ALLEN-BRADLEY
A ROCKWELL INTERNATIONAL COMPANY

Instruction Manual

Bulletin 1379 Three Phase DC Drive Modules

Series B

Price: $25.00

Important User Information

Because of the variety of uses for this equipment and because of the differences between this solid state equipment and electromechanical equipment, the user of and those responsible for applying this equipment must satisfy themselves as to the acceptability of each application and use of the equipment. ***In no event*** will Allen-Bradley Company be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The illustrations, charts and layout examples shown in this manual are intended solely to illustrate the text of this manual. Because of the many variables and requirements associated with any particular installation, the Allen-Bradley Company ***cannot*** assume responsibility or liability for actual use based upon the illustrative uses and applications.

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WARNING: Warnings tell readers where people may be hurt if procedures are not followed properly.

CAUTION: Cautions tell them where machinery may be damaged or economic loss can occur if procedures are not followed properly.

Both of these:

- Identify a possible problem.
- Tell what causes the problem.
- Give the results of improper action.
- Tell the reader how to avoid the problem.

Repair/Exchange Procedure

For your convenience, the Allen-Bradley Company Drives Division and the Allen-Bradley Company Customer Support Services Division provide an efficient and convenient method of returning equipment eligible for repair or repair/exchange.

A Product Service Report (PSR) number is required to return any equipment for repair. This may be obtained from your local Allen-Bradley Distributor, Sales Office, or Area Service Center.

Return any equipment to be repaired to the Area Service Center nearest you. Be sure to reference the PSR number on the carton and packing slip. Include your company name and address, your repair purchase order number, and a brief description of the problem. This will facilitate quick return of your equipment.

A complete listing of Area Service Centers may be found in Publication CSS GI-1.1 or call your local Allen-Bradley Distributor or Sales Office.

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SPECIFICATIONS

AC LINE VOLTAGE

Three phase 230V AC or 460V AC
(+10%, −5%)

AC LINE FREQUENCY

50 or 60 Hz

ARMATURE POWER SUPPLY

3 phase, full wave (6 pulse)

ARMATURE CURRENT LIMIT RANGE

0% to 100% rated current for continuous operation; to 150% current for 1 minute.

MOTOR FIELD SUPPLY RATING

3 phase, rectified power at 150 or 300V DC
(10 Amperes maximum)

MODULE HP RANGE

105 Amp Module —
7½ to 30 HP at 240V DC
7½ to 60 HP at 500V DC

250 Amp Module —
40 to 75 HP at 240V DC
75 to 150 HP at 500V DC

345 Amp Module —
100 HP at 240V DC
200 HP at 500V DC

REGULATION TYPES

Armature Voltage

Speed

SPEED REGULATION (% OF BASE SPEED)

Feedback Source	Operating Deviation	Service Deviation
Armature Voltage	2%	5%
AC Tachometer (Type AN)	1%	2%
DC Tachometer (Type PY)	1%	1%
DC Tachometer (Type 42)	0.5%	0.5%
DC Tachometer (Type 46)	0.1%	0.15%

CURRENT LIMIT

Adjustable 0 to 150%

IR COMPENSATION

Adjustable from 0 to 10% of maximum armature terminal voltage

ADJUSTABLE MAXIMUM SPEED

80 to 110% of motor base speed

ADJUSTABLE MINIMUM SPEED

0 to 33% of maximum speed

ADJUSTABLE JOG SPEED

0 to 50% of maximum speed

ADJUSTABLE PRESET SPEED

0 to 100% of maximum speed

LINEAR ACCEL/DECEL RATES

Separately adjustable/Dual Range
0.4 to 15 seconds
3.0 to 60 seconds

DC MOTOR POWER SUPPLY CODE

NEMA Design "C"

AMBIENT TEMPERATURE RANGE

0°C (32°F) to 40°C (104°F) - Operating
0°C (32°F) to 60°C (140°F) - Storage

RELATIVE HUMIDITY

5 to 95% (non-condensing)

OPERATIONAL ALTITUDE

3300 ft. (1000 m)

APPROXIMATE SHIPPING WEIGHT

105 Amp Module — 60 lbs. (27.18 kg)
250/345 Amp Module — 87 lbs. (39.41 kg)

IMPORTANT: SAVE THESE INSTRUCTIONS FOR FUTURE REFERENCE.

1.0 INTRODUCTION

1.1 GENERAL — This manual contains information needed to install, start up and maintain the Allen-Bradley Bulletin 1379 Series B Non-Regenerative DC Drive Module.

> **WARNING:**
>
> The National Electrical Code (NEC) and local codes outline provisions for safely installing electrical equipment. Installation must comply with specifications regarding wire types, conductor sizes, branch circuit protection, and disconnect devices. Failure to do so may result in personal injury and/or equipment damage.

> **CAUTION:**
>
> An incorrectly applied or installed Drive Module can result in component damage or a reduction in product life. Wiring or application errors, such as, undersizing the motor, incorrect or inadequate AC supply, or ambient temperatures above or below specified temperature range may result in malfunction of drive.

1.2 MODULE COMPONENTS —

THYRISTOR CONVERSION UNIT —

- 6-thyristor full wave armature power conversion unit.
- Incoming AC power is converted into adjustable DC voltage. This DC power is then typically delivered to the DC motor armature through the contacts of an optionally supplied DC loop contactor. The speed and armature current of the DC motor are controlled by regulating the output voltage of the armature power conversion unit.
- Armature power conversion unit assembly can be conveniently removed from the module to facilitate quick replacement and/or repair.

MAIN REGULATOR BOARD —

- Regulator — The regulator incorporates high gain operational amplifiers to provide a wide range of motor speed control. A major integrating speed loop is combined with an "inner" armature current loop to provide precise "no overshoot" current limit control.
- Digital Gating Circuit — Precise gating of the SCRs is accomplished by digitally combining the phase control signal and line sync signals at optimum time and energy levels to gate the thyristors while maintaining excellent electrical noise immunity characteristics.
- Protective Circuits With Light Emitting Diode (LED) Fault Indication simultaneously activates the fault relay and provides memory-type indication of Overload, Field Loss, Phase Loss, and Thyristor Overtemperature conditions.
- Digital Static Overload Circuit — Armature current level controls the counting rate of a digital counter to provide an inverse time versus current trip characteristic.
- Isolated Armature Voltage and Armature Current Feedback Signals.

POTENTIOMETER ADJUSTMENT BOARD — All the necessary set-up adjustments are located on this board, which permits replacement of Main Regulator Board without recalibration.

RELAY BOARD — Provides mounting and wiring of four "plug-in" relays for AC Logic functions of Run, Reference, Preset Speed, and Jog.

FIELD LOSS BOARD — Field current is sensed with an isolated current transformer to actuate a relay mounted on the Main Regulator Board. Loss of field current causes the relay to de-energize and shut down the DC Drive Module output and drop out the DC loop contactor.

1.3 OPERATION — The Allen-Bradley Bulletin 1379 Series B DC Drive Module converts incoming three-phase AC power into the controlled DC voltage and current used by a DC motor.

In general the Drive Module provides a means of regulating Armature Voltage or Speed within the following limits.

1.3.1 SPEED RANGE — The normal range in speed for these drives is from base speed to 1/20 of base speed, although they may be operated over a greater range. Operating motors continuously at or above rated full load torque at reduced speeds may cause an above normal temperature rise and derating of motor may be necessary to achieve a greater speed range.

1.3.2 SPEED REGULATION — Speed regulating performance of DC SCR drives is specified in two ways: **operating deviation** and **service deviation.**

Operating deviation defines speed change due to load change and typically assumes:

1. A change from one steady state load value to another. (Not transient).
2. A 95% maximum load change.

Service deviation defines speed change due to changes in ambient conditions with typical variations as follows:

Condition	Change
AC line voltage	+10% −5%
AC line frequency	+ 1% −1%
Ambient temperature	15°C

The speed regulating performance is specified as **operating/service** band. For example:

Basic — 2%/5% of base speed (Voltage Regulated)

Modified — 1%/2% of base speed (AC Tachometer)
1%/1% of base speed (DC Tachometer)
0.5%/0.5% of base speed (DC Tachometer)
to 0.1%/0.15 % of base speed (DC Tachometer)

1.3.3 STARTING — A smooth cushioned start is provided by proper adjustment of the acceleration time control. The starting or acceleration time may be adjusted over a range of 0.4 to 15 seconds or 3.0 to 60 seconds. If the speed control device is set lower than base speed, the total acceleration time is reduced in proportion. The acceleration is constant over this interval unless the load and its moment of inertia are too great for the available torque. This torque and the corresponding armature current are limited by the setting of the adjustable current limit control and the motor rating.

1.3.4 STOPPING — When the Stop button is operated, the motor armature is disconnected allowing the motor and driven machine to coast to a stop. The time required to stop depends upon the inertia of moving parts and friction of the system. Dynamic braking is available to reduce stopping times but is not recommended for overhauling loads or repetitive operation.

1.3.5 MAXIMUM SPEED — Calibration adjustment of the speed feedback signal to limit the motor to maximum speed when the speed reference is at a maximum setting (not to exceed the rated rpm).

1.3.6 STABILITY — Compensates for various load inertia levels to achieve stable operation.

1.3.7 MOTOR CURRENT LIMIT — Calibration adjustment to limit the maximum amount of current that is applied to the armature. Current Limit is adjustable from 0% to 150% of rated armature current.

1.3.8 OVERLOAD CAPACITY — The current limiting circuits are intended to protect the thyristors from damaging currents during starting or running, and the driven machine from excessive shock of torque under overload or starting conditions. The thyristors, (SCR's) and other components will withstand 150% of full load current for 1 minute. If this limit is exceeded the semiconductors and other components may be damaged.

1.3.9 ACCEL RATE — Controls the time it will take for the drive motor to accelerate to a set speed when the reference signal is increased.

1.3.10 DECEL RATE — Controls the time it will take for the drive motor to decelerate when the reference signal is decreased provided machine coasting time is shorter than Decel setting.

1.3.11 RATE SELECTION — The Accel and Decel rate pots share a common ramp generator circuit with two pre-selectable time rates to provide a greater degree of flexibility in establishing an optimum setting for various applications.

Selection of either a 0.4 to 15 second or a 3.0 to 60 second rate can be accomplished at the job-site without disturbing the wiring by using the "SIP" Jumper module provided on each potentiometer board.

1.3.12 IR COMP. — This adjustment compensates for the armature voltage drop under a heavy load condition to maintain the selected speed via an armature voltage signal to the speed amplifier. (Armature voltage feedback drives only).

1.3.13 PRESET SPEED — Provides an independent separately adjustable motor speed from 0% to 100% of maximum speed.

1.3.14 MINIMUM SPEED — Sets the minimum motor speed from 0% to 33% of maximum speed.

1.3.15 JOG SPEED — Adjusts the speed of the drive motor during the Jog mode from 0% to 50% of maximum speed.

1.3.16 OPTIONAL C.L. — Custom design feature.

1.4 DIAGNOSTICS —

OVERLOAD — A red indicator is illuminated whenever a current limit overload condition exists for a predetermined time. For example, this indicator will become illuminated if a 150% current limit condition exists for one minute, causing the drive to shut down. Lower current limit levels will permit continued drive operation for a longer period before drive shut-down will occur.

PHASE LOSS — A red indicator is illuminated whenever irregularities in armature current caused by either a loss of phase or a loss of thyristor firing pulses are sensed. This condition causes the drive to shut down immediately.

FIELD LOSS — A red indicator is illuminated whenever shunt field current is lost, causing the drive to shut down immediately.

THYRISTOR OVER TEMP. — A red indicator is illuminated whenever the Thyristor heatsinks become overheated, causing the drive to shut down.

RESET INHIBIT — An amber indicator is illuminated at approximately 105% current limit. If an overload occurs with this indicator illuminated, the drive will shut down and disable the Reset button for a period of four minutes after which time the Reset Inhibit indicator will extinguish, allowing the drive to be reset.

OVERLOAD CONDITION — An amber indicator is illuminated at approximately 105% current limit. When this indicator is illuminated the drive will shut down after a predetermined time, dependent upon the armature current level (see Overload description above) or immediately if any of the other fault conditions described above occur. The amber indicator extinguishes when the drive shuts down.

RESET — The Reset button must be depressed and held in for 2 seconds to 3 seconds subsequent to a fault trip (as determined by the front panel Visual indicators) in order to enable the drive control functions.

MEMORY — Red diagnostic indicators remain lighted after shutdown to aid in troubleshooting.

1.5 OPTIONAL EQUIPMENT —

1.5.1 DC LOOP CONTACTORS — Magnetically operated DC contactors provide an additional margin of safety by disconnecting the motor armature from the power converter when a stop is initiated or in the event of a power failure.

1.5.2 DYNAMIC BRAKING — Power resistors are electrically connected across the DC motor armature after it is disconnected from the power converter circuit. Power generated by the load driving the motor is dissipated by the resistors and rapid stopping of the motor is accomplished by dynamic braking. Peak braking torque is 150% of continuous motor torque. Braking effect decreases as motor slows down. Not recommended for overhauling loads or repetitive operation.

1.5.3 TACH FEEDBACK BOARD — The purpose of the Tachometer Feedback Board is to provide an interface between the speed feedback signal and the drive speed amplifier.

Since the tachometer generator is connected to the motor shaft, it furnishes a voltage signal which is proportional to the actual speed at which the shaft is rotating.

The drive speed amplifier along with the speed reference and tachometer feedback signals are interconnected such that the speed amplifier can compare the two signals to determine any difference (error). If a difference exists, the speed amplifier uses that difference as the input signal to allow the drive to respond in the direction that tends to reduce the error. In this manner, the speed amplifier forms a regulator loop which attempts to make the reference and feedback signals equal to enable the drive to operate at regulated speed.

1.5.4 PROCESS INSTRUMENT FOLLOWER — The unit serves as an interface between analog reference signals and the Bulletin 1379 Drive Module. The unit converts an input voltage signal (computer or other device) of 0V DC to + 10V DC or an input current signal (transducer) of 4mA to 20mA to an output voltage level of 0V DC to −7V DC through the use of operational amplifiers. A transformer provides inherent isolation between input and output signals. The board contains individual ±6.2V DC power supplies for offset biasing.

The Process Instrument Follower is connected in place of the Speed Potentiometer and is utilized in the Run mode of operation. The input signal is applied to terminals #1 and #2 (+) for 4mA to 20mA and to terminals #1 and #3 (+) for 0V DC to +10V DC and then directed to a scaling amplifier.

Potentiometer 1RH varies the gain of the amplifier while 2RH permits nulling the output to zero to compensate for any amplifier offset. The succeeding amplifiers function as a triangle wave generator to produce a fixed frequency pulse train precisely clamped to ±6.2V DC. The pulse train is differentiated and directed to a transformer which electrically isolates the input and output circuitry. The resulting AC signal is demodulated at the secondary side of the transformer and again precisely clamped at ±6.2V DC. The pulse train is then averaged to a voltage level and filtered, producing an output from 0V DC to −7V DC. The Preset Speed and Jog modes function independently of the Process Instrument Follower, however the minimum speed pot is bypassed and no longer functional in the auto mode.

1.5.5 CIRCUIT CHECKER — The purpose of the Circuit Checker is to provide selectable test points that may be monitored by a meter or oscilloscope.

This assembly will allow monitoring of six vital signals in the Bulletin 1379 Drive Module regulator.

A multi-range, zero center meter is connected to the appropriate scaling resistors and connection points in the drive via a seven position pushbutton switch.

Depressing any of the six black pushbuttons connects the meter to the corresponding test point in the Drive Module. Depressing the red pushbutton disconnects the meter from all test points.

The test points are indicated on the Drive Module schematic diagram as small hexagons with the test point number within the hexagon.

The schematic diagram will also have a Circuit Checker table showing test point number, full scale voltage, and maximum voltage to be expected at that test point.

Use of the Circuit Checker in troubleshooting enables rapid isolation of faults to one or two possible circuit locations.

The two test jacks located on the front panel of the Circuit Checker are used for connecting an oscilloscope or other test equipment.

The meter needle deflects to the left for negative polarity signals and to the right for positive polarity signals.

The bottom scale of the meter is read for signals up to 10 volts and the top scale indicates 2.5, 25 or 250 volts.

1.5.6 SPEED INDICATOR — 4½″ meter and special factory designed calibration adjustment for separate mounting. Meters are marked zero to 100 percent of base speed.

1.5.7 LOAD INDICATOR — 4½″ 50 mV shunt rated meter for separate mounting. Meters are marked zero to 150 percent load. The load signal is obtained from armature current feedback element.

1.5.8 OPERATOR'S CONTROL STATION — Remote mounting NEMA Type 13 units provide the appropriate drive control functions desired.

1.5.9 ISOLATION TRANSFORMER — All units have NEMA Type 1 enclosed construction for remote mounting. Full capacity above and below normal primary taps are provided to accommodate typical input voltage variances. Isolation transformers provide these benefits:

- Guards against inadvertant grounding of plant power lines through grounds in the DC motor armature circuit.
- Enhances protection of semiconductors from line voltage transients.
- Reduces disturbances from other solid state control equipment such as drives without isolation transformers, time clock systems, electronic counters, etc.

2.0 UNPACKING AND INSPECTION

2.1 UNPACKING — Remove all packing material, wedges, or braces from within the drive controller. If any part of the equipment will not be installed when it is unpacked, it should be stored in a clean, dry place. The storage temperature must be between 0°C and 60°C to guard against damage to components.

2.2 INSPECTION — After unpacking, check the material received against the Bill of Lading to assure that the nameplate description of each item agrees with the material ordered. Inspect the controller for physical damage such as dents or broken wire. If damage is found, a claim should be filed immediately with the carrier.

NOTE:

Before the installation and start-up of a drive, a general inspection of mechanical integrity, i.e. loose parts, wires, connections, packing materials, etc. should be made.

3.0 INSTALLATION

WARNING:

The National Electrical Code (NEC) and local codes outline provisions for safely installing electrical equipment. Installation must comply with specifications regarding wire types, conductor sizes, branch circuit protection, and disconnect devices. Failure to do so may result in personal injury and/or equipment damage.

WARNING:

Only qualified personnel familiar with Drives and associated machinery should plan or implement the installation, start-up and subsequent maintenance of the Drive. Improper installation, start-up, or maintenance procedures could result in injury to personnel and/or damage to equipment.

3.1 GENERAL — The National Electric Code and/or local codes will govern the installation and wiring of this equipment. Connections can be made in accordance with the typical wiring diagrams shown in **APPENDIX A** through **K.** Since most start-up difficulties are the result of incorrect wiring, every precaution should be taken to assure that the wiring is as shown on the diagram.

3.2 WIRING — Check all external connections carefully against the wiring diagrams. Make sure shielded cables are used where called for on the wiring diagram. Shields are to be grounded only at the controller end.

Wires connected to the Drive Module terminal block should be routed to the side of the drive cabinet and brought out through the bottom of the cabinet. These wires must not pass in front of the fan blades and obstruct the flow of cooling air through the heat sinks and over the silicon controlled rectifiers.

ITEM 1, CONDUITS — Separate steel conduits are recommended for:

Incoming AC Power conductors

Outgoing DC Power conductors

Control circuit wires from push buttons or equivalent contacts

Low-Level (analog) signal wires (See Table 3-C for recommended type)

ITEM 2, GROUNDING — To ground the motor armature or field circuit, an isolation transformer must be connected at the 3-Phase AC input circuit of the controller. The armature and field circuits must not be grounded at the same time.

3.3 DISCONNECT — Provisions must be made for a suitable disconnect means located on the AC supply line in order to allow for a complete removal of power from the Drive Module. If an isolation transformer is used, the disconnect is to be wired into the secondary circuit. Refer to **APPENDIX A.** The switch installation must meet NEC and local requirements.

3.4 ISOLATION TRANSFORMER — Location and installation is to be in compliance with all local and national safety codes and manufacturer's recommendations. Adequate ventilation must be provided for proper operation. Refer to **APPENDIX A** and **B** for wiring diagrams. REMOVE EXCESS PROTECTIVE VARNISH FROM ALL TERMINALS BEFORE MAKING ELECTRICAL CONNECTIONS.

3.5 MOTOR/TACHOMETER — Mount motor on rigid support base and carefully align shaft with load and tachometer coupling. If a belt or chain drive is used, excessive tension must be avoided to minimize the radial forces on the bearings. Refer to manufacturer's instructions packed with the motor and tachometer. Adequate ventilation must be provided for proper operation. Refer to nameplate data and **APPENDIX A** and **E** for wiring diagrams. All wiring is to be done in accordance with local and national electrical codes.

> **NOTE:**
>
> Motor and tachometer shafts should be rotated manually to verify free rotation. Obstructions detected must be removed before any power is applied.

3.6 THERMOSTATS — When the motor or transformer chosen for the application has an internal thermostat, the normally closed contacts are to be wired in Series with the Stop push button. Refer to **APPENDIX B** and **D.**

3.7 CONTROLLER — The Drive Module should be mounted securely in an upright position on a flat, vertical mounting surface. Allow at least **four inches** of clearance at the top and bottom of the enclosure for ventilation. Control connections are made to the terminal strip at the bottom of the controller assembly and power connections to the terminations on top.

The controller should not be subjected to shock, vibration, moisture, dust or corrosive vapors. Ventilating openings must not be obstructed. The maximum ambient temperature should not exceed 40°C (104°F).

ITEM 1, FIELD LOSS CALIBRATION — Install a one-half watt, 5% resistor (furnished with the module) between the terminals on the 2-terminal strip on the Field Loss Board located just below the terminal block 1TB (see Figure 3-1). The value of this resistor depends upon the rated shunt field current of the motor used with the drive, and can be found in Table 3-A.

TABLE 3-A — FIELD LOSS RESISTOR SELECTION TABLE

Motor Field Current (Amperes) [1]		Resistor [2] (OHMS)
From	To	
8.739	10.401	6.8
7.337	8.744	8.2
6.664	7.947	9.1
5.604	6.694	11.0
4.824	5.771	13.0
4.251	5.094	15.0
3.631	4.360	18.0
3.067	3.693	22.0
2.597	3.138	27.0
2.221	2.693	33.0
1.961	2.385	39.0
1.624	1.987	51.0
1.351	1.664	68.0
1.088	1.353	100.0
0.879	1.105	160.0
0.737	0.937	270.0
0.586	0.759	1000

[1] Motor field current is taken from the name plate of the motor.

[2] 5%, 1/2-watt or greater.

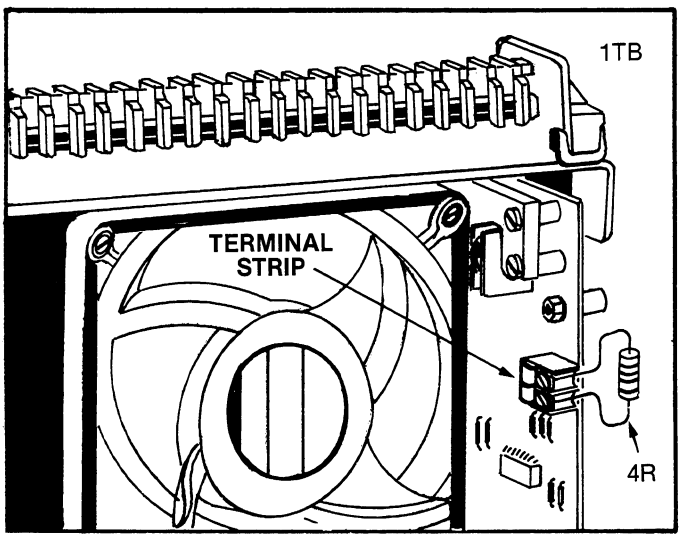


Figure 3-1 — Location of Field Loss Calibration Resistor (Bottom View of Module)

ITEM 2, SHUNT INSTALLATION — Installation of the ammeter shunt can be accomplished by following a few simple steps with the aid of the accompanying diagram.

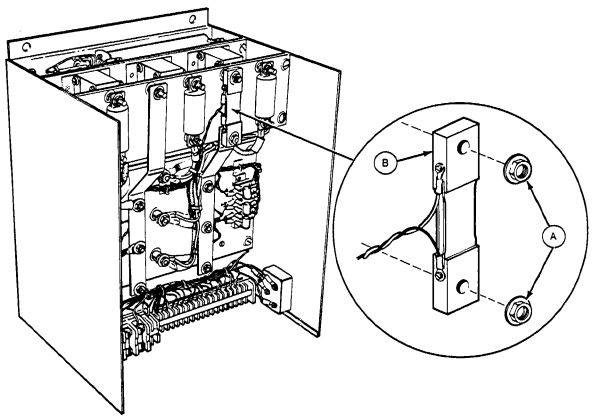
> **WARNING:**
>
> Disconnect and lock out control equipment from power sources before maintenance or repair to avoid hazards of electrical shock or unintended actuation of controlled equipment.

TABLE 3-B — SHUNT SELECTION DATA

Motor Armature Voltage	Horsepower	Shunts	
		Ampere Rating	Catalog Number
240 Volts DC	7½	45A	1370-SL66
	10	59A	1370-SL67
	15	85A	1370-SL68
	20	111A	1370-SL69
	25	137A	1370-SL70
	30	164A	1370-SL71
	40	217A	1370-SL72
	50	268A	1370-SL73
	60	320A	1370-SL74
	75	395A	1370-SL75
	100	529A	1370-SL76
500 Volts DC	7½	21A	1370-SH66
	10	28A	1370-SH67
	15	45A	1370-SH68
	20	53A	1370-SH69
	25	67A	1370-SH70
	30	85A	1370-SH71
	40	111A	1370-SH72
	50	137A	1370-SH73
	60	164A	1370-SH74
	75	191A	1370-SH75
	100	268A	1370-SH76
	125	320A	1370-SH77
	150	395A	1370-SH78
	200	529A	1370-SH79

105 AMP MODULES —

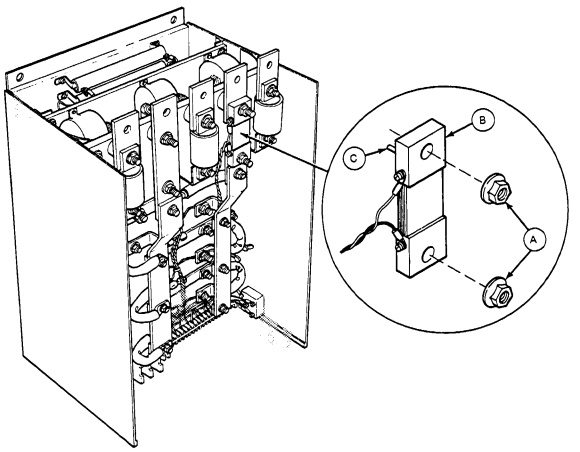
1. Remove keps-nuts (A) from two brass bolts located on upper right-hand side of fuse mounting plate.
2. Orient shunt (B) such that screw terminals are located on left side.



3. Using the screws provided on the side of the armature current shunt, connect existing gray-black twisted pair of wires. The location of the gray conductor on the side of the shunt does not affect drive operation.
4. Install shunt over the two brass bolts described in step 1. Wires must not be routed over front of shunt.
5. Reinstall the keps-nuts. Then tighten the keps-nuts to (35) inch pounds.

250 AMP AND 345 AMP MODULES —

1. Remove two keps-nuts (A) from two brass bolts located on upper right-hand side of fuse mounting plate. Do not remove the short piece of bus bar from the upper bolt.
2. Orient shunt (B) such that screw terminals are located on left side with orientation pin (C) toward rear of drive.
3. Using the screws provided on the side of the armature current shunt, connect the existing gray/black twisted pair of wires. The location of the connection of the gray conductor on the side of the shunt, does not affect drive operation.
4. Assure that the screw terminals with attached wires are located on left side of the shunt and the orientation pin (C) is facing the bus bar. Install shunt over the two brass bolts described in step 1. Assure that the orientation pin (C) properly engages with the hole in the upper short piece of bus bar. Wires must not be routed over front of shunt.
5. Reinstall the keps-nuts. Then tighten the keps-nuts to (75) inch pounds.



ITEM 3, CONTROL TRANSFORMER WIRING —

1. The Drive Module, as shipped from the factory is wired for 460V AC operation. If 230V AC operation is desired, remove the jumper between terminals H2 and H3 on the control transformer (as shown in Figure 1a), and connect jumpers between H1 and H3 and between H2 and H4 (as shown in Figure 1b).

   In addition for 230V AC operation, install a jumper wire between terminals 38 and 39 on the right-hand terminal strip on the Main Control Board. (See Figure 4-2).

> **NOTE:**
>
> This transformer is located on the rear panel of the Module. See **APPENDIX L.**

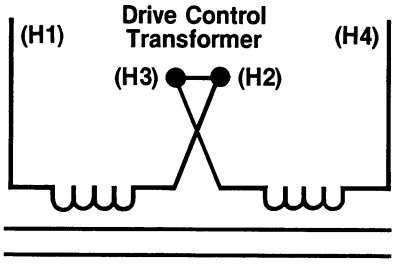


Figure 1a — Connection for 460V AC Operation of 1 PT

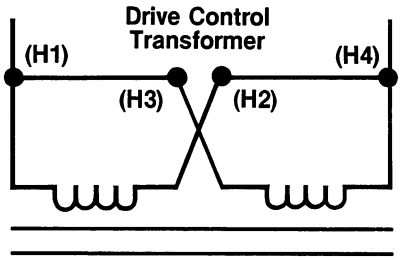


Figure 1b — Connection for 230V AC Operation of 1 PT

3.8 DYNAMIC BRAKING — Dynamic braking resistor (DBR) quantities and configurations depend upon both the armature voltage and horsepower rating of the motor. Refer to **APPENDIX C** for wiring diagrams.

3.9 DC LOOP CONTACTORS — DC Loop contactors are current rated devices and are furnished in either non-reversing or reversing styles depending upon application. Contactors should be located on a flat vertical surface reasonably free from vibrations and airborn abrasive particles for best performance. Plan to mount contactors near the Drive Module and avoid excessively long runs of power wiring between the Module and contactor. Refer to **APPENDIX C** for wiring diagrams pertaining to contactors.

3.10 TACHOMETER FEEDBACK BOARD — Tachometer Feedback Board Kits are required when a higher degree of speed regulation is desired. It is recommended that this kit be installed before initial start-up to assure proper calibration of the maximum speed circuit. Refer to **APPENDIX F** for installation and wiring diagrams.

> **NOTE:**
>
> The Acceleration rate selection procedure must be done before installing the tach feedback board. Refer to paragraph 4.13.

3.11 PROCESS INSTRUMENT FOLLOWER — Process Instrument Follower units should be located near the Drive Module in a position that will allow maximum access for calibration. Input and output signal wires should not be routed or harnessed with high current or voltage carrying conductors to avoid pick-up of undesirable noise. Refer to **APPENDIX G** for installation, wiring and adjustment procedures.

3.12 CIRCUIT CHECKER — The circuit checker is designed to be mounted to the bottom of the Drive Module door utilizing pre-drilled holes. Refer to **APPENDIX H** for installation and wiring diagrams.

3.13 CONTROL CIRCUIT DEVICES — In instances when users supply operator control devices, only momentary contact types may be used as Start or Jog devices.

3.14 SPEED POT — If the user supplies the speed pot, it must be a linear 1000 ohm, 1/4 watt minimum with a tolerance of ±10%, or better. (See Table 3-B for wire type.) Refer to **APPENDIX D.**

3.15 METERS — When using optional Speed and/or Load Meters, use shielded, twisted-pair cable, as specified in Table 3-C. Route wires 6 in. (15 cm) minimum from high voltage/current carrying conductors and run in a separate steel conduit. Maximum distance between drive and meter is not to exceed 100 feet.

When installing, locate meter on a flat surface in an area reasonably free from vibrations, moisture, extremes of temperature and protected from physical damage.

When connecting the meters, it is recommended that 16 gauge (minimum) two conductor shielded wire be used (local codes must be followed). The shield conductor is to be grounded at the drive enclosure only, and the shield conductor at the meter cut and taped off. Use of ring lugs at the shunt connections are strongly recommended. When bolting the Load Indicator wires to the shunt, make sure that secure connections are made. Refer to **APPENDIX I** for wiring diagrams.

> **NOTE:**
>
> Leads of Load Meter and Speed Meter must be clearly identified at controller and meter.

> **NOTE:**
>
> Refer to paragraph 4.15 for Load meter polarity check and paragraph 4.14 for Speed meter calibration.

TABLE 3-C — RECOMMENDED SIGNAL WIRE AND LUGS

Type	Typical Brand
2 conductor, shielded twisted pair (2 turns per inch) stranded copper, AWG No. 16 (min.)	Belden No. 8719
3 conductor, shielded twisted (2 turns per inch) stranded copper, AWG No. 16 (min.)	Belden No. 8618
No. 10 22-16 ga. lugs.	T & B No. RA-877

3.16 CONTROL STATION — Mount the optional control station in any convenient location where it will be protected from mechanical damage. For best performance, the wires from the Speed potentiometer should be run through separate conduit or otherwise isolated from the AC control wires. This will minimize electrical noise pick-up and possible misfiring of the controller, of particular importance if the control station will be a long distance (100 feet or more) from the controller. Shielded wire is always recommended for remote reference signals (Refer to Table 3-C). Refer to **APPENDIX D** for wiring diagrams.

4.0 BASIC START-UP INSTRUCTIONS

WARNING:

Exercise extreme care when performing any task on the drive control, or on the drive motor.

Become familiar with the equipment, installation and start-up procedures before attempting to interconnect the drive equipment and perform this start-up.

WARNING:

Power must be applied to the drive to perform many of the adjustments specified in the following paragraphs. Voltages behind the front panel are at incoming line potential. To avoid injury to personnel and/or damage to equipment, make all adjustments with the front panel closed. Remove power prior to making specified connection behind front panel. Refer to NFPA 70B, RECOMMENDED PRACTICE FOR ELECTRICAL EQUIPMENT MAINTENANCE, published by the National Fire Protection Association, for additional information.

CAUTION:

While performing this start-up, if an event does not occur as indicated, do not proceed. **REMOVE POWER** by opening the branch circuit disconnect device and correct the malfunction before continuing.

NOTE:

Each Drive Module is functionally tested at the factory. However, many of the functional adjustments must be made to meet the specific machine's characteristics or operator preferences. Read these instructions carefully before attempting to start the drive.

4.1 PRELIMINARY CHECKS AND ADJUSTMENTS —

4.1.1 ISOLATION TRANSFORMER CHECK (OPTIONAL)

It is recommended that the secondary voltage of the isolation transformer be checked before wiring to the Drive Module to avoid applying incorrect voltage. It should be kept in mind that the voltage can vary +10% to −5% of the specified secondary voltage.

1. **REMOVE POWER.**
2. Connect an AC voltmeter (observe correct voltage range) to the secondary of the isolation transformer, terminals (X1) and (X2).
3. Apply power and read the AC voltmeter. If the secondary voltage does not coincide with the input rating on the Drive Module nameplate, the secondary connections should be checked against the transformer nameplate and/or **APPENDIX B** and the condition corrected.
4. **REMOVE POWER.**
5. Re-connect the AC voltmeter to the secondary of the isolation transformer, terminals (X1) and (X3).
6. Apply power and read the AC voltmeter. If the secondary voltage does not coincide with the input rating on the Drive Module nameplate, the secondary connections should be checked against the transformer nameplate and/or **APPENDIX B** and the condition corrected.
7. **REMOVE POWER.**
8. Re-connect the AC voltmeter to the secondary of the isolation transformer, terminals (X2) and (X3).
9. Apply power and read the AC voltmeter. If the secondary voltage does not coincide with the input rating on the Drive Module nameplate, the secondary connections should be checked against the transformer nameplate and/or **APPENDIX B** and the condition corrected.
10. **REMOVE POWER.**

4.1.2 INITIAL SETTING OF POTENTIOMETERS — The pots located on the front panel shall initially be set fully counter-clockwise (CCW) at 0% except for the stability pot, which shall be set at 50%, and the Motor Current Limit, which has been preset to 125% current limit of the motor at the factory.

4.1.3 INITIAL POWER VERIFICATION — With line power applied, verify that none of the front panel Visual Indicators are illuminated before performing this start-up. If any of the indicators (Overload, Phase Loss, Field Loss, Thyristor Over-Temperature, etc.) are illuminated, **REMOVE POWER.** Locate and correct the malfunction with the aid of the Troubleshooting Guide within these instructions before proceeding with the start-up.

4.5 DIRECTION OF ROTATION CHECK —

1. Remove load from motor.
2. Mark the position at which the Motor Current Limit pot is set.
3. Set the Motor Current Limit pot to approximately 10%.
4. Set the Jog Speed pot to approximately 20%.
5. Apply drive power.
6. Depress and hold the Jog pushbutton.
7. Check the direction of motor rotation. If it is incorrect, release the Jog pushbutton, **REMOVE POWER,** and interchange F1 and F2 motor leads at the controller.
8. Set the Motor Current Limit pot to the position marked in step 2.

4.5 TACHOMETER FEEDBACK CHECK (optional DC Tachometer feedback for 0.5%/0.5% and 0.1%/0.15% regulation only).

CAUTION:

If the tachometer feedback is incorrectly connected it is possible that the motor will accelerate above maximum speed without any control. To avoid damage to equipment, have someone at the disconnect ready to remove power if the motor starts to accelerate to maximum speed.

1. **REMOVE POWER.**
2. Mark the setting of the Motor Current Limit potentiometer, and then turn it fully counterclockwise (CCW).
3. Set the Jog Speed pot to 20%.
4. Connect the negative lead of a DC voltmeter to terminal (20) and the positive lead to terminal (19) on the drive terminal block.
5. Apply power, depress and hold the Jog pushbutton.
6. Very slowly turn the Motor Current Limit pot clockwise (CW) just until the motor starts to turn.
7. Observe that the polarity of the tachometer voltage is positive, if the tachometer voltage is negative, **REMOVE POWER** and interchange the tachometer leads (at terminals 19 and 20).
8. Return the Motor Current Limit pot to the position marked in step 2.

4.6 CURRENT LIMIT ADJUSTMENT —

1. Current Limit has been preset at the factory at 125%. If it is desired to change this current limit level (between 50% and 150%), the following steps will enable setting a new current limit to within 10%.
2. **REMOVE POWER.**
3. Remove an armature power lead (either A1 or A2) from the drive power bus and temporarily tape up this lead.
4. Connect a DC voltmeter (10-volt range) between terminal 7 on the Main Circuit Board (−) and common terminal 24 (+) on this board.
5. Apply power, initiate a start in the Run mode, and set the Speed pot 100% clockwise (the motor will not rotate because the armature lead is disconnected).
6. Read the indication on the voltmeter: 2.57 volts represents 100% current limit, and higher or lower voltages indicate proportionally higher or lower current limit levels.
7. Turn the Motor Current Limit pot until the voltage that equals the desired current limit is indicated on the voltmeter. For example, if 135% current limit is desired, turn the Motor Current Limit pot clockwise until the meter reads 1.35 x 2.57V = 3.47V.
8. **REMOVE POWER** and reconnect the armature lead disconnected in step 3.

4.7 STABILITY ADJUSTMENT —

1. Apply power.
2. Apply rated load to motor.
3. Initiate a Start in the Run mode.
4. Apply the appropriate Reference Signal for normal running speed.
5. Turn the Stability pot counterclockwise until the motor speed begins to fluctuate producing a condition called "hunting". Slowly turn the Stability pot clockwise until no speed fluctuations can be detected. The Stability setting is optimum when the motor does not hunt excessively in response to changes in speed settings or load conditions. THIS IS A DYNAMIC ADJUSTMENT PROCEDURE AND MAY REQUIRE REPETITION TO ACHIEVE OPTIMUM DRIVE RESPONSE.

> **NOTE:**
>
> If drive instability becomes severe, a Phase Loss drive trip may occur, requiring a drive Reset after the Stability pot setting has been changed.

6. Initiate a Stop. **REMOVE POWER.**

> **NOTE:**
>
> A hand held tachometer or speed indicator will be required to measure motor speed for the following adjustments.

4.8 MAXIMUM SPEED ADJUSTMENT —

1. Apply power, initiate a Start in the Run mode and set the Speed pot fully clockwise (100%).
2. While monitoring the motor speed with a hand tachometer, rotate the Maximum Speed pot clockwise until motor base speed is achieved. (See the motor nameplate for base speed data.)
3. Initiate a Stop. **REMOVE POWER.**

4.9 PRESET SPEED ADJUSTMENT (If Preset Switch is used) —

> **NOTE:**
>
> The Preset Speed is adjustable from 0% to 100% of maximum speed.

1. Apply drive power.
2. Close the Preset switch.
3. Set the Speed pot to 0%. Initiate a Start.
4. While monitoring the speed with a hand tachometer, adjust the Preset Speed pot until the desired Preset Speed is achieved.
5. Initiate a Stop. **REMOVE POWER.** Open the Preset Switch.

4.10 MINIMUM SPEED ADJUSTMENT —

> **NOTE:**
>
> The Minimum Speed is adjustable from 0% to 33% of maximum speed.

1. Apply power.
2. Set the Speed pot to 0%. Initiate a Start in the Run mode.
3. While monitoring motor speed with a hand tachometer, adjust the Minimum Speed pot to achieve the desired Minimum Speed.
4. Initiate a Stop. **REMOVE POWER.**

4.11 JOG SPEED ADJUSTMENT (If optional Jog push button is supplied)

NOTE:

The Jog Speed is adjustable from 0% to 50% of maximum speed.

1. Apply power.
2. Set the Speed pot to 0%.
3. Depress and hold the Jog push button.
4. While monitoring motor speed with a hand tachometer, adjust the Jog Speed pot until the desired Jog Speed is achieved.
5. Release Jog push button. **REMOVE POWER.**

4.12 IR COMP. ADJUSTMENT — This adjustment should be utilized when improved drive regulation is desired. The IR Comp. pot should be adjusted at the speed and load at which the motor is normally to be run ONLY if the Drive Module is NOT equipped with an optional Tachometer Feedback Board.

CAUTION:

Excessive IR compensation feedback may cause drive instability.

1. Prepare to run motor and measure speed.
2. Apply MINIMUM load.
3. Apply power, initiate a Start, set Speed pot or apply an appropriate Reference Signal to obtain normal operating speed of the motor. Measure and record this as NO-LOAD speed.
4. Initiate a Stop.
5. Apply MAXIMUM load to motor.
6. Initiate a Start. The Speed pot or the Reference Signal MUST remain at the settings determined in step 3. Measure and record this as FULL LOAD Speed.
7. Turn IR Comp pot until FULL LOAD speed equals NO LOAD speed.
8. Initiate a Stop. **REMOVE POWER.**
9. Reset Reference Signal or Speed pot to Zero.

4.13 ACCELERATION/DECELERATION ADJUSTMENT — The Main Control Board has built-in linear acceleration/deceleration circuits. The rates are separately adjustable and selectable between 0.4 seconds to approximately 15 seconds and 3.0 seconds to approximately 60 seconds for Run and Preset speeds. Jog speed bypasses the Linear Accel/Decel circuit via control logic and is not affected by either adjustment.

1. **REMOVE POWER.**
2. Locate the "SIP" Jumper Module on the potentiometer board (2 EA).

   Select the desired range by removing the Jumper Module and reinserting it according to the positions depicted in Figure 4a and 4b.

NOTE:

The circuit is designed to default to the 60 second range if no Jumper is inserted.

3. Set Speed pot to 0%. Apply drive power, initiate a Start in the Run Mode, and adjust the Accel Rate pot to the desired acceleration rate. Set the Speed pot to 100% and observe acceleration rate.
4. Repeat step 3 as necessary, until desired Accel Rate is achieved.
5. Once the motor is at the desired speed, adjust the Decel Rate pot to the desired deceleration rate. Turn the Speed pot fully counterclockwise and observe deceleration rate.
6. Repeat step 5 as necessary, until desired Decel Rate is achieved.

NOTE:

Decel Rate adjustment is effective only if the machine coasting time is shorter than the Decel Rate setting.

7. Initiate a Stop. **REMOVE POWER.**

CAUTION:

With fixed field excitation, damage to motor shunt field windings can occur if power to the shunt field circuit is not removed when motors without forced air ventilation are stopped for more than 30 minutes.

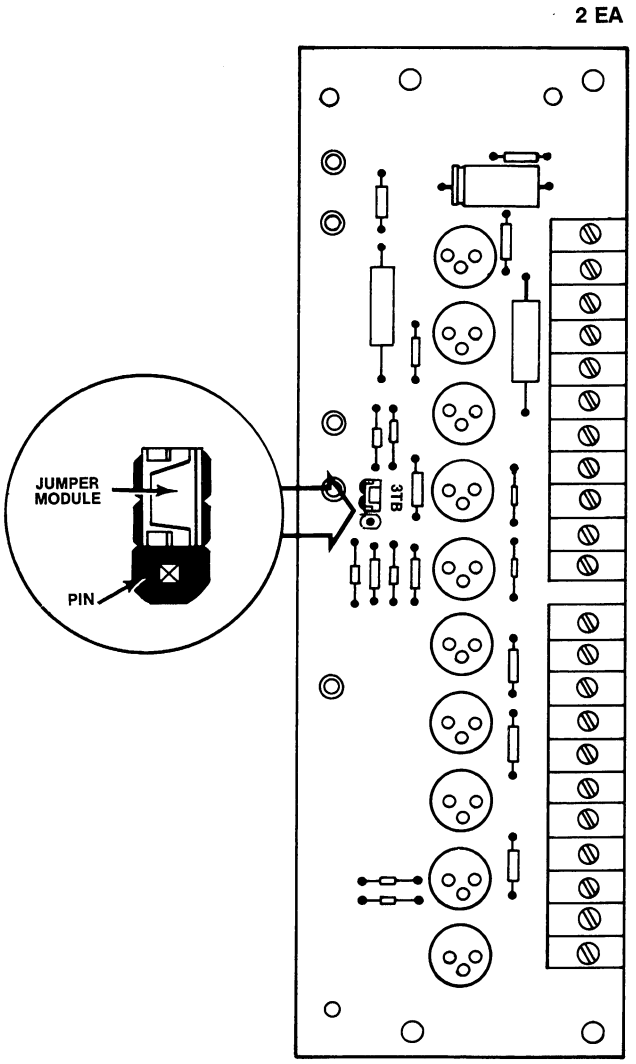


Figure 4a — 15 sec range

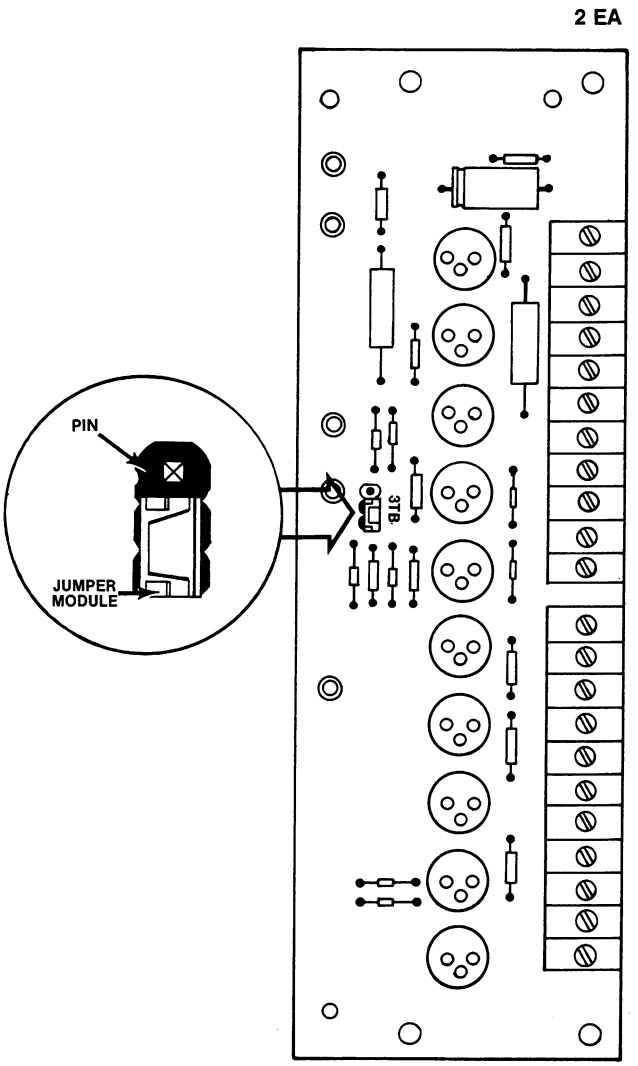


Figure 4b — 60 sec range

4.14 SPEED INDICATOR CALIBRATION

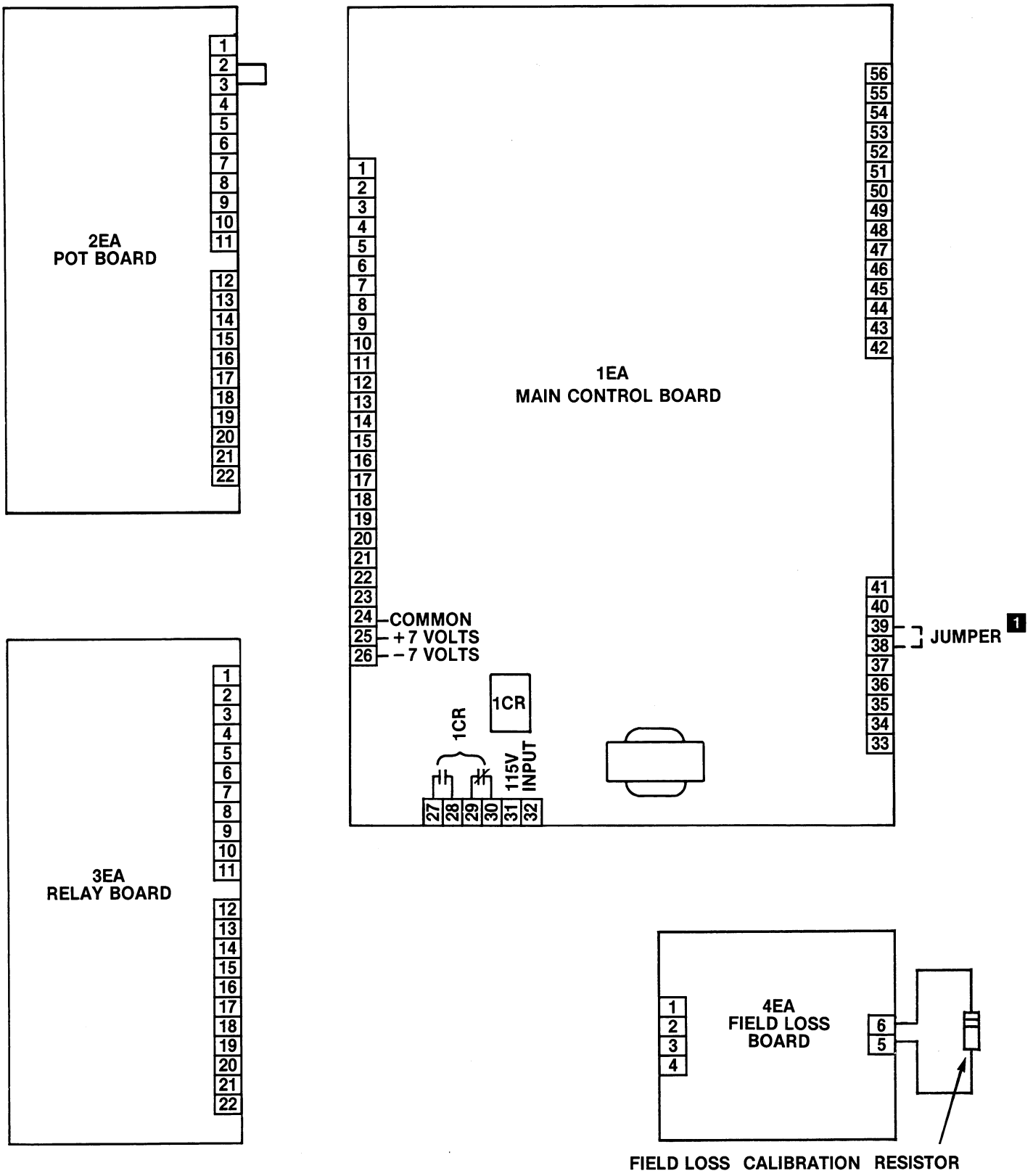
NOTE:

Maximum Speed set up procedure in basic start up must be performed prior to Speed Indicator calibration.

1. Apply power.
2. Momentarily Start and Stop or Jog the drive while observing meter needle deflection. If needle does not deflect "upscale", remove power and interchange wires at the meter.
3. **REMOVE POWER.**
4. Loosen lock nut on meter calibration pot.
5. Apply power.
6. Initiate a Start and apply an appropriate Reference Signal that will run the motor at base speed.
7. With the motor running at base speed, turn the calibration pot located on the rear of the meter until the pointer corresponds with 100% on the meter scale.
8. Initiate a Stop. **REMOVE POWER.**
9. Re-tighten lock nut on calibration pot.

4.15 LOAD METER POLARITY CHECK

1. Apply power.
2. Momentarily Start and Stop or Jog the drive while observing meter needle deflection. If needle does not deflect "upscale", remove power and interchange wires at the meter.
3. **REMOVE POWER.**



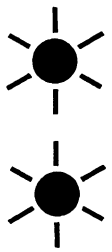
1 This jumper is to be added for 230V AC operation, see paragraph 3.7, item 3.

Figure 4-2 — Printed Circuit Board Locations

5.0 TROUBLE SHOOTING GUIDE

INDICATOR LIGHT	SYMPTOM	PROBABLE CAUSE	SOLUTION
 OVERLOAD LIGHT ILLUMINATED	1. Drive runs momentarily then trips out.	1A. Fault condition — check Overload conditions.	1A. Clear fault and push Reset button for 2-3 sec. Reset Inhibit lamp (amber) should extinguish. If trip was due to overload, 4 minutes must elapse before Reset will be enabled (Reset Inhibit lamp extinguishes).
		1B. Excessive mechanical load.	1B. Check mechanical operation of motor and machine. Correct as necessary.
		1C. Improper connection of the motor field windings.	1C. Refer to appendix "A" for proper field connection diagrams.
		1D. Incorrect Current Limit pot setting.	1D. Reset Current Limit pot (per instructions).
	2. Drive will not start.	2A. Twisted pair feedback wires from the Main Control Board are not connected to the shunt.	2A. Connect the twisted pair to the side of the shunt. Location of the gray wire does not affect drive operation.
 PHASE LOSS LIGHT ILLUMINATED	1. Drive runs momentarily then trips out.	1A. Fault condition — check Phase Loss conditions.	1A. Clear fault and push Reset button for 2-3 sec. Reset Inhibit lamp (amber) should extinguish. If trip was due to overload, 4 minutes must elapse before Reset will be enabled (Reset Inhibit lamp extinguishes).
		1B. Missing one or two incoming AC line phases.	1B. Check incoming AC lines for presence of AC voltage (phases) on line and load side of 1, 2, 3F. Determine cause of fault and replace fuses or check branch circuit disconnect devices as necessary.
		1C. Missing thyristor gate pulses.	1C. Check gate connections and/or replace Main Control Board.
		1D. Shorted or open thyristors.	1D. Locate and replace faulty thyristors.
		1E. Main Control Board malfunction.	1E. Replace Main Control Board.
		1F. Excessive IR Compensation	1F. Readjust IR Compensation pot per instructions.

5.0 TROUBLE SHOOTING GUIDE (CONT.)

INDICATOR LIGHT	SYMPTOM	PROBABLE CAUSE	SOLUTION
 BOTH OVERLOAD AND PHASE LOSS LIGHTS ILLUMINATED	1. Drive will not start	1A. Fault condition — check Overload, Phase Loss conditions.	1A. Clear fault and push Reset button for 2-3 sec. Reset Inhibit lamp (amber) should extinguish. If trip was due to overload, 4 minutes must elapse before Reset will be enabled (Reset Inhibit lamp extinguishes).
		1B. Twisted-pair feedback wires from the Main Control Board are not connected to the shunt.	1B. Connect the twisted pair to the side of the shunt. Location of the gray wire does not affect drive operation.
	2. Line fuses (1, 2, 3F) blow or circuit breaker trips while running or upon initial application of speed signal.	2A. Loose power connections or broken wires.	2A. Tighten all power connections. Visually inspect exposed wiring.
		2B. Incorrect power connections.	2B. Check continuity of power wiring. Check Power connections per wiring diagrams in appendix "A" and "B".
		2C. Incorrect shunt value.	2C. Refer to table 3-B for proper shunt catalog number. Replace shunt if necessary.
 FIELD LOSS LIGHT ILLUMINATED	1. Drive will not start.	1A. Fault condition — check Field Loss conditions.	1A. Clear fault and push Reset button for 2-3 sec. Reset Inhibit lamp (amber) should extinguish. If trip was due to overload, 4 minutes must elapse before Reset will be enabled (Reset Inhibit lamp extinguishes).
		1B. Field fuses blown.	1B. Locate and correct fault. Replace blown field fuses (4F, 5F).
		1C. Field rectifier bridge open or shorted.	1C. Replace field rectifier bridge.
	2. Drive runs momentarily and trips out.	2A. Improper connection of the motor field coils at motor.	2A. Refer to appendix "A" for proper field connection diagram, and reconnect if necessary.
		2B. Open field windings in motor and/or wiring to motor.	2B. Check resistance of motor field with ohmmeter per nameplate rating. Check for loose connections or broken field wires at motor or in Drive Module.
		2C. Missing or incorrect calibration resistor on Field Loss Board (4EA).	2C. Check field loss calibration resistor and refer to paragraph 3.7 item 1.
		2D. Field Loss Board malfunction.	2D. Replace Field Loss Board.

5.0 TROUBLE SHOOTING GUIDE (CONT.)

INDICATOR LIGHT	SYMPTOM	PROBABLE CAUSE	SOLUTION
 THRYSITOR OVER TEMPERATURE LIGHT ILLUMINATED	1. Drive will not start	1A. Fault condition — check Thyristor over-temperature conditions.	1A. Clear fault and push Reset button for 2-3 sec. Reset Inhibit lamp (amber) should extinguish. If trip was due to overload, 4 minutes must elapse before Reset will be enabled (Reset Inhibit lamp extinguishes).
	2. Drive runs momentarily and trips out.	2A. Air temperature is too hot or too cold; broken thermistor lead wire.	2A. Measure ambient temperature. A range of 0 degrees C to 40 degrees C is within Drive Module tolerances. Replace thermistor assemblies having broken wires.
		2B. Shorted or open thyristor or loose connection on thyristor mounting or wiring.	2B. Locate and replace faulty thyristor(s). Check torque on all power connections, refer to Appendix "L".
		2C. Loss of cooling air.	2C. Check and replace faulty fans as required.
 RESET INHIBIT LIGHT ILLUMINATED	1. Drive will not start.	1A. Fault condition — check Overload, Phase Loss conditions.	1A. Clear fault and push Reset button for 2-3 sec. Reset Inhibit lamp (amber) should extinguish. If trip was due to overload, 4 minutes must elapse before Reset will be enabled (Reset Inhibit lamp extinguishes).
 OVERLOAD CONDITION LIGHT ILLUMINATED	1. Drive runs but Overload Condition light stays illuminated.	1A. Excessive mechanical load.	1A. Check mechanical operation of motor and machine. Correct as necessary.
		1B. Improper connection of the motor field windings.	1B. Refer to appendix "A" for proper field connection diagrams.
		1C. Incorrect Current Limit pot setting.	1C. Reset Current Limit pot (per start-up instructions).

5.0 TROUBLE SHOOTING GUIDE (CONT.)

INDICATOR LIGHT	SYMPTOM	PROBABLE CAUSE	SOLUTION
NO LIGHTS ILLUMINATED	1. Drive will not start.	1A. Loss of AC power.	1A. Check incoming AC lines for presence of AC voltage (phases) on line and load side of 1, 2, 3F. Determine cause of fault and replace fuses or check branch circuit disconnect devices as necessary.
		1B. Loss of 115V AC control or DC power supply voltage.	1B. Check for 115V AC at Main Control Board terminals (31) and (32). Check fuses 1F and 3F. Check for +7V at terminals (25) and (24) (common) of the main circuit board, and for −7V at terminals (26) and (24) (common). If voltages are not present, replace Main Control Board or correct faults and replace blown fuses.
		1C. Open control circuit or blown control fuse(s).	1C. Check for proper continuity or fault per wiring diagrams. Check 6, 7, 8, 9, and 10F. Correct faults and replace blown fuses.
		1D. Relay board or DC Loop contactor failure.	1D. Check operation of control logic relays and replace if necessary. Make audio/visual inspection of mechanical operation of DC Loop contactor. Replace if necessary.
		1E. Current Limit pot set too low.	1E. Reset Current Limit pot to correct clockwise position (per start-up instructions).
		1F. Open control transformer.	1F. Check and replace control transformer 1 PT or 2 PT.
	2. Drive runs erratically.	2A. Improper Stability or I.R. Comp adjustment.	2A. Re-adjust Stability and/or I.R. Comp pot (per start-up instructions).
		2B. Main Control Board malfunction.	2B. Replace Main Control Board.
	3. Drive will not get up speed.	3A. Maximum Speed pot set too low.	3A. Reset Maximum Speed pot (per start-up instructions).
		3B. Main Control Board malfunction.	3B. Replace Main Control Board.
		3C. Current Limit pot set too low.	3C. Reset Current Limit pot (per start-up instructions).
		3D. Excessive mechanical load.	3D. Reduce loading to within motor torque output limits.

5.0 TROUBLE SHOOTING GUIDE (CONT.)

INDICATOR LIGHT	SYMPTOM	PROBABLE CAUSE	SOLUTION
NO LIGHTS ILLUMINATED	4. Motor accelerates to maximum speed without any control.	4A. Speed feedback level too low.	4A. Check for correct tachometer voltage rating and mechanical coupling. Check for incorrect wiring on Tach Feedback Board.
		4B. Main Control Board malfunction.	4B. Replace Main Control Board.
		4C. Faulty tachometer generator or tach conductors open.	4C. Repair/replace tachometer or tach conductors.
	5. Thyristor gate pulse missing (as observed on an oscilloscope).	5A. Main Control Board malfunction.	5A. Replace the Main Control Board.
		5B. Open thyristors.	5B. Locate and replace faulty thyristors.
	6. Drive will not go into continuous Run mode.	6A. Main Control Board malfunction.	6A. Replace Main Control Board.
		6B. Inoperative relay on the relay board.	6B. Visually check relay(s) on the relay board. From top to bottom, the first three relays should energize when the Run button is depressed. Replace relays as required.
		6C. Auxiliary contact on DC loop contactor is inoperative.	6C. Replace auxiliary contact.
		6D. Inoperative Run pushbutton.	6D. Replace Run pushbutton and/or contact block.

6.0 TROUBLE SHOOTING GUIDE
USING THE OPTIONAL CIRCUIT CHECKER

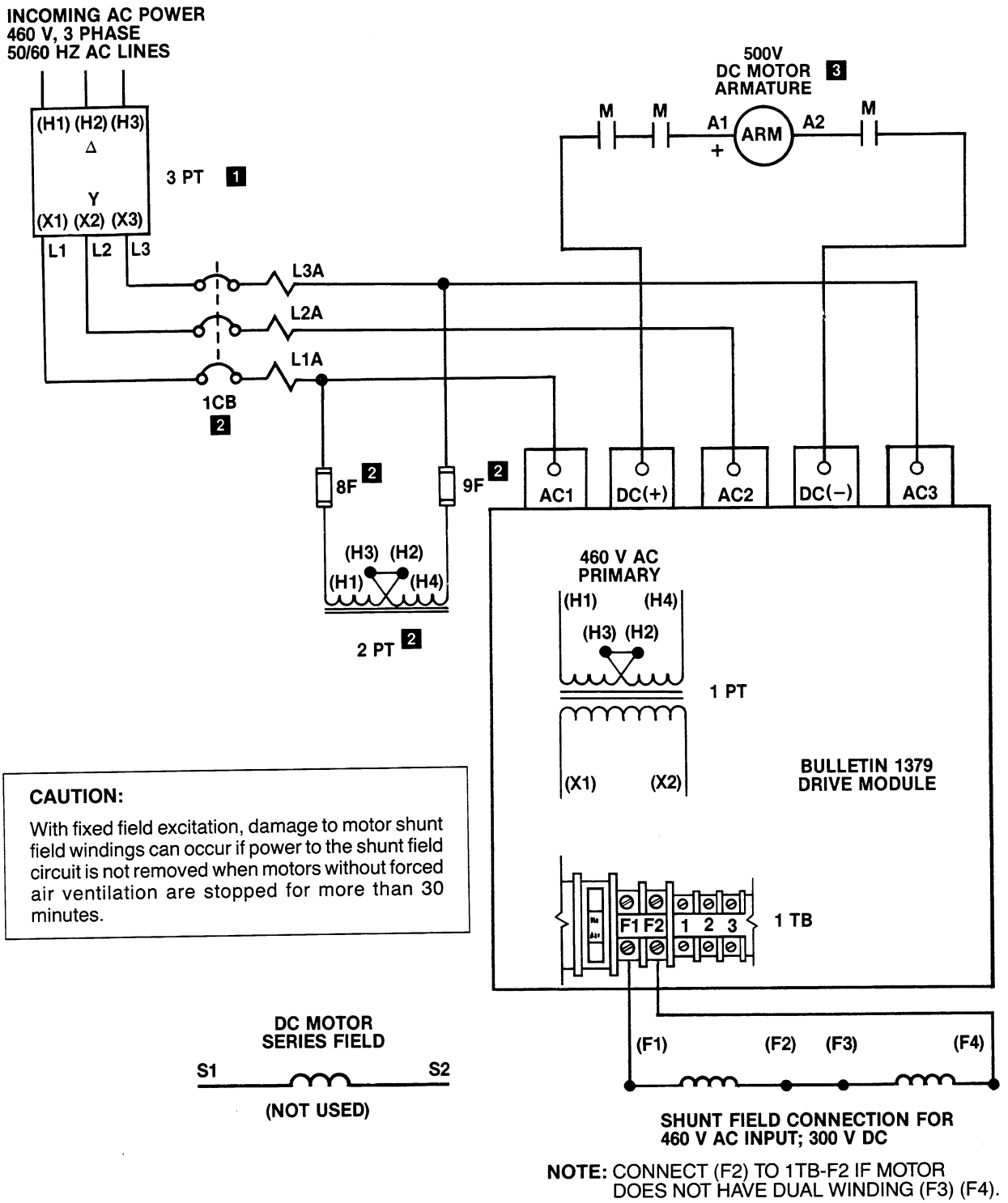
TEST POINT	DESCRIPTION
1	The "Reference Signal", test point is measuring DC regulated power supply for Jog, Preset, and Run. Scale for reading the signal is 0 to − 10V.
2	The "Speed Reference" test point is measuring the speed potentiometer setting. Scale for reading the signal is 0 to − 10V.
3	The "Tach Gen. Feedback", test point is measuring the tachometer generator output of an AC or DC tachometer generator. Outputs of AC tachometer generators are converted to DC by full wave rectifier bridges on the tachometer feedback board. Maximum voltage is dependent upon motor base speed and tachometer generator nameplate voltage rating. Scale for reading the signal is 0 to − 250V.
4	The "Regulator Output", test point is measuring the voltage output of the speed amplifier on the Main Control Board. Scale for reading the signal is 0 to ± 10V.
5	The "Armature Current", test point measures the output voltage of the armature current isolator circuit which is a voltage feedback level directly proportional to the actual armature current flowing. Scale for reading the signal is 0 to + 2.5V.
6	The "Armature Voltage", test point measures the output of the armature voltage isolator circuit which is a reduced voltage feedback level directly proportional to actual armature terminal voltage. Scale for reading the signal is 0 to − 10V.

	SYMPTOM	PROBABLE CAUSE	SOLUTION
	1. Drive will not start.	1A. Loss of AC power.	1A. Check incoming AC lines for presence of AC voltage (phases) on line and load side of 1, 2, 3F. Determine cause of fault and replace fuses or check branch circuit disconnect devices as necessary.
		1B. Main Control Board malfunction.	1B. Check for − 7 volts at test point 1 on the circuit checker. If voltage is not present replace Main Control Board.
		1C. Main Control Board malfunction.	1C. Check for − 7 volts in drive acceleration and for + 7 volts in drive deceleration at test point 4 on the circuit checker. If voltage is not present replace Main Control Board.
		1D. Main Control Board malfunction.	1D. Check for a proportional voltage in relation to armature current at test point 5 on the circuit checker. If voltage is not present replace Main Control Board.

6.0 TROUBLE SHOOTING GUIDE
USING THE OPTIONAL CIRCUIT CHECKER (CONT.)

TEST POINT	SYMPTOM	PROBABLE CAUSE	SOLUTION
	1. Drive will not start. (Continued)	1E. Malfunction in reference voltage circuit. Speed pot set at zero, improper wiring or connection.	1E. Check for a – 7 volts at test point 2 on the circuit checker. If voltage is not present check speed potentiometer wiring connection, and setting and/or replace Main Control Board.

460 V MAIN POWER INTERCONNECTION DIAGRAM



CAUTION:

With fixed field excitation, damage to motor shunt field windings can occur if power to the shunt field circuit is not removed when motors without forced air ventilation are stopped for more than 30 minutes.

NOTE: CONNECT (F2) TO 1TB-F2 IF MOTOR DOES NOT HAVE DUAL WINDING (F3) (F4).

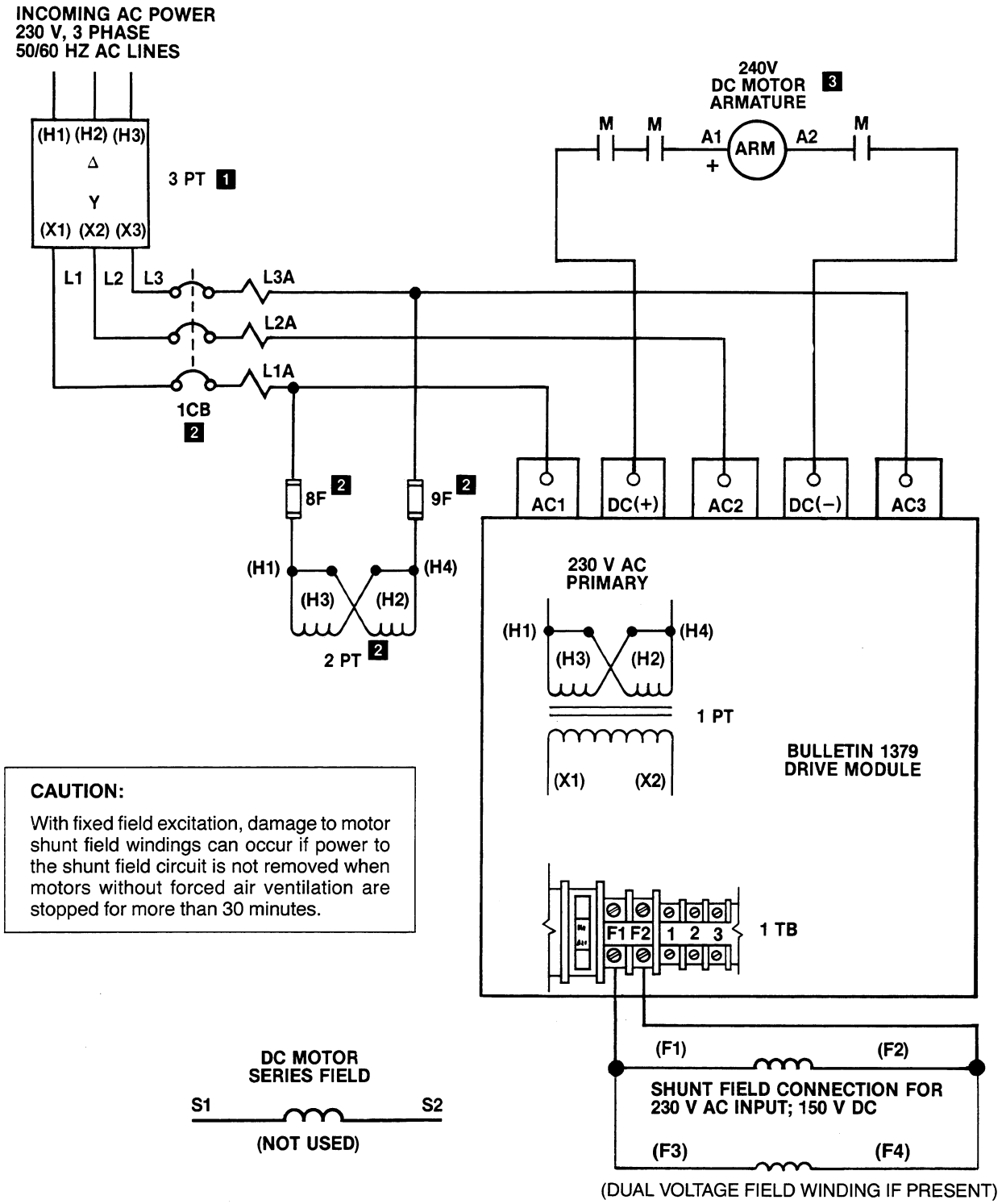
1 See Appendix "B" for isolation transformer wiring diagrams.

2 Indicates components supplied by others.

3 Recommended DC power loop circuit. See Appendix "C" for optional DC contactor connections.

APPENDIX A

230 V MAIN POWER INTERCONNECTION DIAGRAM

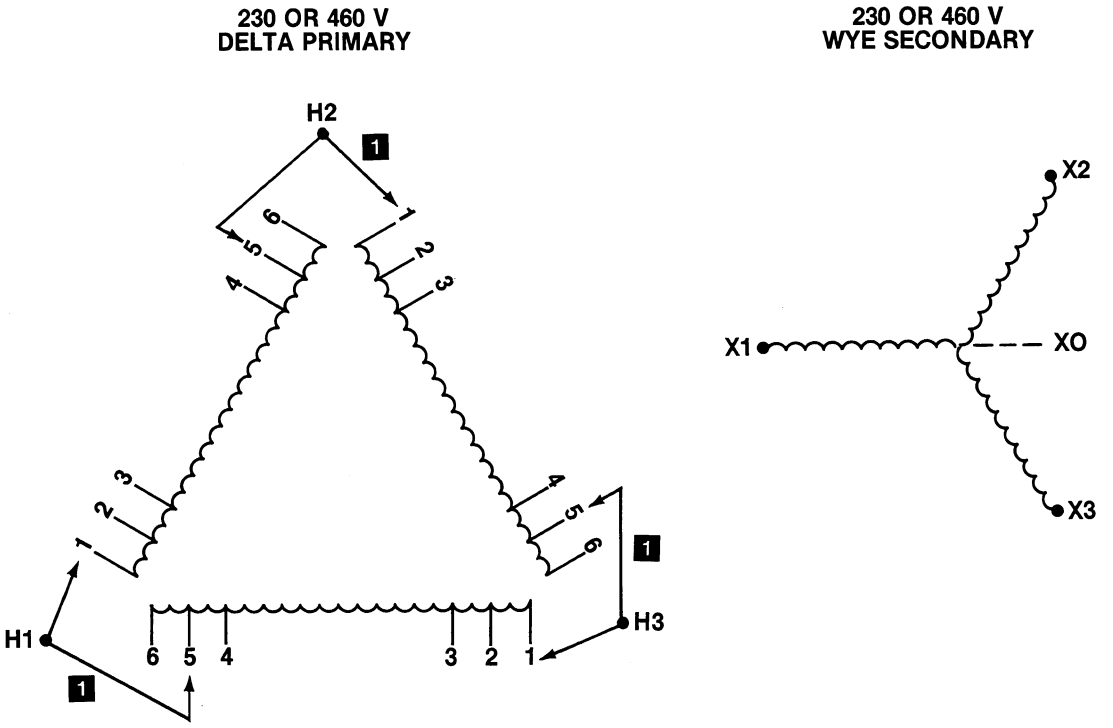


1 See Appendix "B" for optional isolation trnasformer wiring diagrams.

2 Indicates components supplied by others.

3 Recommended DC power loop circuit. See Appendix "C" for optional DC contactor connections.

CONNECTION DIAGRAM FOR OPTIONAL ISOLATION TRANSFORMER

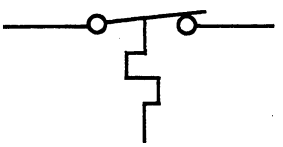


NOTE:

Grounding of "XO" connection on secondary is not recommended unless required by local codes or codes specifically covering SCR drive transformers.

TRANSFORMER THERMOSTAT

2 TAS

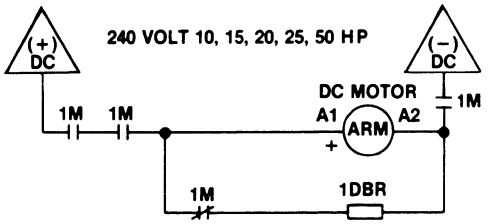


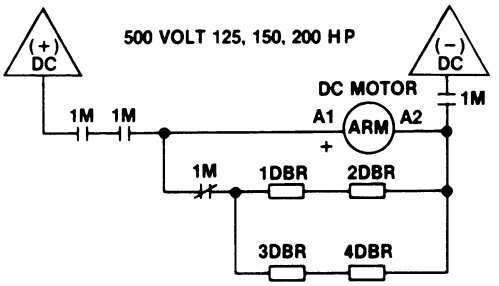
SEE APPENDIX D FOR CONTROL WIRING

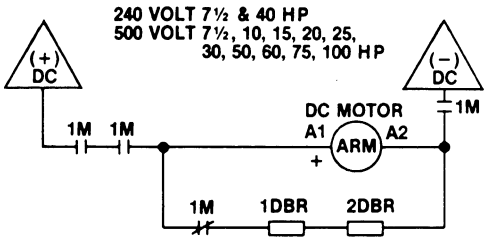
1 Follow national and/or local codes for recommended wire sizes.

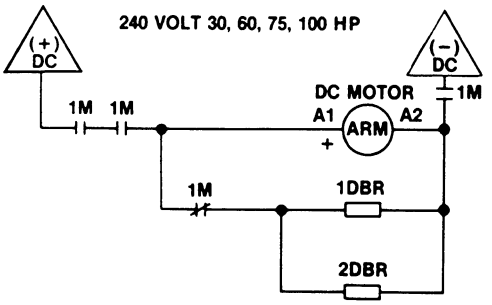
APPENDIX C

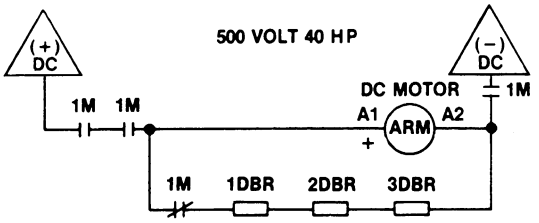
DC POWER SCHEMATIC DIAGRAM FOR NON-REVERSING DRIVES WITH OPTIONAL DYNAMIC BRAKING 1 2







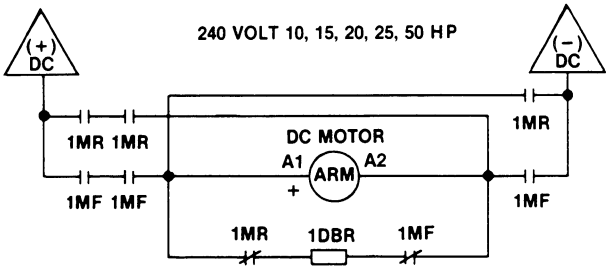


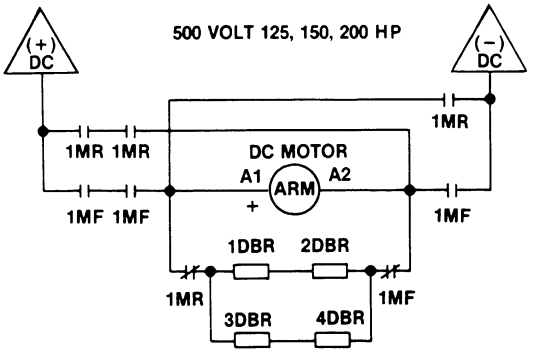


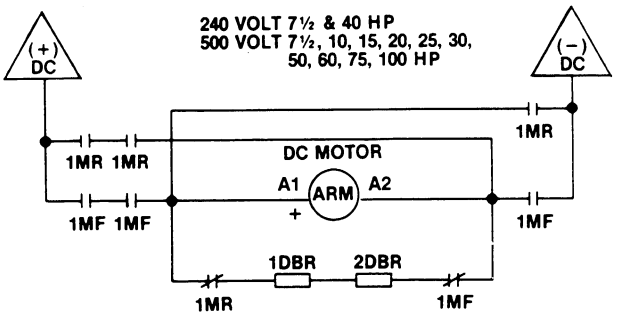
1 (+) DC Indicates bus bar connection on DC Drive Module. All Module Power Connections Keps-nuts are to be installed to the following Torque Settings. 1/4 inch bolt — 35 inch pounds; 3/8 inch bolt — 75 inch pounds; 1/2 inch bolt — 150 inch pounds, 3/4 inch bolt — 300 inch pounds.

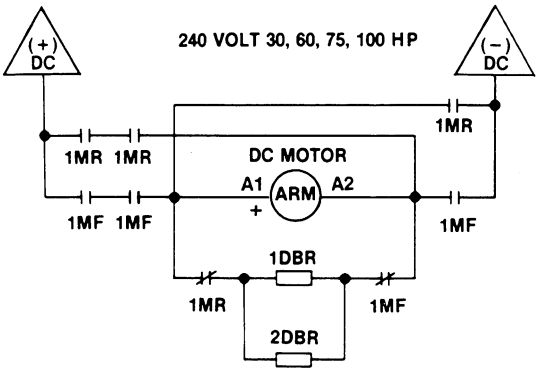
2 Follow industry standards for recommended wire sizing practices.

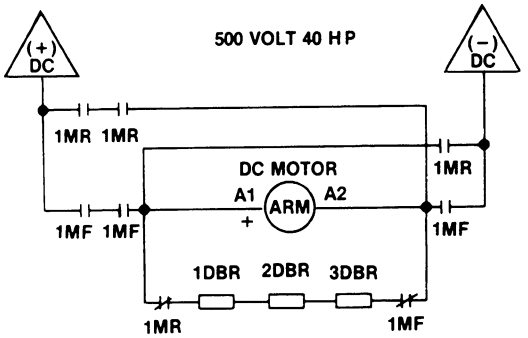
DC POWER SCHEMATIC DIAGRAM FOR REVERSING DRIVES WITH OPTIONAL DYNAMIC BRAKING [1] [2]









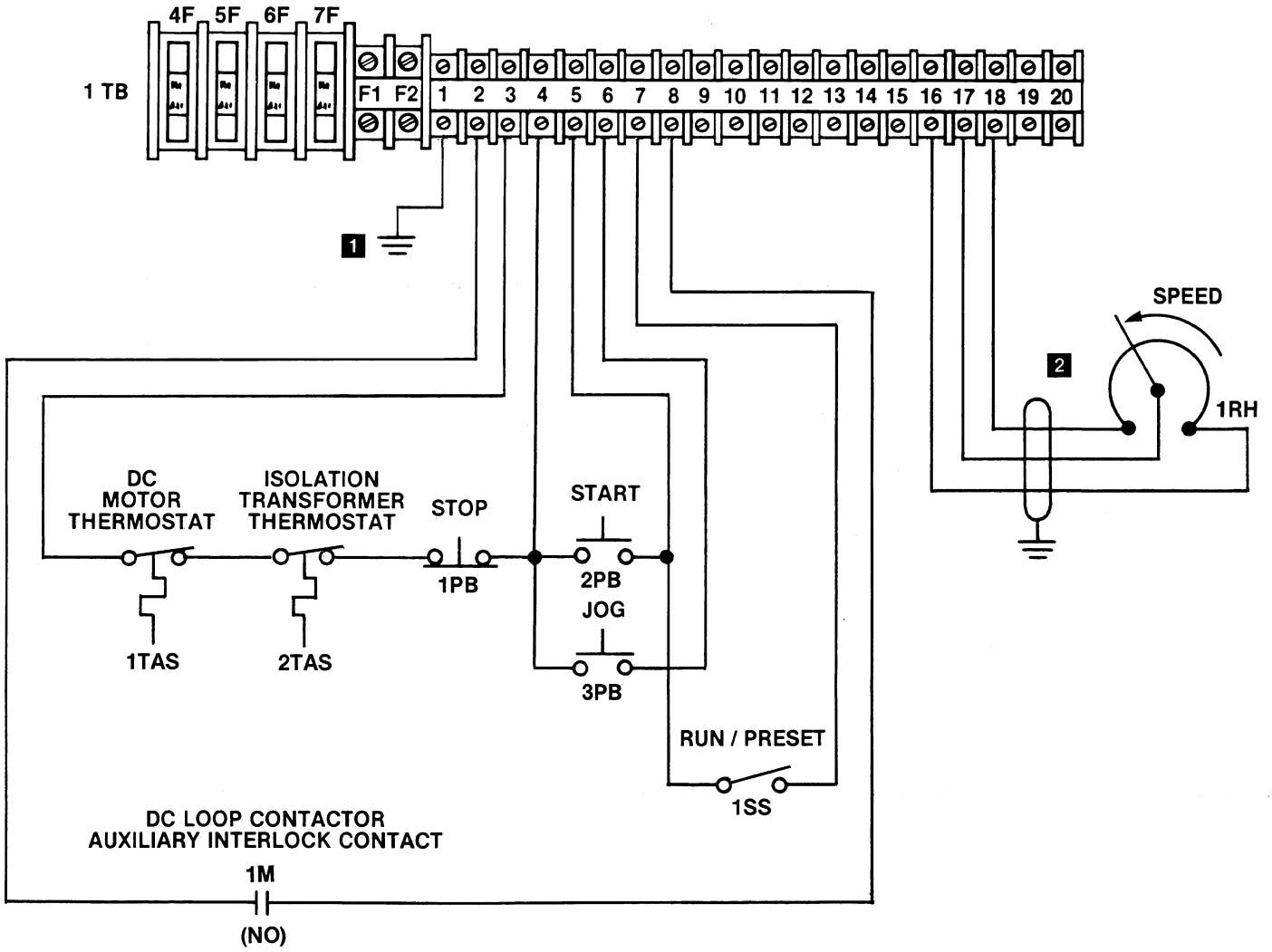


[1] (+) DC Indicates bus bar connection on DC Drive Module. All Module Power Connections Keps-nuts are to be installed to the following Torque Settings. 1/4 inch bolt — 35 inch pounds; 3/8 inch bolt — 75 inch pounds; 1/2 inch bolt — 150 inch pounds, 3/4 inch bolt — 300 inch pounds.

[2] Follow industry standards for recommended wire sizing practices.

APPENDIX D

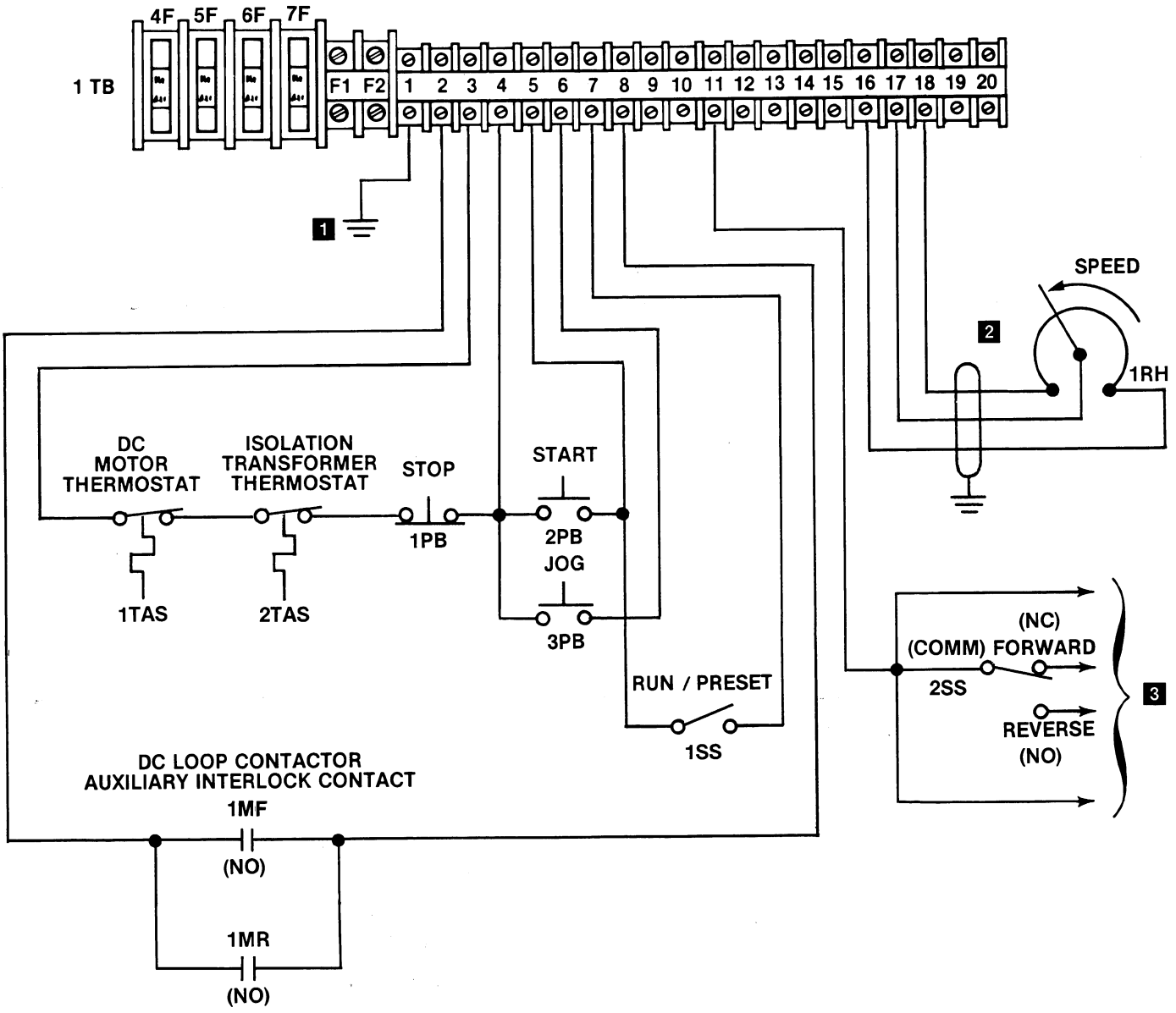
CONTROL INTERCONNECTIONS FOR NON-REVERSING DRIVES



1 To be grounded by customer if conditions permit.

2 Wire with insulated shield is required. Shield is to be grounded at the controller only. Wires interconnecting these terminals may be run in a common conduit. This conduit must not contain power, AC control, motor armature, or field conductors.

CONTROL INTERCONNECTIONS FOR REVERSING DRIVES



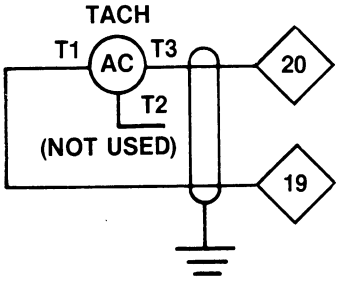
1 To be grounded by customer if conditions permit.

2 Wire with insulated shield is required. Shield is to be grounded at the controller only. Wires interconnecting these terminals may be run in a common conduit. This conduit must not contain power, AC control, motor armature, or field conductors.

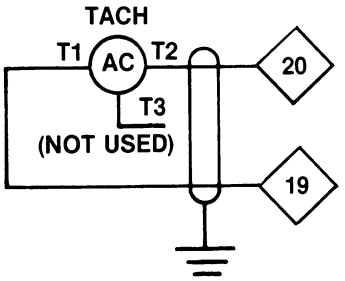
3 See Appendix "K", Control Logic Schematics

APPENDIX E

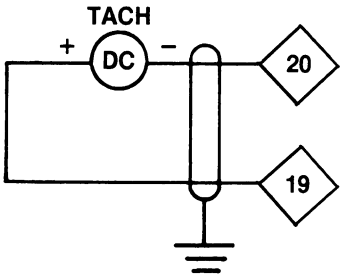
INTERCONNECTION DIAGRAM FOR OPTIONAL AC AND DC TACHOMETERS [1] [2]



AC TACHOMETER
90 V/1000 RPM



AC TACHOMETER
45 V/1000 RPM



DC TACHOMETER
50 OR 100 V/1000 RPM

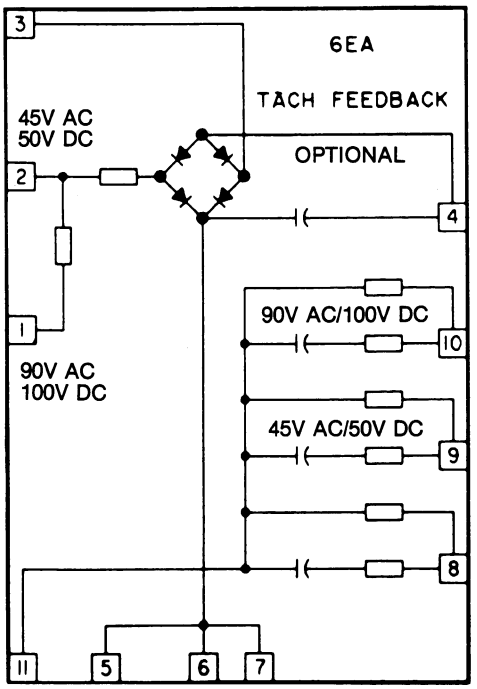
NOTE:
A TACHOMETER CHECK MUST BE MADE WITH THESE CONNECTIONS. SEE PARAGRAPH 4.5

[1] —◇1◇— Indicates outgoing terminal from the Drive Module terminal block (1 TB).

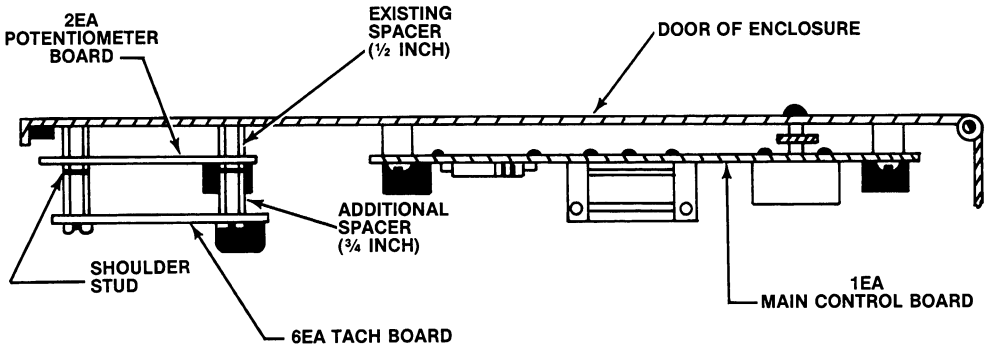
[2] Wire with insulated shield is required. Shield is to be grounded at the controller only. Wires interconnecting these terminals may be run in a common conduit. This conduit must not contain power, AC control, or field conductors.

INSTALLATION INSTRUCTIONS FOR OPTIONAL TACHOMETER FEEDBACK PRINTED CIRCUIT BOARD

BLOCK DIAGRAM



END VIEW OF DOOR VIEWED FROM THE TOP OF ENCLOSURE



INSTALLATION

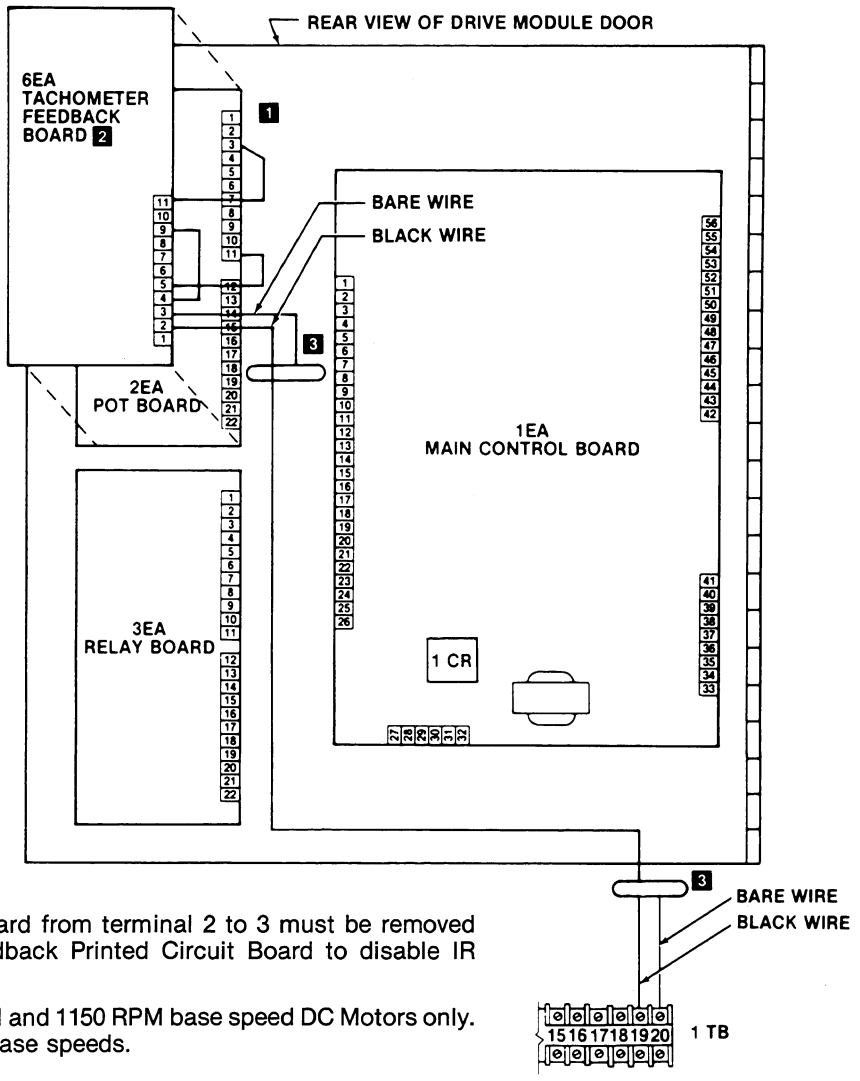
1. **REMOVE POWER.**
2. Remove the jumper from terminal (2) to (3) on 2EA potentiometer board.
3. Install one end of the No. 22 gauge black wires supplied to the terminals of 2EA as shown in the wiring diagram for the appropriate speed regulation characteristic and tachometer voltage.
4. Remove the (4) screws that secure 2EA to the existing spacers. Save these screws.
5. Resecure 2EA to the existing spacers using the (4) shoulder studs provided.
6. Install the (4) ¾-inch spacers provided on the remaining exposed threaded end of the shoulder studs.
7. Secure 6EA tachometer feedback board to the ¾-inch spacers with the (4) screws removed in step 4.
8. Connect the remaining ends of the No. 22 gauge black wires to 6EA as shown in the wiring diagrams.
9. Connect the gray, one conductor insulated wire with shield between 6EA and 1TB as shown in the wiring diagrams. Route this conductor along the wire bundle from the potentiometer board (2EA) to the terminal block (1TB) in the chassis.

APPENDIX F

WIRING DIAGRAM FOR OPTIONAL TACHOMETER FEEDBACK PRINTED CIRCUIT BOARD

CAT. NO. [4] SUFFIX	REGULATION	STYLE
10A	1%/2%	Non-Reversing and Reversing
10A	1%/1%	Non-Reversing and Reversing
10A	0.5%/0.5%	Reversing Only
10A	0.1%/0.15%	Reversing Only

TACHOMETER VOLTAGE	
AC	DC
45V/1000 RPM	50V/1000 RPM



[1] Jumper on 2EA Potentiometer Board from terminal 2 to 3 must be removed when using the Tachometer Feedback Printed Circuit Board to disable IR Comp pot.

[2] Connections for use with 1750 RPM and 1150 RPM base speed DC Motors only. Consult Drives Division for other base speeds.

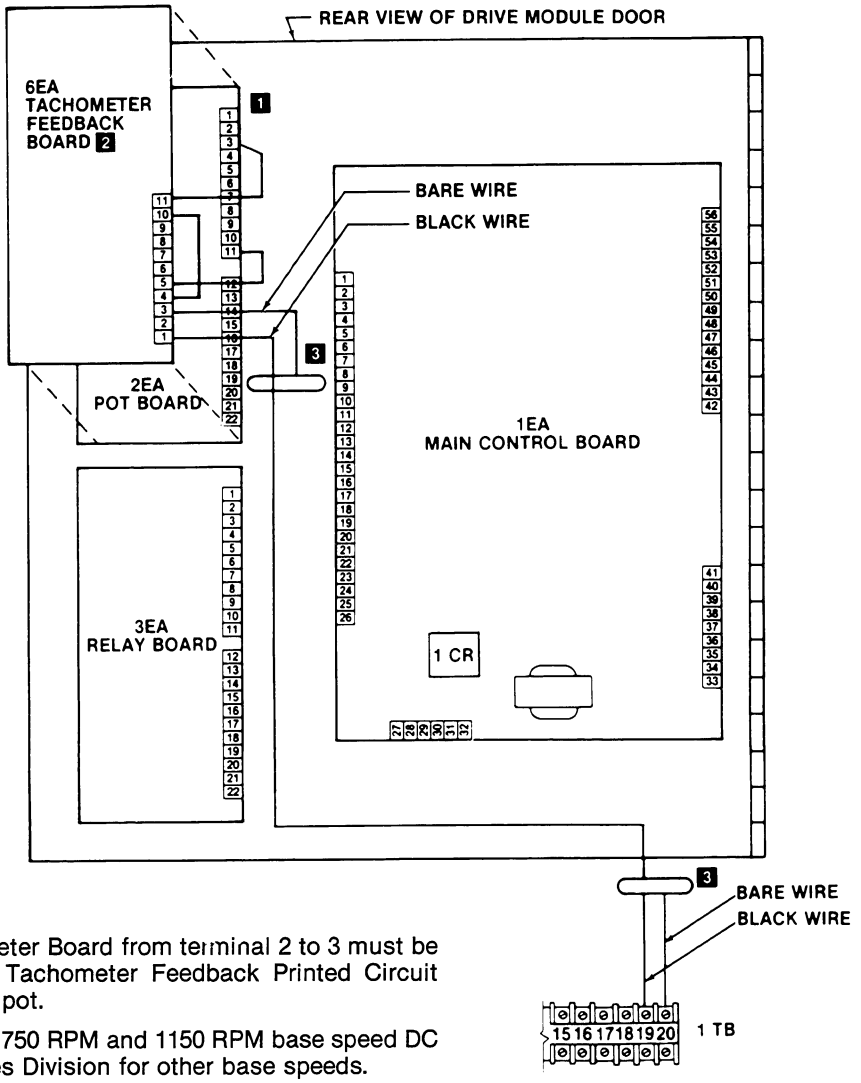
[3] ⊂⊃ Wire is one conductor with insulated shield.

[4] Bulletin 1381 catalog numbers only.

WIRING DIAGRAM FOR OPTIONAL TACHOMETER FEEDBACK PRINTED CIRCUIT BOARD

CAT. NO. [4] SUFFIX	REGULATION	STYLE
10B	1%/2%	Non-Reversing and Reversing
10B	1%/1%	Non-Reversing and Reversing
10B	0.5%/0.5%	Reversing Only
10B	0.1%/0.15%	Reversing Only

TACHOMETER VOLTAGE	
AC	DC
90V/1000 RPM	100V/1000 RPM



1 Jumper on 2EA Potentiometer Board from terminal 2 to 3 must be removed when using the Tachometer Feedback Printed Circuit Board to disable IR Comp pot.

2 Connections for use with 1750 RPM and 1150 RPM base speed DC Motors only. Consult Drives Division for other base speeds.

3 ⊂⊃ Wire is one conductor with insulated shield.

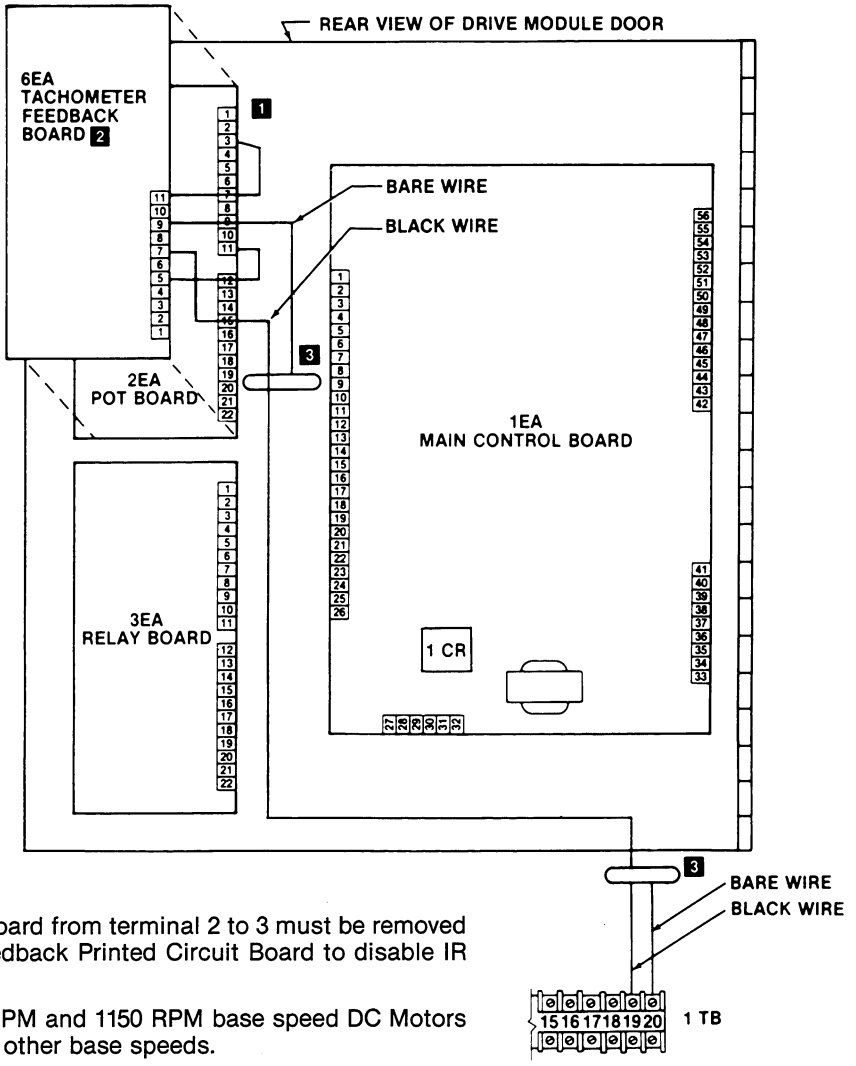
4 Bulletin 1381 catalog numbers only.

APPENDIX F

WIRING DIAGRAM FOR OPTIONAL TACHOMETER FEEDBACK PRINTED CIRCUIT BOARD

CAT. NO. [4] SUFFIX	REGULATION	STYLE
10C	0.5%/0.5%	Non-Reversing Only
10C	0.1%/0.15%	Non-Reversing Only

TACHOMETER VOLTAGE	
AC	DC
N/A	50V/1000 RPM



1 Jumper on 2EA Potentiometer Board from terminal 2 to 3 must be removed when using the Tachometer Feedback Printed Circuit Board to disable IR Comp pot.

2 Connections for use with 1750 RPM and 1150 RPM base speed DC Motors only. Consult Drives Division for other base speeds.

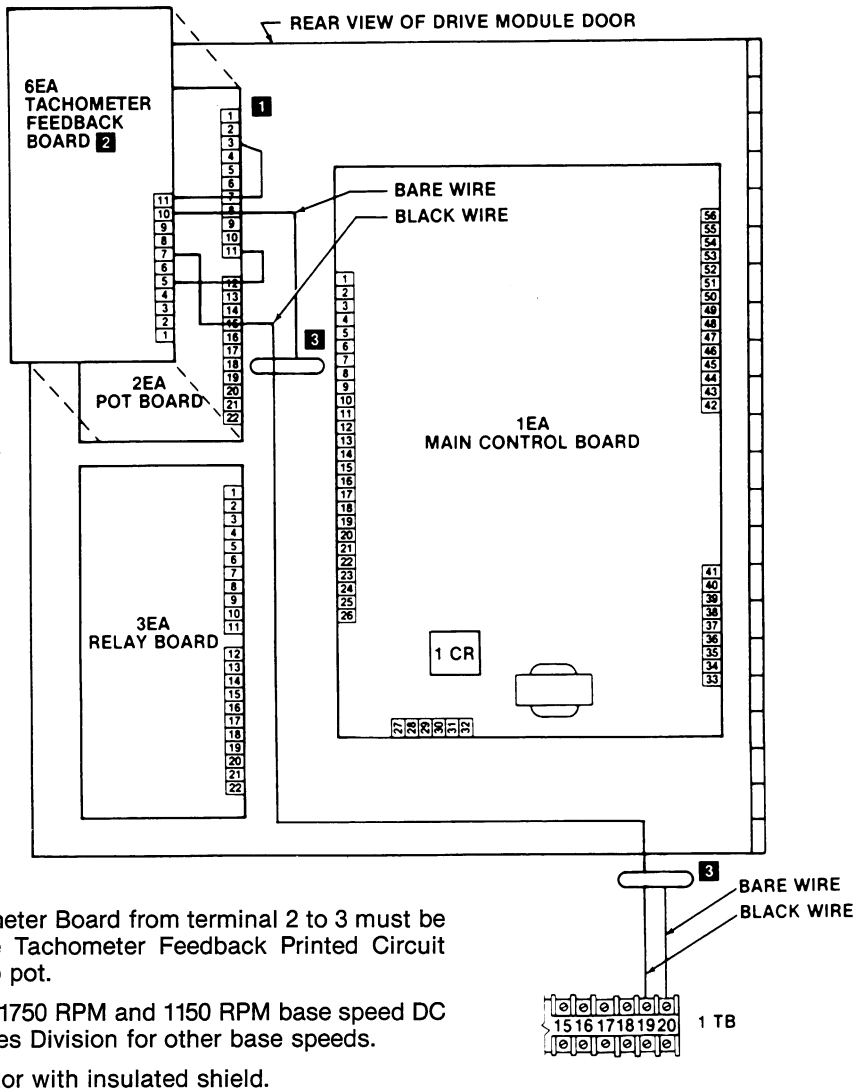
3 ⊂⊃ Wire is one conductor with insulated shield.

4 Bulletin 1381 catalog numbers only.

WIRING DIAGRAM FOR OPTIONAL TACHOMETER FEEDBACK PRINTED CIRCUIT BOARD

CAT. NO. [4] SUFFIX	REGULATION	STYLE
10D	0.5%/0.5%	Non-Reversing Only
10D	0.1%/0.15%	Non-Reversing Only

TACHOMETER VOLTAGE	
AC	DC
N/A	100V/1000 RPM



1 Jumper on 2EA Potentiometer Board from terminal 2 to 3 must be removed when using the Tachometer Feedback Printed Circuit Board to disable IR Comp pot.

2 Connections for use with 1750 RPM and 1150 RPM base speed DC Motors only. Consult Drives Division for other base speeds.

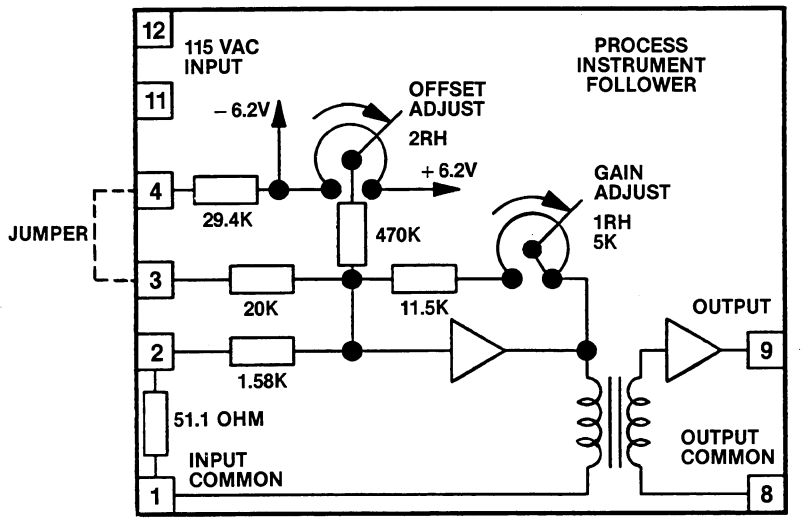
3 ⊂⊃ Wire is one conductor with insulated shield.

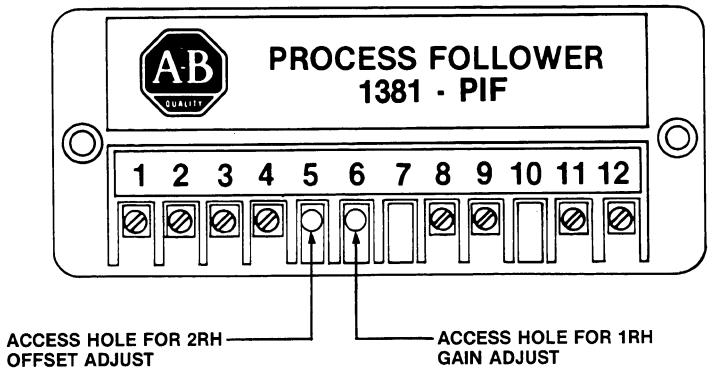
4 Bulletin 1381 catalog numbers only.

APPENDIX G

INSTALLATION AND ADJUSTMENT INSTRUCTIONS FOR OPTIONAL PROCESS INSTRUMENT FOLLOWER

BLOCK DIAGRAM





INSTALLATION

When installing, locate on a flat surface in an area reasonably free from vibrations, moisture, extremes of temperature and protected from physical damage.

Bulletin 1381 Package Drive panels are pre-drilled to accept this modification. Mount the Process Instrument Follower directly below 2PT with 8-32 mounting screws. 120V AC power may be obtained from the secondary of 2PT (X2) and load side of 10F.

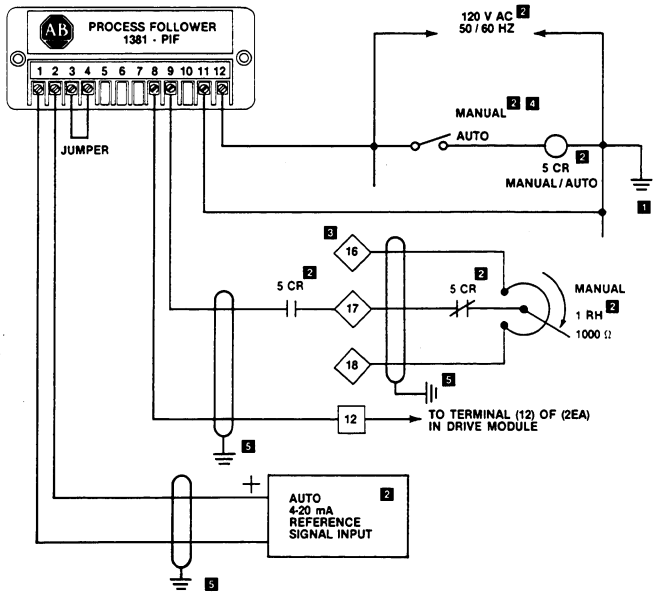
Wiring is to be done in accordance with local codes. Refer to wiring diagrams for appropriate connections and notes. Auto/Manual circuitry is provided for reference only.

ADJUSTMENT

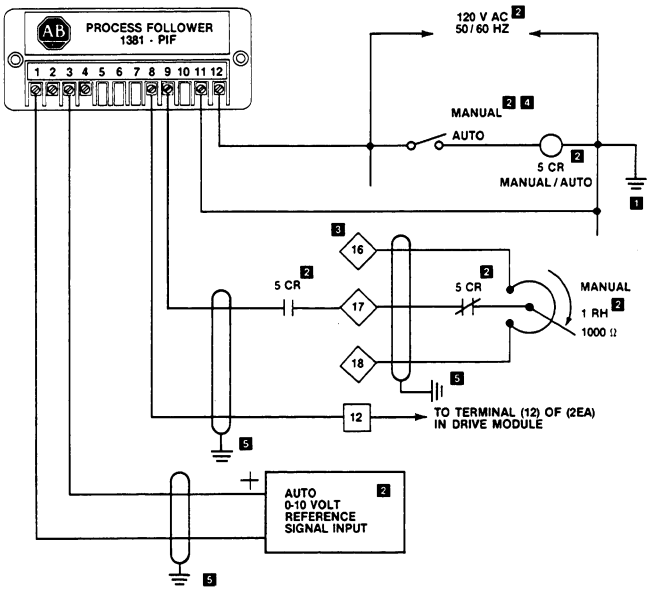
1. **REMOVE POWER.**
2. Connect a DC voltmeter across terminals (8) positive and (9) negative of the Process Instrument Follower.
3. Set voltmeter to the 1 volt DC range.
4. Set the Input Signal to minimum. (0V DC or 4mA DC).
5. Apply drive power, but DO NOT Start the drive.
6. While monitoring the voltmeter, adjust the Offset Adjust Pot (2RH) until the voltmeter indicates 0.0 volts. Reset voltmeter to 10V DC range.
7. Select the Run mode (Auto).
8. Initiate a Start.
9. Set the Input Signal to 100%. (+ 10V DC or 20mA DC).
10. Adjust the Gain Adjust Pot (1RH) until the voltmeter indicates – 7V DC.
11. Initiate a Stop. **REMOVE POWER.**

INTERCONNECTION DIAGRAM FOR OPTIONAL PROCESS INSTRUMENT FOLLOWER

A 4-20 mA DC INPUT SIGNAL



A 0-10 VOLT DC INPUT SIGNAL



NOTES:

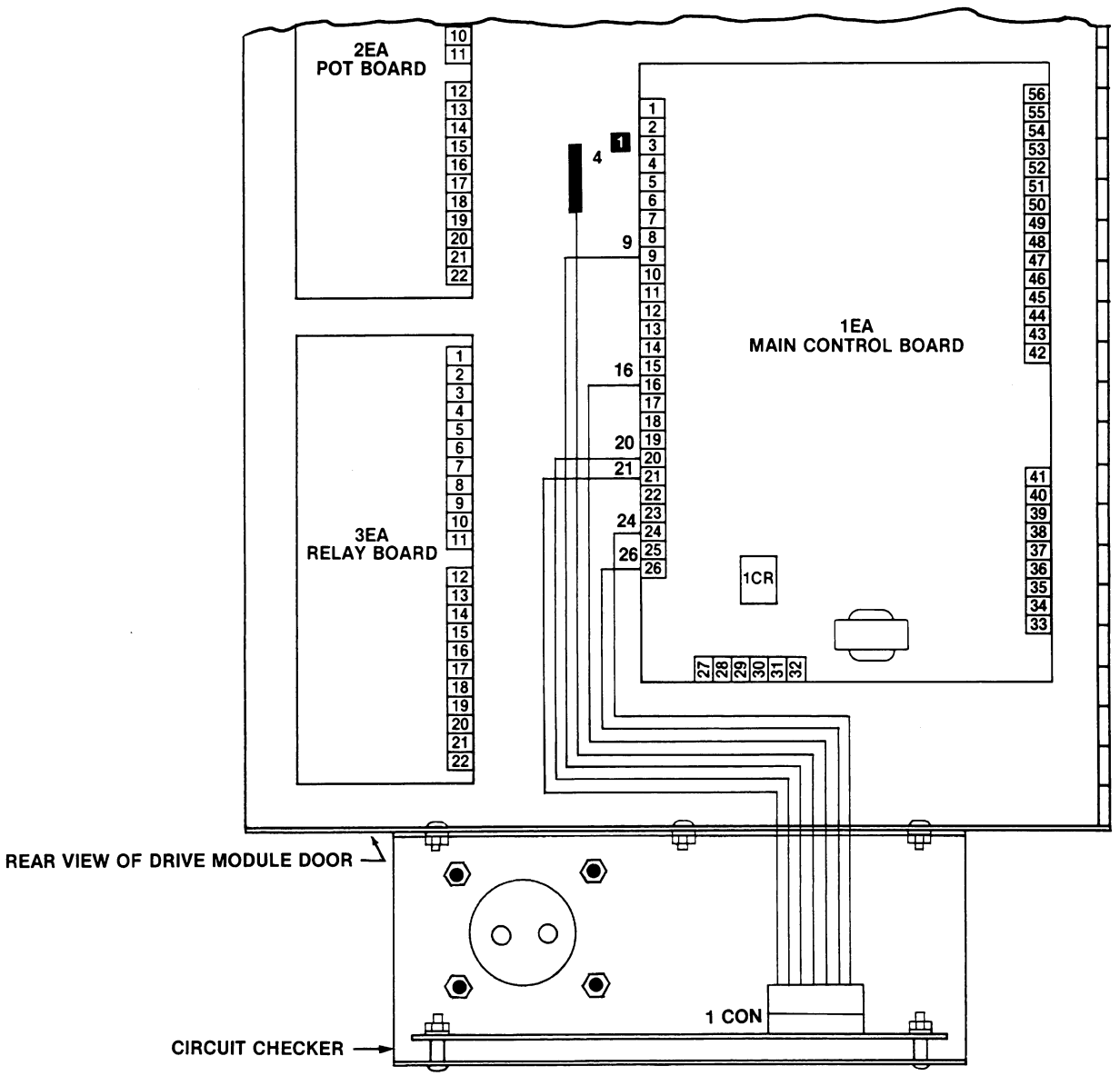
1. To be grounded by customer if conditions permit.
2. Indicates components supplied by others.
3. (1) Indicates outgoing terminal from the drive module terminal block (1 TB).
4. Typical manual / auto control circuit.
5. Wire with insulated shield is required. Shield is to be grounded at the controller only. Wires interconnecting these terminals may be run in a common conduit. This conduit must not contain power, AC control, or field conductors.

APPENDIX H

WIRING DIAGRAM AND INSTALLATION INSTRUCTIONS FOR OPTIONAL CIRCUIT CHECKER

Cat. No. [2] Suffix	Regulation	Style
None	2% / 5%	Non-Reversing and Reversing

Tachometer Voltage
Not Used (Armature Voltage Feedback Only)



The Circuit Checker is designed to mount on the bulletin 1379 drive module enclosure door. The three holes on the top of the Circuit Checker will line up with the three holes in the flange on the bottom of the enclosure door. Use three #6-32 x 1/2" machine screws, three #6 internal tooth lock washers, and three #6-32 hex nuts to secure the Circuit Checker to the drive module.

Connect the supplied harness to the Circuit Checker printed circuit board connector labeled 1CON. Route the wiring harness along with the drive module's existing wiring harness on the bottom of the enclosure door. Follow the existing harness to the left, then upward between the drive module's printed circuit boards.

[1] Insulate wire number (4) with electrical tape or equivalent. Secure this wire to the harness from the Circuit Checker so it does not hang loose.

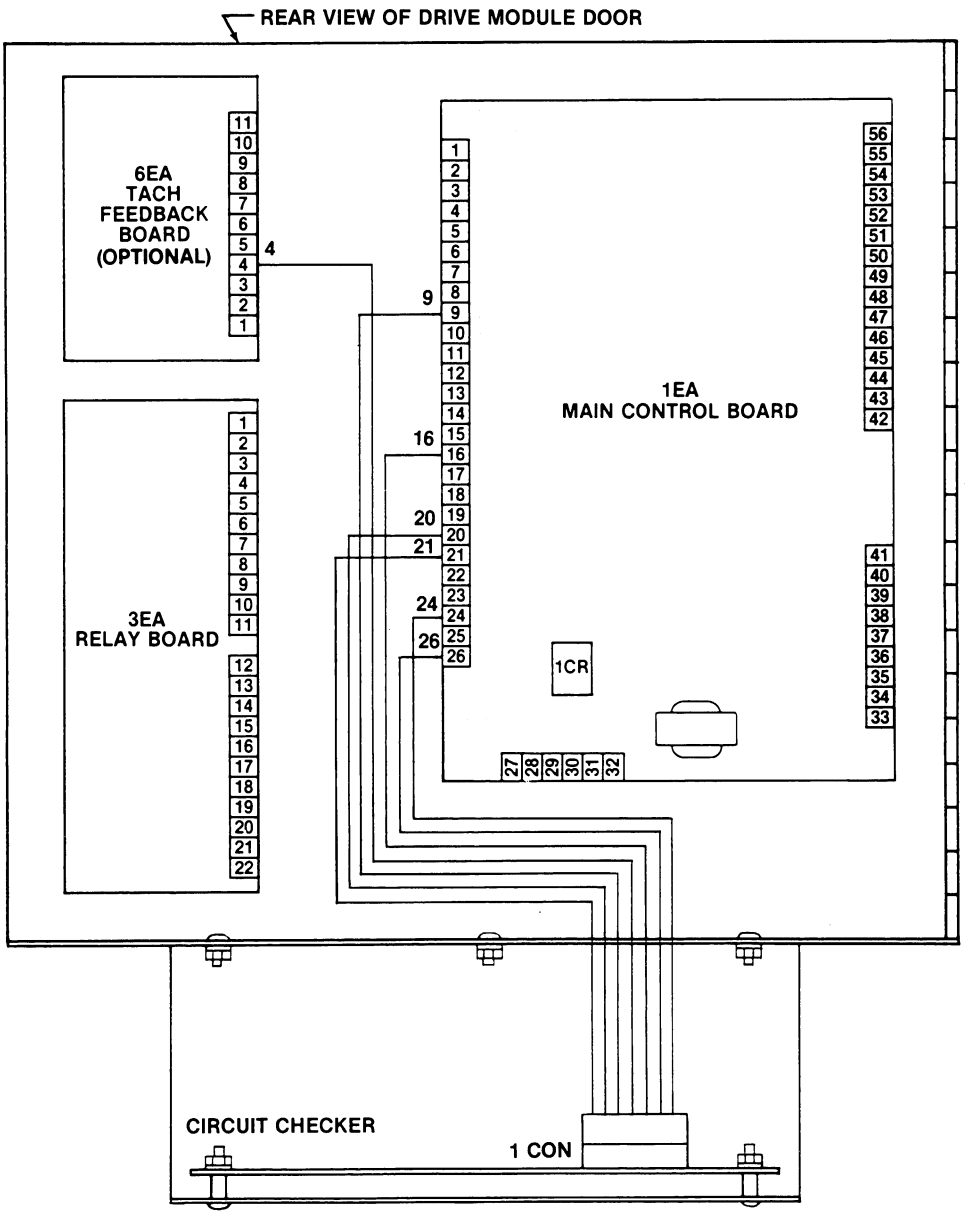
[2] Bulletin 1381 applications only.

WIRING DIAGRAM FOR OPTIONAL CIRCUIT CHECKER

Cat. No. [1] Suffix	Regulation	Style
10A 10B	1% / 2%	Non-Reversing and Reversing
10A 10B	1% / 1%	Non-Reversing and Reversing
10A 10B	0.5% / 0.5%	Reversing Only
10A 10B	0.1% / 0.15%	Reversing Only

[1] Bulletin 1381 applications only.

Tachometer Voltage	
AC	DC
90V / 1000 RPM	100V / 1000 RPM
45V / 1000 RPM	50V / 1000 RPM



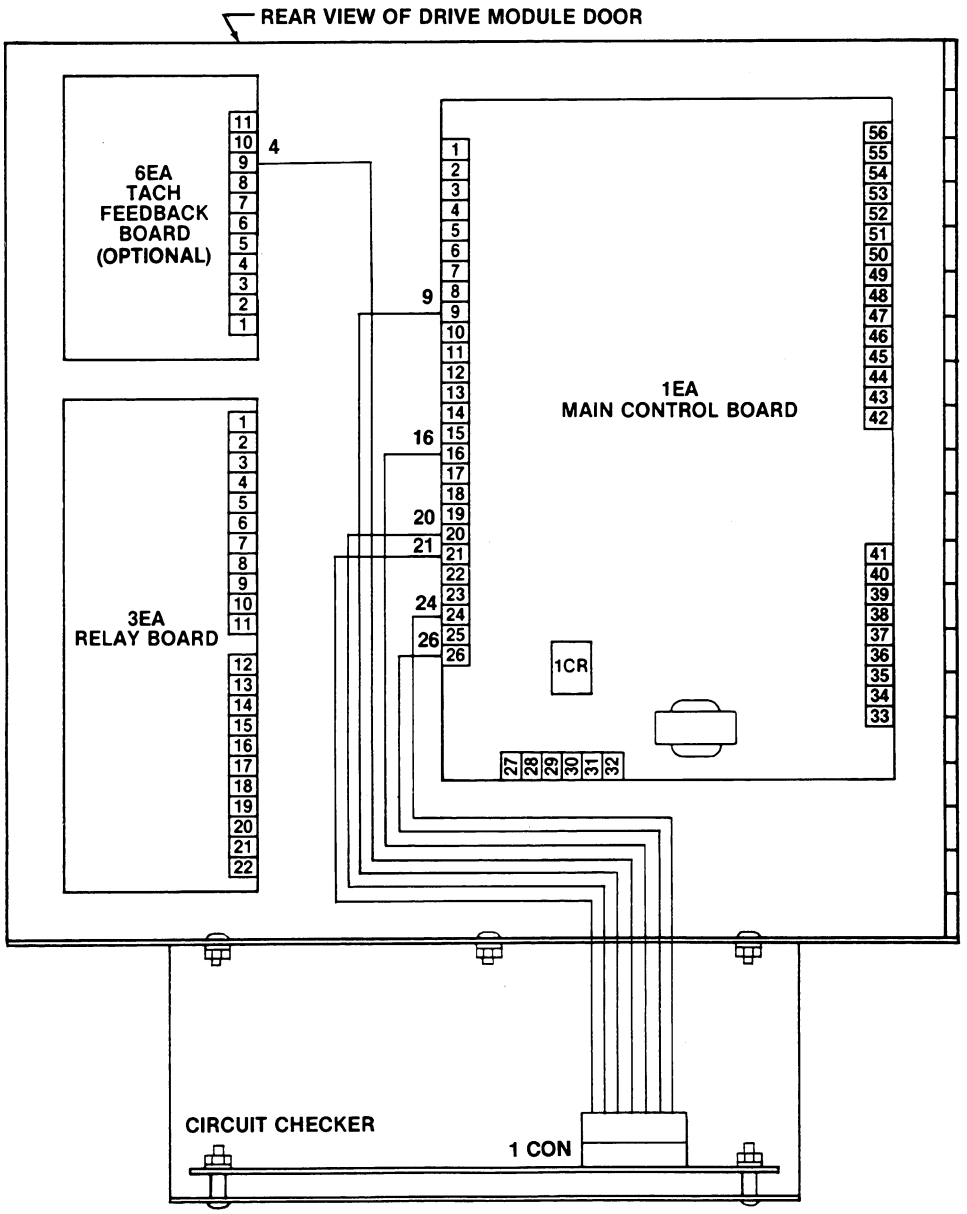
APPENDIX H

WIRING DIAGRAM FOR OPTIONAL CIRCUIT CHECKER

Cat. No. [1] Suffix	Regulation	Style
10C	0.5% / 0.5%	Non-Reversing Only
10C	0.1% / 0.15%	Non-Reversing Only

Tachometer Voltage	
AC	DC
Not Available	50V / 1000 RPM

[1] Bulletin 1381 applications only.

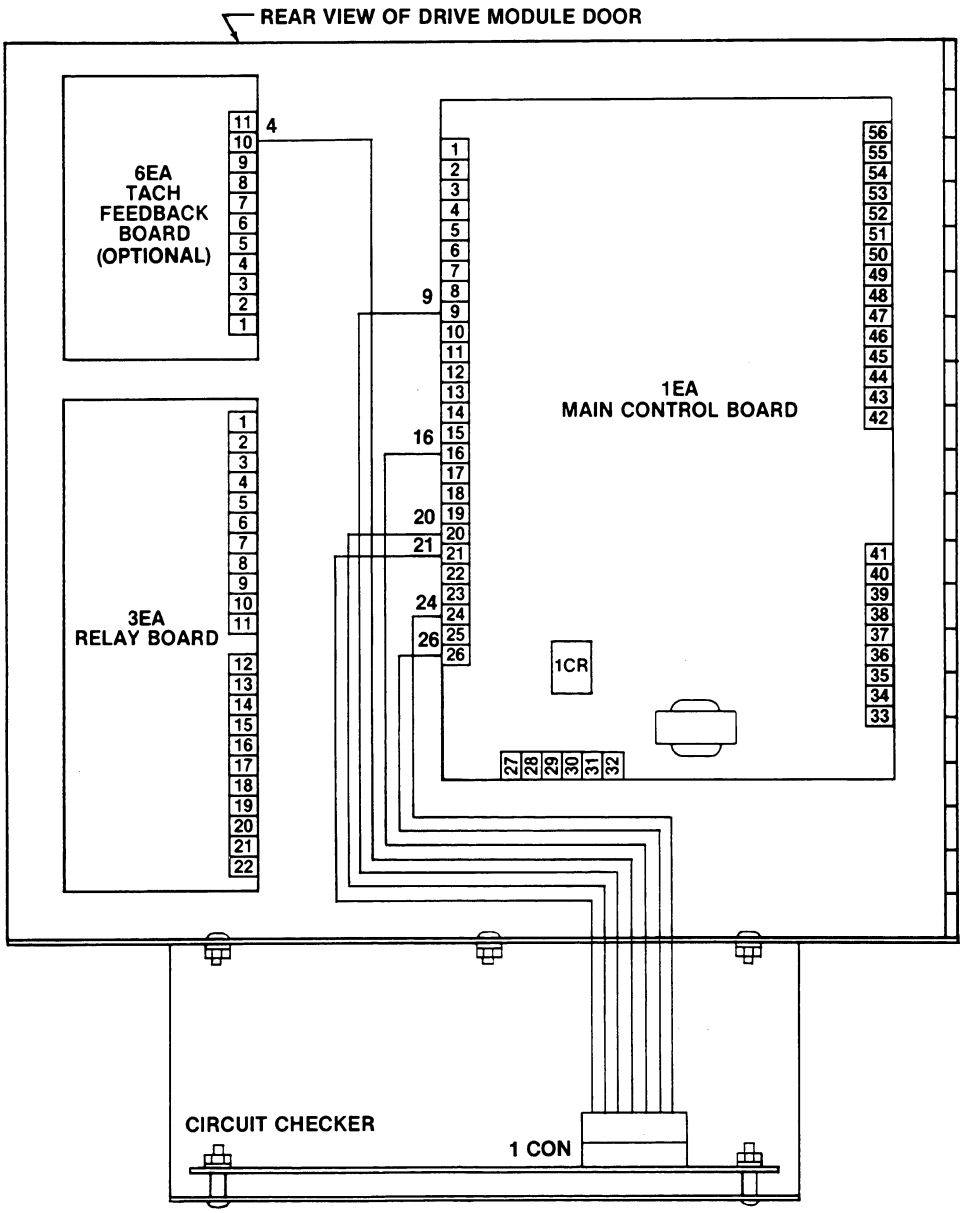


WIRING DIAGRAM FOR OPTIONAL CIRCUIT CHECKER

Cat. No. [1] Suffix	Regulation	Style
10D	0.5% / 0.5%	Non-Reversing Only
10D	0.1% / 0.15%	Non-Reversing Only

Tachometer Voltage	
AC	DC
Not Available	100V / 1000 RPM

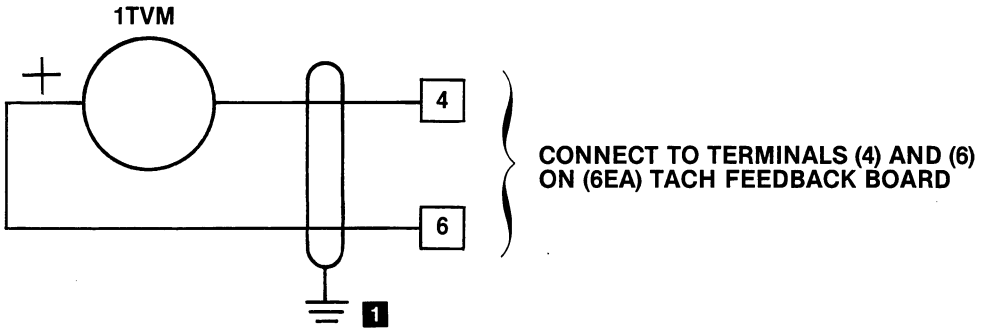
[1] Bulletin 1381 applications only.



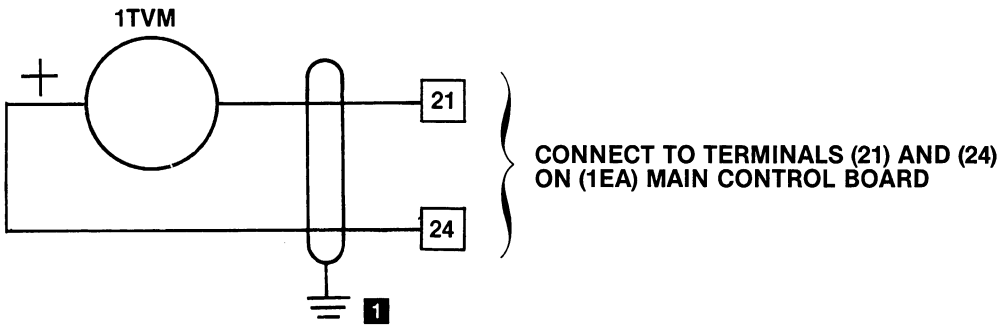
APPENDIX I

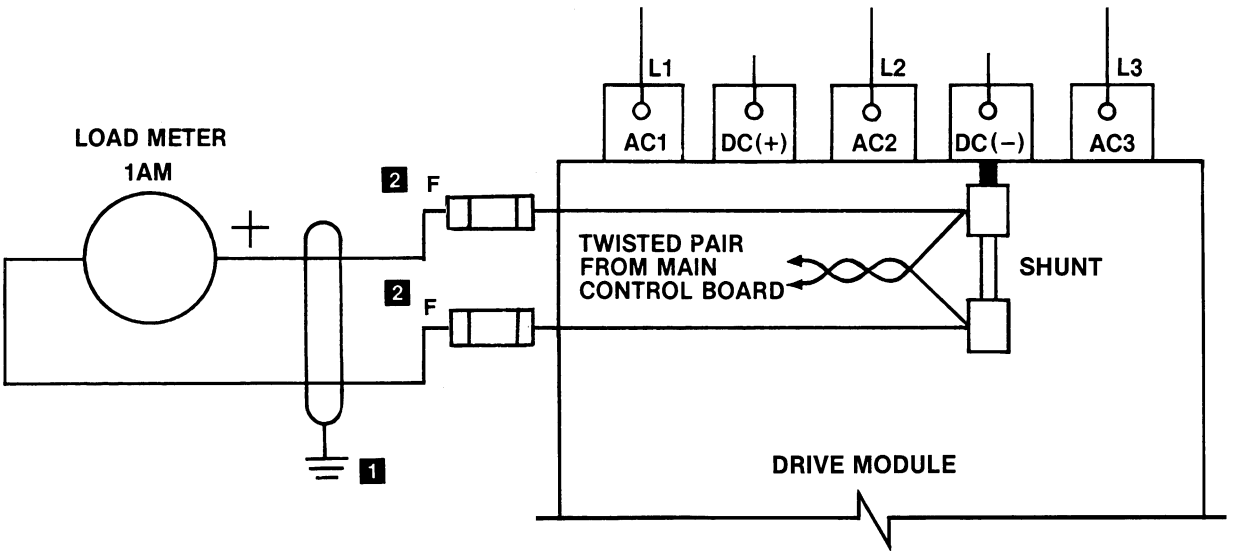
INTERCONNECTION DIAGRAM FOR OPTIONAL SPEED METER AND LOAD METER

CONNECTIONS FOR TACHOMETER FEEDBACK



CONNECTIONS FOR ARMATURE VOLTAGE FEEDBACK



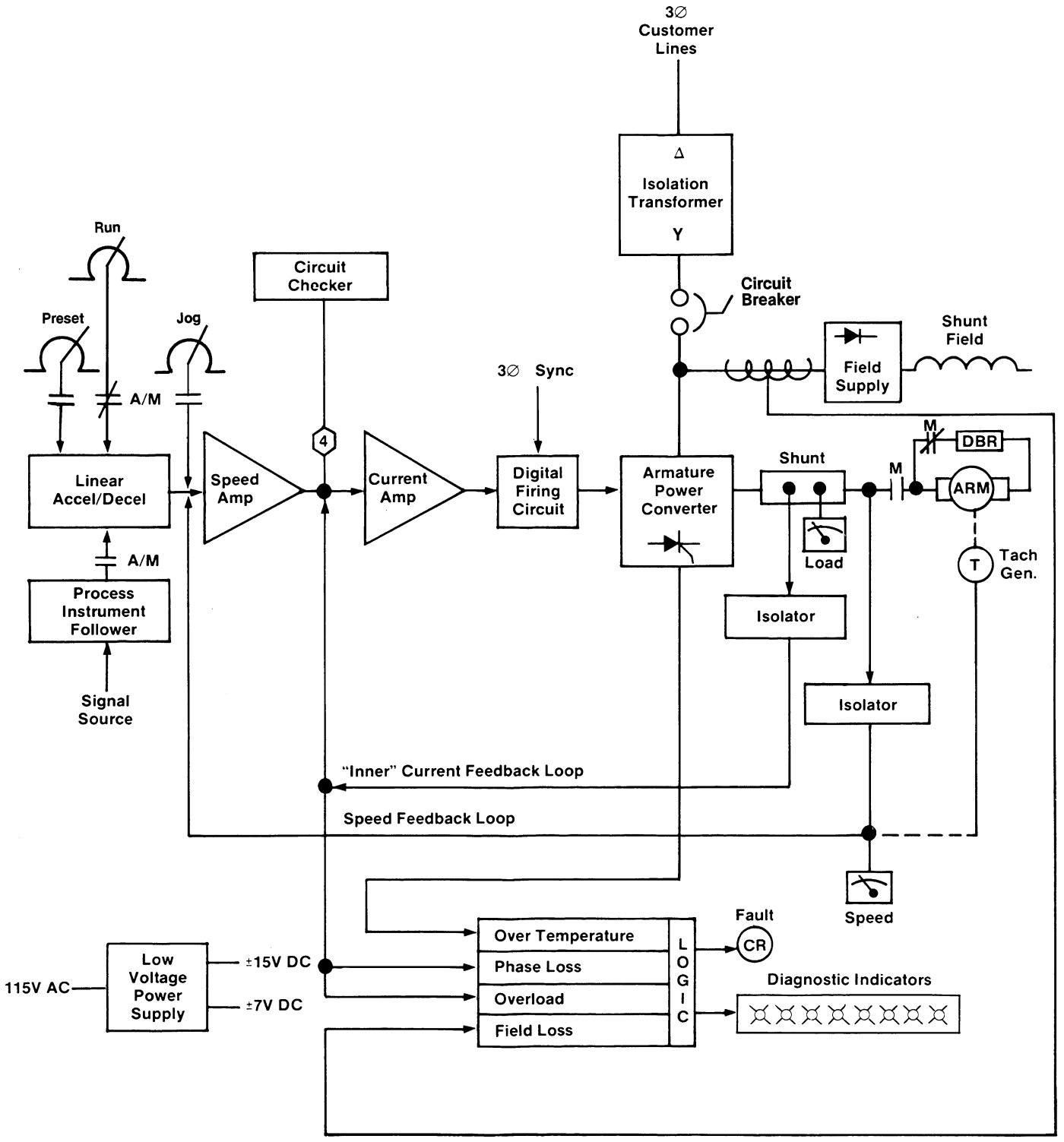


1 Wire with insulated shield is required. Shield is to be grounded at the controller only. Wire interconnecting these terminals may be run in a common conduit. This conduit must not contain power, AC control, or field conductors.

2 Type KTK, 1 Amp, 600 volt fuses are to be supplied by user and wired as shown when a Drive isolation transformer is NOT used.

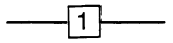
DC MODULE BLOCK DIAGRAM

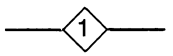
(Shown with Optional Equipment)

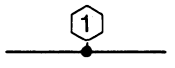


APPENDIX K

NOTES FOR THE DRIVE MODULE SCHEMATIC

1. To be grounded by customer if conditions permit.
2. Indicates components supplied by others.
3.  Indicates terminal on electronic assembly printed circuit board (EA).

    Indicates outgoing terminal from the Drive Module terminal block (1TB).

    Indicates Circuit Checker test point and red test jack.

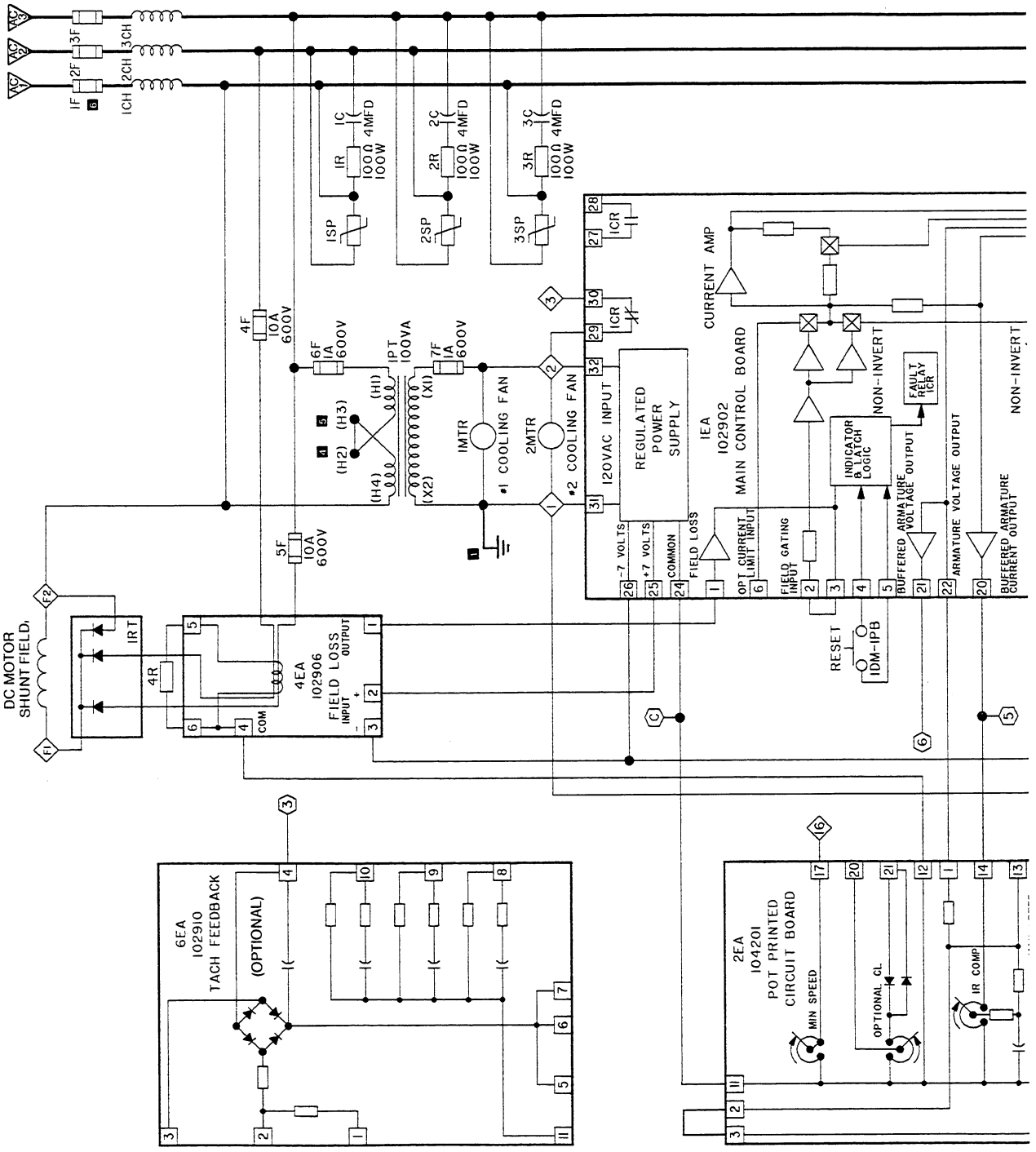
    Indicates regulator common and Circuit Checker black test jack.

    Indicates bus bar connection on Drive Module.
4. Module is connected for 480 volt AC input; for 240 volt AC input, reconnect transformer 1PT by removing jumper from H2 to H3 and adding jumper from H1 to H3, H2 to H4; also add jumper on main control board 1EA, terminals 38 and 39.
5. For primary connection see Appendix "A".
6. See Appendix "L" for fuse rating.

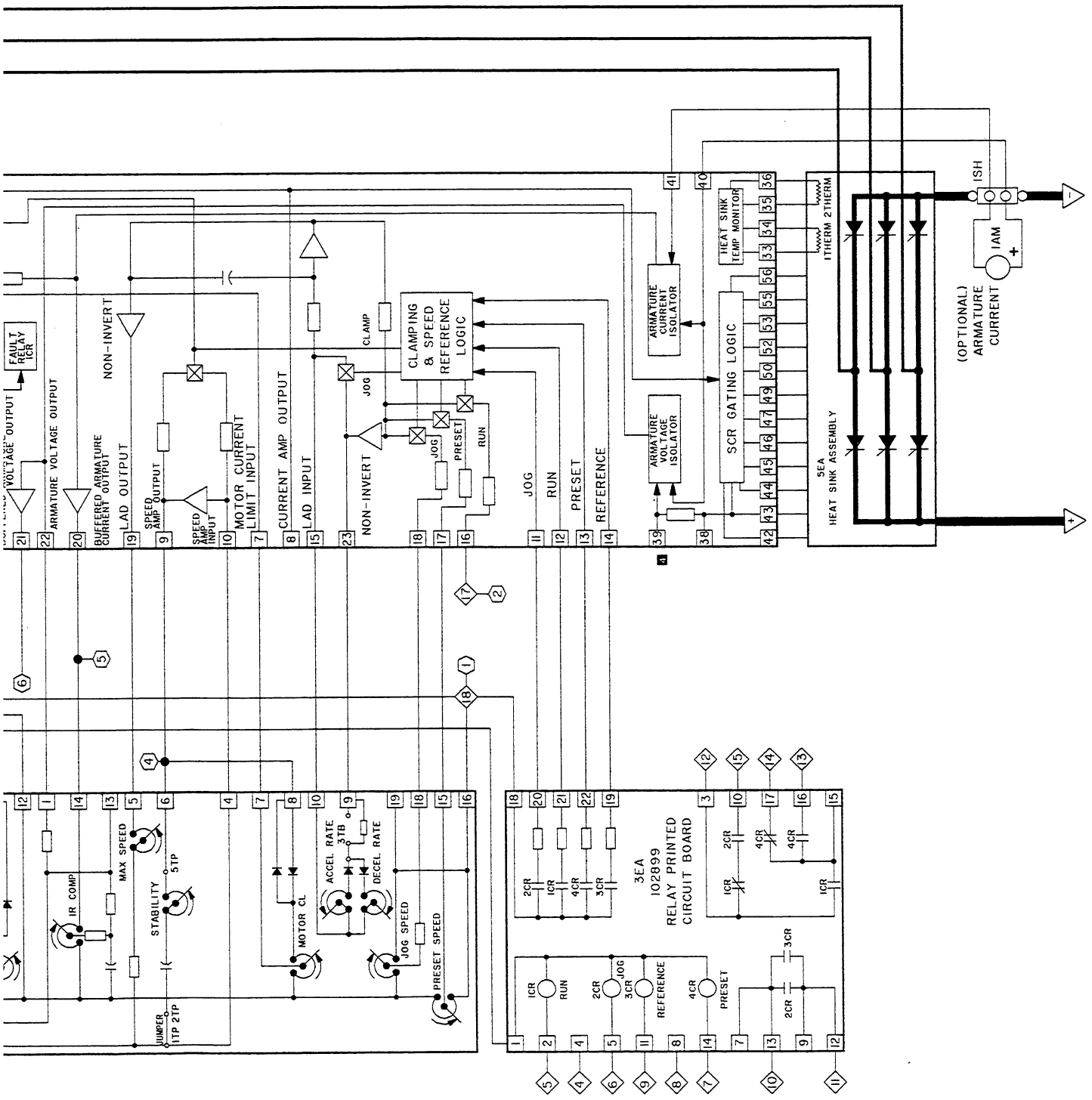
APPENDIX K

DRIVE MODULE SCHEMATIC

DRIVE MODULE



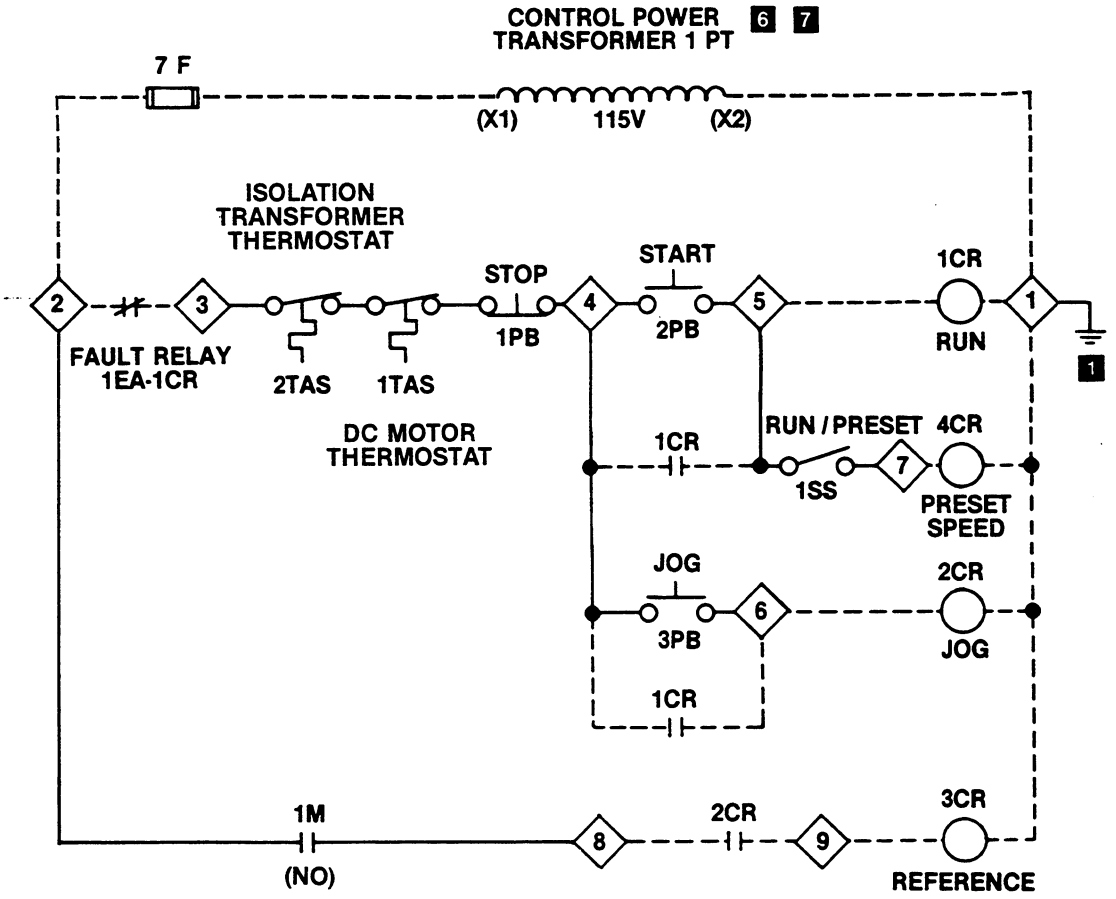
MODULE SCHEMATIC [3]



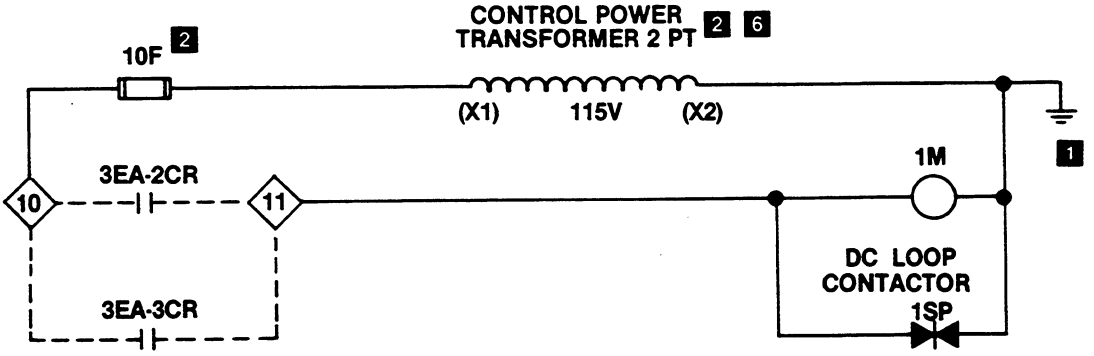
APPENDIX K

AC CONTROL LOGIC SCHEMATICS
NON-REVERSING [3] [4] [5]

DRIVE MODULE



OPTIONAL DC LOOP CONTACTOR



[1] To be grounded by customer if conditions permit.

[2] Indicates components supplied by others.

[3] —(1)— Indicates outgoing terminal from the Drive Module terminal block (1TB).

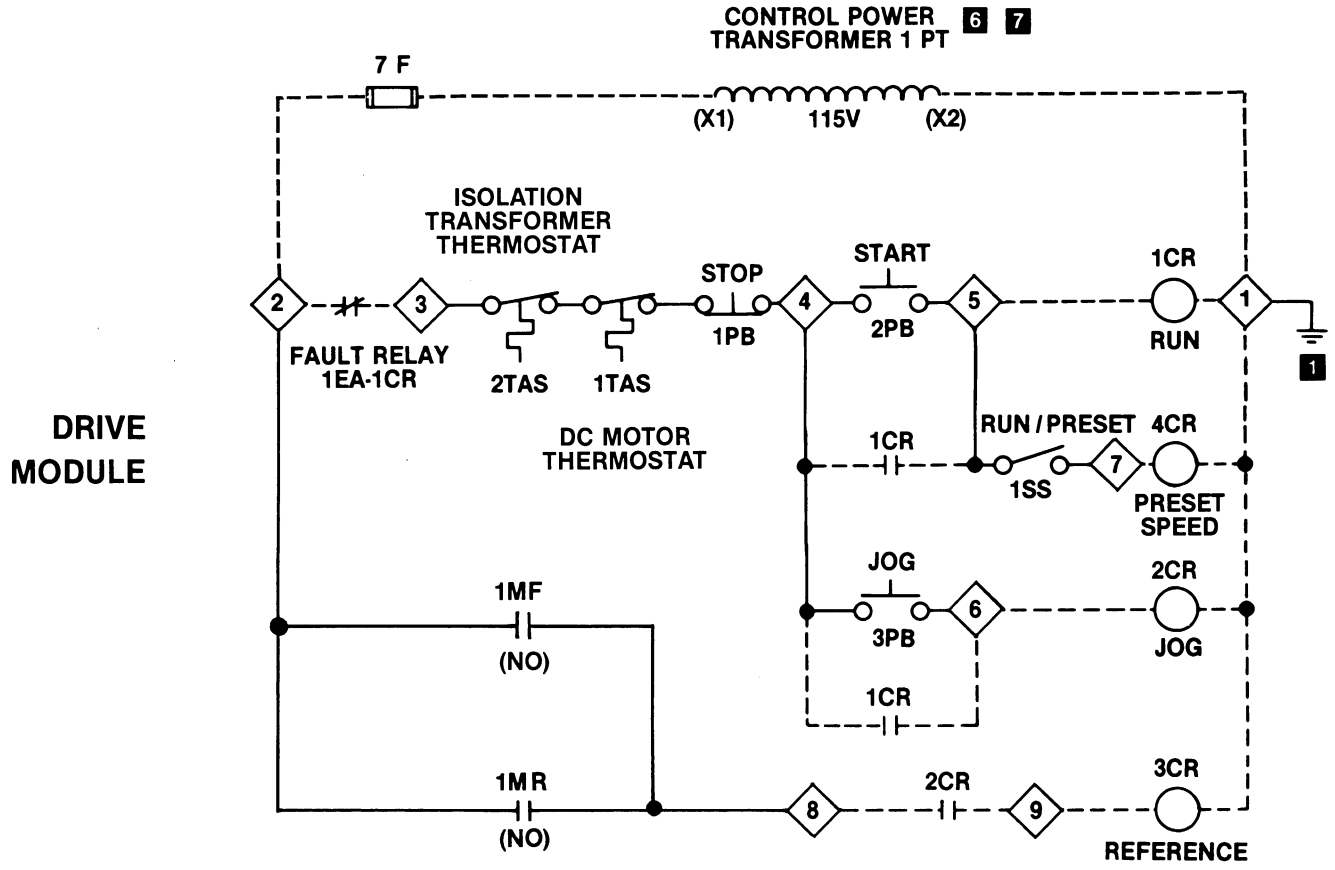
[4] ——— Indicates external customer wiring.

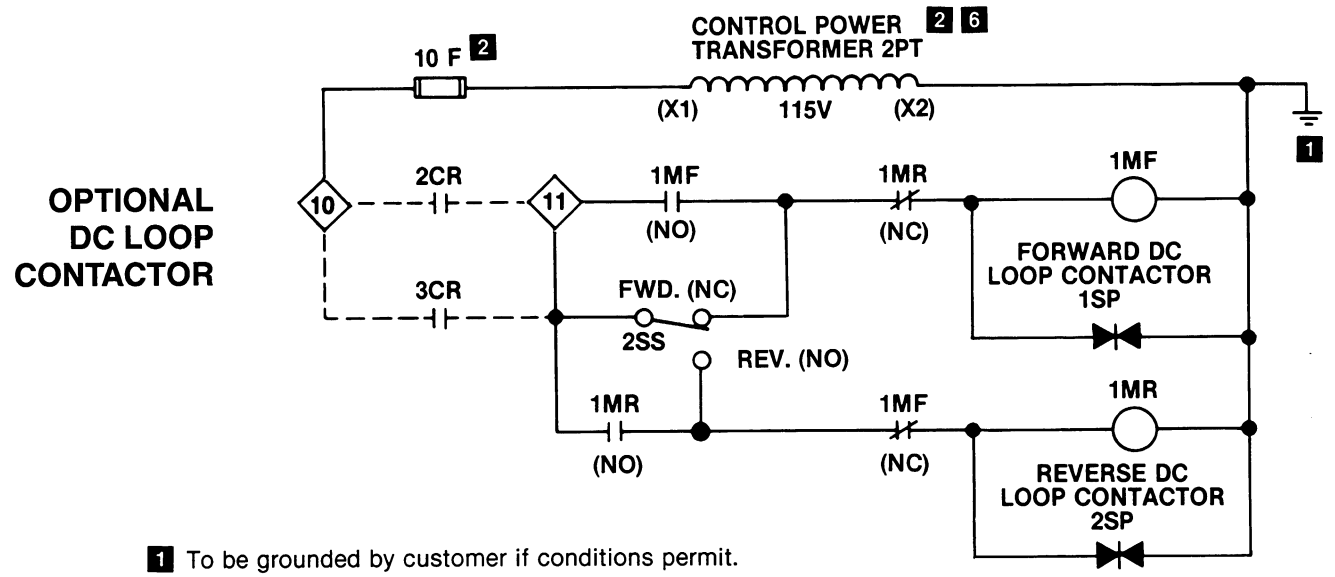
[5] - - - - - - Indicates components and wiring of DC Drive Module.

[6] For primary connection see Appendix "A".

[7] DO NOT use for DC contactor control power source.

AC CONTROL LOGIC SCHEMATICS
REVERSING 3 4 5





1 To be grounded by customer if conditions permit.

2 Indicates components supplied by others.

3 —(1)— Indicates outgoing terminal from the Drive Module terminal block (1TB).

4 ——— Indicates external customer wiring.

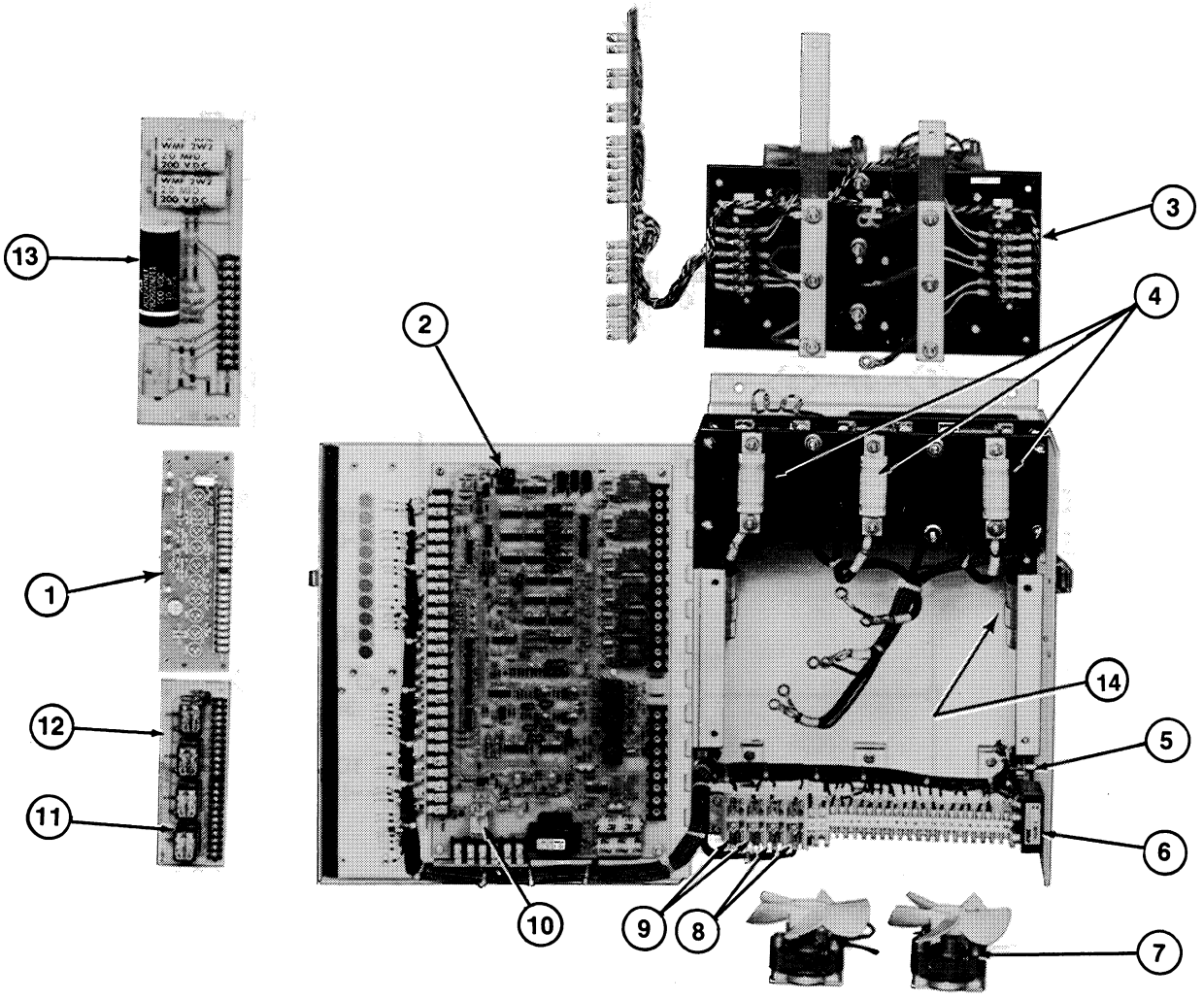
5 - - - - - - - Indicates components and wiring of DC Drive Module.

6 For primary connection see Appendix "A".

7 DO NOT use for DC contactor control power source.

APPENDIX L

RENEWAL PARTS

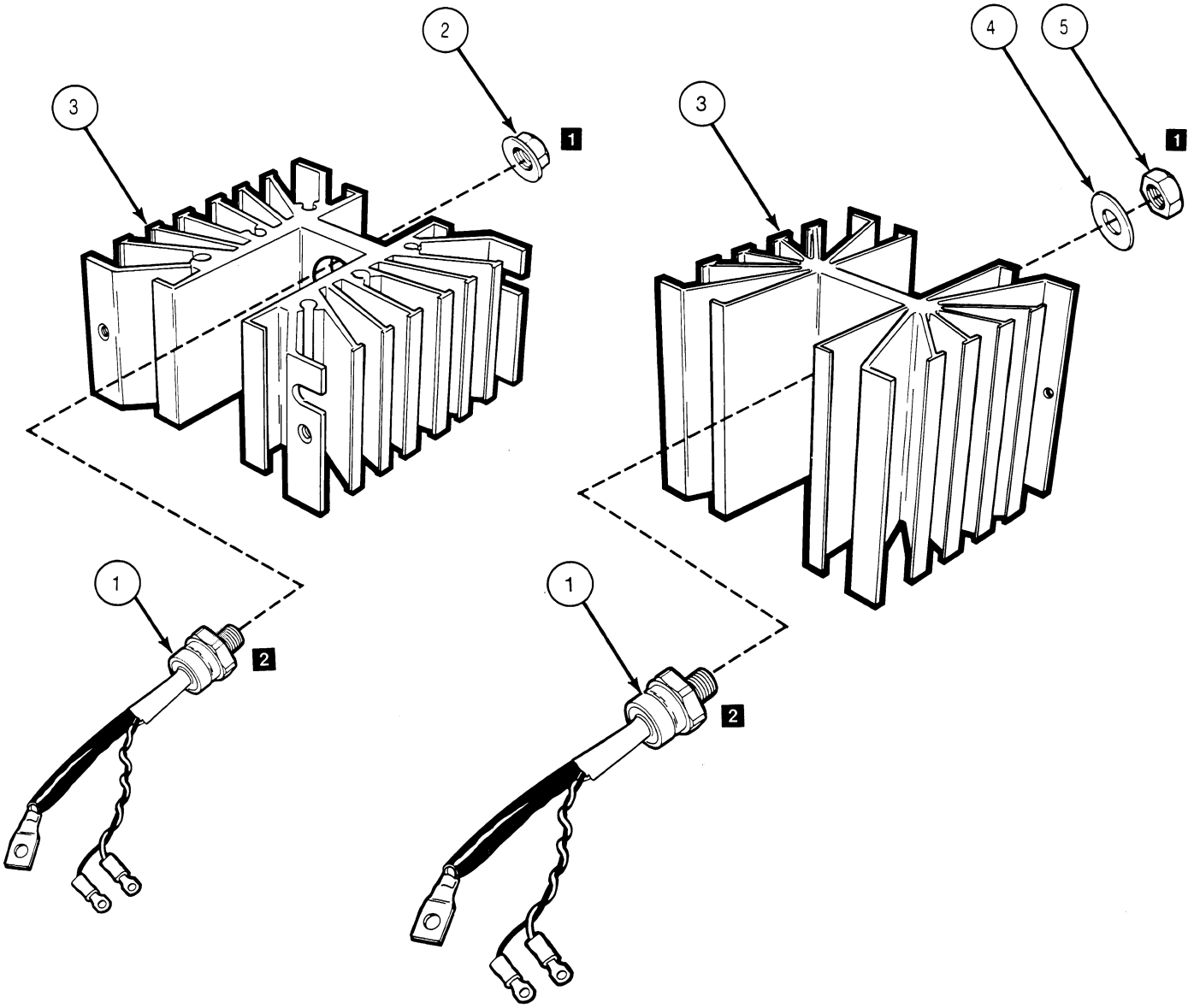


Key No.	Description	Part Number			QUANTITY
		105-AMP MODULE	250-AMP MODULE	345-AMP MODULE	
1	Potentiometer Board	116184	116184	116184	1
2	Main Control Board	111741	111741	111741	1
3	Armature Power Supply	102897	102898	102909	1
4	Line Fuse	101749	101750	101756	3
5	Field Loss Board	116183	116183	116183	1
6	Field Bridge Rectifier	101024	101024	101024	1
7	Fan	103042	103042	103042	2
8	Control Transformer Fuse 600V., 1A	101665	101665	101665	2
9	Field Fuse 600V., 10A	101667	101667	101667	2
10	Fault Relay	101184	101184	101184	1
—	Retaining Clip for Fault Relay	101472	101472	101472	1
11	Plug-in Relay	101215	101215	101215	4
—	Retaining Clip for Plug-in Relay	101474	101474	101474	4
12	Relay Board Assembly	116185	116185	116185	1
13	Tach Feedback Board (Optional)	102910	102910	102910	1
14	Capacitor 4 Mfd.	100778	100778	100778	3

RENEWAL PARTS

105 AMP HEAT SINK

250 / 345 AMP HEAT SINK



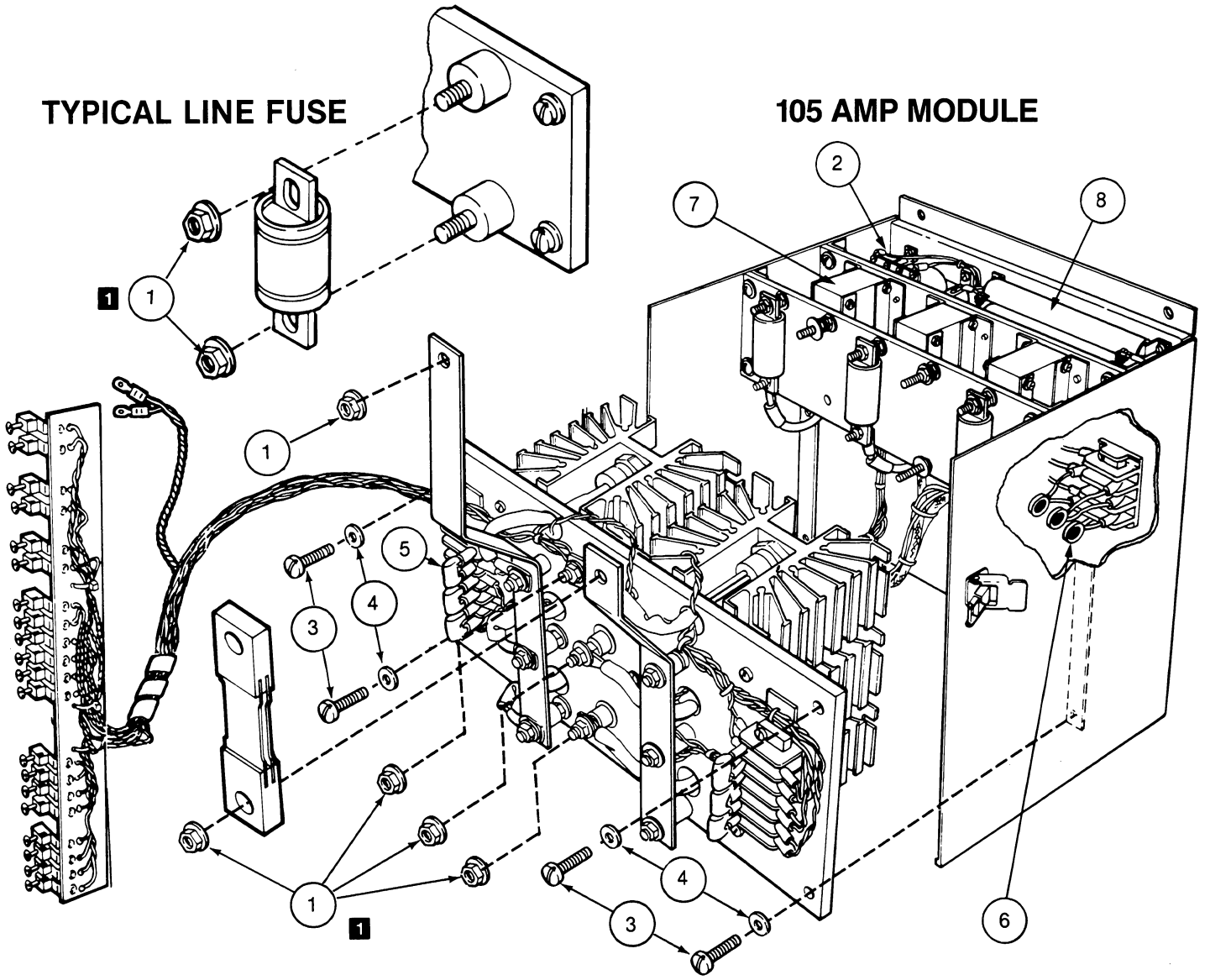
Key No.	Description	Part Number			QUANTITY
		105-AMP	250-AMP	345-AMP	
1	Silicon Controlled Rectifiers	101110	101112	101113	6
2	Keps-Nut 1/2-20	103196	—	—	6
3	Heat Sink	101167	101168	101168	6
4	Belleville Washer 3/4	—	103239	103239	6
5	Nut 3/4-16	—	Furnished with SCR	Furnished with SCR	6

1 Silicone Controlled Rectifiers are to be installed to the following torque settings: 1/2 inch bolt — 150 inch pounds; 3/4 inch bolt — 300 inch pounds.

2 PENETROX "A" (heat transfer) joint compound shall be applied to the anode mounting surface of the SCR before assembly. All excess compound squeezed out after the joint has been torqued to the proper level shall be removed.

APPENDIX L

RENEWAL PARTS

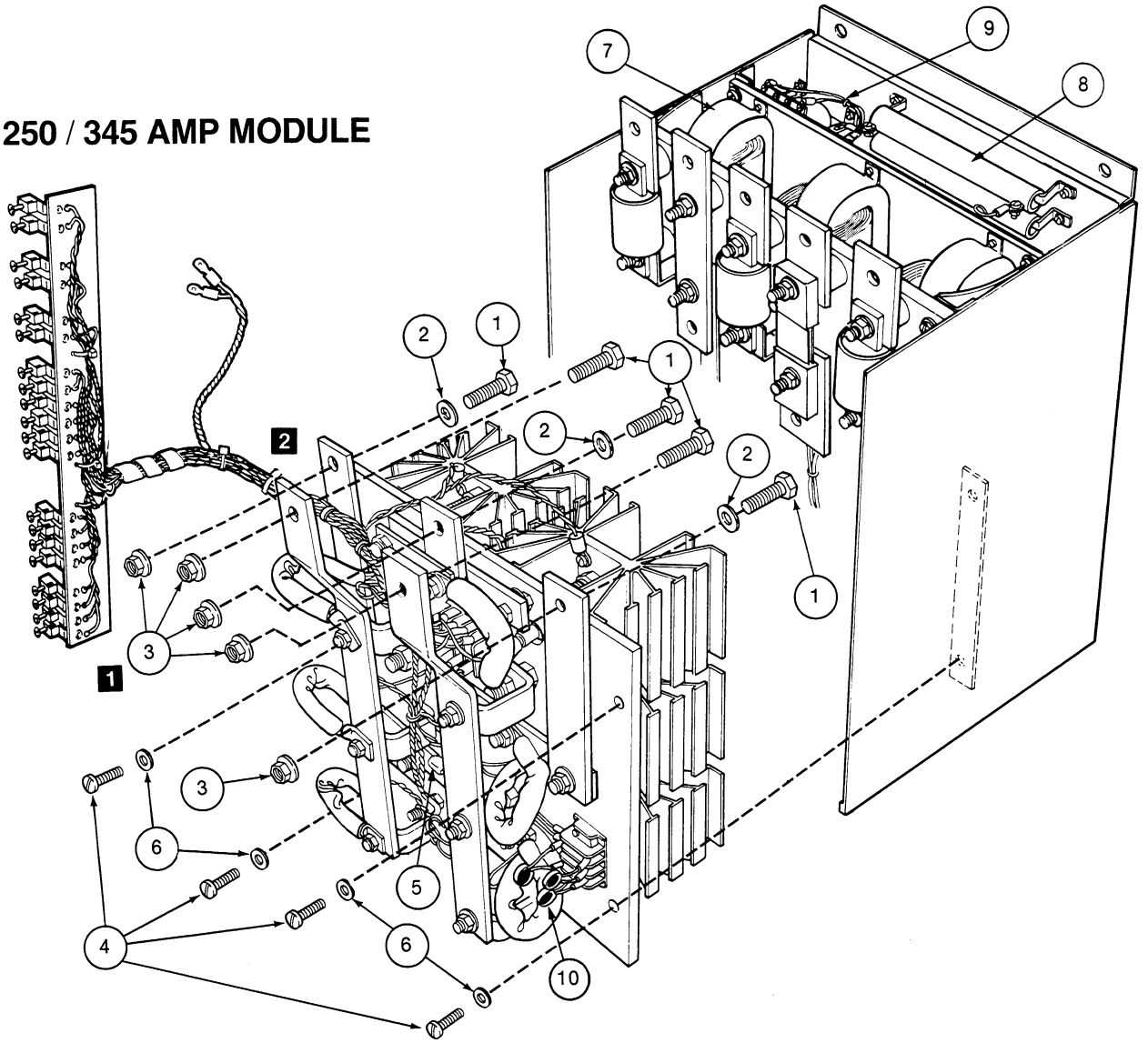


Key No.	Description	Part Number 105-AMP	QUANTITY
1	Keps-Nut	103182	15
2	Control Transformer 100VA	100840	1
3	Pan Head Mach. Screw 1/4-20 x 3/4	103136	4
4	Flat Washer 1/4	103220	4
5	Capacitor	100806	6
6	Surge Suppressor	101063	3
7	Choke	100908	3
8	Resistor	100209	3

1 All Module Power Connections Keps-nuts are to be installed to the following Torque Settings. 1/4 inch bolt — 35 inch pounds; 3/8 inch bolt — 75 inch pounds; 1/2 inch bolt — 150 inch pounds; 3/4 inch bolt — 300 inch pounds.

RENEWAL PARTS

250 / 345 AMP MODULE



Key No.	Description	Part Number		QUANTITY
		250-AMP	345-AMP	
1	Hex Head Cap Screw 3/8-24 x 1	103154	103154	5
2	Flat Washer	103230	103230	3
3	Keps-Nut 3/8-24	103195	103195	5
4	Pan Head Mach. Screw 1/4-20 x 3/4	103136	103136	4
5	Capacitor	100806	100806	6
6	Flat Washer 1/4	103220	103220	4
7	Choke	100907	100907	3
8	Resistor	100209	100209	3
9	Control Transformer 100VA	100840	100840	1
10	Surge Suppressor	101063	101063	3

1 All Module Power Connections Keps-nuts are to be installed to the following Torque Settings. 1/4 inch bolt — 35 inch pounds; 3/8 inch bolt — 75 inch pounds; 1/2 inch bolt — 150 inch pounds; 3/4 inch bolt — 300 inch pounds.

2 PENETROX "A" (heat transfer) joint compound shall be applied to the electrically conductive surfaces of the Bus Bar connections (5 places) before assembly. All excess compound squeezed out after the joint has been torqued to the proper level shall be removed.

APPENDIX M

RECOMMENDED SPARE PARTS LIST

Description	Part Number			QUANTITY
	105-AMP MODULE	250-AMP MODULE	345-AMP MODULE	
Potentiometer Board	116184	116184	116184	1
Main Control Board	111741	111741	111741	1
Line Fuse	101749	101750	101756	3
Field Loss Board	116183	116183	116183	1
Field Bridge Rectifier	101024	101024	101024	1
Relay Board Assembly	116185	116185	116185	1
Tach Feedback Board (Optional)	102910	102910	102910	1
Silicon Controlled Rectifier	101110	101112	101113	6
Surge Suppressor	101063	101063	101063	3

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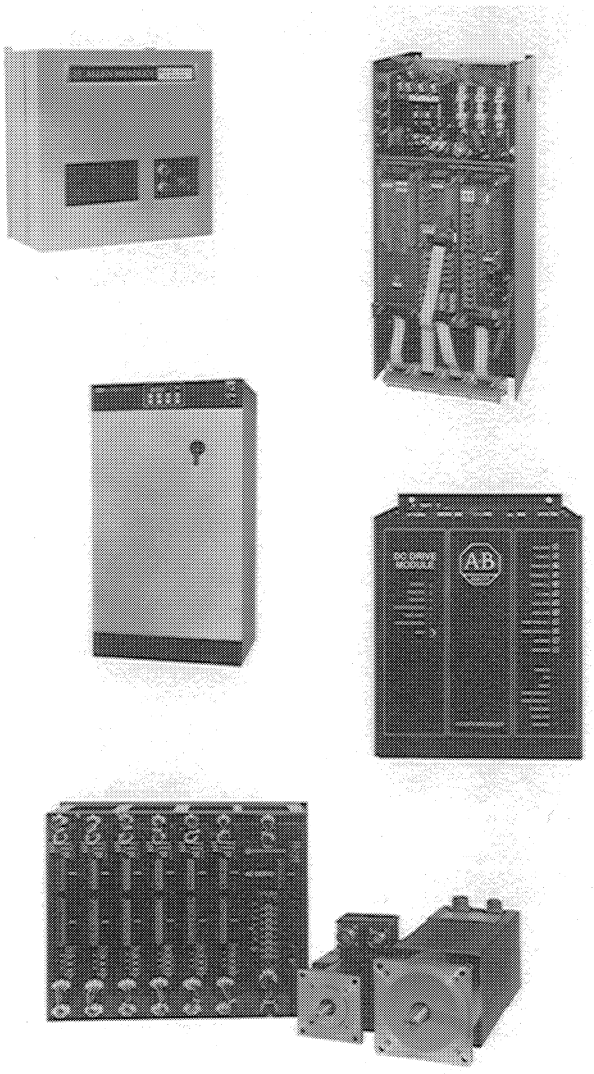

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- **Motion Control Drives**
  Bulletins 1387, 1388, 1389, 1390
  1391, 1392
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