



**Drives Inc.**

# **Installation & Operating Procedures**

# **Opal SS6 Series**

**SOLID STATE REDUCED VOLTAGE STARTER**

**FOR 3 PHASE INDUCTION MOTORS**



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**REDUCED VOLTAGE  
SOLID STATE STARTERS  
FOR 3 PHASE INDUCTION MOTORS**

**INSTALLATION & OPERATING PROCEDURE**



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## **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.

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## **TABLE OF CONTENTS**

<b>1.0</b>	<b>DESCRIPTION .....</b>	<b>1</b>
1.1	OVERVIEW .....	1
1.1.1	STANDARD FEATURES.....	1
1.1.2	OPTIONAL FEATURES .....	2
1.2	APPLICATION NOTES .....	2
1.2.1	OPERATION MODES .....	2
1.2.2	CHOOSING STARTING MODE .....	3
1.2.3	MOTOR AND LOAD TYPES .....	4
1.2.4	STARTING AC MOTORS IN PARALLEL .....	5
<b>2.0</b>	<b>SPECIFICATIONS.....</b>	<b>6</b>
2.1	POWER RATING.....	6
2.2	MAXIMUM RATINGS .....	6
2.3	SERVICE CONDITIONS .....	6
2.4	FUSE SIZING .....	7
2.5	DIMENSIONS .....	8
2.5.1	STANDARD UNIT .....	8
2.5.2	REVERSING UNITS .....	9
2.6	SCR INSTALLATION SPECIFICATIONS.....	10
2.6.1	SCR TIGHTENING PROCEDURE .....	10
<b>3.0</b>	<b>CARD FUNCTIONS.....</b>	<b>12</b>
3.1	CARD LAYOUT.....	12
3.2	ANNUNCIATION.....	13
3.2.1	LED INDICATIONS .....	13
3.2.2	NEON INDICATIONS.....	13
3.3	ADJUSTMENTS.....	13
3.3.1	POTENTIOMETERS .....	13
3.3.2	LINK SELECTION .....	14
3.3.3	PUSHBUTTON AND SWITCHES .....	14
3.4	TERMINALS.....	14
3.4.1	CUSTOMER TERMINALS.....	14
3.4.2	TERMINALS FOR INTERNAL USE.....	15
3.5.1	OVER TEMPERATURE .....	15
3.5.2	MOTOR OVERLOAD .....	15
3.5.3	PHASE LOSS .....	15
<b>4.0</b>	<b>INSTALLATION AND START-UP .....</b>	<b>16</b>
4.1	INSPECTION.....	16
4.2	SAFETY PRECAUTIONS .....	16
4.5.1	BEFORE POWER-UP.....	17
4.5.2	WITH POWER ON.....	18
4.5.3	HEAVY DUTY CURRENT CALIBRATION TABLE .....	19

<b>5.0</b>	<b>OPAL OPTION CARDS.....</b>	<b>20</b>
5.1	SOFT STOP.....	20
5.2	SOLID STATE REVERSING.....	21
5.3	UP-TO-SPEED, SHEAR PIN, AND ENERGY SAVER .....	22
5.3.1	UP-TO-SPEED AND SCR BY-PASS.....	22
5.3.2	SHEAR PIN PROTECTION.....	23
5.3.3	ENERGY SAVER .....	23
5.3.4	EXTENDED OVERLOAD .....	23
5.4	SHORTED SCR DETECTION.....	24
5.5	LINEAR ACCEL/DECEL OPTION.....	25
5.5.1	POTENTIOMETERS .....	25
5.5.2	LINK SELECTION .....	26
5.5.3	TERMINALS.....	26
5.5.4	START-UP .....	26
<b>6.0</b>	<b>TYPICAL CONNECTIONS .....</b>	<b>27</b>
6.1	OPAL WITH 2-WIRE CONTROL AND EXTERNAL RESET .....	28
6.2	OPAL WITH 3-WIRE CONTROL, OPTIONAL RUN AND READY PILOT LIGHT .....	29
6.3	OPAL WITH SOFT STOP.....	30
6.4	OPAL WITH SOLID STATE REVERSING .....	31
6.5	OPAL WITH BYPASS CONTACTOR FOR NEMA 4 OR 12 125A AND BELOW .....	32
6.6	OPAL WITH BYPASS CONTACTOR FOR NEMA 4 OR 12 200A AND ABOVE .....	33
6.7	OPAL WITH SHORTED SCR OPTION.....	34
6.8	OPAL WITH LINEAR ACCEL/DECEL CARD.....	35
<b>7.0</b>	<b>SPARE PARTS .....</b>	<b>36</b>
7.1	STANDARD UNIT .....	36
7.2	OPTION CARDS.....	36
<b>8.0</b>	<b>TROUBLESHOOTING .....</b>	<b>37</b>



## **1.0 DESCRIPTION**

### **1.1 OVERVIEW**

The OPAL series is a line of solid state reduced voltage starters for use with 3 $\phi$  induction motors. This series also includes various optional features that can be easily appended.

A solid state starter provides a step-less, thus 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 $\phi$  Universal voltage, 50/60Hz with no adjustments
- Single controller card throughout the OPAL 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
- LED and NEON status and diagnostics
- Prevents starting with any phase missing
- Phase rotation insensitive
- Instantaneous electronic over-current trip
- Class 20 electronic motor overload
- Overload capacity:
  - 500 % for 35 seconds
  - 115 % continuous
- Form C dry fault contact
- N/O dry run contact
- Simple user set-up and current calibration by rotary switch
- Two or three wire control



### 1.1.2 OPTIONAL FEATURES

- Solid State Reversing

Through the addition of 4 Silicon Controlled Rectifiers ( SCR's ) and a reversing card, smooth motor reversing is achieved without having to stop the motor.

- Soft Stop

Motor deceleration is controlled to eliminate water hammer effect on pump applications.

- 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.

- Up-To-Speed Contact / Shear Pin Protection / Energy Saver

- Shorted SCR Sensor and Protection

Sensor detects shorted SCR and trips circuit breaker or contactor upstream.

- Linear Accel\Decel Card

Provides linear accel and decel independent of load with the use of speed feedback

- DC Injection Braking

Through the addition of 4 SCR's and a DC Injection card, adjustable braking of an AC motor is performed. More information is provided in the OP-STOP, DC INJECTION manual.

- External Reset Push Button

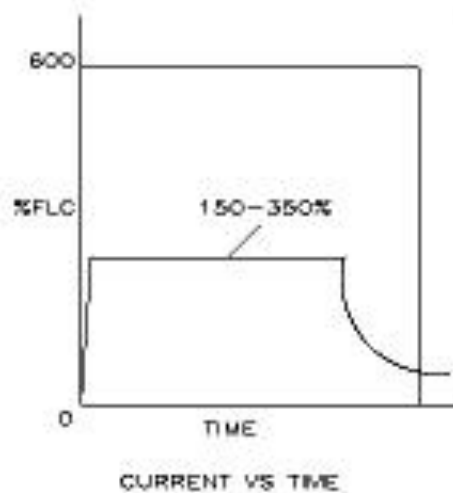
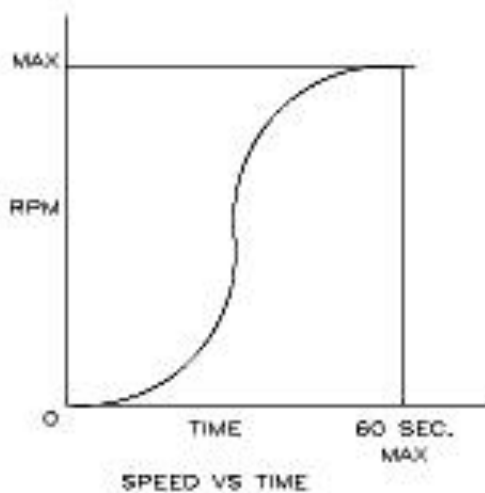
- Start, Stop, Reverse Push Buttons

- NEMA 4 or NEMA 12 Enclosures

## 1.2 APPLICATION NOTES

### 1.2.1 OPERATION MODES

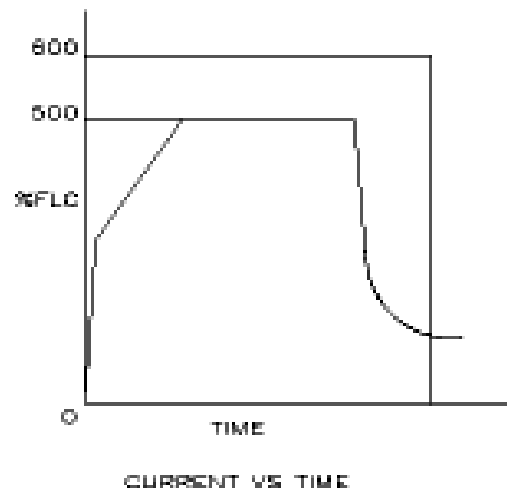
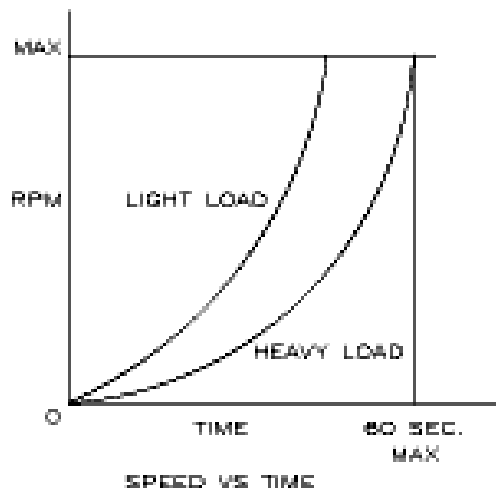
#### 1.2.1.1 Constant Current Mode



#### Applications

- \*Compressors
- \*Empty Mixers
- \*Empty Crushers
- \*Chippers
- \*Pumps/Fans
- \*Centrifuges

### 1.2.1.2 Current Ramp Mode



#### Applications

- \* Conveyors
- \* Extruders
- \* Mixers
- \* Stamping Machines
- \* Cranes
- \* Shredders
- \* Hammer Mills

### 1.2.2 CHOOSING STARTING MODE

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.

**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.

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

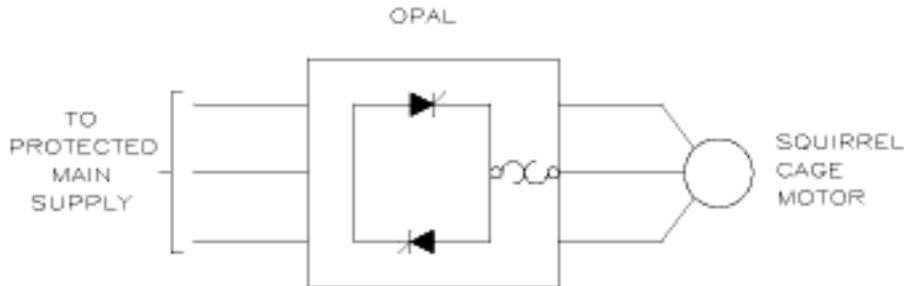
On some applications the starting time is still too fast in the current ramp mode because the load is too light. In this application it is best to select the constant current mode which will allow the acceleration torque to be better controlled, actually kept constant.

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**.

### 1.2.3 MOTOR AND LOAD TYPES

#### 1.2.3.1 Squirrel Cage Motors

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

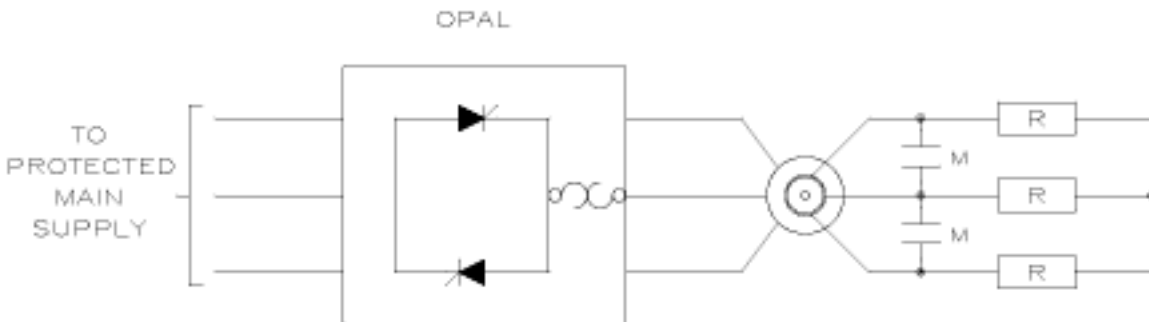


#### 1.2.3.2 Wound Rotor Motors

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 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 realised 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 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.



### **1.2.3.3 Other Types of AC Motors**

OPAL 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.

### **1.2.3.4 Resistive and Inductive Loads**

The TRU-START 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 TRU-START 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 SS6 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 size is determined by the total of the motor current ratings.

## **2.0 SPECIFICATIONS**

### **2.1 POWER RATING**

**POWER** 3 $\phi$ , 200-600VAC, 50/60 Hz  
**CONTROL** 115 VAC@50 Hz or 120 VAC@60 Hz, 12VA (fans are extra)  
**RATING** See Section 2.2  
All models have 1600V PIV SCR's  
**CONTACTS** Run and fault relay contacts rated at 0.2A, 115VAC  
**PROTECTION** Short circuit by HRC fuses or circuit breaker (supplied upon request)  
Voltage surge protection by MOV's across the SCR's

### **2.2 MAXIMUM RATINGS**

<b>OPAL MODEL</b>	<b>HORSEPOWER</b>		
	<b>230V</b>	<b>460V</b>	<b>575V</b>
SS6-15	5	10	15
SS6-30	10	25	30
SS6-50	20	40	50
SS6-80	30	60	75
SS6-125	50	100	125
SS6-200	75	150	200
SS6-360	150	300	350
SS6-500	200	400	500
SS6-600	250	500	600
SS6-800	300	600	800

### **2.3 SERVICE CONDITIONS**

**ELEVATION** For altitudes in excess of 2000 meters / 6600 feet above sea level, all assemblies must be derated 1% for every 100 meters / 330 feet above  
**AMBIENT** Do not install in areas where ambient temperature falls below  
**TEMPERATURE** 0°C / 32°F or exceeds 40 °C / 104°F

**2.4 FUSE SIZING**

OPAL MODEL	MOTOR FLC	HP		J FUSE AMPS	
		460V	575V	FAST ACTING	TME DELAYED
SS6-15	5	3	5	15	10
	10	7.5	10	25	15
	15	10	15	40	25
SS6-30	20	15	20	50	30
	25	20	25	60	40
	30	--	30	70	50
SS6-50	34	25	30	70	50
	0	30	40	80	60
	52	40	50	100	80
SS6-80	60	--	60	125	90
	65	50	--	150	90
	75	60	75	150	100
SS6-125	100	75	100	200	150
	125	100	125	250	175
SS6-200	150	125	150	300	200
	180	150	--	400	250
	200	--	200	400	300
SS6-360	250	200	250	500	350
	300	250	300	600	400
	360	300	--	--	500
SS6-500	400	--	400	--	500
	500	400	500	--	600

## 2.5 DIMENSIONS

This is a general guideline for dimensions as they may change slightly based on different options used.

### 2.5.1 STANDARD UNIT

OPAL MODEL	Height × Width × Depth		
	CHASSIS	NEMA 1	NEMA 12
SS6-15	33cm × 22cm × 15cm 13" × 8.5" × 6"	33cm × 22cm × 18cm 13" × 8.5" × 7"	33cm × 22cm × 18cm 13" × 8.5" × 7"
SS6-30	41cm × 22cm × 15cm 16" × 8.5" × 6"	41cm × 22cm × 18cm 16" × 8.5" × 7"	61cm × 50cm × 30cm 24" × 20" × 12"
SS6-50	43cm × 27cm × 19cm 17" × 10.5" × 7.5"	43cm × 30cm × 27cm 17" × 12" × 10.5"	43cm × 30cm × 27cm 17" × 12" × 10.5"
SS6-80	43cm × 27cm × 22cm 17" × 10.5" × 8.5"	43cm × 30cm × 27cm 17" × 12" × 10.5"	43cm × 30cm × 27cm 17" × 12" × 10.5"
SS6-125	53cm × 27cm × 24cm 21" × 10.5" × 9.5"	53cm × 30cm × 27cm 21" × 12" × 10.5"	53cm × 30cm × 27cm 21" × 12" × 10.5"
SS6-200	34cm × 52cm × 27cm 13.5" × 20.5" × 10.5"	76cm × 61cm × 41cm 30" × 24" × 16"	122cm × 91cm × 41cm 48" × 36" × 16"
SS6-360	48cm × 56cm × 28cm 19" × 22" × 11"	91cm × 76cm × 41cm 36" × 30" × 16"	122cm × 91cm × 41cm 48" × 36" × 16"
SS6-500	50cm × 64cm × 34cm 19.5" × 25" × 13.5"	107cm × 91cm × 41cm 42" × 36" × 16"	152cm × 122cm × 41cm 60" × 48" × 16"
SS6-600	50cm × 64cm × 34cm 19.5" × 25" × 13.5"	107cm × 91cm × 41cm 42" × 36" × 16"	152cm × 122cm × 41cm 60" × 48" × 16"
SS6-800	65cm × 71cm × 42cm 25.5" × 28" × 16.5"	122cm × 91cm × 51cm 48" × 36" × 20"	152cm × 152cm × 51cm 60" × 60" × 20"

**2.5.2 REVERSING UNITS**

OPAL MODEL	Height × Width × Depth		
	CHASSIS	NEMA 1	NEMA 12
SS6-15R	33cm × 22cm × 17cm 13" × 8.5" × 6.5"	33cm × 22cm × 18cm 13" × 8.5" × 7"	33cm × 22cm × 18cm 13" × 8.5" × 7"
SS6-30R	41cm × 22cm × 17cm 16" × 8.5" × 6.5"	41cm × 22cm × 18cm 16" × 8.5" × 7"	61cm × 50cm × 30cm 24" × 20" × 12"
SS6-50R	43cm × 27cm × 20cm 17" × 10.5" × 8"	43cm × 30cm × 27cm 17" × 12" × 10.5"	43cm × 30cm × 27cm 17" × 12" × 10.5"
SS6-80R	43cm × 27cm × 22cm 17" × 10.5" × 8.5"	43cm × 30cm × 27cm 17" × 12" × 10.5"	43cm × 30cm × 27cm 17" × 12" × 10.5"
SS6-125R	53cm × 27cm × 24cm 21" × 10.5" × 9.5"	53cm × 30cm × 27cm 21" × 12" × 10.5"	53cm × 30cm × 27cm 21" × 12" × 10.5"
SS6-200R	34cm × 52cm × 28cm 13.5" × 20.5" × 11"	91cm × 76cm × 41cm 36" × 30" × 16"	122cm × 91cm × 41cm 48" × 36" × 16"
SS6-360R	48cm × 56cm × 29cm 19" × 22" × 11.5"	122cm × 76cm × 41cm 48" × 30" × 16"	122cm × 91cm × 41cm 48" × 36" × 16"
SS6-500R	50cm × 64cm × 36cm 19.5" × 25" × 14"	122cm × 91cm × 41cm 42" × 36" × 16"	152cm × 122cm × 41cm 60" × 48" × 16"
SS6-600R	50cm × 64cm × 36cm 19.5" × 25" × 14"	122cm × 91cm × 41cm 42" × 36" × 16"	152cm × 122cm × 41cm 60" × 48" × 16"
SS6-800R	65cm × 71cm × 42cm 25.5" × 28" × 16.5"	152cm × 91cm × 51cm 60" × 36" × 20"	183cm × 152cm × 51cm 72" × 60" × 20"



## **2.6 SCR INSTALLATION SPECIFICATIONS**

### **2.6.1 SCR TIGHTENING PROCEDURE**

2.6.1.1 Clean both heat sink and SCR surfaces.

2.6.1.2 Apply a thin layer of joint compound (Noalox) to both SCR surfaces.

2.6.1.3 Observe correct SCR polarity.

2.6.1.4 Install SCR so that roll pins engage dimples on both sides of the SCR.

2.6.1.5 Tighten clamp bolts evenly until finger-tight.

2.6.1.6 Tighten each bolt according to table below (based on number of spring bars and size of bars).

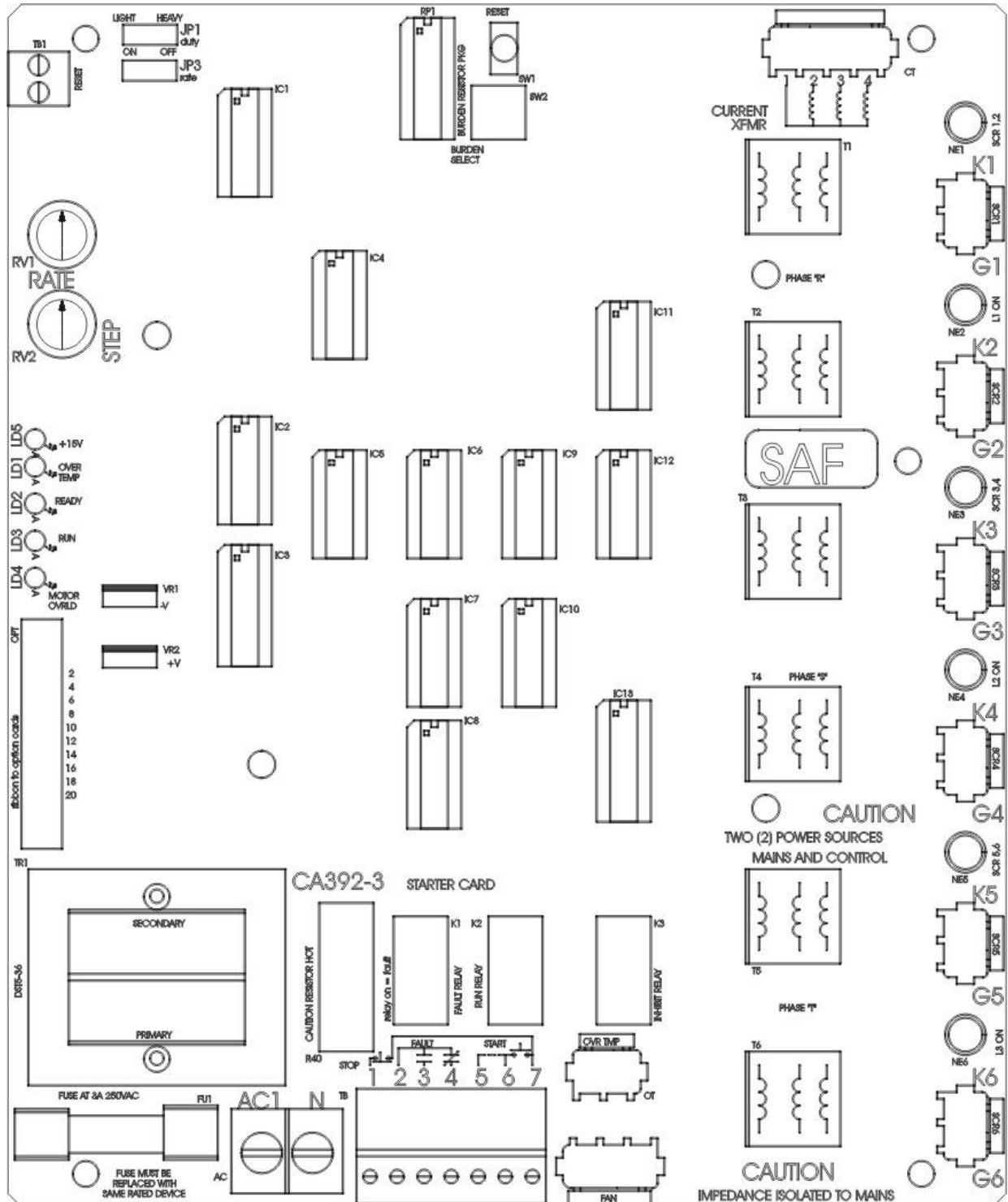
\* Note: SMALL clamps are 4.25 inches / 10.5 cm and LARGE clamps are 5 inches / 12.5 cm.

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



### 3.0 CARD FUNCTIONS

#### 3.1 CARD LAYOUT



**CA392 - OPAL CONTROLLER CARD**

## **3.2 ANNUNCIATION**

### **3.2.1 LED INDICATIONS**

<b>LED</b>	<b>NAME</b>	<b>COLOUR</b>	<b>DESCRIPTION</b>
LD1	OVER TEMP	RED	On when unit is faulted because of an open Over Temperature switch at the OT terminal
LD2	READY	GREEN	This LED is illuminated when there are no faults
LD3	RUN	GREEN	Indication of run commanded to starter
LD4	MOTOR OVRD	RED	When lit an IOC (instantaneous over-current) or an inverse time overload fault exists
LD5	+15V	GREEN	Illuminated when +15V power supply is okay

### **3.2.2 NEON INDICATIONS**

<b>NEON</b>	<b>NAME</b>	<b>DESCRIPTION</b>
NE1	SCR 1,2	Should be lit during stop and extinguished when the motor is up to speed. This represents the status of SCR 1 and 2
NE2	L1 ON	Indicates voltage is present on L1
NE3	SCR 3,4	Should be lit during stop and extinguished when the motor is up to speed. This represents the status of SCR 3 and 4
NE4	L2 ON	Indicates voltage is present on L2
NE5	SCR 5,6	Should be lit during stop and extinguished when the motor is up to speed. This represents the status of SCR 5 and 6
NE6	L3 ON	Indicates voltage is present on L3

## **3.3 ADJUSTMENTS**

### **3.3.1 POTENTIOMETERS**

<b>POT</b>	<b>NAME</b>	<b>RANGE</b>	<b>DEFAULT SETTING</b>	<b>DESCRIPTION</b>
RV1	RATE	2-3 SEC	50%	Adjusts the time of the current ramping CW rotation decreases the time
RV2	STEP	150-350%	50%	Adjusts the starting current or breakaway torque CW increases the torque (current)

**3.3.2 LINK SELECTION**

LINK	NAME	POSITION	DESCRIPTION
JP1	DUTY	NO JUMPER	With no jumper present, heavy duty mode selected Shipped from factory with no jumper
JP3	RATE	OFF	Selects constant current mode RV1 has no bearing
		ON	This selects current ramp mode which is dependent on RV1

\*Note : JP2 does not exist on this version

**3.3.3 PUSHBUTTON AND SWITCHES**

SWITCH	NAME	DESCRIPTION
SW1	RESET	Resets IOC or inverse time overload fault
SW2	BURDEN SELECT	Calibrates current for nameplate rating of motor Refer to current table on starter or Section 4.5.3.

**3.4 TERMINALS****3.4.1 CUSTOMER TERMINALS**

TERMINAL	NO.	DESCRIPTION
TB	1	115 VAC supplied to this input will enable the unit to run
	2	Common Fault relay contact. The relay is energized when a fault exists
	3	Normally open Fault relay contact
	4	Normally closed Fault relay contact
	5	115 VAC supplied for control logic
	6,7	Dry run contact for external use or sealing contact for start pushbutton with three wire control
AC	AC1, N	115 VAC control voltage input AC1, N AC1 input is protected with internal fuse, 3A 250 VAC
TB1	RESET	A contact closure across these terminals will reset any faults that exist. For local panel door use, low voltage control.

### 3.4.2 TERMINALS FOR INTERNAL USE

TERMINAL	DESCRIPTION
OT	This two pin connector is for an over temperature switch on units with fans and must be shorted if an OT switch is not used
FAN	Fused 115 VAC for fan connection
SCR1-6	Gate lead connections for SCR firing
OPT	Provided for ribbon cable link to SAF's OPAL option cards

### 3.5 FAULTS

Any OPAL fault energizes the fault relay and shuts down the starter. Whenever any fault exists, the READY LED will be off indicating the starter won't run. Once the fault is cleared, READY will be illuminated if no other faults exist. Terminal TB-2 to 3 will be open when no fault exists and closed during a fault condition, TB2 to 4 is vice versa.

#### 3.5.1 OVER TEMPERATURE

OPAL units with fans have over temperature switches fastened to the heatsink(s). This switch or switches in series, are connected in the OT terminal on the control card. Units without fans have a jumper installed. In the case where there is a fan failure or fan blockage and the heatsink temperature exceeds  $85^{\circ}\text{C} / 185^{\circ}\text{F} \pm 5^{\circ}\text{C} / 41^{\circ}\text{F}$ , the over temperature switch opens, faulting the OPAL. This fault is indicated by LD1, OVERTEMP. When the heatsink cools enough, creating switch closure, the OVER TEMP LED will extinguish.

#### 3.5.2 MOTOR OVERLOAD

This fault has two conditions, instantaneous over current (IOC) or inverse timed overload. Both of these faults are indicated by LD4, MOTOR OVRLD. If started into a short, the OPAL should trip on an IOC dependent upon the impedance of the incoming lines. This condition is resettable instantly by the RESET button. The inverse time overload is a class 20 overload that simulates the heating of the motor.

This electronic circuitry begins to integrate whenever the current to the motor exceeds 115% of the current setup with SW2. This current calibration switch should be setup to the name plate current rating of the motor. Once the overload circuitry reaches the trip level, the unit faults and shuts down. This trip is allowed to be cleared with the RESET button after a time period of approximately 5-7 minutes. This time allows for the motor to cool before restarting.

#### 3.5.3 PHASE LOSS

If any of the incoming lines are not present before starting the OPAL will be faulted. Each line is indicated by a corresponding neon lamp. Once the missing phase(s) is/are present and no other faults exist, the unit will be ready to run.

## **4.0 INSTALLATION AND START-UP**

### **4.1 INSPECTION**

The OPAL has been packaged to protect it from damage caused by normal handling during shipment; however mishandling may cause damage to the OPAL. 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. SAF plant unless otherwise specified.

If the OPAL is not installed when received, store it in a clean, dry, well ventilated area, free from heat, humidity, oil, dust, and metal particles.

### **4.2 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.

### **4.3 MOUNTING GUIDELINES**

Standard Nema 1 OPAL 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 can not accept this temperature.

The starter must be mounted vertically and where it will not experience excessive shock or vibration.

## **4.4 WIRING GUIDELINES**

The electrical code requires that an approved circuit disconnecting device be installed in the incoming AC supply, 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 must be added ahead of the starter. Capacitors can be connected before starting or after the motor has reached full speed. It is recommended that the Up-to-Speed option card be used to connect the capacitors after full speed has been reached.

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.

For short-circuit fuse protection, we suggest referencing the table in Section 2.

## **4.5 START-UP**

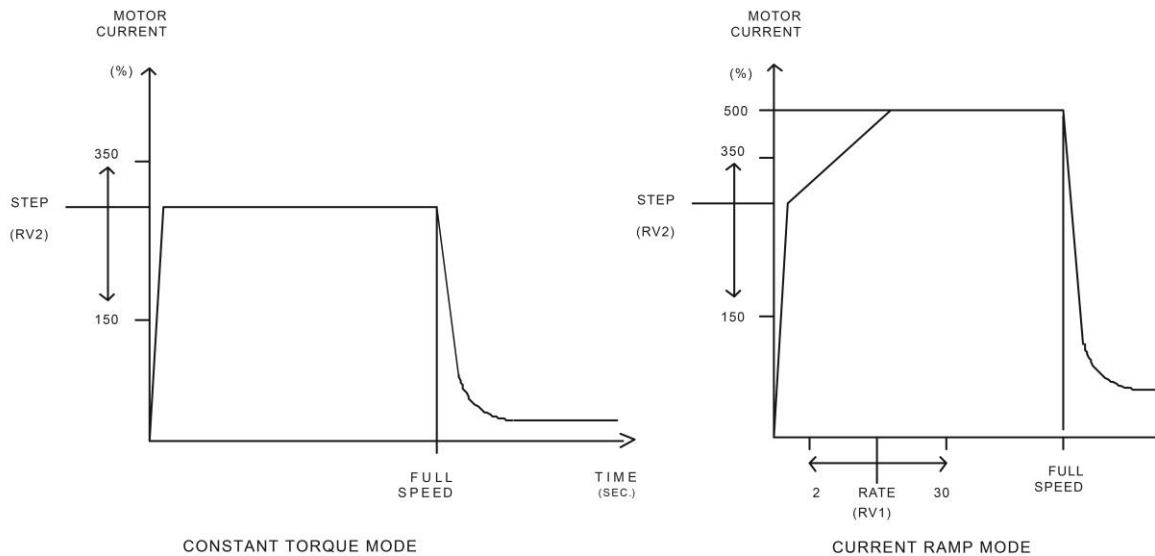
### **4.5.1 BEFORE POWER-UP**

- 4.5.1.1 Ensure that all electrical connections are completed as shown on the schematics, and that connections are properly tightened.
- 4.5.1.2 Read motor full load current from the nameplate and rotate SW2 to match the motor full load current, according to the label attached or the current chart in Section 4.5.3.
- 4.5.1.3 Check 120 VAC control voltage to the OPAL unit.
- 4.5.1.4 Set RV1 and RV2 to mid-position, for 15 sec ramp time and 250% starting current.
- 4.5.1.5 Check link positions. The factory settings are current ramp mode and no jumper for heavy duty.



## 4.5.2 WITH POWER ON

- 4.5.2.1 With the motor connected and power on, all neon lamps should be illuminated and no faults should exist.
- 4.5.2.2 Once start has been initiated the motor must start rotating immediately, it must not stall. Increase the starting current if necessary by rotating RV2, STEP, clockwise.
- 4.5.2.3 The RATE could be re-adjusted to extend or decrease the accelerating time. To speed up the acceleration rate, turn RV1 clockwise. The actual motor accelerating time depends on the motor current as well as the mechanical load. This setting has no effect when constant current mode has been selected. Refer to diagram below.
- 4.5.2.4 The RATE adjusts the time from the STEP setting to 500% of motor full load current.
- 4.5.2.5 Some readjustments may be required when the motor is started to suit specific applications.



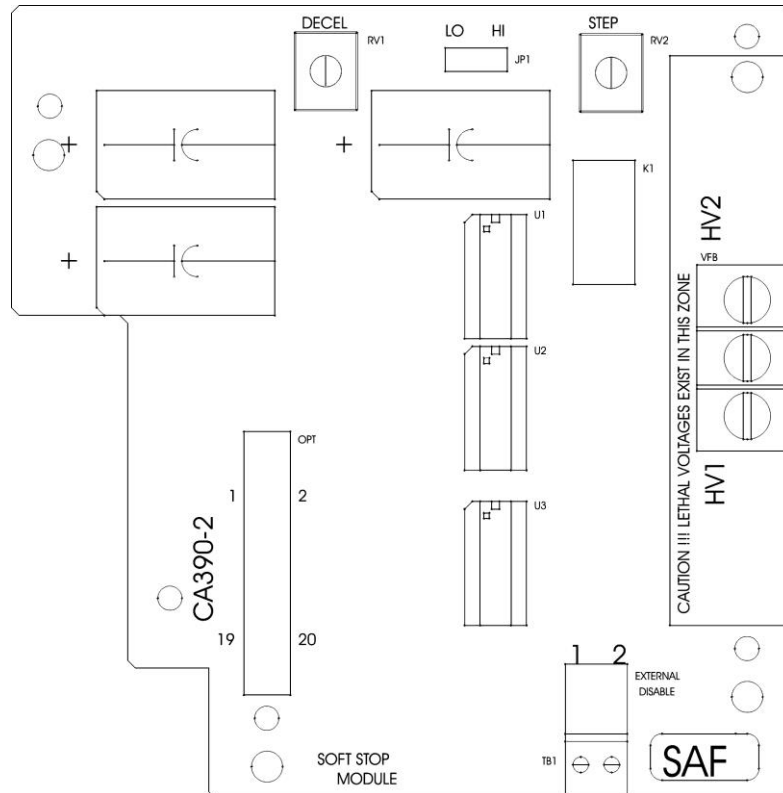
**4.5.3 HEAVY DUTY CURRENT CALIBRATION TABLE**

SW2 POSITION	OPAL MODEL (SS6 -)									
	15	30	50	80	125	200	360	500	600	800
0	1	12	24	47	77	103	150	286	420	494
1	2	13	26	50	80	109	164	300	432	514
2	3	15	28	52	84	116	178	315	444	535
3	4	16	30	54	87	122	192	330	456	555
4	5	17	32	56	90	129	206	343	468	576
5	6	19	34	58	93	135	220	357	480	596
6	7	20	36	61	96	142	234	372	492	616
7	8	22	38	63	100	148	248	386	504	637
8	9	23	40	65	103	155	262	400	516	657
9	10	24	42	67	106	161	276	415	528	678
A	11	6	44	69	109	168	290	429	540	698
B	12	27	46	72	112	174	304	443	552	718
C	13	29	48	74	116	181	318	458	564	739
D	14	30	51	76	119	187	332	472	576	759
E	15	31	53	78	122	194	346	486	588	780
F	16	33	55	80	125	200	360	500	600	800

## 5.0 OPAL OPTION CARDS

Refer to Section 6 for typical connections of any of the options listed in this section.

### 5.1 SOFT STOP



**CA390 - SOFT STOP CARD**

This option has been designed to provide a controlled stop, to eliminate the water hammering effect associated with fluid pumping applications.

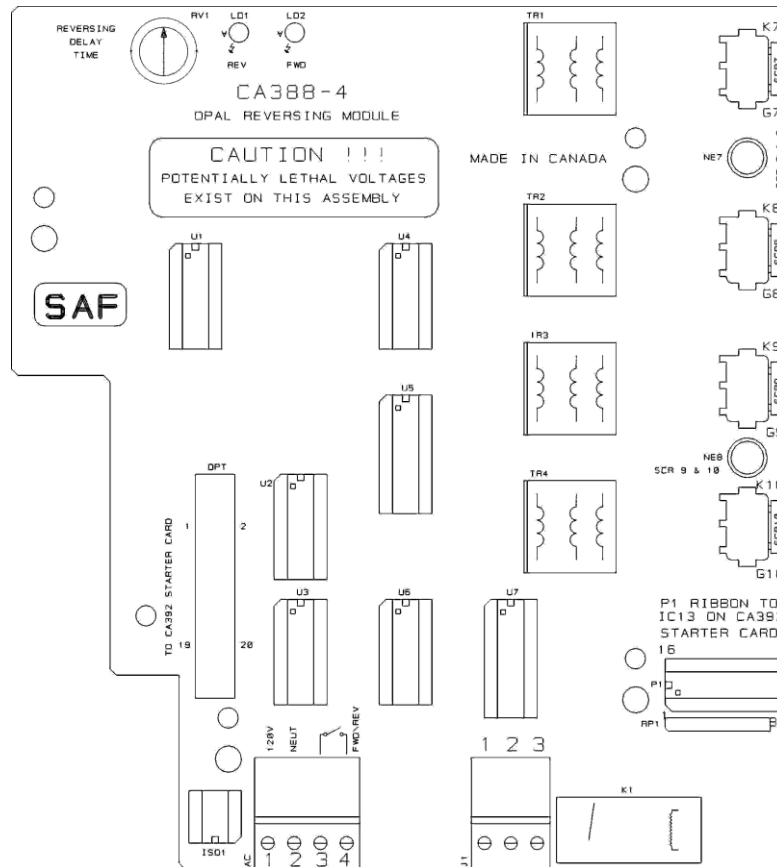
The Soft Stop card works in the opposite fashion as the OPAL starting. When stop is commanded, the OPAL output voltage drops to a level set by STEP, RV2, and begins to ramp down following a rate set by the potentiometer DECEL, RV1. The OPAL will remain on until the motor terminal voltage has decreased to a set voltage level, at which time the starter switches off. The maximum ramp time is limited to a maximum 15-20 seconds. This is the time that the relay in the OPAL controller card, CA392, is maintained energized.

The majority of AC induction motors experience a region of instability when phased back or voltage is reduced. The STEP potentiometer should be adjusted to a level, which is just below this point. Fully counter-clockwise provides little decrease in voltage step when stop is commanded. Clockwise rotation of RV1 slows the ramp down from this point.

The voltage level jumper, J1, set at LO ceases starter operation at 15% voltage while at H1, the OPAL stops at 20% line voltage.

Terminals 1 and 2 on this option card are provided to wire an external selector switch to enable or disable the soft stop mode. When terminals 1 and 2 of TB1 are shorted, the OPAL will coast to a rest when stop is commanded.

## 5.2 SOLID STATE REVERSING



**CA388 - SOLID STATE REVERSING CARD**

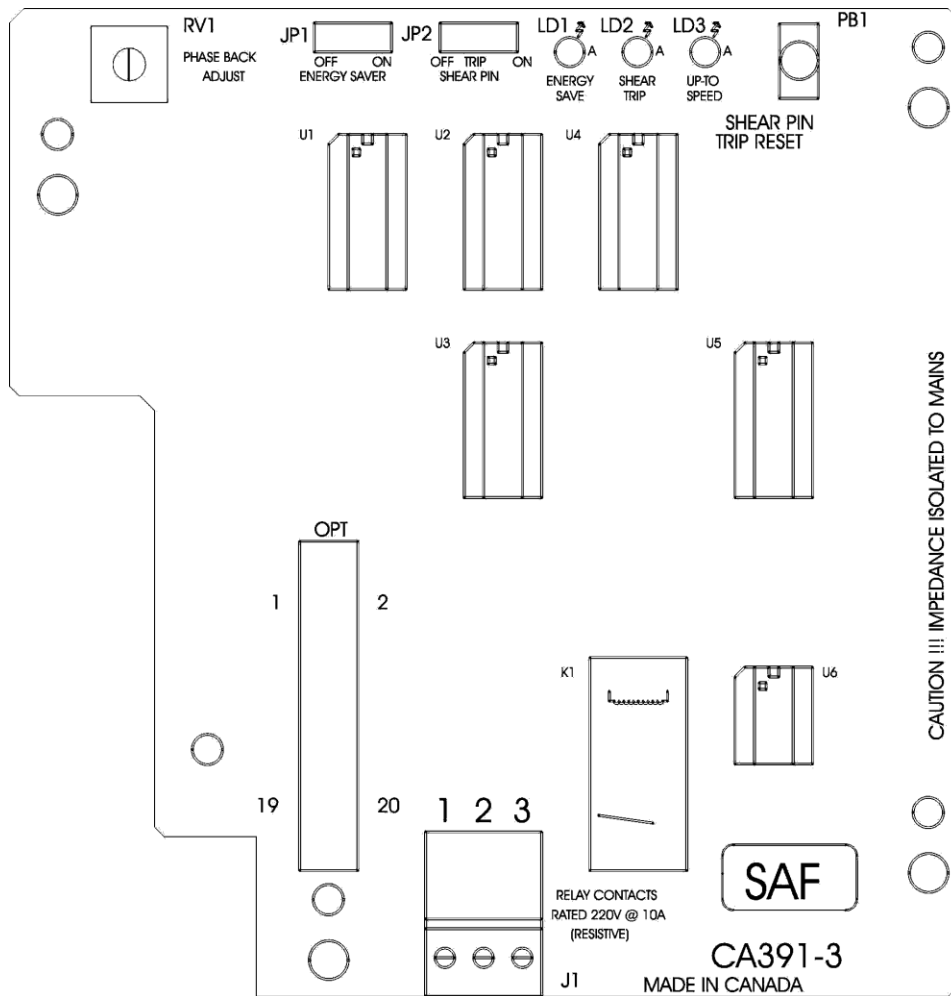
This option provides a smooth, current controlled, motor rotation reversal without any current surge or torque jerk. Motor stopping is not required. Additions to the OPAL include a reversing card, CA388, plus four additional SCR's.

Terminal block AC, terminals 1 and 2 are to be connected to 115 VAC control voltage. An external switch or contact must be connected to AC, terminals 3 and 4 of this card. The forward bridge is selected with the switch closed. With the switch open the starter will fire the reverse bridge. Terminal block J1 is a form C dry contact rated at 0.2A, 115 VAC for an indication of the direction selected and by-pass contactor sequencing for a reverse/by-pass combination. The red LED, LD1 indicates the reverse selection and the green LED, LD2 annunciates that the forward bridge is chosen.

A REVERSING DELAY TIME potentiometer, RV1, sets the time the OPAL remains off when switching directions, from 1 to 10 seconds. Clockwise rotation increases dwell time. The factory default setting is 1 second.

When the motor is running and the forward/reverse switch changes states, the OPAL turns all SCR's off. After an adjustable time delay set up by RV1, the OPAL 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 and STEP potentiometers on the CA392.

**5.3 UP-TO-SPEED, SHEAR PIN, AND ENERGY SAVER**



**CA391 - MULTI OPTION CARD**

**5.3.1 UP-TO-SPEED AND SCR BY-PASS**

A three pole contactor used in conjunction with the Up-To-Speed 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 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 FWD/REV contacts of the CA388 must be connected in series for proper sequencing of the contactor(s).

When the motor reaches full speed, the Up-To-Speed relay is energized and the red UP-TO-SPEED LED, LD3 is illuminated. A form C dry relay contact rated at 1A, 120VAC, is provided on J1 terminals 1, 2 and 3 for by-pass sequencing. Large contactors require a control relay to handle the high inrush current to the coil.

### **5.3.2 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, indicated by LD3 being on, the OPAL will trip if the motor current increases to 300%. The red SHEAR TRIP LED, LD2 will indicate this trip and is resettable via the red RESET pushbutton on the option card. Link JP2 enables or disables this optional feature.

### **5.3.3 ENERGY SAVER**

This option is designed to phase back the SCR's under light load, and keep them fully phased on under medium to full load. This optional feature is intended for use on small motors in applications where the motor runs under no load for an extensive time but can not be switched off. The energy save is not effective on motors over 25 HP. The OPAL starter is designed for repeated starting and stopping. The most efficient operation is to switch the motor off when ever possible.

Link JP1 enables or disables this optional feature. The red ENERGY SAVE LED, LD1 will come on to announce that this feature is active. To calibrate this feature, turn RV1, PHASE BACK ADJUST pot clockwise until the motor starts to become unstable. Once this occurs, turn the pot slightly counter-clockwise until the motor is again stable. Energy save is not operational with the use of a bypass contactor.

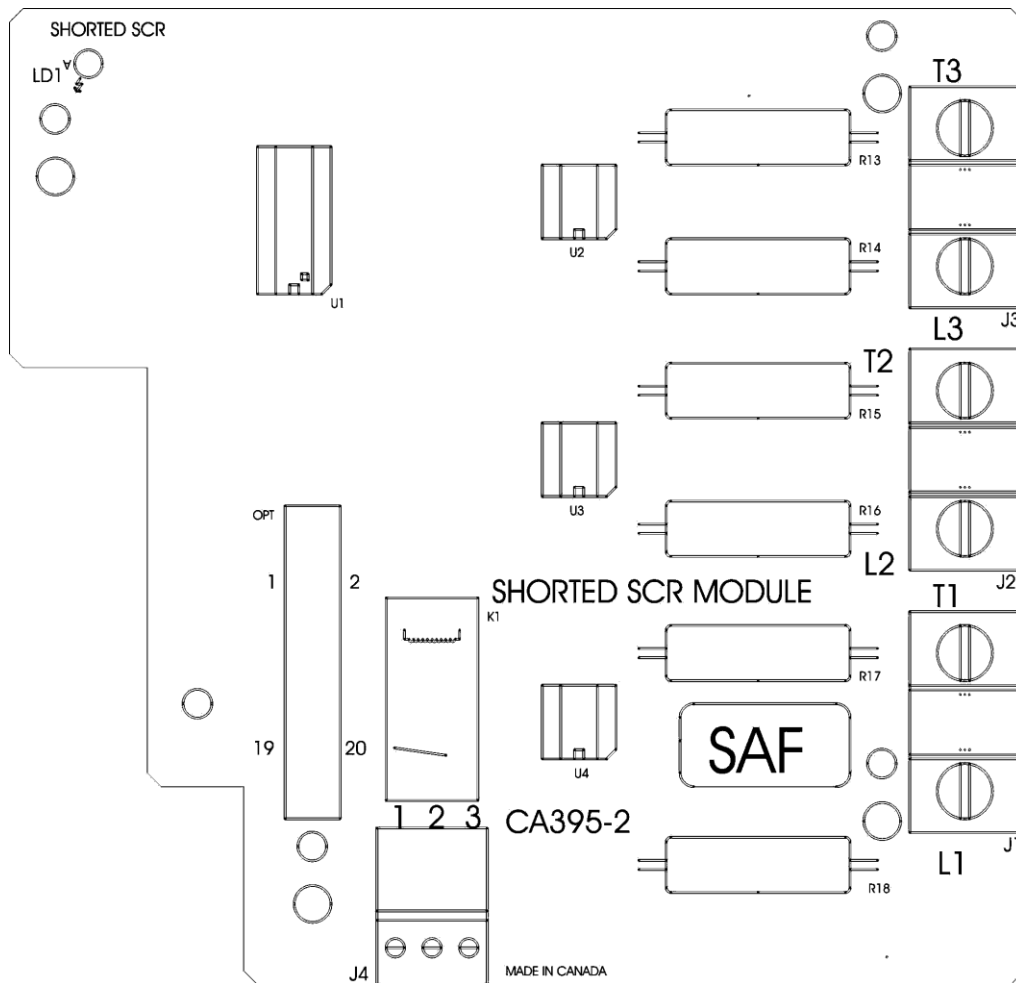
### **5.3.4 EXTENDED OVERLOAD**

With a high inertia load such as a chipper, a Class 20 overload may not allow enough time for the motor to reach full speed without nuisance overload tripping.

In such a scenario an extended overload option can be implemented. This allows the motor 500% current for a longer period of time. This option only affects the overload when the motor is started.

The extended overload is not a factory option and must be specifically requested. Consult factory for more details.

**5.4 SHORTED SCR DETECTION**



**CA395 - SHORTED SCR CARD**

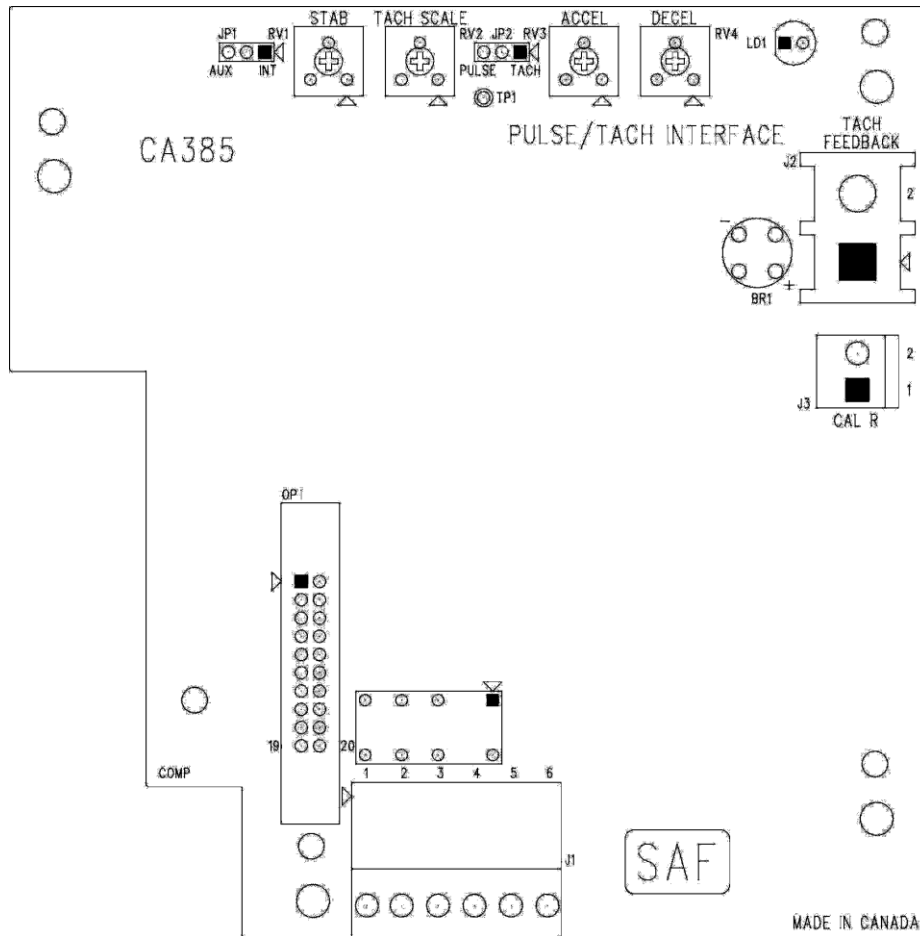
This option provides protection against the unlikely event of a shorted Silicon Controlled Rectifier (SCR). This card only functions when the OPAL is not running and should be used in conjunction with a shunt trip circuit breaker or an in-line contactor.

In the event of a shorted SCR, it is not sufficient to merely trip the starter. The incoming 3 $\phi$  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 contact rated at 1 Amp, 120 VAC on terminals 1, 2 and 3 of J1, is provided for means of opening the circuit breaker or contactor used. Large contactors require a control relay to handle the high inrush current to the coil. A red LED, LD1 will illuminate during this condition of a shorted device.

The CA395 will indicate a shorted SCR if the motor is not connected. In reversing applications, two shorted SCR cards must be used. When using an OPAL with an integral DC Injection option, the DCI contact from the OP-STOP must be used in conjunction with the shorted SCR contact to eliminate erroneous trips during DC injection.

## 5.5 LINEAR ACCEL/DECEL OPTION



**CA385 - LINEAR ACCEL/DECEL CARD**

This option card combined with a 60 tooth magnetic pulse pick-up or a tachometer provides linear acceleration and deceleration independent of load. The ramp reference can be via internal ramp generator or an auxiliary reference. A form C dry contact indicating when the unit is running is available for external use and illuminated via LD1.

### 5.5.1 POTENTIOMETERS

POT	NAME	DESCRIPTION
RV1	STAB	Adjustment for stability of the ramping transition
RV2	TACH SCALE	Sets up speed feedback for the regulator by adjusting voltage at TP1 (below JP2), CW decreases voltage at TP1 For internal ramp set TP1 for -9.2V or less at full speed For aux ref set TP1 = maximum reference -0.667 or slightly less at full speed
RV3	DECEL	Adjusts decel time of ramp, 5 - 50 seconds, CW increases time
RV4	ACCEL	Adjusts accel time of ramp, 5 - 50 seconds, CW increases time



**5.5.2 LINK SELECTION**

LINK	NAME	DESCRIPTION
JP1	AUX	Reference from auxiliary input
	INT	Internal reference from ramp generator
JP2	PULSE	Feedback from magnetic pick-up input on J1
	TACH	Feedback from tachometer input on J2

**5.5.3 TERMINALS**

TERMINAL	NO.	NAME	DESCRIPTION
J1	1	PULSE FEEDBACK	Connection point for pulse pick up feedback
	2	COMMON	Common point for pulse pick up feedback and auxiliary reference
	3	AUX REF	Input for auxiliary reference when JP1 is at AUX Range is 0 - 15V maximum
	4	NO	Normally open starter status contact
	5	NC	Normally closed starter status contact
	6	COM	Common of ramp status form C contacts Energized when unit started and de-energized when ramp reference or auxiliary input reaches 0V
J2		TACH FEEDBACK	Input for tachometer feedback Scaled by resistor at J3
J3		CAL R	Scaling resistor for tach feedback Resistor should be 1 Watt or greater $CAL R = (\text{max. tach volts} - 13.4) \div 12$ in kilo-ohms

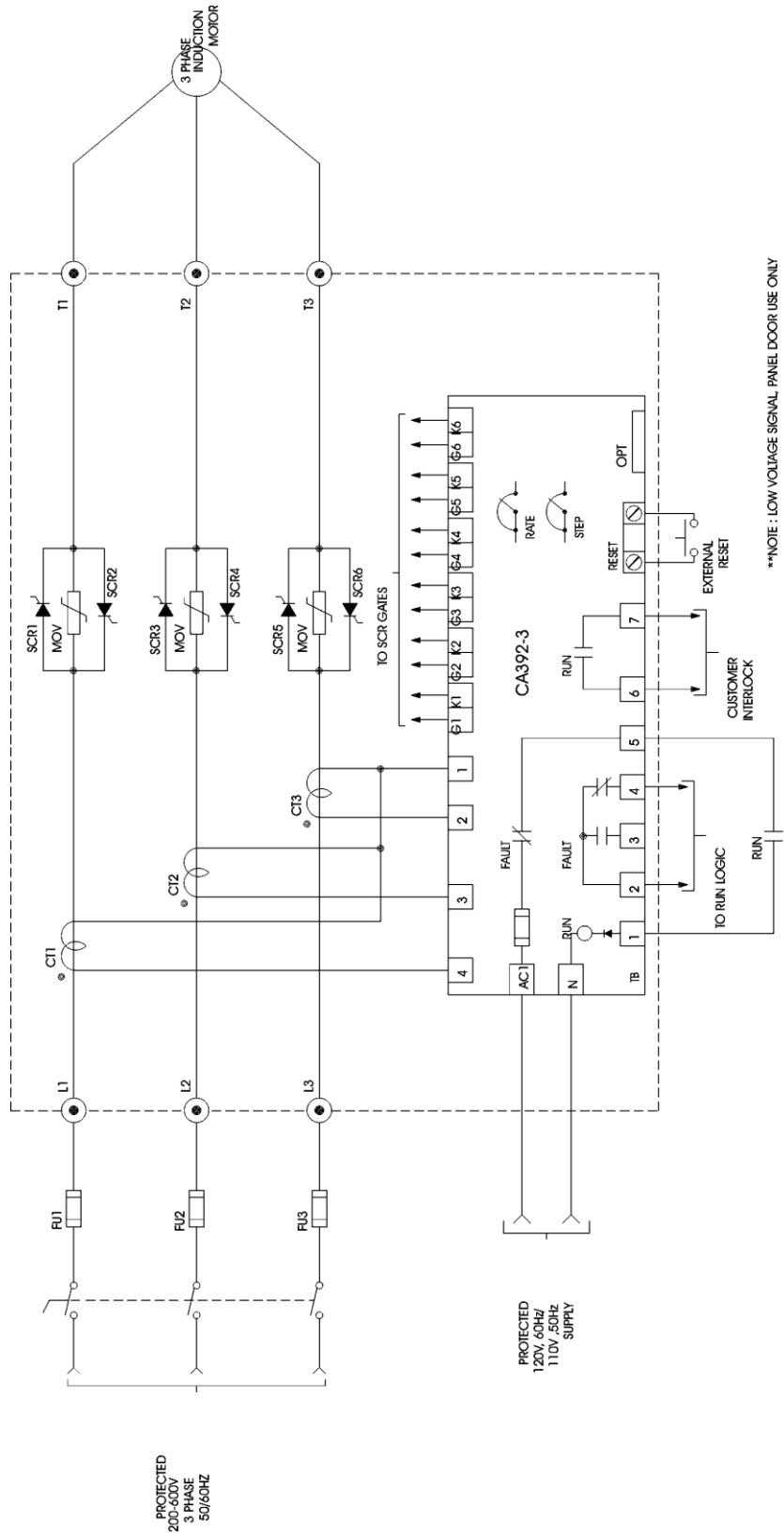
**5.5.4 START-UP**

- 5.5.4.1 STEP (RV2) should be set at 0 and the RATE jumper (JP3) must be OFF or removed on the CA392 control card. Ensure SW2 is in correct position.
- 5.5.4.2 Set JP1 and JP2 on CA385 at settings for your application. If tach feedback is being used, install resistor as per above procedure in TERMINALS.
- 5.5.4.3 Set all pots to 50%.
- 5.5.4.4 Start unit and adjust speed feedback according to the procedure in the table POTENTIOMETERS, RV2 description when at full speed. If accel or decel is too slow adjust appropriate pot. If motor does not seem to get up to full speed, reduce the level at TP1 by turning RV2 clock-wise.

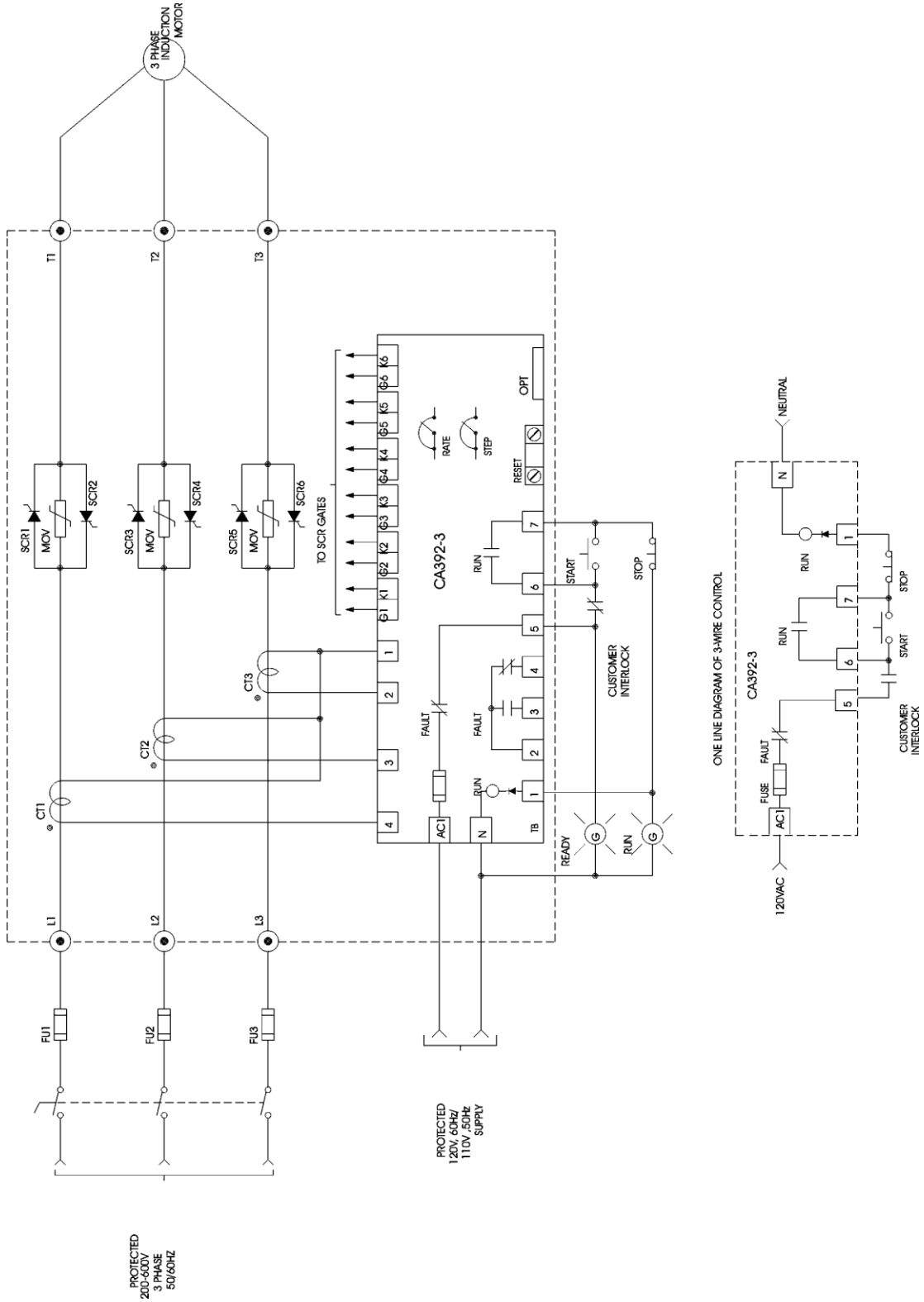
## **6.0 TYPICAL CONNECTIONS**

Listed in this section are diagrams containing typical single option connections. Notice that multi-option connections are possible, meaning a combination of a starter with two or more options attached. The only connection difference between the various sized OPAL power units, other than the obvious sizes and ratings of devices, is the location of the current transformers. This should be of no concern because any modification involving this configuration should be done at the factory or be consulted by SAF Drives Inc.

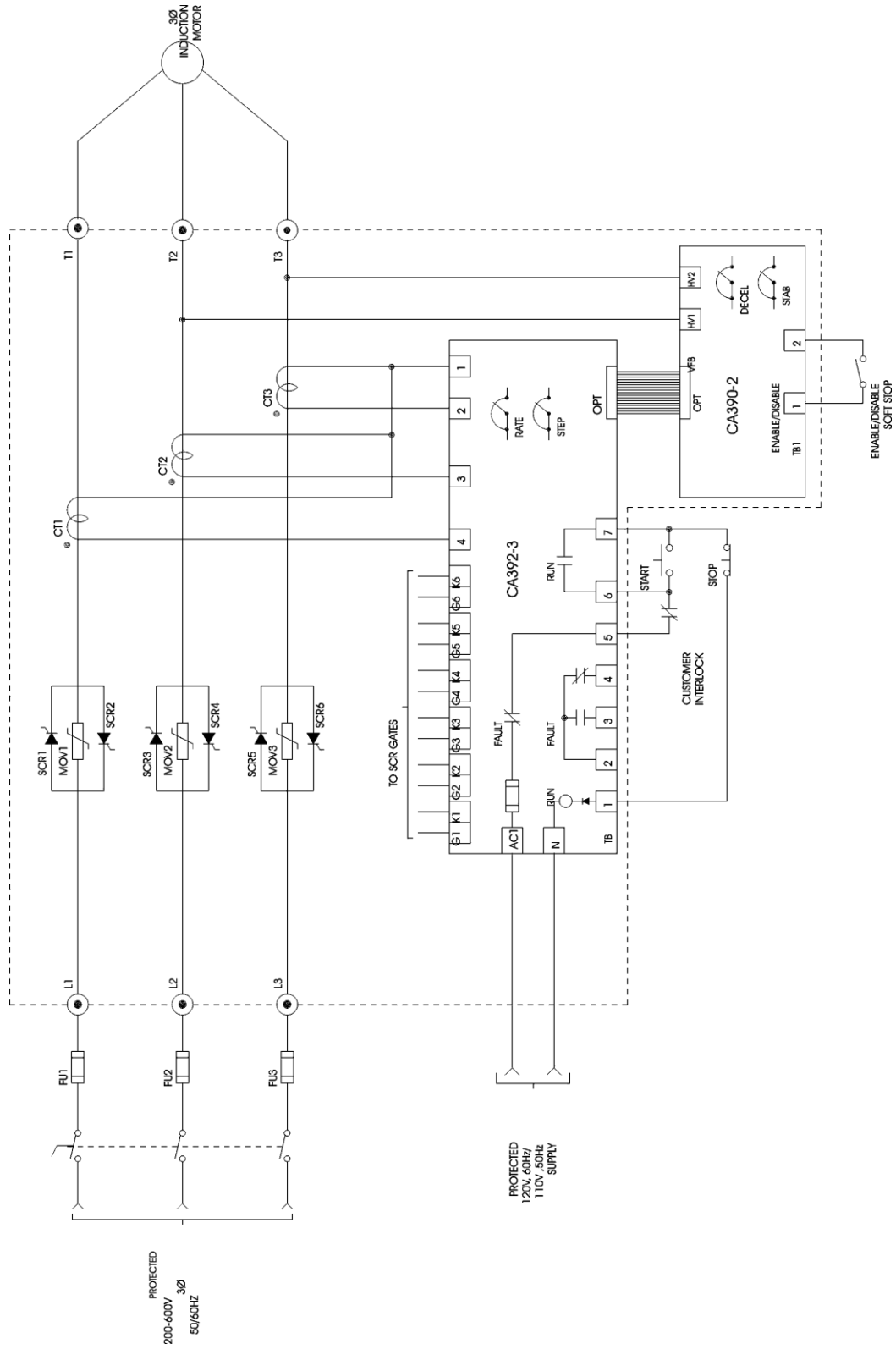
**6.1 OPAL WITH 2-WIRE CONTROL AND EXTERNAL RESET**



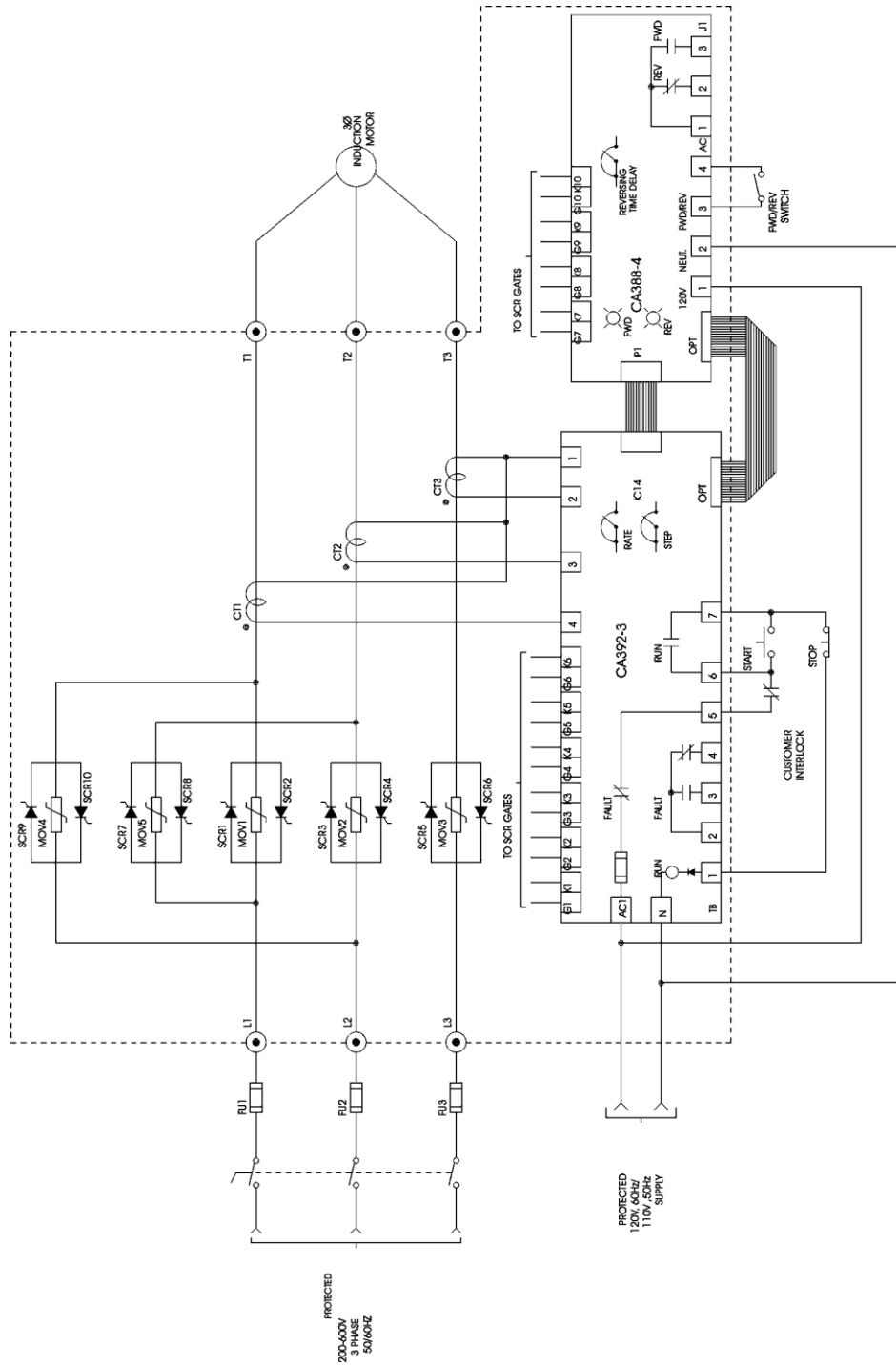
## 6.2 OPAL WITH 3-WIRE CONTROL, OPTIONAL RUN AND READY PILOT LIGHT



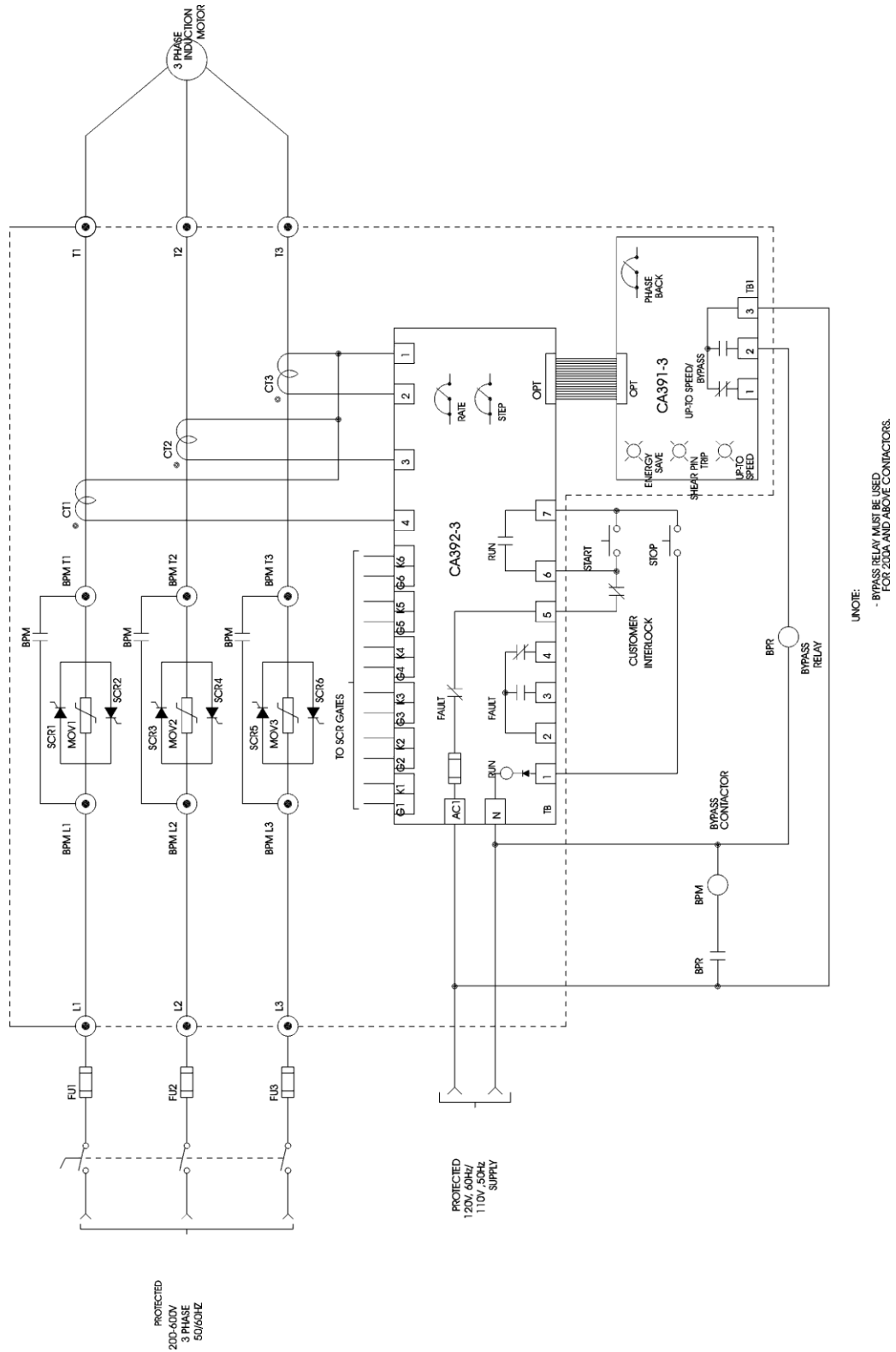
**6.3 OPAL WITH SOFT STOP**



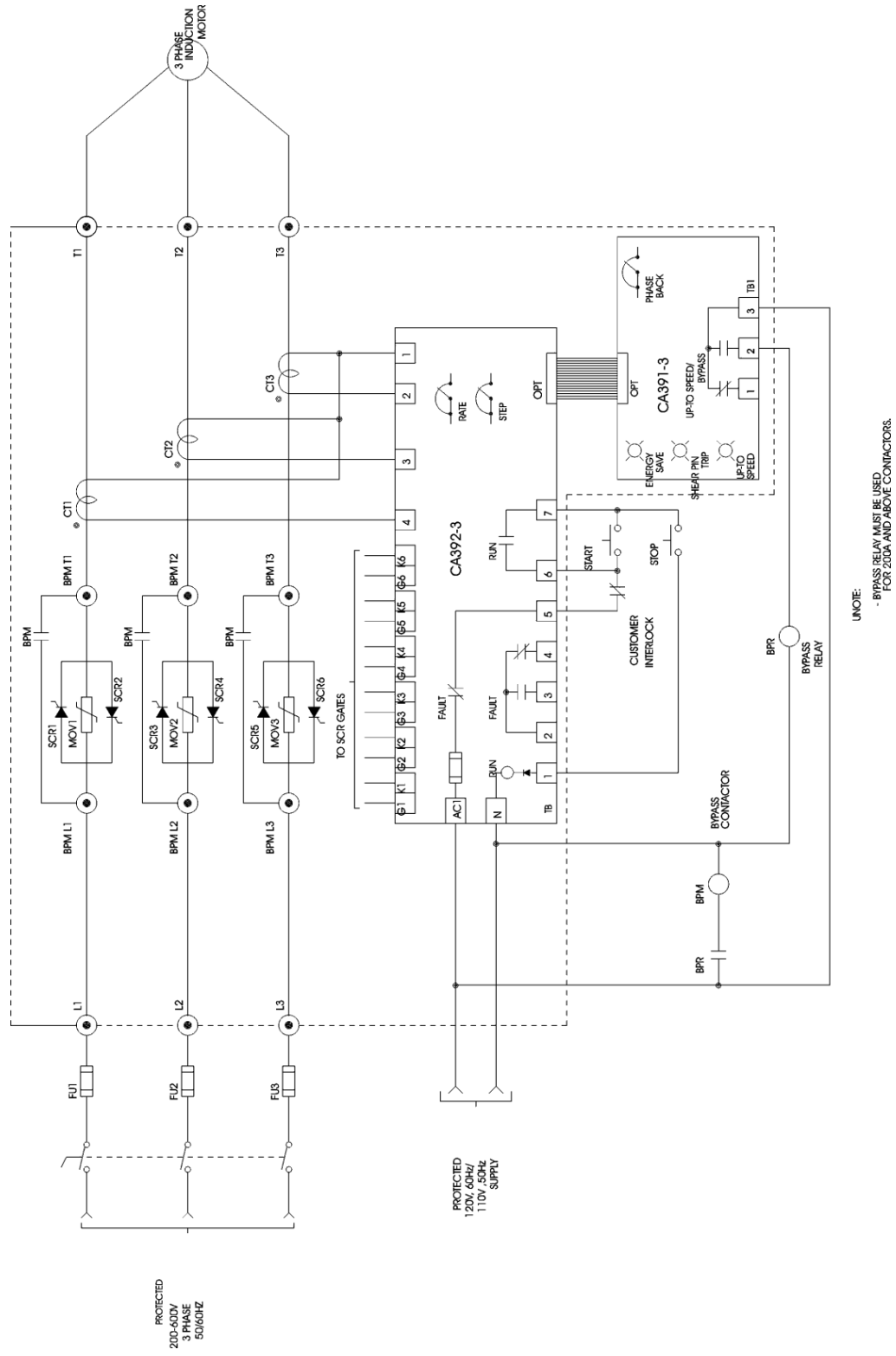
### 6.4 OPAL WITH SOLID STATE REVERSING



## 6.5 OPAL WITH BYPASS CONTACTOR FOR NEMA 4 OR 12 125A AND BELOW

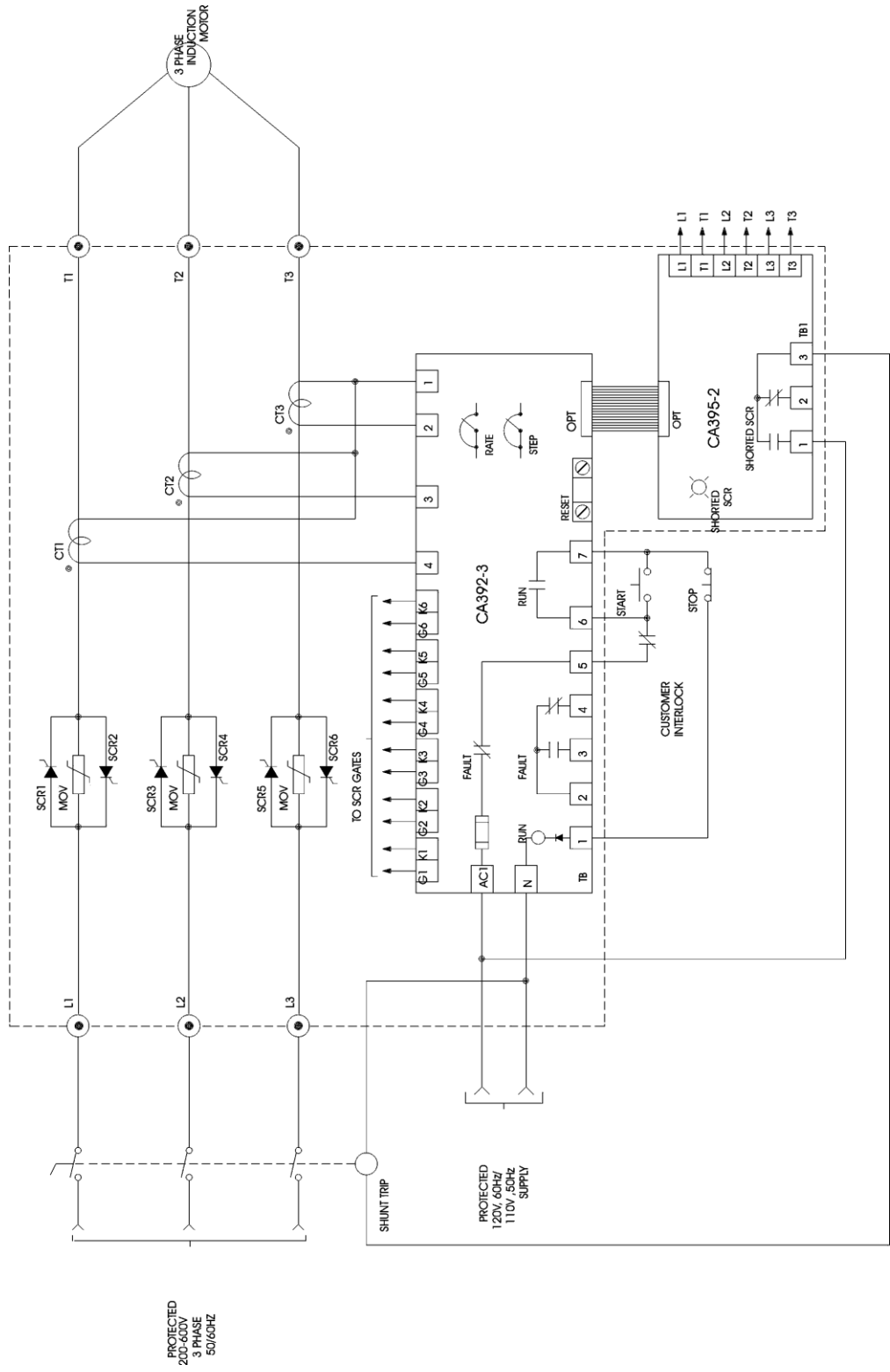


## 6.6 OPAL WITH BYPASS CONTACTOR FOR NEMA 4 OR 12 200A AND ABOVE

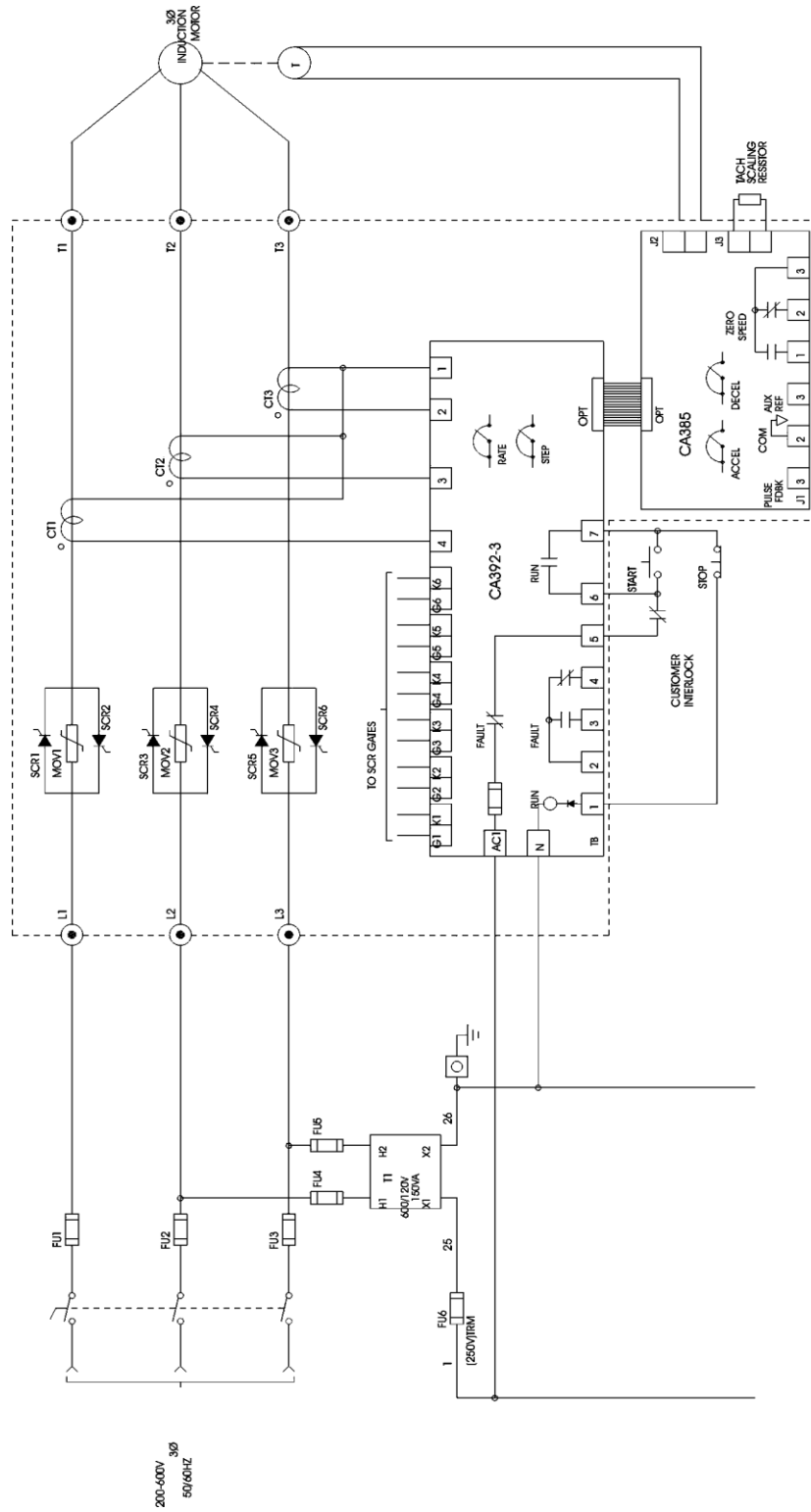




**6.7 OPAL WITH SHORTED SCR OPTION**



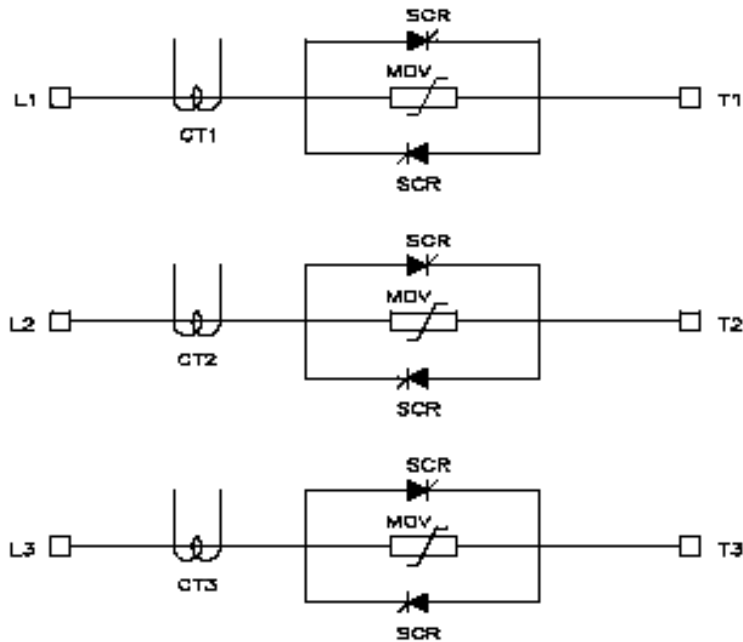
6.8 OPAL WITH LINEAR ACCEL/DECEL CARD



## 7.0 SPARE PARTS

### 7.1 STANDARD UNIT

OPAL MODEL	C/T RATIO	C/T PART NO.	SCR PART NO.	MOV PART NO.	CONROL CARD
SS6-15	1500:1	T261122	N10SP03	O210050	CA392
SS6-30	1500:1	T261122	N10SP03	O210050	CA392
SS6-50	1500:1	T261122	N10SP06	O210050	CA392
SS6-80	2500:1	T262320	N10SP16	O210050	CA392
SS6-125	2500:1	T262320	N20SP06	O210050	CA392
SS6-200	2500:1	T262320	N728452	O210050	CA392
SS6-360	5000:1	T265320	N718133	O210050	CA392
SS6-500	8500:1	T268320	N718552	O210050	CA392
SS6-600	8500:1	T268320	---	O210050	CA392
SS6-800	10000:1	T261321	---	O210050	CA392



### 7.2 OPTION CARDS

DESCRIPTION	MULTI OPTION	SOLID STATE REVERSING	SOFT STOP	SHORTED SCR	LINEAR ACCEL/DECEL
OPTION CARD	CA391	CA388	CA390	CA395	CA385

## 8.0 TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	CORRECTION
OVER TEMP (LD1) lit	Fan failure	Replace fan
	Fan blockage	Clear blockage
	Jumper missing from OT	Replace jumper, units without fans only
READY (LD2) not lit	Fault present	Refer to section 3.5 FAULTS
Does not start & RUN (LD3) doesn't illuminate	Control wiring	Refer to section 6 TYPICAL CONNECTIONS and check wiring
MOTOR OVRLD (LD4) lit	Shorted motor or output	Check motor and output
	SW2 not calibrated for motor	Refer to current calibration chart on unit
	Burden pack not installed or not installed correctly	Install burden pack and/or correctly
Motor overload trips before motor is up to speed	SW2 setup may be wrong	Confirm SW2 is setup for the motor connected
	RAMP and STEP setup or extended overload necessary	Increase RV1 and RV2, refer to section 4
+15V (LD5) not lit	Control voltage not present	Check control voltage and FU1 on control card
Motor runs in wrong direction	Phase reversal	Interchange any two incoming or motor leads
Neons 1, 3, or 5 not lit at stop	Shorted SCR	Measure continuity between line and output terminals
	Motor not connected	Connect motor
Neons 2, 4, or 6 not lit	3 $\phi$ supply	Check incoming line voltage
Motor sounds rough when starting	Loose connections or gate leads	Confirm good connections and all gate leads to SCR's and the CA392 control card are secure
Motor starts similar to across the line	Lightly loaded	Decrease STEP and RAMP or maybe try CONSTANT CURRENT mode
	Incorrect line, terminal and bypass connections	Incoming lines must be connected to L1, L2, L3 Motor must be connected to T1, T2,T3 Bypass contactor must be connected to BPM L1-3, BPM T1-T3



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