SAF Drives Inc.

Installation & Operating Procedures

Opal Pro MS6 Series

SOLID STATE REDUCED VOLTAGE STARTER

FOR 3 PHASE INDUCTION MOTORS

Opal Pro MS6 SERIES

SOLID STATE REDUCED VOLTAGE STARTER

FOR 3 PHASE INDUCTION MOTORS

Revision 1.08 - 01/2011

FOR YOUR SAFETY

Only qualified personnel should install this equipment, after first reading and understanding all the information in this manual. All instructions should be strictly adhered to. The user should consult SAF Drives Inc. or a SAF OPAL Starters supplier for clarification of the contents of this manual should any doubt or questions arise.

The installation of this equipment must be conducted in accordance with all national, regional and local electrical codes.

All drawings and technical representations included in this manual are for typical installations and should not in any way be considered for specific applications or modifications. Consult SAF OPAL Starters for supplemental instructions.

SAF Drives Inc. accepts no liability for any consequences resulting from inappropriate, negligent or incorrect installation, application or adjustment of this equipment.

The contents of this manual are believed to be correct at the time of printing. In following with our commitment to the ongoing development and improvement of our products SAF OPAL Starters reserves the right to change the specification of this product and/or the content of this instruction manual without notice.

TABLE OF CONTENTS

1 MS6 GENERAL DESCRIPTION

1.1 OVERVIEW

The Opal Pro series is a processor controlled line of solid state reduced voltage starters for use with 3 phase induction motors. This series also includes various communication options, which can be easily added to connect to standard industrial networks.
A solid state starter provides a step-less, smooth current ramp to the motor. This characteristic eliminates current surges and mechanical torque transients. Since these units are solid state, we now eliminate the maintenance of moving contacts, which are involved in almost any other method of starting an AC induction motor.

1.1.1 STANDARD FEATURES

- 200 – 600 VAC 3 phase universal voltage, 50/60Hz with no adjustment
- Single control card through out Opal Pro range
- Current regulated closed loop
- Dual operation modes to match any application:
  - Constant Current mode for light loads or limited power supplies
  - Current Ramp mode for high inertia or heavy loads
- Soft stop
- Jog Speed:
  - 14% of full speed forward
  - 20% of full speed reverse
- Two or three wire control
- 120 VAC control inputs for:
  - Start
  - Stop
  - Jog
  - Reverse
  - Reset
  - Enable
- Keypad and LCD display for starter setup and diagnostics
- Single phase protection
- Phase rotation insensitive
- Instantaneous over-current trip
- Class 10, 15, 20, or 30 electronic motor overload
- Shorted SCR Fault output
- Shear pin Fault
- Dry contact relay outputs for:
  - Fault
  - By-pass
  - Shorted SCR
  - Running
  - Reverse

1.1.2 OPTIONAL FEATURES

- By-Pass Contactor
  Once the motor has reached operational speed, the by-pass contactor is closed. This shorts the SCR's which eliminates the voltage drop across the SCR's, in turn being more efficient and ridding excess heat.
- Solid State Full Speed Reversing
  Through the addition of 4 SCR's and a reversing card, smooth motor reversing is achieved without having to stop the motor.
- DC Injection Braking
  Through the addition of SCR's and a DC injection card, adjustable electric braking of the AC motor is performed.
- Various communication options, which will allow connection to standard industrial networks
- NEMA 4 or NEMA 12 enclosures

1.2 APPLICATION NOTES

1.2.1 OPERATION MODES

With any induction motor the design is such that starting currents and torques are very high. Across the line starting for a basic NEMA B design motor creates an in-rush current of 600% or more of the nameplate rating. Often these levels are so high that they cause problems with mechanical or auxiliary electrical. An example of this is the high starting torques which cause belt slip and high currents, creating large voltage dips. The basis of choosing the correct starting mode is determining the problem to be solved.

1.2.2 CHOOSING STARTING MODE

Constant Current Mode

Soft Starting for light loads or reducing starting current are accomplished by using the Constant Current Mode.

On some applications the starting time is still too fast in the current ramp mode because the load is too light. In this application it is best to select the constant current mode which will allow the acceleration torque to be better controlled, actually kept constant.

If the available current is limited and causes significant voltage drops, the constant current mode will allow flexibility in setting the current draw. Remember that the current level must be great enough to provide acceleration torque and this level is determined by the load.

For all other applications, or if in doubt, select the Current Ramp Mode.

Current Ramp Mode

Torque Reduction on heavy loads is accomplished by using the Current Ramp Mode.

The idea is to reduce starting current to just above the level, which will produce enough torque to get the motor to move. This is commonly referred to as "break-away torque". As the current ramps up from this point, the torque also increases as time passes. If at the initiation of start, the motor torque is less than the load, the motor will remain stalled until the torque ramps to a sufficient level for acceleration.

1.2.3 MOTOR AND LOAD TYPES

Squirrel Cage Motors

Squirrel cage motors, with a single winding and of any NEMA design may be connected to the Opal Pro starter.

Wound Rotor Motors

Wound Rotor Induction Motors (WRIM) and solid state starters make an excellent combination for frequent starting, jogging, plug-stopping and reversing applications. These WRIM motors use multiple steps of resistors to provide various speed torque characteristics. This allows a high starting torque characteristic while providing low starting current when compared to NEMA B designs.

One disadvantage has been the high maintenance costs of the resistor and shorting contactor bank. The use of an Opal Pro allows an improvement to this arrangement by allowing the current to be limited without use of the multiple steps. Usually the load characteristic is such that this starting may be accomplished with only one or two starting steps. By eliminating several contactors a major savings is realized that often pays for the installation cost.

The common method is to add only one step of resistance at 20% (Rotor volts divided by Rotor Amps times 20%). This resistance value will provide relatively high starting torque and the Opal Pro will be used to limit the current. As little as 200% of motor full load current can provide 100% starting torque unlike squirrel cage NEMA B motors which would require 500% current. The resistor bank may be shorted with a contactor at full speed to reduce the slip and eliminate the watt losses in the resistors.

Other Types of AC Motors

Opal Pro starters may also be used to start 2-speed motors with multiple windings or connections. Proper contactor selection and sequencing is required for the specific motor.

Resistive and Inductive Loads

The Opal Pro MS6 is well suited for use as a phase controller or current regulator on resistive or inductive loads such as heaters. When applied with a Temperature PI controller, the Opal Pro MS6 will maintain smooth control to avoid the overheating associated with on/off type controllers. Improved temperature accuracy and longer heater element life can be expected over standard control methods.

1.2.4 STARTING AC MOTORS IN PARALLEL

Opal Pro MS6 starters can be used to start motors in parallel but they must have individual overload devices added.

When the paralleled motors are also connected to the same load, mechanically or through the material, then load sharing must be considered.

When the motors are mechanically tied, the load sharing is determined by how closely the motor characteristics are to each other. It is important to keep the motors exactly the same. Even changing the manufacturers of the motors can cause some variations in load sharing. The Opal Pro size is determined by the total of the motor current ratings.

2 SPECIFICATIONS

2.1 POWER RATING

Power 3 phase, 200-600 VAC, 50/60Hz
Control 115VAC 50Hz or 120VAC 60Hz
Rating See Section 2.2
All models have 1600V PIV SCR's
Digital Inputs 120VAC, 2mA
Digital Outputs Relay contacts rated at 0.2A, 120VAC
By-Pass Output Relay contact rated at 5A, 120VAC
Analog Input **0 – 10Vdc**
Analog Output **0 – 5Vdc, 5mA max**
Protection Short circuit by HRC fuses or circuit breaker (supplied upon request)

2.2 MAXIMUM RATINGS

OPAL PRO MODEL	HORSE POWER		
	230VAC	460VAC	575VAC
MS6-30	10	25	30
MS6-50	20	40	50
MS6-80	30	60	75
MS6-125	40	100	125
MS6-250	100	200	250
MS6-420	175	350	420
MS6-500	200	400	500
MS6-600	200	500	600
MS6-800	300	600	800

* HP Rating for estimate only. Size by motor FLA

2.3 SERVICE CONDITIONS

Elevation For altitudes in excess of 1000 meters (3300 feet) above sea level, all assemblies must be de-rated 1% for every 100 meters (330 feet) above

Ambient Temperature Do not install in areas where the ambient temperature falls below 0°C(32°F) or exceeds 40°C(104°F)

2.4 FUSE SIZING

OPAL PRO MODEL	MOTOR FLC	HP			J FUSE AMPS	
		240V	460V	575V	FAST ACTING	TIME DELAY
MS6-30	20	---	15	20	50	30
	25	10	20	25	60	40
	30	---	25	30	70	50
MS6-50	37	15	---	---	70	50
	40	---	30	40	80	60
	50	20	40	50	100	80
MS6-80	60	25	---	60	125	90
	65	---	50	---	150	100
	75	30	60	75	150	125
MS6-125	90	---	75	---	200	150
	100	40	---	100	200	150
	125	50	100	125	250	200
MS6-250	150	60	125	150	300	225
	180	75	150	---	400	250
	200	---	---	200	400	300
	250	100	200	250	500	350
MS6-420	300	125	250	300	600	450
					L FUSE AMPS	
	360	150	300	---	600	500
	400	---	---	400	600	600
MS6-500	500	200	400	500	800	600
						L FUSE AMPS
MS6-600	600	250	500	600	900	800
MS6-800	700	300	---	700	1000	1000
	720	---	600	---	1100	1000
	800	---	---	800	1200	1200
MS6-1000	840	---	700	---	1400	1200
	850	350	---	---	1400	1200
	900	---	---	900	1500	1200
	960	---	800	---	1500	1600
	1000	---	---	1000	1600	1600

2.5 DIMENSIONS

2.5.1 STANDARD UNIT

MODEL	DIMENSIONS			
	HEIGHT	WIDTH	DEPTH	WEIGHT
MS6-30-N1	43.2cm(17”)	30.5cm(12”)	26.75cm(10.5”)	13.6kg(30 lbs.)
MS6-50-N1	43.2cm(17”)	30.5cm(12”)	26.75cm(10.5”)	13.6kg(30 lbs.)
MS6-80-N1	43.2cm(17”)	30.5cm(12”)	26.75cm(10.5”)	13.6kg(30 lbs.)
MS6-125-CH	38cm(15”)	38cm(15”)	29.25cm(11.5”)	18.2kg(40 lbs.)
MS6-250-CH	38cm(15”)	38cm(15”)	29.25cm(11.5”)	18.2kg(40 lbs.)
MS6-420-CH	49.5cm(19.5”)	38cm(15”)	29.25cm(11.5”)	22.6kg(50 lbs.)
MS6-500-CH	49.5cm(19.5”)	45.75cm(18”)	33cm(13”)	42.2kg(93 lbs.)
MS6-600-CH	49.5cm(19.5”)	45.75cm(18”)	33cm(13”)	42.2kg(93 lbs.)
MS6-800-CH	68.6cm(27”)	61cm(24”)	38.1cm(15”)	56.7kg(125 lbs.)
MS6-1000-CH	68.6cm(27”)	61cm(24”)	38.1cm(15”)	56.7kg(125 lbs.)

2.5.2 REVERSING UNIT (or STANDARD UNIT WITH DC INJECTION)

MODEL	DIMENSIONS			
	HEIGHT	WIDTH	DEPTH	WEIGHT
MS6R-30-N1	43.2cm(17”)	30.5cm(12”)	26.75cm(10.5”)	13.6kg(30 lbs.)
MS6R-50-N1	43.2cm(17”)	30.5cm(12”)	26.75cm(10.5”)	13.6kg(30 lbs.)
MS6R-80-N1	43.2cm(17”)	30.5cm(12”)	26.75cm(10.5”)	13.6kg(30 lbs.)
MS6R-125-CH	62cm(24.5”)	38cm(15”)	29.25cm(11.5”)	27kg(60 lbs.)
MS6R-250-CH	62cm(24.5”)	38cm(15”)	29.25cm(11.5”)	27kg(60 lbs.)
MS6R-420-CH	83cm(32.5”)	38cm(15”)	29.25cm(11.5”)	34kg(75 lbs.)
MS6R-500-CH	83cm(32.5”)	45.75cm(18”)	33cm(13”)	63kg(140 lbs.)
MS6R-600-CH	83cm(32.5”)	45.75cm(18”)	33cm(13”)	63kg(140 lbs.)
MS6R-800-CH	113cm(44.5”)	61cm(24”)	38.1cm(15”)	85kg(188 lbs.)
MS6R-1000-CH	113cm(44.5”)	61cm(24”)	38.1cm(15”)	85kg(188 lbs.)

3 TERMINALS

CONTROL POWER INPUT		
1	Control Power Line 1 (120VAC ± 10%)	Power for the control card and also for the cooling fans on units below 500A
2	Control Power Neutral	
120VAC INPUT LOGIC		
3	Start Input – 120VAC	Momentary normally open switch for 3 wire control. Maintained normally open switch for 2 wire control
4	Stop Input(three wire control) / DCI or Soft Stop Enable(two wire control) - 120VAC	Momentary normally closed switch for 3 wire control. Maintained normally open switch used to enable or disable a selected stop mode in 2 wire control.
5	Jog Input – 120VAC	Maintained normally open switch used to activate jog function
6	Reverse Input – 120VAC	Maintained normally open switch used to activate reverse function (if installed). If activated along with JOG the unit will run in reverse jog mode
7	Reset Input – 120VAC	Momentary normally open switch use to reset a fault
8	Enable Input – 120VAC	Maintained normally open switch used to enable unit operation. Unit will not run if this input is not active. If opened while running the unit will coast to a stop no matter what stopping method is choosen. If this input is active and all 3 incoming phases are valid a green indicator will be illuminated on the keypad.
9	Input Neutral	Neutral for 120VAC control signals

DRY CONTACT RELAY OUTPUTS		
10	Fault Relay Common	The fault relay is energized in a **NO Fault** condition. In a fault condition or a case of power loss the relay will de-energize and the contacts will go to there normal condition indicating a fault.
11	Fault Relay N.C.	
12	Fault Relay N.O.	
13	Bypass Relay Common	This relay is used to control a by-pass contactor either directly or indirectly if the coil current of the by-pass contactor is to large (>5amps). This relay will energize once the Opal Pro has phased full on and the motor current has dropped below 110% of the nameplate current.
14	Bypass Relay N.O.	
15	Shorted SCR Relay Common	This relay is energized when a shorted SCR is detected and should be used to trip a shunt trip breaker.
16	Shorted SCR Relay N.C.	
17	Shorted SCR Relay N.O.	
18	Run Relay Common	This relay is energized when the unit is running
19	Run Relay N.O.	
20	Reverse Relay Common	This relay is energized when the unit is running is the reverse mode
21	Reverse Relay N.O.	
ANALOG I/O (not isolated)		
22	Analog Input (0 to 10VDC)	
23	Analog Common	
24	Analog Output (0 to 5VDC, max 5mA)	
25	Analog Common	

4 KEY PAD OPERATION

Actual Mode	This is the mode that the unit will be in on power up. If the unit is healthy the actual motor current will be displayed in Amps. If the unit is faulted the fault will be displayed in text format. If the unit is faulted and the user enters any of the other display modes the unit will automatically return to this mode and display the fault every 15 seconds. If the "MENU" key is pressed in this mode the user will enter the Group mode. If you are in the Group Mode you can return to the Actual Mode by pressing the "MENU" key.
Group Mode	This mode allows the user to scroll through the different parameter groups using the up and down arrow keys. This mode can be accessed from either the Actual Mode or Parameter Mode by pressing the "MENU" key. If the "ENTER" key is pressed in this mode you will enter the Parameter mode and be able to view the parameters of the current group that is being displayed.
Parameter Mode	This mode allows the user to view and modify the individual parameters in a particular group. The parameters can be scrolled through using the up and down arrow keys. If a parameter is to be modified the "ENTER" key must be pressed and the parameter value will now blink. At this point it is possible to change the parameter setting using the up and down arrow keys. When the desired setting is reached the "ENTER" key should be pressed again and the blinking of the parameter will now stop and the new parameter setting will be saved. To return to the Group mode the "MENU" key should be pressed.
Reset Key	This key will reset any fault as long as the fault has no longer exists.
Local/Remote Key	This key switches the unit between local and remote control. Local or Remote mode is displayed via LED. In local the unit can be started from the keypad. In local mode the start and stop commands from the terminal strip or communication module are ignored. In Remote mode, the terminal strip becomes active.
Start Stop Key	This key is used to start and stop the motor in local mode. You still need the Enable signal at the terminal strip.
Red LED	This LED will be illuminated during a fault condition or during initial power-up
Green LED	This LED will be illuminated when the starter is ready to be started. This includes the ENABLE signal being active and also having valid three phase power.

5 INSTALLATION AND START-UP

5.1 INSPECTION

- The Opal Pro has been packaged to protect it from damage caused by normal handling during shipment, however mishandling may cause damage to the Opal Pro. Unpack the unit as soon as it is received and check for any shipping or storage damages.
- If damage is found, notify the carrier. Any damage claim must be filed by the customer since all shipments are F.O.B. Manufacturers plant unless otherwise specified.
- If the Opal Pro is not installed when received, store it in a clean, dry, well ventilated area, free from heat, humidity, oil, dust, and metal particles.

5.2 SAFETY PRECAUTIONS

CAUTION

Equipment is at line voltage when AC power is connected.
Pressing "STOP" pushbutton does not remove AC mains potential.
All phases must be disconnected before it is safe to work on machinery, touch motor terminals or control equipment parts.

- The electrical code requires all equipment, starter, motor, operator station, etc. to be grounded properly.
- An incoming circuit breaker or disconnect switch must be locked open before wiring or servicing this starter, motor, or other related equipment. This equipment must be installed and serviced only by qualified personnel, familiar with this starter.
- The user is responsible for ensuring that proper short circuit protection is provided by either a circuit breaker or HRC fuses.

5.3 MOUNTING GUIDELINES

- Standard Nema 1 Opal Pro Starters must be installed indoors in a well ventilated area, free from heat, humidity, oil, dust and metal particles.
- One foot of clearance must be kept all around in a natural cooled unit. The equipment must be mounted away from any heat source. See Section 2 for additional specifications.
- Be aware that the heatsink may reach 70° C / 158°F during normal operation. Do not install the starter in contact with any material that cannot accept this temperature.
- The starter must be mounted vertically and where it will not experience excessive shock or vibration.

5.4 WIRING GUIDELINES

- The electrical code requires that an approved circuit disconnecting device be installed in the incoming AC supply circuit. Mounted in a location readily accessible to personnel installing or servicing this equipment.
- Power factor correcting capacitors MUST NOT be connected to the OPAL output. If desired, they may be added ahead of the starter. Capacitors can be connected before starting or after the motor has reached full speed.
- In-line contactors are not required; however they can be used on the line side or the motor side without detriment to the starter. It is recommended that the contactor be sequenced to open and close under no-load conditions to prolong the life of the contacts.
- Size the power wiring as per local code. On long wire runs it is recommended to use a larger wire size.
- All three phases of the incoming power wires must pass through the same hole in the enclosure. This rule also applies to all phases of the outgoing or motor wires.
- If an electro-mechanical brake is used in the system, it must be powered from the line side of the starter, to ensure full voltage to the brake.

5.5 START-UP

5.5.1 BEFORE POWER-UP

- Ensure that all electrical connections are completed as shown on the schematics, and that connections are properly tightened. Including a solid ground connection.

5.5.2 WITH POWER ON

- Check 120VAC control voltage to terminals 1 & 2 of the Opal Pro
- Set parameter 1001 to the control scheme desired
- Set parameter 1002 to the ramp time desired (set to 0 for constant current mode)
- Set parameter 1003 to step current required (set to required current for constant current mode)
- Set group 11 parameters for desired stopping method and setup
- Set parameter 1301 to motor full load current as read from the motor nameplate
- Set parameter 1302 to the motor nameplate voltage
- Set parameter 1303 to the motor nameplate service factor
- Set group 14 parameters if a communication module is installed on the Opal Pro
- Set group 15 parameters for the desired fault conditions
- Check for the red LED on the keypad to be **NOT** illuminated (if it is illuminated there is a fault which will be shown on the LCD display of the keypad)
- Check for the green LED on the keypad to be illuminated (if it is not, the ENABLE signal (terminal 8) is missing or there is a problem with the incoming 3 phase power)
- Once start has been initiated the motor must start rotating immediately, it must not stall. If it does not rotate immediately the step current (parameter 1003) must be increased
- Parameter 1002 can be adjusted to extend or decrease the acceleration time. The actual motor accelerating time depends on the motor current as well as the mechanical load. The acceleration time entered is the amount of time it will take for the current to increase from the step setting to 500% of the nameplate current

6 FAULTS

Fault (display)	Description
IOC	Instantaneous Over Current - Current has reached a value of 1000% of stack size - Usually a short circuit on the output or misfiring of SCR's - This fault cannot be disabled
MTR OVRLD	Motor Thermal Overload (calculated) - motor has been drawing over 100% of motor nameplate current for a specified amount of time based on the class of overload selected in group 15 parameter 2 - after this fault has occurred the Opal Pro will not allow a reset for approx. 6 minutes (this is to allow the motor to cool down) - this fault can be disabled in group 15 parameter 2
PHASE LOSS	Incoming Phase Loss - one of the incoming phases is missing or abnormally low - phase voltages can be read in group 1 parameters 2, 3, and 4 - this fault will not be triggered until the motor is commanded to start - this fault cannot be disabled
SHEAR PIN	Excessive Motor Current While Running - if the Opal Pro is phased fully on and the motor is up to speed this fault will be triggered if the current goes above 300% - this fault can be disabled in group 15 parameter 1
SHORTED SCR	Shorted SCR Fault - this fault will not be triggered until the motor is commanded to start - this fault cannot be disabled
HEAT SINK OT	Heat Sink Over Temperature - One of three temperature switches mounted on the heat sink has been triggered - These switches trigger at approx. 85 degrees Celsius - The switches are only mounted on units which include fans - This fault cannot be disabled
COMM FLT	Communication Fault - a loss of communication between the Opal Pro and the master device has been detected based on a watch dog bit that is sent back an forth - this fault is disabled when no communication cards are installed on the Opal Pro - this fault can also be disabled in group 15 parameter 3 - the time delay for the watch dog bit can be set in group 15 parameter 4
POWERING UP	Power Up Sequence - the Opal Pro will be faulted for the first 6 seconds after the 120VAC control power is applied - this allows time for everything to initialize and then a fault reset is automatically applied at the end of the 6 seconds

7 FEATURES

7.1 SOFT STOP

- This provides a controlled stopping method to eliminate the water hammering effect associated with fluid pumping applications.
- The Opal Pro operates in the opposite fashion of starting. When stop is initiated the Opal Pro output voltage is reduced to the point set by parameter 1102 and then ramps down based on a rate set in parameter 1103. The Opal Pro will remain on for the amount of time set in parameter 1103. If two wire control is used then terminal 4 is a soft stop enable input and when de-activated will turn the Opal Pro off during a soft stop.

7.2 SCR BY-PASS

- A three pole contactor used in conjunction with the by-pass contact eliminates the SCR losses by shorting them out after the motor has reached full speed. This feature is a true Watt Saver modification and permits the use of the Opal Pro in a NEMA 4 or NEMA 12 enclosure. The by-pass contactor is switched on only after the motor has reached full speed and as such sees only motor full load current. At stop, the by-pass contactor is opened while the SCR's are triggered fully on, limiting the power contacts opening voltage. The SCR's are then switched off without having any voltage surge.
- When a by-pass contactor is used in conjunction with reversing, the REV contact must be used to drive a slave relay that inter-locks the two by-pass contactors to ensure proper sequencing of the contactors.
- This option requires by-pass lugs which are an add on option to the standard Opal Pro

7.3 SHEAR PIN PROTECTION

- This feature has been designed to provide motor jam protection, similar to a mechanical shear pin.
- Once the motor has reached full speed, the MicroOpal will trip if the motor current increases to 300%. Parameter 1501 enables or disables this feature.

7.4 SLOW SPEED FWD/REV (JOG)

- This provides the ability to run an AC motor at 14% speed in the forward direction or 20% in the reverse direction without any added SCR’s.
- To jog in the forward direction the jog input (terminal 5) must be activated
- To jog in the reverse direction the jog input (terminal 5) and the rev input (terminal 6) must be activated.
- Current draw is abnormally high during jog mode therefore it must only be used for very short amount of time to avoid overload trips and excessive motor heating.

7.5 SHORTED SCR DETECTION

- This option provides protection against the unlikely event of a shorted Silicon Controlled Rectifier (SCR).
- The state of the SCR's are checked every time a start or jog command is initiated. An SCR that shorts while the Opal Pro is running will not be identified until the next time the Opal Pro attempts to start or jog.
- This fault should be used in conjunction with a shunt trip circuit breaker or an in-line contactor.
- In the event of a shorted SCR, it is not sufficient to merely trip the starter. The incoming 3 phase power must be removed. The danger associated with a shorted SCR is that even when the starter is not running, current may pass freely through the motor.
- If a shorted SCR is detected, the Shorted SCR relay is energized. The form C relay contacts on terminals 15, 16 and 17, are provided for means of opening the circuit breaker or contactor used.
- When a shorted SCR fault occurs you will have to use an ohm meter to find out which SCR is shorted. This can be done by turning all the power off and using an ohm meter to measure the resistance between L1 and T1. The resistance should be greater than 10Kohms. If it is a short either SCR 1 or 2 is bad. Repeat this for L2 and T2, which will check SCR's 3 and 4. Then finally check L3 and T3, which will check SCR's 5 and 6.

7.6 SOLID STATE FULL SPEED REVERSING

- This option provides a smooth, current controlled, motor rotation reversal without any current surge or torque jerk. Motor stopping is not required. Additions to the Opal Pro include a reversing card, CA531, plus four additional SCR's.
- With the reverse input (terminal 6) enabled the starter will fire the reverse bridge.
- Terminals 20 and 21 dry contact used to indicate the direction selected and by-pass contactor sequencing for a reverse/by-pass combination.
- When the motor is running and the forward/reverse switch changes states, the Mirco Opal turns all SCR's off. After a time delay, the Opal Pro is switched back on, triggering a different set of SCR's. This effectively switches two output lines, decelerates the motor down to zero speed, and continues to accelerate it to full speed in the opposite direction. The motor reversal is performed under complete current control via the RAMP (parameter 1002) and STEP (parameter 1003) settings.
- If a CA531 card is not present on the Opal Pro the reverse command will be ignored for normal running but will still be active for jog reversing.

7.7 DC INJECTION BRAKING

- DC injection braking provides smooth braking for AC induction motors.
- DC injection offers adjustable braking because it is current controlled.
- Unlike a mechanical brake, an electrical brake will never wear out.
- The brake operates by injecting DC current in two phases of the motor to rapidly decelerate it to zero speed.
- When stop is commanded the Opal Pro shuts off for 2 seconds to allow the voltage across the motor to drop. The DC injection current is then applied at a level set in parameter 1104 for the amount of time set in parameter 1105. It does not provide zero speed sensing, although if two wire control is used terminal 4 can be used to disable the DC injection (activated = enabled).
- If braking is released before the motor stops, the motor will coast to rest. If the braking remains on after the motor stops, the DC supply will provide a holding brake.

8 PARAMETERS

GROUP	PARAMETER	DESCRIPTION	RANGE	ACCESS
1		**Actual Values**		
	101	Current of the motor in Amps		Read Only
	102	Line 1 to line 2 volts		Read Only
	103	Line 1 to line 3 volts		Read Only
	104	Line 2 to line 3 volts		Read Only
	105	DI1-DI5 Status right most bit: Start Stop Jog Reverse Reset		Read Only
	106	Analog input 1 value		Read Only
	107	Relay Status right most bit: Run relay By-Pass relay Shorted SCR relay Reverse relay Fault relay		Read Only
	108	Analog output 1 value		Read Only
2		**Version Info**		
	201	Stack size in Amps		Read Only
	202	Communication Module Type		Read Only
	203	Firmware version		Read Only

10		Start Control		
	1001	Start \ Stop control - 2 wire means that you have a single maintained start contact - 3 wire means that you have a momentary normally open start contact and a momentary normally closed stop contact - Comm module means the start command will come from an external device through the communication module installed	2-Wire 3-Wire Comm Module	Read\Write
	1002	Ramp - this is the time that it will take for the current reference to increase from the Step value (parameter 1003) to 500% of the motor name plate current (entered in parameter 1301) - a setting of "0 seconds" will cause the Opal to operate in constant current mode, this means the current reference will be set at the Step value (parameter 1003) and will not change	0 – 60 seconds	Read\Write
	1003	Step Current - this is the amount of current (in percent of motor nameplate current entered in parameter 1301) that will initially be applied to the motor before the current reference begins to ramp up to 500% - this value is usually set as low as possible but still high enough so that the motor begins to rotate and soon and the start command is applied - if the Ramp time is set to 0 (parameter 1002) then this is the value of current (in percent of motor nameplate current entered in parameter 1301) that the Opal will be limited to constantly	20% - 400%	Read\Write
	1004	IREF (Current Reference) - Internal means the current reference is generated internally from the ramp and step parameters - Analog In means that the current reference will be taken from the analog input (0 to 10Vdc = to 0 to 500% of nameplate current) - Comm module means the current reference will be taken from the communication link (0 to 1000 = 0 to 500% of nameplate current)	Internal Analog In Comm Module	Read\Write
	1005	Phase Angle - Internal means the phase angle reference is generated internally from the current loop - Analog In means that the phase angle reference will be taken from the analog input (0 to 10Vdc = to min to max phase angle) - Comm module means the phase angle reference will be taken from the communication link (0 to 1000 = min to max phase angle) - Note that when using a phase angle reference from the analog input or communication link the Opal Pro makes no attempt to limit current	Internal Analog In Comm Module	Read\Write

	1006	Jog Accelerating Current Limit - This is the current limit that will be used when in the jog mode - When jog is initiated the current will ramp up to this value in 1 second and remain here for the amount of time specified in parameter 1008.	0% - 400%	Read\Write
	1007	Jog Current Limit - This is the current limit that will be used in jog mode after the acceleration time has elapsed	0% - 400%	Read\Write
	1008	Jog Ramp - This is the amount of time that the starter will regulate the accelerating current set in parameter 1006 in jog mode before dropping to the current limit set in parameter 1007 -a value of zero will cause the starter to go directly to regulating the current set in parameter 1007	0 – 5 seconds	Read\Write
11		**Stop Control**		
	1101	Stop Mode - Coast means that the Opal will inhibit firing of the SCR's as soon as the stop command is received - Soft Stop means that the Opal will ramp down the current in the amount of time specified in parameter 1102	Coast Soft Stop DC Injection	Read\Write
	1102	Sft Stop Step - This is the amount of motor voltage that the output will step down to when a stop is commanded. If this value is set to high the motor will go through a state of instability.	50% – 85%	Read\Write
	1103	Sft Stop Rmp - This is the amount of time that it will take to ramp the voltage down from the step voltage to 35% of the motor voltage	2 – 60 seconds	Read\Write
	1104	DCI Current - this is the amount of current that will be regulated during DC Injection stopping (represented as a percentage of nameplate current)	100% – 300%	Read\Write
	1105	DCI Time - this is the amount of time that the Opal will DC inject for	1 – 60 seconds	Read\Write

12		**Analog I/O**		
	1201	Analog Output - This parameter designates what signal will be sent out the analog output - Current reference means the current reference that the Opal is currently using (0-5volts = 0 – 615% motor nameplate current) - Current feedback means that the actual motor current will be sent (0-5volts = 0-615% motor nameplate current) - Overload level means that the present calculated thermal capacity will be sent (0-5volts = 0-100% of capacity) - Phase Angle means that the current phase angle will be sent (0-5volts = 0-180 degrees)	Current Reference Current Feedback Overload Level Phase Angle	
13		**Motor Data**		
	1301	Motor Amps - this should be the name plate full load amps of the motor	5 – 1100 Amps	Read\Write
	1302	Motor Volts - this should be the name plate voltage of the motor	240 – 600 Volts	Read\Write
	1303	Service Factor - this should be the name plate service factor of the motor	1.00 – 1.30	Read\Write
14		**Communications**		
	1401	Modbus Slave Node - This is the slave node that the Opal will be seen as - This parameter is only accessible if a Modbus Slave card is installed in the Opal	1 – 7	Read\Write
	1402	MB Slv Baud Rate - This is the baud rate that the MB Slave card will attempt to communicate - This parameter is only accessible if a Modbus Slave card is installed in the Opal	300 Kbaud 1200 Kbaud 2400 Kbaud 4800 Kbaud 9600 Kbaud 19200 Kbaud 38400 Kbaud 57600 Kbaud	Read\Write
	1403	DeviceNet MacID - This is the DeviceNet MacID that the Opal will be seen as - This parameter is only accessible of a DeviceNet Slave card is installed in the Opal	0 – 31	Read\Write
	1404	DeviceNet Slv Baud Rate - This is the baud rate that the DeviceNet Slave card will attempt to communicate - This parameter is only accessible of a DeviceNet Slave card is installed in the Opal	125 Kbaud 250 Kbaud 500 Kbaud	Read\Write
	1405	DH+ Station Address - This is the station address that the Opal will be seen as - This parameter is only accessible if a DH+ card is installed	1 - 32	Read\Write
	1406	DH+ Baud Rate - This is the baud rate that the DH+ card will communicate at - This parameter is only accessible if a DH+ card is installed	57.6 Kbaud 115.2 Kbaud 230.4 Kbaud	Read\Write

15		**Faults**		
	1501	Shear Pin Flt - Enables and disables the shear pin fault - The shear pin fault is automatically disabled during jog	Enable Disable	Read\Write
	1502	MOL Flt - Sets up the class of overload that will be used - Can also disable the overload	Disable Class 10 Class 15 Class 20 Class 30	Read\Write
	1503	Overload Level - Represents has a percentage the amount of overload that has accumulated - Once this level reaches 100% the Opal will trip on a MOL FLT - this level will increase based on the class set in parameter 1502 any time that the current feedback is above the name plate current (parameter 1301) multiplied by the service factor (parameter 1303) - this level will decrease any time that the current feedback is below that level - if this level reaches 100% and the drive trips, a reset will not be allowed until this level has decreased to 15%		Read Only
	1504	Comm Flt - this will enable or disable the communication fault if a communication module is present - a communication fault is detected by monitoring a watch dog bit that the Opal sends out to the master device which has to be inverted and sent back with in a specific amount of time (parameter 1505)	Enable Disable	Read\Write
	1505	Comm Flt Time - this is the time used to determine a communication fault	0.1 – 5.0 seconds	Read\Write

9 SPARES

9.1 SPARE PARTS

Model	SCR	Current Transformer	Control Card	Stack ID Card	MOV
MS6-30	N10SP03(61A SCR)	T261123 (1500:1)	CA530	CA532(30)	O210050
MS6-50	N10SP06(90A SCR)	T261123 (1500:1)	CA530	CA532(50)	O210050
MS6-80	N10SP16(140A SCR)	T262320 (2500:1)	CA530	CA532(80)	O210050
MS6-125	N728352(300A SCR)	T262320 (2500:1)	CA530	CA532(125)	O210050
MS6-250	N728452(580A SCR)	T262320 (2500:1)	CA530	CA532(250)	O210050
MS6-420	N718602(720A SCR)	T265320 (5000:1)	CA530	CA532(420)	O210050
MS6-500	N718133(1100A SCR)	T268320 (8500:1)	CA530	CA532(500)	O210050
MS6-600	N718153(1200A SCR)	T268320 (8500:1)	CA530	CA532(600)	O210050
MS6-800	N718552(1500A SCR)	T261321 (10000:1)	CA530	CA532(800)	O210050

9.2 SCR INSTALLATION PROCEDURE

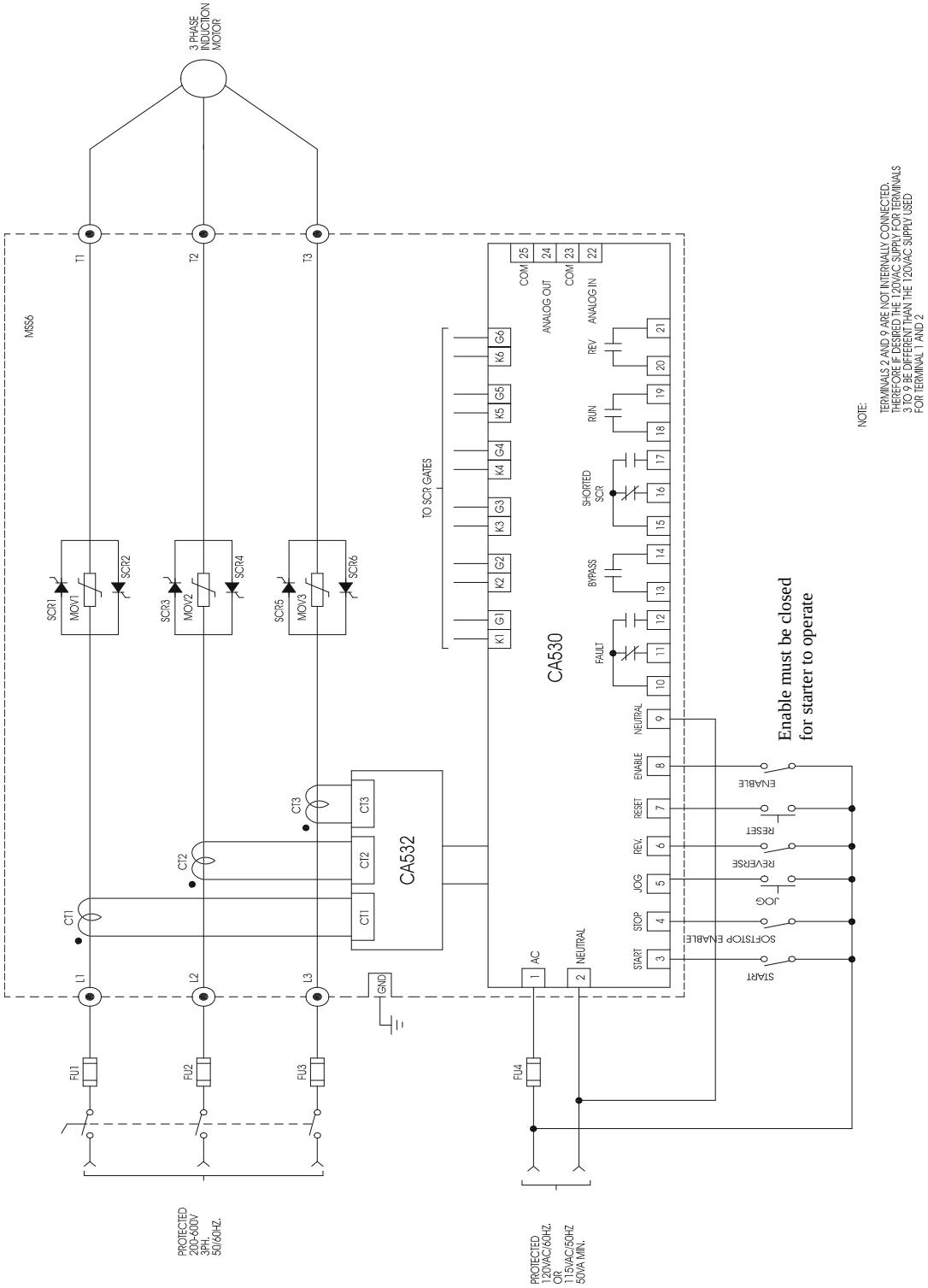
- Clean both heat sink and SCR surfaces.
- Apply a thin layer of joint compound (Noalox) to both SCR surfaces.
- Observe correct SCR polarity.
- Install SCR so that roll pins engage dimples on both sides of the SCR.
- Tighten clamp bolts evenly until finger-tight.
- Tighten each bolt according to table below (based on number of spring bars and size of bars).

Note: SMALL clamps are 10.5cm(4.25inches) and LARGE clamps are 12.5cm(5inches)

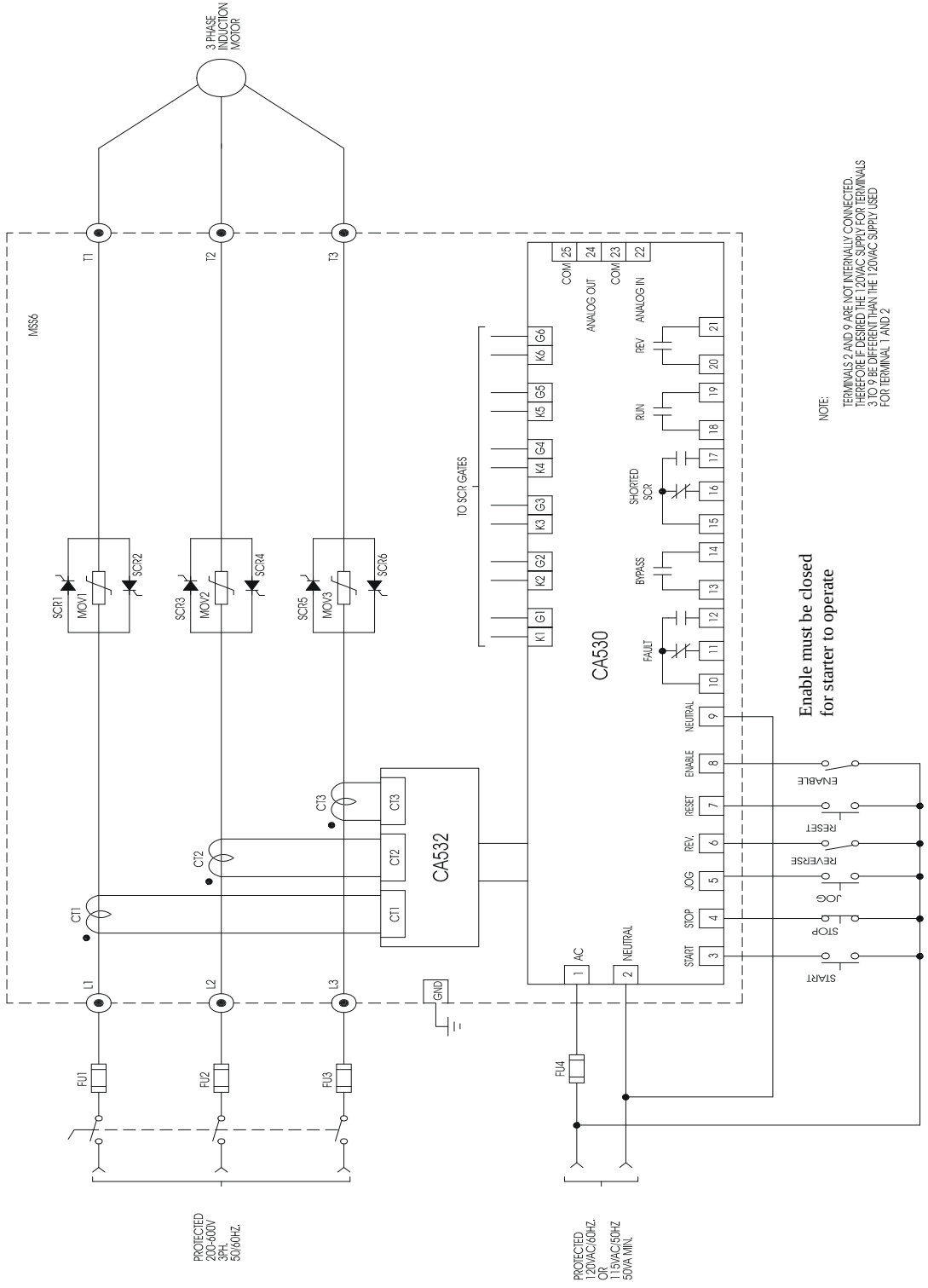
CLAMP SIZE	SPRING BARS	BOLT TURNS PAST FINGER TIGHT
SMALL	1	0.75
SMALL	2	1
LARGE	3	1.75
LARGE	4	1.75

10 CONNECTION DRAWINGS

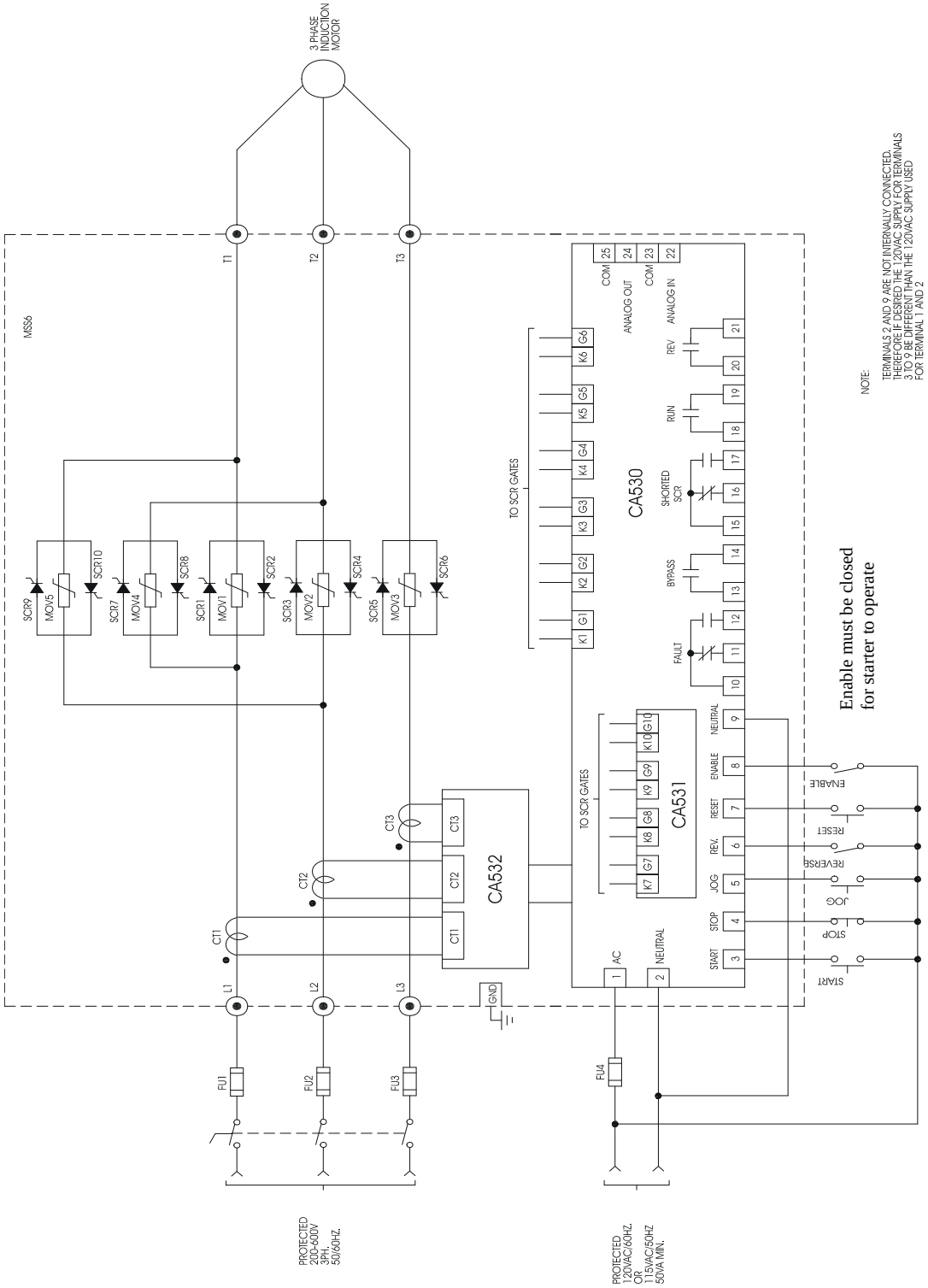
10.1 TWO WIRE CONTROL



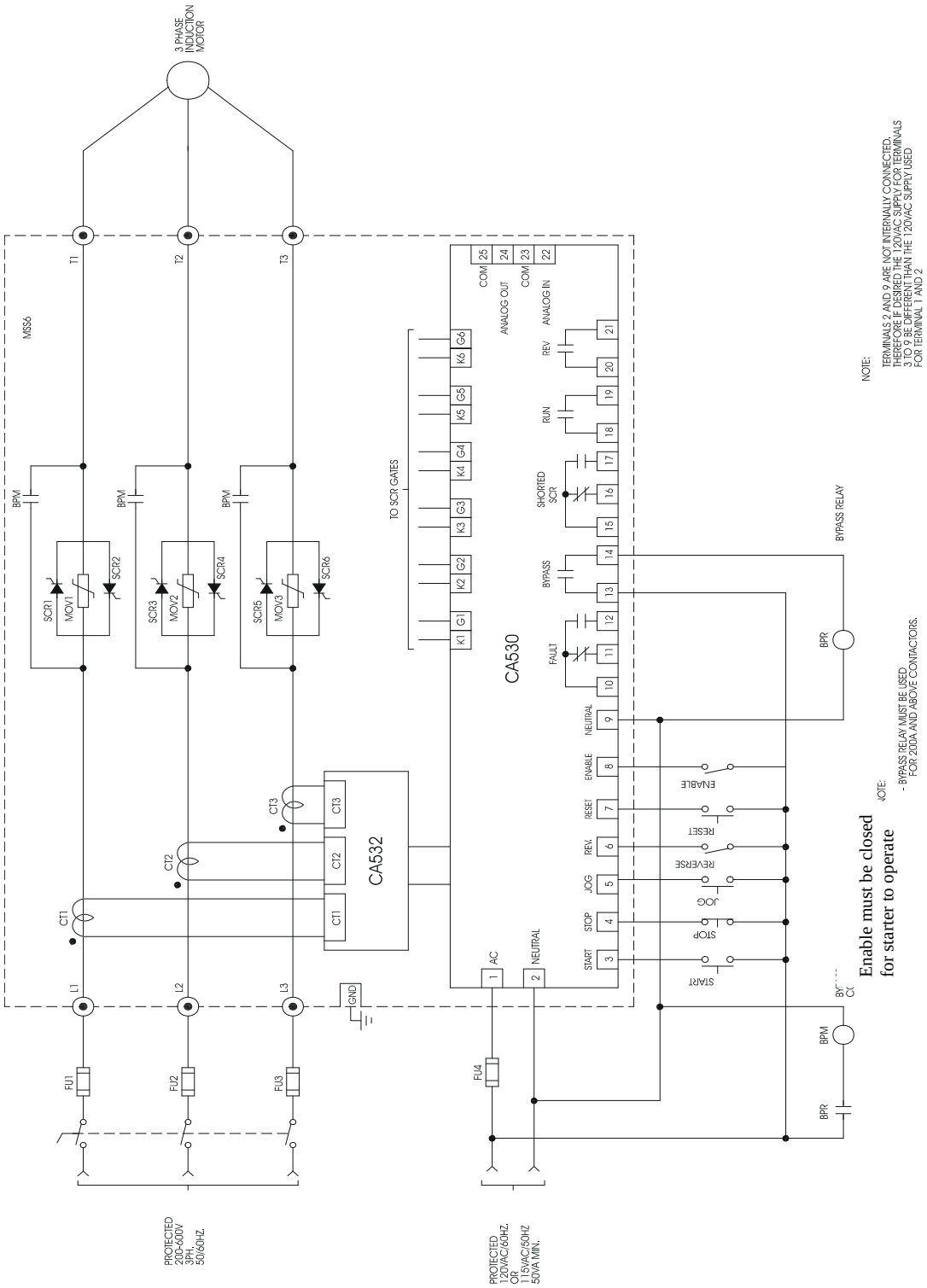
10.2 THREE WIRE CONTROL



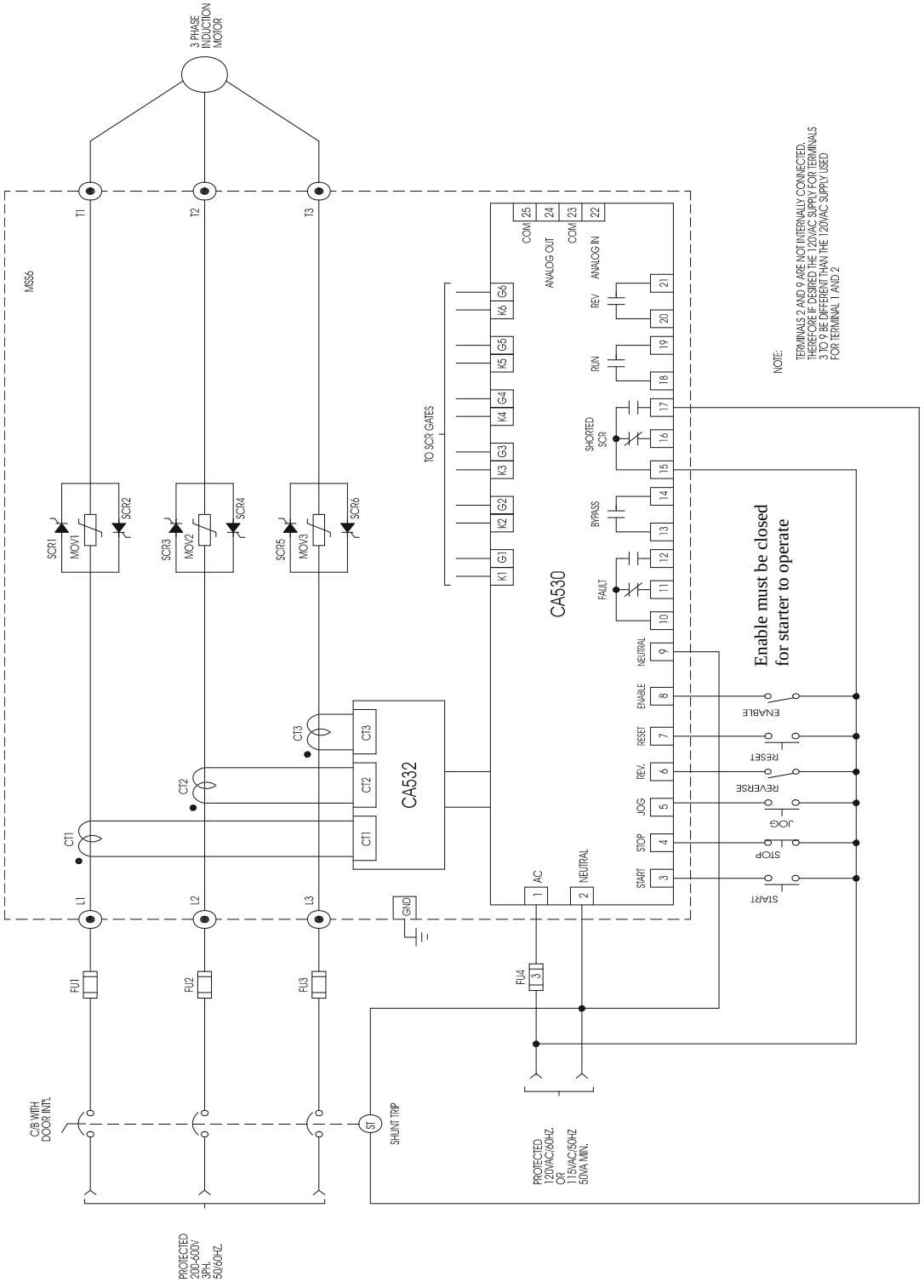
10.3 THREE WIRE REVERSING



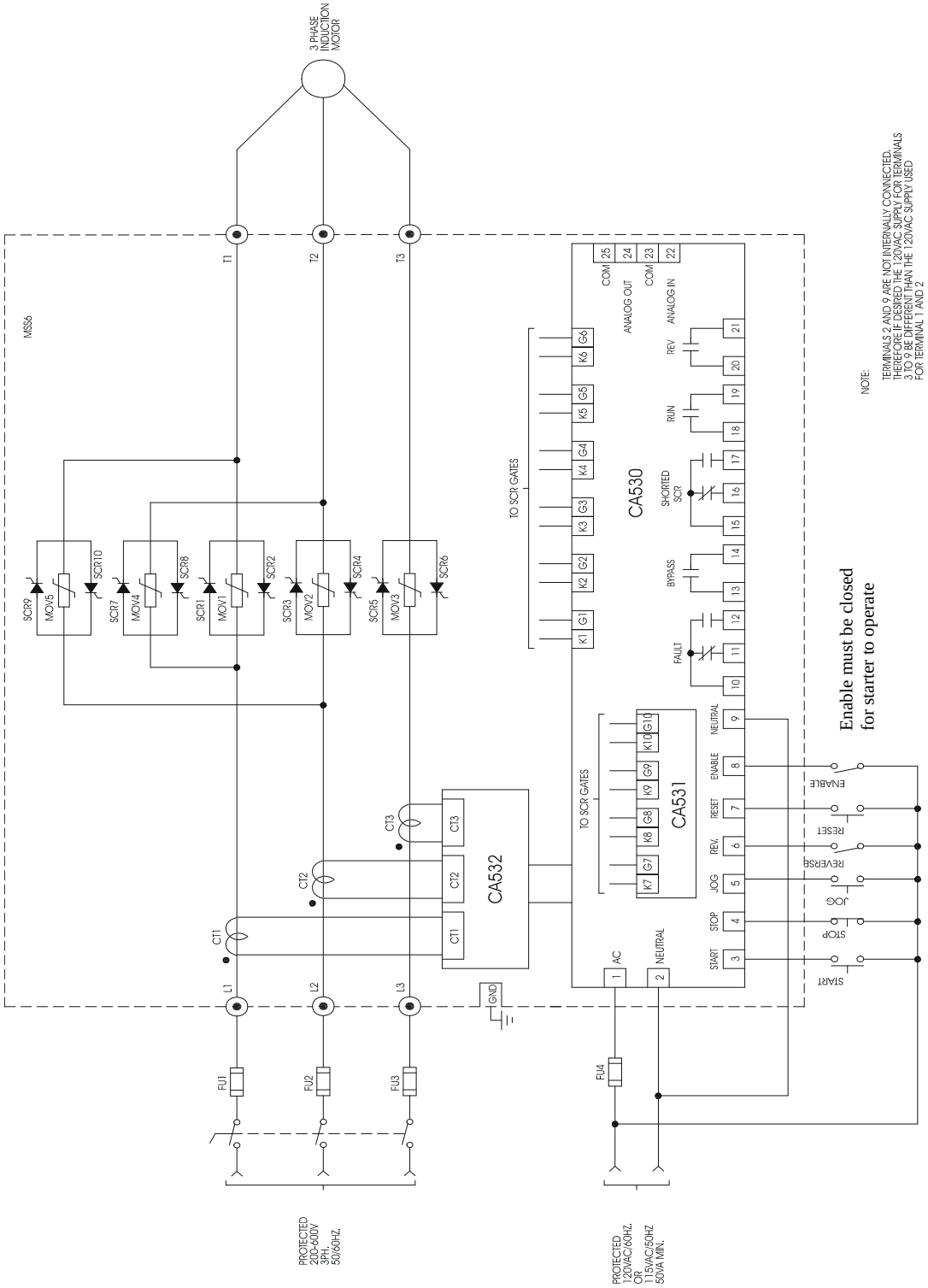
10.4 THREE WIRE WITH BY-PASS



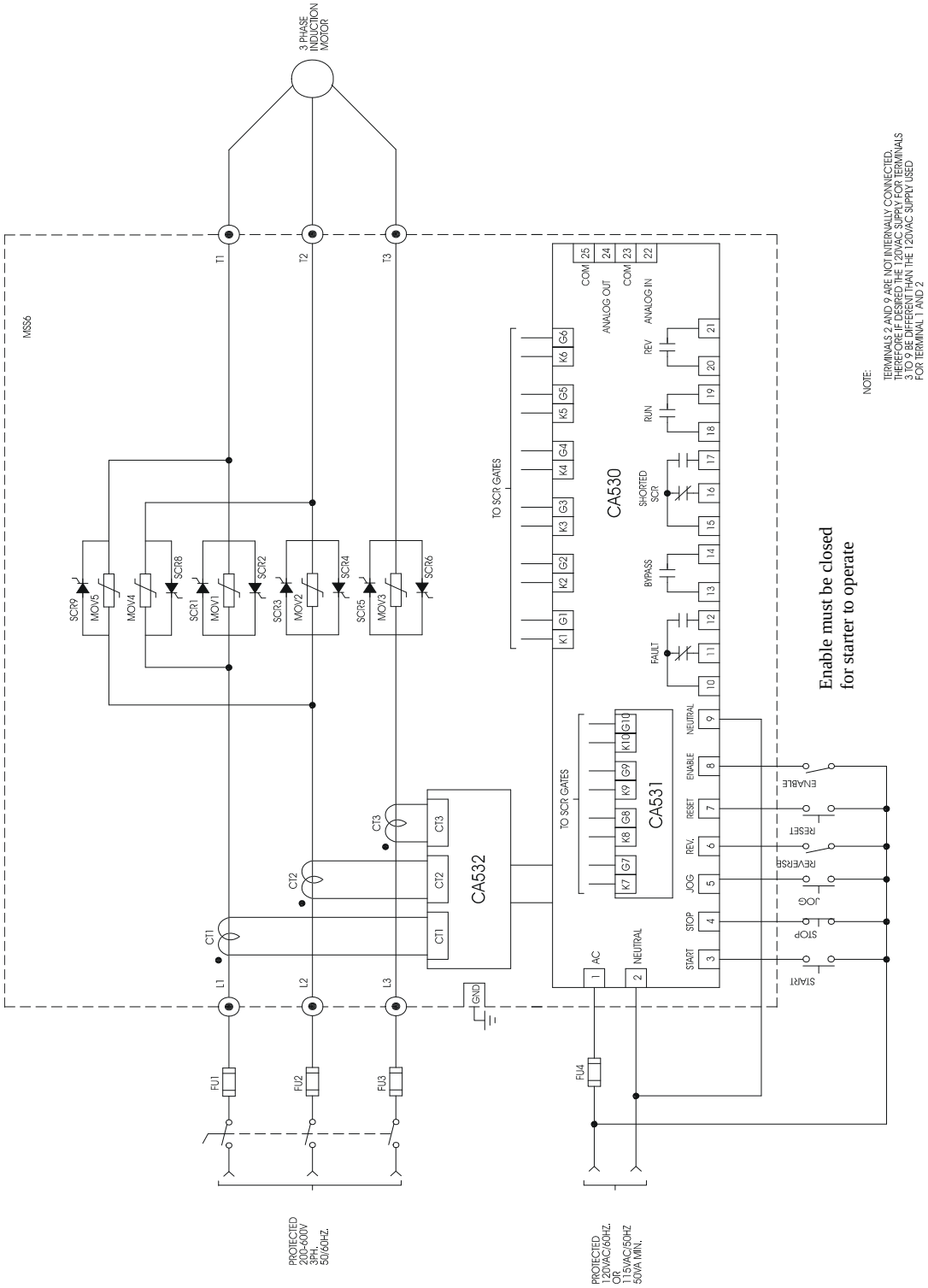
10.5 THREE WIRE CONTROL WITH SHORTED SCR DETECTION



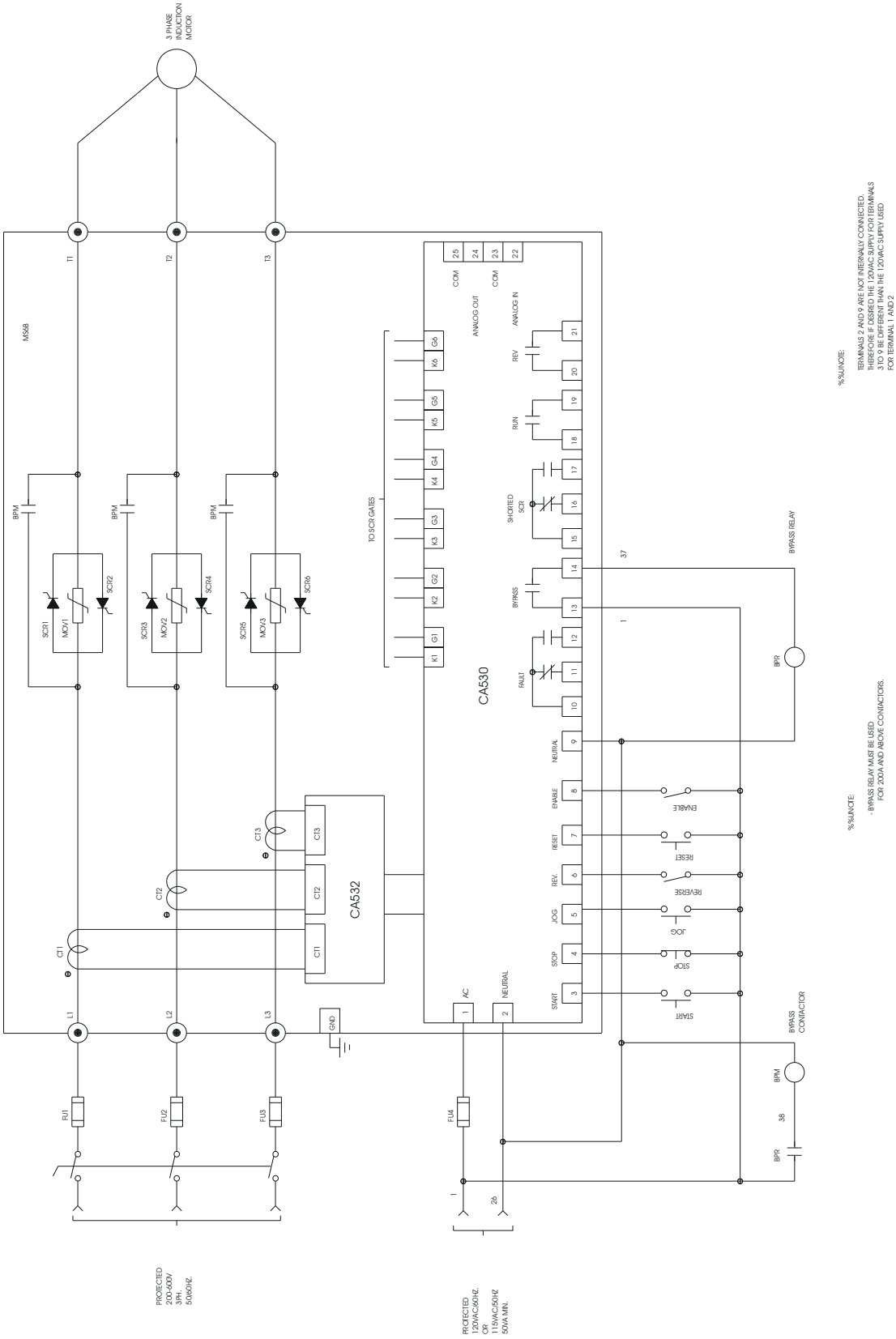
10.6 DCI FOR 80 AMP UNITS AND BELOW



10.7 DCI FOR 125 AMP UNITS AND ABOVE



10.8 INTEGRATED BY-PASS



18 Neville Street, Unit C
New Hamburg, ON N3A 4G7
Tel: 519-662-6489
Fax: 1-866-280-5247

SAF Drives Inc.

www.safdrives.com
www.opalstarters.com
email: answers@opalstarters.com
(Replies given within 24 hours)