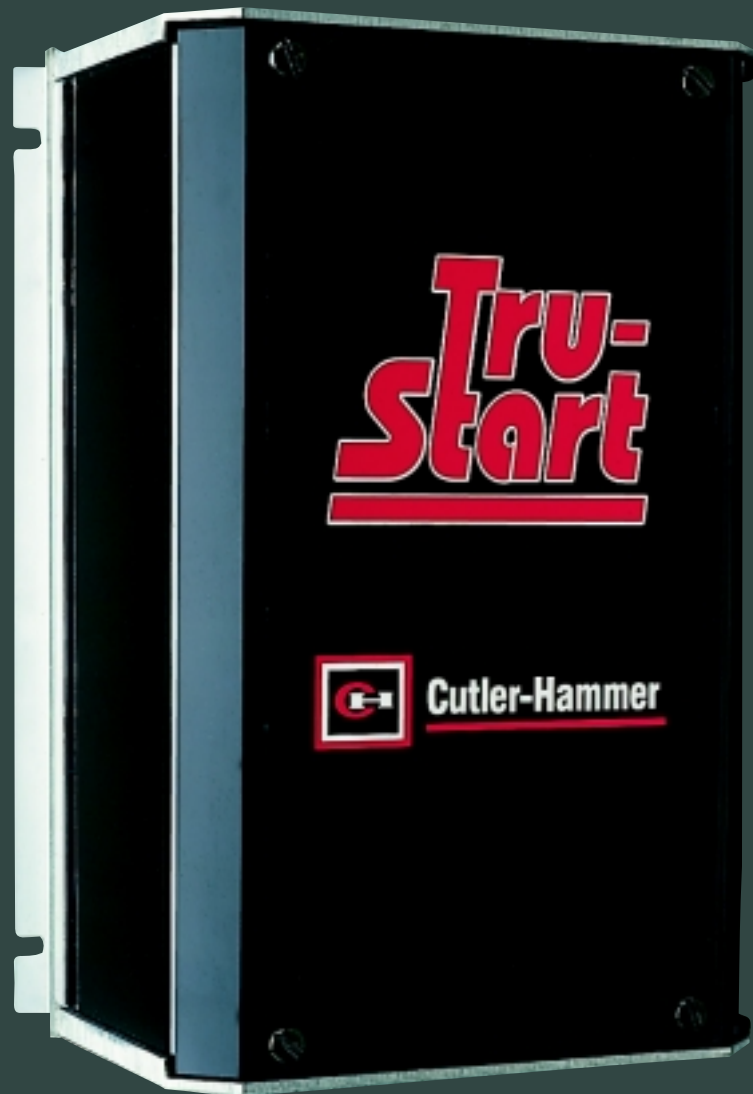


**OPERATION AND
INSTALLATION MANUAL**

Solid State
DC Injection Brake

TRU-START



EATON

Cutler-Hammer

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 Cutler-Hammer or a representative 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 Cutler-Hammer for supplemental instructions.

Cutler-Hammer Canada 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 Cutler-Hammer reserves the right to change the specification of this product and/or the content of this instruction manual without notice.

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1 DESCRIPTION

1.1 OVERVIEW

The TRU-START DC Injection braking units provide smooth braking for AC induction motor. The brake units offer adjustable braking because they are 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.

These units can be supplied as an option to the TRU-START solid state starter, or as stand alone units for new or retrofit installations.

Cutler-Hammer TRU-START DC Injection braking modules offer a unique combination of features that make it very reliable, easy to use, and energy efficient. These features include:

- **Closed Loop Current Regulation:**

The brake, operating with a closed loop current regulator, provides consistent torque every time. This torque is independent of line voltage variations.

- **Direct Power Connection:**

The brake's power input is connected directly to the AC line, and the power output is connected directly to the motor, no contactors are required. The unit adapts itself to any input voltage between 200 and 600 VAC with no adjustments required.

- **Efficient Power Circuit:**

The power circuit is an efficient four Silicon Controlled Rectifier (SCR) configuration which uses some of the SCR's as a "free wheeling diode", thus maximizing the DC current through the motor coils generated by the AC input current.

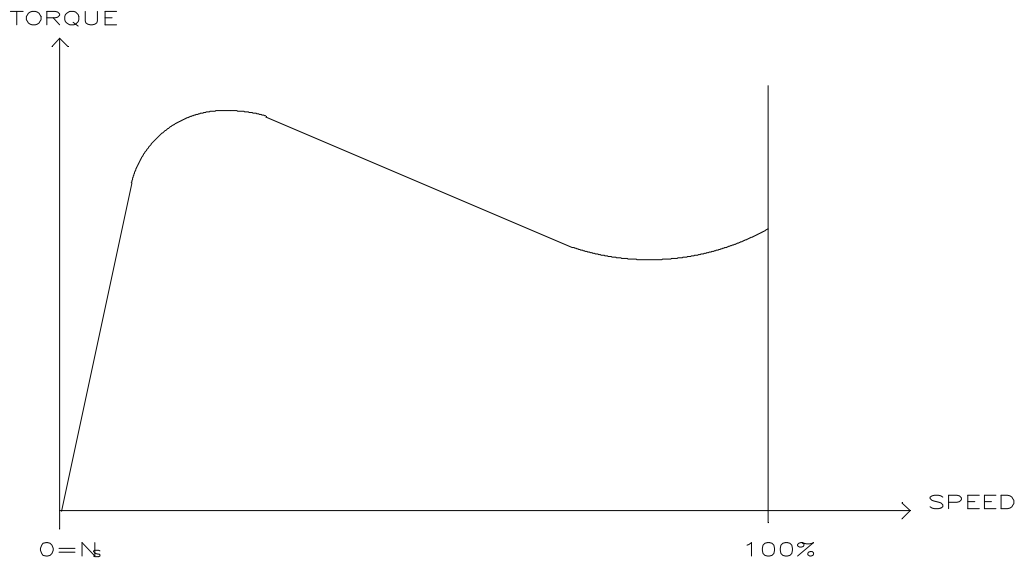
With every benefit there is usually a trade-off. Although the TRU-START DC Injection brake unit will never wear out like a mechanical brake, the trade-off is that should there be a loss of power, the brake unit will not operate without battery back-up. Cutler-Hamer can supply a reliable battery back-up to overcome this disadvantage.

Braking is initiated when the motor starter is opened and the voltage across the motor has dropped to below 30% or 80% of the line supply. DC injection is removed after an adjustable period has elapsed. It does not provide zero speed sensing, although a normally closed contact from a zero speed switch may be connected to the Disable Input.

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.

1.2 APPLICATION NOTES

The motor torque/speed characteristic of an induction motor under DC supply is similar to the normal curve published for constant frequency, at 50 or 60 Hz, but this time having "synchronous speed" zero RPM. This is illustrated below.



For smooth braking the DC current is typically adjusted to 300% of the motor nameplate current. The stopping time depends on the torque setting and also the inertia of the mechanical system.

Electric braking is not recommended for continuous or repetitive operation. The kinetic energy of the mechanical system is transformed into heat during braking (energy conservation). That heat is dissipated in the rotor of the motor.

On wound rotor motors the external rotor resistance will absorb most of the energy. On squirrel cage motors, overheating of the motor is a real danger if frequent operation is used.

Keeping DC current on the motor stator for a short time after the motor has stopped is quite acceptable. The heat produced by the I^2R losses are not significant, and they are dissipated in the stator only, not in the rotor where the rotational energy is dissipated.

1.3 CONTROLS

The OP-STOP unit contains two major parts, the power circuit and the control card.

The power circuit is a 4 SCR single phase full wave controlled rectifier. This configuration optimizes the DC current injected to the motor per input current.

The control is contained in a single PC board, CA398-3. This board is common to all Cutler-Hammer DC Injection models.

1.3.1 CA398-3 LOGIC

DC injection will be applied to the motor when two conditions are met. The starter is opened and the motor terminal voltage has decayed to 30% or 80%, jumper dependent, of the line voltage. The starter can not be energized for a period of 1-2 seconds after the DC injection cycle.

This design has the significant advantage that the braking module will remain off in the case of having an open auxiliary contact from either a broken wire or faulty contact. The braking action can be externally defeated at any time by applying 115 VAC to the Disable Input.

The braking action is inhibited when an instantaneous over current is detected. The IOC fault is detected and latched until the Reset switch is pressed. A form C relay contact is available to interlock the brake unit from the motor starter. The starter cannot be energized while DC current is being applied to the motor or during a fault condition.

1.3.2 CA398-3 REGULATION

The brake module operates in current control at all times. The current is adjusted via an internal potentiometer and the current feedback signal is generated by a current transformer mounted on the AC line. A unique circuitry reconstructs the free wheeling current in the DC output for accurate current regulation.

The output of the current regulator is used in a comparator circuit that performs the phase control on two SCR's. The other two SCR's are fully phased on to provide free wheeling action, minimizing the ripple current.

Two opto-couplers are used to generate the line synchronization signal. Each opto output is used to generate a ramp that is used in the comparator with the current regulator output.

The motor voltage feedback is used to sense voltage levels for proper sequencing and not to perform any regulation.

2 SPECIFICATIONS

2.1 POWER RATING

POWER	200-600VAC, 50/60 Hz
CONTROL	115 VAC@50 Hz or 120 VAC@60 Hz, 10VA
RATING	Intermittent duty, See Section 2.2 300% for 30 seconds, once every 30 minutes All models have 1600V PIV SCR's
CONTACTS	DC injection relay contacts rated at 1A, 120VAC
PROTECTION	Short circuit by HRC fuses or circuit breaker (supplied upon request) Voltage surge protection by snubber's and MOV's across the SCR's

2.2 CURRENT AND FUSE RATING

CURRENT RATING					
DCI MODEL	AMPS	MOTOR HP @ 575 V	MOTOR HP @ 460V	FUSE AMPS	SCR TYPE
TRU-020-DCI	20	20	15	20	Module
TRU-040-DCI	40	40	30	40	Module
TRU-080-DCI	75	75	60	80	Module
TRU-125-DCI	125	125	100	125	Module
TRU-200-DCI	200	200	150	200	Disc
TRU-300-DCI	300	300	250	300	Disc
TRU-500-DCI	500	500	400	500	Disc

2.2.1 NOTES

- 2.2.1.1 The HP listing is for reference only. For proper selection use the current rating.
- 2.2.1.2 The fuses recommended are Class J time-delay type. This fuse is being suggested even though it may not protect the SCR in an output shorted condition while braking. It will protect the unit when starting to operate into a shorted output. In the case of a shorted SCR, the fuse is there to clear the fault only.
- 2.2.1.3 The RMS AC line current is equal to : $AC\ RMS = DC\ Amps \times \sqrt{Duty\ Cycle}$
Assuming 10A motor, TRU-START DC Injection set at 300% current (30 A DC), free wheeling for 70% of the cycle, then the AC current is 16A.
- 2.2.1.4 All TRU-START DC Injection models are built without cooling fans because they are short duty rated.

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 TEMPERATURE	Do not install in areas where ambient temperature falls below 0°C / 32°F or exceeds 40°C / 104°F

2.4 DIMENSIONS

DCI MODEL	Height × Width × Depth	
	CHASSIS	NEMA 1 / NEMA 12
TRU-020-DCI	41cm × 22cm × 15cm	41cm × 22cm × 18cm
	16" × 8.5" × 6"	16" × 8.5" × 7"
TRU-040-DCI	43cm × 27cm × 19cm	43cm × 30cm × 27cm
	17" × 10.5" × 7.5"	17" × 12" × 10.5"
TRU-080-DCI	43cm × 27cm × 22cm	43cm × 30cm × 27cm
	17" × 10.5" × 8"	17" × 12" × 10.5"
TRU-125-DCI	53cm × 27cm × 24cm	53cm × 30cm × 27cm
	21" × 10.5" × 8.5"	21" × 12" × 10.5"
TRU-200-DCI	28cm × 33cm × 27cm	61cm × 61cm × 30cm
	11" × 13" × 10.5"	24" × 24" × 12"
TRU-300-DCI	42cm × 37cm × 28cm	76cm × 61cm × 30cm
	16.5" × 14.5" × 11"	30" × 24" × 12"
TRU-500-DCI	45cm × 42cm × 36cm	76cm × 61cm × 30cm
	17.5" × 16.5" × 14"	30" × 24" × 16"

NOTE : For dimensions of TRU-START DC Injection units in conjunction with solid state C-H's starter, refer to the TRU-START manual reversing chassis dimensions.

2.5 SCR INSTALLATION SPECIFICATIONS

2.5.1 SCR TIGHTENING PROCEDURE

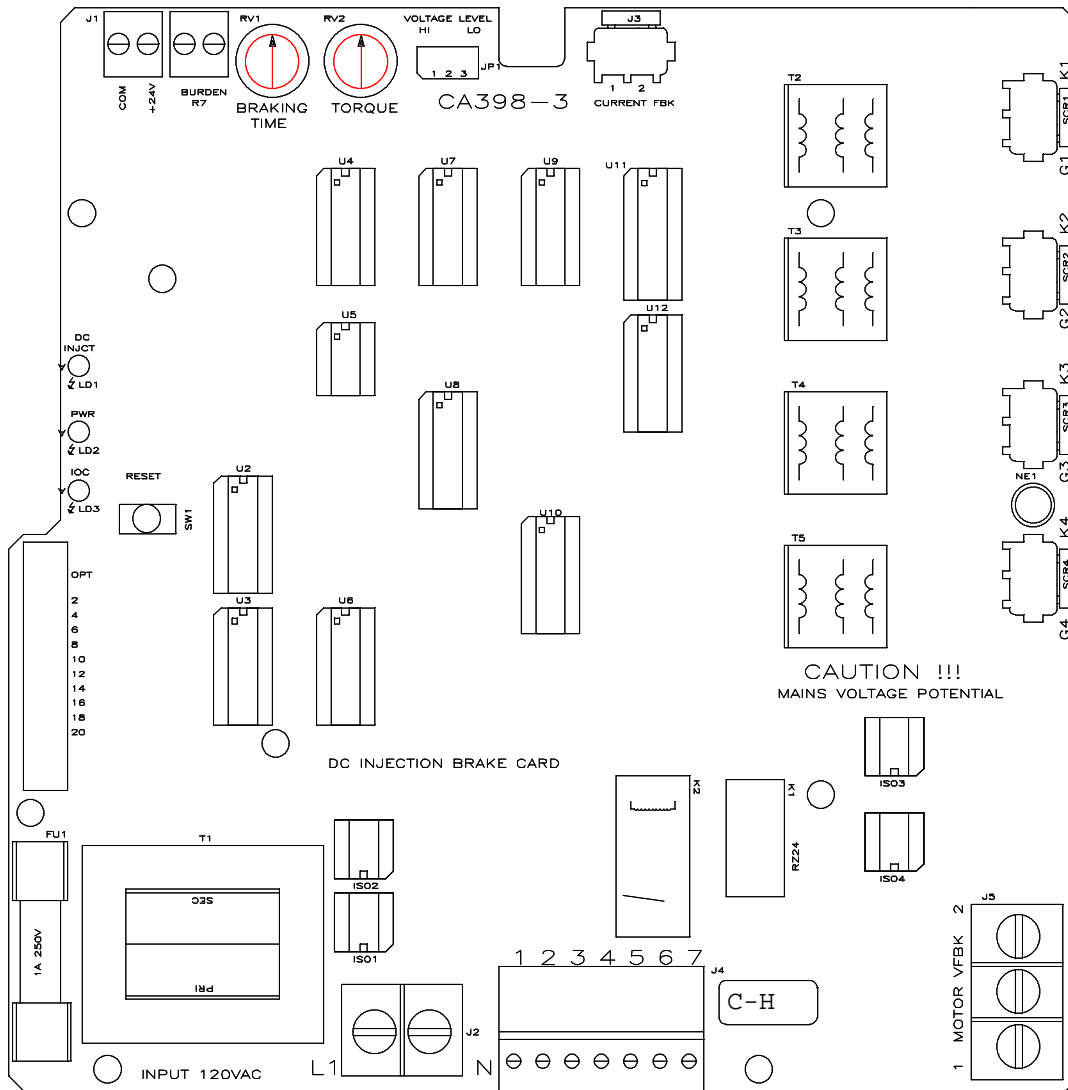
- 2.5.1.1 Clean both heat sink and SCR surfaces.
- 2.5.1.2 Apply a thin layer of joint compound (Noalox) to both SCR surfaces.
- 2.5.1.3 Observe correct SCR polarity.
- 2.5.1.4 Install SCR so that roll pins engage dimples on both sides of the SCR.
- 2.5.1.5 Tighten clamp bolts evenly until finger-tight.
- 2.5.1.6 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.

CLAMP SIZE	SPRING BARS	BOLT TURNS PAST FINGER TIGHT
SMALL	1	0.8
SMALL	2	1
LARGE	3	1.8
LARGE	4	1.8

3 CARD FUNCTIONS

3.1 CARD LAYOUT



CA398-3 - DC INJECTION CARD

3.2 LED AND NEON INDICATIONS

LED	NAME	COLOUR	DESCRIPTION
LD 1	DC INJCT	RED	On when unit is braking
LD 2	PWR	GREEN	Must be On when 115 VAC is applied
LD 3	IOC	RED	Instantaneous Over-Current fault indication when illuminated
NE1	PHASE OK	ORANGE	Phase loss indication when neon not glowing

3.3 ADJUSTMENTS

3.3.1 POTENTIOMETERS

POT	NAME	RANGE	DEFAULT SETTING	DESCRIPTION
RV1	BRAKING TIME	1-60 sec	30%	Adjust the braking time CW rotation increases the time
RV2	TORQUE	100-300%	50%	Adjust DC current CW increases the braking torque (current)

3.3.2 LINK SELECTION

LINK	NAME	POSITION	DESCRIPTION
JP1	VOLTAGE LEVEL	LO (Normal)	Braking action starts when motor starter has opened and the motor terminal voltage has decreased to 30% of the line voltage.
		HI	Braking action starts when motor starter has opened and the motor terminal voltage has decreased to 80% of the line voltage. See important notes below.

HI setting is only used when the stopping time is critical and must be around 1-2 seconds. For this application 300% DC current is not adequate. Consult factory before using this jumper position.

When the DC Injection unit is set on the HI level a current surge could occur due to the motor CEMF and the free wheeling action of the power circuit.

3.3.3 PUSHBUTTON

PUSHBUTTON	NAME	DESCRIPTION
SW1	RESET	Reset IOC fault trip

3.4 TERMINALS

3.4.1 CUSTOMER TERMINALS

TERMINAL	NO.	DESCRIPTION
J2	L1, N	115 VAC control voltage input, L1 being hot and N, neutral L1 input is protected with internal fuse, 1A 250VAC
J4	1, 2	115 VAC supply for external interlock contacts
	3	A normally open contact from the motor starter auxiliary must be connected between this terminal and terminals 1 or 2 to sense when the starter is de-energized to enable braking action When using a TRU-START starter in conjunction with the DC Injection, this terminal is to be jumpered to terminal 1 or 2
	4	When 115VAC from terminals 1 or 2 is applied to this input, braking is disabled
	5	Common DCI relay contact The Form-C relay is de-energized while braking and when a fault exists
	6	Normally open DCI relay auxiliary contact
	7	Normally closed DCI relay auxiliary contact
R7	1, 2	Burden resistor terminals for calibration of DC injection current See table in Section 4.4

3.4.2 TERMINALS FOR INTERNAL USE

TERMINAL	NO.	DESCRIPTION
J1	24V, COM	This terminal is used by C-H as a 24V input to provide battery back up for DC injection in case of power loss
J3	1, 2	CURRENT FBK From current transformer for motor current feedback
J5	1, 2	MOTOR VFBK From T1, T2 motor terminals for motor voltage feedback
SCR1	G1, K1	Gate connection to SCR 1
SCR2	G2, K2	Gate connection to SCR 2
SCR3	G3, K3	Gate connection to SCR 3
SCR4	G4, K4	Gate connection to SCR 4
OPT	1-20	Provided for ribbon cable link to TRU-START starter This provides signals from the TRU-START to the DCI that indicate the run status of the starter, replacing the auxiliary input and prevents starting during DC injection or a fault

3.5 FAULTS

When a fault exists the DC Injection DCI relay is de-energized, preventing a properly interlocked starter from being activated. When an TRU-START DC Injection is used in conjunction with a C-H starter, this interlock is also carried out through signals passed by energized the ribbon cable at OPT. When no faults exist and DC injection is not active, the DCI relay is energize. Therefore, if the 115 VAC supply is not present the "fail-safe" interlock will prevent the use of the starter. The faults are explained below.

3.5.1 PHASE LOSS

If the single phase power (200-600V) to L1 and L2 terminals is not present, NE1 will be off and the DCI relay de-energized. When this condition is corrected the unit will allow the starter to be energized.

3.5.2 INSTANTANEOUS OVER CURRENT (IOC)

If the current feedback exceeds 1000% of the current setup by the burden resistor (Rb), the unit will trip on IOC and de-energize the DCI relay. LD2 will be illuminated to indicate an IOC fault and is reset via SW1, RESET. Causes of this fault may be a shorted output or simply a burden resistor sized too small. Refer to Section 4.4 for burden table.

4 INSTALLATION AND START UP

4.1 INSPECTION

The DC Injection unit has been packaged to protect it from damage caused by normal handling during shipping, however mishandling may cause damage to the DC Injection unit. 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. Cutler-Hammer plant unless otherwise specified.

If the DC Injection unit 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 or touch motor terminals or control equipment parts.

CAUTION

Disconnect incoming voltage from unit before opening load side during DC injection. Failure to observe this precaution can result in damage to disconnecting device and/or bodily injury.

The electrical code requires all equipment, starter motor, operator station, brake, etc... to be grounded properly. An incoming circuit breaker or disconnect switch must be locked open before wiring and servicing this electrical brake, motor, or other related equipment. This equipment must be installed and serviced only by qualified personnel, familiar with this unit. 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 DC Injection units 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 around the perimeter of the unit in a naturally cooled setup. The equipment must be mounted away from any heat source. See Section 2 for additional specifications and derating. Be aware that the heatsink may reach temperatures of 70°C / 158°F during normal operation. Do not install the unit in contact with any material that can not accept this temperature.

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

4.4 WIRING GUIDELINES

Follow all local electrical codes for installation requirements and wire sizing. Size the power wiring as per local code and on long wire runs it is recommended to use a larger wire size.

Power factor correcting capacitors **MUST NOT** be connected to the DC Injection unit output. If desired, they must be connected on the line side of the unit. Capacitors can be connected before starting or preferably after the motor has reached full speed.

For short-circuit fuse protection refer to the table in Section 2.

4.5 START UP

4.5.1 CHECKS BEFORE POWER-UP

4.5.1.1 Ensure that all electrical connections are completed as shown on schematics in section 6, and that connections are properly tightened. The most important connection is the interlock between the DC Injection unit and the starter.

4.5.1.2 Ensure that the burden resistor is equal or larger than the value listed in the following table or calculated by the following equation :

$$R_b = \text{Effective Current Transformer Ratio} \div \text{Motor Nameplate Amps}$$

4.5.1.3 Set JP1 link to LO.

4.5.1.4 Adjust RV2, braking torque, and RV1, braking time, to 50%.

4.5.1.5 Install a Disable switch between terminals 2 and 4 of J3 in the open position. Switch is to be closed once the motor has reached zero speed or if any problems occur during braking.

4.5.1.6 If a Disable switch is not used, then set RV2 to 30%, about 20 seconds or lower.

WARNING

DO NOT OPEN LOAD SIDE DISCONNECTING DEVICE DURING DC INJECTION CYCLE. FAILURE TO OBSERVE THIS WARNING WILL RESULT IN DAMAGE TO THE DISCONNECTING DEVICE AND MAY CAUSE PERSONAL INJURY.

MODEL	MOTOR AMPS	BURDEN RESISTOR (¼ W)	EFFECTIVE CT RATIO
TRU-015-P c/w DCI	10	68 Ω	750 : 1
	15	47 Ω	
TRU-020-DCI or TRU-030-P c/w DCI	20	39 Ω	750 : 1
	30	27 Ω	
TRU-040-DCI or TRU-050-P c/w DCI	40	39 Ω	1500 : 1
	50	33 Ω	
TRU-080-DCI or TRU-080P c/w DCI	60	39 Ω	2500 : 1
	80	33 Ω	
TRU-125-DCI or TRU-125-P c/w DCI	100	27 Ω	2500 : 1
	125	22 Ω	
TRU-200-DCI or TRU-200-P c/w DCI	150	18 Ω	2500 : 1
	200	12 Ω	
TRU-300-DCI or TRU-360-P c/w DCI	200	27Ω	5000 : 1
	300	18 Ω	
TRU-500-DCI or TRU-500-P c/w DCI	400	22 Ω	8500 : 1
	500	18 Ω	

4.5.2 WITH POWER ON

- 4.5.2.1 Run the motor up to full speed and command the starter off. If the motor reaches zero speed from the DC injection cycle, close the switch to the Disable Input to disable the braking.
- 4.5.2.2 Re-adjust the braking torque pot, RV2, if the actual braking time has to be increased or decreased to bring the motor to zero speed.
- 4.5.2.3 Once the braking torque is set, then adjust RV1 to match the DC injection time with the actual stopping time of the motor. Typically, the injection should cease when the motor is at zero speed or shortly after. LD1, DC INJCT is an indication of braking. Each 10% graduation in RV1 corresponds to approximately 6 seconds.

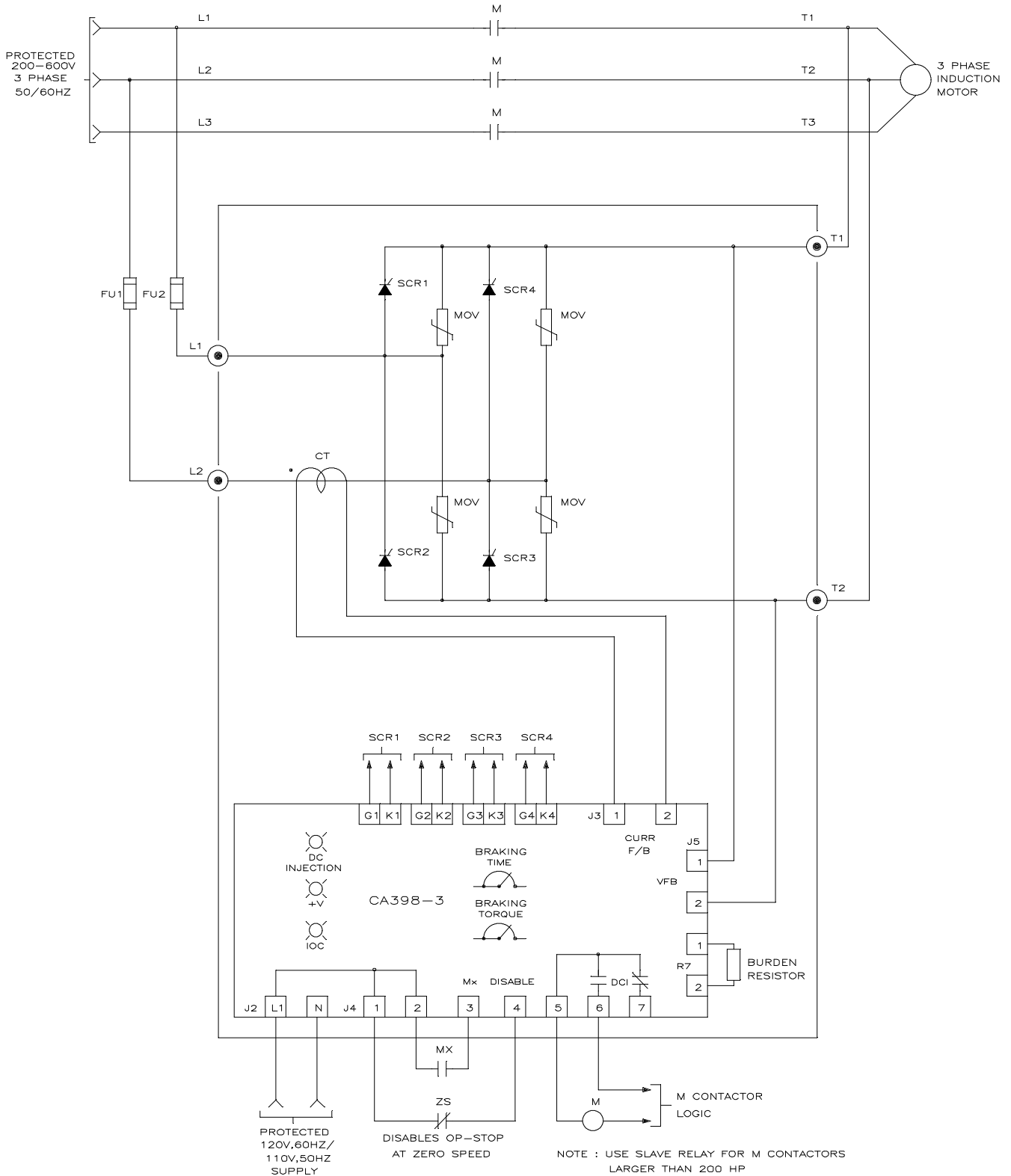
WARNING

ALLOW TIME FOR THE MOTOR TO COOL BEFORE ANOTHER
START / STOP SEQUENCE IS INITIATED

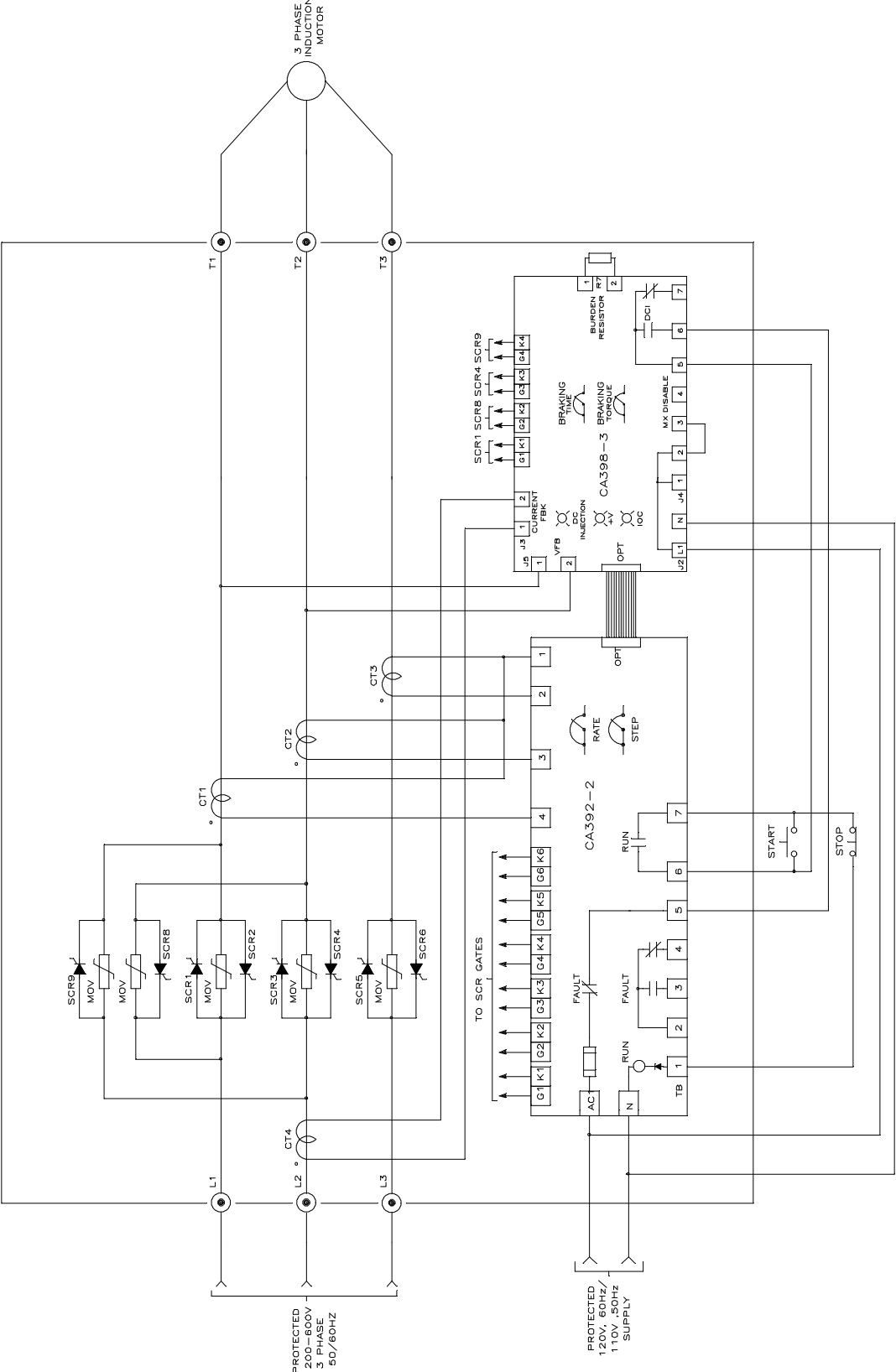
FREQUENT START / STOP COULD CAUSE MOTOR DAMAGE
DUE TO OVERHEATING

5 TYPICAL CONNECTIONS

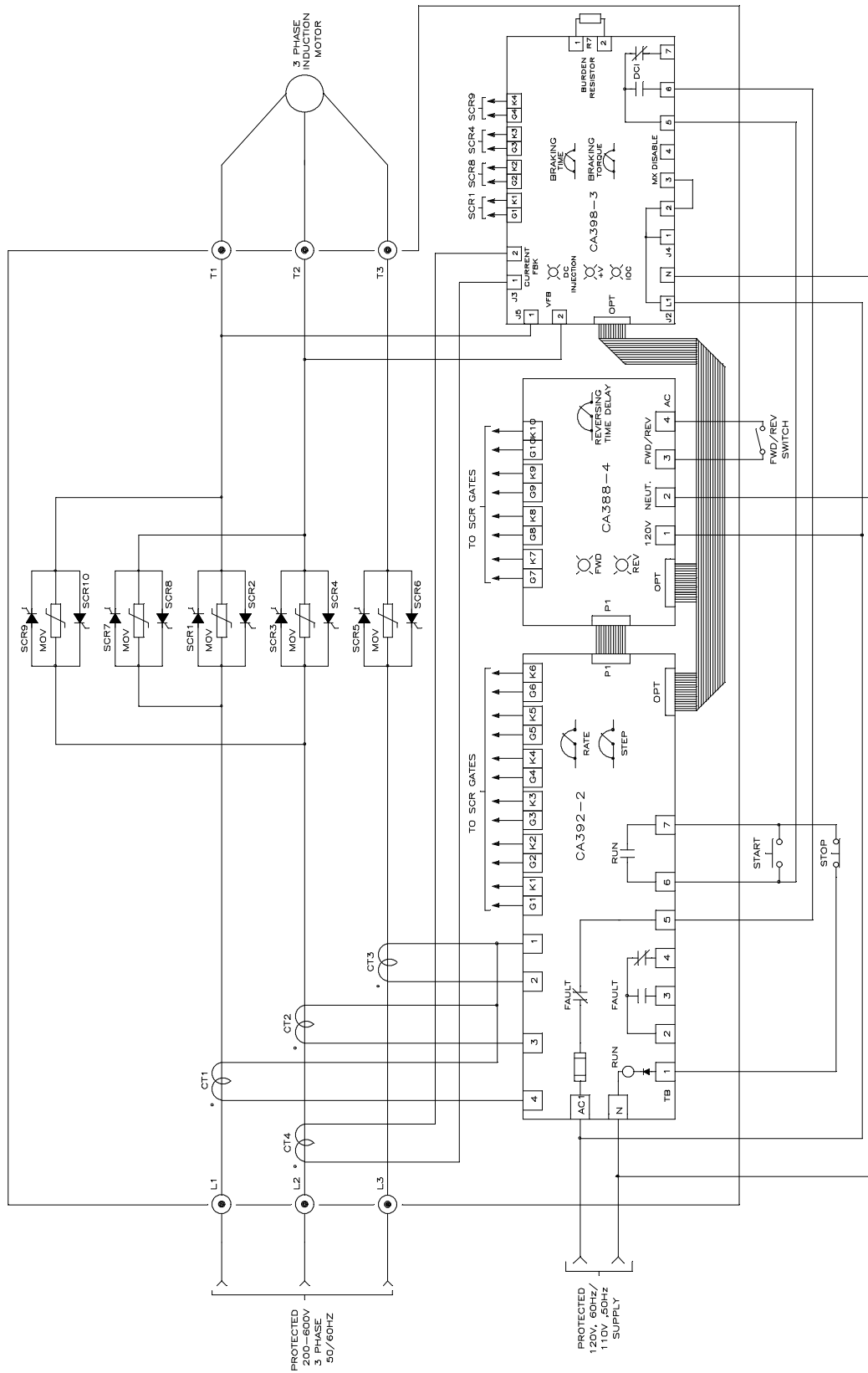
5.1 STAND ALONE DC INJECTION UNIT WITH ZERO SPEED DISABLE



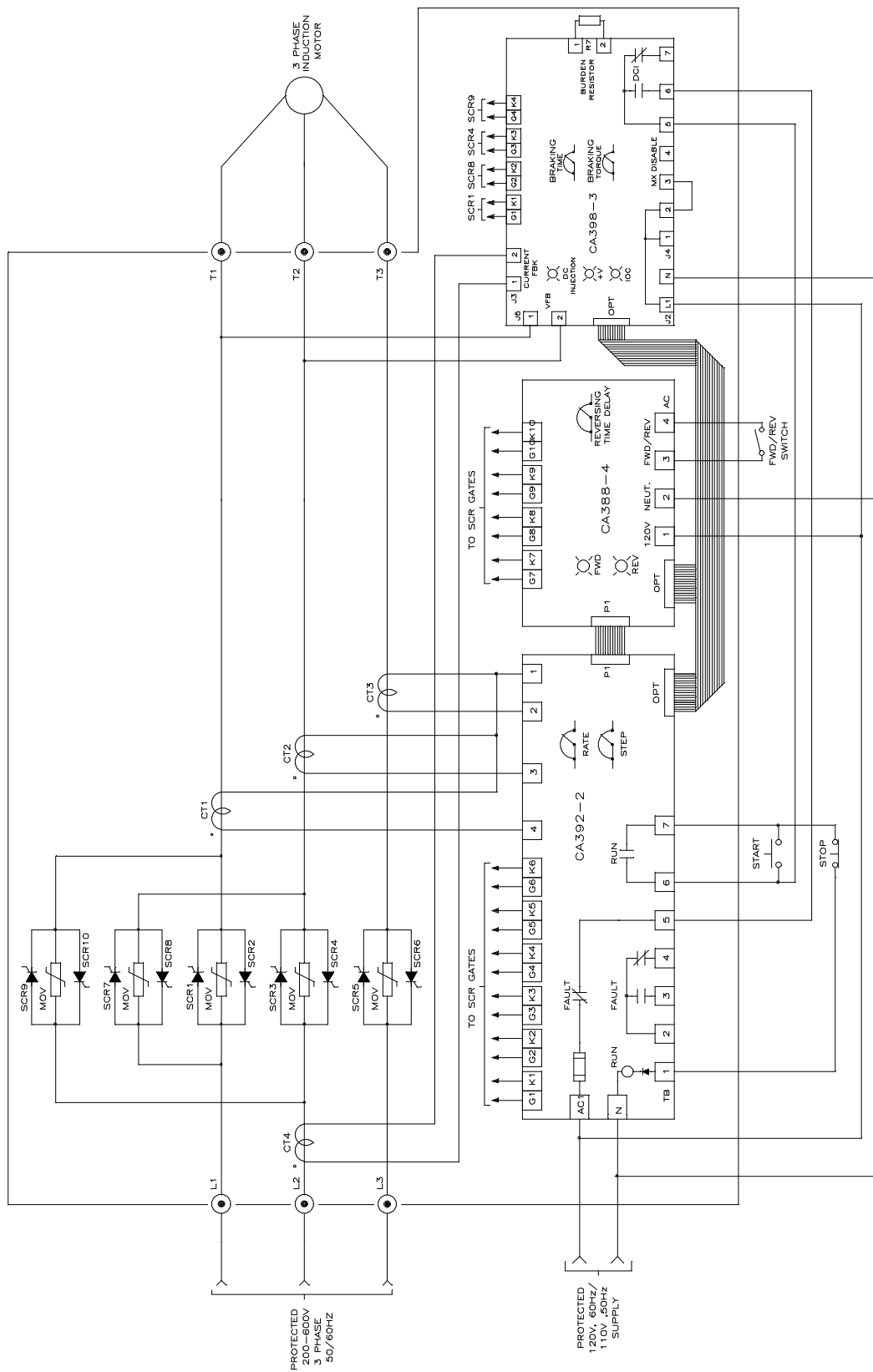
5.2 TRU-START STARTER WITH DC INJECTION



5.3 REVERSING TRU-START STARTER WITH DC INJECTION, 125 AMPS AND BELOW



5.4 REVERSING TRU-START STARTER WITH DC INJECTION, 200 AMPS AND ABOVE



6 SPARE PARTS

MODEL	CT RATIO	CT PART NO.	SCR PART NO.	SNUBBER CARD	CONTROL CARD DESCRIPTION
TRU-020-DCI	1500:1	T261123	N10SP03	CA524	CA398-3
TRU-040-DCI	1500:1	T261123	N10SP06	CA524	CA398-3
TRU-080-DCI	2500:1	T262230	N10SP16	CA524	CA398-3
TRU-125-DCI	2500:1	T262230	N20SP06	CA524	CA398-3
TRU-200-DCI	2500:1	T262230	N728452	CA232	CA398-3
TRU-300-DCI	5000:1	T265320	N718602	CA232	CA398-3
TRU-500-DCI	8500:1	T268320	N718133	CA232	CA398-3

Company Information

Eaton's Cutler-Hammer business is a worldwide leader providing customer-driven solutions. From power distribution and electrical control products to industrial automation, the Cutler-Hammer business utilizes advanced product development, world-class manufacturing and offers global engineering services and support. To learn more about Eaton's innovative Cutler-Hammer products and solutions call 1-800-268-3578, for engineering services call 1-800-498-2678, or visit www.cutler-hammer.ca.

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Printed in Canada
IL_TS-001A
May 2003