Document: VF010H05

TOSHIBA

INSTRUCTION MANUAL

INSTALLATION - OPERATION - MAINTENANCE

TS Series

Low Voltage Solid State Starters

48A to 1250A

Issued: 5/00
Manufactured in the USA

Table of Contents

SAFETY

IMPORTANT MESSAGES

Read this manual and follow its intructions. Signal words such as DANGER, WARNING and CAUTION will be followed by important safety information that must be carefully reviewed.

Indicates a situation which will result in death, serious injury, and severe property damage if you do not follow instructions.

⚠WARNING Means that you might be seriously injured or killed if you do not follow instructions. Severe property damage might also occur.

Means that you might be injured if you do not follow instructions. Equipment damage might also occur.

NOTE Give you helpful information.

READ SAFETY SIGNS

To avoid injury, you must read and follow all safety signs.

Keep the safety signs visible and in good shape. Never remove or cover any safety sign.

QUALIFIED OPERATORS ONLY

Only qualified persons are to install, operate, or service this equipment according to all applicable codes and established safety practices.

A qualified person must:

1) **Carefully read the entire instruction manual.**
2) Be skilled in the installation, construction or operation of the equipment and aware of the hazards involved.
3) Be trained and authorized to safely energize, de-energize, clear, ground, lockout and tag circuits in accordance with established safety practices.
4) Be trained and authorized to perform the service, maintenance or repair of this equipment.
5) Be trained in the proper care and use of protective equipment such as rubber gloves, hard hat, safety glasses, face shield, flash clothing, etc. in accordance with established practices.
6) Be trained in rendering first aid.

SAFETY

SAFETY CODES

Toshiba motor control is designed and built in accordance with the latest applicable provisions of NEMA and the National Electrical Code. Installations must comply with all applicable state and local codes, adhere to all applicable National Electric Code (NFPA 70) standards and instructions provided in this manual.

HAZARDOUS VOLTAGE will cause severe injury, death, fire, explosion and property damage.

- Turn off and lock out Primary and Control Circuit Power before servicing.
- Keep all panels and covers securely in place.
- Never Defeat, Modify, or Bypass any Safety Interlocks.
- Qualified Operators only.

⚠WARNING

Never attempt to install, operate, maintain or dispose of this equipment until you have first read and understood all of the relevant product warnings and user directions that are contained in this Instruction Manual.

Use only Toshiba-authorized replacement parts.

This equipment is designed and built in accordance with applicable safety standards in effect on the date of manufacture. Unauthorized modifications can result in voiding the warranty, severe injury, death and property damage. Do not make any modifications to this equipment without the written approval of Toshiba.

For assistance, address correspondence to:

Toshiba International Corporation
Field Service Department
13131 West Little York Road
Houston, Texas 77041 USA

or call: (713) 466-0277
(800) 231-1412
(800) 527-1204 (Canada)

Fax: (713) 466-8773

Please complete the following information for your records and retain with this manual:

Model: _____

Serial Number: _____

Date of Installation: _____

Inspected by: _____

Reference Number: _____

Chapter 1 - Introduction

1.1 - General

The TS Series solid state reduced voltage soft starter is a six SCR design which features a voltage/current ramp with an anti-oscillation circuit for smooth load acceleration. The SCRs are sized to withstand starting currents of 500% for 60 seconds (compared to 350% for 30 seconds from other manufacturers). The TS Series features smooth, stepless ramp control which reduces motor inrush current and excessive wear on the mechanical drive train components. In addition to having easy to understand diagnostic lights, the TS Series can be set up for the ideal starting cycle. Starting voltage, ramp time, current limit, and decel control are standard adjustments on the TS Series. The starting electrical characteristics of the motor can be matched to the mechanical characteristics of the drive train for controlled acceleration of the load, by simply adjusting the unit's starting torque, ramp time and current limit potentiometers. The TS Series includes adjustable overload protection, shorted SCR detection and phase loss detection. It is factory wired for 120VAC control voltage (or 240VAC for 415 VAC and 380 VAC units) and three-wire start/stop control. Auxiliary contacts and provisions for interlocking are also included.

1.2 - Specifications and Performance Features

Type of Load	Three phase AC induction motor	
AC Supply Voltage	208, 240, 380, 415, 480 or 575 (Vac ± 10%, 50/60 Hz line voltages)	
Continuous Current Ratings	32 - 1250 Amps	
Power Circuit	6 SCRs	
SCR Rating (P-I-V)	Line Voltage	PIV Rating
	208 to 480	1200
	575	1500
Phase Insensitivity	Unit operates with any phase sequence	
Cooling	Convection or fan cooling	
Ambient Operating Temperature	Chassis units: 0° to 50°C (32° to 122°F)	
	Enclosed units: 0° to 40°C (32° to 104°F)	
Control	2 or 3 wire 120Vac (customer supplied). On 380 and 415V units, the control voltage is 240Vac. Optional CPTs are available.	
Standard Adjustments	Starting Voltage	0 to 80%
	Starting Ramp Time	0 to 60 seconds
	Current Limit	200% to 500%
Decel Option Adjustments	Start Deceleration	0 to 100%
	Deceleration Ramp Time	0 to 30 seconds
	Stop Level	0 to 100%
Current Trip	Fixed 10 times FLA	
Auxiliary Contacts	3 Form C (N.O.-N.C.) : 1 programmable relay for "Fault" or "At Speed" 1 programmable "Run" relay 1 Shunt Trip relay	240Vac, 5A, 1200VA (max.)
	1 Form A (N.O.) Optical Output	240Vac, 50mA (max.)
Overload Capacity	115% Continuous - 500% 60 Seconds	
Approvals	UL & CUL	
Standard Overload	Class 10, Trips at 600% 20% within 10 sec.	
Optional Overload	Class 20, Trips at 600% 20% within 20 sec.	
Standard Display / Operator Panel	10 LEDs and all user adjustment potentiometers	
Secondary Display	10 LEDs for visual indication only (Standard on all enclosed unit, optional on panel units.	

Chapter 2 - Installation

2.1 - Receiving and Unpacking

Upon receipt of the product you should immediately do the following:

- Carefully unpack the unit from the shipping carton and inspect it for shipping damage (if damaged, notify the freight carrier and file a claim within 15 days of receipt).
- Verify that the model number on the unit matches your purchase order.
- Confirm that the ratings sticker on the unit matches or is greater than the motor's HP and current rating.

2.2 - Location

Proper location of the TS Series is necessary to achieve specified performance and normal operation lifetime. The TS Series should always be installed in an area where the following conditions exist:

- Ambient operating temperature:
  Chassis unit: 0 to 50°C (32 to 122°F)
  Enclosed unit: 0 to 40°C (32 to 104°F)
- Protected from rain and moisture
- Humidity: 5 to 95% non-condensing
- Free from metallic particles, conductive dust and corrosive gas
- Free from excessive vibration (below 0.5G)
- Open panel units must be mounted in the appropriate type of enclosure. Enclosure size and type must be suitable to dissipate heat generated by the soft starter. Contact factory for assistance in sizing enclosures.

2.3 - Initial Unit Inspection

- Make a complete visual check of the unit for damage which may have occurred during shipping and handling. Do not attempt to continue installation or start up the unit if it is damaged.
- Check for loose mechanical assemblies or broken wires which may have occurred during transportation or handling. Loose electrical connections will increase resistance and cause the unit to function improperly.
- Prior to beginning the installation, verify that the motor and TS unit are rated for the proper amperage and voltage.

2.4 - Warning

⚠WARNING

Do not service equipment with voltage applied! The unit can be the source of fatal electrical shocks! To avoid shock hazard, disconnect main power and control power before working on the unit. Warning labels must be attached to terminals, enclosure and control panel to meet local codes.

2.5 - Mounting and Cleaning

When drilling or punching holes in the enclosure, cover the electrical assembly to prevent metal filings from becoming lodged in areas which can cause clearance reduction or actually short out electronics. After work is complete, thoroughly clean the area and reinspect the unit for foreign material. Make sure there is sufficient clearance (six inches) all around the unit for cooling, wiring and maintenance purposes. To maximize effective air flow and cooling, the unit must be installed with its heat sink ribs oriented vertically and running parallel to the mounting surface.

Remove all sources of power before cleaning the unit.

In dirty or contaminated atmospheres the unit should be cleaned on a regular basis to ensure proper cooling. Do not use any chemicals to clean the unit. To remove surface dust use 80 to 100 psi, clean, dry compressed air only. A three inch, high quality, dry paint brush is helpful to loosen up the dust prior to using compressed air on the unit.

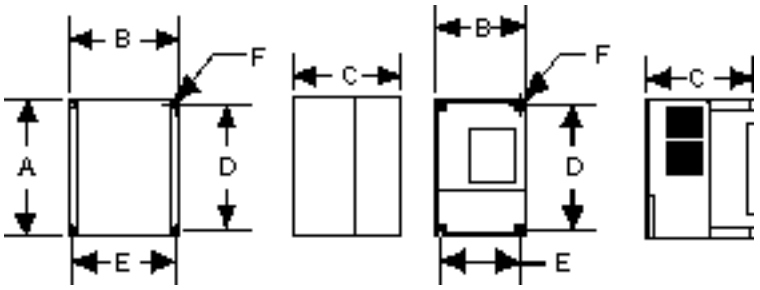
2.6 - Power Terminal Wire Range and Tightening Torque

Model Number	Wire Range	Torque lbs/in
TS_05	#18 - #4	20
TS_06	#14 - #4	50
TS_07	#14 - 1/0	50
TS_08	#6 - 250 kcmil	325
TS_09	(2) #6 - 250 kcmil	325
TS_10		
TS_11	(2) #2 - 250 kcmil	375
TS_12		
TS_13		
TS_14	(3) #2 - 600 kcmil	375
TS_15		
TS_16	(4) 300 kcmil - 800kcmil	500
TS_17		

Note: All wiring must be sized according to NEC standards.

2.7 - Dimensions

TS CHASSIS (PANEL MOUNT) DIMENSIONS						
Model Number	**Overall Dimensions (inches)**			**Mounting Dimensions (inches)**		
	A	**B**	**C**	**D**	**E**	**F**
TS005A to TS007A	16.5	10	10	15.9	9	0.28
TS008A	20	20.1	12	18.5	17.5	0.44
TS009A to TS010A	27	20.1	11.2	25.5	17.5	0.44
TS011A to TS013A	29.5	20.1	11.5	25.5	17.5	0.44
TS014A to TS015A	45	33	12.8	43.3	31.3	0.44
TS016A to TS017A	33	33	15.2	31.2	31.3	0.44



Chapter 3 - Motor Overload Protection

3.1 - Thermal Overload Relay

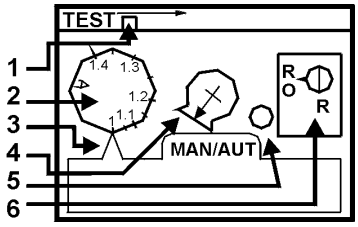
The TS Series provides motor overload protection using an adjustable thermal overload relay. The standard TS Series is furnished with a Class 10 thermal overload, providing an overload rated at 600% current for 10 seconds. Class 20 overload relays, providing an overload rated at 600% current for 20 seconds, are also available in some ratings. A solid state overload relay (Toshiba 2E Relay with Class 3-40) can be provided as an option.

3.2 - Overload Relay

The bimetallic ambient compensated overload relay has an adjustable FLA range set by a dial. The overload relay will ultimately trip at 125% FLA.

3.3 - FLA Dial Adjustment

Setting Overload Relay FLA
The overload relay trip current must be set to assure proper protection of the motor. Turn the rotating knob (2) until the desired dial setting aligns with the arrow (3).



FLA Adjustable Dial

Changing from Manual to Automatic Reset
Note: Unit is shipped in the manual setting.
Select for automatic or manual reset by changing the position of reset button (4) as follows:
MAN = Manual Reset by means of Button
AUT = Automatic Reset
See Section 3.4

Overload Reset (Blue Button)
The arrow setting of the overload reset button (6) must be set to R/O. Red Contact Indicator (5) indicates off position. Press the reset button (6) to reset overload relay.
The overload relay trip function can be tested by pressing the test bar(1) in the direction of the arrow.

⚠WARNING **To provide continued protection against fire or shock hazard, the complete overload relay must be replaced if burnout of the heater element occurs.**

3.4 - Manual/Automatic Reset

The overload relay is factory set at “M” for manual reset operation. The manual setting is recommended. However, for automatic reset operation, turn the reset adjustment dial marked A and M to the “A” position. To prevent automatic restart on over-temperature or motor overload, two-wire control must be interlocked with the auxiliary contact so the start contact is removed on trip. When mounting unit in customer supplied enclosure, place the warning label (provided in manual packet) on the front of the enclosure or on equipment as required by local code. ***Note:*** **When the automatic restart operation is selected the start warning portion of this label must be placed as to be visible after installation. Label states as follows:**

MOTOR CONNECTED TO THIS EQUIPMENT MAY START AUTOMATICALLY WITHOUT WARNING.

Example of Warning Label

3.5 - Test for Trip Indication

To test overload relay for trip indication when in manual reset, activate the test trip button on the overload. An indicator flag appears when the device trips and the LEDs on the display indicate “Overload.” Push the reset button on overload to clear the fault. This test is recommended to ensure that the motor protection is active. Checking, or changing the overload is recommended on major faults.

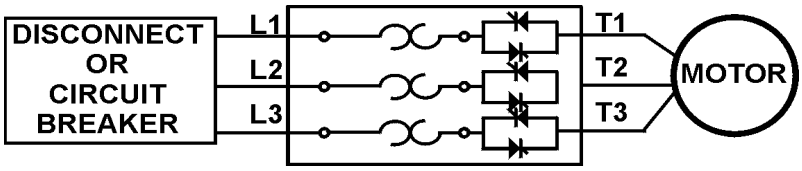
Chapter 4 - Connections

4.1 - Power Connections

Connect appropriate power lines to the unit input terminals marked L1, L2, L3. Avoid routing power wires near the control board. Connect the motor leads to the unit terminals marked T1, T2, T3. Refer to NEC standards for wire length and sizing. Never interchange input and output connections to the unit. This could cause excessive voltage in the control logic circuit and may damage the unit. ***Note:*** **Never connect power factor correction capacitors on the load side of the unit. The SCRs will be seriously damaged if capacitors are located on the load side.**

The unit cannot be tested without a motor or other test load connected to the load side of the unit. It may be necessary to use a load bank to test the unit without a motor. Note that line voltage will appear across the output terminals if there is no motor or load connected to the unit. In areas where lightning is a significant problem, station-type air gap lightning arrestors should be considered and utilized on the input power source.

TS Series Unit



Power Connections

Note: Some units may have the overload on the load side of the starter.

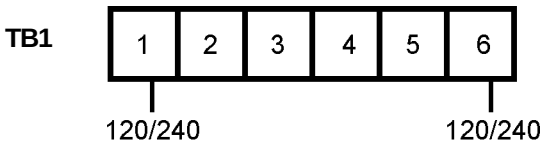
4.1.1 - Grounding

Connect the ground cable to the ground terminal as labeled on the unit. Refer to the National Electrical Code for the proper ground wire sizing and be sure that the ground connector is connected to earth ground.

4.2 - Control Connections

4.2.1 - Control Power Connections

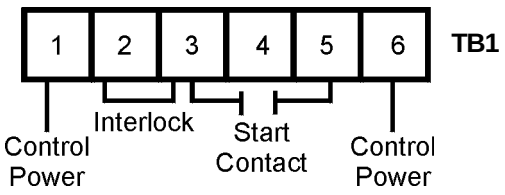
Separate 120VAC supply is required (240VAC for 380V and 415V applications). The control voltage should be connected to pins 1 and 6 of TB1. This control voltage must be customer supplied, unless an optional control power transformer (See chart) has been supplied with the unit. On units rated below 100 HP, the TB1 terminal block is located on the main control board.



4.2.2 - Two-Wire Connection

An alternate connection for unattended operation replaces start/stop push buttons by connecting a maintained contact closure between pins 3 and 5 on TB1. When the maintained contact is used for start/stop it is necessary to set the overload relay to the manual reset position. This will prevent the motor from restarting if the thermal overload trips and then cools off (refer to Chapter 9 for 120 VAC connections and interlocks).

Note: **When two-wire connection method is used, the start circuit must be interlocked to prevent automatic restart when either of the two protective devices (overload or thermostat) reset. Thermostats always automatically reset on cool down.**



Two-Wire Connection

4.2.3 - Three-Wire Connection

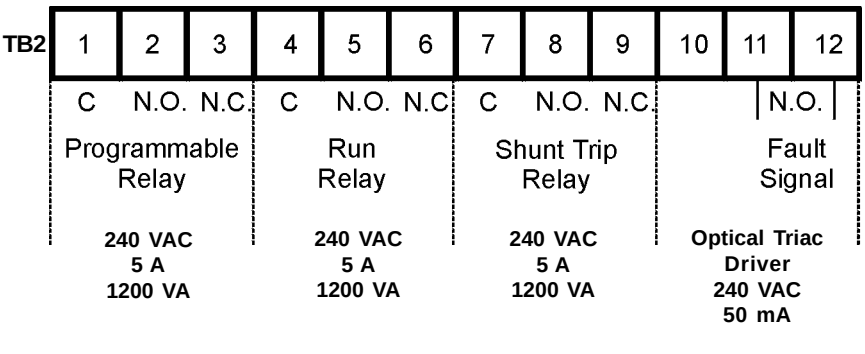
For standard 3-wire control connect 120VAC (or 240VAC for 415V and 380V applications) to pins 1 and 6 of TB1. Connect N.C. (normally closed) stop button between pins 3 and 4 of TB1. Connect N.O. (normally open) start button between pins 4 and 5 of terminal block TB1.

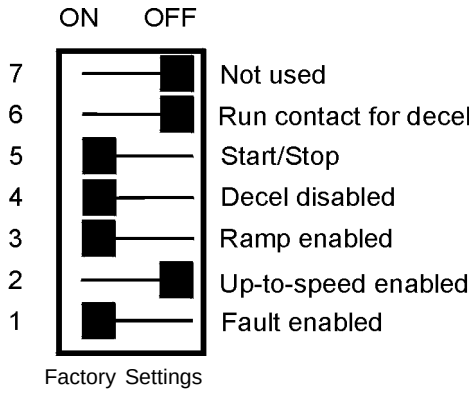
4.2.4 - Resetting Faults

To reset faults, remove the control power for two seconds to clear the fault condition. The unit will also accept a remote reset command via a N.O. dry contact at TB5 located on the main control board, or press the reset button SW2 located near TB5. See Chapter 9 for the main control board layout. Check the unit to ensure that the fault has been corrected before reenergizing unit.

4.2.5 - Relay Contacts

All the relay contacts are FORM C common (N.O., N.C.), except the optical triac output. Toshiba recommends fusing all contacts with external fuses. TB2 is the terminal block for all external contacts. Each contact is explained in the following sections. See Chapter 9 for main control board layout.





Factory Settings

To make changes in the dip switch settings, the front cover of the unit may need to be removed. Do not make adjustments with power applied to the unit, serious injury may result. Do not use a screwdriver or other tool to make adjustments, damage to the unit may result.

4.2.6 - Programmable Relay

The TS includes a programmable relay on TB2 which is located on the main control board. The relay is rated for 240 VAC, 5 A and 1200 VA. The relay responds to either a fault condition or an up-to-speed condition. For the relay to act as a fault relay, turn dip switch 1 (SW1), located on the main control board, “ON” and dip switch 2 “OFF” (Factory Setting). For an up-to-speed contact turn dip switch 1 “OFF” and dip switch 2 “ON”. Refer to Chapter 9 for dip switch location. In the up-to-speed mode, the programmable relay can be used to control a bypass contactor, or signal other systems that need to be brought online after the motor has reached full speed.

4.2.7 - Run Contacts

Auxiliary contacts are available on TB2. These contacts are rated 240 VAC, 5 A, 1200 VA and are for external use. Auxiliary contacts energize (change state) when the start command is given and de-energize (change back) when stop, or fault, condition occurs. In the decel mode, the run contact can be modified to drop out at the stop command, or to stay latched until the end of the decel command. Dip switch 5 is “ON” and dip switch 6 is “OFF” for normal start/stop mode. To keep the run contact latched until the end of decel, turn dip switch 6 “ON” and dip switch 5 “OFF”. The decel mode must be enabled by turning dip switch 4 “OFF”. Refer to Chapter 9 for the main control board layout.

4.2.8 - Emergency Shunt Trip Relay

The shunt trip relay at TB2 on the main control board will activate when a shunt trip signal is received from the motor’s monitoring logic. This relay is rated for 240 VAC, 5 A, 1200 V. This relay can be used in an external shunt trip circuit. Check inrush rating on shunt trip breaker. This relay is not programmable and only operates if current is flowing when the TS is in the off mode. Refer to Chapter 9 for the main control board layout.

4.2.9 - Fault Signal

An optical AC switch triac driver is used for fault indication. This signal energizes with the fault LED. The optical output is rated for 240 VAC, 50 mA (maximum).

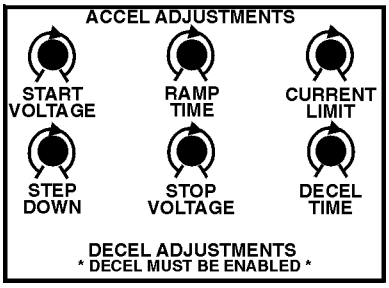
Chapter 5 - Adjustments

5.1 - Introduction

It is best to operate the motor at its full load starting condition to achieve the proper time, torque and ramp settings. Note that the potentiometers have a turning range of 3/4 revolution. Forcing the potentiometer beyond this range will damage the unit. Initial settings are set to accommodate most motor conditions. **TRY INITIAL SETTINGS FIRST.**

5.2 - Acceleration Adjustments

The unit is set at the factory with typical starting characteristics that perform well in most applications. When the system is ready to start, try the initial unit settings. If the motor does not come up to speed, increase the current limit setting. If the motor does not start to turn as soon as desired, raise the starting voltage adjustment. The unit has three accel adjustments. Adjustment description and procedures are described as follows:



Detail of Operator Interface Module

5.2.1 - Starting Voltage Adjustment/Rotation Check

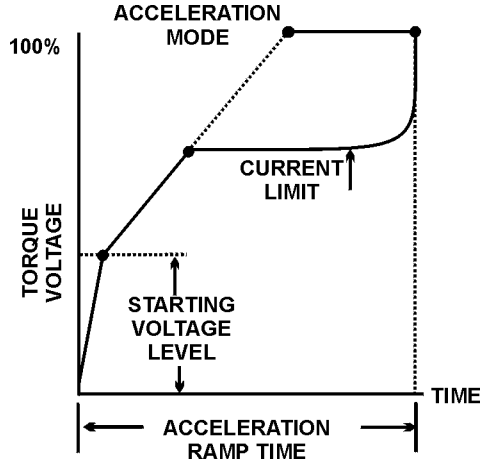
Factory Setting = 60% of line voltage
Range = 0% - 100% of line voltage

Starting voltage adjustment changes the initial starting voltage level to the motor. Start voltage is increased by rotating the starting voltage potentiometer clockwise. Turn dip switch 3 to the "OFF" position, disabling the ramp function and allowing starting voltage adjustment. This will permit adjustment of the starting voltage without activating the ramp. Turn the starting voltage potentiometer FCCW (fully counter-clockwise). Apply power to the TS and give the start command. Observe that the motor does not rotate. Slowly increase the start voltage by turning the potentiometer in a clockwise direction until the motor begins to rotate. When the motor begins to rotate, give a stop command and remove both line and control voltage. Reset dip switch 3 for the "ON" position to re-enable the ramp function. The minimum effective starting voltage is now set. **Do not leave dip switch 3 in the off position!**
Note: Use this time to check the direction of rotation without full speed operation.

5.2.2 - Ramp Time Adjustment

Factory Setting = 10 sec.
Range = 0 - 60 sec.

Ramp time adjustment changes the amount of time it takes to reach the current limit point or full voltage if the current limit point was not reached. Acceleration time (ramp) can be increased by rotating the ramp time potentiometer in a clockwise direction. The ramp time adjustment is made after the starting torque has been set. Set the ramp time potentiometer by slowly rotating it until the desired ramp time is reached. The unit should be stopped and restarted to see if the desired acceleration time has been achieved
Note: Refer to your motor manual for the maximum number of starts allowed by the manufacturer and do not exceed the recommended number.



5.2.3 - Current Limit Adjustment

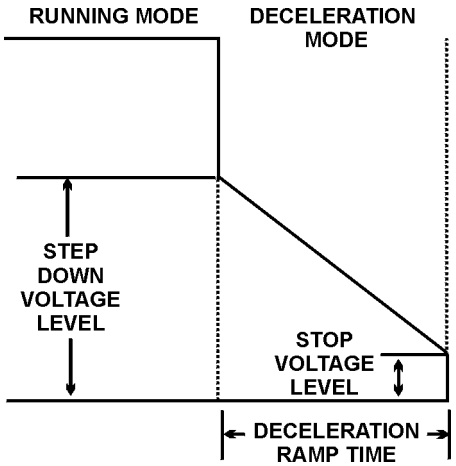
Factory Setting = 350% of unit FLA
Range = 200% - 500% of unit FLA

The current limit adjustment is factory set for 350% of the unit's rating. The range of adjustment is 200% to 500%. The main function of current limit is to cap the peak current. It may also be used to extend the ramping time if desired. The interaction between the voltage ramp and the current limit will allow the soft start to ramp the motor until the maximum current is reached and the current limit will hold the current at that level. The current limit must be set high enough to allow the motor to reach full speed. The factory setting of 350% is a good starting point. **Do not set the current limit too low on variable starting loads, this will cause the motor to stall and eventually cause the system overloads to trip.**
Note: If the motor does stall, refer to the motor manufacturer for the proper cooling time.

5.3 - Deceleration Adjustments

Decel extends the stopping time on loads that stop too quickly, and will provide smooth deceleration until the load stops. Three adjustments optimize the deceleration curve to meet the most demanding requirements. **Try factory settings before adjusting.**

The unit is shipped from the factory with the decel feature disabled. Turn off dip switch 4 to enable the decel control feature before making any adjustments. Apply power and adjust the soft start before enabling or modifying the deceleration adjustments. Both acceleration and deceleration adjustments should be made under normal load conditions. The deceleration adjustments are made in the same manner as the starting adjustments; turning the potentiometer clockwise increases the setting, turning the potentiometer counter-clockwise decreases the setting.



5.3.1 - Step Down Voltage Adjustment

Factory Setting = 60% of line voltage
Range = 0% - 100% of line voltage

The step down voltage adjustment eliminates the dead band in the deceleration mode that is experienced while the voltage drops to a level where the motor deceleration is responsive to decreased voltage. This feature allows for an instantaneous drop in voltage when deceleration is initiated.

5.3.2 - Stop Voltage Level

Factory Setting = 20% of line voltage
Range = 0% - 100% of line voltage

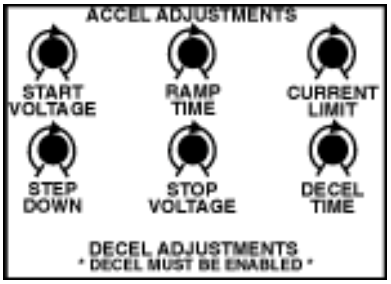
The stop voltage level set point is where the deceleration voltage drops to zero.

5.3.3 - Deceleration Ramp Time

Factory Setting = 5 sec.
Range = 0 - 30 sec.

The deceleration ramp time adjusts the time it takes to reach the stop voltage level set point. The unit should be restarted and stopped to verify that the desired acceleration time has been achieved.

Note: **Do not exceed the motor manufacturer's recommended number of starts per hour. When calculating the number of starts per hour, a decel curve should be counted as a start curve. For example: recommended number of starts per hour = 6, allowable starts with decel cycle per hour = 3.**



Detail of Operator Interface Module

Chapter 6 - Start-up

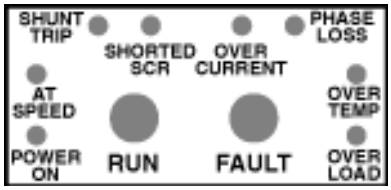
6.1 - Start-up Check List

- Supply voltage matches the rated supply voltage of the unit.
- Horsepower and current ratings of the motor and unit match or the unit is higher rating.
- Initial ramp time and torque adjustments have been checked.
- Power lines are attached to the unit input terminals marked L1, L2 and L3.
- Motor leads are connected to the lower terminals marked T1, T2, and T3.
- Appropriate control power is applied and/or control connections have been made.
- “Power on” light located on the front of the unit turns on when control power is applied.
- The motor area and equipment are clear of people and parts before start-up.
- The thermal overload is set to motor rating.

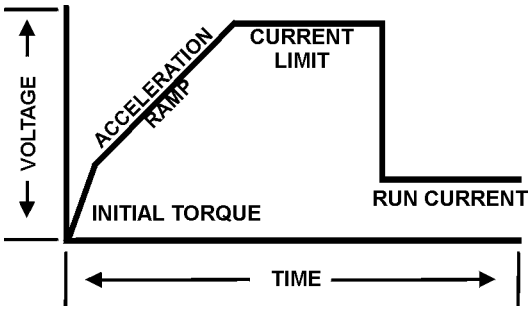
6.2 - Sequence of Operation

- Apply control power and check that the “Power On” LED comes on.
- Apply three phase power to the unit. The motor should run only when the start command is applied.
- Apply the start command. The “Run” LED should light up and the motor should begin to accelerate.
- When the motor reaches full speed, the “At Speed” LED comes on.
- If the motor decelerates, or stops, during the acceleration period, hit the stop button immediately and open the disconnect line.

If the unit does not follow this operational sequence please refer to Chapter 8 - Troubleshooting.



Status Indicator LEDs

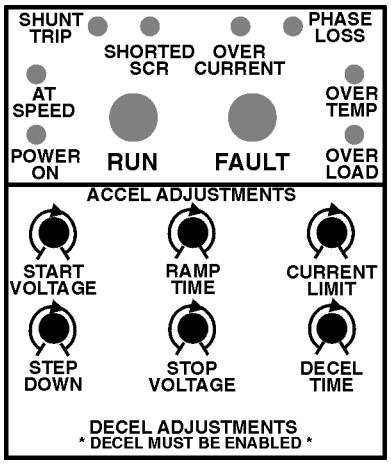


Sequence of Operation

Chapter 7 - Status Indicator LEDs

7.1 - LED Functions

The unit has 10 LEDs on the status display.



Status Indicator LEDs and operator panel

LED		STATUS
Green	Run	Indicates that power is provided to the motor. System is online. (This LED will remain lit during the accel/decel modes and anytime there is a possibility of motor rotation.
	Power On	Indicates control power is present.
	At Speed	Indicates the motor is at full speed and power. The SCRs have phased fully on.
Yellow	Shunt Trip	Indicates the starter has two or more power poles shorted and is passing current to the motor while in the off mode. For positive motor protection the "Shunt Trip" relay on the main circuit board must be interlocked with a shunt trip breaker or contactor in front of the unit. Do not apply power to the unit without repairing the power poles.
	Shorted SCR	Indicates a shorted SCR was detected in the unit. Refer to section 8.2 for instructions on checking SCRs. This fault will prevent a start command.
	Overcurrent	Indicates the unit experienced approximately ten times the unit FLA and has shut down from a load failure of some type such as a phase to ground failure or a phase to phase short. The over current trip is fixed at 10 times the full load motor current and is not adjustable. Press the reset button to reset the over current trip. Removing control power for 2 seconds will also reset the trip. Check for faults before reapplying power.
	Phase Loss /Single Phase	This LED indicates that one of the incoming phases was lost while the motor was running.
	Over Temperature	This LED indicates the motor starter has tripped due to over temperature.
	Overload	This LED indicates the motor overload has tripped. The overload must be reset before the fault can be cleared.
Red	Fault	This is a general indication of a fault occurring in the system. This LED lights with a yellow LED to indicate the specific fault.

Chapter 8 - Troubleshooting

8.1 - Failure Analysis

Problem	Possible LED Display	Possible Causes	Solution
One of the main fuses blows or circuit breaker opens when the power is applied.	Fault and Shunt Trip LEDs: ON	Short circuit between the inputs	Locate and remove the short
		Faulty SCR(s)	Remove power and test the SCR(s). Refer to section 8.2 for SCR Testing procedure.
One of the main fuses blows or circuit breaker opens when the start command is given.	Fault and Overcurrent LEDs: ON	Short circuit or ground fault in motor or cabling	Locate and remove the short or the ground
		Phase Loss	Repair the cause of the phase loss
		Branch circuit protection not correctly sized	Verify the correct sizing of the branch circuit protection
		Faulty SCR(s)	Remove power and test the SCR(s). Refer to section 8.2 for SCR Testing procedure.
	Fault and Phase Loss LEDs: ON	Single phase incoming power	Correct the problem with the incoming power
		Faulty main circuit board	Remove power and replace the main circuit board. Refer to section 8.4 for circuit board replacement procedure.
Motor overload trips during start	Fault and Overload LEDs: ON	Overload improperly adjusted	Adjust the overload
		Excessive load on motor	Lighten the load on the motor
		Current limit set too low	Increase the current limit set point
		Incorrect start adjustment	Readjust the starting parameters. Refer to Chapter 5.
Thermostat trips during run	Fault and Over Temp LEDs: ON	Fan(s) not functioning	If the fans have power, remove power and replace the fan(s). If the fans do not have power, find the cause of the power loss and repair.
		Heatsink coated with dirt	Remove power and clean the heatsink with high pressure air (80-100 psi max., clean and dry air)
		Over current on unit	Verify that the running current does not exceed the unit rating.
		Environment temperature over 120°F (ambient temperature for panel version) or over 104°F (ambient temperature for enclosed version)	Place the unit in environment where the ambient temperature is less than 120°F for the panel version or less than 104°F for the enclosed version.

Problem	Possible LED Display	Possible Causes	Solution
Motor will not start	All LEDs: OFF Power On LED: OFF Start LED: OFF	No control voltage applied to the control board	Apply control voltage to TB1, pins 1 & 6 on the control board
		Control power transformer failure of CPT fuse failure	Remove power and replace the power transformer or CPT fuse
		Start circuit wired incorrectly	Remove power and correct the start circuit wiring
		No start command	Apply the star command
	Fault and Phase Loss LEDs: ON	No 3 phase line voltage	Apply 3 phase line voltage to the unit
		Failure of main circuit board	Replace the main circuit board
		Faulty control logic	Remove power and repair the control logic
	Fault and Shorted SCR LEDs: ON	Shorted SCR in starter	Refer to section 8.2 for SCR testing procedures and replace the faulty (shorted) SCRs.
		Faulty control board	Check the control board for faults and replace the blown fuses.
Motor vibrates/ Motor growls	Fault and Phase Loss LEDs: ON	Faulty motor	Check the motor and the motor connections
		Faulty SCR(s)	Remove power and perform the SCR device check
		Faulty gate/cathode on SCR(s)	Refer to section 8.2 for SCR testing procedures and replace the faulty (shorted) SCRs.
		Faulty main circuit board	Replace the main circuit board
Extremely unbalanced motor currents during start or run mode	Fault and Phase Loss LEDs: ON	Faulty motor / wiring	Troubleshoot and repair
		Faulty wiring	Troubleshoot and repair / replace wiring
		Faulty main circuit board	Replace the main circuit board
Motor stopped during run	Fault and Over Current LEDs: ON	**⚠WARNING**	This is a serious fault condition. Ensure that the fault condition is cleared on the load before attempting to restart the motor.
		Load shorted / grounded / faulted	Remove power and repair
		Faulty main circuit board	Replace the main circuit board
Control circuit fuses blow after control power is applied	All LEDs: OFF	Short in control circuit	Remove power, locate and remove short
		Wrong control voltage	Apply the correct voltage to the control board

8.2 - SCR Testing Procedure

Remove both line power and control power from the unit and lock out. Disconnect any two motor load leads and any two line leads. Disconnect the SCR connections to main control board J5, J6 and J7. Refer the Chapter 9 for the main control board layout. Note the type of color coding of the wires connected to J5, J6 and J7. Toshiba uses two possible configurations. Both configurations have 4 wires going to each plug. The first configuration consists of 4 wires color coded black, yellow, grey and white. The second configuration consists of 4 wires color coded red, white, red, white.

The testing procedure for SCRs is comprised of two separate tests. The first one tests the anode to cathode integrity of the SCR by performing the following ohm checks:

+ Lead	- Lead	Good	Consult factory
L1 Lug	T1 Lug	Greater than 10K ohm	Less than 10K ohm
L2 Lug	T2 Lug	Greater than 10K ohm	Less than 10K ohm
L3 Lug	T3 Lug	Greater than 10K ohm	Less than 10K ohm

The second tests the gate to cathode integrity of the SCR. Place the leads of an ohm meter into the receptacle that was unplugged from the main circuit board. Ohm the pair of wires on one end of the plug. Then ohm the pair of wires on the other end of the plug. The chart below indicates good versus bad readings.

For wire that is color coded black, yellow, gray and white:			
+ Lead	*- Lead*	*Good*	*Bad*
Black	Yellow	Between 5 and 90 ohms	Less than 5, or greater than 90 ohms
Grey	White	Between 5 and 90 ohms	Less than 5, or greater than 90 ohms
For wire that is color coded red, white, red and white:			
Red	White	Between 5 and 90 ohms	Less than 5, or greater than 90 ohms
Red	White	Between 5 and 90 ohms	Less than 5, or greater than 90 ohms

Note: If any of the above readings are out of specifications, replace the faulty SCR.

(Note: The best way to test an SCR is with an SCR Tester and look for leakage current less than the manufacturer specified values.)

8.3 - Replacing SCR Devices

Two types of SCRs are used in the TS Series depending on the horsepower/amperage rating of the unit. Isolated SCRs are used in smaller units and “hockey puck” type SCRs are used in larger units. (Refer to Chapter 9 for the main control board layout.)

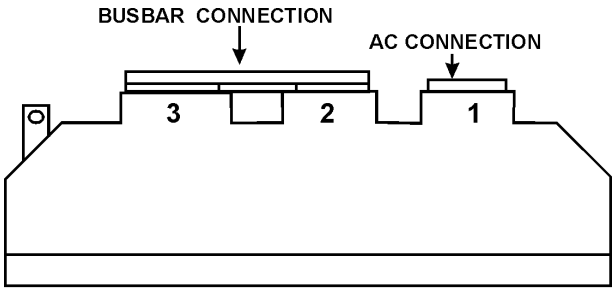
8.3.1 - Changing an Isolated SCR

- Remove both line and control power from unit, tag and lock out.

⚠WARNING *Failure to remove both line and control power before starting this procedure may cause personal injury or death.*

- Label the location of wires connected to the SCR.
- Remove the mounting screws, lugs and associated wiring from the existing SCR.
- Make sure the surface to which the power module mounts is clean and free from dirt, nicks and scratches.
- Apply thermal grease uniformly along the grooved area. Spread the grease thinly (3 mil thick) to completely cover the base of the power module and minimize air pockets. The grease must be free of contamination.
- Replace the screws and tighten down firmly. All mounting screws should be 44lb/in. Units with a maximum amperage rating of up to 48A, should use 26 lbs/in busbar and power lugs. Units with a maximum amperage of 60A - 120A should use 44 lbs/in busbar and power lugs.
- Reconnect all busbars, lugs and wires. Check to make sure the gate and cathode are wired correctly. Use the following chart to verify the wiring of J5, J6 and J7:
- After verifying that all wiring is correctly connected, test the SCR.

Main Circuit Board Pin #	Destination
Pin 1	Load Gate
Pin 2	Load cathode (Output Load Lug)
Pin 5	Line Gate
Pin 6	Line Cathode



Isolated SCR Configuration

8.3.2 - Changing a Hockey Puck Type SCR

- Remove both line and control power from unit, tag and lock out.

⚠ WARNING *Failure to remove both line and control power before starting this procedure may cause personal injury or death.*

- There are two types of clamps with gauges for reading the amount of force on the device. The first type of force gauge uses a spin washer. When the proper force is applied, the washer will be free to spin. The second type of gauge uses a step indicator on the end of the lever. Before proceeding, note the type of clamp used and, if the clamp has a step indicator, document the position of the indicator before removing the clamp to facilitate proper mounting of the new SCR device.

- Label the location of the wires connected to the SCR.

- Remove any lugs, snubbers, printed circuit boards (refer to section X) and associated wiring that may get in the way of reaching the faulty SCR. Document the location and wiring of all parts before removing them to facilitate the reinstallation of the devices later.

- Document the position of the indicator on the SCR clamp. Then remove the top clamp holding the SCR stack together. Remove the top heatsink. Use extreme caution when handling the heat sink so it does not become dented or damaged.

- Remove the faulty SCR device, noting the direction in which the SCR is oriented. The new SCR puck **must be** inserted in the same direction.

- Make sure the SCR mounting surface, tools, and hands are clean and free from dirt, nicks, and scratches. Do not sand or scrape SCR mounting surface. If necessary, super fine Scotch Brite pads can be used to clean the heatsink before installing the new SCR.

- Apply a thin (3 mil thick) layer of thermal grease uniformly along both sides of the SCR. Spread the grease to cover the entire surface of both sides of the SCR in a manner that minimizes air pockets. The grease must be free of contamination.

- Locate the centering pin in the bottom and top of the heatsink and center it in the SCR hole (making sure that the SCR is pointed in the same direction as the SCR that was removed in step 6). Locate the centering pin in the top heatsink and center it in the SCR hole.

⚠ CAUTION **If center pin is not placed correctly it will damage the SCR and the heat sink.**

Hand tighten the clamps evenly so that the same number of threads appear at both ends of the U-clamp. Tighten the clamp 1/4 turn at a time alternating sides of the U-clamp until the correct force is reached. Check the gauge or spin washer every time the clamp nuts are tightened 1/4 turn to ensure that the SCR is not over torqued. The gauge reading should be similar to the initial reading taken in step 2. If the clamp uses the spin washer gauge, verify that the washer spins freely after clamping. Once proper force is reached make sure that the SCR pucks are securely held between the heatsinks and aligned evenly.

- Replace any lugs, MOVs, snubbers, power straps, printed circuit boards and associated wiring that was removed in step 4. Use the following chart to verify wiring of J5, J6 and J7:

Main Circuit Board Pin #	Destination
Pin 1	Load Gate
Pin 2	Load cathode (Output Load Lug)
Pin 5	Line Gate
Pin 6	Line Cathode

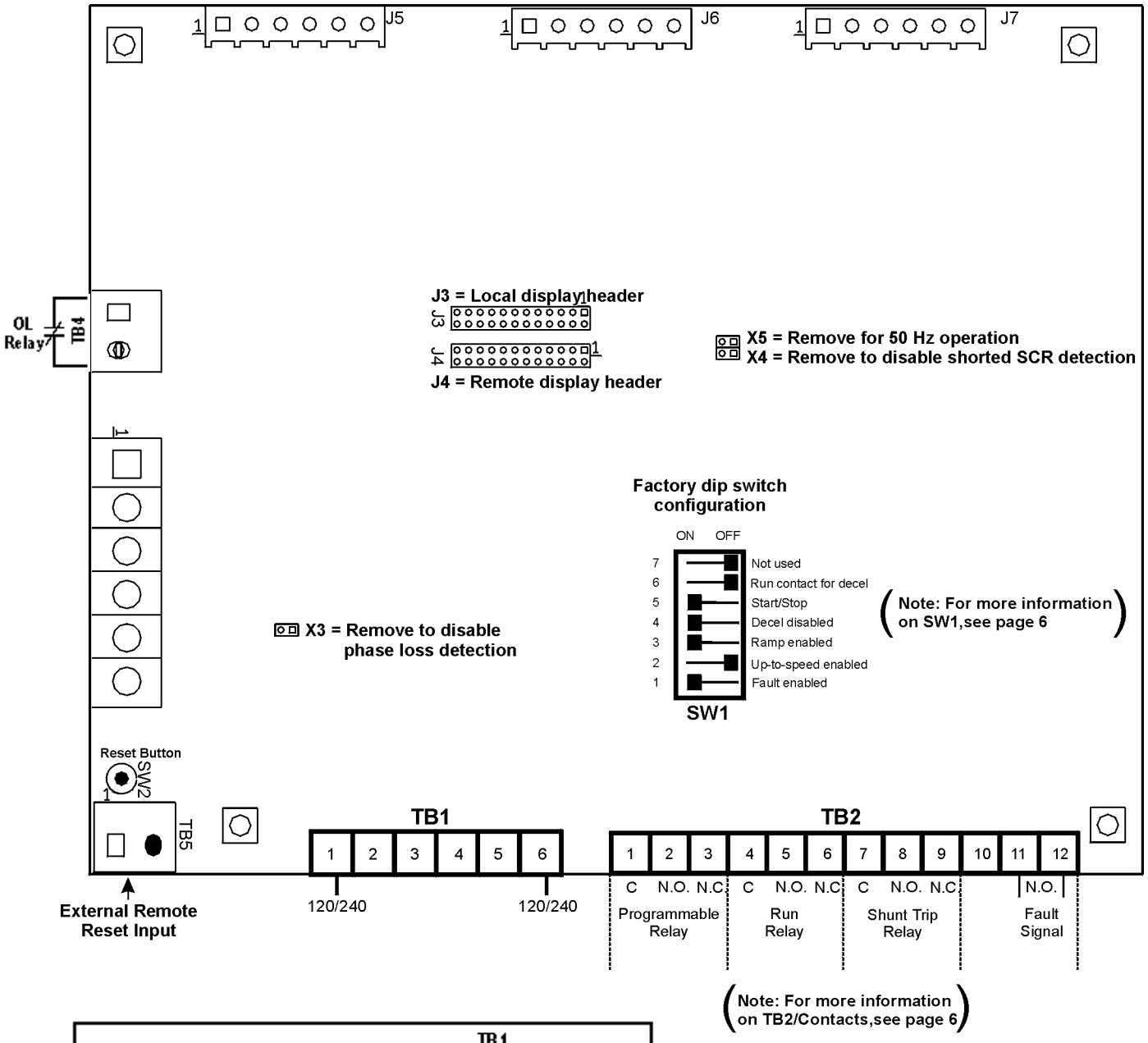
- After verifying that all wiring is correctly connected, test the SCR and then test the unit.

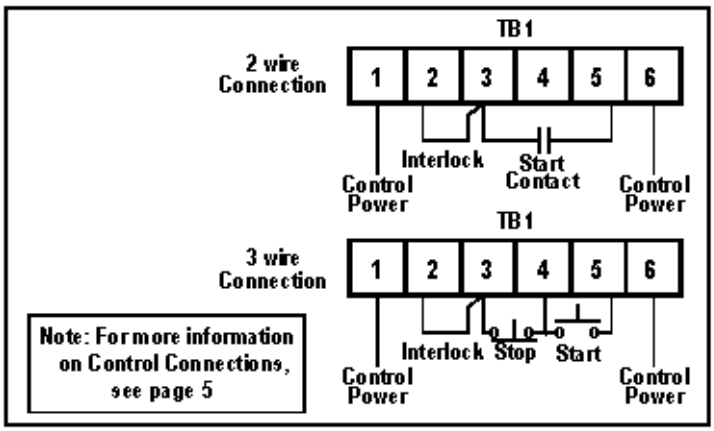
8.4 - Replacing the Main Control Board

The printed circuit board is not intended to be field repaired. If the board is faulty, the entire board should be replaced using the following procedure:
(See Chapter 9 for the main control board layout.)

- Remove three phase power and control power from the unit and lock out.
- Remove plugs and tag plugs with connector numbers.
- Remove control wires from terminals and tag wires with terminal numbers.
- Note the settings of all dip switches.
- Remove the mounting screws.
- Remove the old printed circuit board.
- Mount the new printed circuit board.
- Install the mounting screws.
- Set the dip switches to the same position as on the old board.
- Install the control wires onto correct terminals per tag sequence.
- Install the plugs.
- Apply power to the unit and test.

Chapter 9 - Main Control Board





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