

Document: VF010H06

**TOSHIBA**

## **INSTRUCTION MANUAL**

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**INSTALLATION - OPERATION - MAINTENANCE**

**TS Series**

**Low Voltage Solid State Starters**

**6A to 32A**

Issued: 5/00  
Manufactured in the USA



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## SAFETY

### IMPORTANT MESSAGES

**Read this manual and follow its instructions.** 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.



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.



**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

Fax: (713) 466-8773

(800) 527-1204 (Canada)

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 compact design that features a voltage/current ramp with an anti-oscillation circuit for smooth load acceleration. The power devices are sized to withstand starting currents of 500% for 60 seconds (compared to 350% for 30 seconds from other manufacturers). The TS 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 includes starting torque, ramp time, current limit, and decel control adjustments. 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 making simple potentiometer adjustments.

### 1.2 - Specifications and Performance Features

<b>Type of Load</b>	Three phase AC induction motor	
<b>AC Supply Voltage</b>	208 - 600 VAC ( $\pm$ 10%, 50/60 Hz line voltages)	
<b>Amps</b>	6 - 28 Amps (600 VAC)	
<b>Power Circuit</b>	3 SCRs, 3 Diodes	
<b>SCR/Diode Ratings (Peak Inverse Voltage)</b>	<u>Line Voltage</u> 208 to 480 600	<u>PIV Ratings</u> 1200 1500
<b>Phase Insensitivity</b>	Unit operates with any phase sequence	
<b>Cooling</b>	Convection cooled	
<b>Ambient Operating Temperature</b>	Chassis Units & NEMA1 Enclosures: 0° to 50°C (32° to 122°F) NEMA 4/12 Enclosures: 0° to 40°C (32° to 104°F)	
<b>Control</b>	2 or 3 wire 120 VAC (customer supplied). On 380 and 415V control voltage is selectable for 240 VAC.	
<b>Standard Adjustments</b>	Starting Voltage	0 to 100% of line voltage
	Starting Ramp Time	0 to 60 seconds
	Current Limit	200% to 500%
<b>Decel Option Adjustments</b>	Step Down Voltage	0 to 100% of line voltage
	Stop Voltage Level	0 to 100% of line voltage
	Deceleration Time	0 to 30 seconds
<b>Auxiliary Contacts</b>	One FORM A (optical triac) 240V	
<b>Approvals</b>	UL Listed, Canadian UL Listed, CE Pending	
<b>Standard Display / Operator Panel</b>	6 LEDs and all user adjustment potentiometers	
<b>Overload Capacity</b>	125% Continuous of nominal motor FLA	
	500% 60 Seconds	
<b>Standard Overload</b>	Class 10, 600% + 20% for 10 sec. (adjustable)	

## Chapter 2 - Installation

**▲ CAUTION**     *Please read the following prior to installation.*

- The unit is shipped with the decel/pump control feature disabled. If decel is required, the decel feature must be enabled before installation (see 5.3 - *Deceleration Adjustments*).
- The programmable run contact is shipped factory set for Start/Stop indication, any changes to this must be made prior to installation (see 4.2.4 - *Run Contact*)

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

- Ambient operating temperature: 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)

### 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



**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

Make sure there is sufficient clearance (six inches) at the top and the bottom of 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 Size and Tightening Torque

Model Number	Wire Size	Torque (lbs/in)
TS_02	16 - 14 AWG	4.5
TS_03	16 - 14 AWG	4.5
TS_04	8 AWG	12

## 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. The optional Class 20 overload is also available.

### 3.2 - Overload Relay FLA Range

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 - Overload Relay Settings

#### 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).

#### Changing from Manual to Automatic Reset

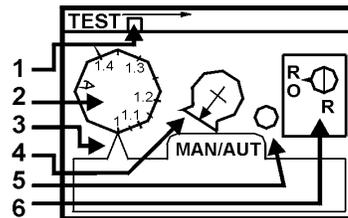
Note: Unit is shipped in the manual setting.

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.



**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 MAN/AUT to the AUT 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:**



Example of Warning Label

### 3.5 - Test for Trip Indication

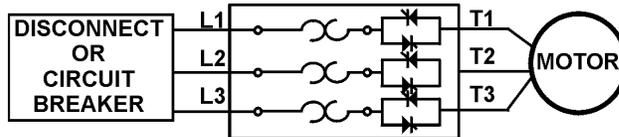
To test overload relay for trip indication when in manual reset, activate the test trip button on the overload. An indicator flag appears when the device trips and the LED on the display indicate “Overload.” Push the reset button on the overload to clear the fault. This test is recommended to ensure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

**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, sizing and lug torque. **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 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 Soft Starter

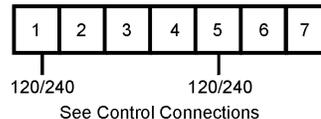
**4.1.1 - Grounding**

Connect the ground wire to the ground terminal (green screw located below power connections). 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**

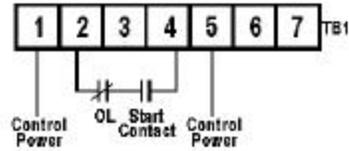
**4.2.1 - Control Power Connections**

Separate 120VAC supply is required (if 240 VAC is required, specify when ordering. See 8.1 PC Board Layout for location of jumpers). The control voltage should be connected to pins 1 and 5 of TB1 located on the main control board. This control voltage must be customer supplied.



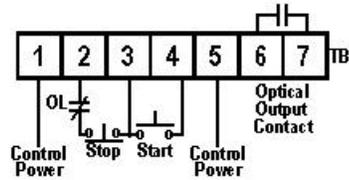
#### 4.2.2 - Two-Wire Connection

An alternate connection for unattended operation replaces start/stop buttons by connecting a maintained contact closure between pins 2 and 4 on TB1. **Note: When two-wire connection method is used, the start circuit must be interlocked to prevent automatic restart when the protective thermostat device resets. The thermostat always automatically resets on cool down.**



#### 4.2.3 - Three-Wire Connection

For standard 3-wire control connect 120VAC (or 240VAC for 415V and 380V units) to pins 1 and 5 of TB1. Connect N.C. (normally closed) stop button between pins 2 and 3 of TB1. Connect N.O. (normally open) start button between pins 3 and 4 of terminal block TB1.



#### 4.2.4 - Run Contact

##### Factory setting = Start/Stop (Jumper X6)

The auxiliary N.O. FORM A (solid state) contact is available on TB1 at pins 6 & 7 (see above). This contact is rated .05 amps, 240 VAC maximum for external use. The auxiliary contact energizes (changes state) when the start command is given and de-energizes (changes back) when stop or fault condition occurs. In decel mode, the run contact can be modified to drop out at the stop command or can stay latched until the end of the decel command. There are three selection jumpers for the auxiliary contact programming options. See Section 8.1 for jumper locations.

Jumper	Energizes Auxiliary Contact	De-energizes Auxiliary Contact
X6	On "Start" Command	On "Stop" Command
X7	At "End of Ramp"	At the end of decel, if decel is inabled (See Sec. 5.3 to enable decel)
X8	At "End of Ramp"	On "Stop" Command (or at beginning of decel ramp, if enabled)

Jumper Descriptions

**Note:** Coils can cause EMI (Electro-magnetic interference). To minimize EMI, Toshiba recommends that all coils be installed with surge suppression components. For AC coil brakes, use an R-C snubber type suppressor. For DC coil brakes use a diode type suppressor (See chart below for detail).

AC Coils

	R	C
120 VAC Relays	150 Ω 2W	0.47 μ F 300 VDC
220 VAC Contactors	150 Ω 5W	0.47 μ F 500 VDC
440 VAC Contactors	220 Ω 5W	0.47 μ F 1000 VDC

DC Coils

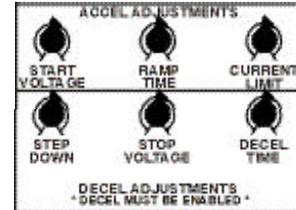
$*Current \geq \frac{Coil\ VA}{Coil\ Voltage}$ $Voltage \geq 2 \times Coil$
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Diode Ratings

## 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 torque adjustment. The unit has three accel adjustments. Adjustment description and procedures are described as follows:

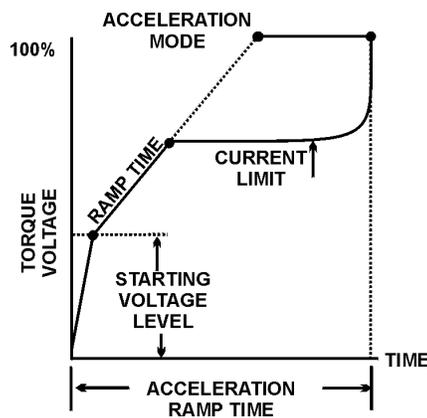
#### 5.2.1 - Starting Voltage Adjustment/Rotation Check

**Factory Setting = 60% of line voltage**

**Range = 0% - 100% of line voltage**

Starting voltage adjustment changes the initial starting voltage (torque) level to the motor. Start voltage is increased by rotating the Start Voltage potentiometer clockwise. Turn the Start Voltage potentiometer fully counterclockwise (FCCW). Apply power to the TS and give the start command. Observe that the motor does not rotate. Slowly increase the initial voltage by turning the potentiometer in a clockwise direction until the motor shaft just begins to rotate. When the motor shaft begins to rotate give a stop command and remove power (both line and control voltage). The minimum effective starting voltage level is set.

**Note:** Use this time to check rotation without full speed operation.



On model TS\_004, the X5 Jumper may be removed to disable the ramp function. This will permit adjustment of the starting torque without activating the ramp. The X5 jumper must be replaced after adjusting the starting voltage to re-enable the ramp function. See Section 8.1 for jumper locations.

## 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 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 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 feature 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 may cause the motor to stall and eventually cause the system overloads to trip.** If the motor bogs down or stops during the acceleration period, hit the stop button immediately. Increase the current limit setting and restart.

**Note:** If the motor does stall, refer to the motor manufacturer's specifications 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. Typical applications are pumps, conveyors and overhead cranes. Three adjustments optimize the deceleration curve for you specific application requirements. **Try factory settings before adjusting.**

**The soft starter is shipped from the factory with the decel feature disabled. The decel feature must be enabled before mounting and wiring the XLS unit.** Remove jumper from X3 (decel disabled) and place it on X4 (decel enabled), (see *Section 8.1 for jumper locations*). Apply power and adjust the soft start before

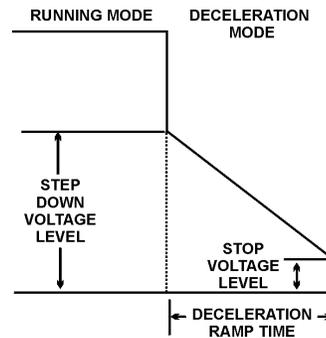
modifying the deceleration adjustments. Both acceleration and deceleration adjustments should be made under normal load conditions. The deceleration adjustments are made in the same manner as the starting adjustments; turning the potentiometer clockwise increases the setting, turning the potentiometer counterclockwise 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 until 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.



Deceleration Ramp

### 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 and the decel mode is ended.

### 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 deceleration time has been achieved.

**Note:** Do not exceed the motor manufacturer's recommended number starts per hour. When calculating the number of starts per hour, a decel curve should be counted as a start curve.

## 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 leads are attached to the unit input terminals marked L1, L2 and L3.
- Motor leads are connected to the terminals marked T1, T2, and T3.
- Appropriate control power is applied and/or control connections have been made.
- The motor area and equipment are clear of people and parts before start-up.

### 6.2 - Sequence of Operation

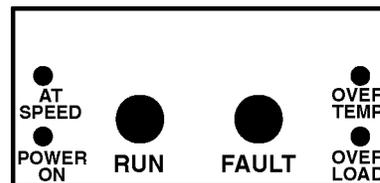
The "Power On" LED should light when control power is applied to the unit.

#### 6.2.1 - Normal Operation with Decel Disabled

Apply the start command. The "Run" LED should light up and the motor should begin to accelerate. When the unit reaches full output, the "At Speed" LED comes on. When the stop command is given, the "Run" and "At Speed" LEDs will turn off, leaving only the "Power On" LED illuminated.

#### 6.2.2 - Normal Operation with Decel Enabled

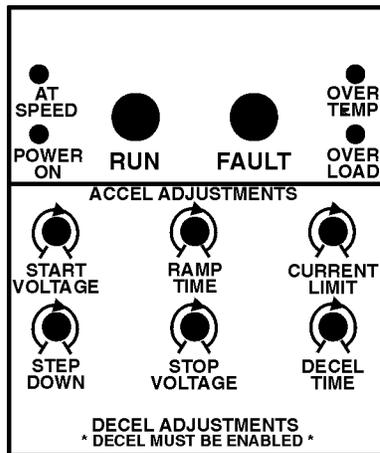
Apply the start command. The "Run" LED should light up and the motor should begin to accelerate. When the unit reaches full output, the "At Speed" LED comes on. When a stop command is given, the decel mode begins, the "At Speed" LED will turn off, leaving the "Run" and "Power On" LEDs illuminated until the decel is complete. Once the decel is complete, the "Run" LED will extinguish, leaving only the "Power On" LED illuminated.



**Chapter 7 - LED Display**

**7.1 - LED Functions**

The TS unit has 6 LEDs on the status display.



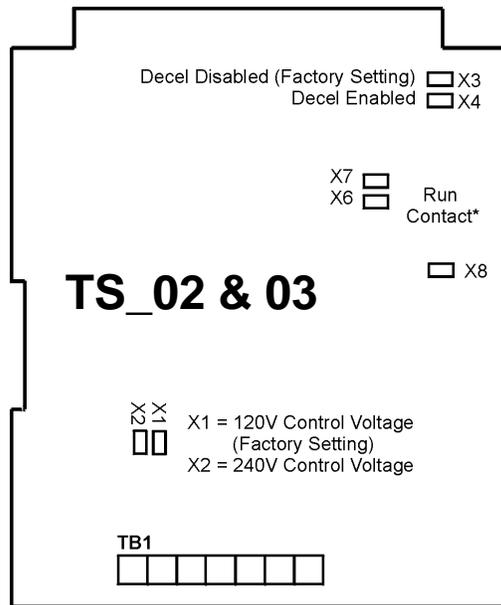
**NOTE: Overload LED is not functional on this model.**

Standard LED display and operator panel for models TS\_02, TS\_03 & TS\_04

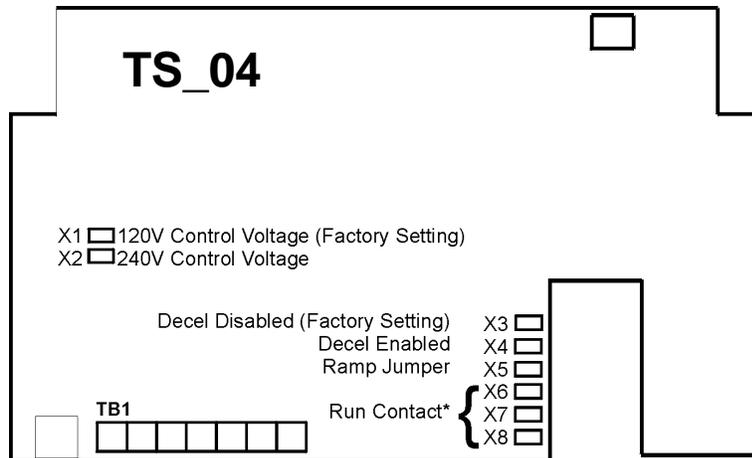
	LED	STATUS
Green	Power On	Indicates control power is present.
	Run	Indicates that power is provided to the motor. System is online. (This LED will remain lit during the accel/decel modes and anytime there is a possibility of motor rotation.)
	At Speed	Indicates the motor is at full speed and power. The SCRs have phased fully on.
Red	Fault	This is a general indication of a fault occurring in the system. The Overtemp LED will be lit.
Yellow	Over Temperature	This LED indicates the soft starter has tripped due to over temperature.
	Overload	This LED is not functional on this model.

**Chapter 8 - Jumper Locations**

**8.1 - PC Board Layout**



\* See section 4.2.4 for jumper descriptions.  
 (Factory Setting: X6= Run contact on Start/Stop command)





## WARRANTY AND LIMITATION OF LIABILITY

Toshiba International Corporation ("Company") warrants that all equipment and parts described herein will be free from defects in materials and workmanship. THIS WARRANTY WILL EXPIRE EIGHTEEN (18) MONTHS AFTER THE DATE ON WHICH SUCH EQUIPMENT AND PARTS (EXCLUDING REPAIRED OR REPLACEMENT EQUIPMENT AND PARTS FURNISHED PURSUANT TO THIS WARRANTY) ARE SHIPPED BY THE COMPANY TO THE INITIAL PURCHASER OR TWELVE (12) MONTHS AFTER SUCH EQUIPMENT AND PARTS (EXCLUDING REPAIRED OR REPLACEMENT EQUIPMENT AND PARTS FURNISHED PURSUANT TO THIS WARRANTY) ARE FIRST PLACED IN OPERATION, WHICHEVER PERIOD FIRST EXPIRES.

The Company will, at its option, repair or replace such equipment or part which is defective under the terms of the foregoing warranty, free of charge; provided the purchaser (1) promptly notifies the Company in writing of such defect, and (2) furnishes the Company satisfactory proof thereof, and (3) establishes that the equipment or part has been properly installed, maintained and operated within the limits of rated capacity and normal usage and in accordance with this manual, and (4) if requested by the Company, returns the defective equipment or part to the Company and pays all expenses incurred in connection with such return. The repaired or replacement equipment or part will be delivered, free of charge, to the purchaser F.O.B. the Company's warehouse or, at the Company's option, F.O.B. a Company authorized service shop, not loaded on truck or other carrier. The purchaser will pay the costs applicable to the equipment or part following such delivery, including, without limitation, all handling, transportation, assembly, insurance, testing and inspection charges.

THE FOREGOING OBLIGATION TO REPAIR OR REPLACE EQUIPMENT PARTS SHALL BE THE SOLE AND EXCLUSIVE REMEDY OF THE PURCHASER, ITS CUSTOMERS AND USERS OF THE EQUIPMENT AND PARTS FOR BREACH OF THE FOREGOING WARRANTY. THE COMPANY WILL HAVE NO OBLIGATIONS TO DISASSEMBLE ANY EQUIPMENT OR PART WHICH IS DEFECTIVE WITHIN THE TERMS OF THE ABOVE WARRANTY OR TO INSTALL ANY REPAIRED OR REPLACEMENT PART OR EQUIPMENT OR TO PAY ANY COSTS INCURRED IN CONNECTION WITH ANY SUCH DISASSEMBLY OR INSTALLATION. THE COMPANY, TOSHIBA CORPORATION AND THEIR SUPPLIERS AND SUBCONTRACTORS HEREBY DISCLAIM ALL OTHER EXPRESS, STATUTORY AND IMPLIED WARRANTIES, INCLUDING, WITHOUT LIMITATION, ALL EQUIPMENT AND PARTS FURNISHED PURSUANT TO THE FOREGOING WARRANTY AND ALL IMPLIED WARRANTIES OF MERCHANTABILITY.

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