp & 480V, 7.5-15Hp)

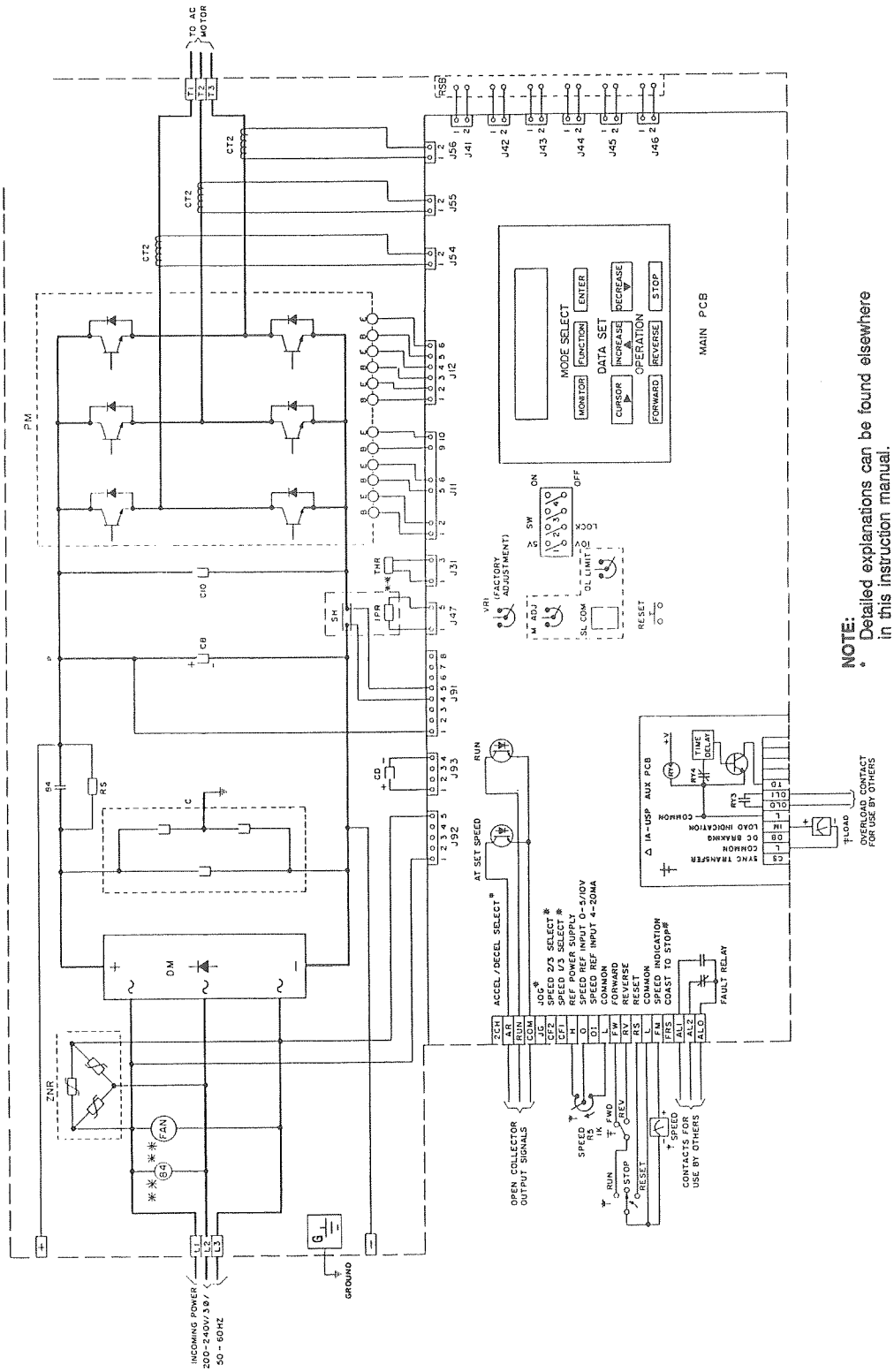
28 Fault alarm relay

RY3 Overload warning relay

RY4 Start delay relay

Block Diagram for 240 V and 480 V Models

Figure 2-2



NOTE:
* Detailed explanations can be found elsewhere in this instruction manual.

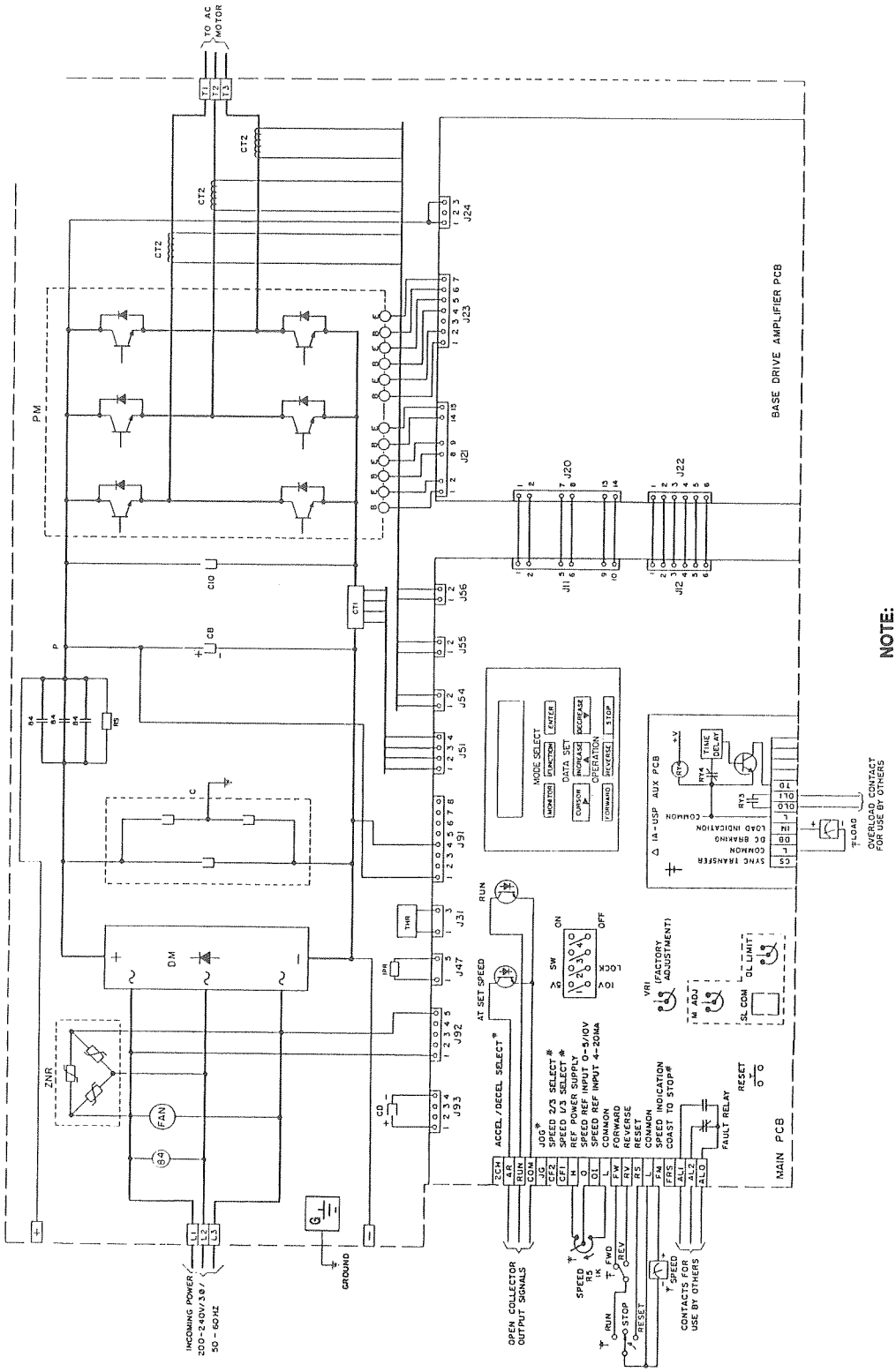
** Used on 3 hp and 5 hp drives only.

‡ Items furnished only when specified.

Revision C of the 1A-USP Aux PCB is shown in this diagram. Revision B of this PCB is shown in Figure 8-1 in the Appendix.

ED-60521-1(1)/C

Schematic Diagram for Models AF-150102-0240 Through AF-150502-0240 Figure 2-3



NOTE:

- Detailed explanations can be found elsewhere in this instruction manual.

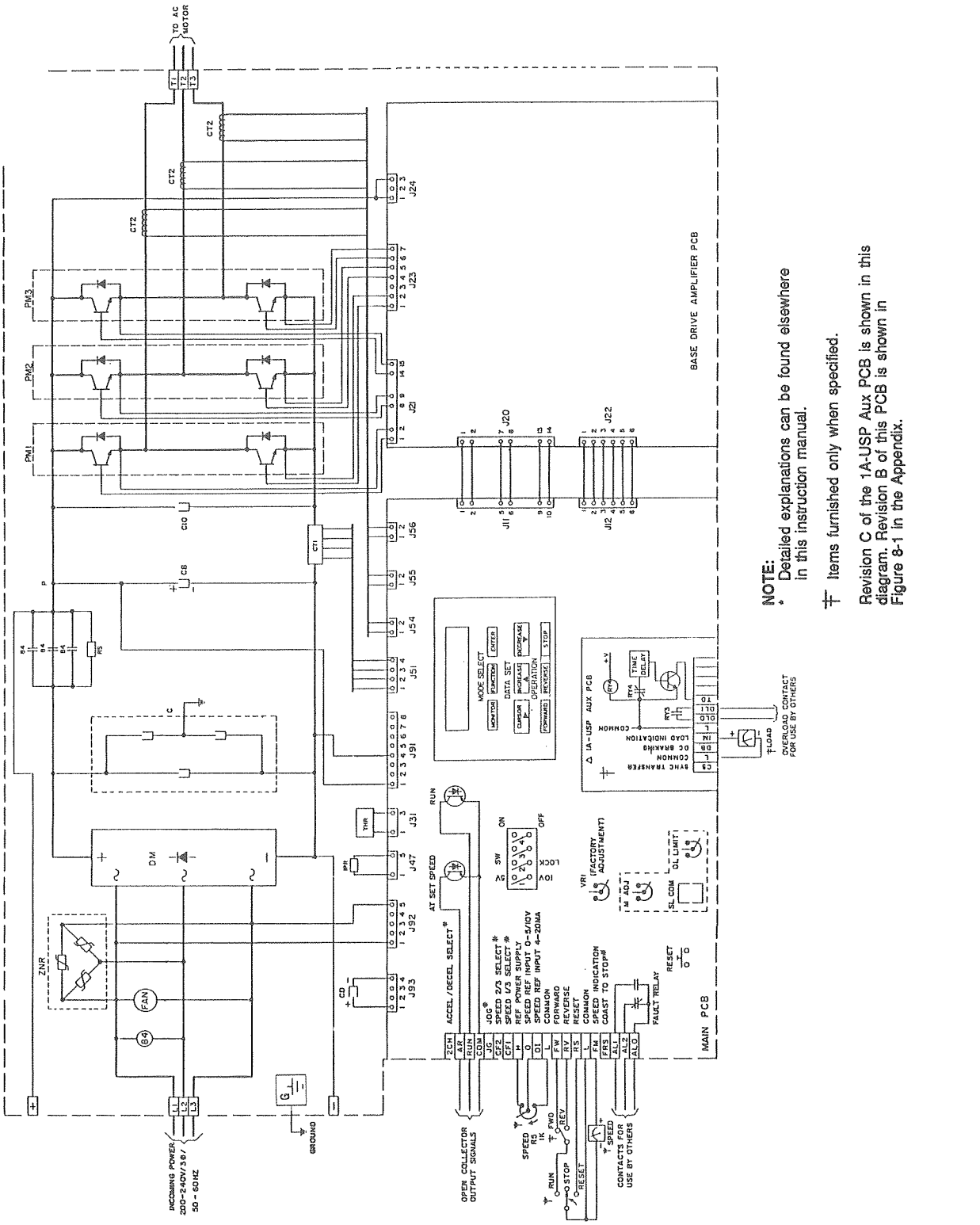
† Items furnished only when specified.

Revision C of the 1A-USP Aux PCB is shown in this diagram. Revision B of this PCB is shown in Figure 8-1 in the Appendix.

ED-60521-12/-

Schematic Diagram for Model AF-150702-0240

Figure 2-4



NOTE:

* Detailed explanations can be found elsewhere in this instruction manual.

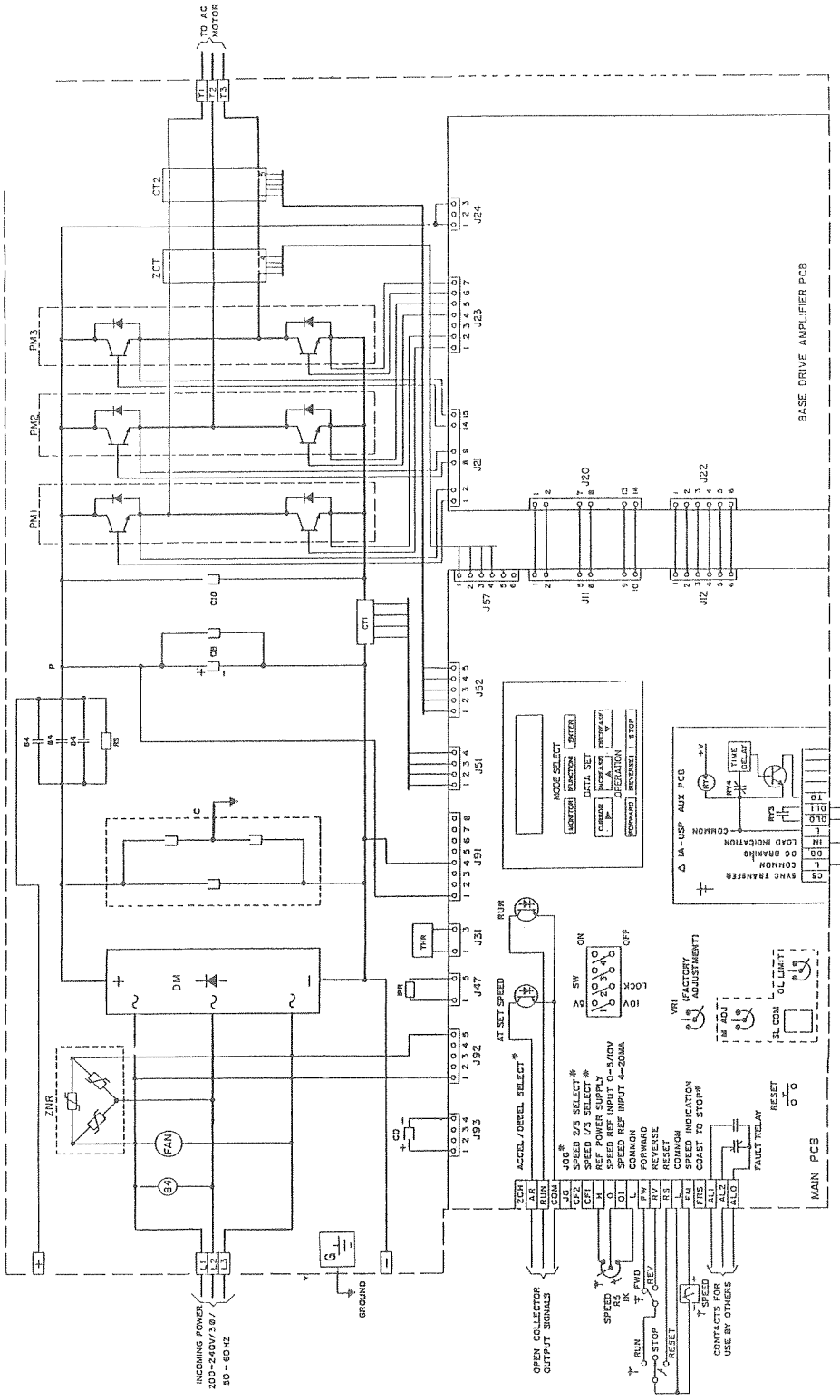
‡ Items furnished only when specified.

Revision C of the 1A-USP Aux PCB is shown in this diagram. Revision B of this PCB is shown in Figure 8-1 in the Appendix.

ED-60521-13/-

Schematic Diagram for Model AF-151002-0240

Figure 2-5



NOTE:
* Detailed explanations can be found elsewhere in this instruction manual.

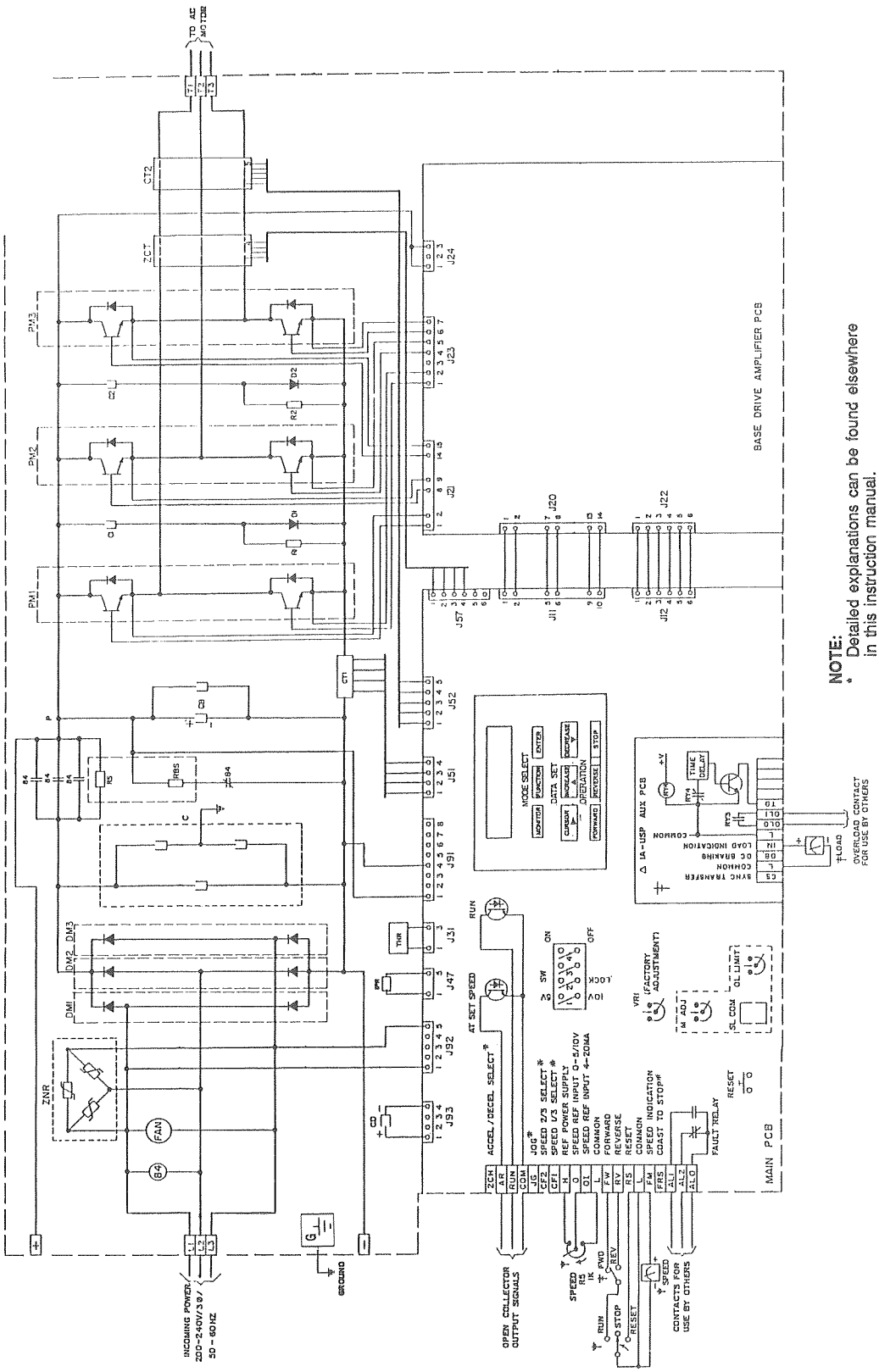
⏚ Items furnished only when specified.

Revision C of the 1A-USP Aux PCB is shown in this diagram. Revision B of this PCB is shown in Figure 8-1 in the Appendix.

ED-60521-14/-

Schematic Diagram for Models AF-151502-0240

Figure 2-6



NOTE:

* Detailed explanations can be found elsewhere in this instruction manual.

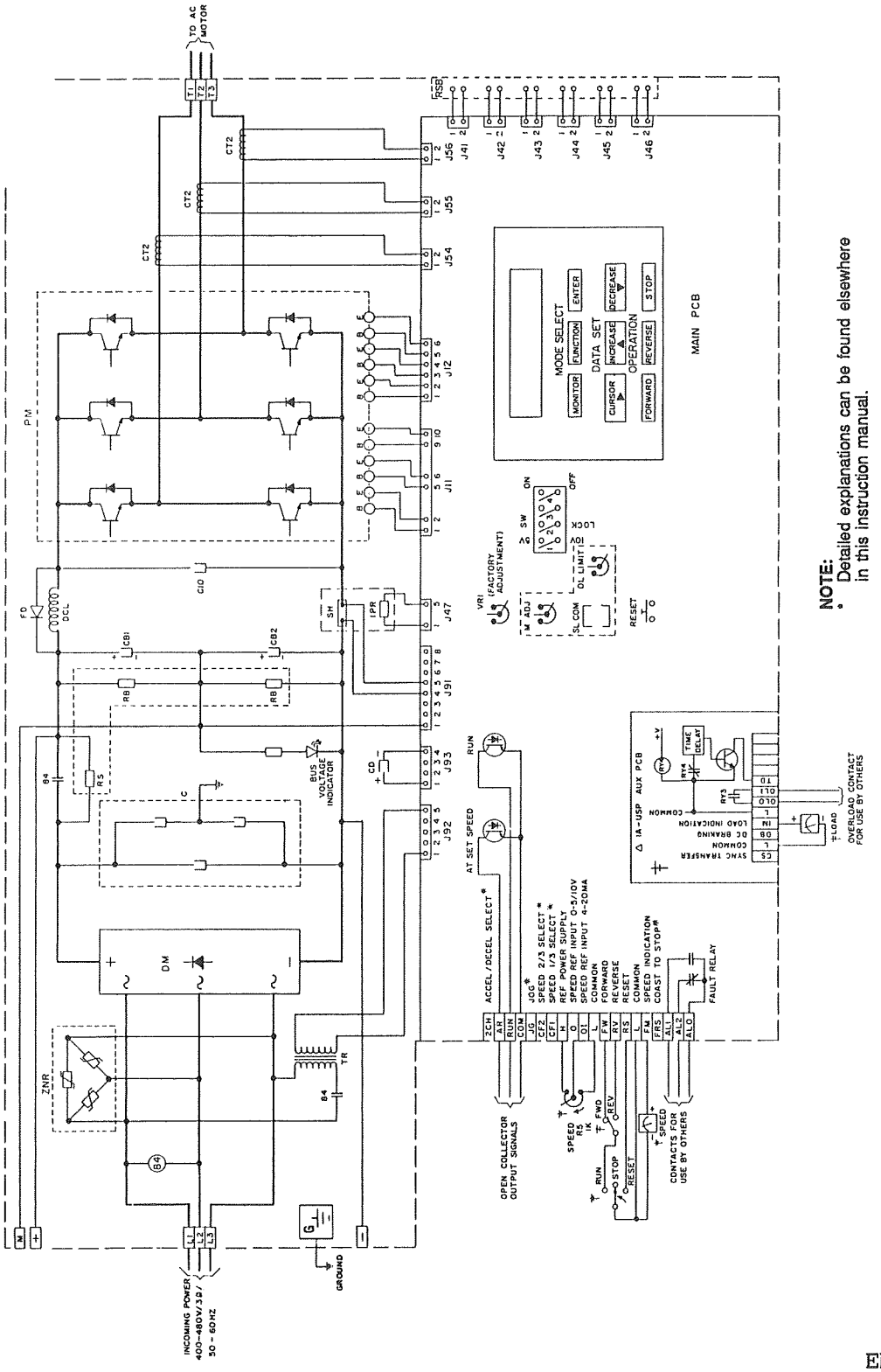
∓ Items furnished only when specified.

Revision C of the 1A-USP Aux PCB is shown in this diagram. Revision B of this PCB is shown in Figure 8-1 in the Appendix.

ED-60521-15/-

Schematic Diagram for Model AF-152002-0240

Figure 2-7



NOTE:

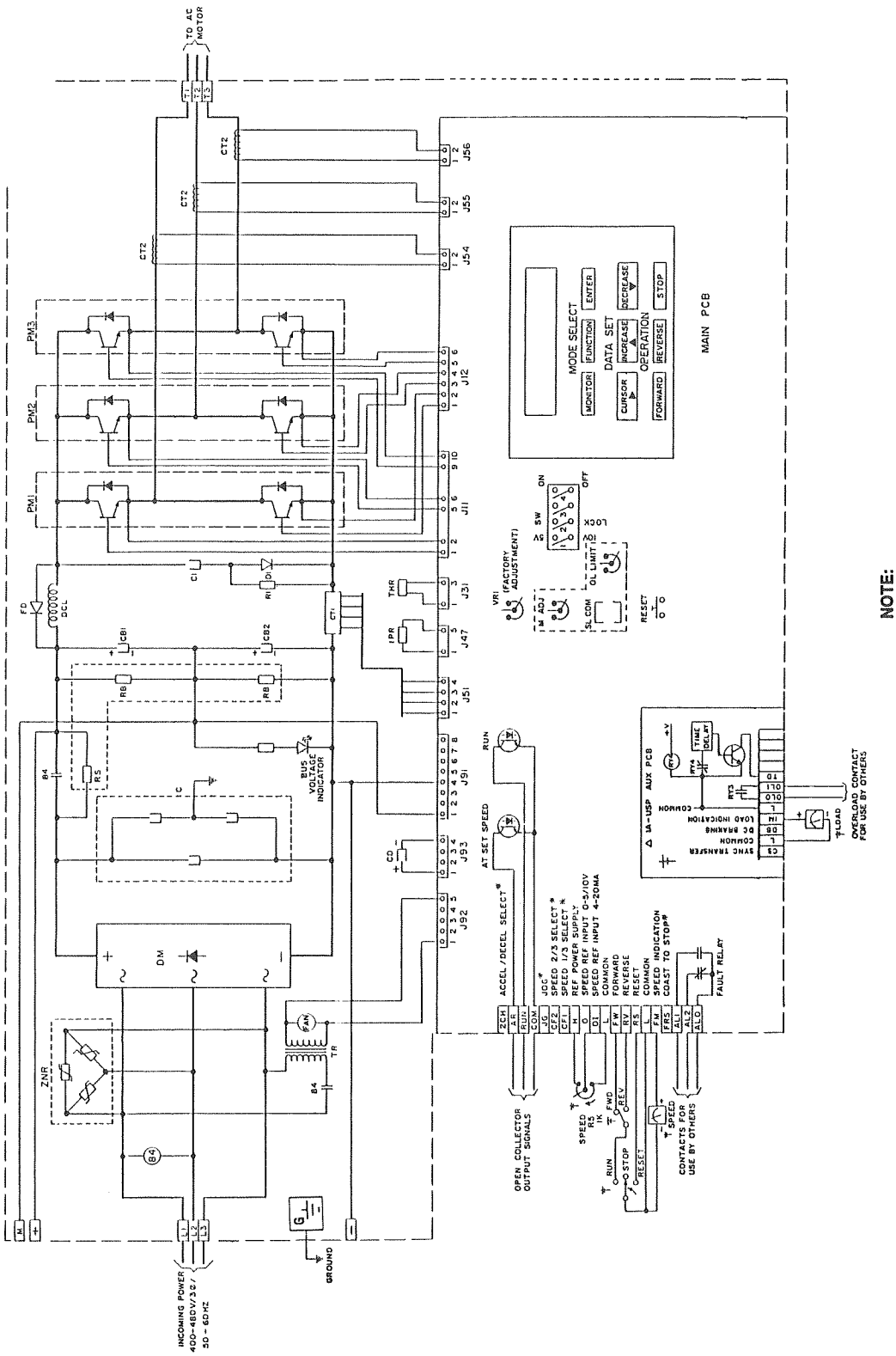
- Detailed explanations can be found elsewhere in this instruction manual.

‡ Items furnished only when specified.

Revision C of the 1A-USP Aux PCB is shown in this diagram. Revision B of this PCB is shown in Figure 8-1 in the Appendix.

ED-60521-1(2)/C

Schematic Diagram for Models AF-150202-0480 Through AF-150502-0480 Figure 2-8



NOTE:

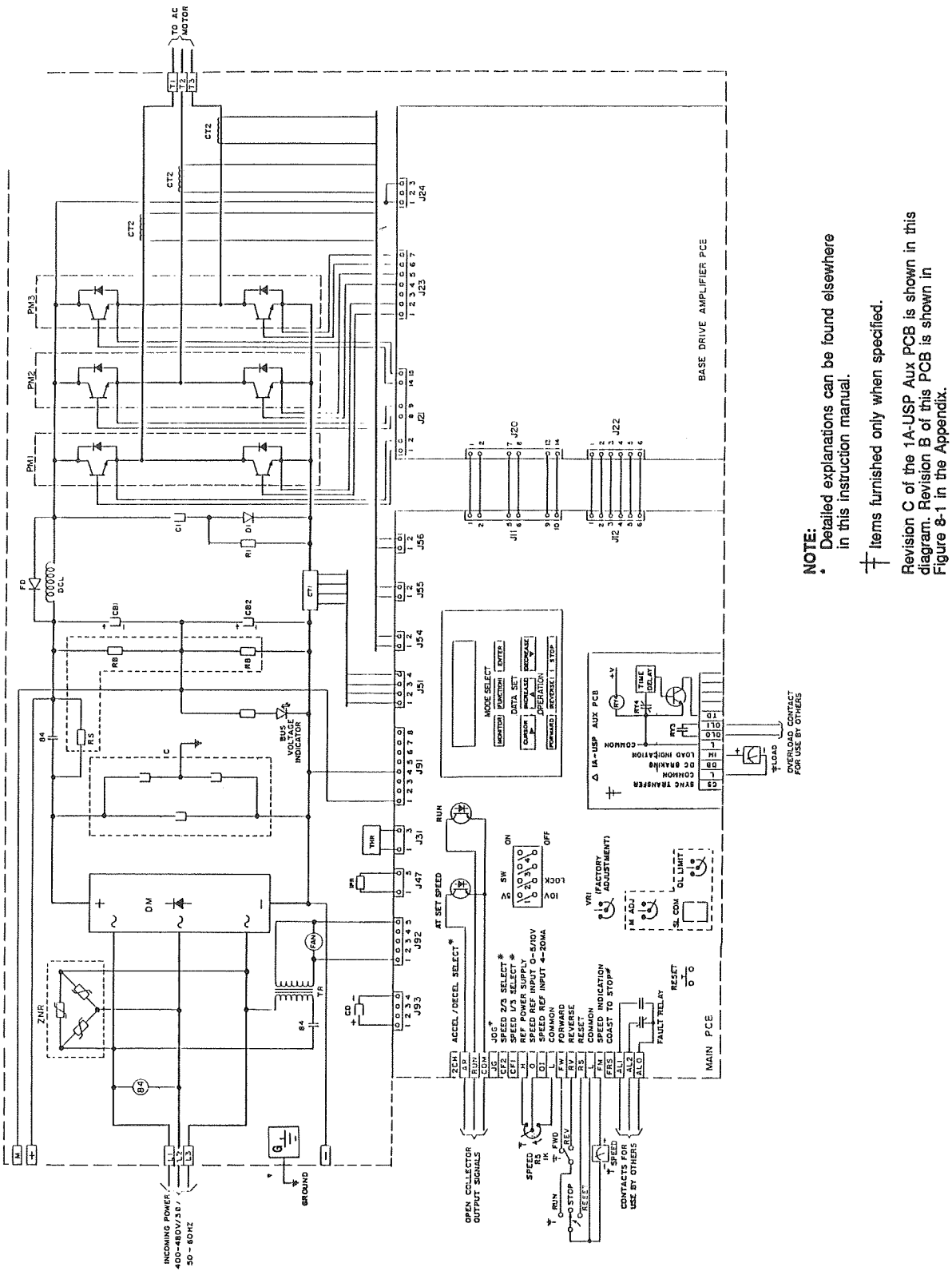
* Detailed explanations can be found elsewhere in this instruction manual.

‡ Items furnished only when specified.

Revision C of the 1A-USP Aux PCB is shown in this diagram. Revision B of this PCB is shown in Figure 8-1 in the Appendix.

ED-60521-16/-

Schematic Diagram for Model AF-150702-0480 Figure 2-9



NOTE:

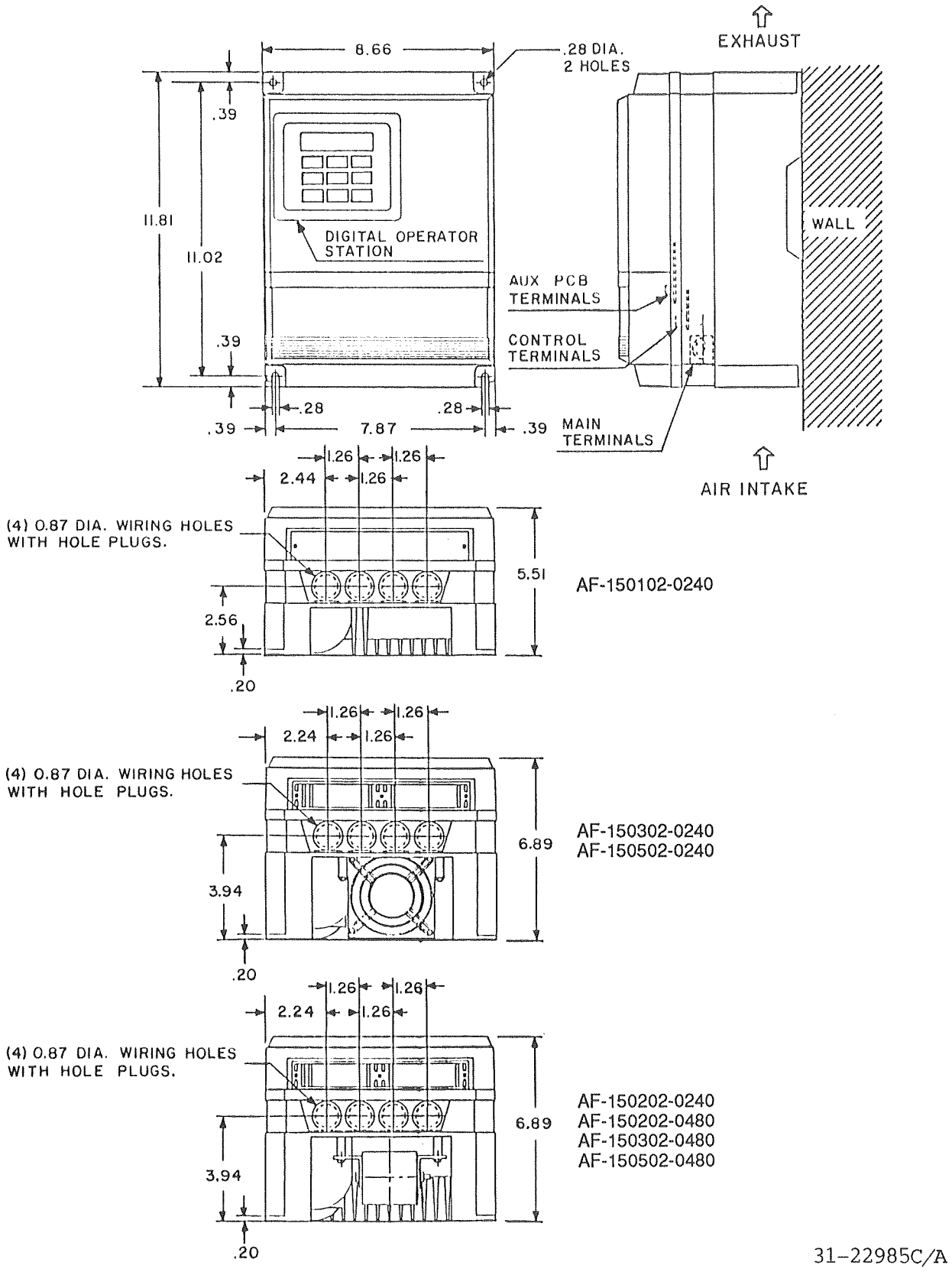
* Detailed explanations can be found elsewhere in this instruction manual.

‡ Items furnished only when specified.

Revision C of the 1A-USP Aux PCB is shown in this diagram. Revision B of this PCB is shown in Figure 8-1 in the Appendix.

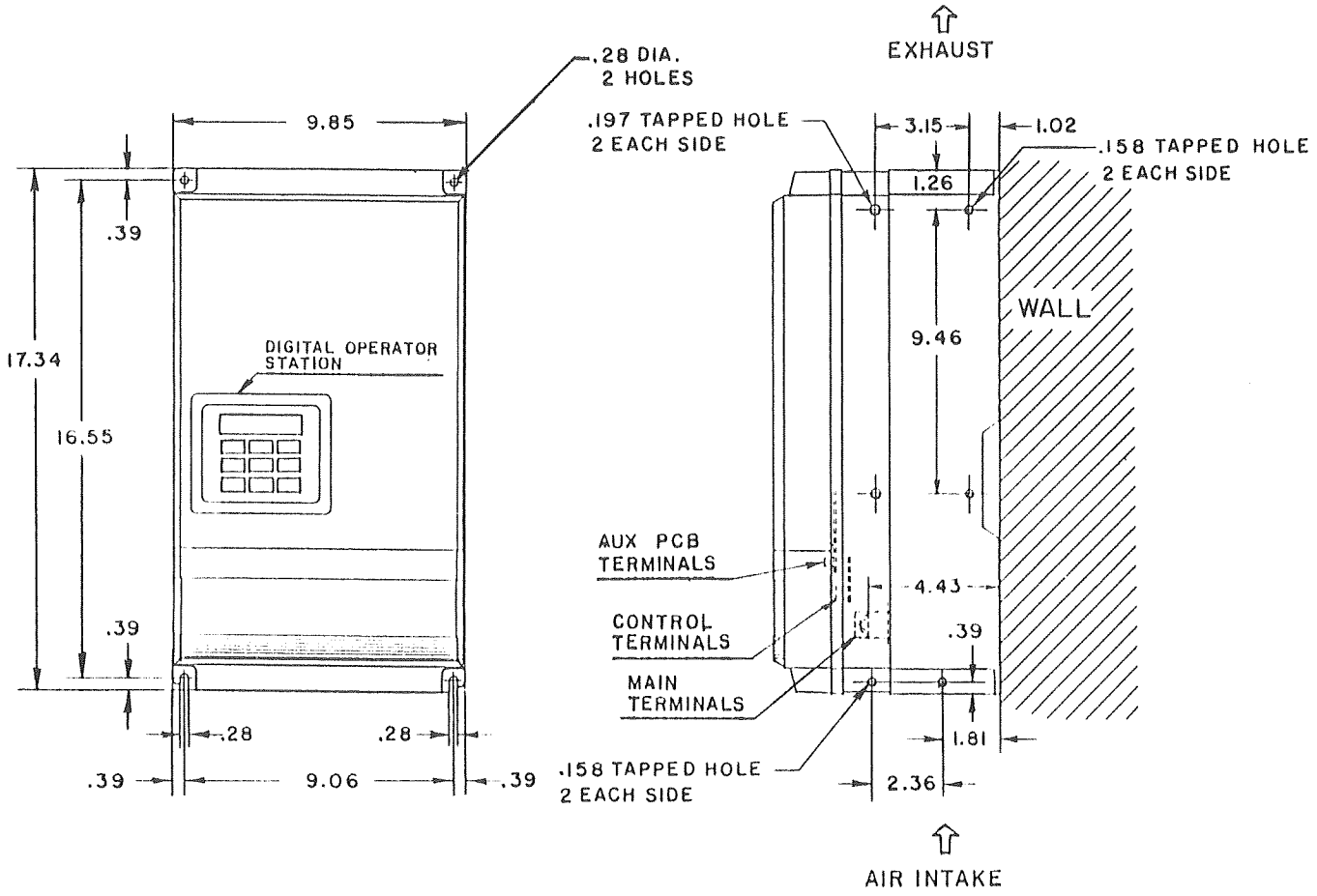
ED-60521-17/-

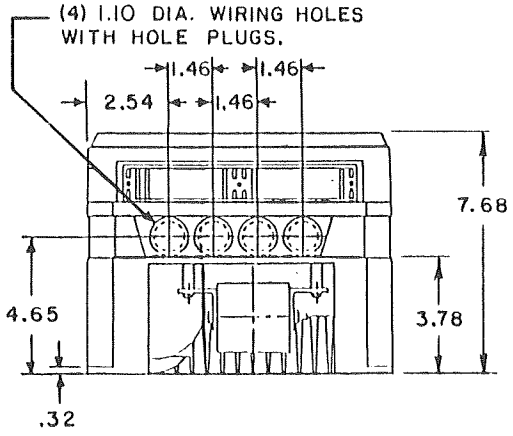
Schematic Diagram for Models AF-151002-0480 Through AF-151502-0480 Figure 2-10



31-22985C/A

Outline Dimensions for AC Drives (Models listed above) Figure 2-11

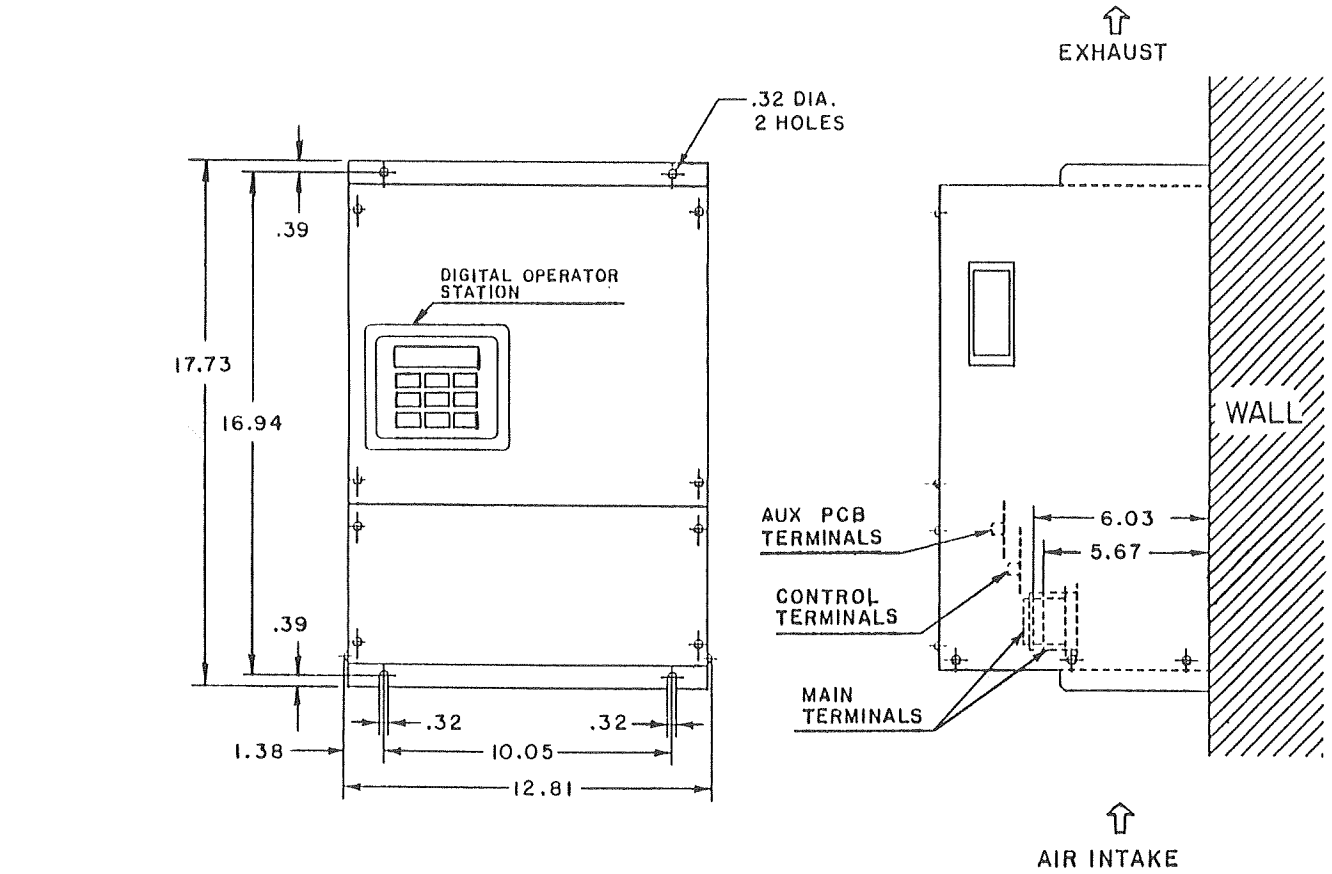


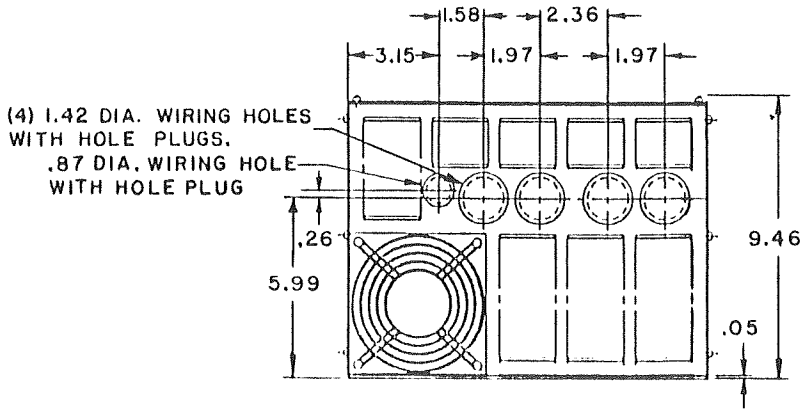


AF-150702-0240
AF-151002-0240
AF-151502-0240
AF-150702-0480
AF-151002-0480

31-23010C/A

Outline Dimensions for AC Drives (Models listed above) Figure 2-12





AF-152002-0240
AF-151502-0480

31-23011C/A

Outline Dimensions for AC Drives (Models listed above) Figure 2-13

SECTION 3

INSTALLATION

WARNING: This equipment must be installed, adjusted and serviced only by qualified personnel familiar with the construction and operation of the equipment and the hazards involved. Failure to observe this precaution could result in personal injury and/or equipment damage.

These instructions cover the standard AF-1500 product as described in Section 2 of this manual. Separate instruction sheets and/or drawings are required for any accessories furnished or modifications installed by Eaton, by a distributor or by another party. All certified drawings and specific instructions for this equipment must take precedence over these instructions.

Refer questions and requests for additional information to Eaton Corporation, Electric Drives Division, 3122 14th Avenue, Kenosha, WI 53141, or contact your local Eaton sales office or distributor.

Location and Environment

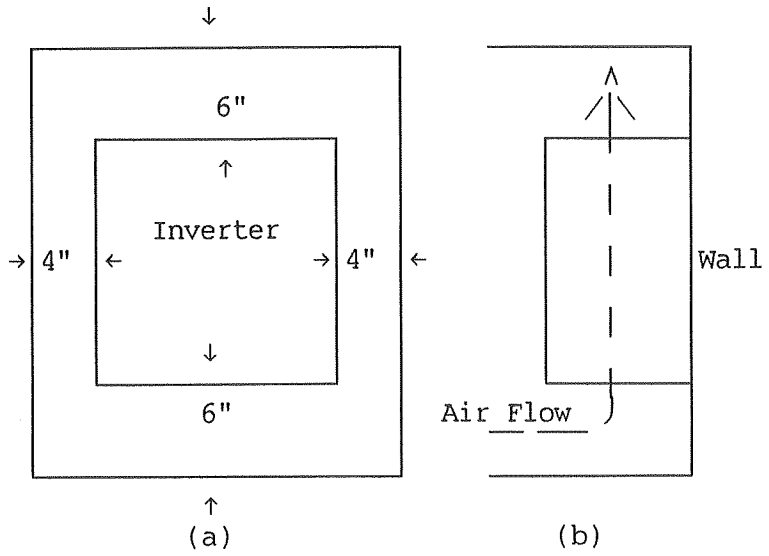
The service life of this unit can be reduced by an unsatisfactory operating environment. It is important that the equipment be installed and operated within the conditions for which it is designed.

AC drives are suitable for most factory areas where industrial electrical equipment is installed. The drive should be installed in a clean, well ventilated area. Avoid high temperature, high humidity environments, high vibration areas and places exposed to dust or dirt, corrosive gas and coolant mist. The unit should be mounted in a place not exposed to direct sunlight. When installing the unit within an enclosure, leave the terminal cover and conduit bracket removed (necessary to extend the allowable operating temperature range to -10° - 50°C (14° - 122°F)). Mount it on a nonflammable surface.

The AF-1500 must be located in an area providing an unobstructed flow of clean cooling air. Refer to Figure 3-1 for air flow requirements. The unit should be mounted where it will be accessible to maintenance personnel. If it is mounted in a location accessible to operating personnel, the front mounted keypad can be used to start and stop the drive and set the operating speed. For best viewability of the LCD display, mount the AF-1500 with the display at eye level or slightly above eye level.

Site Preparation

The job site should be cleared of any dirt or construction debris before beginning installation.



Inverter Air Flow Requirements ——————— Figure 3-1

Mounting The AF-1500

The standard Model AF-1500 is supplied in a NEMA 1 enclosure suitable for wall mounting. Weights and mounting dimensions of these units are included in Section 2. NEMA 12 enclosure kits are also available. Refer to the Eaton Industrial Drives Catalog.

The AF-1500 must be mounted upright on a solid vertical flat surface. Do not allow any space between the vertical mounting surface and the back surface of the AF-1500. If the wall is not smooth insert a metal plate between the AF-1500 and wall to eliminate any looseness. Overheating and failure can result if the unit is not mounted properly. Remember that the inverter heat sink can run at temperatures up to 100°C (212°F), so avoid contact with anything that might be harmed at this temperature.

For mounting in customer enclosures, allow ventilation for approximately 5% of the rated capacity in heat loss from the AF-1500. When installing more than one AF-1500 in an enclosure, mount the units side by side (not one above another). For operation temperatures up to 50°C inside the enclosure, remove the terminal cover, conduit bracket and top cover plates. Refer to Figure 3-2.

Electrical Wiring Connections

WARNING: Equipment is at line voltage when ac power is connected to the input terminals. All ungrounded conductors of the ac power line must be disconnected before it is safe to touch any internal parts of this equipment. After power is removed, use a voltmeter at dc bus terminals marked + and - to verify that the dc bus capacitors are discharged before touching any internal parts of the equipment. Failure to observe these precautions could result in fatal injury.

GENERAL WIRING REQUIREMENTS

All wiring must be in accordance with the National Electrical Code (NEC), or Canadian Electrical Code (CEC), and applicable local codes. An interconnection diagram showing the connections between the AF-1500 and related components is shown in Figure 3-3. The electrical connections completed by the installer must conform to this connection diagram. When the installation wiring is complete, check the connections against the interconnection diagram and verify the connections by continuity tests. All connections should be checked for tightness. Be sure to make a thorough visual inspection to be sure that the unit is free from wire clippings, etc. and that no components or plug connections have been disturbed during installation.

The following considerations must be observed when designing the layout of the conduit and wiring to prevent problems with electrical interference.

1. Control wiring must be separated from power wiring. Control wiring includes wiring of the Speed potentiometer, pushbuttons, switches, meters, etc. Power wiring is for input power and output power to the motor. Control wiring must never be run in the same conduit or cable tray as the power wiring or wiring to other equipment.

   The control wiring must be separated from control wiring to other equipment. A metal divider can be used in cable trays or two inches of separation allowed between runs. Power trays should be separated from control circuit wiring trays as much as possible.

   Unsuppressed relays, solenoids or brake coils, located near the inverter, may cause faults to occur due to electrical transients. Installing an RC suppressor or "Quench Arc," such as Dynamatic part No. 33-1-101, across the coils of these devices will reduce problems of this type.

2. Use shielded cable where indicated on the connection diagram (Figure 3-3). Figure 3-6 shows how to correctly terminate and ground the shield. Potentiometer leads and other signal leads should be always shielded. If the distance from the AF-1500 to the operator station exceeds 75 feet, all control circuit wiring should be shielded.

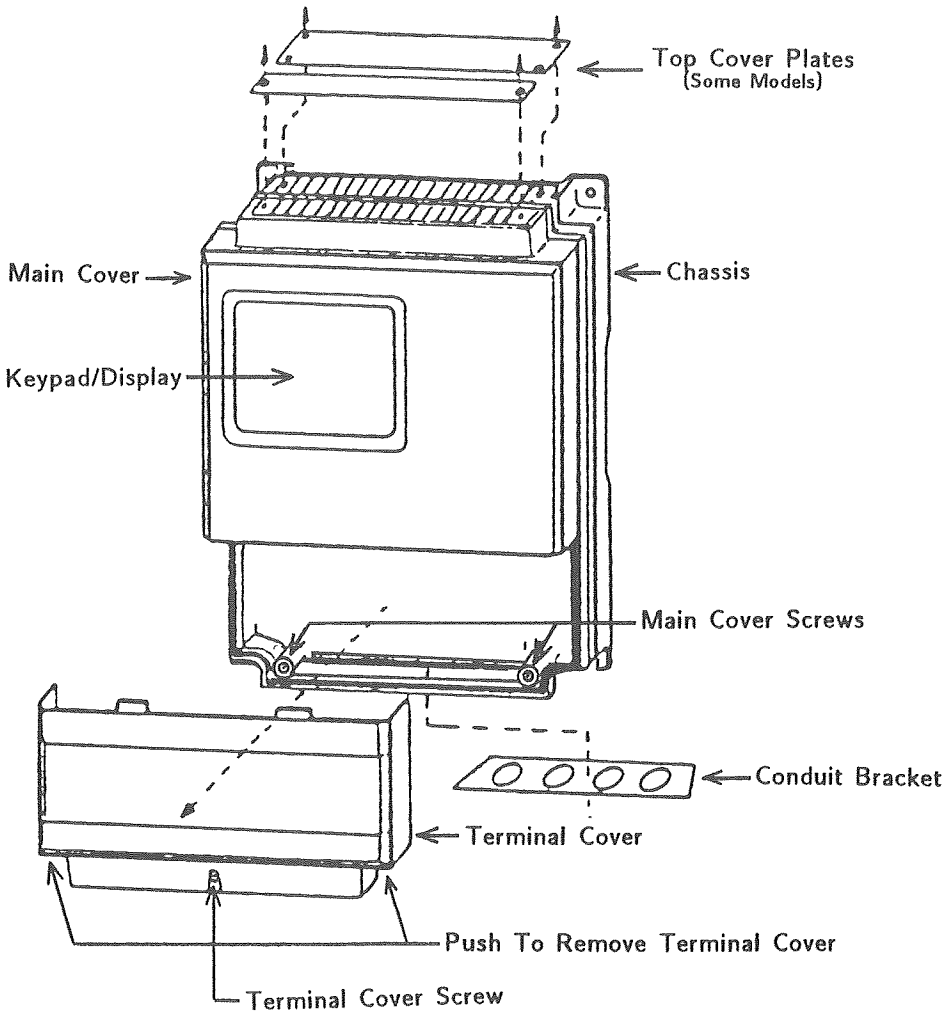
3. Keep the motor wires separated from wiring to any electrical equipment which may be sensitive to electrical noise.

4. Inserting an ac contactor between the inverter and motor for starting and stopping is not recommended because the inrush currents will shorten the life of the bus capacitor(s). If an ac contactor must be used, be sure to turn it on after both the inverter and motor have stopped.

5. Do not install power factor capacitors or surge absorbers between the inverter and motor. An input circuit breaker may be used to protect the inverter wiring.

6. Input wire size should be chosen according to local codes. Output wire should also be sized according to local codes for the motor rating, and the distance between the controller and the motor. To avoid excessive voltage drop with wire runs over 100 feet, increase the wire size according to Table 3-2.

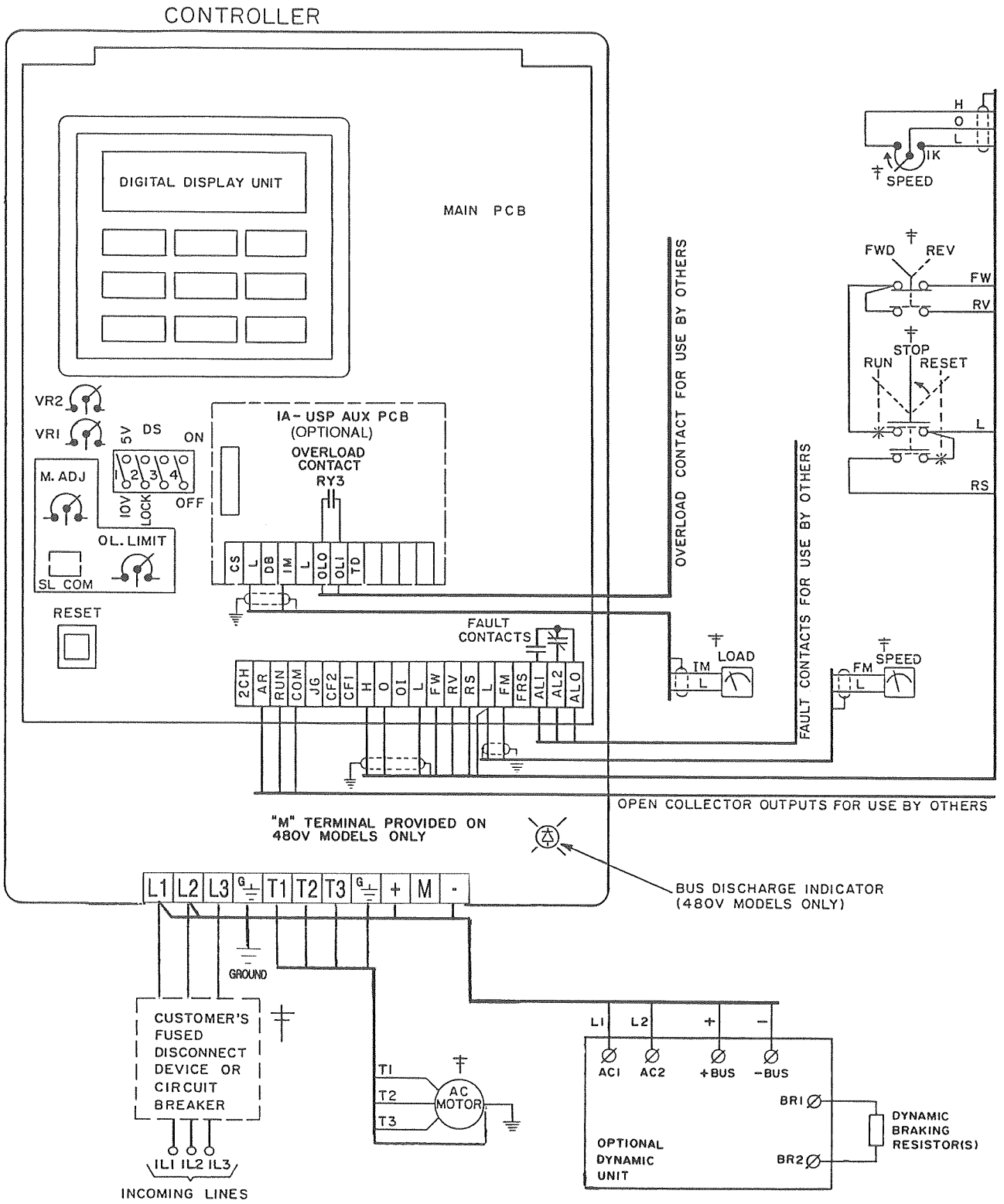
CAUTION: When removing the terminal cover, be careful not to damage the main cover or the terminal cover. Refer to Figure 3-2. On all models except AF-152002-0240, the a plastic terminal cover is secured to the main plastic cover by a single screw. When this screw is loosened sufficiently, the cover can easily be removed by placing your thumbs on the ridged areas at the bottom corners and pushing upward. Model AF-152002-0240 has a metal terminal cover secured by four screws.



Cover Removal Details for All Models Except AF-152002-0240 ——— Figure 3-2

CONNECTION DIAGRAMS AND TERMINAL DESCRIPTIONS

Terminal locations and standard wiring connections are shown in the connection diagram, Figure 3-3. Figure 3-8 shows optional connections for manual/automatic speed reference selection, and Figure 3-13 shows connections for automatic restart upon restoration of input power. Tables 3-6, 3-7 and 3-8 and Figures 3-15 and 3-16 describe the control circuit inputs and outputs. Schematic diagrams are provided in Section 2 of this manual. For additional information concerning optional connections, refer to publication 053-4037, "AF-1500 System Design Guide."



For operation with single phase input power, connect the incoming lines to terminals L1 and L2 and install a jumper wire between terminals L2 and L3.

With single phase input power, the maximum output current must be derated. Ratings for models AF-150102-0240 and AF-150202-0240 are listed on page 2-1. Contact Eaton for ratings for other models.

⏚ = Customer furnished.

ED-60521-2/B

Model AF-1500 Connection Diagram ——— Figure 3-3

INPUT POWER CONNECTIONS

AF-1500 models are available for use with 380-480 Vac or 200-240 Vac, 3 phase, 50/60 Hz power. Check the drive nameplate for the rated input voltage and refer to the connection diagram (Figure 3-3) for terminal locations and connection information. Models AF-150102-0240 and AF-150202-0240 can be used with 1 phase input power. Table 2-1 lists the output current ratings that apply when 1 phase input power is used.

> **CAUTION:** National Electric Code Article 430-102 requires a disconnecting means for each motor and controller located in sight from the motor, controller and driven machinery locations or capable of being locked in the open position if not located in sight. This disconnecting means is not included with the AF-1500 unless specifically ordered.

The disconnect device and all other components of the input power circuit must be sized adequately for the required input current. The drive input current is approximately equal to the motor current plus the input harmonic current. Table 3-1 provides a listing of adjustment factors which can be used to estimate input current as a percent of motor current.

Input Current Percentages Table 3-1

Percent Source Impedance	Input Current as a Percent of Motor Current
3.00%	101%
2.00%	104%
1.00%	112%
0.70%	117%
0.50%	122%
0.25%	135%
0.10%	156%
0.05%	178%

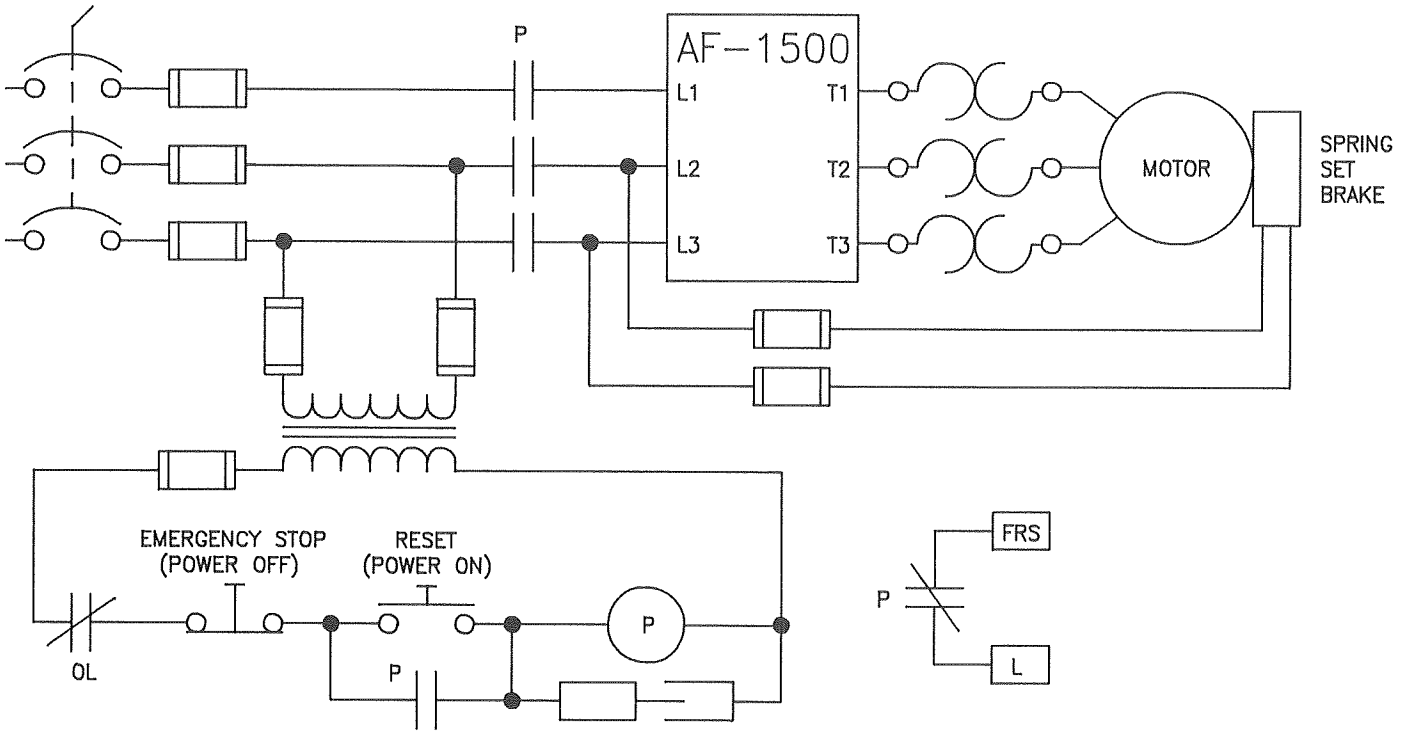
AF-1500 drives are designed to operate directly from three phase industrial power lines without using an isolation transformer. They are designed to withstand line-to-line and line-to-ground voltage surges up to 6000 volts, 120 Joules per ANSI/IEEE C62.41-1980. Electronic protection circuits protect the AF-1500 against short circuits and ground faults.

It is recommended that the impedance of the source providing power to the drive should be at least 0.5% of the effective impedance of the drive. Up to 3% line impedance may be needed to protect the drive if: the drive is connected to a power distribution system which also provides power to large SCR type drives; the input voltage is more than 3% unbalanced; or power factor correction capacitors are switched on the power distribution system. Additional line impedance may also be desirable to limit the harmonic content of the input line current to the drive. Due to harmonic content, the input line current may be significantly higher than the motor current as Table 3-1 shows. When the drive is lightly loaded, line voltage notching and ringing voltages caused by other power conversion equipment may cause it to shut down due to dc bus overvoltage. Adding line impedance may alleviate this problem. It may also help to connect a resistor to the brake unit terminals: (+) and (-). Use a 1000 ohm, 200 watt resistor for 240 volt models; use two of these resistors in series for 480 volt models.

INPUT POWER CONTACTOR AND EMERGENCY STOP CIRCUIT

An input power contactor and emergency stop circuit must be provided as part of any installation where personnel may come into contact with the moving parts of the machinery. This safety circuitry must be installed whenever it cannot be assured that the NEC required disconnect device will be open whenever the moving parts of the machinery are accessible. Figure 3-5 shows a suggested input power contactor and emergency stop circuit. The spring set brake can be omitted if the inherent friction load of the machinery assures that it will stop immediately when deenergized. This electromagnetic safety circuitry is necessary because a failure of an electronic component in the drive could result in the loss of Run/Stop control. The motor could start without being given a start command or it could fail to stop when commanded to do so.

Opening and closing the input contactor is not a suitable means for frequently starting and stopping the drive. Frequent charging and discharging the drive's power supply capacitors will shorten the life of the drive. If a contactor and/or friction brake must be used in an application requiring frequent starting and stopping, refer to publication 053-4037 "AF-1500 System Design Guide" for information regarding the use of output contactors and friction brakes.



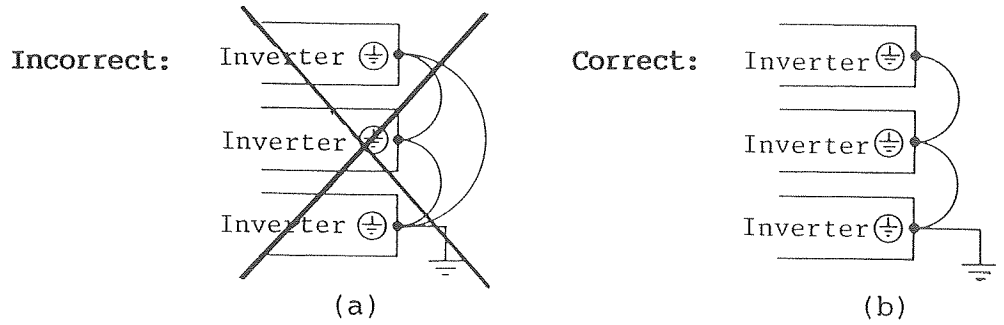
Input Power Contactor
And Emergency Stop Circuit ——————————— Figure 3-5

GROUND CONNECTIONS

For personnel safety and reliable equipment operation, firmly earth ground each cabinet as shown on the connection diagram. Use the ground stud provided in the inverter cabinet identified with the green label.

The ground conductor should be the same size as the incoming power wires or sized according to NEC Table 250-95. Be sure of the quality of the plant ground used; it should read less than one ohm to earth ground. A copper or aluminum conductor must be used. Grounded conduit connections are not adequate for equip-

ment ground connections. Also make sure that all operator's control stations and motor frames are adequately grounded. When grounding several inverters, make connections as shown in Figure 3-4(b) so that no loops exist as shown in Figure 3-4(a).



Grounding — Figure 3-4

MOTOR CONNECTIONS

Check the motor and controller nameplates to be sure that the motor nameplate data matches the controller output ratings. If the motor has dual voltage capability, verify that it is connected to correspond to the output voltage rating of the inverter.

Select a wire size adequate for the rated motor current. To avoid excessive voltage drop with wire runs over 100 feet, increase the wire size according to Table 3-2.

Wire Sizes Recommended to Prevent Excessive Voltage Drop With Long Wire Runs Between Inverter and Motor — Table 3-2

Hp	Typical Current per NEC (Amps)	Recommended Minimum Wire Size (AWG and MCM) For Various Wire Run Distances (Feet)					
		300 Ft.	500 Ft.	700 Ft.	1,000 Ft.	1,500 Ft.	2,000 Ft.
240 Volt Motors							
1	3.6	14	14	14	12	10	8
2	6.8	14	12	12	10	8	6
3	9.6	14	12	10	8	6	4
5	15.2	12	10	8	6	6	4
7½	22	10	8	6	6	4	2
10	28	8	8	6	4	2	1
15	42	8	6	4	2	1/0	2/0
20	54	6	4	4	1	2/0	4/0
480 Volt Motors							
2	3.4	14	14	14	14	12	10
3	4.8	14	14	14	12	10	8
5	7.6	14	12	12	10	8	6
7½	11	14	12	10	8	6	4
10	14	12	10	8	6	6	4
15	21	10	8	6	6	4	2

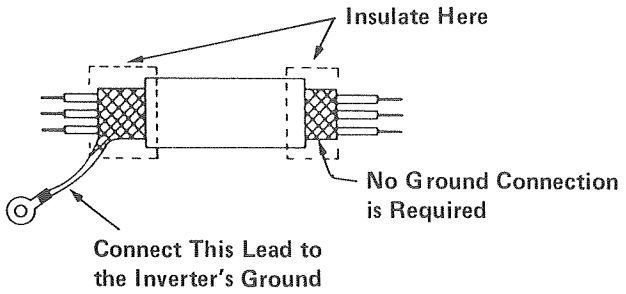
CONTROL WIRING CONNECTIONS

When the AF-1500 drive is shipped, it is set up for run/stop and speed setting control using the keypad as described in the Simplified Start-Up Procedure inside the front cover of this manual. To start and stop the drive using a run/stop and/or forward/reverse switch connected to the terminal block, the Monitor Mode parameter, "F/R-SW" must be changed from "Ope.-Key" to "Terminal." When "F/R-SW" is set to "Terminal," the drive will not respond to the Forward and Reverse keys on the keypad, but the Stop key can still be used to stop the drive. To control the speed of the drive using a speed potentiometer or reference signal connected to the terminal block, the Monitor Mode parameter, "F-SET-M" must be changed from "Ope.-Key" to "Terminal." When "F-SET-M" is set to "Terminal," the Increase and Decrease keys on the keypad can not be used to change the frequency setting, "FS." Table 3-3 provides a step by step description of the procedure for switching between keypad operator control and terminal block (operator station) control. This procedure can be performed only when the drive is stopped.

Eaton's Dynamatic Industrial Drives Catalog lists several operator stations that can be purchased for use with the AF-1500. To install any of these, follow the directions furnished with the operator station.

Figures 3-3 and 3-8 show typical connections for operator control devices. The following paragraphs describe the essential requirements for operator control functions. Tables 3-6, 3-7 and 3-8 and Figures 3-15 and 3-16 briefly describe all of the control circuit inputs and outputs.

Use shielded cable where indicated on the connection diagram (Figure 3-3). Figure 3-6 shows how to correctly terminate and ground the shield. Potentiometer leads and other signal leads should be always shielded. If the distance from the AF-1500 to the operator station exceeds 75 feet, all control circuit wiring should be shielded.



Shield Processing ——————————————— Figure 3-6

RUN/STOP CONTROL

External Run/Stop control requires that a maintained contact switch connected between terminal L (circuit common) and either terminal FW (run forward) or terminal RV (run reverse). The AF-1500 can not directly utilize momentary contact run and stop pushbuttons. Figure 3-3 shows typical run/stop and forward/reverse switch connections.

Switching Between Keypad Operator Control and Remote Operator Station (Terminal Block) Control — Table 3-3

Step	Key Operation	Display	Explanation
1	Function then Monitor	Any Display then FM 000.0 Hz	Jumps to the first line of the Monitor Mode display.
2	Increase ∧ (press twice)	F-SET-M Ope.-Key or F-SET-M Terminal	Steps to the function for selecting the Frequency SETting Method. "Ope.-Key" indicates keypad control. "Terminal" indicates terminal block control (Potentiometer or external signal input).
3	Cursor >	F-SET-M Ope.-Key or F-SET-M Terminal	Moves the cursor (underscore) under the first letter of the word "Ope.-Key" or "Terminal" so that a new selection can be made.
4	Increase ∧ or Decrease ∨	F-SET-M Terminal or F-SET-M Ope.-Key	Changes selection from "Ope.-Key" to "Terminal" and vice versa.
5	Cursor >	F-SET-M Terminal or F-SET-M Ope.-Key	Moves the cursor back to the "home" position so that the Increase and Decrease keys can be used to step to another function.
6	Increase ∧	F/R SW Ope.-Key or F/R SW Terminal	Steps to the function for selecting the Forward and Reverse SWitching method. "Ope.-Key" indicates keypad control. "Terminal" indicates terminal block control (Forward/Reverse and Run/Stop switches).
7	Cursor >	F/R SW Ope.-Key or F/R SW Terminal	Moves the cursor under the first letter of the word "Ope.-Key" or "Terminal" so that a new selection can be made.
8	Increase ∧ or Decrease ∨	F/R SW Terminal or F/R SW Ope.-Key	Changes selection from "Ope.-Key" to "Terminal" and vice versa.
9	Cursor >	F/R SW Terminal or F/R SW Ope.-Key	Moves the cursor back to the "home" position so that the Increase and Decrease keys can be used to step to another function.

RESETTING FAULTS

Faults can not be reset using the keypad. One of the following methods must be used to reset the drive after a fault shutdown:

a. Remove and reapply power
b. Push the white reset button inside the drive on the lower left corner of the PCB.
c. Use a reset pushbutton wired between terminal RS and terminal L.

Figure 3-3 shows a 3 position Run-Stop-Reset switch with spring return to the Stop position from the Reset position. This is the configuration supplied on the NEMA 1 operator stations listed in the Industrial Drives Catalog. A separate normally open momentary contact Reset pushbutton is supplied on the NEMA 12 operator station listed in the catalog.

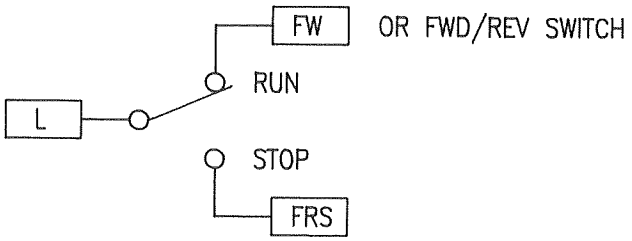
After a fault, when the reset terminal (RS) is grounded, the fault relay pulls in, the fault message remains on the display, and the keypad is disabled. After grounding, when the RS connection is released, the display changes to "[redacted]," then shows the EPROM part number "B00nnn," and finally shows "FM 000.0 Hz" indicating that the drive is reset. If the FW or RV terminal is grounded when the drive is reset, the drive immediately restarts.

The RS terminal should not be wired to a contact that remains closed when the drive is stopped. The keypad is locked and the drive can not be adjusted when terminal RS is grounded. If RS is grounded when power is first applied to the drive, the display will show eight boxes ([redacted]) until RS is disconnected. If the drive is reset after setting changes have been made but before power has been turned off, the new settings will be erased when the power is turned off. To avoid losing settings, turn the power off immediately after completing the setting changes.

COAST STOP

The standard stopping sequence for the AF-1500 is ramp to stop. When the stop key is pressed or when the switch or relay control connection to terminal FW or RV releases the connection to ground (terminal L), the drive first decelerates to the stop frequency (F-04 Fmin) and then the motor is deenergized.

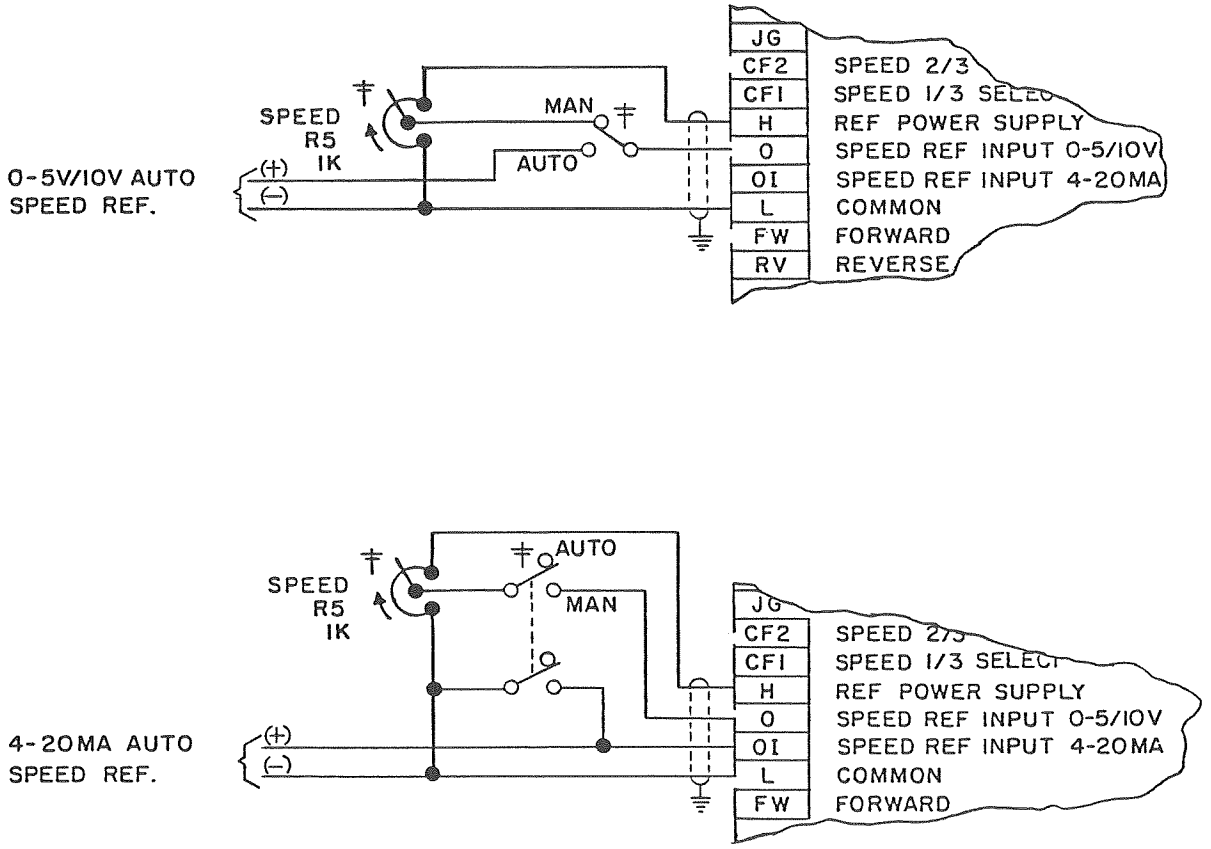
The drive can be forced to coast to a stop using the FRS terminal as shown in Figure 3-7. The drive may start to ramp down before coasting due to a 100 ms delay in the drive's response to the FRS input. If this delay causes difficulty, a time delay relay can be used to momentarily ground terminal RS to force a coast stop. Refer to publication 053-4037, "AF-1500 System Design Guide," for additional information.



Coast Stop Connections ——— Figure 3-7

FREQUENCY OR SPEED SETTING (TERMINAL "O" OR "OI")

Figure 3-3 shows the connections for a Speed setting potentiometer. Figure 3-8 shows typical connections for a Manual Speed potentiometer, a manual/automatic switch and a 4 to 20 mA, 0 to 5 V or 0 to 10 V automatic speed control signal. Note that there is no means for using the keypad to switch between the potentiometer or voltage signal input (terminal O) and the 4 to 20 mA signal input (terminal OI). A selector switch is required if input signals must be connected to both terminals O and OI. If inputs are applied to both the voltage reference terminal O and the current reference terminal OI, the drive will run at a speed corresponding to the sum of the references. With reference summing, 4 ma is summed as zero and 20 ma as 100%. The drive does not respond to negative reference voltages or currents except that a negative reference voltage input subtracts from a positive reference current input.



ED-60521-1/B

Connection Diagram For
Manual/Automatic Speed Selection ——————— Figure 3-8

SELECTION OF PRESET SPEEDS BY CONTACT CLOSURE

Terminals CF1 and CF2 are used to select speeds that are set using Function Mode Parameters F-12 Speed-1, F-13 Speed-2 and F-14 Speed-3. Grounding Terminal CF1 and/or CF2 will override the keypad "FS" setting or the external frequency command signal connected to terminal "O" or "OI" and forces the drive to operate at the preset speeds as shown in Table 3-4. If a F-SET-M is set to Terminal but a potentiometer or speed reference signal is not connected to terminals O or OI, two additional preset speeds can be selected using a contact connected between terminals H and O as shown in Table 3-5.

Three Preset Speeds — Table 3-4

Contact Closures CF1 to L	Contact Closures CF2 to L	Resulting Output Frequency Control Method or Setpoint
Open	Open	Frequency set by keypad operator control FS or by terminal block input O or OI.
Closed	Open	Frequency set by Speed-1
Open	Closed	Frequency set by Speed-2
Closed	Closed	Frequency set by Speed-3

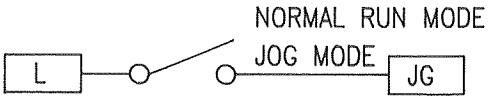
Two Additional Preset Speeds — Table 3-5

Contact Closures H to O	Contact Closures CF1 to L and CF2 to L	Resulting Output Frequency Control Method or Setpoint
Open	Open	Frequency set by F-06 L-LIM-F
Closed	Open	Frequency set by F-05 H-LIM-F

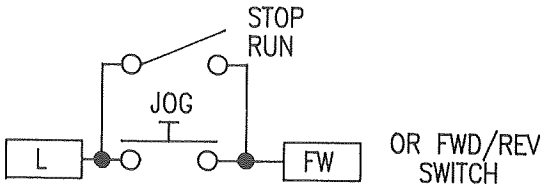
JOG

Grounding the Jog terminal (JG) activates the jog function but does not start the drive. While a Forward or Reverse command is maintained, the drive runs at the jogging frequency. Acceleration is set to the fastest rate; the adjustable accel rate is not in effect. When the Run command is released, the drive coasts to a stop. Controlled deceleration and DC braking are not in effect. It is not possible to make a running transition from jog to run. If the JG terminal is released before the Run command is released, the drive stops. The FW/RV terminal must be released and then grounded in order to restart the drive. If the JG terminal is grounded while the drive is running, the drive ramps to the jog speed. If the JG terminal is then released, the drive ramps to the run speed.

There is no means of selecting the Jog function using only the keypad. The drive can be jogged from the keypad, but the Jog mode must first be selected using a separate selector switch as shown in figure 3-9. Once the Jog mode has been selected, the drive will run at the Jog speed as long as the Forward or Reverse key is held depressed. When the key is released, the drive will coast to a stop. The Jog speed can be adjusted between 0.5 to 9.9 Hz using the Monitor Mode parameter, "Jogging 0.5 Hz."



Jog Mode Selector Switch
Figure 3-9

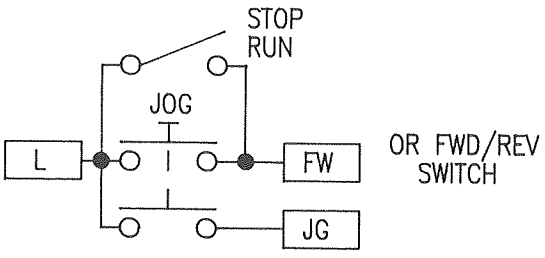


Jog Pushbutton
Figure 3-10

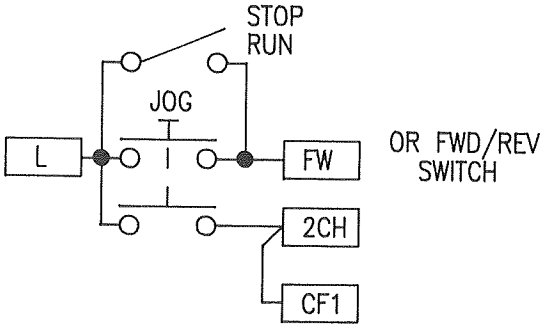
If terminal block Run/Stop control (F/R-SW Terminal) is selected, the drive can be jogged by connecting a Jog pushbutton in parallel with the Run/Stop switch as shown in Figure 3-10. Once the Jog mode has been selected, the drive responds to the Jog in the manner described above with reference to the keypad.

If the Jog Mode selector switch is opened while the drive is running, the drive will stop. In order to restart the drive, it is necessary to open and reclose the Run/Stop switch and/or the Jog button. If the Jog mode selector switch is closed while the drive is running, the drive speed will change to the Jog speed. Once the drive is running in the Normal Run Mode, the drive can be freely switched back and forth between the Run speed and the Jog speed using the Jog Mode selector switch.

The drive can be jogged at run speed simply by using the Jog button without selecting the Jog Mode. In this case, the drive will accelerate toward the set frequency (FS) as long as the Jog button is held depressed. Ramp-to-stop will be in effect and DC braking will be in effect if enabled using F-28 SWITCH1. The Jog Mode can be selected using a contact on the Jog pushbutton as shown in Figure 3-11, but Jog operation may be slightly delayed due to the time required for the drive to recognize the input to terminal JG and switch to the Jog Mode.



Pushbutton Selection of Jog Mode
Figure 3-11



Jog with 2CH and CF1 Connection
Figure 3-12

Figure 3-12 shows the use of terminals 2CH and CF1 to implement Jog with adjustments F-12 Speed-1, F-18 Accel-2, and F-19 Decel-2. With this implementation, ramp-to-stop is in effect and DC braking is available. If the Jog button is pushed while the drive is running, the drive speed will change to Speed-1 at accel/decel rate 2. With DC braking enabled, when the Jog button is released and then immediately pressed again, the drive will not restart until the DC braking time (F-22 T-DCB) has expired.

UNATTENDED START PROTECTION

The AF-1500 is equipped with unattended start protection to prevent the drive from starting automatically upon application of input power or upon restoration of power after a power interruption.

If keypad run/stop control is selected (F/R-SW Ope.-Key), the momentary contact Forward, Reverse, and Stop keys are used to start and stop the drive. Unattended start protection is always in effect in this mode of operation.

If terminal run/stop control is selected (F/R-SW Terminal), the drive is controlled by maintained contact switches connected to the FW and RV terminals (refer to the connection diagram). If one of these switches is closed prior to applying power to the drive, the drive will not start upon application of power but will display: ?ERROR USP. To start the drive, the operator must turn the switch OFF and then ON or press the Reset button connected to the RS terminal. In the event of a momentary loss of power, the drive may display ?ERROR UNDER V. or ?ERROR INST.P-F. In these cases, it is necessary to press the Reset button twice to restart the drive.

> **WARNING:** The automatic start and automatic restart modifications automatically start or restart the drive without warning and without requiring operating personnel to reiniate the start sequence. These modifications must be applied only to machinery with all moving parts completely inaccessible to personnel.

AUTOMATIC START UPON APPLICATION OF POWER

In some applications, the user may want to configure the drive to start automatically upon application of input power. To do this, it is necessary to delay the run command by about 1/2 second after power is applied to the drive. Terminal TD on the auxiliary PCB is provided for this purpose. To provide automatic restart upon application of power, connect the Run/Stop switch to terminal TD instead of terminal L. Figure 3-13 shows the automatic start connections. Note that terminal TD is not provided in revision B of the auxiliary PCB (1A-USP B). Refer to the appendix for instructions on implementing automatic restart on drives not furnished with the 1A-USP PCB, revision C or later.

In the configuration described above, with the run/stop switch closed, the drive will start automatically upon application of input power. The drive will also automatically restart upon restoration of power after a power interruption. In the event of a momentary loss of power, the drive will display ?ERROR UNDER V. and will not restart unless it is programmed to restart automatically after a fault.

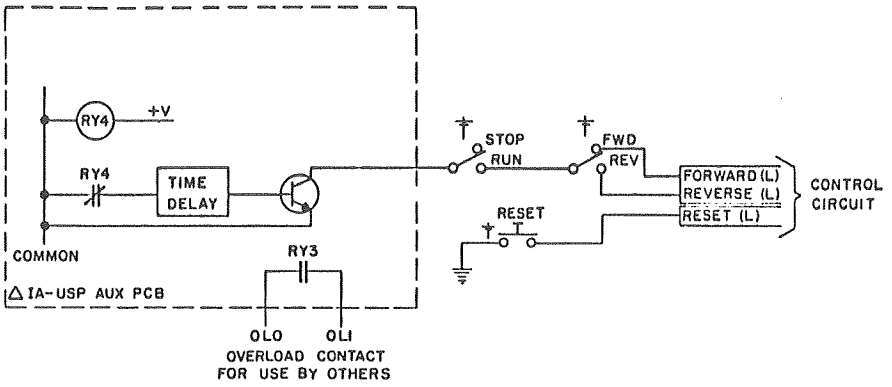
AUTOMATIC RESTART AFTER FAULT

The drive can be programmed to restart automatically after a fault using position 2 of Function F-28 SWITCH1. Refer to Tables 5-4 and 5-6. If automatic restart is selected, the drive will make three attempts to restart after a fault. If the drive successfully restarts, the attempt counter will reset to zero after 10 minutes. If the drive does not successfully restart, a fault diagnostic message will be displayed after the third attempt. In attempting to restart after

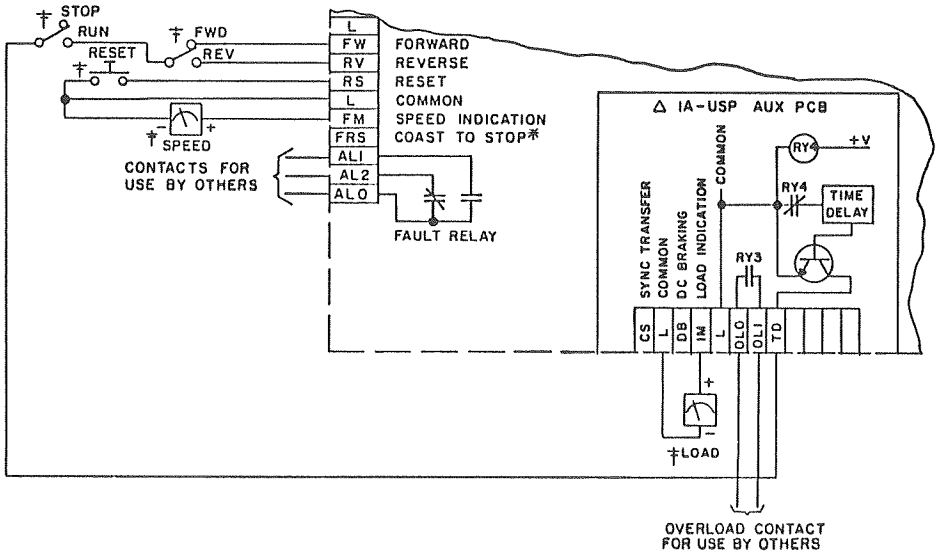
a fault, the drive attempts to synchronize with the spinning motor. Under some operating conditions, motor synchronization is not possible; in this case, the drive restarts at the start frequency after a time delay set by F-36 IPS-R-T.

For restarting after an instantaneous power interruption, there are two methods of executing automatic restart which can be selected by settings of F-28 SWITCH1, position 2. With setting 01, the drive attempts to restart the motor without allowing it to coast to a stop. With setting 11, after the time delay F-36 IPS-R-T, the drive restarts at the start frequency and ramps to set frequency. The time delay F-33 IPS-T sets the instantaneous power interruption time that the drive will accept for a restart.

SCHEMATIC



WIRING CONNECTIONS



ED-60521-1/B

Connection Diagram For
Automatic Start Upon Application Of Power

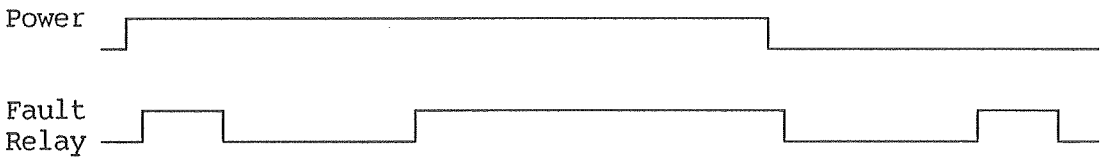
Figure 3-13

Output Signals And Contact Closures

READY/FAULT RELAY

The Ready/Fault relay pulls in automatically when power is applied to the drive unless a fault is present. If a fault is present, a fault message will be displayed. Any previous fault information was lost when power was turned off.

The relay pulls in about 50 ms after power is applied. After about 240 ms, the relay drops out for about 560 ms and then pulls in again. This is a peculiarity of the power up sequence. See Figure 3-14.



Fault Relay Operating Sequence ——— Figure 3-14

The fault relay does not drop out again while power is applied to the drive unless the drive shuts down due to a fault. When power is turned off, the relay drops out, pulls in for a short time and then drops out again -- the reverse of the power up sequence. The relay out-in-out sequence does not occur when power is shut off if F-28 SWITCH1 is set for automatic restart.

The fault relay is unaffected by normal start/stop operation. There is no way to force a fault shutdown. Grounding the RS or the FRS terminal while running will stop the drive, but the fault relay will not drop out and the drive will restart when the connection is broken unless keypad start/stop is in effect (F/R-SW Terminal).

OVERLOAD WARNING RELAY

The overload warning relay, RY3, simply provides a relay contact for customer use. It is completely independent of the drive's protective circuitry. It pulls in when the drive's output current is above the F-31 OLalarm setting -- 100 to 150% of the drive's nameplate current -- and drops out when the output current is below that setting. The F-31 setting has no affect on any other operating or protective function. The function and circuitry driving RY3 will not shut down the drive.

With revision B of the auxiliary PCB (1A-USP B), RY3 can be forced to function the same as the fault relay by installing jumpers as described in the appendix. This arrangement is provided to allow automatic start upon application of power and still provide a fault relay function. Revision C of the 1A-USP AUX PCB makes this arrangement unnecessary.

DRIVE RUNNING OUTPUT (RUN-COM)

The drive running output is an open collector transistor wired to the terminal block. The transistor is on when the drive is running. On stopping, it turns off at the end of the decel ramp after the DC braking timer times out. If the drive stops due to a fault or due to grounding RS or FRS, the run transistor turns off immediately.

FREQUENCY ARRIVAL OUTPUT (AR-COM)

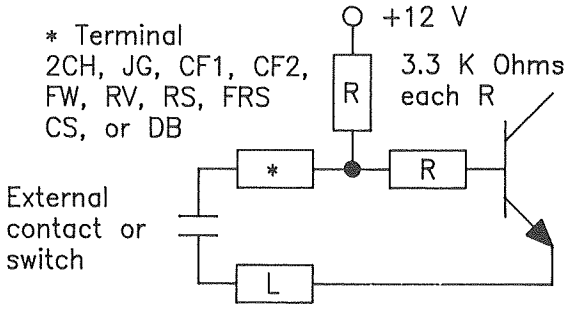
The frequency arrival output is an open collector transistor wired to the terminal block. It could also be called "at setpoint," "ramp complete," or "up to speed." It is on when the drive is running at the set speed (FM=FS).

FREQUENCY METER SIGNAL

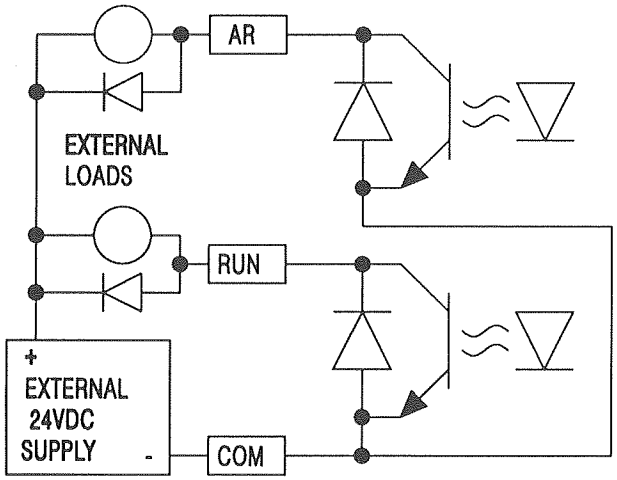
This signal can be selected by the function key to be either a pulse width modulated signal for an analog meter or a square wave signal for a frequency counter. Function F-28 SWITCH1 is used to make the selection. (See Table 5-6.)

The square wave signal frequency is equal to the drive's output frequency. The signal amplitude is approximately 10 volts. The duty cycle is approximately 50% (on time equals off time).

The PWM signal frequency is approximately 90 Hz. The signal amplitude is 10 volts when the "M ADJ" potentiometer is properly adjusted. The load resistance must be between 10kΩ and 22kΩ (1 mA maximum load current). The on time vs off time is modulated so that the average voltage is 0 to 10 volts proportional to 0 to 100% of drive output frequency. Analog dc meters indicate the signal accurately, but electronic meters do not. The PWM signal is not suitable for use as a speed reference signal for tach follower type cascade systems. It is not suitable for use as an input to a process control computer or a PLC.



Logic L/H Input Circuit Diagram ——— Figure 3-15



Open Collector Output Circuit Diagram ——— Figure 3-16

Note:
To suppress voltage transients, diodes must be connected as shown, in parallel with external inductive loads.

Control Connections for the Main PCB I/O — Table 3-6

Terminal	Type	Functional Description
2CH	I,L	Selects preset Accel/Decel rates "ACCEL 2" and "DECEL 2."
AR	O,C	"Drive Running at Set Speed" or "Accel/Decel Ramp Complete."
RUN	O,C	"Drive Running."
COM	O,E	AR/RUN Common emitter connection.
JG	I,L	Selects Jog function and speed(input FW or RV must be closed after closing JG to jog the drive).
CF2	I,L	Selects preset speed "SPEED 2" } Both together select "SPEED 3." When neither input is selected, "FS" or inputs "O" & "OI" control speed.
CF1	I,L	Selects preset speed "SPEED 1" }
H	PS	Speed pot supply voltage; 10 volts, 20 mA maximum.
O	I,A	Speed reference voltage input; 0 to 5 Vdc into 15K ohms or 0 to 10 Vdc into 30K ohms.
OI	I,A	Speed reference current input; 4 to 20 mA dc into 250 ohms.
L	Com	Logic circuit common; common connection for all inputs and for analog outputs.
FW	I,L	"Run Forward."
RV	I,L	"Run Reverse."
RS	I,L	"Reset" (motor will coast if input is closed while running).
L	Com	Logic circuit common; common connection for all inputs and for analog outputs.
FM	O,S	Frequency meter signal; Select with function mode F-28: 1. Square wave; 10 volt amplitude; frequency equal to output frequency; 50% duty cycle; or 2. Square wave; 10 volt amplitude; 90 Hz; duty cycle modulated for a 0 to 10 volt, 1 mA analog meter.
FRS	I,L	"Free Run Stop" (motor will coast while the input is closed).
AL1	O,R	Fault Alarm Relay NO Contact.
AL2	O,R	Fault Alarm Relay NC Contact.
AL0	O,R	Fault Alarm Relay Common.

Control Connections for the Optional IA-USP Aux PCB I/O — Table 3-7

Aux PCB Terminal	I/O Type	Functional Description
CS	I,L	Synchronized motor transfer command. (See publication 053-4037, "AF-1500 System Design Guide.")
L	Com	Logic circuit common for all inputs and analog outputs.
DB	I,L	Dc Braking control input. (See publication 053-4037, "AF-1500 System Design Guide.")
IM	O,A	Motor ammeter signal; 0 to 6 Vdc = 0 to 150% current.
L	Com	Logic circuit common for all inputs and analog outputs.
OL0	O,R	Overload Warning Relay, (RY3) NO contact (See F-31, Table 5-4)
OL1	O,R	Overload Warning Relay, (RY3) NO contact (See F-31, Table 5-4)
TD	O,S	Grounded after a time delay on power up. See schematic and connection diagrams.

Explanation of I/O Type Designations — Table 3-8

Type	Description
I,L	Input: Low (shorted to terminal L; 0 to 0.3 V is approximately 3.5 mA) for the function indicated.
I,H	Input: High (open; 2.4 to 12 V) for the function indicated.
I,A	Input: Analog signal proportional to the function indicated.
I,S	Input: Special (See detailed description and schematic diagrams).
O,A	Output: Analog signal proportional to the function indicated.
O,R	Output: Relay contacts rated: 250 Vac, 2.5 A resistive, 0.2 A inductive (0.4 pf) 30 Vdc, 3.0 A resistive, 0.7 A inductive
O,C	Output: Transistor open collector, 27 V, 50 mA maximum, forward voltage drop approximately 1 V, leakage <1μA.
O,E	Output: Transistor emitter connection.
O,S	Output: Special (See detailed description and schematic diagrams).
PS	Power supply.

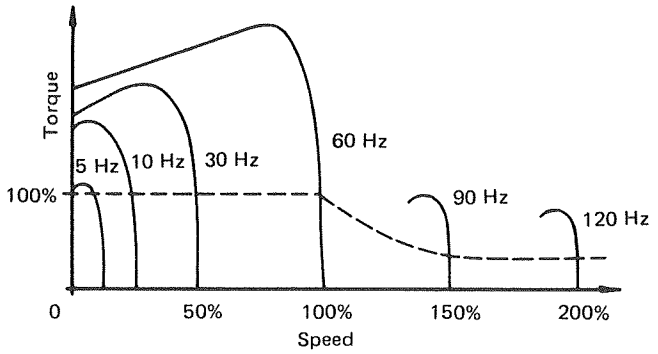
SECTION 4

MODEL AF-1500 INVERTER OPERATION

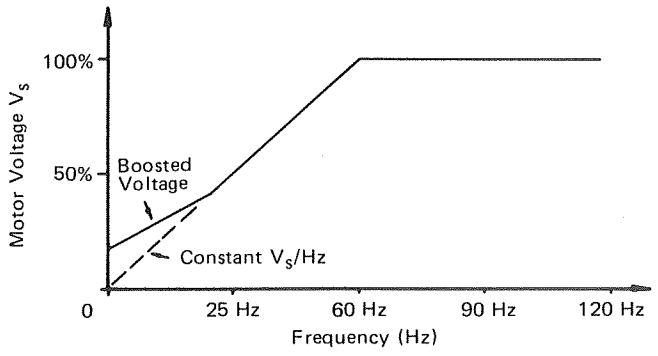
General Description

The synchronous speed (N) of a three phase induction motor is determined by the number of poles (P) and the frequency (F) of the applied voltage: $N = 120F/P$.

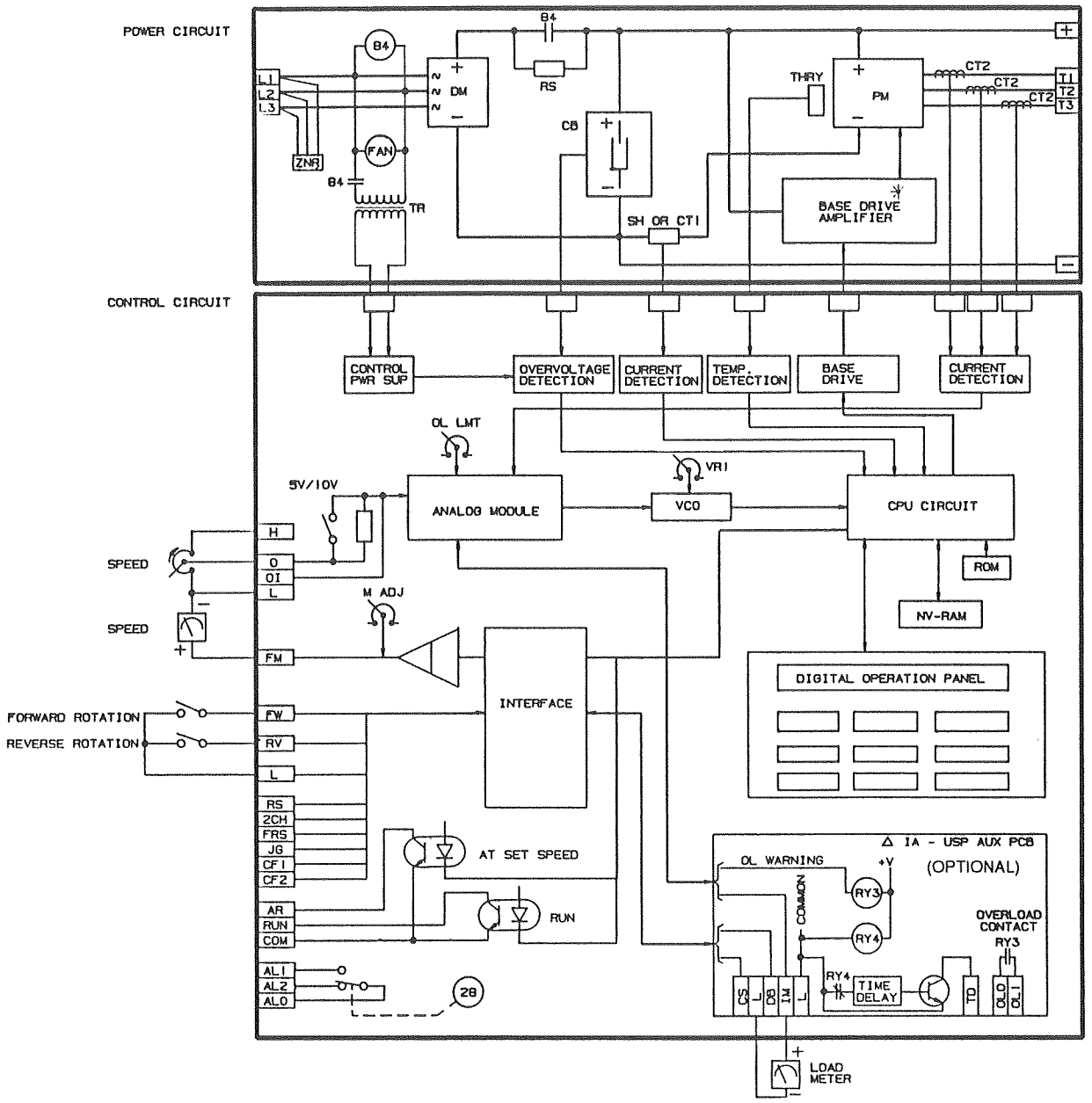
For variable speed, it is necessary to change the frequency of the applied voltage; it is also necessary, however, to reduce the applied voltage proportionally in order to maintain constant flux and avoid motor saturation. Figures 4-1 and 4-2 show the relationship between frequency and applied voltage. "Boost" is required to maintain rated torque at low frequency. Figure 4-3 illustrates the basic block diagram of the Model AF-1500 inverter.



Typical Torque/Speed Characteristic With Standard Motor — Figure 4-1



Relationship Between Motor Frequency and Voltage — Figure 4-2



NOTE:

* Revision C of the 1A-USP Aux PCB is shown in this diagram. Revision B of this PCB is shown in Figure 8-1 in the Appendix.

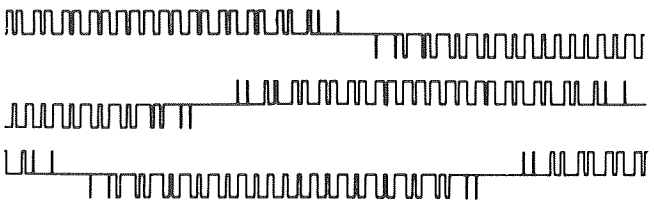
** Refer to Figure 2-2 for additional notes.

ED-60521-3/A

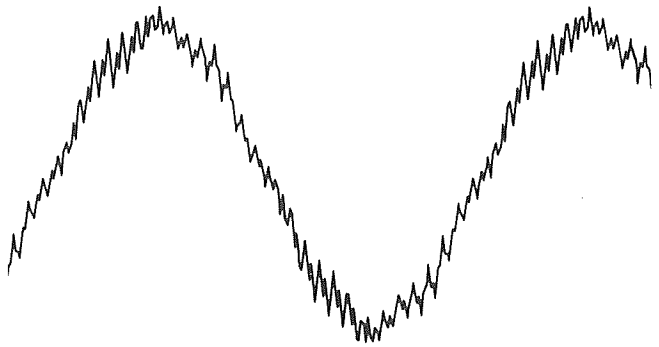
Inverter Block Diagram Figure 4-3

The input power is rectified by a three phase bridge, which is then filtered by bus capacitors CB. Upon initial application of power, these capacitors are charged through RS, which is shorted out by relay 84, after a time delay. The voltage across the dc bus is approximately 350 Vdc (230 Vac units) or 700 Vdc (460 Vac units). Bus voltage is then supplied to the output transistor module. The bus currents and voltage are monitored and by the electronic control circuits.

The output transistors are switched in such a way that each output line voltage is as shown in Figure 4-4. This results in a motor line current as shown in Figure 4-5, with the ripple being limited by the motor inductance. There are back diodes across each transistor to provide paths for the reverse inductive currents. Hence, when the inverter is running at low power factor (light load), the current drawn by the dc bus is low, due to the current return by these diodes. Also, as frequency is reduced the motor will regenerate into the dc bus. When this happens, the dc bus voltage will rise and the inverter may trip off (dependent on decel rate and load inertia). The base drive signals for the power transistors and the current and voltage feedback are isolated from the control circuitry on the circuit board. PWM waveforms are generated by the microprocessor based circuits in response to the reference, feedback and parameters programmed into the memory. The trip circuits operate by inhibiting the inverter and generating OFF pulses to the appropriate transistors. The inverter is also inhibited at power up for 0.3 seconds.



Motor Line to Line Voltage Waveforms at 30 Hz Figure 4-4

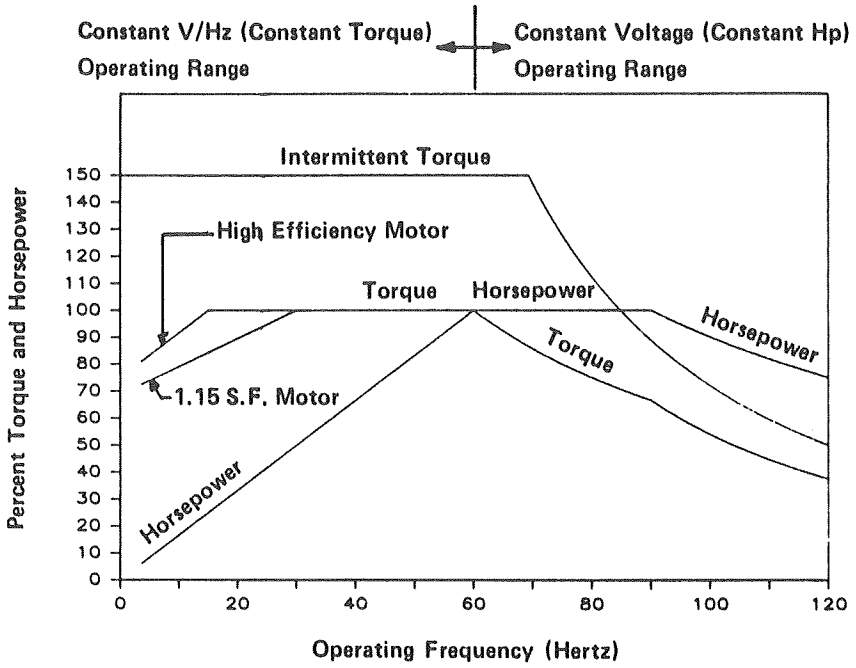


Motor Current Waveform at 30 Hz Figure 4-5

Restrictions Due to Motor/Inverter Characteristics

When the speed of a standard induction motor is reduced, fan speed, and therefore motor cooling, is reduced. Additionally, motor losses are also slightly increased due to inverter harmonics which do not contribute to torque. These factors result in restrictions in continuous operation at full rated torque at less than top speed. Figure 4-6 shows typical continuous torques available when using a standard induction motor. It may be necessary to provide motor protection such as thermal relays, etc. The Model AF-1500 also has an adjustable electronic overload trip circuit for this purpose. It is possible to use a motor of larger frame size than the rating of the inverter; however, it is important to check that it is compatible with the inverter current rating. Due to the lower inductance of the larger motor, higher ripple currents may require

derating. As a general rule, if the next frame size larger than the rated motor is used, derate the inverter output current to 90%. For more precise information on the motor ratings, consult the factory.



Motor Derating at Reduced Speed Figure 4-6

Refer to publication 053-4037, "AF-1500 System Design Guide," for additional application information.

SECTION 5

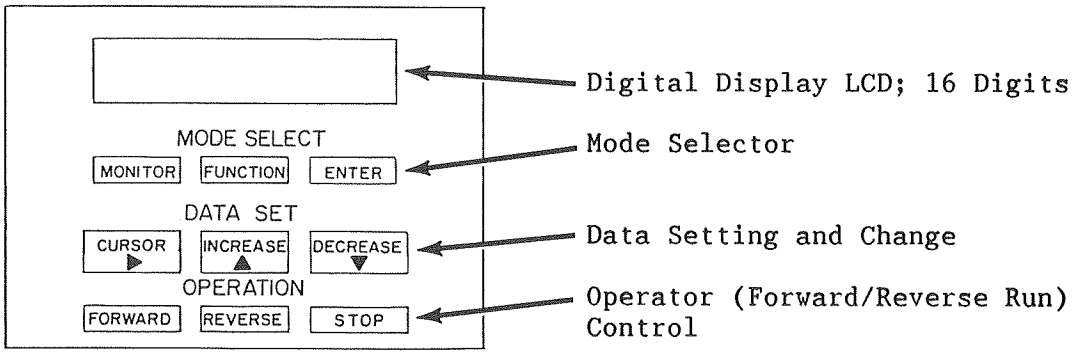
START UP AND ADJUSTMENT

WARNING: Equipment is at line voltage when ac power is connected to the input terminals. All ungrounded conductors of the ac power line must be disconnected before it is safe to touch any internal parts of this equipment. After power is removed, use a voltmeter at dc bus terminals marked + and - to verify that the dc bus capacitors are discharged before touching any internal parts of the equipment. Failure to observe these precautions could result in fatal injury.

Configuration of Digital Operation Panel

Figure 5-1 is an illustration of the digital operation panel (keypad). This panel provides a quick, convenient, and accurate method for adjusting, monitoring, and controlling drive functions. Table 5-1 describes the function of each key. Review this table carefully to learn how to use the keypad.

The AF-1500 drive may be used with keypad Run/Stop and Frequency control; with external switches and Frequency potentiometer; or with any combination of these methods. Refer to Section 3 of this manual for additional information regarding operator control and control wiring connections.



Digital Operation Panel Figure 5-1

Precautions After Changing Data

When parameters are changed in the Monitor or Function Modes, the new data is stored only in temporary memory until the power is turned off. When the power is turned off, the data will be stored in the non-volatile RAM memory so that it will be recalled when the unit is turned on again. If the drive is reset after changes have been made but before power has been turned off, the new settings will be erased when the power is turned off. To avoid losing settings, turn the power off immediately after completing the setting changes. The operational life time for the non-volatile RAM memory element will be approximately ten years if power is not turned on and off more often than several times per day.

Keypad Function Descriptions Table 5-1

Key	Description of Function
Monitor	The Monitor key sets the keypad/display to the Monitor Mode. The drive must be in the Monitor Mode to run. Table 5-2 lists the ten items which can be displayed and/or changed when the display is in the monitor mode. Repeated pressing of the Monitor key steps the display through the ten item list.
Function	The Function key sets the keypad/display to the Function Mode. The Function Mode is used to perform setup adjustments. Table 5-4 lists the thirty one items which can be displayed and/or changed when the display is in the Function Mode. Each time the Function key is pressed, the display toggles back and forth between the function identification and the function data display.
Enter	The Enter key is used to enter a change made to a parameter in the Function Mode. An asterisk (*) appears when a change has been made but not entered. When the Enter key is pressed, the cursor returns to the leftmost position. The Enter key is used only in the Function Mode. Changes made in the Monitor Mode take effect immediately. The Cursor key is used to return the cursor key to the leftmost position.
Cursor	The Cursor key moves the cursor across the display line. The cursor is an underscore that appears under one character of the display line. The cursor may be difficult to see if the display is viewed at an angle above the display. When he cursor is under the leftmost character, the Increase and Decrease keys scroll the display up and down the item list. When the cursor is under a digit or character in the middle of the display line, the Increase and Decrease keys change the digit, character or word. The cursor moves only to the right. When the right hand limit is reached, it wraps around to the leftmost character.
Increase and Decrease	These keys are used in conjunction with the Cursor key to change the display as described above. An exclamation point (!) appears when the limit of adjustment is reached.
Forward and Reverse	When keypad forward/reverse operation is enabled, pressing the Forward or Reverse key starts the drive in the direction indicated or initiates a change in operating direction. When the drive is started, the motor is energized at minimum frequency (Fmin) and proceeds to set frequency (FS) under the control of the acceleration ramp. When a direction change is initiated, the motor decelerates to Fmin under control of the deceleration ramp, reverses and reaccelerates back to FS again under the control of the acceleration ramp.
Stop	Pressing the Stop key stops the drive. When the Stop key is pressed, the motor decelerates to the minimum frequency Fmin under the control of the deceleration ramp and is then deenergized. If keypad forward/reverse operation is not enabled, the external forward or reverse contact must be opened and reclosed to restart the drive.

Monitor Mode Display Parameters

Table 5-2 provides a brief description for each display parameter in the Monitor Mode. Table 5-1 describes the procedure for using the keypad to adjust the parameters. A step by step example is provided inside the front cover of this manual. When power is first applied to the AF-1500, the display is automatically set to the first item in the Monitor Mode unless there is some problem with the drive in which case, refer to Section 6. You can always return to the first item in the Monitor Mode by pressing the Function key and then the Monitor key.

Detailed adjustment information is provided later in this section of the manual.

Description of Monitor Mode Display Parameters — Table 5-2

Item	Display (Defaults shown)	Description and Adjustment Range
1	FM 000.0 Hz	Motor Frequency (Inverter output frequency) Display only
1	FM▒> F030.0 Hz (Display for) (Drive Running)	When the drive is running, frequency is displayed and a bar graph indicates percent of max frequency. ▒ indicates each 20% increment and > indicates 10%. F or R indicates forward or reverse operation.
2	FS 000.0 Hz	Set Frequency -- .1, 1, 10, & 100 Hz steps within limits set in function mode. A bar graph indicates set frequency as % of max. ▒ indicates each 20% increment and > indicates 10%. When the drive is running, F or R indicates direction of operation.
3	F-SET-M Ope.-Key	Frequency Setting Method; Operator keypad or Terminal block input. Changeable only when drive is not running.
4	F/R-SW Ope.-Key	Forward and Reverse Run Command Method; Operator keypad or Terminal block input. Changeable only when drive is not running.
5	RPM 4P 00000rpm	Motor Speed. Enter the number of motor poles.
6	IF-----A Im000.0%	IF = Rated Output Current Im = Indicated Output Current Leave IF blank for Im readout in %; fill in drive nameplate current for Im readout in amps.
7	V-Boost Code<31>	Voltage Boost Setting Code -- 0 to 99 (99 = approximately 18% boost.)
8	V-Gain 100%	Voltage Gain Setting (V/Hz) -- 50 to 100%, 1% steps (See Fig. 5-2.)
9	Jogging 01.0 Hz	Jogging Frequency -- 0.5 to 9.9 Hz; 0.1 Hz steps
10	#	Fault Diagnostic Message -- See section 6.

Function Mode Adjustments

Table 5-4 provides a brief description for each display parameter in the Function Mode. Table 5-1 describes the procedure for using the keypad to adjust the parameters. Table 5-3 provides a step by step example for making an adjustment in the Function Mode. You can always return to the first item in the Function Mode by pressing the Monitor key and then the Function key.

The second column of Table 5-4 shows the Function Identification Display which lists the parameter number (address) and title, such as F-01 ACCEL-1. The third column of Table 5-4 shows the Function Adjustment Display which lists the parameter title and value. Each time the Function key is pressed, the display toggles back and forth between the Function Identification Display and the Function Data Display. When the cursor is in the leftmost position, the Increase and Decrease keys can be used to step up and down either column.

To change the given parameter in the Function Mode, the Adjustment Display must be selected. The AF-1500 must also be in the "Stop" condition. The "Stop" condition is described as any of the following:

1. The condition immediately after power is turned ON.
2. The condition after which the Stop key has been pressed during operation.
3. The conditions in which the inverter is stopped by open switch contacts between terminals FW-L or RV-L.
4. The conditions in which the inverter is stopped by closed contacts between terminals RS-L or FRS-L.

After each Function mode data change, press the Enter button to change memory. If this step is neglected, the previous data remains and the changes will be lost. It is not possible to operate the drive in the Function mode; so after the changes have been "Entered," exit by going to the Monitor mode.

I/O Signal Functions

Some of the adjustments are related to Input/Output Signal Functions. The description and electrical characteristics of basic input and output signals are located in Section 3.

PCB Adjustments

There are only two user trim pot adjustments on the circuit board along with four DIP switches and a reset button. The adjustments are listed in Table 5-7. All other functional settings are made with the keypad.

Detailed adjustment information is provided later in this section of the manual.

Function Mode Operating Procedure (Example) Table 5-3

Step	Operation	Key	Description
1	Press the Function key	Function	Enter the Function Mode -- Function identification display
2	Press the Increase or Decrease Key	Increase or Decrease	Step the display to the Function that you wish to program or adjust.
3	Press the function key again.	Function	Change the display to the Function Data display.
4	Press the cursor key	Cursor	Position the cursor under the digit of the data that you wish to change.
5	Press the Increase or Decrease key	Increase or Decrease	Change the digit to the desired value.
6	Repeat steps 4 and 5 as required.		Change all digits of the data as required.
7			An exclamation point appears at the center of the display if you attempt to change the data outside of the adjustment range.
8	Press the Enter key	Enter	Enter the data change. An asteric appears at the center of the display when the data has been changed but the change has not been entered. If you leave the display of a particular function without entering the change, the data returns to the previous value.
9	Press the Increase or Decrease key.	Increase or Decrease	Step to the next Function that you wish to adjust. You can step through the Function display in either the function identification display or the function data display. Each time the Function key is pressed, the display toggles between the two display modes.
10	Press the Monitor key.	Monitor	Return to the monitor mode after all adjustments are made. The drive must be in the monitor mode in order to start the motor.

Detailed Description of Function Mode

Table 5-4

Item	ID Display	Adj. Display (Defaults shown)	Description and Adjustment Range
1	F-00 VFE-VC	VFE-VC 060-060	Selects base frequency and maximum frequency; and selects constant V/Hz or economy curve reduced V/Hz for variable torque. (See Fig. 5-2.)
2	F-01 ACCEL-1	ACCEL-1 0030.0 S	Time for acceleration from minimum to maximum frequency. Linear accel: 0.1 to 2999.9 sec; S curve: 0.1 to 230 sec
3	F-02 DECEL-1	DECEL-1 0030.0 S	Time for deceleration from maximum to minimum frequency. Linear decel: 0.1 to 2999.9 sec; S curve: 0.1 to 230 sec
4	F-03 +Fmax.	+Fmax. 000.0 Hz	Extended frequency adjustment for operation above maximum frequency. 0.0 to 15.0 Hz extension. (See Fig. 5-2.)
5	F-04 Fmin.	Fmin. 000.5 Hz	Starting frequency adjustment -- 0.5 to 5.0 Hz (See Fig. 5-3.)
6	F-05 H-LIM-F	H-LIM-F 000.0 Hz	Maximum frequency limit (clamp) -- 0.0 to 135.0 Hz (must be > L-LIM)
7	F-06 L-LIM-F	L-LIM-F 000.0 Hz	Minimum frequency limit (clamp) -- 0.0 to 135.0 Hz (must be < H-LIM)
8	F-07 JUMP-F1	JUMP-F1 000.0 Hz	The drive will not operate in the range of JUMP-F setting +/-0.3 Hz. These settings are used to prevent operation at speeds which excite mechanical resonance in the load. 0.0 to 135.0 Hz. (See Fig. 5-5.)
9	F-08 JUMP-F2	JUMP-F2 000.0 Hz	
10	F-09 JUMP-F3	JUMP-F3 000.0 Hz	
11	F-10 CF-code	CF-code <N>	Adjusts PWM carrier frequency to minimize accoustical noise. C to U
12	F-11 Fstop-T	Fstop-T 001.0 S	Dwell time hesitation at start to optimize starting torque. 0.0 to 15.0 S. (See Fig. 5-3.)
13	F-12 Speed-1	Speed-1 000.0 Hz	Preset operating speeds selected by contact closures. Adjustable from 0.0 to 135.0 Hz within limit settings. Selected by connections to terminals CF1 & CF2. (See Table 5-5.)
14	F-13 Speed-2	Speed-2 000.0 Hz	
15	F-14 Speed-3	Speed-3 000.0 Hz	
16	F-18 ACCEL-2	ACCEL-2 0030.0 S	Alternate acceleration and deceleration rates selected by grounding terminal 2CH. Same adjustment range as ACCEL/DECEL-1.
17	F-19 DECEL-2	DECEL-2 0030.0 S	
18	F-20 F-DCB	F-DCB 001.0 Hz	Frequency at which DC braking is applied. 0.5 to 15.0 Hz (See Fig. 5-6.)
19	F-21 V-DCB	V-DCB 000	DC braking voltage adjustment. 0 to 20 (20 = approx. 1% of bus voltage.)
20	F-22 T-DCB	T-DCB 000.0 S	DC braking time adjustment. 0.0 to 15.0 sec. (See Fig. 5-6.)
21	F-23 E-therm	E-therm 100%	Motor nameplate current as a percent of drive nameplate current for calibration of electronic overload relay. 50 to 100% (See Figs. 5-7 & 5-8.)
22	F-24 ACCline	ACCline Linear	Selects linear or S curve acceleration control. (See Fig. 5-9)
23	F-25 DECline	DECline Linear	Selects linear or S curve deceleration control. (See Fig. 5-9.)
24	F-26 F-START	F-START 000.0 Hz	Start point or bias adjustment for external speed setting signal input. 0.0 to 135.0 Hz. (See Fig. 5-4)
25	F-27 F-END	F-END 000.0 Hz	End point or gain adjustment for external speed setting signal input. 0.0 to 135.0 Hz. (See Fig. 5-4.)
26	F-28 SWITCH1	SWITCH1 00000111	Selection switches for automatic restart, current limit, external frequency meter, and DC braking. (See Table 5-6.)
27	F-30 LM.CONS	LM.CONS 0001.0	Current limit time constant. (Decel time) 0.3 to 30 seconds
28	F-31 OLalarm	OLalarm 100%	Overload warning level adjustment. 100 to 150% (See OL0 & OL1, Table 3-7)
29	F-32 V-auto	V-auto +00	Voltage boost during acceleration. 0 to 20 (20 = approx. 10% boost.)
30	F-33 IPS-T	IPS-T 001.0 S	Instantaneous power failure time setting. 0.3 to 3 seconds
31	F-36 IPS-R-T	IPS-R-T 0001.0 S	Time delay for automatic restart. 0.3 to 30 sec

The adjustment resolution is 0.1 Hz for frequency settings, 0.1 second for time settings, and 1% for percentage settings.

Three Preset Speeds

Table 5-5

Contact Closures CF1 to L	CF2 to L	Resulting Output Frequency Control Method or Setpoint
Open	Open	Frequency is set by keypad operator control FS if F-SET-M is set to Ope.-Key; or by terminal block input O or OI if F-SET-M is set to Terminal. If F-SET-M is set to Terminal and there is no input signal connected, the frequency is set by F-06 L-LIM-F. If F-SET-M is set to Terminal and terminal O is connected to terminal H, frequency is set by F-05 H-LIM-F.
Closed	Open	Frequency set by Speed-1
Open	Closed	Frequency set by Speed-2
Closed	Closed	Frequency set by Speed-3

F-28 SWITCH1 Settings

Table 5-6

Pos	Setting	F-28 SWITCH1: 00 00 0 1 1 1 Pos: (1) (2) (3) (4) (5) (6)
(1)	00 or 01	Not used
(2)	00	Default setting. The automatic restart function is not enabled. In the event of a fault or a power interruption, the drive must be reset and restarted manually.
	10	Automatic restart after fault or instantaneous power interruption with synchronized start of spinning motor.
	11	Automatic restart after instantaneous power interruption with acceleration from zero speed. Automatic restart after fault with synchronized start of spinning motor.
	01	Invalid setting. Do not set 01.
(3)	0	Default setting. Normal current limit function.
	1	Current limit is disabled during acceleration.
(4)	0	The frequency/speed indicating signal (terminal FM) is set for use with a frequency counter.
	1	Default setting. The frequency/speed indicating signal (terminal FM) is set for use with an analog meter.
(5)	0	The DC braking function is turned off.
	1	Default setting. The DC braking function is turned on.
(6)	0	Special setup for output frequency and voltage programming. Do not use this setting unless special instructions have been provided.
	1	Default setting. Standard setting for output frequency and voltage programming (Function F-00) as described in this manual.

Potentiometer Adjustments and DIP switch settings — Table 5-7

VR1 Potentiometer		For factory use only. Do not adjust.
VR2 Potentiometer		For factory use only (if installed). Do not adjust.
M ADJ Potentiometer		External analog frequency meter calibration.
SL COM Potentiometer		Not used. Not installed.
OL LMT Potentiometer		Current limit adjustment Center of rotation = 100% of rated output current Full counterclockwise setting = 50 to 80% Full clockwise = 150% Recommended initial setting: 125%
DIP SW	Section 1	OFF = 0 to 10V speed reference from potentiometer or external signal source. 10V = Fmax. ON = 0 to 5V speed reference from external signal source. 5V = Fmax
	Section 2	OFF = No restriction on use of keypad. ON = Keypad locked. The display can be changed, but no settings can be changed. The drive can be stopped by pressing the STOP key. If F/R-SW Ope.-Key was selected before locking, the drive can be started by pressing the FORWARD or REVERSE key.
	Section 3	Not used. Switch must remain OFF.
	Section 4	Returns all settings to factory set values using the following procedure: 1. Turn the power on. 2. Set section 4 of the DIP SW to ON. 3. Press the three keys: "Monitor," "Function," and "Enter." While holding these three keys depressed at the same time, push and release the reset button. One or two seconds after releasing the reset button, release the three keys. 4. The display should show the ROM number such as: B00742. If the ROM number is not displayed, the three keys have been released too soon and step 3 must be repeated. 5. Turn the power off. 6. Set section 4 of the DIP SW to OFF. 7. Turn the power on again.
Reset Button		Resets the drive in the event of a fault trip. For use during trouble shooting. For normal operation, the drive can be reset by removing and reapplying power or by closing and opening a reset switch connected to terminal RS.

Refer to the connection diagram for potentiometer and DIP switch locations.

Detailed Adjustment Information

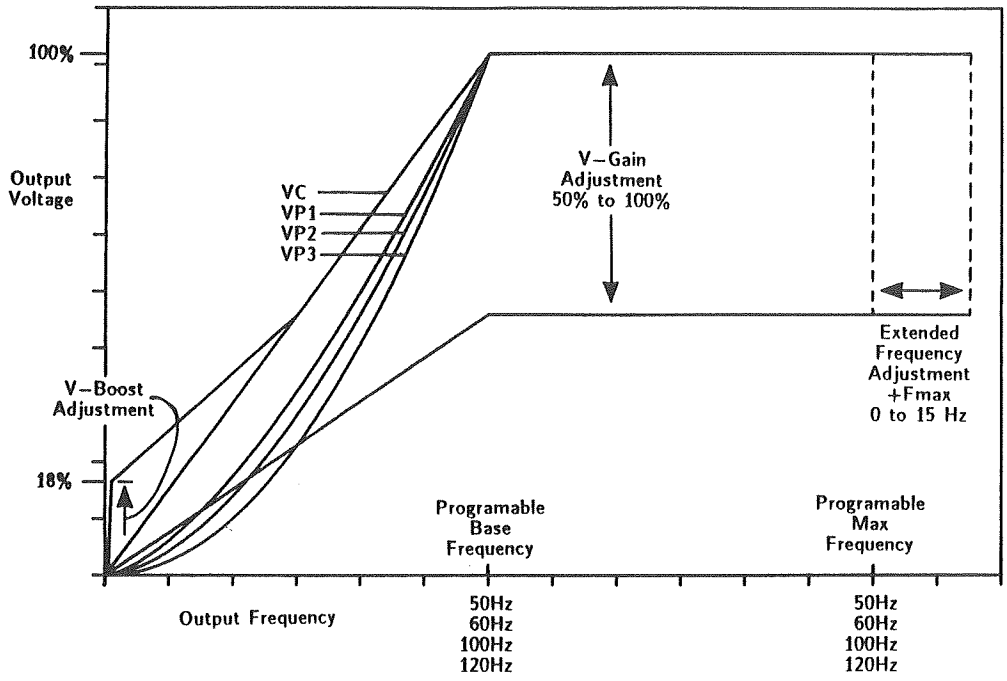
OUTPUT FREQUENCY AND VOLTAGE PROGRAMMING

Function F-00 VFE-VC programs the output frequency range vs. the output voltage. Base Frequency and Max Frequency must be selected to suit the motor and the application. The available selections are shown in Figure 5-2. Application information is provided in the Electric Drive Application Guide Section of the Industrial Drives Catalog. The drive's default setting provides for constant torque or variable torque operation between zero and 60 Hz with a standard 60 Hz three phase motor connected for motor nameplate voltage equal to drive input line voltage. Function F-03 +Fmax. can be used to extend the maximum frequency by 0.1 to 15 Hz above the Max Frequency set by function F-00. F-03 extends only the Max Frequency, not the Base Frequency.

If the motor nameplate voltage is less than the input line voltage, the Monitor Mode V-Gain adjustment must be used to reduce the drive output voltage as a percent of input voltage. Set V-Gain = motor voltage/line voltage. Make sure that the output current rating of the selected AF-1500 model is greater than or equal to the motor current required at the motor voltage connection selected. The V-Gain adjustment may also be reduced if the motor always runs at less than full load. Reducing the motor voltage will increase the operating efficiency and reduce the acoustical noise produced by the motor. With the motor running at full speed under the maximum load conditions, reduce the V-Gain setting while observing the motor current. Set V-Gain at the point of minimum motor current.

By selecting a base frequency of 120 Hz, a 230/460 volt motor can be operated above 60 Hz with constant torque operation. The motor must be connected for 230 volt operation and the input line voltage to the AF-1500 must be 480 volts. The output voltage applied to the motor will thus be 230 volts at 60 Hz and 460 volts at 120 Hz. At 120 Hz, the motor will be operating at rated torque but at twice rated speed. The motor will thus be operating at twice its rated horsepower. The motor should not be operated in this manner unless the motor manufacturer verifies that the motor can withstand this duty. Note that the motor requires twice as much current for 230 volt operation as compared to 460 volt operation. An AF-1500 model must be selected which has an output current rating which is equal to or greater than the motor current required at 230 volts.

The voltage vs. frequency curves marked VP1, VP2 and VP3 in Figure 5-2 are reduced V/Hz curves which may be useful for variable torque fan and pump loads. Since variable torque loads only require torque proportional to percent speed squared (25% torque at 50% speed), the V/Hz can be reduced below the constant V/Hz line. Reducing the V/Hz when the load torque is reduced results in more efficient and quieter motor operation. Although the efficiency increase may be small, the reduction in acoustical noise generated in the motor may be quite significant. Note that operation at reduced V/Hz may require setting the acceleration rate for a slower acceleration to limit the torque demand during acceleration of the load inertia.



Output Frequency and Voltage Programming

VFE–VC 060–060

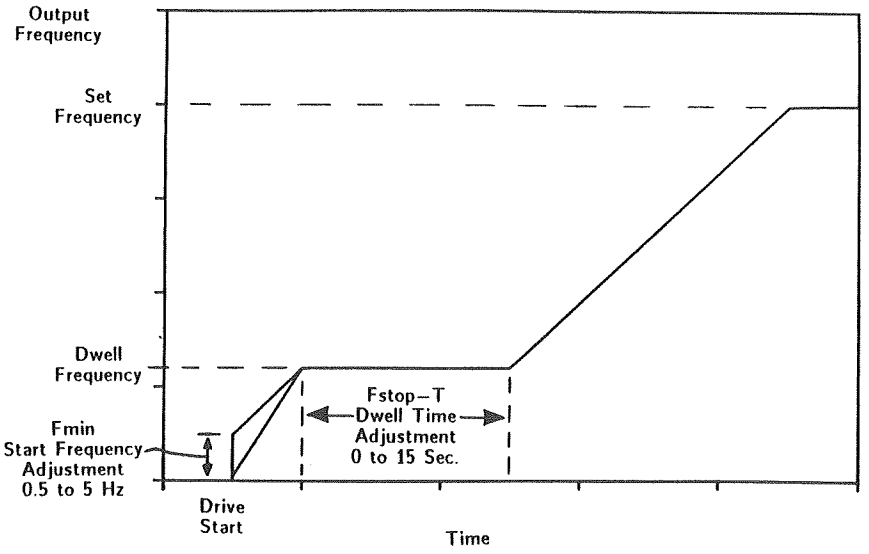
- 060–060 → Max Frequency / Base Frequency
- VFE–VC → Sets V/Hz for Operation Below Base Frequency
  - VC = Constant V/Hz ($V = Kf$)
  - VP1 = Reduced V/Hz ($V = Kf^{1.5}$)
  - VP2 = Reduced V/Hz ($V = Kf^{1.7}$)
  - VP3 = Reduced V/Hz ($V = Kf^{2}$)
- VFE–VC → Sets Base Frequency and Max Frequency
  - VFA = 050–050
  - VFB = 050–060
  - VFC = 050–100
  - VFD = 050–120
  - VFE = 060–060
  - VFF = 060–100
  - VFG = 060–120
  - VFH = 100–100
  - VFI = 120–120

Output Frequency and Voltage Programming Figure 5–2

Figure 5-2 shows the effect of the Monitor Mode V-Boost adjustment. This adjustment boosts the motor voltage above the constant V/Hz curve to overcome the IR voltage drop that prevents the motor from developing maximum torque at full speed. This adjustment, as do many other AF drive adjustments, must be adjusted by trial and error to achieve optimum motor performance under actual operating conditions. If the V-Boost is not set high enough, the motor may not develop enough torque to start the load. If the V-Boost is set too high, the motor will saturate and draw excessive current without developing more torque. F-32 V-auto sets a voltage boost that is effective only during acceleration. This adjustment may help the motor develop torque to accelerate a high inertia, low friction load whereas the V-Boost adjustment might cause the motor to saturate when running lightly loaded at a low speed setting.

Figure 5-3 shows the effect of the F-04 Fmin Start Frequency adjustment and the F-11 Fstop-T Dwell Time adjustments. These adjustments determine how the motor performs when the drive is started. The motor can not develop maximum torque until the frequency reaches 1.5 to 5 Hz. If the Start Frequency is set to 0.5 Hz, the motor will develop torque slowly as the frequency ramps up from 0.5 Hz. If the Start Frequency is set above 0.5 Hz, the motor will develop torque more quickly.

Function F-11 Fstop-T adjusts the time that the AF-1500 pauses during the acceleration ramp. This pause is called the Dwell Time. The dwell occurs only upon starting the drive, not when changing the speed setting. The Dwell Frequency is not adjustable; the dwell occurs at either 1/12 of Base Frequency or at Start Frequency, whichever is greater. The purpose of the dwell is to allow the actual speed of the motor to catch up with the frequency ramp. If the motor is allowed time to break away the load and accelerate to a low slip point on the torque vs. speed curve, it is less likely that the drive will go into current limit during acceleration. When using a synchronous reluctance motor, the dwell time may be required to give the motor time to lock in to synchronous operation before accelerating. The optimum setting can be determined only by trial and error. The best setting is the shortest time which will allow a fast acceleration rate without going into current limit.



Start Frequency and Dwell Time Adjustments

Figure 5-3

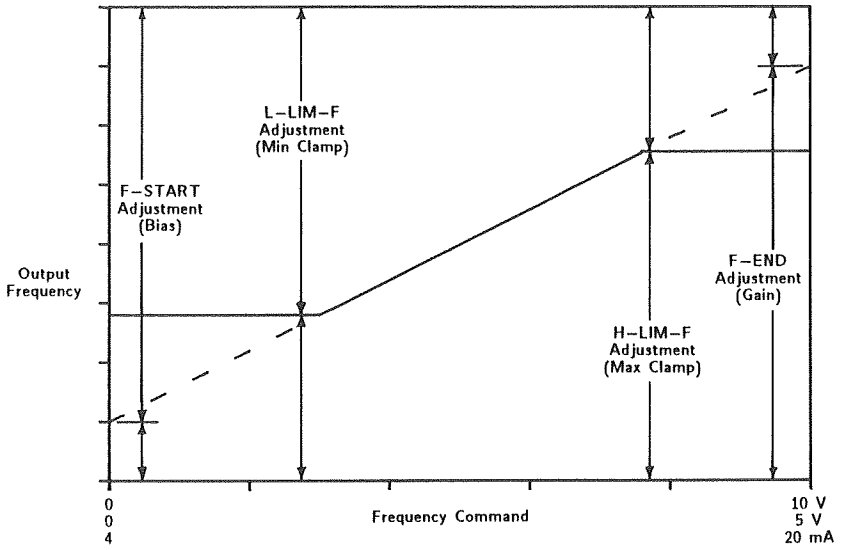
SPEED COMMAND BIAS AND GAIN ADJUSTMENTS

F-26 F-START and F-27 F-END set the output frequencies corresponding to the minimum speed reference and the maximum speed reference inputs respectively. The minimum speed reference is 4 milliamps or zero volts and the maximum speed reference is 20 milliamps or either 5 or 10 volts depending on the setting of DIP SW section 1. Between F-START and F-END, there is a linear relationship between the speed reference input and the output frequency.

Note that it is possible to set F-START higher than F-END. If the drive is adjusted in this manner, output speed will be inversely proportional to the speed reference. Speed will decrease as the reference signal increases.

The factory setting is 0.0 Hz for both F-START and F-END. With this setting, the effective value of F-START is 0.0 Hz and the effective value of F-END is the maximum frequency set by F-00 plus F-03.

Figure 5-4 also shows the effect of the maximum and minimum frequency clamp adjustments, F-05 H-LIM-F and F-06 L-LIM-F. The H-LIM-F and L-LIM-F settings limit the output frequency range for both keypad frequency adjustment and for external voltage or current frequency command signal inputs. When both H-LIM-F and L-LIM-F are set to zero, settings have no effect. The F-START and F-END adjustments affect only the external command signal inputs. Note that H-LIM-F must be set higher than L-LIM-F. Set H-LIM-F first, and then set L-LIM-F. When resetting to zero, reset L-LIM-F first, and then reset H-LIM-F.



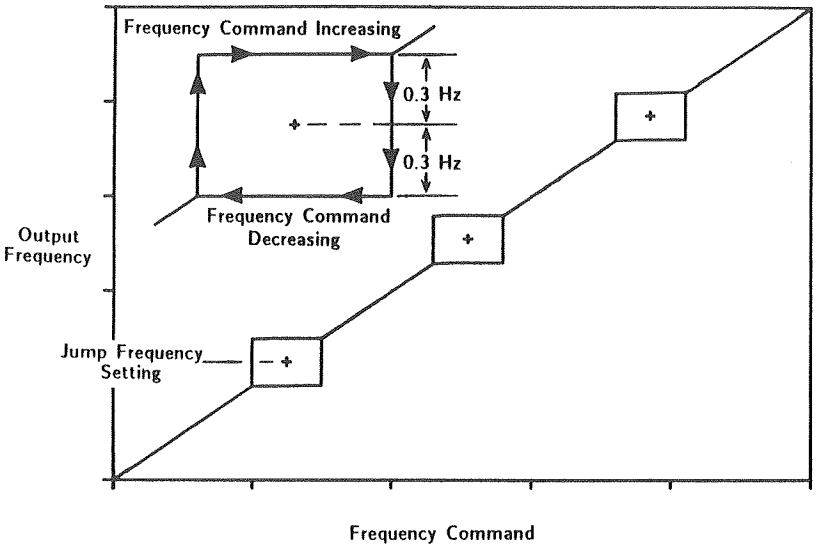
Frequency Command vs. Output Frequency Adjustments Figure 5-4

CARRIER FREQUENCY ADJUSTMENT

Function F-10 CF-code adjusts the carrier frequency of the PWM waveform. The code letters C through U correspond to carrier frequencies from approximately 600 to 1300 Hz. If objectionable acoustical noise is generated in the motor, changing the carrier frequency may reduce the noise level. This adjustment must be done by trial and error. Set the drive to various carrier frequency codes and observe the noise generated by the motor. Use the setting that produces the quietest motor operation.

JUMP FREQUENCY ADJUSTMENTS

The Jump Frequency adjustments are used to avoid operating at speeds which cause difficulty with the driven machine due to mechanical resonnance. When the frequency command calls for operation within ±0.3 Hz of the Jump Frequency, the AF-1500 operates either above or below the Jump Frequency as shown by Figure 5-5. Note that Figure 5-5 shows Output Frequency vs. Frequency Command, not Output Frequency vs. Time. When the output frequency increases or decreases through a Jump Frequency window, the frequency change follows the normal acceleration or deceleration ramp. While changing frequency, the drive operates at frequencies inside the window, but it can only accelerate or decelerate smoothly through the window, it can not sustain operation at any set frequency within ±0.3 Hz of a Jump Frequency setting.



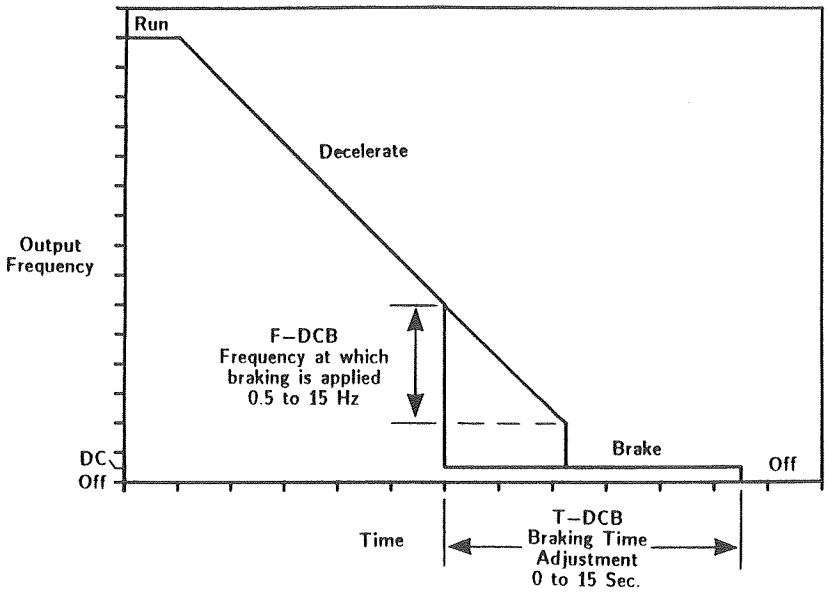
Jump Frequency Adjustments Figure 5-5

DC BRAKING

When a dc current flows in the windings of an induction motor, the motor acts as a brake. The available braking torque is relatively low when the motor speed is high and decreases as motor speed decreases. The energy absorbed during braking is dissipated as heat in the motor rotor. The AF-1500 provides dc braking by changing the switching sequence of the transistors to apply an adjustable dc voltage to the motor windings. Function F-28 SWITCH1 is used to enable or disable the dc braking feature. Refer to Table 5-6, item 5.

Figure 5-6 shows the effect of the adjustments F-20 F-DCB and F-22 T-DCB. F-DCB sets the frequency at which the drive switches from linear deceleration to dc braking. This adjustment is effective only when using the DB input to the 1A-USP AUX PCB as shown. If the DB input is not used, the drive switches into dc braking when the deceleration ramp reaches 0.5 Hz. T-DCB sets the time that the dc braking voltage is applied. The braking voltage can be adjusted using F-19 V-DCB. A V-DCB setting of 20 is equivalent to approximately 1% of the dc bus voltage.

Set the dc braking adjustments by trial and error for optimum stopping performance. If V-DCB is set too high, the drive may shut down due to overcurrent trip. If F-DCB is set too high, the drive may shut down on overcurrent trip regardless of the V-DCB setting. The drive cannot be restarted until the Braking Time (T-DCB) has expired.



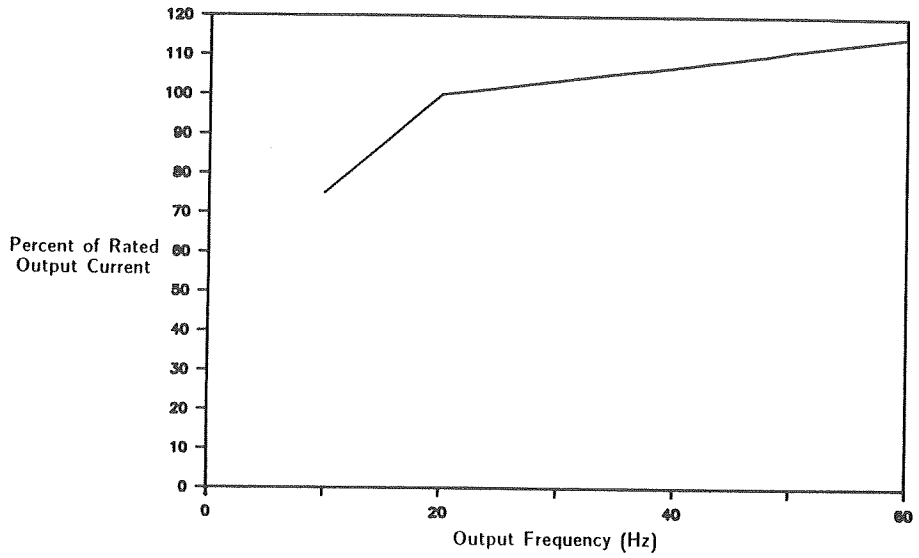
Dc Braking

Figure 5-6

ELECTRONIC OVERLOAD RELAY

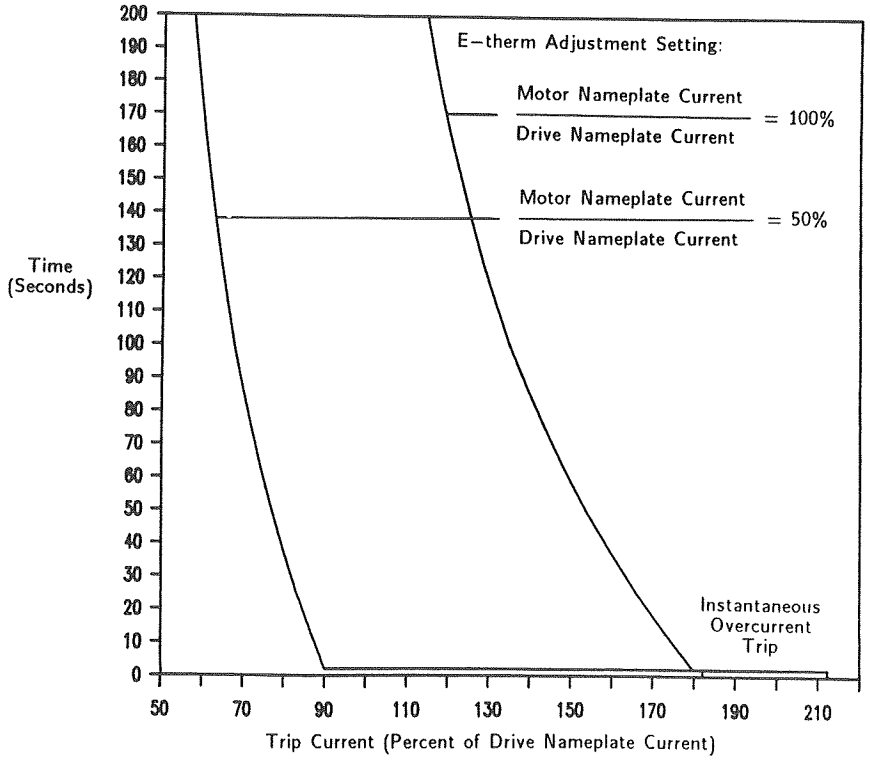
Figures 5-7 and 5-8 show the performance of the electronic overload relay feature that is included in the AF-1500 to provide motor protection. Figure 5-8 shows the Ultimate Trip Current vs. Output Frequency as a percent of rated output current. Note that the protection circuit does not allow continuous operation at rated output current for operation below 20 Hz. This reflects the reduced cooling effectiveness of a typical motor when operating below 1/3 of base speed. If the motor must be operated continuously at full torque below 20 Hz, it may be necessary to oversize both the motor and the AF-1500. The curve shown in Figure 5-7 is not adjustable; the relationship between the Ultimate Trip Current and Output Frequency cannot be changed.

Figure 5-8 shows the Trip Current vs. Time for continuous operation at 20 Hz. Above and below 20 Hz, the curves shift to the right or left in proportion to the position of the curve in Figure 5-7 above or below 100% of rated current. Function F-23 E-therm can be used to reduce the trip point to provide protection for motors which have a nameplate current that is less than the rated output current of the AF-1500.



Electronic Overload Relay
Ultimate Trip Current vs. Output Frequency

Figure 5-7



Electronic Overload Relay

Figure 5-8

Linear/S-Curve Acceleration and Deceleration Control

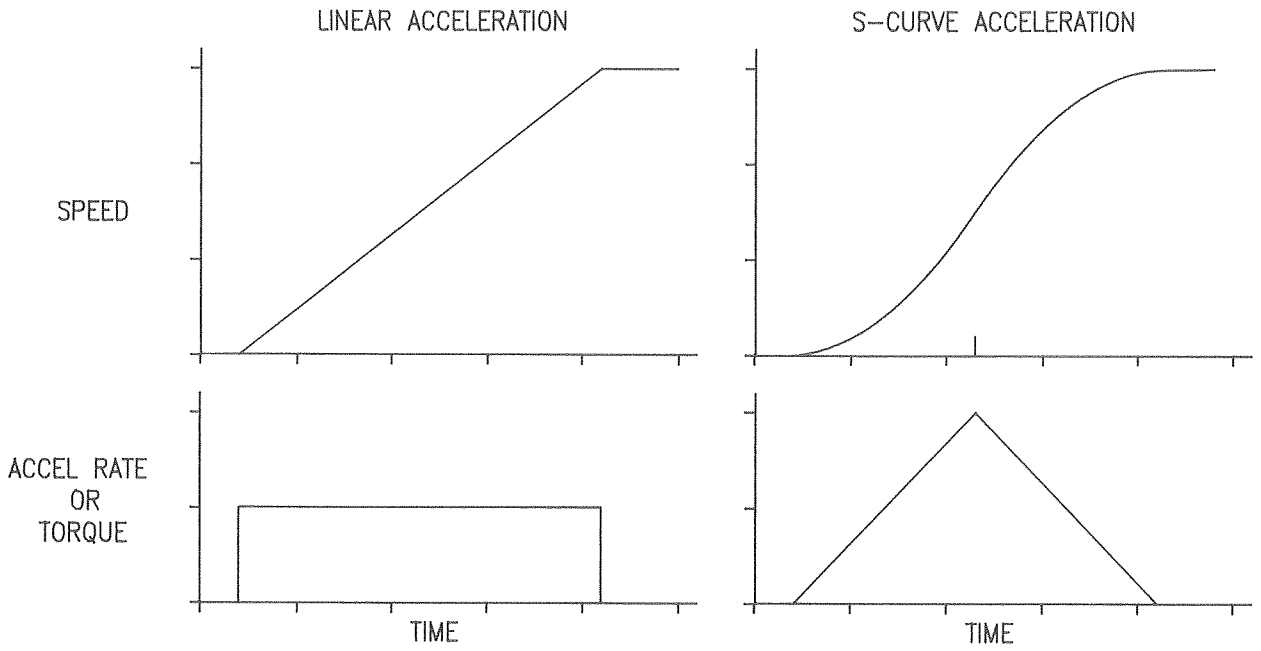
Functions F-24 ACCline and F-25 DECline allow the selection of either linear or S-Curve acceleration and/or deceleration. Linear acceleration and deceleration result in a constant torque demand for accelerating and decelerating inertia. The total torque demand on the motor is the sum of the torque required to overcome friction, or do work, plus the torque required to accelerate inertia. If, as is often the case, constant torque is required to overcome friction and do work, then linear acceleration results in the total torque demand being constant. Since the torque available from the drive is constant, linear acceleration results in a good match between drive capability and load demand. Much the same situation is true for deceleration. If the friction and work load is constant, linear deceleration best matches the capability of the drive.

If there is a high breakaway torque requirement, then the friction requirement of the load takes more of the drive's capacity at low speed. This leaves less torque available to accelerate the inertia. In this case, S-Curve acceleration may provide a better match between drive capability and load requirement. Linear deceleration would probably be the best selection in this instance.

The torque required for fans and pumps to do work increases as the speed increases. At full speed, all or most of the capacity of the drive is used for doing work and only the overload capacity is available to accelerate inertia. At zero speed, some torque may be required to break the load away, but once the load is moving, most of the drive's capacity is available to accelerate inertia. S-Curve acceleration may be the best selection in this case. Linear deceleration is probably the best selection since the load will help decelerate the inertia at full speed.

If the driven machine has a high inertia and low friction, most of the braking torque required to decelerate the inertia must be supplied by the drive. This means that braking power must be dissipated by the motor and drive. Although linear deceleration of inertia requires constant braking torque, the braking power dissipation requirement is directly proportional to speed. Power is proportional to torque times speed. S-Curve acceleration will reduce the deceleration torque requirement when the speed is high and increase it as the speed decreases. This will result in a more constant power dissipation requirement. Selecting S-Curve deceleration in this instance may allow a faster overall deceleration time without the occurrence of a dc bus overvoltage trip.

Since the torque required to accelerate or decelerate inertia is proportional to the acceleration rate, S-Curve acceleration and deceleration result in a linear increase and decrease in torque during the acceleration or deceleration time. Figure 5-9 shows the change in speed, acceleration, and torque during the acceleration time for both linear and S-Curve acceleration. Note that with linear acceleration, there is a sudden change in torque at the beginning and end of the acceleration ramp, while S-Curve acceleration results in a linear increase in torque followed by a linear decrease in torque. Since items riding on a conveyor belt are accelerated by a force that is not applied at the center of gravity, the sudden application and removal of the acceleration force tends to make the items tip over. If torque or force is applied to the driven machine through springy machine parts, the springiness will cause the machine to jerk whenever the torque of force changes suddenly. Selection of S-Curve acceleration and deceleration will minimize the jerk and provide smoother operation of machines which are sensitive to sudden changes in torque.



Linear and S-Curve Acceleration Control

Figure 5-9

Current Limit Adjustments

Located in the lower left corner of the logic board is a potentiometer marked "OL LIM" which is used to set the level of output current at which the drive goes into current limit. When the drive goes into current limit, the drive begins to decelerate to a lower speed and continues to decelerate until the output current decreases below the current limit setting. The rate at which the drive decelerates is set by function F-30 LM.CONS. The range of adjustment is 0.3 to 30 seconds. The factory setting is 1 second. Both the current limit and LM.CONS must be set by trial and error. If the current limit is being used to limit the torque transmitted to the driven machine, the torque must be estimated by observing the motor current or by observing the performance of the machine. Usually the current limit is used to prevent nuisance shutdowns during acceleration or during momentary overload conditions. In this case, the current limit should be set high enough to avoid going into current limit unnecessarily, but not so high as to permit nuisance overcurrent trips (OC.Accel or OC.Drive). The LM.CONS deceleration rate should be set fast enough so that the current limit will prevent the current from overshooting the setpoint and causing an overcurrent trip. If the LM.CONS deceleration rate is too fast, the drive will regenerate and trip due to dc bus overvoltage (Over V) or overcurrent deceleration (OC.Decel).

In some applications, it is desirable to accelerate as quickly as possible using the full overload capability of the drive; but once the drive is at operating speed, it is desirable to limit the current to a lower level to protect the driven machine. Some machine tools can be accelerated to operating speed at 150% torque, but once the tool has begun to cut into the workpiece, exceeding full torque would damage the tool. In this case, the current limit function can be set to the lower level, but disabled during acceleration by setting function F-28 SWITCH1 as shown in Table 5-6. If the current limit is disabled during acceleration, the acceleration rate must be carefully adjusted to prevent the drive from tripping on overcurrent during acceleration (OC.Accel).

SECTION 6

TROUBLESHOOTING

Preliminary Information

Prior to maintenance and troubleshooting, note the following:

1. Before starting any maintenance procedures, be sure to turn the power OFF.

2. When removing connectors, do not pull by the wires.

3. Take special care to insert the connector in the correct location and with the proper orientation.

CAUTION: Allow the bus capacitors to discharge for 1 minute after power is turned off before doing any work on the circuitry. On 240 V models, this is when the display on the digital operation panel goes off; on 480 V models, this is when the LED at the right side of the terminal, under the cover, goes out.

General Precautions

Always keep the unit free of dust, dirt and iron powder which could compromise the insulation systems and cause failure. Also it should be noted that electronic equipment is sensitive to moisture.

Check the tightness of the terminals and connectors.

Routine Inspections

When inspecting an inverter, certain observations should be made routinely. They are as follows:

1. Supply voltage: All three phases should be within tolerance, and within 3% of each other.

2. Output frequency, output voltage and output current as setup are within nameplate limits.

3. Are there any abnormal noises in either the inverter or motor?

4. Is the ambient temperature within specified limits? Does the inverter or motor seem to be overheating?

5. Is there excessive humidity? Remember, no condensation is allowed.

6. Oil mists and coolants should not be allowed to enter the inverter unit.

7. Disconnect leads at inverter and check insulation resistance of the motor and its wires with a megger; compare with previously recorded readings.

Testing Methods

To measure the output voltage, use an RMS sensing meter rated for peak voltages of 400 V for the 240 V units and 800 V for the 480 V units.

CAUTION: Disconnect power before connecting or disconnecting meter leads. Due to leakage, voltage is present on the output terminals even at zero output frequency, if there is no load connected.

Component replacement on the circuit board should only be done by highly skilled technicians. Contact Eaton's Electric Drives Division Service Department in Kenosha, Wisconsin if you have any questions. If field service is attempted, note the following: integrated circuits may be damaged by static electricity; and be sure to ground the workbench, soldering iron and the individual handling those parts.

Component Service Lifetimes

DC bus capacitors have a life expectancy of 5 to 10 years depending on load, ambient temperature and line voltage. Toward the end of its useful life, the capacitance of a capacitor goes down. The resulting increased bus voltage ripple will affect the output voltage waveform and possibly cause unstable motor operation. When a replacement capacitor has been stored for more than three years, it should be reformed in the following manner: at room temperature, apply 80% of rated voltage for one hour, 90% of rated voltage for one hour, and then full rated voltage for five hours.

Cooling fans have a life expectancy 5 years or more depending on operating temperature and air quality. Fans should be checked periodically for noise and vibration which might indicate impending failure.

The life span of the digital operation panel is approximately seven years. If the display becomes hard to read, it should be replaced. Note that the liquid crystal display has an optimum viewing angle, which is generally level and straight on; this should be taken into account when mounting the inverter.

The soft memory element used to store parameter changes has a ten year lifetime when the inverter is powered up several times daily.

Output Transistor Ohmmeter Tests

The transistor module can be checked by measuring it with an ohmmeter in the low ohm range at the terminals. First, disconnect the motor leads from the output terminal strip. Refer to Figure 6-1 for the locations of the terminals and Figure 6-2 to check them. When making these tests, leave the ohmmeter connected for at least ten seconds. This gives the snubber circuits time to charge and for the readings to settle to the normal values.

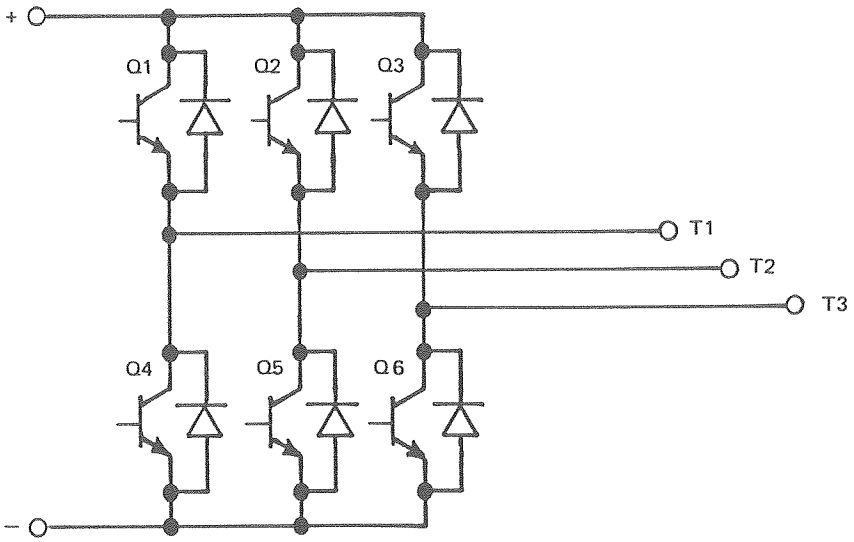
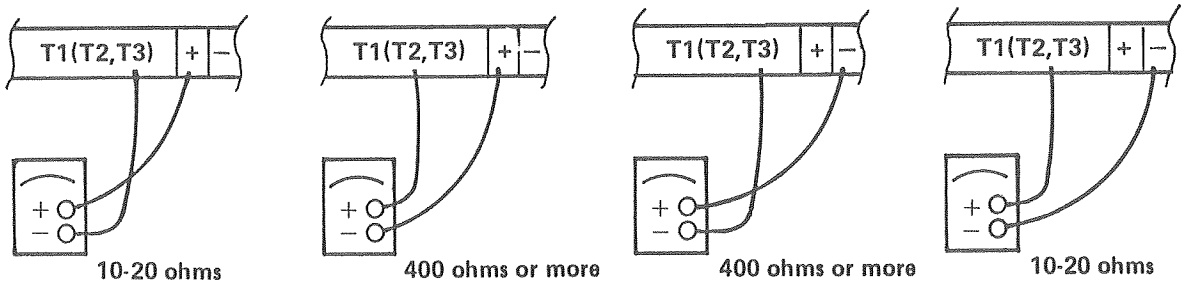
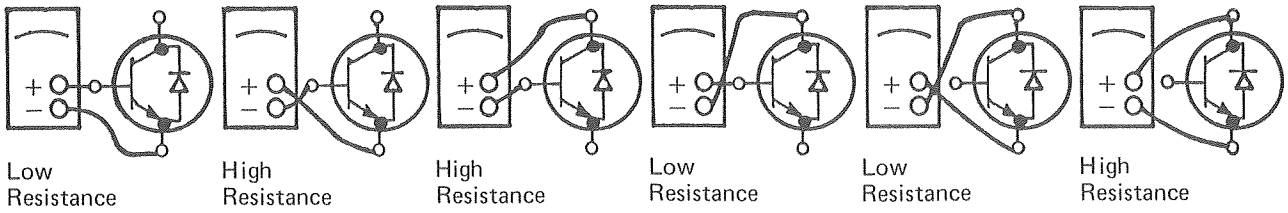


Diagram of the Transistor Module Figure 6-1



Ohmmeter Test Connections at Terminal Strip Figure 6-2

The values should be as shown in Figure 6-3. When a module is replaced, a thermal conductive silicone grease, such as Dynamatic part number DY-12084, must be used on the heat sink surface. If a transistor has been found to be shorted, it is possible that a base drive on the PCB may also be damaged. Visually check their condition, and proceed with caution.



Ohmmeter Testing at Transistor Module With Proper Indications Shown Figure 6-3

Diagnosing Faults

If a fault has occurred, locate the symptom in Table 6-1 to determine the cause and take corrective measures before restarting operation. Also see the troubleshooting flow charts in Figures 6-4 to 6-11 in this section.

Resetting

Faults may be cleared by:

1. A contact closure between terminals RS and L on the PCB.

2. Push Reset button at the lower left portion of the PCB.

3. Remove and restore the input power to the inverter.

If the display appears normal, but the unit will not run, refer to Table 6-2. If the drive will not run, even when a forced reset or the initial set up is selected, it is possible that the finite service life of the soft memory element has been exceeded. This will require that the PCB be changed.

When no data is stored in the memory after various operations are performed, it may be that the Reset button was pushed or a contact closure occurred between RS and L. Try "Entering" (Enter key) the data and turning the power off immediately afterwards. The data should now be immune to resets.

Flowcharts

A number of flowcharts follow to help in troubleshooting the inverter follow. Use Figure 6-4 when the motor will not rotate and Figure 6-5 when the motor will not accelerate. If the motor rotation is too high, check for the proper Function mode settings VFE-VC and +Fmax. Additional flowcharts are presented as an aid for inverter faults in Figures 6-6 to 6-11. Read the type of fault from the display and follow the appropriate chart.

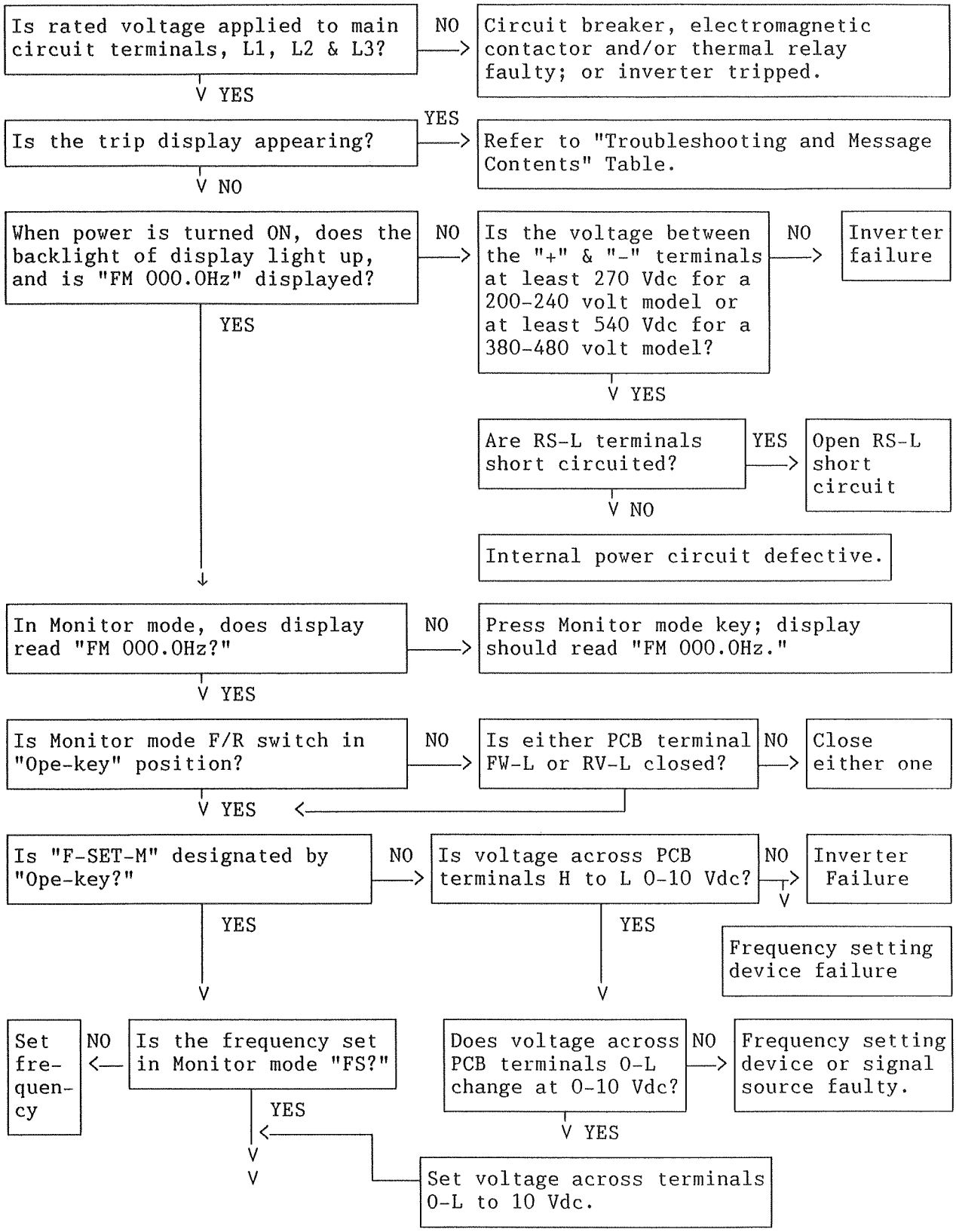
Fault Messages and Diagnosis

Table 6-1

ERROR MESSAGE DISPLAYED	MEANING OF MESSAGE	CHECK POINTS	SUGGESTED REMEDY
B00nnn	EPROM number is displayed	Check for electrical noise source.	Suppress the noise source. Force reset the drive using the internal reset button. Return all settings to the factory set values using the procedure given in Table 5-7.
		Defective PCB	Replace PCB
?Error Adjust 0.5S	Input power interruption	Defective PCB or internal wiring.	Repair
?Error CPU	Microprocessor Error	Check for electrical noise source.	Suppress the noise source.
		Defective PCB	Repair
?Error DB OT	Error in using the DC braking control input. (Terminal DB)	Check that the DC braking external command input time does not exceed the time preset by F-22 T-DCB.	Reset the T-DCB time or adjust DC braking external command input time to less than T-DCB.
?Error Gnd Flt	Ground fault on output.	Check for grounded motor wiring or defective motor.	Repair
?Error Inst. P-F	Instantaneous power failure	Determine the reason for the power interruption.	Repair
		Check input disconnect device and input contactor.	Replace defective equipment.
?Error NG.DB	Error in using the DC braking control input. (Terminal DB)	Power was turned ON or the drive was reset while DC braking was in use.	Correct the sequence of operation.
?Error NG. FRS	Error in using the coast stop command. (Terminal FRS)	Power was turned on or the drive was reset while the coast stop input was connected to common.	Correct the sequence of operation.
		Undervoltage or instantaneous power failure has occurred while the motor was coasting.	Reset the drive.
?Error NG.Jog	Error in useing the jog command. (Terminal JG)	Power was turned ON or the drive was reset while the JG terminal connected to common.	Correct the sequence of operation.
?Error OC Accel	Overcurrent during motor acceleration	Connected inertia is too large to be accelerated within the time set.	Increase the acceleration time.
		Check for output short ciruit or ground fault.	Repair the short circuit.
		Check for voltage boost set too high.	Reduce the circuit adjustment.
		Check for jogging frequency set too high.	Reduce the jogging frequency adjustment.

Fault Messages and Diagnosis (continued) Table 6-1

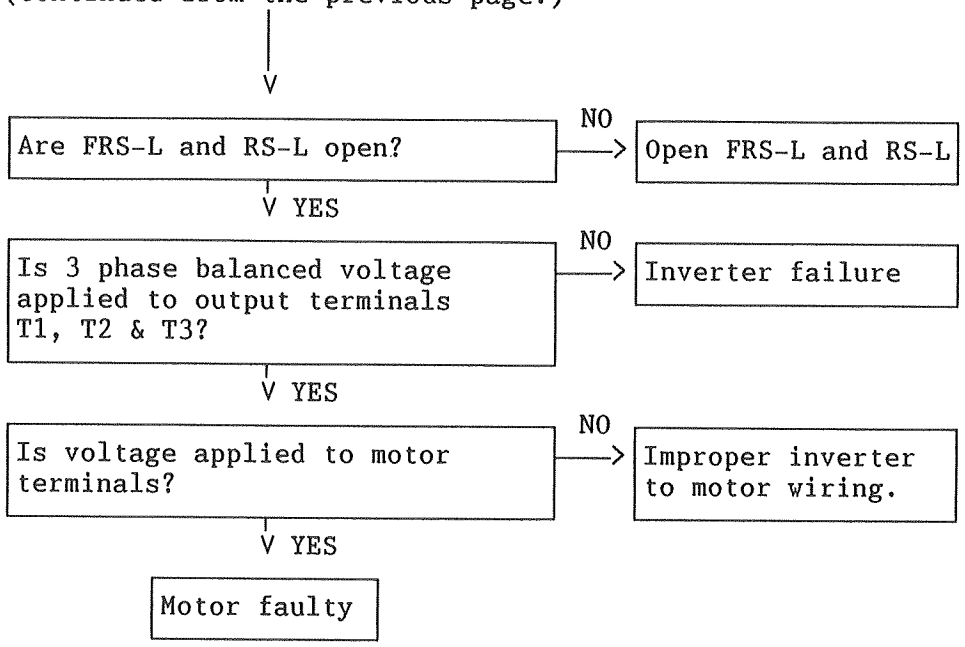
ERROR MESSAGE DISPLAYED	MEANING OF MESSAGE	CHECK POINTS	SUGGESTED REMEDY
?Error OC.Decel	Overcurrent during motor deceleration.	Connected inertia is too large to be decelerated within the time set.	Increase the deceleration time.
		Check for output short circuit or ground fault.	Repair the short circuit.
?Error OC.Drive	Overcurrent during operation of motor at set speed.	Check for overload caused by the driven equipment.	Correct the problem in the driven equipment.
		Check for output short circuit or ground fault.	Repair the short circuit.
?Error OH Fin	Heatsink fin temperature high.	Check the cooling fan.	Replace the cooling fan.
		Check the ambient temperature.	Reduce the ambient temperature.
?Error Over C	Overcurrent detection just after power ON.	Defective drive.	Repair drive.
?Error Over L	Motor overload trip (inverse time)	Check for overload caused by the driven equipment.	Correct the problem in the driven equipment.
		Check adjustment of overload setting vs motor rating.	Adjust F-23 E-therm.
		Check output current rating of inverter vs motor.	Install a larger inverter.
?Error Over.V	DC bus - overvoltage	Connected inertia is too large to be decelerated within the time set.	Increase the deceleration time
		Check for overhauling load.	The drive cannot be applied to a continuously regenerative load.
?Error OV SRC	Overvoltage Source (High line voltage)	Check incoming line voltage.	Correct the line voltage.
?Error Under V	Low input line voltage	Check incoming line voltage.	Correct the line voltage.
		Check input disconnect device and input contactor.	Replace defective equipment.
		Momentary power loss or voltage fluctuation.	Correct the problem in the power distribution system.
?Error USP	Unattended start protection.	The Run switch was closed before power was applied to the drive. (Terminal FR or RV connected to common)	Correct the sequence of operation.
?Error UV Wait	Low input voltage at automatic restart	Check incoming line voltage.	Correct the line voltage.



(Continued on the next page.)

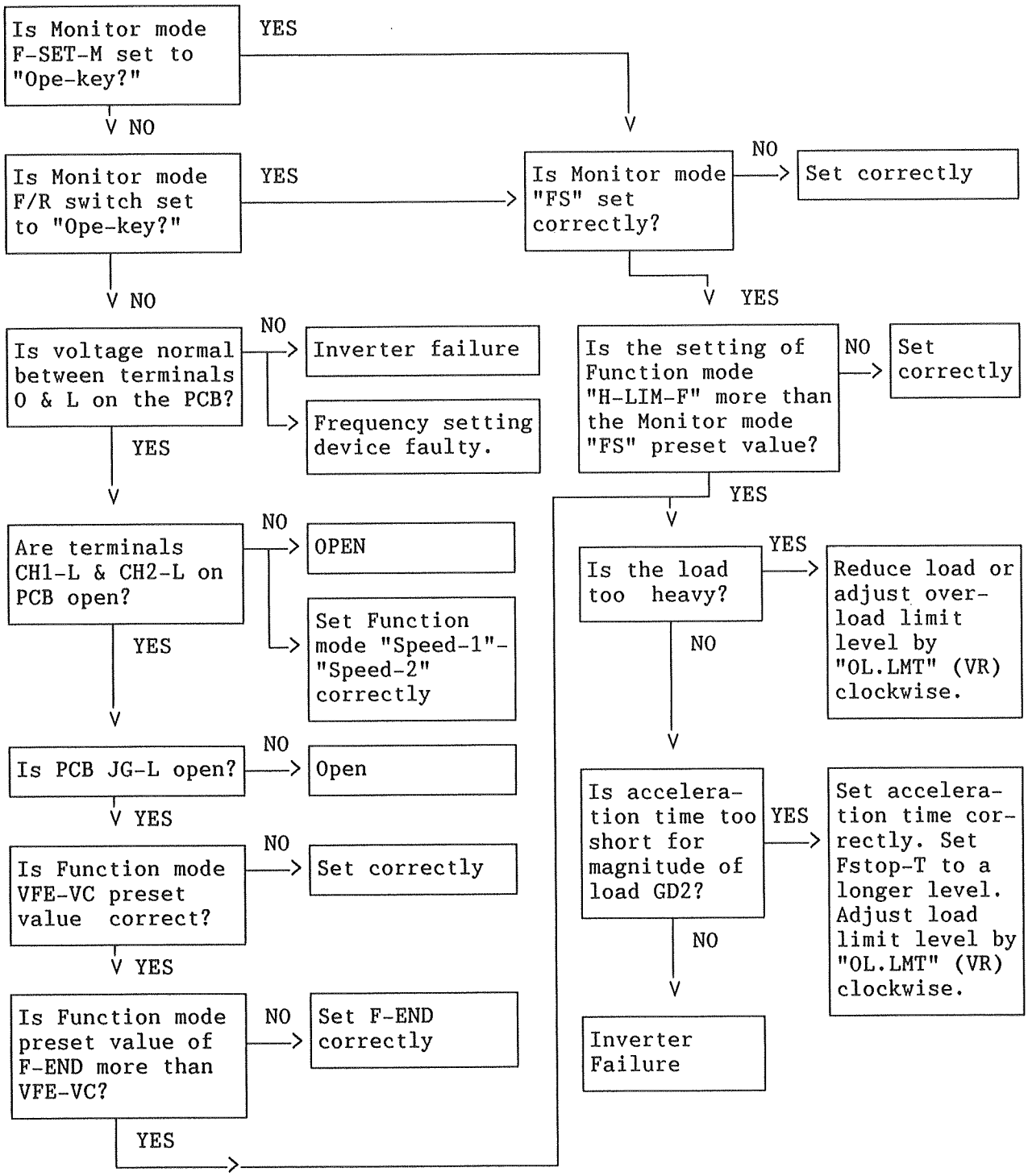
Flowchart When the Motor Will Not Rotate Figure 6-4

(Continued from the previous page.)



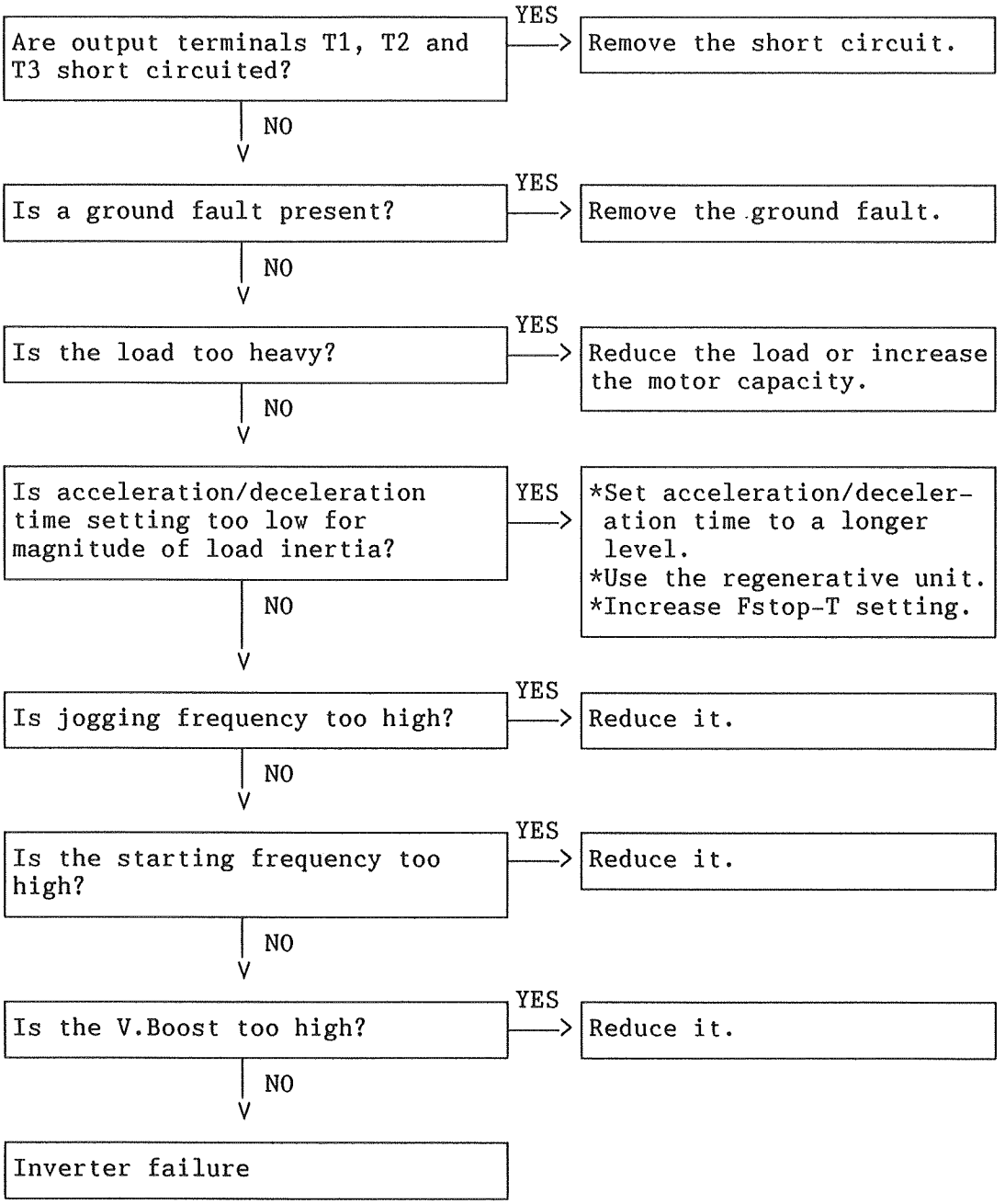
Flowchart When the Motor Will Not Rotate (continued)

Figure 6-4



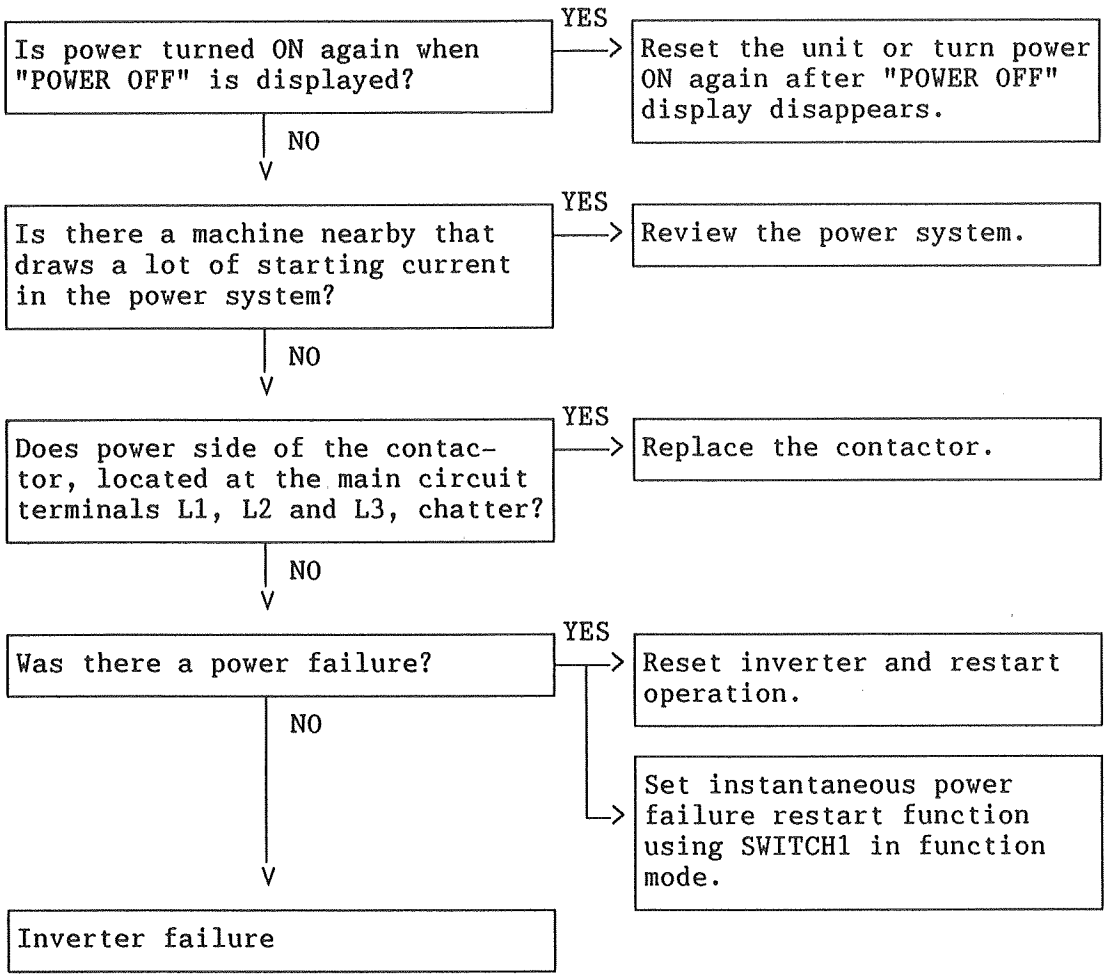
Flowchart When the Motor Will Not Accelerate

Figure 6-5



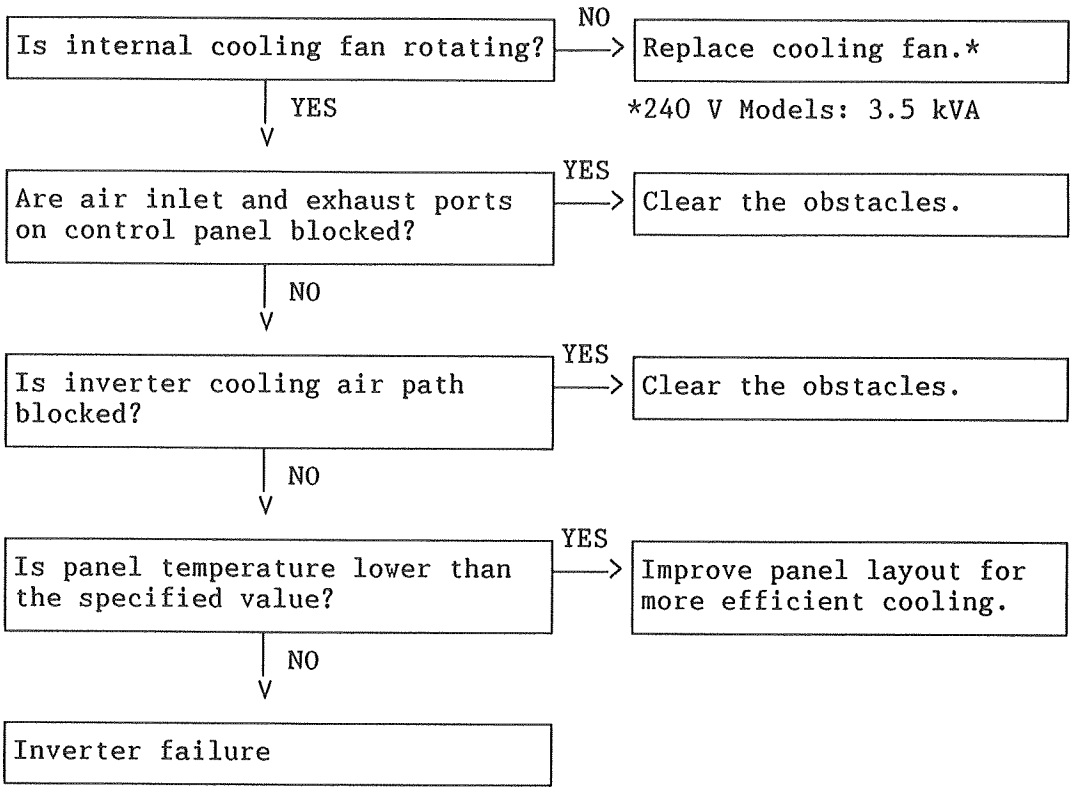
Overcurrent Trip Flowchart

Figure 6-6



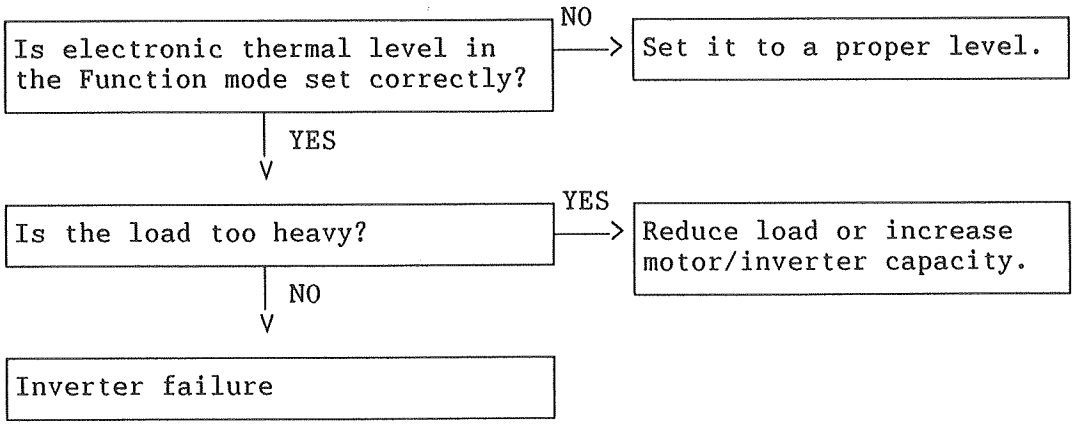
Power Outage Trip Flowchart

Figure 6-7



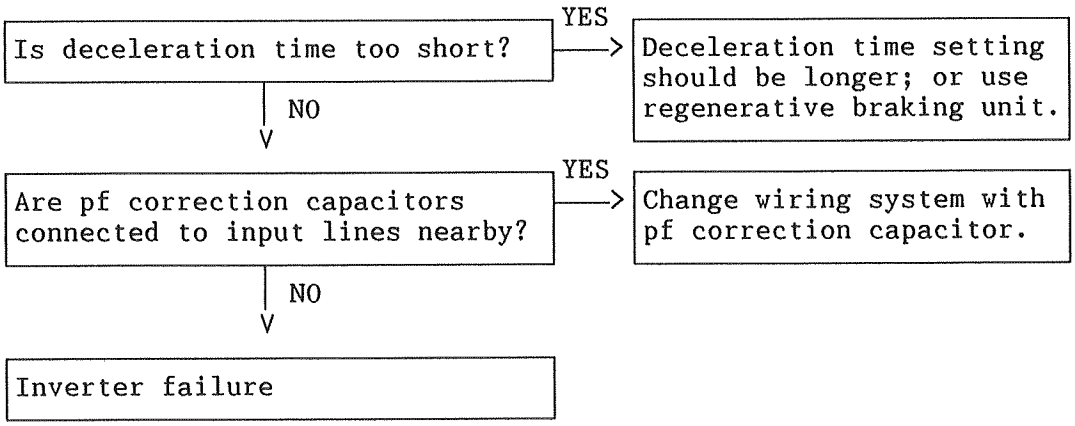
Fin Overheat Trip Flowchart

Figure 6-8



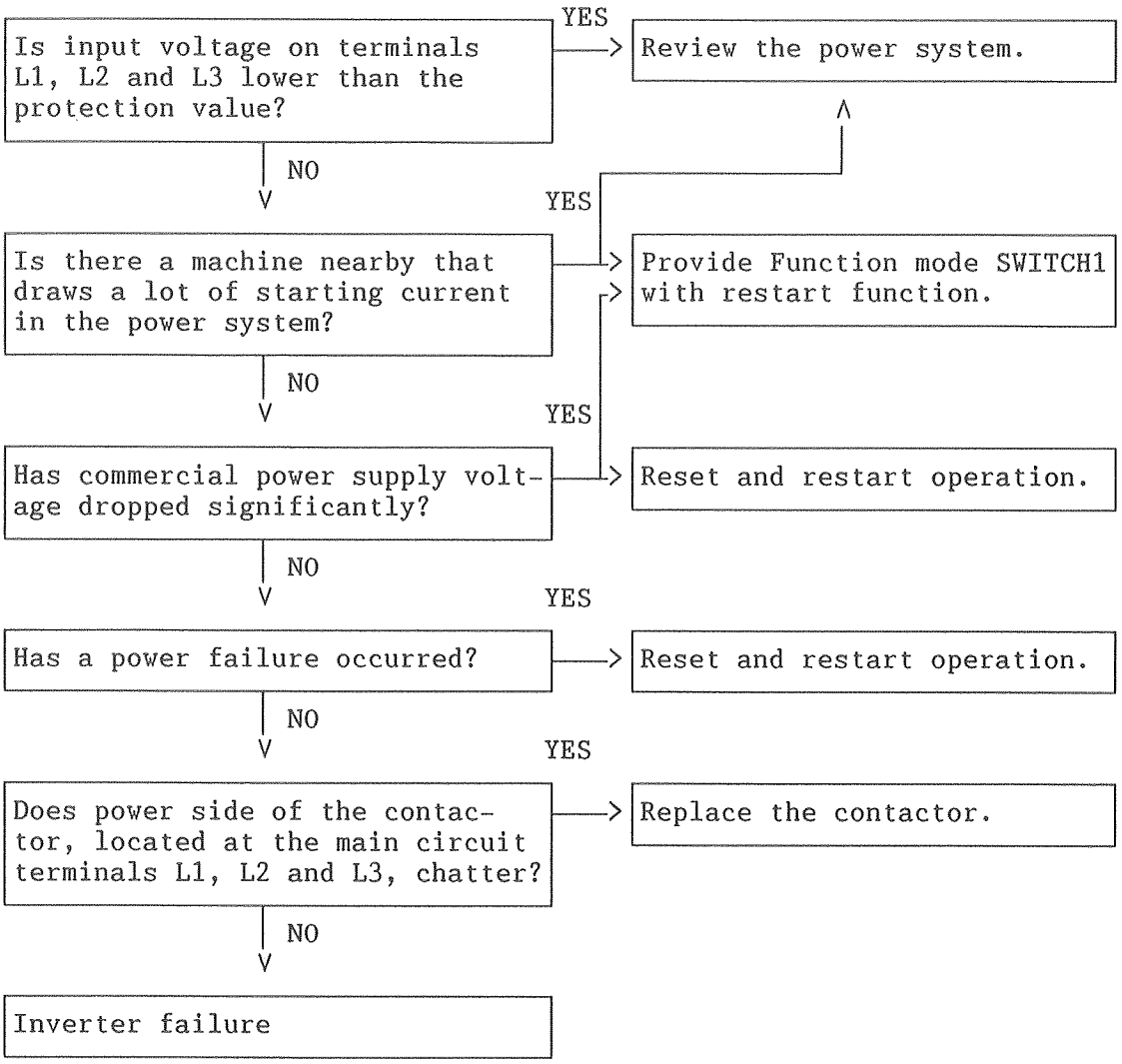
Overload Trip Flowchart

Figure 6-9



Overvoltage Trip Flowchart

Figure 6-10



Undervoltage Trip Flowchart

Figure 6-11

If the inverter will not Run or jog, refer to Table 6-2 for points to check, with suggested remedies. If these items are all OK, check for an open input phase. Also, check the transistor module as shown in Figures 6-1 to 6-3.

Check List for Drive Failure to Run With No Error Message Displayed Table 6-2

CHECK POINTS	SUGGESTED REMEDY
The Stop key may have been pressed while the drive was programmed for "F/R-SW terminal."	Open and reclose the external run/stop switch.
The DC braking command may be present. Terminal DB connected to common (L)	Open the DB terminal connection. (Correct the sequence of operation.)
The coast stop command may be present. Terminal FRS connected to common (L)	Open the FRS terminal connection. (Correct the sequence of operation.)
The frequency command may be set to zero. (FS=000.0HZ)	Set the frequency above zero.
The drive may be in the Function mode.	Press the monitor key.
The drive may be tripped but not displaying an error message because the display has been changed.	Look at line 10 of the Monitor mode display. Reset the drive.
If the drive is set for "F-SET-M terminal," check the speed reference signal on terminal O or OI.	Correct problem with speed signal source.
Terminals CF1 &/or CF2 are connected to common (L) to select Speed-1, 2 or 3, but Speed selected is set to zero.	Set the speed required or correct the speed selection connections.
The drive reset terminal (RS) is connected to common (L).	Correct the reset circuit.
"F/R-SW Ope.-Key" is selected while attempting to use external Run/Stop switch or "F/R-SW Terminal" is selected while attempting to use the Forward or Reverse keys on the operator panel.	Set the operating mode to correspond with the required method of operation.
The jog command may have been disconnected while jogging.	Press the Stop key and then the Forward or Reverse key or open the Run/Stop switch and then reclose it. Correct the sequence of operation.
A Run command may have been given less than 100ms after disconnecting the Jog command.	Correct the sequence of operation.
Both "Run Forward" and "Run Reverse" commands may have been given. Terminals FW and RV both connected to common (L).	Correct sequence of operation.
In attempting to jog, the jogging frequency may be set less then F-04 Fmin.	Set the jogging frequency higher than F-04 Fmin.

Branch Circuit Protection

If the input circuit breaker trips or if the input line fuses blow, there may be a shorted power circuit component in the drive. Check the diode bridge module (DM), the dc bus filter capacitors (CB), and the transistor module (PM). Also check the wiring between the branch circuit protective device and the drive input power terminals. Check the sizing of the branch circuit protection. Note that input line current may be higher than motor current due to harmonic content. Refer to Table 3-1.

Open Input Power Phase

This inverter will not run properly and damage may occur if there is an open input phase. The indication will vary as outlined below:

For 1 and 2 Hp, 240 V - When almost no load is present, the inverter may operate normally. There is high bus capacitor ripple current which will reduce the service life. When a load is applied, the overcurrent or undervoltage protection will function, but the rectifier module may possibly be damaged.

For 3 and 5 Hp, 240 V - For L1 or L2 phases, resistor RS will overheat and open because relay 84 will not pull in. For the L3 phase, refer to the 1 and 2 hp explanation above.

For 480 V - An 84a contact in series with the power supply transformer provides complete protection against damage.

CAUTION: With one missing phase, the LCD will be off, but the bus capacitors will be charged (LED "on"). Allow the bus capacitors to discharge for 1 minute after power is turned off before doing any work on the circuitry. On 240 V models, this is when the display on the digital operation panel goes off; on 480 V models, this is when the LED at the right side of the terminal, under the cover, goes out.

The following input power line conditions may damage the rectifier module: unbalance between phases of more than 3%, or line capacity greater than 500 kVA with severe voltage transients occurring.

As an example, a converter module can be damaged when a number of inverters are connected together with very low impedance line connections, or if power factor correction capacitors may be switched on line. If one of the above conditions exists, damage may be avoided by using a reactor of approximately 3% impedance (percentage of the voltage drop at the rated current) in series with the input power lines for each inverter.

SECTION 7

RENEWAL PARTS AND SERVICE

Good maintenance alone is not always sufficient to keep equipment running. As a service to you, Eaton Corporation maintains an Aftermarket Sales and Service Department in Kenosha, Wisconsin. The services offered include technical assistance, field service engineers, factory repair service and renewal parts stock. So, be sure to take advantage of the technical assistance available; the company has a worldwide network of authorized Service Centers, and Major Parts Distributors.

Spare Parts

Serious consideration should be given to the value of having a replacement unit on hand. The lost profits due to downtime vs. the cost of a spare unit on hand must be evaluated individually. Each installation is unique, and dependent on the output volume of the machine among other factors. For a recommended spare, please contact the Renewal Parts Department at the factory in Kenosha, Wisconsin. In order for the factory to furnish you with accurate information for your particular inverter, please specify the model number.

Ordering Instructions

A list of Eaton's Electric Drives Division Sales Offices and Representatives is included on the back cover of this instruction manual. Become acquainted with the Representatives in your area so you will know where to obtain assistance when necessary. Place orders for renewal parts with the Major Parts Distributor located in your area. If not available, contact the nearest Sales Office directly.

To ensure that correct replacement parts are furnished, include complete nameplate data (model number, date code, etc.) from your specific unit, a purchase order number, description of the part and the quantity required.

Renewal parts will be shipped from distributor stock or factory stock. The standard renewal parts warranty, as published in the Company Terms and Condition of Sales for renewal parts, will apply.

Field Service

We have trained field service engineers at the factory and in key cities around the world. Assistance can be provided over the telephone or by a field trip if circumstances require. A current listing of Field Service Offices, Sales Offices and Major Parts Distributors is available on request.

Repair Service

The service engineers at the factory are available to assist you with repairs. All warranty repairs must be authorized by the Field Service Manager or Repair Service Supervisor at the factory; be sure to furnish the date the drive was purchased.

Return Instructions

Items being returned for warranty repair require a Repair Instruction form, a copy of which is attached. If additional copies are required, contact the nearest Sales Office. To expedite warranty exchange or repair, the form must be filled out accurately and completely. Those items not manufactured by Eaton's Electric Drives Division, such as instruments, meters and digital counters, will be repaired by the original manufacturer; returning them to the Electric Drives Division may delay the repair. Any return, for reasons other than repair or exchange, requires a Return Authorization form from the Product Manager.

SECTION 8

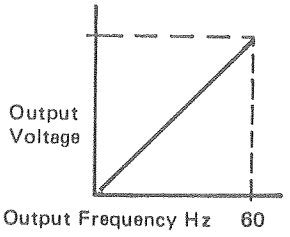
APPENDIX

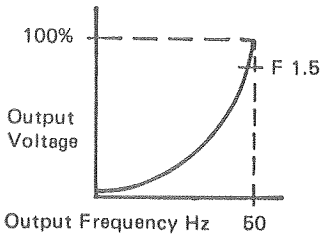
Contents Page No.

Explanation of Appendix Contents

Tables 8-1 and 8-2 are presented to illustrate sample settings and change operations. Table 8-1 consists of V/Hz pattern settings and changes; Table 8-2 shows acceleration/deceleration examples.

Sample V/Hz Pattern Settings and Changes Table 8-1





Operation Step	Key Operation	Display	Explanation
1	Function	F-00 VFE-VC	Selects both Function mode 1 and V/Hz pattern mode.
2	Function	VFE-VC 060-060	Selects Function mode 2.
3	>	VFE-VC 060-060	Press > , and adjust it to the setting and changing position.
4	∧ or ∨	VFA-VC * 050-050	Press ∧ or ∨ : the character will change. Adjust it to a desired character.
5	>	VFA-VC * 050-050	Press > , and adjust it to the setting and changing position.
6	∧ or ∨	VFA-VP1 * 050-050	Press ∧ or ∨ : the code will change. Adjust it to a desired code.
7	Enter	VFA-VP1 050-050	Enters the preset data in memory. NOTE: "When data is saved, "*" will disappear.
8	Monitor	FM 000.00H	Press "Monitor:" the Monitor mode is seleted again. The motor starts running when the operation and frequency commands are entered.
9	Turn Power OFF	_____	Data is stored in an element in which to store it even when power is turned OFF. ??

Sample Acceleration/Deceleration Time Changes — Table 8-2

Operation Step	Key Operation	Display	Explanation
1	Function	F-00 VFA-VC	Selects the Function mode.
2	∧	F-01 ACCEL-1	Selects acceleration time setting mode.
3	Function	ACCEL-1 0030.0 S	Selects the Function 2 mode of acceleration time setting mode.
4	>	ACCEL-1 0030.0 S |__||_| cursor movable	Move cursor and adjust it to the setting and changing position.
5	∧ or ∨	ACCEL-1 * 0130.00S	Press ∧ or ∨ , and adjust to a desired time. NOTE: "!" is displayed when the setting limit is reached.
6	Enter	ACCEL-1 0130.00S	Enters the preset data in memory. NOTE: When data is saved, "*" disappears.
7	Function	F-01 ACCEL-1	After acceleration time is entered the display will return to step 2 above if "Function" is pressed.
8	∧	F-02 DECEL-1	Selects deceleration time setting mode.
9	Function	DECEL-1 0030.0 S	Selects the Function 2 mode of deceleration time setting mode.
10	>	DECEL-1 0030.0 S |__||_| cursor movable	Move cursor to the position in which to set and change the data.
11	∧ or ∨	DECEL-1 * 0130.0 S	Press ∧ or ∨ : the figure in the position at which the cursor is stopping will be changed. Adjust to the desired time. NOTE: "!" is displayed when the preset value limit is reached.
12	Enter	DECEL-1 0130.0 S	Enters the data in memory. NOTE: When data is saved, "*" disappears.

(continued on the next page.)

Sample Acceleration/Deceleration Time Changes (continued) Table 8-2

Operation Step	Key Operation	Display	Explanation
13	Monitor	FM 000.0H	Press "Monitor:" the monitor mode is selected again. The motor starts running when operation and frequency commands are entered.
14	Turn Power OFF	———————	Data is entered in an element in which to save it even when power is turned off.

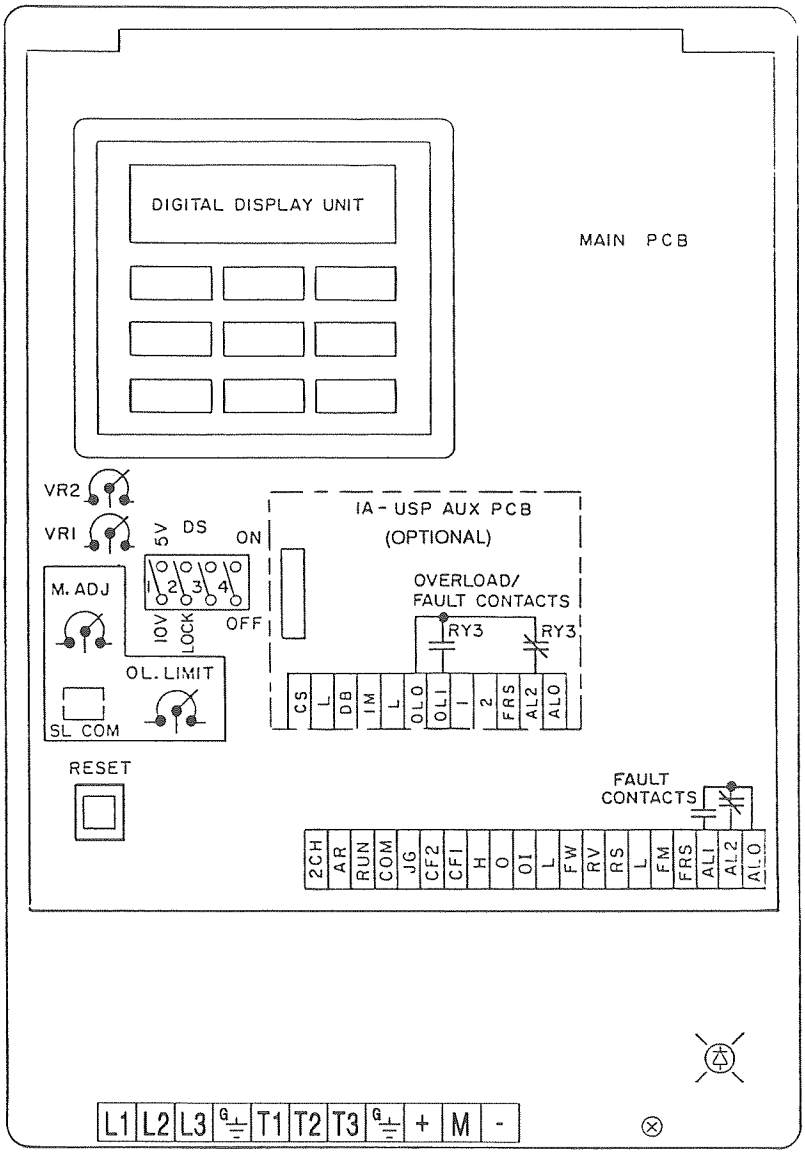
1A-USP Auxiliary PCB, Revision B

AUTOMATIC START UPON APPLICATION OF POWER

> **WARNING:** The automatic start modification automatically starts the drive without warning and without requiring operating personnel to reiniate the start sequence. This modification must be applied only to machinery with all moving parts completely unaccessible to personnel.

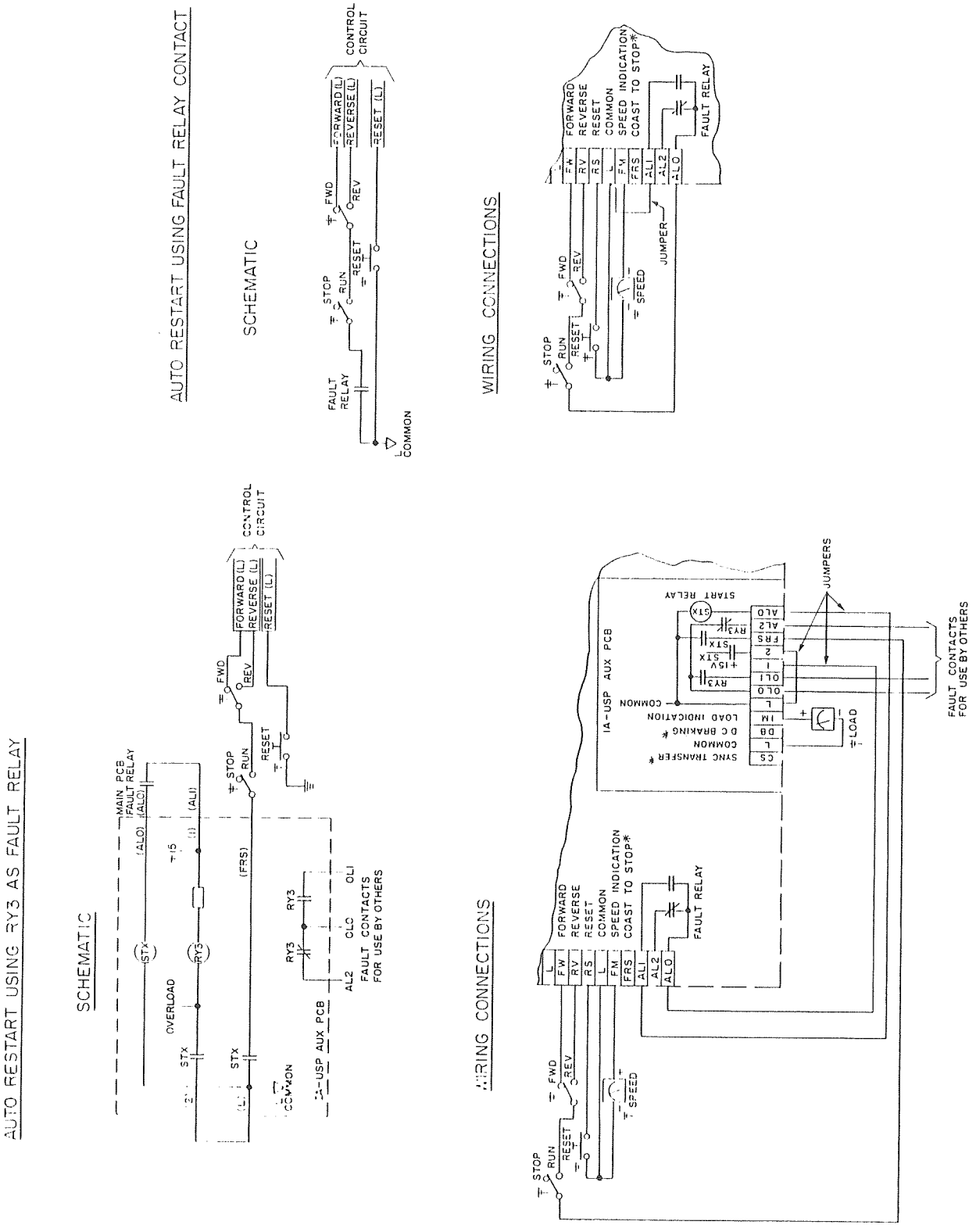
The following instructions are for drives not equipped with auxiliary PCB 1A-USP revision C or later. Follow the instructions given on page 3-15 if 1A-USP revision C or later is installed.

To configure the drive to start automatically upon application of input power, it is necessary to insert, in series with the Run/Stop switch, a relay contact which closes about 1/2 second after power is applied to the drive. The connection diagrams show how the drive's fault relay can be used for this purpose. The connection diagram also shows alternate connections in which a contact of the STX relay is connected in series with the Run/Stop switch. This alternate connection allows the overload warning relay RY3 to be used as a fault relay with one set of form C contacts available for customer use.



PCB Location With 1A-USP Auxiliary PCB, Revision B

Figure 8-1



(1A-USP Auxiliary PCB, Revision B Shown)

ED-60520-1/A

Optional Operator Element Configuration Schematic Diagrams

Figure 8-2

Control Connections for the Aux PCB I/O Table 8-3

Terminal	Type	Functional Description
CS	I,L	Synchronized motor transfer command.
L	Com	Logic circuit common for all inputs and analog outputs.
DB	I,L	Dc Braking control input.
IM	O,A	Motor ammeter signal; 0 to 6 Vdc = 0 to 150% current.
L	Com	Logic circuit common for all inputs and analog outputs.
OLO	O,R	RY3 Relay, NO/NC contact common.
OL1	O,R	RY3 Relay, NO contact.
1	PS	+15 volt power supply.
2	I,*	Jumper connection point for STX relay to pilot RY3. See schematic and connection diagrams.
FRS	O,*	Grounded by closure of NO STX contact. See schematic and connection diagrams.
AL2	O,R	RY3 Relay, NC contact.
ALO	I,*	STX relay coil (15 V, 15 mA). See schematic and connection diagrams.

Monitor Mode Reference and Setting Record — Table 8-4

Item	Display (Defaults shown)	Setting Record	Notes
1	FM 000.0 Hz		
2	FS 000.0 Hz		
3	F-SET-M Ope.-Key		
4	F/R-SW Ope.-Key		
5	RPM 4P 00000rpm		
6	IF----A Im000.0%		
7	V-Boost Code<31>		
8	V-Gain 100%		
9	Jogging 01.0 Hz		
10	#		

Function Mode Reference and Setting Record — Table 8-5

Item	ID Display	Adjustment Display (Defaults shown)	Setting Record	Notes
1	F-00 VFE-VC	VFE-VC 060-060		
2	F-01 ACCEL-1	ACCEL-1 0030.0 S		
3	F-02 DECEL-1	DECEL-1 0030.0 S		
4	F-03 +Fmax.	+Fmax. 000.0 Hz		
5	F-04 Fmin.	Fmin. 000.5 Hz		
6	F-05 H-LIM-F	H-LIM-F 000.0 Hz		
7	F-06 L-LIM-F	L-LIM-F 000.0 Hz		
8	F-07 JUMP-F1	JUMP-F1 000.0 Hz		
9	F-08 JUMP-F2	JUMP-F2 000.0 Hz		
10	F-09 JUMP-F3	JUMP-F3 000.0 Hz		
11	F-10 CF-code	CF-code <N>		
12	F-11 Fstop-T	Fstop-T 001.0 S		
13	F-12 Speed-1	Speed-1 000.0 Hz		
14	F-13 Speed-2	Speed-2 000.0 Hz		
15	F-14 Speed-3	Speed-3 000.0 Hz		
16	F-18 ACCEL-2	ACCEL-2 0030.0 S		
17	F-19 DECEL-2	DECEL-2 0030.0 S		
18	F-20 F-DCB	F-DCB 001.0 Hz		
19	F-21 V-DCB	V-DCB 000		
20	F-22 T-DCB	T-DCB 000.0 S		
21	F-23 E-therm	E-therm 100%		
22	F-24 ACCline	ACCline Linear		
23	F-25 DECline	DECline Linear		
24	F-26 F-START	F-START 000.0 Hz		
25	F-27 F-END	F-END 000.0 Hz		
26	F-28 SWITCH1	SWITCH1 00000111		
27	F-30 LM.CONS	LM.CONS 0001.0		
28	F-31 OLalarm	OLalarm 100%		
29	F-32 V-auto	V-auto +00		
30	F-33 IPS-T	IPS-T 001.0 S		
31	F-36 IPS-R-T	IPS-R-T 0001.0 S		

This equipment contains electronic components that can be damaged by static electricity. The following precautions will reduce the possibility of damaging electrostatic sensitive components.

CAUTION Disconnect power before working on the equipment. Installation and service must be performed only by qualified personnel observing appropriate safety precautions and following the instructions provided for the equipment.

Before opening the enclosure, discharge static electricity from your body by touching a grounded metal object.

When installing the equipment, connect the equipment ground conductor as soon as possible.

Keep your hands and tools away from the electronic circuitry as much as possible. Non-conductive materials such as paper, plastic and Styrofoam must be kept away from the electronic circuitry. Do not use tape in the equipment enclosure. Pulling tape from a roll generates a high static charge.

When working on the electronic circuitry, wear a high resistance grounded wrist strap (sold by many consumer and industrial electronic component suppliers).

When replacing a printed circuit board, do not remove the board from its static shielding bag until you are prepared to install it. While wearing a grounded wrist strap, transfer the board directly from the bag to the mounting position.

Printed circuit boards must be repaired by technicians trained for working with electrostatic sensitive components. Repair must be performed at an electrostatic protected workbench using appropriate tools.

Contact Eaton for additional information regarding proper handling and repair of electrostatic sensitive electronic circuitry. Additional information is also available in a variety of handbooks and electronics industry publications.

⚠ Caution

Please Observe The Following Safety Guidelines

Allow Installation and Service by Qualified Personnel Only

Electrical rotating equipment and associated controls can be dangerous. Therefore, it is essential that only trained personnel be allowed to work with this equipment, under competent supervision. The danger is increased when the equipment is not handled, installed, maintained or used properly.This equipment must be installed, adjusted and serviced only by qualified personnel familiar with the construction and operation of the equipment and the hazards involved. Failure to observe this precaution could result in personal injury and/or equipment damage.

Read Instructions and Warnings

These instructions should be read and clearly understood before working on the equipment. Become especially familiar with all safety instructions and procedures. Read and heed all danger, warning and caution notices contained in this manual and attached to the equipment and be sure to instruct others in their meaning and importance.

Danger, High Voltage
Disconnect Power Before Servicing Equipment

Various component parts and terminals of the drive equipment are at or above line voltage when AC power is connected to the input terminals. All ungrounded conductors of the AC power line must be disconnected before it is safe to touch any internal parts of this equipment. Some control equipment may contain capacitors that retain a hazardous electrical charge for a period of time after power is removed. After power is removed, wait at least two minutes to allow capacitors to discharge before touching any internal parts of the equipment. Failure to observe these precautions could result in fatal injury.

Precautions When Working On Live Circuits

Stand on an insulating mat. Make a habit of using only one hand. Make sure that there is another person nearby in case emergency assistance is required.

Application of Equipment and Safety Devices

The adjustable speed drive and all components of the drive system, such as operator control devices, electrical power distribution equipment, the motor and mechanical power transmission equipment, must be properly selected and applied to assure a safe and reliable installation. Each individual installation has unique requirements for safety equipment such as emergency stop pushbuttons, pre-start alarms, motor and power disconnect devices and guards on mechanical power transmission apparatus. The party responsible for the overall design and operation of the facility must make sure that qualified personnel are employed to select and apply all components of the drive system including appropriate safety devices.

Hazard of personal injury or equipment damage exists if the drive and/or the driven machine are operated above their rated speed due to misadjustment or electronic failure. Be sure to consider this factor in selecting gear ratios and safety devices.

Always Wear Safety Glasses

Safety glasses should be worn by all personnel involved in installing or maintaining the equipment. This applies equally to all electrical and mechanical workers. Other safety clothing should be selected as appropriate to the task and work environment.

Handle With Care

Handle the equipment carefully to avoid personal injury or damage to the unit.

Provide Appropriate Guards Around Moving Parts

Before operating the equipment, make sure that appropriate guards and other safety devices are in place. Refer to OSHA rules and regulations, paragraph 1910.219 for guards on mechanical power transmission apparatus.

Observe Requirements of the National Electric Code

All wiring must be in accordance with the National Electrical Code (NEC) and/or other codes as required by the authority having jurisdiction. The electrical connections completed by the installer must conform to the instructions and diagrams supplied.

National Electric Code Article 430-102 requires a disconnecting means for each motor and controller located in sight from the motor, controller and driven machinery locations or capable of being locked in the open position if not located in sight. This disconnecting means is not included with the drive equipment unless specifically ordered.

Not for Use in Hazardous Locations

Unless specifically labelled as approved for such use, this equipment is not suitable for use in an explosive atmosphere or in a "Hazardous (Classified) Location" as defined in article 500 of the National Electrical Code.

Provide Adequate Ground Connections

For personnel safety and reliable equipment operation, firmly earth ground each piece of equipment as directed in this manual and shown on the connection diagrams provided. The ground conductor should be the same size as the incoming power wires or sized according to NEC table 250-95. A copper or aluminum conductor must be used. Grounded conduit connections are not adequate for use as equipment ground connections.

Instruction Material and Drawings

In addition to this manual, data sheets, drawings, supplementary instruction sheets and errata sheets may be included in the package of instruction material that is furnished for each drive. Be sure to save each of these items for future reference. The drawings and data included in this manual are generally representative of the product line, but do not accurately include every detail pertaining to specific equipment provided for an individual customer order. Drawings and data sheets which are identified by PRO/Serial number as pertaining to a specific piece of equipment take precedence over this manual. **Note:** The information furnished may not cover changes made to the equipment after shipment. **All data is subject to change without notice.**

Technical Assistance

It is usually best to request assistance through your local Eaton Dynamatic Products distributor or your local Eaton Cutler-Hammer and Dynamatic Products sales office. Sales office locations are listed on the back cover of this manual. To obtain the phone number of your local sales office or distributor, call our customer service department at 1-800-833-3927. The customer service department can also provide phone numbers for contacting various departments at our factory in Kenosha, Wisconsin.

Eaton provides a comprehensive range of customer support services for Electric Drives and other Industrial Control and Power Distribution products.

- Product specifications, catlogs, sales literature and technical publications
- Price quotations
- Order entry
- Order scheduling information
- Application engineering consultation
- Training seminars
- Retrieval of equipment data for specific serial numbers
- Instruction materials, drawings and data sheets
- Technical support by telephone
- Field service repair assistance
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- Equipment modification and upgrading services
- Warranty service
- Replacement parts

Call 1-800-833-3927 to contact your regional Eaton Customer Support Center and obtain the telephone number for the assistance you need.

Eaton's total customer support network includes:

- Regional Eaton Customer Support Centers
- Eaton Sales Offices located in most major metropolitan areas
- A large network of Electric Drive Distributors
- Major Parts Distributors that maintain a stock of replacement parts in various regional locations
- Field service technicians located near most major industrial areas

Eaton Industrial Control and Power Distribution Sales Office Locations:

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