

INSTRUCTION MANUAL

INSTALLATION - OPERATION - MAINTENANCE

TX SERIES

**Low Voltage
Digital Solid State Starter**

48 - 1250 A

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.

DANGER

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.

CAUTION

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

NOTE

Give you helpful information.

Note: The contents of this manual will not become apart of or modify the warranty policy, the terms of which are set forth at the end of this manual.

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.

DANGER

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
(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: _____

TX Series
Digital Solid State
Soft Starter
48 - 1250A

Installation &
Operation Manual

Chapter 1: Introduction	1
1.1 General	
1.2 Specifications	
1.3 Theory of Operation	
1.4 General Protection	
1.5 Thermal Overload Protection	
Chapter 2: Installation	8
2.1 Receiving and Unpacking	
2.2 Initial Unit Inspection	
2.3 Location	
2.4 Mounting & Cleaning	
2.5 Power Wire Range and Tightening Torque	
2.6 Dimensions	
2.7 Power Connections	
2.8 Control Connections	
2.9 CPU Board Connections	
2.10 Communications Board	
2.11 RTD Board (Optional)	
Chapter 3: Start-Up	16
3.1 Preliminary Start-up Check List	
3.2 Introduction	
3.3 Acceleration Adjustments	
3.4 Deceleration Adjustments	
3.5 Sequence of Normal Operation	
Chapter 4: User Interface and Menu Navigation	20
4.1 Keypad/Operator Interface	
4.2 Menu Navigation	
Chapter 5: Setpoint Programming	23
5.1 Setpoints Page List	
5.2 Setpoint Menu	
SP.1 Basic Configuration	33
SP.2 Starter Configuration	34
SP.3 Phase & Ground Settings	37
SP.4 Relay Assignment	40
SP.5 Relay Configuration	42
SP.6 I/O Configuration	43
SP.7 Custom Acceleration Curve	46
SP.8 Overload Curve Configuration	49
SP.9 RTD Configuration	50
SP.10 Set Password	52
SP.11 Communications	53
SP.12 System Setpoints	54
SP.13 Calibration & Service	56
Chapter 6: Metering Pages	57
6.1 Metering Page List	
Chapter 7: Maintenance and Troubleshooting/Disposal/Storage	67
7.1 Failure Analysis	
7.2 SCR Testing Procedure	
7.3 Replacing SCR devices	
7.4 Replacing the Main Control Board	
7.5 Interconnect Drawing	
7.6 Maintenance Program	
7.7 Disposal/Storage	
Appendix A: Reference Section	78
Appendix B: Record of Setpoint Adjustments	81
Warranty Policy	89

Chapter 1 - Introduction

This chapter is a brief introduction to the **TX Series** soft starter and describes product operation and unit features.

1.1 - General

The **TX Series** is a high-end digitally programmable solid state reduced voltage soft starter. This heavy duty starter provides reduced voltage, stepless soft starting of 3-phase AC induction motors, protecting mechanical components from excessive torque stress and electrical systems from the effects of high motor inrush currents. The **TX Series** includes advanced motor and load protection features just like those found in expensive motor protection relays. These include retentive thermal memory, dynamic reset capacity, true thermal modeling, separate trip curves for start and run protection, overload alarm, etc. In the case of the **TX Series**, these features are built in as standard features, providing a cost effective and reliable motor starting and protection scheme for your critical motor applications.

The **TX Series** features an easy to use interface operator for programming and status indication. It includes a large tactile feedback keypad, LED status indicators and a 2 line x 20 character backlit display using plain English text readout. In addition to programming the standard parameters such as starting torque, ramp time, current limit, dual ramp and decel control, other features like programmable overload trip curves (NEMA/UL Classes 5 - 30), starts-per-hour, time between starts and coast down/back spin lockout protection can also be programmed for your specific application needs.

1.2 Specifications

Type of Load	Three phase AC induction motors or synchronous motors
AC Supply Voltage	208 - 600 VAC \pm 10%, 50/60 Hz
HP Ratings	39 - 1250 Amps, 10 - 1125 HP
Unit Overload Capacity (Percent of motor FLA)	125% - Continuous 500% - 60 seconds 600% - 30 seconds
Power Circuit	6 SCRs
SCR Diode Ratings (Peak Inverse Voltage)	1600V
Phase Insensitivity	Unit operates with any phase sequence
Transient Voltage Protection	RC snubber dv/dt networks on each phase
Cooling	Convection up to 180A, fan assisted 78 - 120A Fan ventilated 220 - 1250A
Bypass Contactor	Full horsepower rated contactor included as standard in all Type 12, 3R, 4 & 4X enclosed units 120A and above.
Ambient Condition Design	Chassis units: 0° to 50 °C (32° to 122°F) Enclosed units: 0° to 40°C (32° to 104°F) 5 - 95% relative humidity 0 - 3300 ft. (1000m) above sea level without derating
Control	2 or 3 wire 120VAC (customer supplied) Optional 240VAC control voltage and CPTs are available
Auxiliary Contacts	Type/Rating: FORM C (SPDT), rated 5 Amps, 240VAC max. (1200VA) 4 Programmable Relays
Approvals	UL Listed, Canadian UL (cUL)

1.2 Specifications (continued)

Advanced Motor Protection	
Two Stage Electronic Overload Curves	Starting: programmable for Class 5 - 30 or locked rotor time. Run: Programmable for Class 5 - 30 when "At-Speed" is detected.
Overload Reset	Manual (default) or automatic
Retentive Thermal Memory	Overload circuit retains thermal condition of the motor regardless of control power status. Unit uses real time clock to adjust for off time.
Dynamic Reset Capacity	Overload will not reset until thermal capacity available in the motor is enough for a successful restart. Starter learns and retains this information by monitoring previous successful starts.
Phase Current Imbalance Protection	Imbalance Trip Level: 5 - 30% current between any two phases Imbalance Trip Delay: 1 -20 seconds
Over Current Protection (Electronic Shear Pin)	Trip Level: 100 - 300% of motor FLA while running not starting or OFF Trip Delay: 1 - 20 seconds
Load Loss Trip Protection	Under Current Trip Level: 10 -90 % of motor FLA or OFF Under Current Trip Delay: 1 - 60 seconds
Coast Down (Back Spin) Lockout Timer	Coast Down Time Range: 1 - 60 minutes or OFF
Starts-per-hour Lockout Timer	Range: 1 - 6 successful starts per hour Time between starts: 1 - 60 minutes between start attempts
Programmable Outputs	
Type / Rating	Form C (DPDT), Rated 5 amps 240 VAC max, (1200 VA)
Run Indication	Start/Stop or Start/End of Decel
At Speed Indication	At Speed/Stop or At Speed/End of Decel
Acceleration Adjustments	Programmable Ramp Types: Voltage or Current Ramp (VR or CR) Starting Torque: 0 - 100% of line voltage (VR) or 0 - 600% of motor FLA (CR) Ramp Time: 1 to 120 seconds Current Limit: 200 - 600% (VR or CR)
Dual Ramp Settings	4 Options: VR1+VR2; VR1+CR2; CR1+CR2; CR1+VR2 Dual Ramp Control: Ramp 1 = Default Ramp 2 = selectable via dry contact input
Deceleration Adjustments	Begin Decel Level: 0 - 100% of line voltage Stop Level: 0 to 1% less than Begin Decel Level Decel Time: 1 - 60 seconds Programmable to decel or coast to stop upon overload trip
Jog Settings (Function selected via programming input)	Voltage Jog: 5 - 100% or OFF Time of Voltage Jog: 1 - 20 seconds Current Jog: 100 - 500%
Kick Start Settings	Kick Voltage: 10 - 100% or OFF Kick Time: 0.1 - 2 seconds
Fault Display	Shorted SCR, Phase Loss, Shunt Trip, Phase Imbalance Trip, Overload, Overtemp, Overcurrent, Short Circuit, Load Loss, Undervoltage or Any Trip
Lockout Display	Coast Down Time, Starts Per Hour, Time Between Starts, and Any Lockout

1.2 Specifications (continued)

Event History	
Up to 60 Events	Data includes cause of event, time, date, and current for each phase and ground fault current at time of event
Metering Functions	
Motor Load	Percent of FLA
Current Data	A, B, C Phase Current, Avg Current, Ground Fault
Thermal Data	Remaining thermal register; thermal capacity to start
Start Data	Avg Start Time, Avg Start Current, Measured Capacity to start, time since last start
RTD Data	Temperature readings from up to 12 RTDs (6 stators)
Voltage Metering	KW, KVAR, PF, KWH
Serial Communications	
Protocol	Modbus RTU
Signal	RS-485 or RS-422
Network	Up to 247 devices per mode
Functionality	Full operation, status view, and programming via communications port
Operator Interface	
LCD Readout	Alpha numeric LCD display
Keypad	8 function keys with tactile feedback
Status Indicators	8 LEDs include Power, Run, Alarm, Trip, Aux Relays
Remote Mount Capability	Up to 1000 feet from chassis (use twisted, shielded wire)
Clock and Memory	
Operating Memory	DRAM loaded from EPROM and EEPROM at initialization
Factory Default Storage	Flash EPROM, field replaceable
Customer Settings and Status	Non-volatile EEPROM, no battery backup necessary
Real Time Clock	Lithium ion battery for clock memory only

1.3 - Theory of Operation

The power of the **TX Series** is in the CPU, a microprocessor based protection and control system for the motor and starter assembly. The CPU uses Phase Angle Firing of the SCRs to apply a reduced voltage to the motor, and then slowly and gently increases torque through control of the voltage and current until the motor accelerates to full speed. This starting method lowers the starting current of the motor, reducing electrical stresses on the power system and motor. It also reduces peak starting torque stresses on both the motor and load mechanical components, promoting longer service life and less downtime.

Acceleration: The **TX Series** comes standard with several methods of accelerating the motor so that it can be programmed to match almost any industrial AC motor application.

The factory default setting applies a **Voltage Ramp** with **Current Limit** as this has been proven the most reliable starting method for the vast majority of applications. Using this starting method, the Initial Torque setting applies just enough voltage to the motor to cause the motor shaft to begin to turn. This voltage is then gradually increased over time (as per the Ramp Time setting) until one of three things happen: the motor accelerates to full speed, the Ramp Time expires or a Current Limit setting is reached.

If the motor accelerates to full speed before the ramp time setting has expired, an automatic Anti-Oscillation feature will override the remaining ramp time and full voltage will be applied. This will prevent any surging or pulsation in the motor torque, which might otherwise occur due to the load not being fully coupled to the motor when operating at reduced voltage and torque levels.

If the motor has not reached full speed at the end of the ramp time setting, the current limit setting will proportionally control the maximum output torque. Feedback sensors in the **TX Series** provide protection from a stall condition, an overload condition or excessive acceleration time.

The Current Limit feature is provided to accommodate installations where there is limited power available (for example, on-site generator power or utility lines with limited capacity). The torque is increased until the motor current reaches the preset Current Limit point and it is then held at that level. Current Limit overrides the ramp time setting so if the motor has not accelerated to full speed under the Current Limit setting, the current remains limited for as long as it takes the motor to accelerate to full speed.

When the motor reaches full speed and the current drops to running levels, the **TX Series** detects an At-Speed condition and will close the Bypass Contactor (if provided). The Bypass Contactor serves to shunt power around the SCR stack assemblies to prevent heat build-up NEMA 12, 3R, 4 and 4X enclosed units due to the slight voltage drop across the SCRs. At this point, the **TX Series** has the motor operating at full voltage, just as any other starter would.

Other starting methods available in the **TX Series** are:

- **Current Ramp:** uses a closed current feedback PID loop to provide a linear torque increase up to a Maximum Current level.
- **Constant Current:** current is immediately increased to the Current Limit point and held there until the motor reaches full speed.
- **Custom Curve:** gives the user the ability to plot torque and time points on a graph. The soft starter will then accelerate the motor following these points.
- **Tachometer Feedback Ramp:** uses a closed loop speed follower method monitoring a tachometer input signal from the motor or load shaft. (PENDING)

Deceleration: the **TX Series** provides the user with the option of having the load coast to a stop or controlling the deceleration by slowly reducing the voltage to the motor upon initiating a stop command. The Decel feature is the **opposite of DC injection braking** in that the motor will actually take longer to come to a stop than if allowed to coast to a stop. The most common application for the Decel feature is pumping applications where a controlled stop prevents water hammer and mechanical damage to the system.

1.4 General Protection

Operation of the **TX Series** can be divided into 4 modes; Ready, Start, Run and Stop. The CPU provides motor and load protection in all four modes. Additional details on each protection feature can be found in later chapters.

Ready Mode: In this mode, control and line power are applied and the starter is ready for a start command. Protection during this mode includes the monitoring of current for leakage through multiple shorted SCRs. Other protection features in effect are:

- Starter Temperature
- Shorted SCR
- Phase Reversal (if enabled)
- Line Frequency Trip Window
- External Input Faults

Note: The “Programming Mode” can only be entered from the Ready Mode. During programming, all protection features and start command are disabled.

Start Mode: These additional protection functions are enabled when the soft starter receives a valid Start command:

- Phase Reversal (if enabled)
- Start Curve
- Acceleration Timer
- Phase Imbalance
- Short Circuit / Load Pre-check (Toe-in-the-Water)
- Ground Fault
- External Input Faults
- Accumulated Starting FLA Units (I²t Protection)
- Overload Protection
- Thermal Capacity

Note: Shorted SCR and Shunt Trip protection are no longer in effect once the soft starter goes into the Start Mode.

Run Mode: The soft starter enters the Run Mode when it reaches full output voltage and the motor current drops below the FLA setting (motor nameplate FLA plus service factor) for a predetermined period of time. During the Run Mode these additional protection features are enabled:

- Running Overload Curve
- Phase Loss
- Under Current / Load Loss
- Over Current / Electronic Shear Pin
- External Input Faults

Stop Mode: Once a Stop command has been given, the **TX Series** protection features change depending on which Stop Mode is selected.

- **Decel Mode:** retains all protection features of the Run Mode. At the end of Decel, the motor will be stopped and the protection features change as indicated below.
- **Coast-To-Stop Mode:** power is immediately removed from the motor and the soft starter returns to the Ready Mode. Additional protection features activated when the stop command is given include:
 - Coast-Down / Back Spin Timer
 - Starts-per-Hour
 - Time Between Starts
 - External Input Faults

1.5 Thermal Overload Protection

The **TX Series** plays an important role in the protection of your motor in that it monitors the motor for excessive thermal conditions due to starting, running or even ambient conditions. The **TX Series** has a Dynamic Thermal Register system in the CPU that provides a mathematical representation of the thermal state of the motor. This thermal state information is kept in memory and is monitored for excesses in both value and rate of change. Input is derived from current imbalances and (optional) RTD measurements making it dynamic to all processes involving the motor. The **TX Series** monitors these conditions separately during Start and Run modes to provide proper thermal overload protection at all times.

Start Mode overload protection is selectable using one of three methods:

- **Basic Protection:** I²t data is accumulated and plotted based on an Overload Curve selected in programming. This is programmed per NEMA Class 5-30 standard curves and is based on the Locked Rotor Current (from the motor nameplate) as programmed into the soft starter.
- **Measured Start Capacity:** the user enters a measured amount of thermal capacity from a pre-selected successful start as a setpoint to the Thermal Register for the soft starter to follow.
- **Learned Curve Protection:** the user sets the soft starter to the "LEARN" mode and starts the motor under normal starting conditions. The CPU then samples and records 100 data points during the start curve, analyzes them and creates a graphical representation in memory. The soft starter is then switched to Curve Follow protection mode and monitors motor performance against this curve. This feature is especially useful in initial commissioning tests to record a base line performance sample (in this case, it is not necessarily used for motor protection).

Run Mode overload protection is initiated when the **TX Series** determines that the motor is At-Speed. Overload Protection is initiated when the motor RMS current rises above a “pick-up point” (as determined by the motor nameplate FLA and service factor). Run mode protection is provided by the CPU monitoring the Dynamic Thermal Register. Data for the Dynamic Thermal Register is accumulated from I^2t calculations and cooling rates. A trip occurs when the register reaches 100% as determined by the selected Overload Protection Curve (NEMA Class 5-30 standard curves) and is based on the programmed Locked Rotor Current indicated on the motor nameplate. The Dynamic Thermal Register is altered, or “biased”, by the following conditions:

- **Current Imbalance:** will bias the register higher to add protection from additional motor heating during a current imbalance condition.
- **Normal Cooling:** provided when the motor current drops below the pick-up point or the motor is off line. The cooling rate is lower for motors that are off-line (such as after a trip) since cooling fans are also inoperative.
- **RTD Input:** (requires the optional RTD monitor card): will bias the register in either direction based on real-time input of the motor, bearing and even ambient temperature conditions.
- **Dynamic Reset** is another feature that adds reliability and consistency to the performance of the **TX Series** soft starter. If a motor overload condition occurs and the soft starter trips, it cannot be reset until sufficient cool down time has elapsed. This cool down time is determined by the thermal state of the motor when it tripped (i.e. hot motors cool more quickly due to additional convection). The cool down time is also biased by RTD measurements when used.

Retentive Thermal Memory provides continuous overload protection and real time reset even if power is lost. Upon restoration of power, the **TX Series** will read the Real Time Clock and restore the thermal register to what it should be given the elapsed time.

- **Learned Reset Capacity** is a feature that is unique to the **TX Series**. By sampling the amount of thermal capacity used in the previous three successful starts, the **TX Series** will not allow a reset until a sufficient amount of thermal capacity has been regained in the motor. This prevents nuisance tripping and insures that unsuccessful start attempts (which would otherwise use up the starts-per-hour capacity of the motor) are not allowed.

Chapter 2 - Installation

2.1 Receiving and Unpacking

Upon receipt of the unit:

- Carefully unpack the unit and inspect it for any shipping damage. Report any damage immediately and file a claim with the freight carrier within 15 days of receipt.
- Verify that the model number on your unit matches your purchase order.
- Confirm that the ratings label on the unit matches or is greater than the motor's HP and current rating.

2.2 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 **TX** unit are rated for the proper amperage and voltage.

2.3 Location

The proper location of the unit is an important factor in achieving the unit's specified performance and normal operation lifetime. The unit should always be installed in an area where the following conditions exist:

- Ambient Operating Temperature: 0° C to 50° C (32° F to 122° F) (Optional space heaters can be provided for operation in ambient temperature to -20° C.)
- Protected from rain and moisture.
- Humidity: 5% to 95% non-condensing.
- Free from metallic particles, conductive dust and corrosive gas.
- Free from excess 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 the enclosure.



***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.***

2.4 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 completed, 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.

▲WARNING 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.

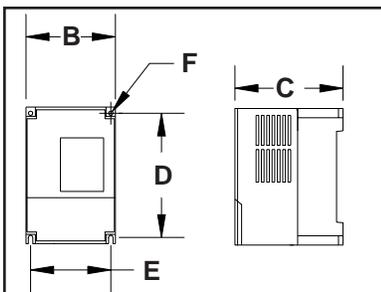
2.5 Power Terminal Wire Range and Tightening Torque

Model Number	Max Amps	Max HP				kW		Wire Range	Torque lbs/in
		208V	230V	480V	600V	230V	400V		
TX005	48	10	15	30	40	11	22	#18 - #4	20
TX006	78	20	25	50	60	22	37	#14 - #2	50
TX007	120	30	40	75	100	30	55	#6 - 250 kcmil	325
TX008	180	50	60	125	150	55	90		
TX009	220	60	75	150	200		110	(2) #6 - 600 kcmil	375
TX010	288	75	100	200	250	75	132		
TX011	414	125	150	300	350		200	(2) #2 - 600 kcmil	375
TX012	476	-	-	350	400	132	250		
TX013	550	150	200	400	500	160		(3) #2 - 600 kcmil	375
TX014	718	200	250	500	600	200	315		
TX015	1006	300	350	700	800		400	(4) #2 - 600 kcmil	375
TX016	1150	350	400	800	900				
TX017	1250	450	500	1000	1125				

Note: All wiring must be sized according to NEC standards

2.6 Dimensions

TX DIMENSIONS							
Enclosure	Model Number	Overall Dimensions			Mounting Dimensions		
		A	B	C	D	E	F
PANEL (OPEN CHASSIS TYPE)	TX005 to TX007	16.5	10	10	15.9	9	0.28
	TX008	20	20.1	12	18.5	17.5	0.44
	TX009 to TX010	27	20.1	11.2	25.5	17.5	0.44
	TX011 to TX013	29.5	20.1	11.5	25.5	17.5	0.44
	TX014 to TX015	45	33	12.8	43.3	31.3	0.44
	TX016 to TX017	33	33	15.2	31.2	31.2	0.44

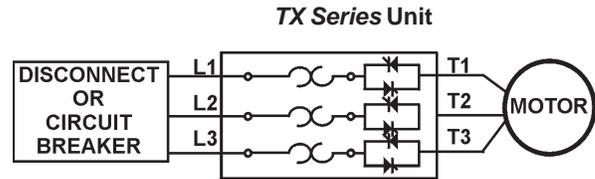


2.7 Power Connections

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.



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.



Power Connections

The unit must be tested with a motor or other test load connected to the load side of the unit. (A load bank can be used if a motor is not available). 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.

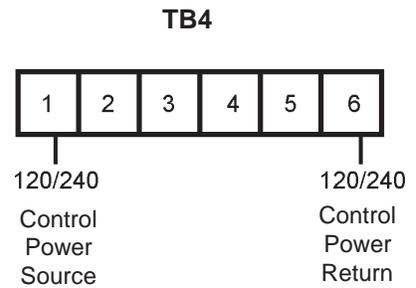
2.7.1 Grounding

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.

2.8 Control Connections

Separate 120Vac supply is required (240Vac for 380V and 415V applications). The control voltage should be connected to pins 1 and 6 of TB4 on the power board. This control voltage must be customer supplied, unless an optional control power transformer (See chart) has been supplied with the unit.

TX Model	Recommended Transformer Sizes		
	Panel	NEMA Type 1	NEMA Type 12/3R/4
TX008	50 VA	100 VA	250 VA*
TX009	50 VA	100 VA	500 VA*
TX010	250 VA	250 VA	500 VA*
TX011 to TX013	250 VA	250 VA	750 VA*
TX014	500 VA	500 VA	1 KVA*
TX015 to TX016	500 VA	750 VA	1.5 KVA*
TX017	500 VA	750 VA	1.5 KVA*



Unit comes standard with 120Vac control. Order 240Vac control as an option if required.

* Transformer size is adequate to power built-in bypass contactors on these models.

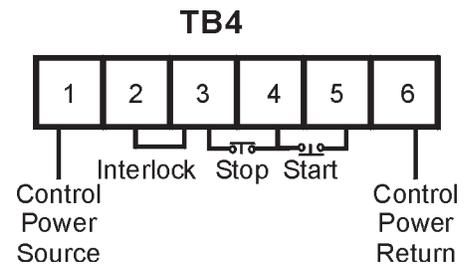
Recommended Transformer Sizes for Control Power

Note:

1. If power is used for additional accessory items (Lights, fans, etc.) contact factory for sizing.

2.8.1 Three-Wire Connection

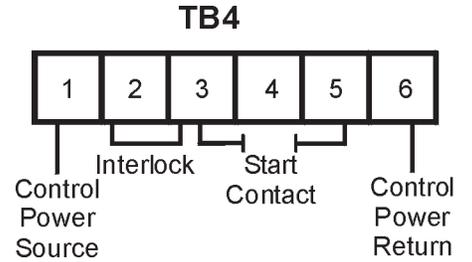
For standard 3-wire control connect 120Vac (or 240Vac for 415V and 380V applications) to pins 1 and 6 of TB4. Connect N.C. (normally closed) stop button between pins 3 and 4 of TB4. Connect N.O. (normally open) start button between pins 4 and 5 of terminal block TB4.



Three-Wire Connection

2.8.2 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 TB4. When the maintained contact is used for start/stop it is necessary to set the overload setpoint to the manual reset position. This will prevent the motor from restarting if the thermal overload trips and then cools off.



Two-Wire Connection



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.

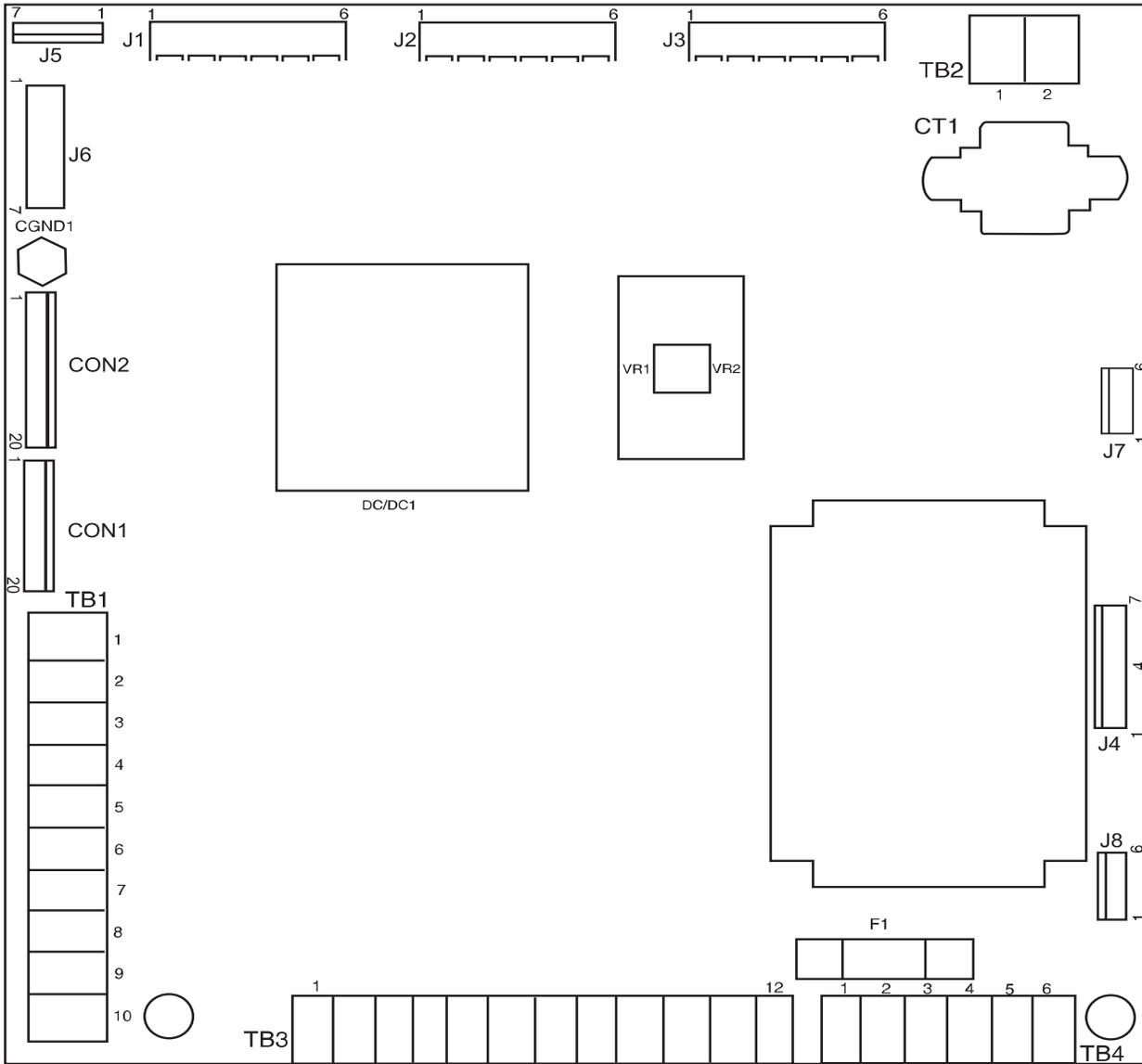
2.8.3 Programmable Relays/Relay Contacts

All the relay contacts are FORM C (Com, N.O., N.C.). Toshiba recommends fusing all contacts with external fuses. The TX has four programmable relays on TB3 on the power board. The relays are rated for 240Vac, 5 A and 1200 VA. These relays can respond to either a fault condition or an up-to-speed condition. In the TX all tripping functions have been assigned to the TRIP (AUX1) relay, and all alarm (warning) condition has been configured to the ALARM (AUX2) relay. AUX 3 is factory programmed for a SHUNT TRIP indication and can be connected to a shunt trip coil on an incoming circuit breaker or open an input isolation contactor. AUX4 is the AT SPEED contact. When the motor has reached the end of its acceleration ramp, the TX will wait until the AT SPEED programmed time delay has expired. Then, the relay will energize until a stop command has been received. The AT SPEED contact can be used to operate a bypass contactor (used for shorting the load current around the SCRs. To change AUX3 or AUX4 functions, see Setpoint Page 4.

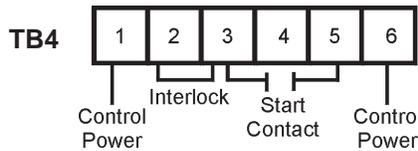
TB3	1	2	3	4	5	6	7	8	9	10	11	12
	C	N.O.	N.C.	C	N.O.	N.C.	C	N.O.	N.C.	C	N.O.	N.C.
	AUX1 (TRIP)			AUX2 (ALARM)			AUX3 (SHUNT TRIP)			AUX4 (AT SPEED)		

**Relay Contacts on Power Board
Rated 240Vac, 5A, 1200VA**

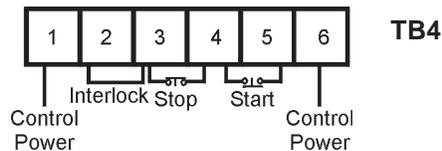
2.8.4 Power Board



2.8.4a Power Board Connections



Three-Wire Control Connection



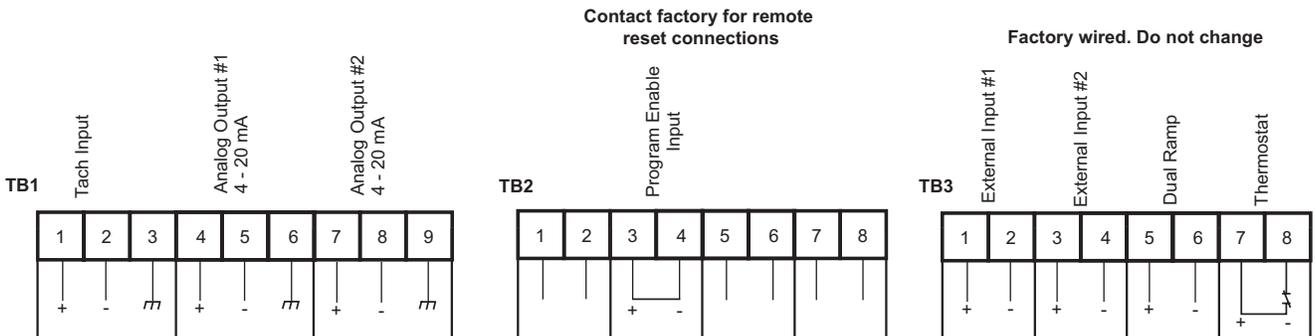
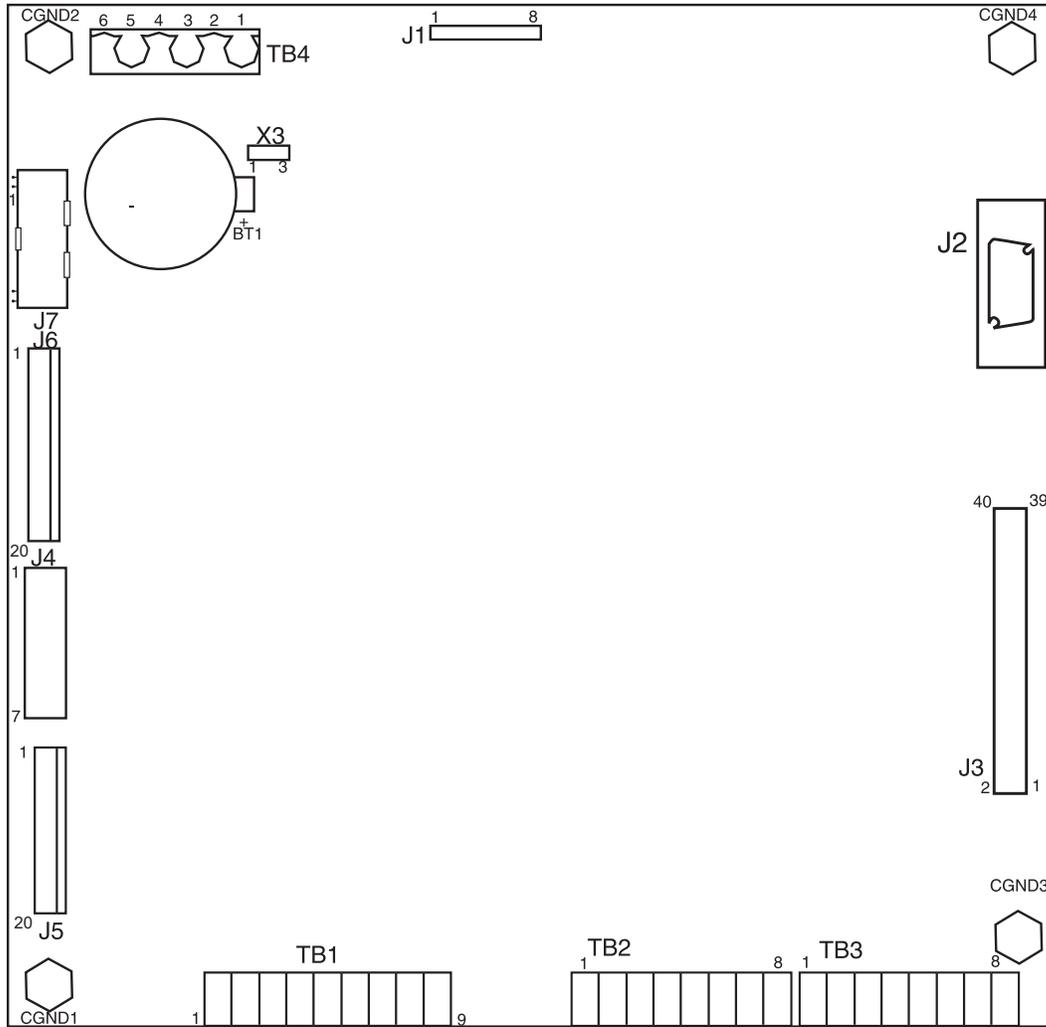
Two-Wire Control Connection

TB3	1	2	3	4	5	6	7	8	9	10	11	12
	C	N.O.	N.C.	C	N.O.	N.C.	C	N.O.	N.C.	C	N.O.	N.C.
	AUX1 (TRIP)			AUX2 (ALARM)			AUX3 (SHUNT TRIP)			AUX4 (AT SPEED)		

Relay Contacts on Power Board
Rated 240Vac, 5A, 1200VA

2.9 CPU Board Connections

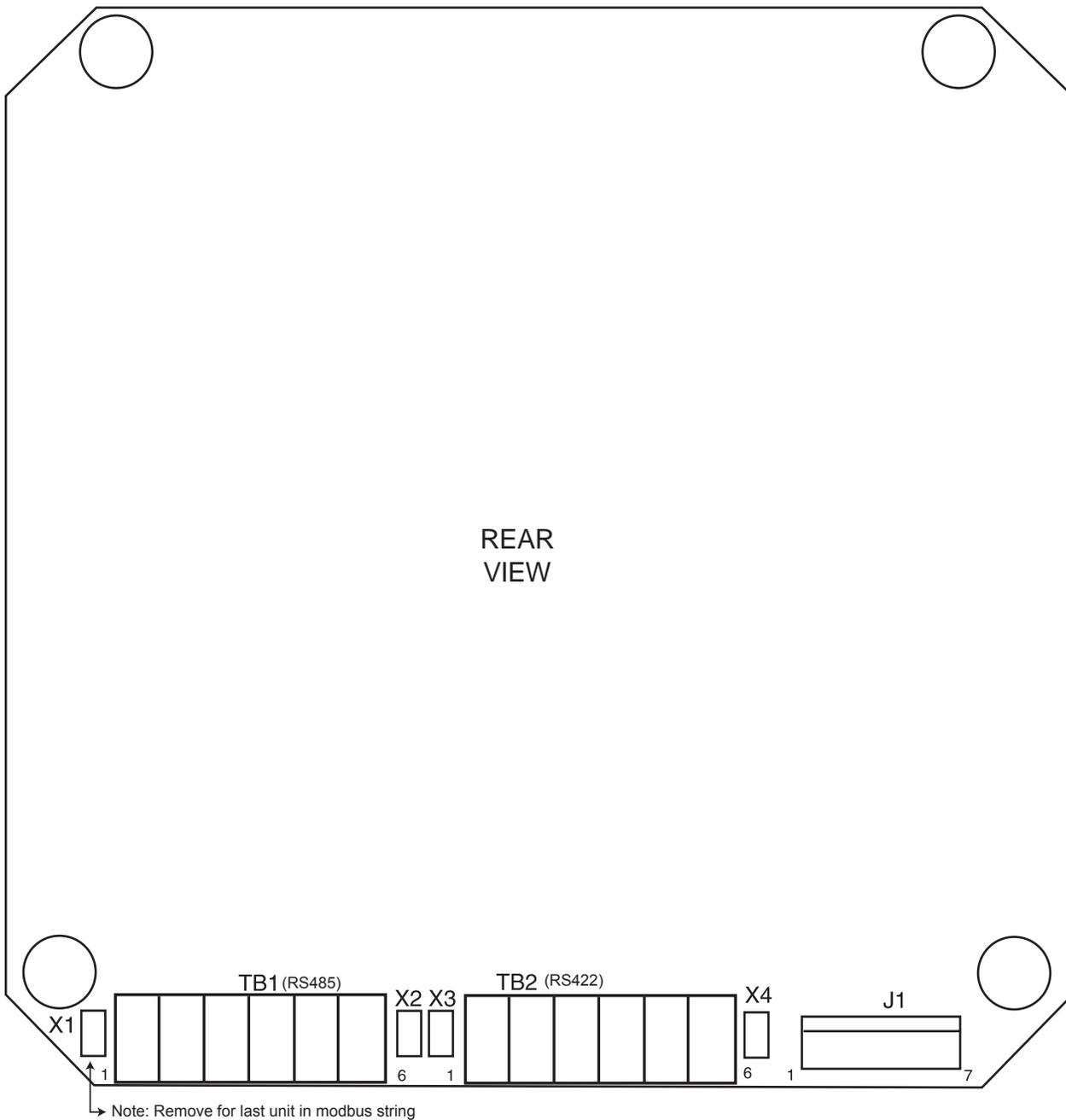
There are eight digital inputs on the CPU board. Four of the inputs are user programmable. There are also two analog outputs, a tachometer feedback input.



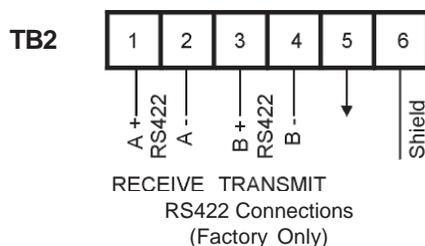
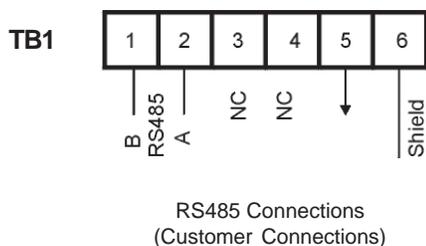
Note: Install program jumper to enable setpoint programming. Jumper must be removed after programming or for prolonged storage to preserve settings.

2.10 Communications Board

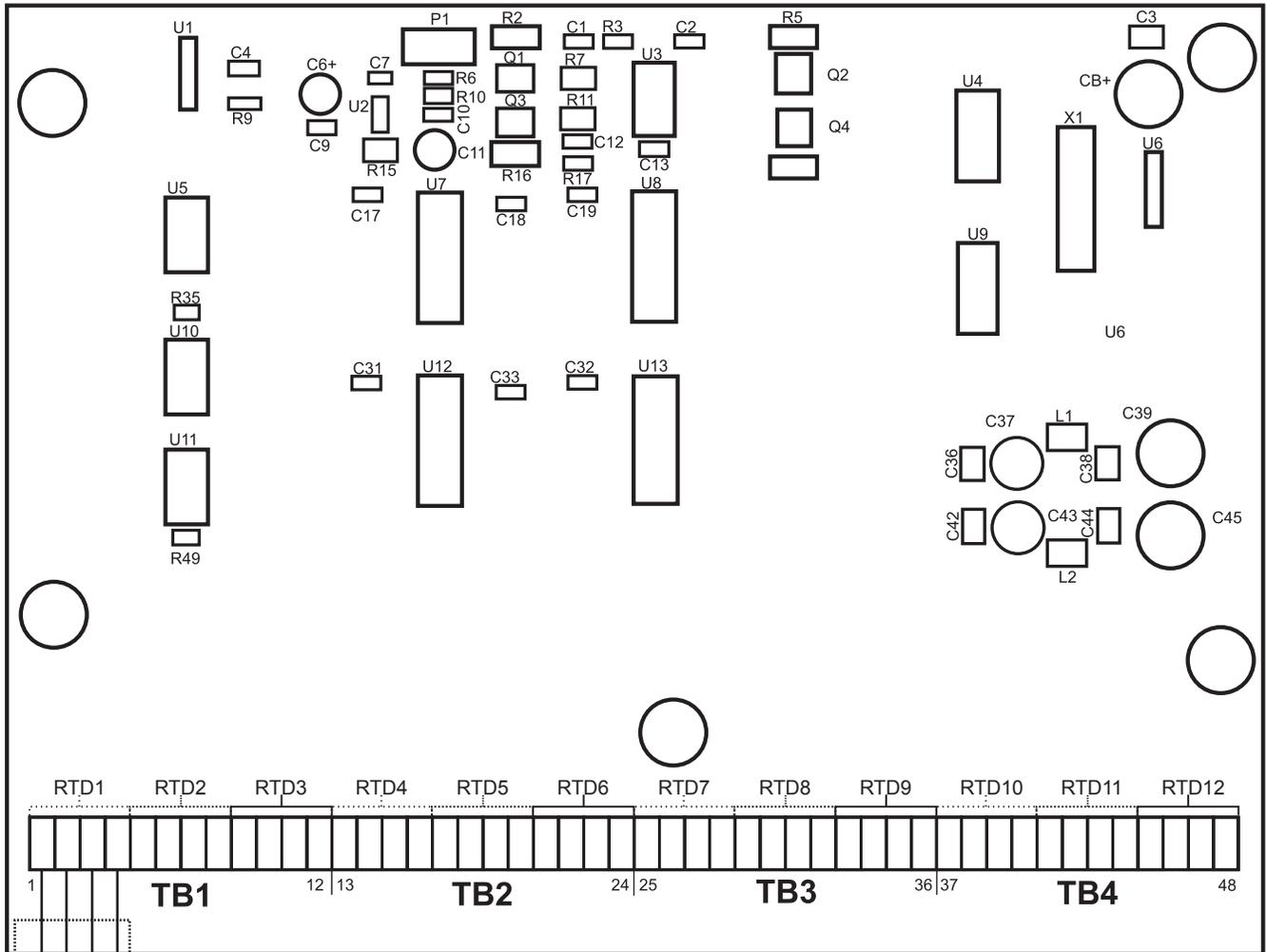
Full (RS422) or half (RS485) duplex Modbus communications port is available at TB1 on the communications board. No field wiring connections are required for TB2.



2.10.1 Communication Board Connections



2.11 Optional RTD Board



Typical RTD Installation

Chapter 3 - Start-up



THE TX UNIT DEALS WITH POTENTIALLY LETHAL VOLTAGE LEVELS. YOU MUST BE CERTAIN THAT PERSONNEL ARE THOROUGHLY TRAINED IN THE APPLICABLE SAFETY PRECAUTIONS BEFORE PROCEEDING WITH THIS SECTION!

3.1 Preliminary Start-Up Check List

Please make the following checks before applying power to the unit:

- Supply voltage matches the rated supply voltage of the unit.
- Horsepower and current ratings of the motor and unit match or the unit has a 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.
- The motor's FLA has been programmed.
- The thermal overload parameters are properly set.
- The motor area and equipment are clear of people and parts before start-up.

3.2 Introduction

It is best to operate the motor at its full load starting condition to achieve the proper time, torque and ramp settings. Initial settings are set to accommodate most motor conditions. **TRY INITIAL SETTINGS FIRST.** See Setpoints Page 2 to make any adjustments.

3.3 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. Adjustment description and procedures are described as follows (See section 4.5.2 for additional Accel settings):

3.3.1 Starting Voltage

Factory Setting = 20% of line voltage

Range = 0% - 100% of line voltage

Starting voltage adjustment changes the initial starting voltage level to the motor.

3.3.2 Ramp Time

Factory Setting = 10 sec.

Range = 0 - 120 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.

3.3.3 Current Limit

Factory Setting = 350% of unit FLA

Range = 200% - 600% of unit FLA

The current limit adjustment is factory set for 350% of the unit's rating. The range of adjustment is 200% to 600%. The main function of current limit is to cap the peak current. It may also be used to extend the ramping time if required. 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 could cause the motor to stall and eventually cause the overload protection to trip.**

3.4 Deceleration Adjustments (Pump Control)

Decel extends the stopping time on loads that would otherwise stop too quickly if allowed to coast to stop. Decel control provides smooth deceleration until the load comes to a stop. Three adjustments optimize the deceleration curve to meet the most demanding requirements. **Try factory settings before adjusting.**

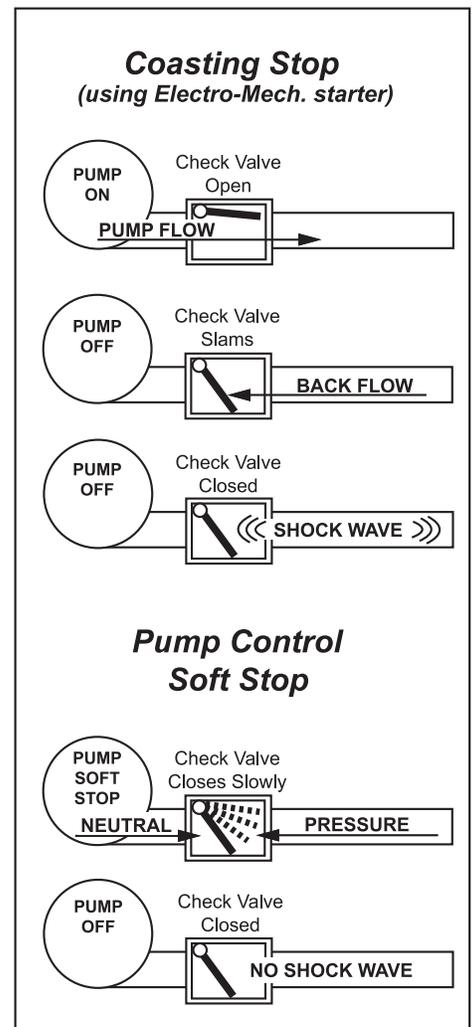
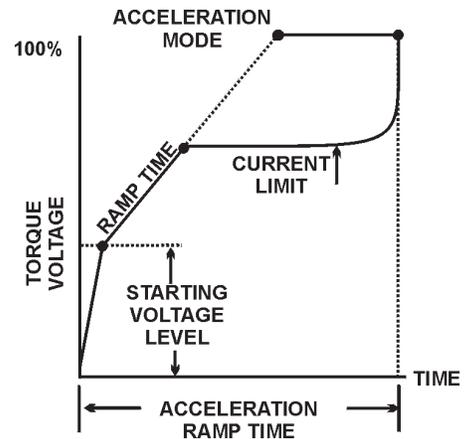
Deceleration Applications

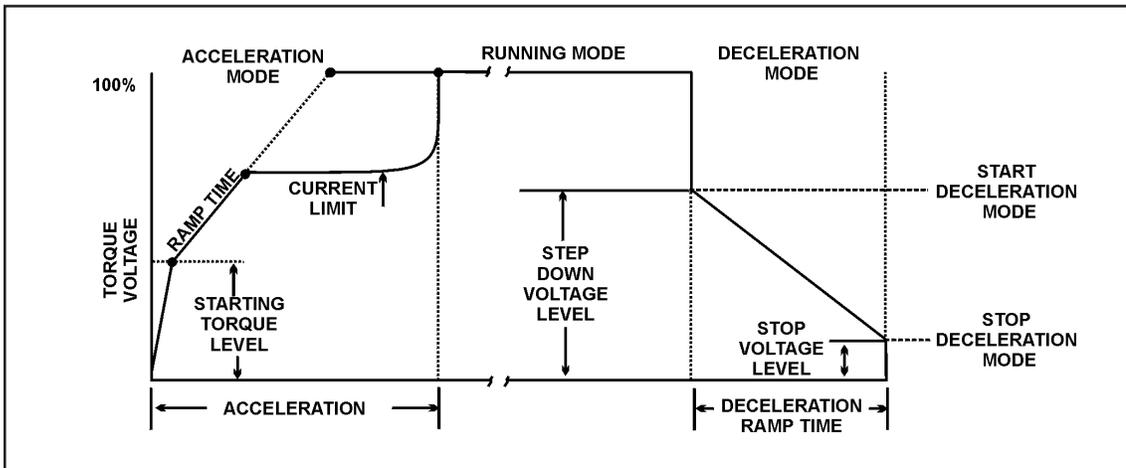
The unit is shipped from the factory with the decel feature disabled. Apply power and adjust the soft start before enabling or modifying the deceleration adjustments. Both acceleration and deceleration adjustments should be made under normal load conditions.

The deceleration feature provides a slow decrease in the output voltage, accomplishing a gentle decrease in motor torque during the stopping mode. This is the **OPPOSITE OF BRAKING** in that it will take **longer** to come to a stop than if the starter were just turned off. The primary use of this function is to reduce the sudden changes in pressure that are associated with “Water Hammer” and slamming of check valves with centrifugal pumps. Decel control in pump applications is often referred to as **Pump Control**.

In a pump system, liquid is being pushed uphill. The force exerted by gravity on the column of liquid as it goes up hill is called the “Head Pressure” in the system. The pump is sized to provide enough Output Pressure to overcome the Head Pressure and move the fluid up the pipe. When the pump is turned off, the Output Pressure rapidly drops to zero and the Head Pressure takes over to send the fluid back down the hill. A “Check Valve” is used somewhere in the system to prevent this (if necessary) by only allowing the liquid to flow in one direction. The kinetic energy in that moving fluid is suddenly trapped when the valve slams closed. Since fluids can’t compress, that energy is transformed into a “Shock Wave” that travels through the piping system looking for an outlet in which it dissipates. The sound of that shock wave is referred to as “Water Hammer”. The energy in that shock wave can be extremely damaging to pipes, fittings, flanges, seals and mounting systems.

By using the Soft Stop/Deceleration feature of the **TX**, the pump output torque is gradually and gently reduced, which slowly reduces the pressure in the pipe. When the Output Pressure is just slightly lower than the Head Pressure, the flow slowly reverses and closes the Check Valve. By this time there is very little energy left in the moving fluid and the Shock Wave is avoided. When the output voltage to the motor is low enough to no longer be needed, the **TX** will end the Decel cycle and turn itself off.





Another common application for decel control is on material handling conveyors as a means to prevent sudden stops that may cause products to fall over or to bump into one another. In overhead crane applications, soft stopping of the Bridge or Trolley can prevent loads from beginning to over swing on sudden stops.

3.4.1 Start Deceleration Voltage

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.

3.4.2 Stop Deceleration Voltage

Factory Setting = 20% of line voltage

Range = 0% - 100% of line voltage

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

3.4.3 Deceleration Time

Factory Setting = 5 sec.

Range = 0 - 60 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.



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.

3.5 Sequence of Normal Operation

- Apply control power and check that the “Power” LED comes on. (Display 1)
- Apply three phase power to the unit. The motor should run only when the start command is applied.
- Apply the start command. (Display 2). The RUN LED will be lit. (Display 3) The AUX3 LEDs will be lit. If the motor does not enter run mode in the set time, a trip will occur.
- The POWER, RUN, AUX3 LEDs will be lit, indicating that the contact has energized. IA, IB, IC will display the current setting for Phase A, Phase B, and Phase C and the G/F indicates ground fault. (Display 4)
- When the motor reaches full speed, the “AUX4” LED (At Speed) will be lit.
- 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 the Troubleshooting Chapter.

It is best to operate the motor at its full load starting condition to achieve the proper time, torque and ramp settings. Initial settings are set to accommodate most motor conditions. **TRY INITIAL SETTINGS FIRST.** See Setpoint Page 2 to make any adjustments.

- Initial Voltage
- Soft Start Curve
- Current Limit
- Acceleration Time

If decel is enabled, the following parameters for Deceleration Time, Start Decel Voltage (see SP2) and Stop Decel Voltage (see SP2) must also be programmed.

1.

MOTOR STOPPED READY TO START

2.

MOTOR STARTING 00 X FLA

3.

OVERLOAD ALARM TIME TO TRIP: XXX SECS.

4.

IA: ___ IB: ___
IC: ___ G/F: ___

Chapter 4 - User Interface & Menu Navigation

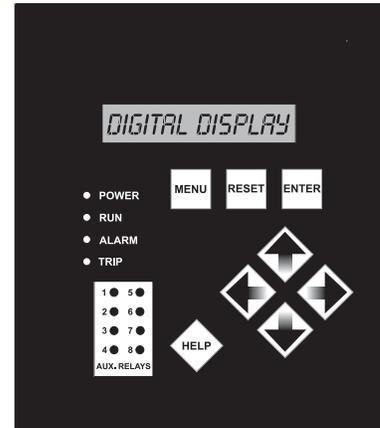
This chapter explains the keypad operator interface, the LCD descriptions and the programming features

4.1 Keypad/Operator Interface

The **TX Series** user keypad/keypad operator interface consists of:

- 2 row by 20 characters Liquid Crystal Display (LCD)
- 12 LEDs
- 8 pushbuttons

Note: The **TX Series** is menu driven and there are three levels of programming. The programming for two of these levels is password protected. Level two requires a three digit password and level three requires a four digit password.

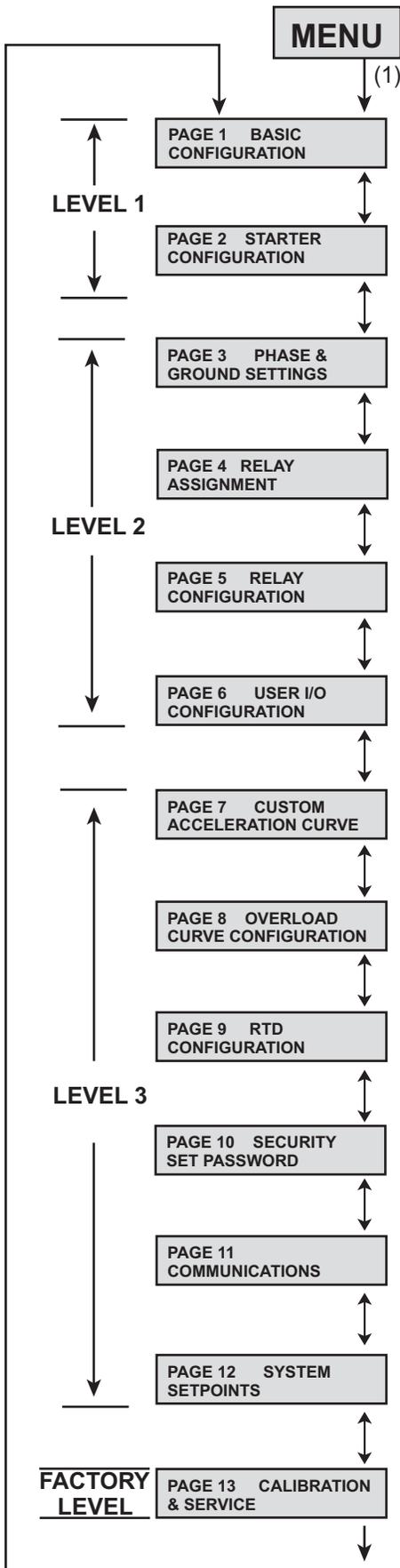


Keypad Operator Interface

Button	MENU	Toggle between the menu selection for metering and setpoint pages.
	RESET	Will clear the trip indicator and release the trip relay.
	ENTER	In the edit mode, press the ENTER pushbutton so the unit will accept the new programming information. When not in the edit mode, the ENTER pushbutton will toggle through the event indicator list (such as alarms or trips)
	HELP	Provides general help information about a specific setpoint or action.
	UP ARROW	Will scroll up through the setpoint and metering menu page. It will scroll to the top of the setpoint page or a section. In edit mode it will increase a setpoint in an incremental step or toggle through the available options in the setpoint.
	RIGHT ARROW	In the main menu the RIGHT ARROW button provides access to the setpoint page. For setpoint pages with multiple columns, the RIGHT ARROW will scroll the setpoint page to the right. When in edit mode it will shift one character to the right.
	DOWN ARROW	Will scroll down through the setpoint pages and down through the setpoints. In edit mode, it will decrement through values and toggle available options in the setpoint.
	LEFT ARROW	Will move to the left through setpoint pages with multiple columns. When in edit mode it will become the backspace key and will shift one character to the left.
LED	Power	Indicates control power is present
	Run	Indicates unit/motor is running
	Alarm	Lights in conjunction with AUX 2 to indicate event or warn of possible critical condition.
	Trip	Lights in conjunction with AUX 1 to indicate a critical condition has occurred.
	AUX 1-4	Auxiliary relays

Note: The directional arrow buttons are sensitive. In edit mode, if the buttons are held for a long period, the scrolling speed will increase.

4.2 Menu Navigation



Notes:

1. The MENU keys allow you to toggle the screens between the Setpoint Menu and the Metering Menu. Simply use the arrow keys to get to the different screens within each menu.
Example: To access Setpoint Page 3: PHASE & GROUND SETTINGS, press the MENU key once and the DOWN ARROW two times.
2. Levels 1, 2 and 3 indicate password protection levels for these setpoint pages.

4.2.1 Password Access

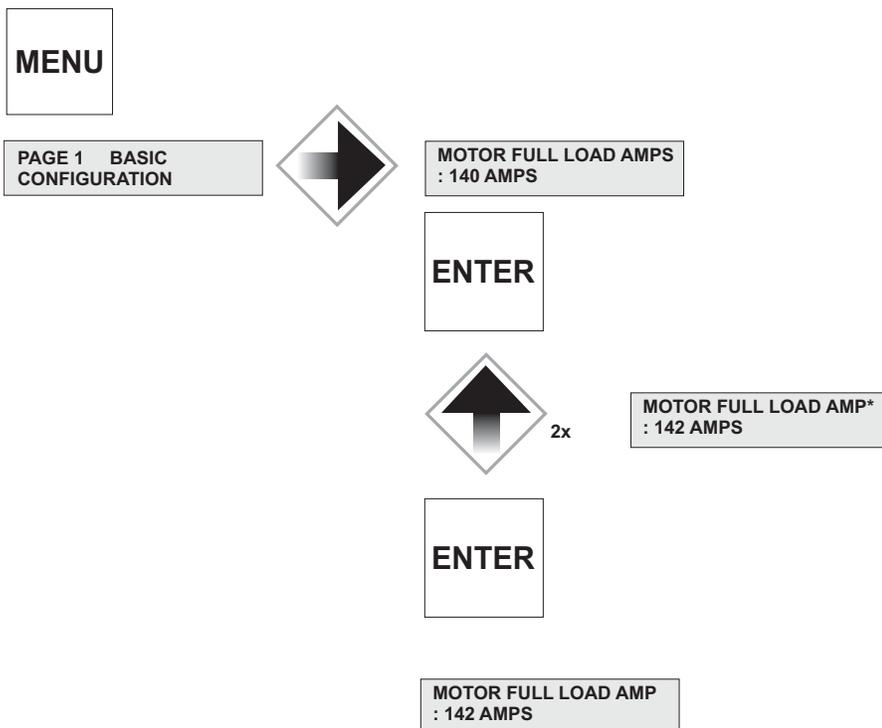
Screens in Level 1 of the setpoint menu can be changed without password access because they list basic motor information. Screens in Levels 2 and 3 require passwords because they provide more in-depth protection and control of the **TX Series** unit. The password in Levels 2 and 3 can be changed by the user.

NOTE: Setpoints can only be changed when the motor is in Stop/Ready Mode! The TX will not allow a start if it is still in the Edit Mode. When the unit is in the Edit Mode, a “*” is in the top right corner of the display.

4.2.2 Changing Setpoints

Example 1: Changing Motor FLA

- A. Press MENU button to display Setpoint Page 1, Basic Configuration
- B. Press the RIGHT ARROW you will view the screen Motor Full Load Amps.
- C. Press the ENTER button for edit mode. Note the asterisk (*) in the top right corner of the LCD screen that indicates Edit Mode.
- D. To change the value, select the UP ARROW or DOWN ARROW.
- E. To accept the new value, press the ENTER button. The unit will accept the changes and will leave the edit mode. Note the * is no longer in the top right corner of the LCD Display.



Chapter 5 - Setpoint Programming

The **TX Series** has twelve programmable setpoint pages which define the motor data, ramp curves, protection, I/O configuration and communications. In Section 5.1, the setpoint pages are outlined in chart form. In Section 5.2 the setpoint pages are illustrated and defined for easy navigation and programming. Note: Setpoints can only be changed when the starter is in the Ready Mode. Also the soft start will not start when it is in programming mode.

5.1 Setpoints Page List

The following charts list each Setpoint Page and the programmable functions within that page. The applicable section of the manual is also referenced.

5.1.1 Basic Configuration (Setpoint Page 1)

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Section
Page 1 Basic Configuration	Level 1 No Password Required	Motor Full Load Amps (FLA)	Model dependent	50 - 100% of Unit Max Current Rating (Model and Service Factor dependent)	SP1.1
		Service Factor	1.15	1.00 – 1.3	SP1.2
		Overload Class	10	O/L Class 5-30	SP1.3
		NEMA Design	B	A-F	SP1.4
		Insulation Class	B	A, B, C, E, F, H, K, N, S	SP1.5
		Line Voltage	480	208 to 600V	SP1.6
		Line Frequency	60	50 or 60 HZ	SP1.7

5.1.2 Starter Configuration (Setpoint Page 2)

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Section
Page 2 Starter Configuration	Level 1 No Password Required	Start Control Mode	Start Ramp 1	Jog, Start Ramp 1, Start Ramp 2, Custom Accel Curve, Start Disabled, Dual Ramp	SP2.1
		Jog Voltage	Off	5-75%, Off	SP2.2
		Start Ramp #1 Type	Voltage	Current, Voltage, Off	SP2.3
		Initial Voltage #1	20%	0-100%	
		Ramp Time #1	10 sec	0-120 sec	
		Current Limit #1	350% FLA	200-600 %	
		Initial Current #1	200% FLA	0-300%	
		Ramp Time #1	10 sec	0-120 sec	SP2.4
		Maximum Current #1	350% FLA	200-600 %	
		Start Ramp #2 Type	Off	Current, Voltage, Off	
		Initial Voltage #2	60%	0-100 %	
		Ramp Time #2	10 sec	0-120 sec	
		Current Limit #2	350 % FLA	200-600 %	SP2.5
		Initial Current #2	200% FLA	0-600 %	
		Ramp Time #2	10 sec	0-120 sec	
		Maximum Current #2	350% FLA	200-600 %	SP2.6
		Kick Start Type	Off	Voltage or Off	
		Kick Start Voltage	65%	10-100 %	
		Kick Start Time	0.50 sec	0.10-2.00	
		Deceleration	Disabled	Enabled or Disabled	SP2.7
Start Deceleration Voltage	60%	0-100 %			
Stop Deceleration Voltage	30%	0-59 %			
Deceleration Time	5 sec	1-60 sec	SP2.8		
Timed Output Time	Off	1-1000 sec, Off	SP2.8		
Run Delay Time	1 Sec	1-30 sec, Off	SP2.9		
At Speed Delay Time	1 Sec	1-30 sec, Off	SP2.9		
Bypass Pull-in Current	100% FLA	90 - 300%	SP2.10		

5.1.3 Phase and Ground Settings (Setpoint Page 3)

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Section
Page 3 Phase and Ground Settings	Level 2 Password Protection	Imbalance Alarm Level	15% FLA	5-30 %, Off	SP3.1
		Imbalance Alarm Delay	1.5 sec	1.0-20.0 sec	
		Imbalance Trip Level	20%	5-30 %, Off	SP3.2
		Imbalance Trip Delay	2.0 sec	1.0-20.0 sec	
		Undercurrent Alarm Level	Off	10-90 %, Off	SP3.3
		Undercurrent Alarm Delay	2.0 sec	1.0-60.0 sec	
		Overcurrent Alarm Level	Off	100-300 %, Off	SP3.4
		Overcurrent Alarm Delay	2.0 sec	1.0-20.0 sec	
		Overcurrent Trip Level	Off	100-300 %, Off	SP3.5
		Overcurrent Trip Delay	2.0 sec	1.0-20.0 sec	
		Phase Loss Trip	Disabled	Enabled or Disabled	SP3.6
		Phase Loss Trip Delay	0.1 sec	0-20.0 sec	
		Phase Rotation Detection	Enabled	Enabled Only	SP3.7
		Phase Rotation	ABC	ABC	
		Ground Fault Alarm Level	Off	5-90 %, Off	SP3.8
		Ground Fault Alarm Delay	0.1 sec	0.1-20.0 sec	
		Ground Fault Loset Trip Level	Off	5-90 %, Off	SP3.9
		Ground Fault Loset Trip Delay	0.5 sec	0.1-20 sec	
		Ground Fault Hiset Trip Level	Off	5-90 %, Off	SP3.10
		Ground Fault Hiset Trip Delay	0.008 sec	0.008-0.250 sec	
		Overvoltage Alarm Level	Off	5 -30%, Off	SP3.11
		Overvoltage Alarm Delay	1.0 sec	1.0-30.0 sec	
		Overvoltage Trip Level	Off	5-30%, Off	SP3.12
		Overvoltage Trip Delay	2.0 sec	1.0-30.0 sec	
		Undervoltage Alarm Level	Off	5-30%, Off	SP3.13
		Undervoltage Alarm Delay	1.0 sec	1.0-30.0 sec	
		Undervoltage Trip Level	Off	5-30%, Off	SP3.14
		Undervoltage Trip Delay	2.0 sec	1.0-30.0 sec	
		Line Frequency Trip Window	Disabled	0-6 Hz, Disabled	SP3.15
		Line Frequency Trip Delay	1.0 sec	1.0-20.0 sec	
		P/F Lead P/F Alarm	Off	0.1-1.00, Off	SP3.16
		P/F Lead Alarm Delay	1.0 sec	1-120 sec	
P/F Lead P/F Trip	Off	.01-1.00, Off	SP3.17		
P/F Lead Trip Delay	1.0 sec	1-120 sec			
P/F Lag P/F Alarm	Off	.01-1.00, Off	SP3.18		
P/F Lag Alarm Delay	1.0 sec	1-120 sec			
P/F Lag P/F Trip	Off	.01-1.00, Off	SP3.19		
P/F Lag Trip Delay	1.0 sec	1-120 sec			
Power Demand Period	10 min	1 - 60 min	SP3.20		
KW Demand Alarm Pickup	Off KW	Off, 1-100000			
KVA Demand Alarm Pickup	Off KVA	Off, 1-100000			
KVAR Demand Alarm Pickup	Off KVAR	Off, 1-100000			
Amps Demand Alarm Pickup	Off Amps	Off, 1-100000			

5.1.4 Relay Assignments (Setpoint Page 4)

Setpoint Page	Security Level	Description	Factory Setting			Range	Section
			1st	2nd	3rd		
Page 4 Relay Assignments	Level 2 Password Protection	O/L Trip	Trip Only	None	None	None Trip(AUX1) Alarm(AUX2) AUX3 AUX4	SP4.1
		I/B Trip	Trip	None	None		
		S/C Trip	Trip Only	None	None		
		Overcurrent Trip	Trip	None	None		
		Stator RTD Trip	Trip	None	None		
		Non-stator RTD Trip	Trip	None	None		
		G/F Hi Set Trip	Trip	None	None		
		G/F Lo Set Trip	Trip	None	None		
		Phase Loss Trip	Trip	None	None		
		Accel. Time Trip	Trip Only	None	None		
		Start Curve Trip	Trip Only	None	None		
		Over Frequency Trip	Trip	None	None		
		Under Frequency Trip	Trip	None	None		
		I*I*T Start Curve	Trip	None	None		
		Learned Start Curve	Trip	None	None		
		Phase Reversal	Trip	None	None		
		Overvoltage Trip	Trip	None	None		
		Undervoltage Trip	Trip	None	None		
		Power Factor Trip	Trip	None	None		
		Tach Accel Trip	Trip	None	None		
		Inhibits Trip	Trip	None	None		
		Shunt Trip	AUX3	None	None		
		Bypass Discrepancy	None	None	None		
		External Input #1	None	None	None		
		External Input #2	None	None	None		
		Dual Ramp	None	None	None		
		Thermostat	Trip	None	None		
		O/L Warning	Alarm	None	None		
		Overcurrent Alarm	Alarm	None	None		
		Ground Fault Alarm	Alarm	None	None		
		Under Current Alarm	Alarm	None	None		
		Motor Running	None	None	None		
		I/B Alarm	Alarm	None	None		
		Stator RTD Alarm	Alarm	None	None		
		Non-Stator RTD Alarm	Alarm	None	None		
		RTD Failure Alarm	Alarm	None	None		
		Self Test Fail	Trip	None	None		
		Thermal Register	Alarm	None	None		
		U/V Alarm	Alarm	None	None		
		O/V Alarm	Alarm	None	None		
Power Factor Alarm	Alarm	None	None				
KW Demand Alarm	Alarm	None	None				
KVA Demand Alarm	Alarm	None	None				
KVAR Demand Alarm	Alarm	None	None				
Amps Demand Alarm	Alarm	None	None				
Timed Output	None	None	None				
Run Delay Time	None	None	None				
At Speed	AUX4	None	None				

5.1.5 Relay Configuration (Setpoint Page 5)

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Section
Page 5 Relay Configuration	Level 2 Password Protection	Trip (AUX1) Fail-Safe	No	Yes or No	SP5.1
		Trip (AUX1) Relay Latched	Yes	Yes or No	SP5.2
		Alarm (AUX2) Fail-Safe	No	Yes or No	SP5.1
		Alarm (AUX2) Relay Latched	No	Yes or No	SP5.2
		AUX3 Relay Fail-Safe	No	Yes or No	SP5.1
		AUX3 Relay Latched	No	Yes or No	SP5.2
		AUX4 Relay Fail-Safe	No	Yes or No	SP5.1
		AUX4 Relay Latched	No	Yes or No	SP5.2

5.1.6 User I/O Configuration (Setpoint Page 6)

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Section
Page 6 User I/O Configuration	Level 2 Password Protection	Tachometer Scale Selection	Disabled	Enabled or Disabled	SP6.1
		Manual Tach Scale 4.0 mA:	0 RPM	0 - 3600	
		Manual Tach Scale 20.0 mA:	2000 RPM	0 - 3600	
		Tach Accel Trip Mode Select	Disabled	Underspeed, Overspeed or Disabled	SP6.2
		Tach Ramp Time	20 sec	1 - 120	
		Tach Underspeed Trip PT	1650 RPM	0-3600	
		Tach Overspeed Trip PT	1850 RPM	0 - 3600	
		Tach Accel Trip Delay	1 sec	1 - 60	
		Analog Output #1	RMS Current	Off, RPM 0-3600, Hottest Non-Stator RTD 0-200°C, Hottest Stator RTD 0 - 200°C, RMS Current 0 - 7500 A, % Motor Load 0 - 600%, kw 0 - 30000kw.	SP6.3
		Analog Output #1 4mA:	0	0-65535	
		Analog Output #1 20mA:	250	0-65535	
		Analog Output #2	% Motor Load	Same As Analog Input #1	SP6.4
		Analog Output #2 4mA:	0	0-1000%	
		Analog Output #2 20mA:	1000	0-1000%	
		User Programmable External Inputs			SP6.5
		External Input #1	Disabled	Enabled or Disabled	
		Name Ext. Input #1		User Defined, up to 15 Characters	
		External Input #1	NO	Normally Open or Closed	
		External Input #1	0 sec	0-60 sec	
		External Input #2	Disabled	Enabled or Disabled	
		Name Ext. Input #2		User Defined, up to 15 Characters	
		External Input #2 Type	NO	Normally Open or Closed	
		External Input #2 Time Delay	0 sec	0-60 sec	
		Dual Ramp	Dual Ramp	Enabled or Disabled or Dual Ramp	
		Name Ext. Input #3	Dual Ramp	User Defined, up to 15 Characters	
		Dual Ramp Type	NO	Normally Open or Closed	
		Dual Ramp Time Delay	0 sec	0-60 sec	
		Thermostat	Enabled	Enabled or Disabled	
		Name Ext. Input #4	Thermostat	User Defined, up to 15 Characters	
		Thermostat Type	NC	Normally Open or Closed	
Thermostat Time Delay	1 sec	0-60 sec			

5.1.7 Custom Acceleration Curve (Setpoint Page 7)

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Section
Page 7 Custom Acceleration Curve	Level 3 Password Protection	Custom Accel Curve	Disabled	Disabled, Curve A, B, or C	SP7.1
		Custom Curve A			
		Curve A Voltage Level 1	25%	0-100%	
		Curve A Ramp Time 1	2 sec	1-60 sec	
		Curve A Voltage Level 2	30%	0-100%	
		Curve A Ramp Time 2	2 sec	1-60 sec	
		Curve A Voltage Level 3	37%	0-100%	
		Curve A Ramp Time 3	2 sec	1-60 sec	
		Curve A Voltage Level 4	45%	0-100%	
		Curve A Ramp Time 4	2 sec	1-60 sec	
		Curve A Voltage Level 5	55%	0-100%	
		Curve A Ramp Time 5	2 sec	1-60 sec	
		Curve A Voltage Level 6	67%	0-100%	
		Curve A Ramp Time 6	2 sec	1-60 sec	
		Curve A Voltage Level 7	82%	0-100%	
		Curve A Ramp Time 7	2 sec	1-60 sec	
		Curve A Voltage Level 8	100%	0-100%	
		Curve A Ramp Time 8	2 sec	1-60 sec	
		Curve A Current Limit	350% FLA	200-600%	
		Custom Curve B		Same Programmable Data Points and Ranges as Custom Curve A	
Custom Curve C		Same Programmable Data Points and Ranges as Custom Curve A			

5.1.8 Overload Curve Configuration (Setpoint Page 8)

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Section
Page 8 Overload Curve Configuration	Level 3 Password Protection	Basic Run Overload Curve			SP8.1
		Run Curve Locked Rotor Time	O/L Class	1-30 sec, O/L Class	
		Run Locked Rotor Current	600% FLA	400-800%	
		Coast Down Timer	Disabled	1-60 Min, Disabled	
		Basic Start Overload Curve			SP8.2
		Start Curve Locked Rotor Time	O/L Class	1-30 sec, O/L Class	
		Start Locked Rotor Current	600% FLA	400-800%	
		Acceleration Time Limit	30 sec	1-300 sec, Disabled	
		Number of Starts Per Hour	Disabled	1-6, Disabled	
		Time Between Starts Time	Disabled	1-60 Min, Disabled	SP8.3
		Area Under Curve Protection	Disabled	Enabled or Disabled	
		Max I*T Start	368 FLA	1-2500 FLA*FLA*sec	
		Current Over Curve	Disabled	Disabled, Learn, Enabled	SP8.4
		Learned Start Curve Bias	10%	5-40%	
		Time for Sampling	30 sec	1-300 sec	

5.1.9 RTD Option Configuration (Setpoint Page 9)

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Section
Page 9 RTD Configuration	Level 3 Password Protection	Use NEMA Temp for RTD Values	Disabled	Enabled or Disabled	SP9.1
		# of RTD Used for Stator	4	0-6	SP9.2
		RTD Voting	Disabled	Enabled or Disabled	SP9.3
		Stator Phase A1 Type	Off	120 OHM NI, 100 OHM NI, 100 OHM PT, 10 OHM CU	SP9.4
		RTD #1 Description	Stator A1	User defined, Up to 15 Characters	
		Stator Phase A1 Alarm Level	Off	0-240C (32-464F), Off	
		Stator Phase A1 Trip Level	Off	0-240C (32-464F), Off	
		Stator Phase A2 Type	Off	Same as Stator Phase A1	
		RTD #2 Description	Stator A2	User defined, Up to 15 Characters	
		Stator Phase A2 Alarm	Off	0-240C (32-464F), Off	
		Stator Phase A2 Trip Level	Off	0-240C (32-464F), Off	
		Stator Phase B1 Type	Off	Same as Stator Phase A1	
		RTD #3 Description	Stator B1	User defined, Up to 15 Characters	
		Stator Phase B1 Alarm Level	Off	0-240C (32-464F), Off	
		Stator Phase B1 Trip Level	Off	0-240C (32-464F), Off	
		Stator Phase B2 Type	Off	Same as Stator Phase A1	
		RTD #4 Description	Stator B2	User defined, Up to 15 Characters	
		Stator Phase B2 Alarm Level	Off	0-240C (32-464F), Off	
		Stator Phase B2 Trip Level	Off	0-240C (32-464F), Off	
		Stator Phase C1 Type	Off	Same as Stator Phase A1	
		RTD #5 Description	Stator C1	User defined, Up to 15 Characters	
		Stator Phase C1 Alarm Level	Off	0-240C (32-464F), Off	
		Stator Phase C1 Trip Level	Off	0-240C (32-464F), Off	
		Stator Phase C2 Type	Off	Same as Stator Phase A1	
		RTD #6 Description	Stator C2	User defined, Up to 15 Characters	
		Stator Phase C2 Alarm Level	Off	0-240C (32-464F), Off	
		Stator Phase C2 Trip Level	Off	0-240C (32-464F), Off	
		End Bearing Type	Off	Same as Stator A1	
		RTD #7 Description	End Bearing	User defined, Up to 15 Characters	
		End Bearing Alarm Level	Off	0-240C (32-464F), Off	
		End Bearing Trip Level	Off	0-240C (32-464F), Off	
		Shaft Bearing Type	Off	Same as Stator Phase A1	
		RTD #8 Description	Shaft Bearing	User defined, Up to 15 Characters	
Shaft Bearing Alarm Level	Off	0-240C (32-464F), Off			
Shaft Bearing Trip Level	Off	0-240C (32-464F), Off			
RTD #9 Type	Off	Same as Stator Phase A1			
RTD #9 Description	User defined	User defined, Up to 15 Characters			
RTD #9 Alarm Level	Off	0-240C (32-464F), Off			
RTD #9 Trip Level	Off	0-240C (32-464F), Off			

5.1.9 RTD Option Configuration Page 9 Cont'd

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Section
Page 9 RTD Configuration	Level 3 Password Protection	RTD #10 Type	Off	Same as Stator Phase A1	SP9.4
		RTD #10 Description	User defined	User defined, Up to 15 Characters	
		RTD #10 Alarm Level	Off	0-240C (32-464F), Off	
		RTD #10 Trip Level	Off	0-240C (32-464F), Off	
		RTD #11 Type	Off	Same as Stator Phase A1	
		RTD #11 Description	User defined	User defined, Up to 15 Characters	
		RTD #11 Alarm Level	Off	0-240C (32-464F), Off	
		RTD #11 Trip Level	Off	0-240C (32-464F), Off	
		RTD #12 Type	Off	Same as Stator Phase A1	
		RTD #12 Description	User defined	User defined, Up to 15 Characters	
		RTD #12 Alarm Level	Off	0-240C (32-464F), Off	
		RTD #12 Trip Level	Off	0-240C (32-464F), Off	

5.1.10 Security Set Password Page 10

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Section
Page 10	Level 3	Set Level 2 Password	100	000 – 999 Three Digits	SP10.1
		Set Level 3 Password	1000	0000 – 9999 Four Digits	SP10.2

5.1.11 Communications Page 11

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Section
Page 11 Communications	Level 3 Password Protection	Set Front Baud Rate	9.6 KB/sec	2.4, 4.8, 9.6, 19.2, 38.4 KB/sec	SP11.1
		Set Modbus Baud Rate	9.6 KB/sec	2.4, 4.8, 9.6, 19.2, 38.4 KB/sec	SP11.2
		Modbus Address Number	247	1 – 247	SP11.3
		Set Access Code	1	1 – 999	SP11.4
		Set Link Baud Rate	38.4 KB/sec	2.4, 4.8, 9.6, 19.2, 38.4 KB/sec	SP11.5
		Remote Start/Stop	Disabled	Enabled or Disabled	SP11.6

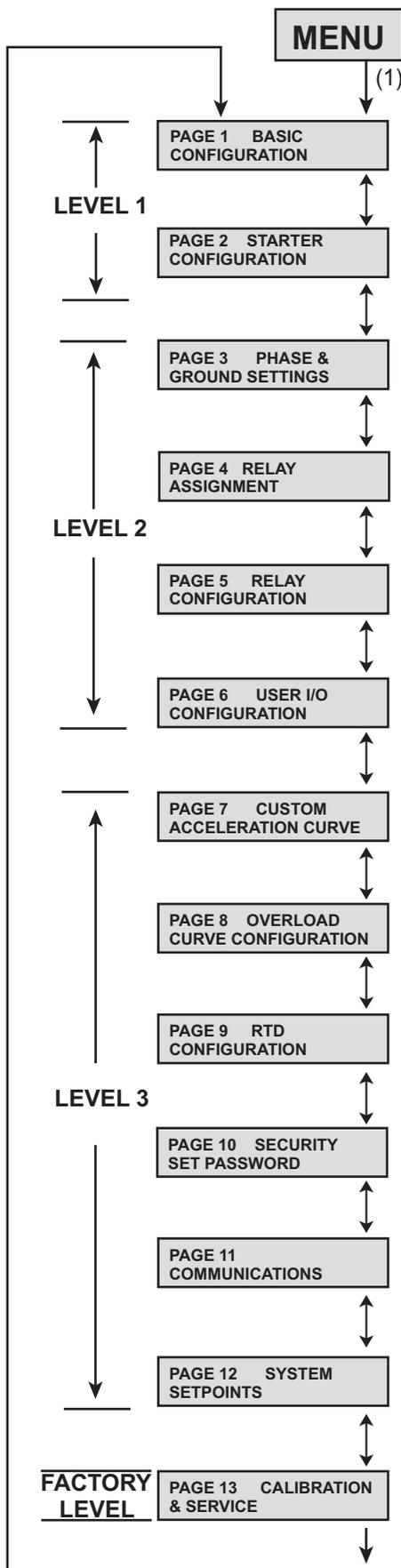
5.1.12 System (Setpoint Page 12)

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Section
Page 12 System Setpoints	Level 3 Password Protection	Default Display Screen			SP12.1
		Metering Data Page #	1	Enter Metering Page (1-4)	
		Metering Data Screen #	1	Enter Metering Screen Page 1(1-10) Page 2 (1-11) Page 3 (1 - 29) Page 4 (1 - 6)	
		Alarms			SP12.2
		RTD Failure Alarm	Disabled	Enabled or Disabled	
		Thermal Register Alarm	90%	Off, 40-95%	
		Thermal Alarm Delay	10 sec	1-20 sec	
		Thermal Register Setup Info			SP12.3
		Cold Stall Time	O/L Class	O/L Class (5-30) or 4-40 second time delay	
		Hot Stall Time	½ O/L Class	½ O/L Class, 4-40 sec	
		Stopped Cool Down Time	30 Min	10-300 Min	
		Runing Cool Down Time	15 Min	10-300 Min	
		Relay Measured Cool Rates	Disabled	Enabled or Disabled	
		Thermal Register Minimum	15%	10-50%	
		Motor Design Ambient Temp	40C	10-90C	
		Motor Design Run Temperature	80% Max	50-100% of Motor Stator Max Temp	
		Motor Stator Max Temp	INS CLS	INS CLS, 10-240 C	
		I/B Input to Thermal Register	Enabled	Enabled Only	SP12.4
		Use Calculated K or Assign	7	1-50, On	
		Press Enter to Clr Thermal Register			

5.1.13 Calibration and Service (Setpoint Page 13)

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Section
Page 13 Calibration & Service	FACTORY USE ONLY	Set Date and Time (DDMMYY:HHMM)	FACTORY SET; ###/###/### ##:##		SP13.1
		Enter Date (DDMMYYYY)	FACTORY SET; ###/###/####	D=1-31, M=1-12, Y=1970-2069	
		Enter Time (HH:MM)	FACTORY SET; ##:##	H=00-23, M=0-59	
		Model # Firmware REV. #	FACTORY SET; #####	Display Only, Cannot be changed	SP13.2
		Press Enter to Access Factory Settings		Available to Qualified Factory Personnel	SP13.3

5.2 Setpoint Menu

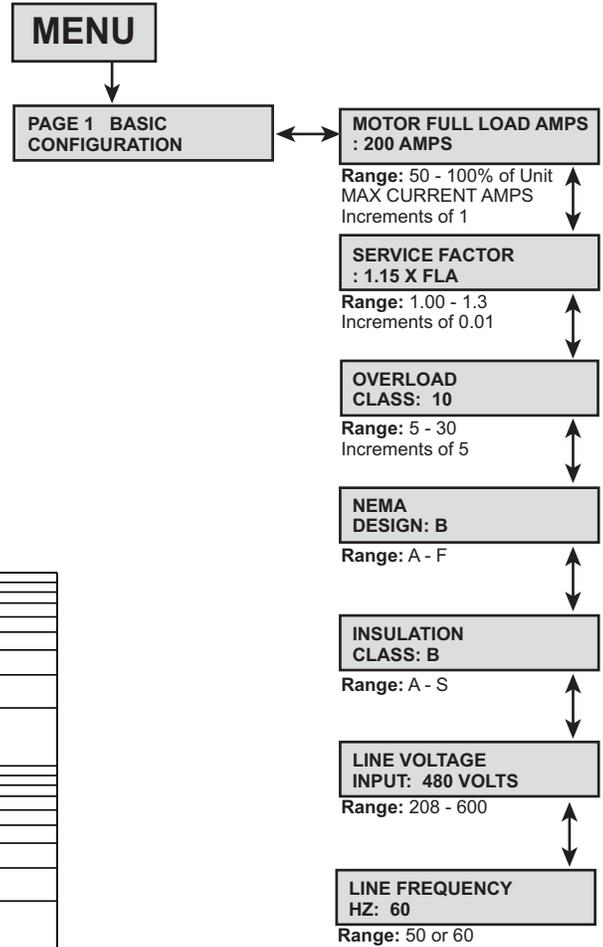


Note:

1. Push MENU key to toggle the screens between Setpoint Menu and Metering Menu.
2. Follow the arrow keys to get to different screens.
Example: For Page 3 PHASE & GROUND SETTINGS, press the MENU key and the DOWN ARROW two times.

SP.1 Basic Configuration (Setpoint Page 1)

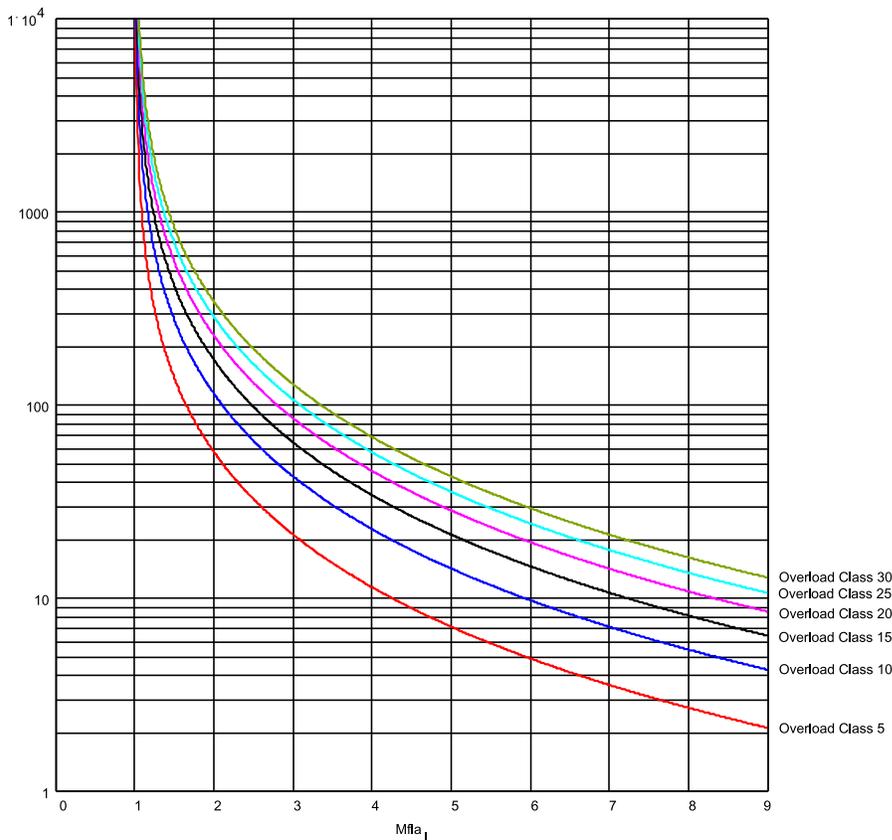
In Setpoint Page 1, the TX is looking for the following basic nameplate data of the motor.



SP1.1 Motor Full Load Amps: Allows the user to enter the motor's FLA rating. Range of adjustment is 50 - 100% (less programmed service factor).

SP1.2 Service Factor: Sets the pickup point on the overload curve as defined by the programmed motor full load current. Ex: If the motor FLA is 100 and the service factor is 1.15, the TX overload pickup point will be 115 Amps.

SP1.3 Overload Class: Choose the motor protection overload class, range from 5-30.
Ex: Overload Class 10 will trip in 10 seconds at six times FLA.



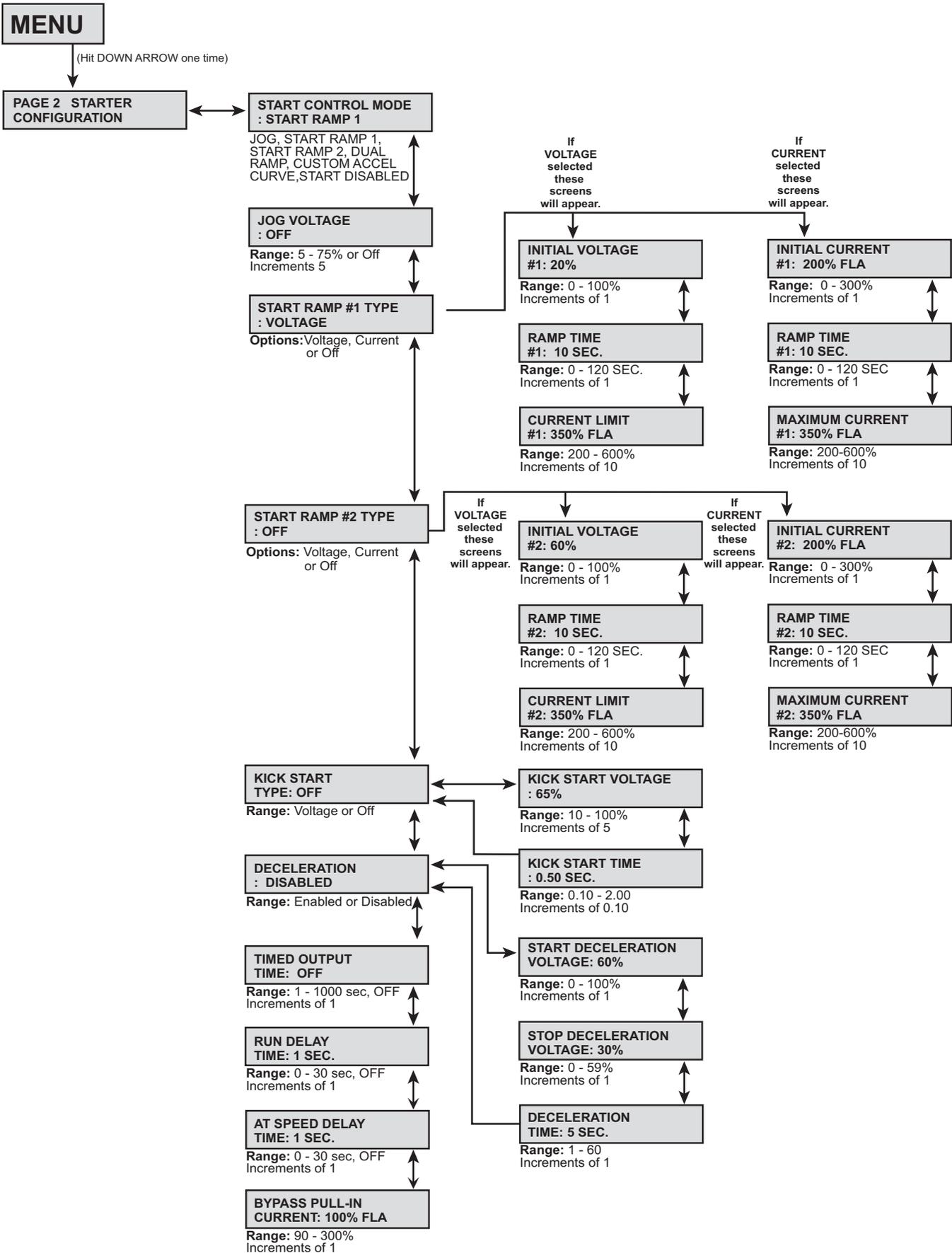
SP1.4 NEMA design: The motor design maximum allowed slip (Select from Class A through F).

SP1.5 Insulation Class: The motor insulation temperature class (Select A, B, C, E, F, H, K, N or S).

SP1.6 Line Voltage Inut: Applied system nominal voltage.

SP1.7 Line Frequency: The user may choose either 50 Hz or 60 Hz.

SP.2 Starter Configuration (Setpoint Page 2)



SP.2 Starter Configuration (Setpoint Page 2)

Provides multiple choices for starting ramps that can be selected for particular loads and applications.

SP2.1 Start Control Mode: Dual Ramp, Custom Accel Curve, Tach Ramp, Jog Voltage, Start Ramp 1, Start Ramp 2.

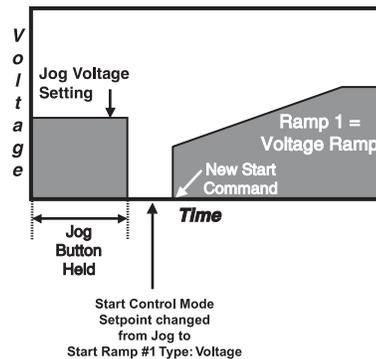
- **Dual Ramp:** The dual ramp mode works in conjunction with External Input #3. This allows the user to switch between the two start ramps without having to reconfigure the start mode. (For details on configuring External Input #3 for DUAL RAMP see Setpoint Page 6.)
- **Custom Accel Curve:** Allows the user to custom design the acceleration start curve to the application. (See setpoint page 7 for configuration setup.) *Note:* If Custom Accel Curve has not been enabled in setpoint page 7, the **TX** will ignore the start control mode and read this setpoint as disabled.
- **Tach Ramp:** See setpoint page 6 for configuration setup of tachometer input. (Pending)

SP2.2 Jog Voltage: The voltage level necessary to cause the motor to slowly rotate.

SP2.3 Start Ramp 1 Type: The ramp type can be setup for either Voltage or Current. If Voltage is selected, initial voltage, ramp time and current limit are adjustable. If Current is selected, initial current, ramp time and maximum current are adjustable.

Start Ramp 1 Type: Voltage

- **Voltage Ramping** is the most reliable starting method, because the starter will eventually reach an output voltage high enough to draw full current and develop full torque. This method is useful for applications where the load conditions change frequently and where different levels of torque are required. Typical applications include material handling conveyors, positive displacement pumps and drum mixers. Voltage is increased from a starting point (Initial Torque) to full voltage over an adjustable period of time (Ramp Time). To achieve Voltage Ramping, select VOLTAGE for the START RAMP #1 TYPE setpoint and set CURRENT LIMIT #1 setpoint to 600% (the maximum setting). Since



this is essentially Locked Rotor Current on most motors, there is little or no Current Limit effect on the Ramp profile.

- **Voltage Ramping with Current Limit** is the most used curve and is similar to voltage ramping. However, it adds an adjustable maximum current output. Voltage is increased gradually until the setting of the Maximum Current Limit setpoint is reached. The voltage is held at this level until the motor accelerates to full speed. This may be necessary in applications where the electrical power is limited. Typical applications include portable or emergency generator supplies, utility power near the end of a transmission line and utility starting power demand restrictions. *Note:* Using Current Limit will override the Ramp Time setting if necessary, so use this feature when acceleration time is not critical. To achieve Voltage Ramping with Current Limit, select VOLTAGE for the START RAMP #1 setpoint and set CURRENT LIMIT #1 setpoint to a desired lower setting, as determined by your application requirements.

Start Ramp 1 Type: Current

Current Ramping (Closed Loop Torque Ramping) is used for smooth linear acceleration of output torque. Output voltage is constantly updated to provide the linear current ramp, and therefore the available torque is maximized at any given speed. This is for applications where rapid changes in torque may result in load damage or equipment changes. Typical applications include overland conveyors if belt stretching occurs; fans and mixers if blade warping is a problem; and material handling systems if stacked products fall over or break. This feature can be used with or without the Maximum Current Limit setting. To achieve Current Ramping select CURRENT for START RAMP #1 TYPE setpoint and the MAXIMUM CURRENT #1 setpoint to the desired level.

Current Limit Only: (Current Step) start uses the Current Limit feature exclusively. This method of starting eliminates the soft start voltage/current ramp and instead, maximizes the effective application of motor torque within the limits of the motor. In this mode, setpoint RAMP TIME #1 is set to zero (0), so the output current jumps to the current limit setting immediately. Typically used in with a limited power supply, when starting a difficult load such as a centrifuge or deep well pump, when the motor capacity is barely adequate (stall condition or overloading occurs) or if other starting modes fail. Since ramp times are set to zero (0). START RAMP #1 TYPE is set to

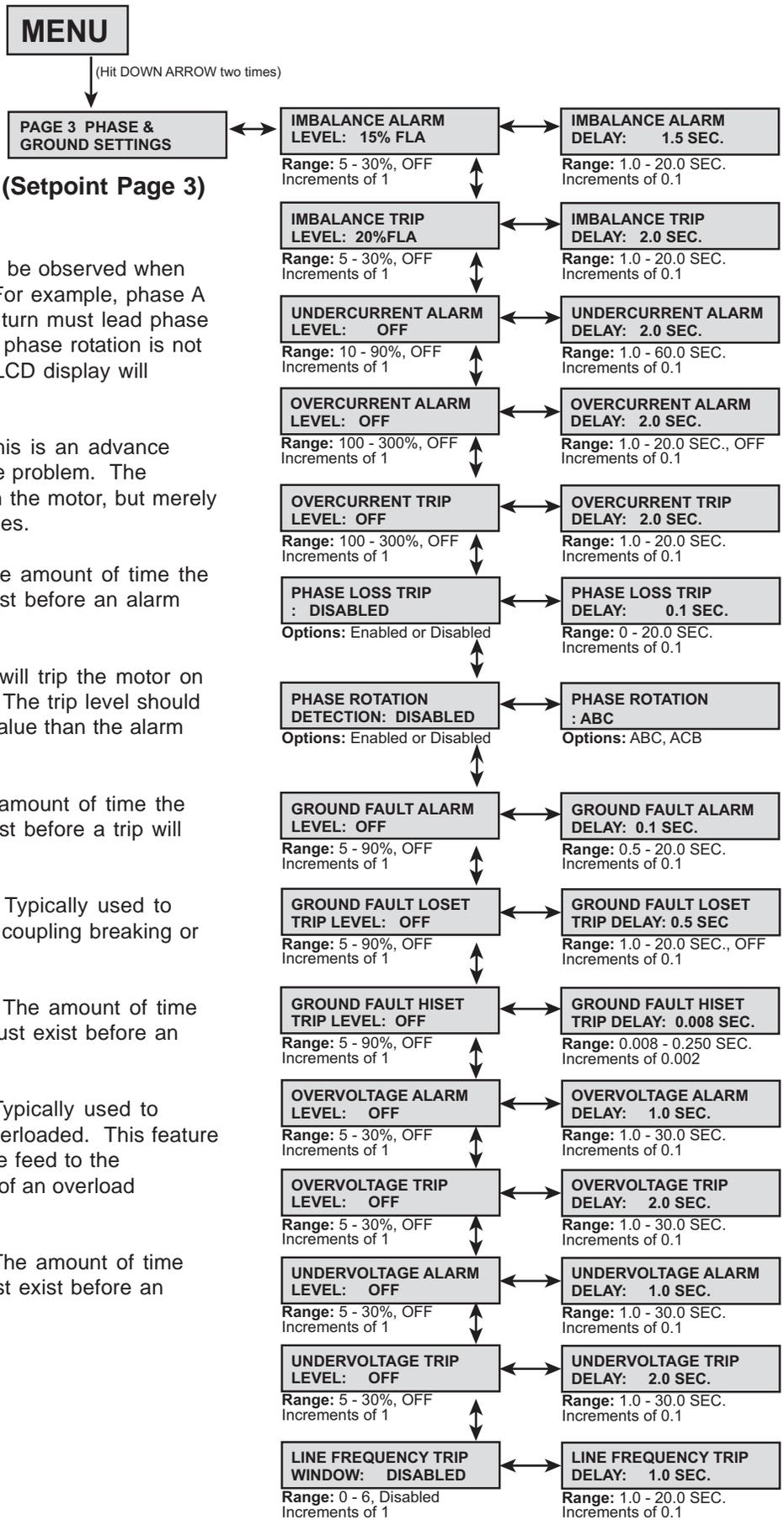
either VOLTAGE or CURRENT.

- **Initial Torque (Initial Voltage #1 or Initial Current #1):** Sets the initial start point of either the Voltage Ramp or the Current Ramp. Every load requires some amount of torque to start from a standstill. It is inefficient to begin ramping the motor from zero every time, since between zero and the WK2 break-away torque level, no work is being performed. The initial torque level should be set to provide enough torque to start rotating the motor shaft, enabling a soft start and preventing torque shock damage. Setting this start point too high will not damage the starter, but may reduce or eliminate the soft start effect.
- **Ramp Time #1:** Sets the maximum allowable time for ramping the initial voltage or current (torque) setting to either of the following:
 - 1) the Current Limit setting when the motor is still accelerating, or
 - 2) full output voltage if the Current Limit is set to maximum.
 Increasing the ramp time softens the start process by gradually increasing the voltage or current. Ideally, the ramp time should be set for the longest amount of time the application will allow (without stalling the motor). Some applications require a short ramp time due to the mechanics of the system. (i.e., centrifugal pumps, because pump problems can occur due to insufficient torque).
- **Current Limit:** Sets the maximum motor current the starter will allow during Ramping. As the motor begins to ramp, the Current Limit feature sets a ceiling at which the current draw is held. Current Limit remains in effect until the following occurs:
 - 1) the motor reaches full speed (detected by the At-Speed detection circuit) or
 - 2) the Overload Protection trips on Motor Thermal Overload.
 Once the motor reaches full speed, the Current Limit feature becomes inactive.

In the Voltage Ramp Profile, the voltage output is increased until it reaches the Current Limit. Ramp time is the maximum amount of time it takes for the voltage to increase until the Current Limit setting takes over. With some load conditions, the Current Limit is reached before the Ramp Time expires.

The Current Ramp profile varies the output voltage to provide a linear increase in current up to the Maximum Current setpoint value. A closed loop feedback of motor current maintains the Current Ramp profile.

- SP2.4 Start Ramp 2:** The same options and screen setups as Start Ramp 1. Note: CUSTOM ACCEL CURVE overrides the voltage or current start in Ramps 1 and 2 when selected to be the start control mode.
- SP2.5 Kick Start:** Used as an initial energy burst in applications with high friction loads.
 - **Kick Start Voltage:** The initial voltage (as a percent of full voltage value) that is needed to start the motor (i.e. Breakaway or Initial Torque).
 - **Kick Start Time:** The time the initial torque boost is applied.
- SP2.6 Deceleration:** Allows the motor to gradually come to a soft stop.
 - **Start Deceleration Voltage:** The first part of the deceleration ramp. The **TX** initially drops to this voltage level upon receiving a STOP command. (Represented as a percent of voltage value.)
 - **Stop Deceleration Voltage:** The drop-off point of the deceleration ramp. (Percent of voltage value.)
 - **Deceleration Time:** Decel ramp time.
- SP2.7 Timed Output:** Used with an AUX relay. When enabled, and upon a start command, it energizes the assigned relay for the programmed time. At the end of the programmed time the relay de-energizes. See Setpoint Page 4.
- SP2.8 Run Delay Time:** Used with an AUX3 relay. When enabled, and upon a start command, it waits until the programmed time has expired. The relay energizes and remains so until a stop command is received. It de-energizes upon receiving a stop command. See Setpoint Page 4.
- SP2.9 At Speed Delay Time:** Used with an AUX4 relay, it waits until after the motor reaches the end of ramp and the programmed delay time has expired. The relay energizes until a stop command has been received. See Setpoint Page 4.



SP.3 Phase & Ground Settings (Setpoint Page 3) (Security Level: 2)

Note: Proper phase sequence must be observed when connecting the input power. For example, phase A must lead phase B, which in turn must lead phase C by 120° respectively. If the phase rotation is not correct, a fault light and the LCD display will indicate the problem.

SP3.1 Imbalance Alarm Level: This is an advance warning of a phase imbalance problem. The problem may not be a fault in the motor, but merely caused by imbalanced voltages.

- **Imbalance Alarm Delay:** The amount of time the imbalance condition must exist before an alarm occurs.

SP3.2 Imbalance Trip Level: This will trip the motor on excessive phase imbalance. The trip level should be programmed to a higher value than the alarm level.

- **Imbalance Trip Delay:** The amount of time the imbalance condition must exist before a trip will occur.

SP3.3 Undercurrent Alarm Level: Typically used to warn of possible load loss, a coupling breaking or other mechanical problems.

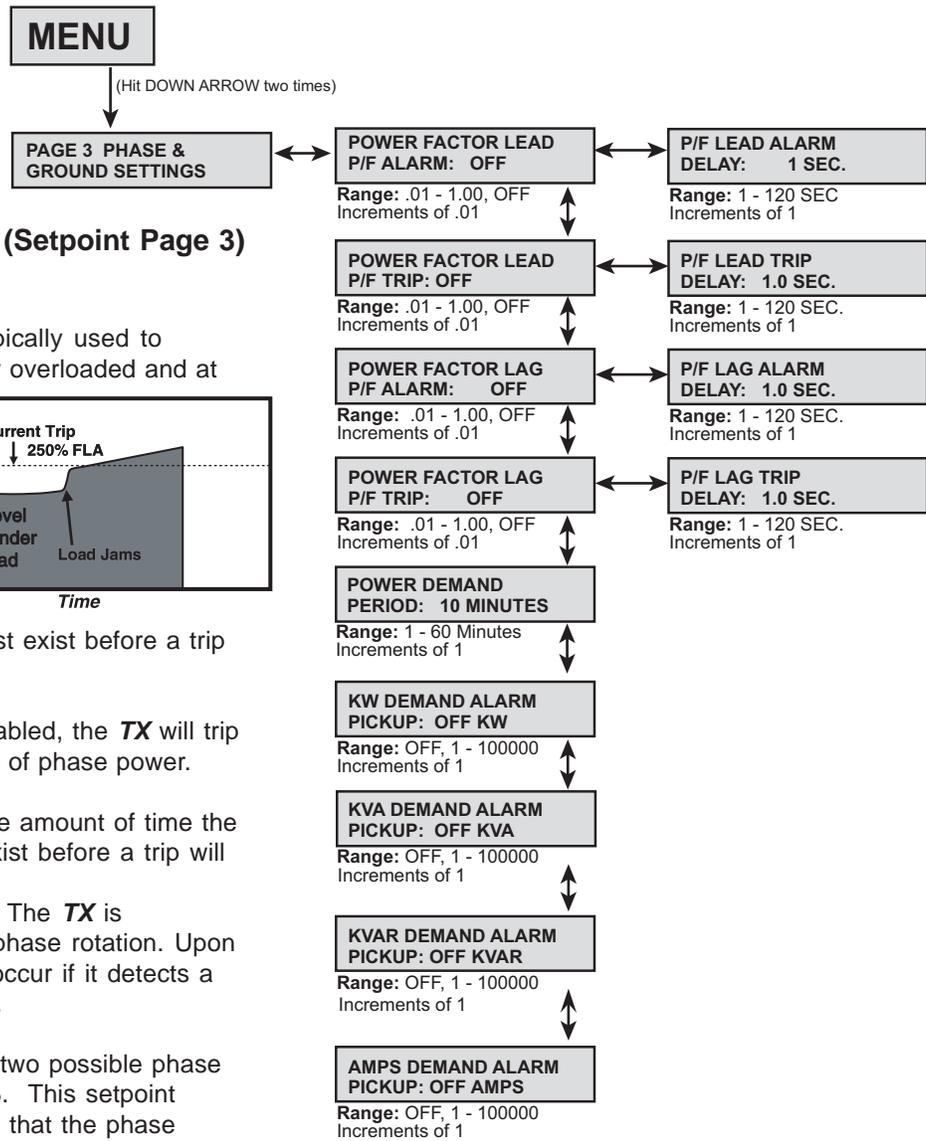
- **Undercurrent Alarm Delay:** The amount of time the undercurrent condition must exist before an alarm will occur.

SP3.4 Overcurrent Alarm Level: Typically used to indicate when the motor is overloaded. This feature can be used to either stop the feed to the equipment or warn operators of an overload condition.

- **Overcurrent Alarm Delay:** The amount of time the overcurrent condition must exist before an alarm will occur.

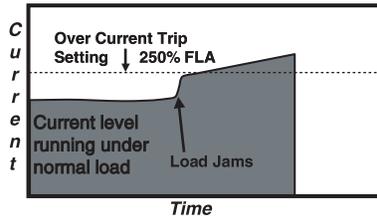
SP.3 Phase & Ground Settings (Setpoint Page 3)

continued



**SP.3 Phase & Ground Settings (Setpoint Page 3)
(Security Level: 2)**

SP3.5 Overcurrent Trip Level: Typically used to indicate the motor is severely overloaded and at which point a trip occurs.



- **Overcurrent Trip Delay:** The amount of time the overcurrent condition must exist before a trip will occur.

SP3.6 Phase Loss Trip: When enabled, the TX will trip the motor off-line upon a loss of phase power.

- **Phase Loss Trip Delay:** The amount of time the phase loss condition must exist before a trip will occur.

SP3.7 Phase Rotation Detection: The TX is continuously monitoring the phase rotation. Upon a start command, a trip will occur if it detects a change in the phase rotation.

- **Phase Rotation:** There are two possible phase rotation options: ABC or ACB. This setpoint monitors the wiring to ensure that the phase rotation is correct. To view the present phase rotation, go to Metering Page1, screen number 4.

SP3.8 Ground Fault Alarm: Typically used to warn of low level ground current leakage

- **Ground Fault Alarm Delay:** The amount of time that the ground fault condition must exist before an alarm will occur.

SP3.9 Ground Fault Loset Trip Level: Typically used to trip the motor on a low level of ground current leakage. This setpoint is intended to detect high impedance faults. (Pending)

- **Ground Fault Loset Trip Delay:** The amount of time that the ground fault condition must exist before a trip will occur.

SP3.10 Ground Fault Hiset Trip Level: Used to trip the motor (within milliseconds) upon detecting a high level of ground current leakage. This setpoint is intended to detect low impedance faults. (Pending)

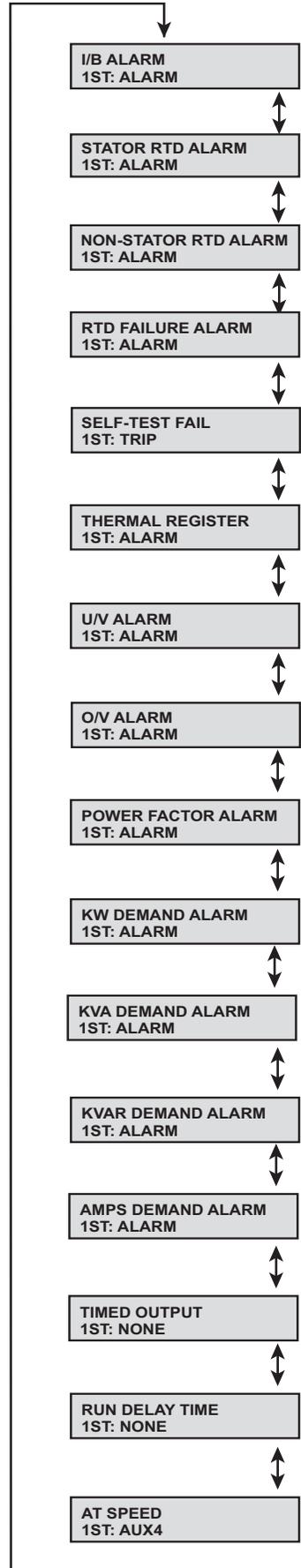
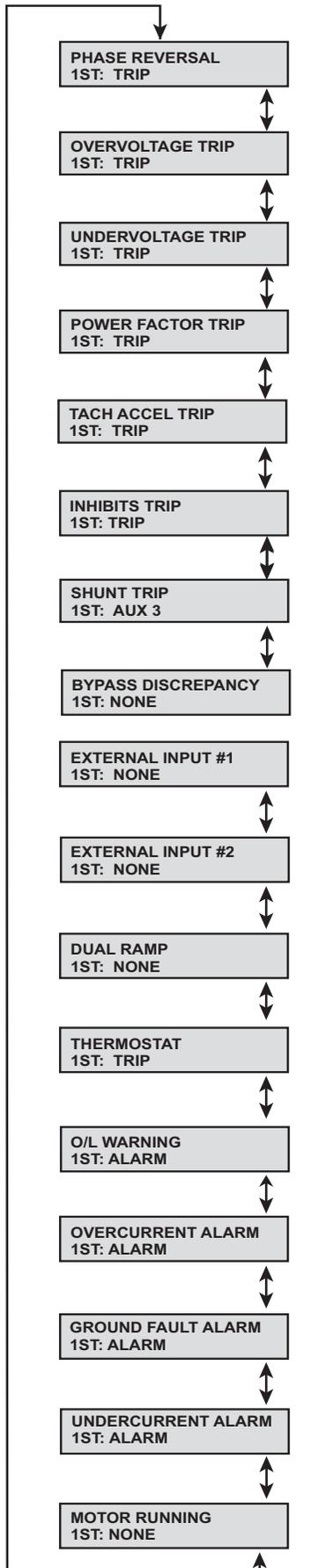
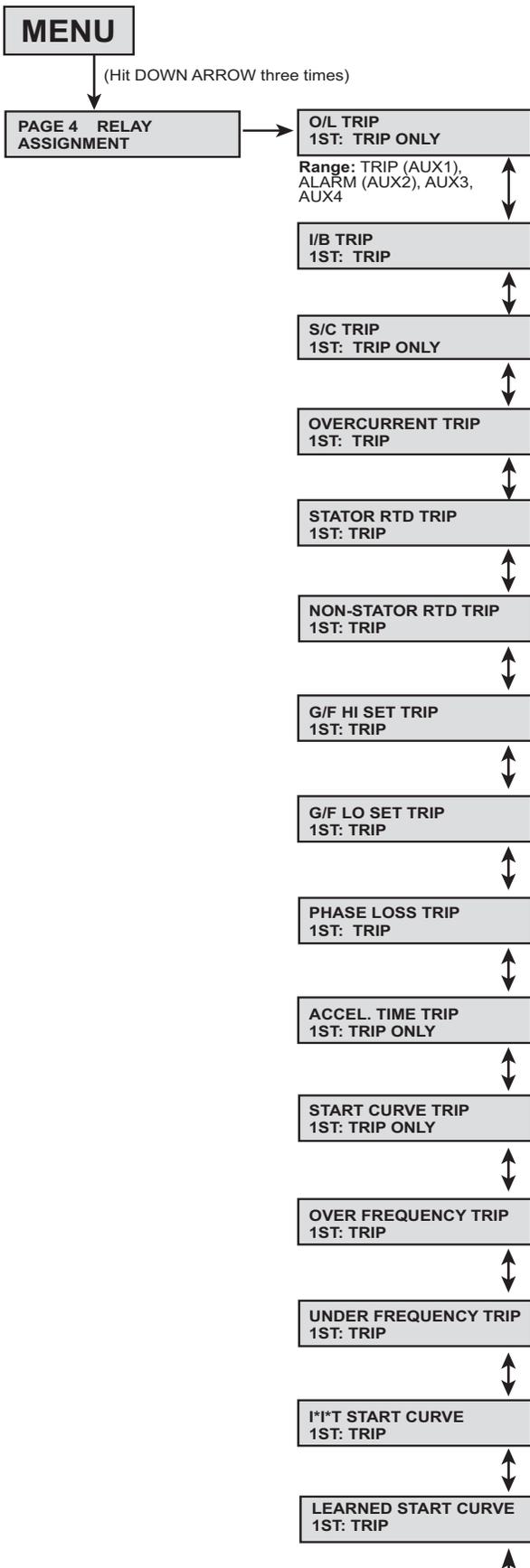
- **Ground Fault Hiset Trip Delay:** The amount of time that the ground fault condition must exist before a trip will occur.

SP3.11 Overvoltage Alarm Level: Typically used to indicate when the line voltage is too high. This is an alarm level.

- **Overvoltage Alarm Delay:** The amount of time that the overvoltage condition must exist before a trip will occur.

- SP3.12 Overvoltage Trip Level:** Typically used to indicate that the line voltage is too high and at which point a trip occurs
- **Overvoltage Trip Delay:** The amount of time that the overvoltage condition must exist before a trip will occur.
- SP3.13 Undervoltage Alarm Level:** Typically used to indicate when the line voltage is too low. This is an alarm level.
- **Undervoltage Alarm Delay:** The amount of time that the overvoltage condition must exist before a trip will occur.
- SP3.14 Undervoltage Trip Level:** Typically used to indicate that the line voltage is too low and at which point a trip occurs
- **Undervoltage Trip Delay:** The amount of time that the undervoltage condition must exist before a trip will occur.
- SP3.15 Line Frequency Trip Window:** The acceptable amount of drift above or below the line frequency before a trip is generated.
- **Line Frequency Trip Delay:** The amount of time that the frequency drift condition must exist beyond the window before a trip will occur.
- SP3.16 Power Factor Lead Alarm:** Typically used to indicate a leading power factor.
- **Power Factor Lead Alarm Delay:** The amount of time that the power factor lead condition must exist beyond the window before a trip will occur.
- SP3.17 Power Factor Lead Trip:** The acceptable amount of power factor lead before a trip is generated.
- **Power Factor Lead Delay:** The amount of time that the power factor lead condition must exist beyond the window before a trip will occur.
- SP3.18 Power Factor Lag Alarm:** Typically used to indicate a lagging power factor.
- **Power Factor Lag Alarm Delay:** The amount of time that the power factor lagging condition must exist beyond the window before a trip will occur.
- SP3.19 Power Factor Lag Trip:** The acceptable amount of power factor lag before a trip is generated.
- **Power Factor Lag Delay:** The amount of time that the power factor lag condition must exist beyond the window before a trip will occur.
- SP3.20 Power Demand Period:** The TX Series measures the demand of the motor for several parameters (current, kW, kvar, kVA). The demand values of motors assists in energy management programs where processes may be altered or scheduled to reduce overall demand. Demand is calculated by a programmed amount of time where current, kW, kvar and kva samples are taken and then averaged and stored to assess demand.

SP.4 Relay Assignment (Setpoint Page 4)



SP.4 Relay Assignment (Setpoint Page 4)
(Security Level: 2)

All of the protection functions of the **TX** are user programmable to an output relay. The factory will ship with all tripping functions assigned to TRIP (AUX1) relay, and all alarm functions to ALARM (AUX2) relay. Note: AUX1 - 4 are Factory Set and should not be changed.

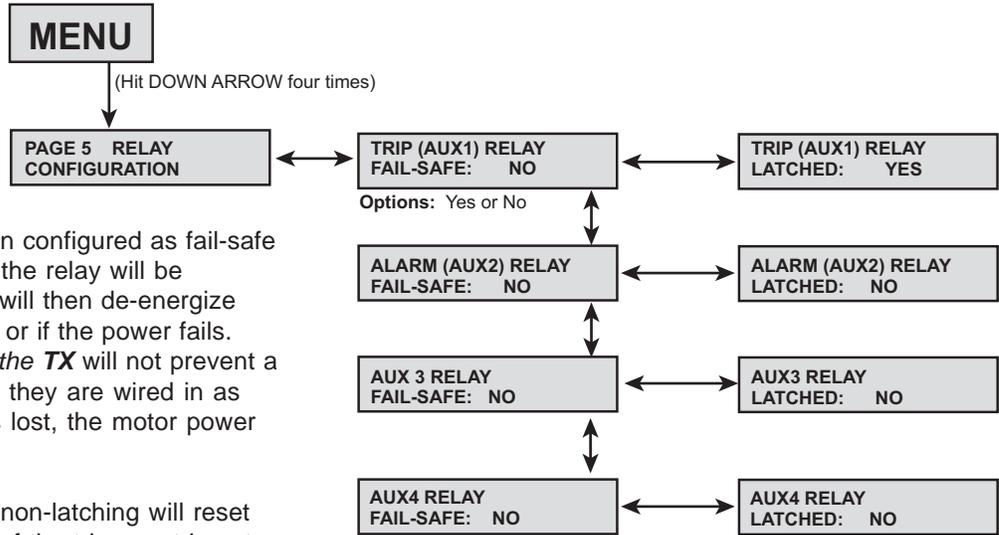
SP4.1 The following is a list of all the user programmable functions.

Note: The Relay Assignments are factory defaults.

<u>FUNCTIONS</u>	<u>RELAY ASSIGNMENT</u>
IMBALANCE TRIP	TRIP (AUX1)
SHORT CIRCUIT TRIP	TRIP (AUX1)
OVERCURRENT TRIP	TRIP (AUX1)
STATOR RTD TRIP	TRIP (AUX1)
NON-STATOR RTD TRIP	TRIP (AUX1)
GROUND FAULT HI SET TRIP	TRIP (AUX1)
GROUND FAULT LO SET TRIP	TRIP (AUX1)
PHASE LOSS TRIP	TRIP (AUX1)
ACCELERATION TIME	TRIP (AUX1)
START CURVE TRIP	TRIP (AUX1)
OVER FREQUENCY TRIP	TRIP (AUX1)
UNDER FREQUENCY TRIP	TRIP (AUX1)
I**T START CURVE	TRIP (AUX1)
LEARNED START CURVE	TRIP (AUX1)
PHASE REVERSAL	TRIP
OVERVOLTAGE TRIP	TRIP
UNDERVOLTAGE TRIP	TRIP
POWER FACTOR TRIP	TRIP
TACH ACCEL TRIP	TRIP
INHIBITS TRIP	TRIP
SHUNT TRIP	AUX 3
BYPASS DISCREPANCY	NONE
EXTERNAL INPUT 1	NONE
EXTERNAL INPUT 2	NONE
DUAL RAMP	NONE
THERMOSTAT	TRIP (AUX 1)
OVERLOAD WARNING	ALARM (AUX2)
OVERCURRENT ALARM	ALARM (AUX2)
GROUND FAULT ALARM	ALARM (AUX2)
UNDERCURRENT ALARM	ALARM (AUX2)
MOTOR RUNNING	NONE
IMBALANCE ALARM	ALARM (AUX2)
STATOR RTD ALARM	ALARM (AUX2)
NON-STATOR RTD ALARM	ALARM (AUX2)
RTD FAILURE ALARM	ALARM (AUX2)
SELF TEST FAIL	TRIP (AUX1)
THERMAL REGISTER	ALARM (AUX2)
U/V ALARM	ALARM
O/V ALARM	ALARM
POWER FACTOR ALARM	ALARM
KW DEMAND ALARM	ALARM
KVA DEMAND ALARM	ALARM
KVAR DEMAND ALARM	ALARM
AMPS DEMAND ALARM	ALARM
TIMED OUTPUT	NONE
RUN DELAY TIME	NONE
AT SPEED	AUX4

**SP.5 Relay Configuration (Setpoint Page 5)
(Security Level: 2)**

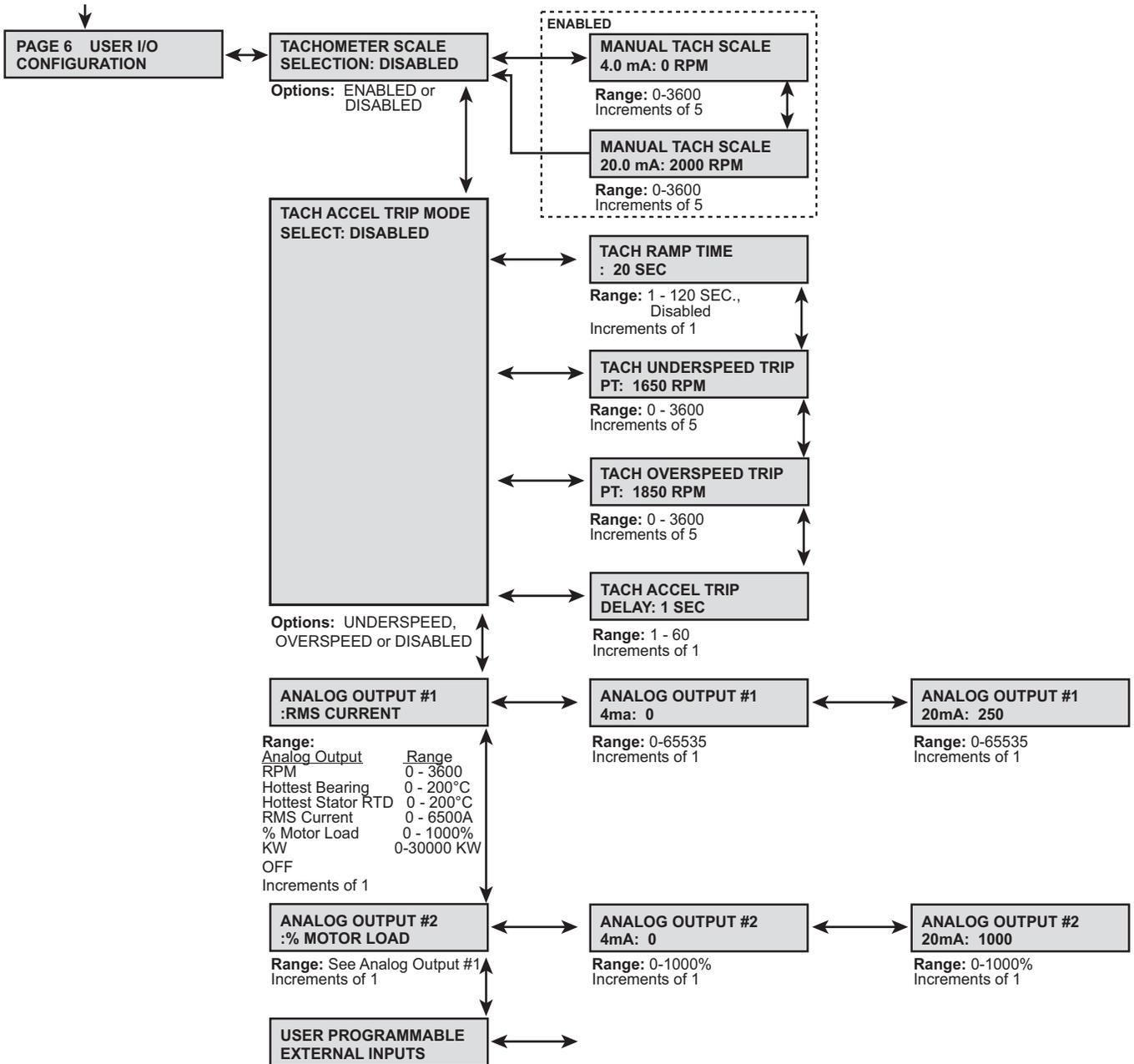
In Setpoint Page 5 the user can configure the four output relays as either fail-safe or non fail-safe and latching or non-latching.



SP5.1 When a relay has been configured as fail-safe and power is applied, the relay will be energized. The relay will then de-energize when an event occurs or if the power fails.
NOTE: The relays in *the TX* will not prevent a start sequence unless they are wired in as interlocks. If power is lost, the motor power is also lost.

SP5.2 A relay configured as non-latching will reset itself when the cause of the trip event is not continuous. *The TRIP (AUX1) relay should always be programmed for latching, because this trip should require a visual inspection of the motor and starter before issuing a manual reset to release the relay after a trip has been stored.*

SP.6 User I/O Configuration (Setpoint Page 6)
(Security Level: 2)



Continued...

SP.6 User I/O Configuration (Setpoint Page 6) (Security Level: 2)

The **TX** can be configured to accept a tachometer feedback signal through the 4-20mA input and has two options available for scaling the tachometer input. Note: At the time of this printing, SP6.1 - SP6.4 are pending.

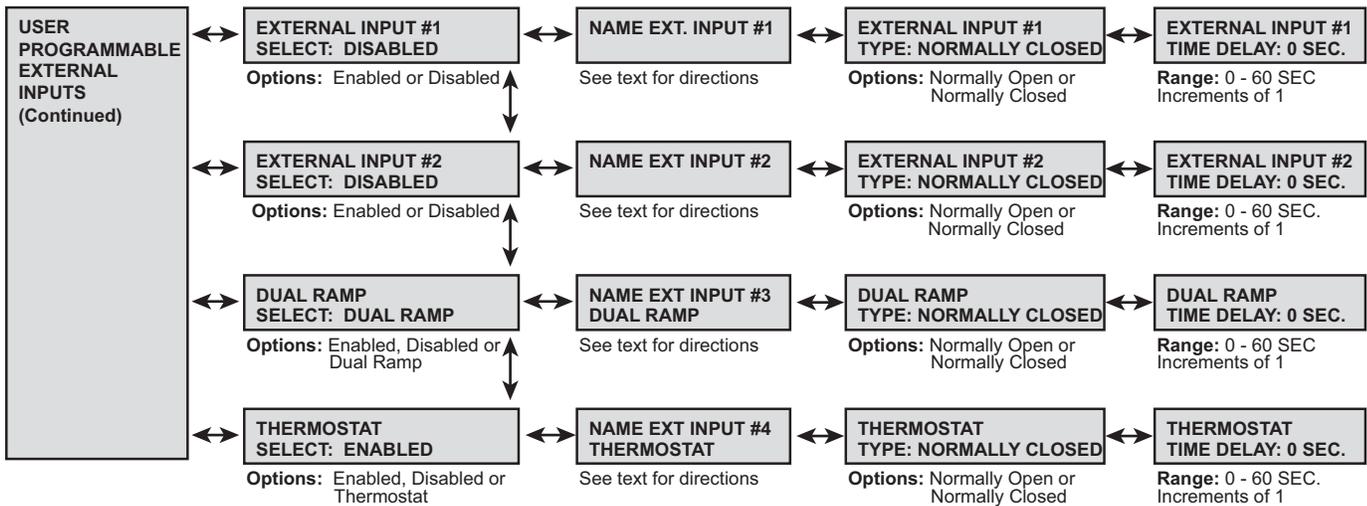
- SP6.1** The first screen of setpoint page 6 is TACHOMETER SCALE SELECTION. When this is set to AUTO, the display prompts the user to program the **TX** to sense when the motor speed is zero. It will prompt again when the motor speed is at maximum RPM. Once these inputs are given, the **TX** automatically scales the range of the tachometer feedback to give a linear RPM ramp. When this is set to MANUAL, the user will need to input the tachometer scale of the 4-20mA input range.
- **Press Enter if Motor Speed = 0 RPM:** This setpoint will be displayed when the user has selected Auto Scaling Mode. The **TX** is prompting the user to program when the motor speed is at zero. This will be the lowest value on the scale.
 - **Press Enter if Motor Speed = MAX RPM:** The **TX** is now prompting the user to program the unit when the motor is at maximum speed. This will be the highest value on the scale.
 - **Press Enter to Scale:** This is a prompt to the user that the unit has recorded the values of the tachometer input based on input from the user and is now ready to automatically scale the range of the tachometer input.
 - **Manual Tach Scale 4.0 mA:** The unit is looking for an RPM value to assign to the lowest point on the scale. This value should represent the motor at zero speed.
 - **Manual Tach Scale 20.0 mA:** The unit is looking for an RPM value to assign to the highest point on the scale. This value should represent the motor at full speed.
- SP6.2 Feedback Ramp Time:** This is the duration of the tachometer ramp time.
- SP6.3 Tach Accel Trip:** The maximum allowed percentage of slip per NEMA design of the motor.
- SP6.4 Tach Accel Trip Delay:** The duration of time that the Tach Accel trip condition must persist before a trip is generated.

SP6.5 The **TX** provides two 4-20mA analog outputs. Each analog output is independent of the other and can be assigned to monitor different functions. The available output ranges are RPM, Hottest Non-Stator (Bearing) RTD, Hottest Stator RTD, RMS current, or % Motor Load.

- **Analog Output #1** – Select a function from the available five options to be transmitted from the 4-20mA output. *Note:* If selecting RPM, the Tachometer feedback input signal must be present in order for the **TX** to give proper output. If selecting RTD, the RTD option must be installed and an RTD input signal must be present for a proper output to be given from the analog output.
- **Analog Output #1 4 mA:** Enter a value that the 4mA level will represent for the selected function; typically this value should be 0.
- **Analog Output #1 20 mA:** Enter a value that the 20mA level will represent for the selected function.

SP6.6 Analog Output #2 – All of the setpoints and setup screens for Analog Output #2 are the same as those for Analog Output #1.

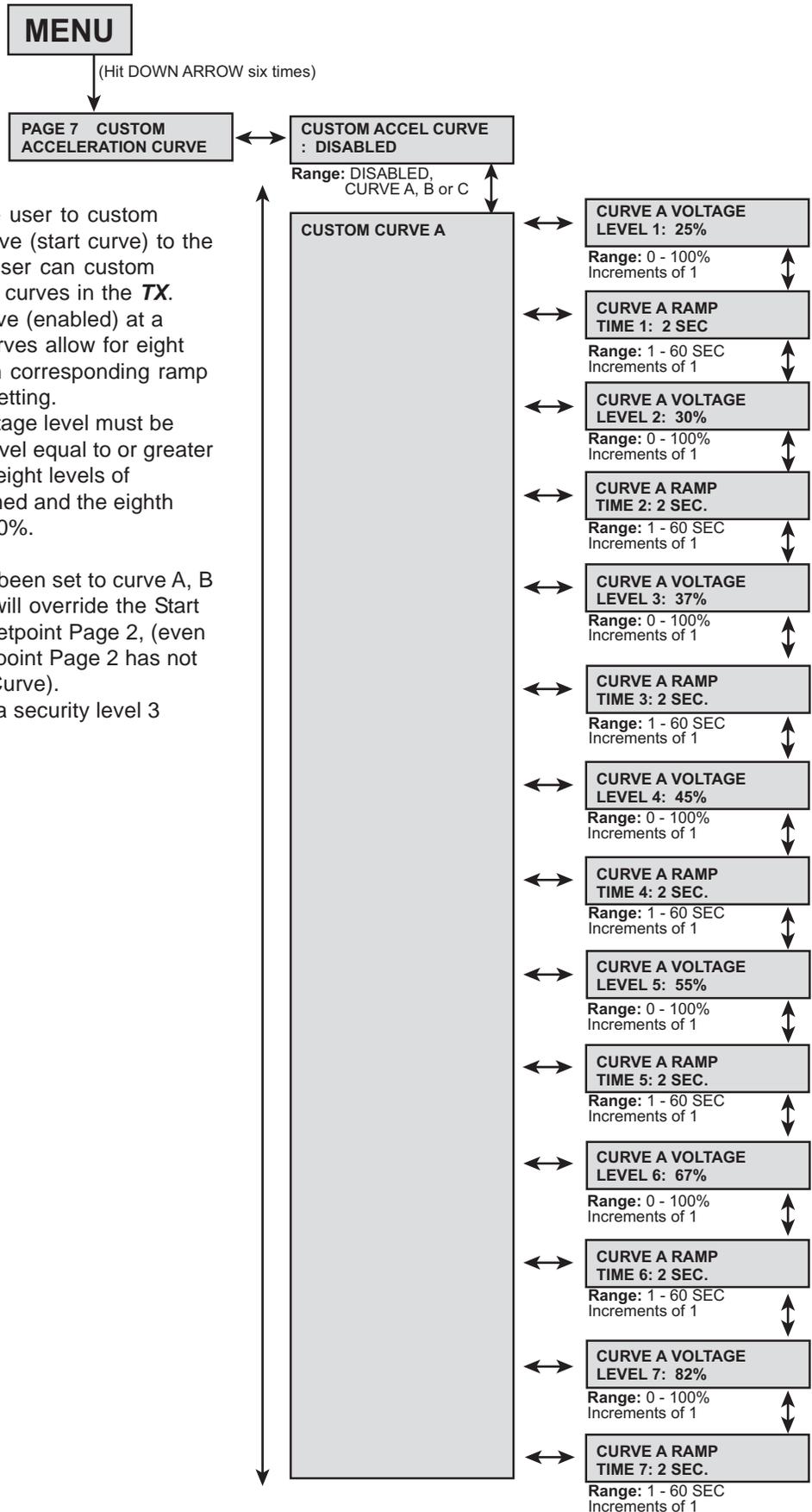
SP.6 User I/O Configuration (Setpoint Page 6) (Security Level: 2)



SP6.7 User Programmable External Inputs: The **TX** provides up to 4 digital external inputs which are individually programmable. A description name can be assigned to each individual input for easy identification.

- **External Input #1:** If used, this setpoint must be enabled.
- **Name Ext. Input #1:** The user can assign a description name to the input to easily identify the cause of external trip or alarm. Up to 15 characters including spaces can be used to assign the name.
- **External Input #1 Type:** The external input can be set as either a normally open or normally closed contact.
- **External Input #1 Time Delay:** Upon a change in contact setting, the unit will wait the programmed amount of time before generating an output. If no delay is needed, then input 0 seconds. The **TX** will post an event upon seeing a change in state.
- **External Input #2:** The setup screens and setpoints for External Input #2 includes the option of programming the unit for Under Voltage Phase Rotation.
- **External Input #3:** The setup screens and setpoints for External Input #3 includes the option of being configured for Dual Ramp. In Dual Ramp mode, the initial contact setting is the same as the START RAMP #1. Upon a change in input contact state, the **TX** will switch over to START RAMP #2 and use that setting for start control mode. *Note:* The start RAMP types should only be switched while the motor is stopped. In Setpoint Page 4 Relay Assignments, do not assign any output relay to this function. The **TX** will ship with External input #3 programmed for dual ramp. If it is not needed, disable the dual ramp.
- **External Input #4** – These input screens are for the thermostat input and can be enabled or disabled. *Note:* *Toshiba recommends that this function remain enabled. If the thermostat indicates an over temperature condition, the TX will trip the motor.*

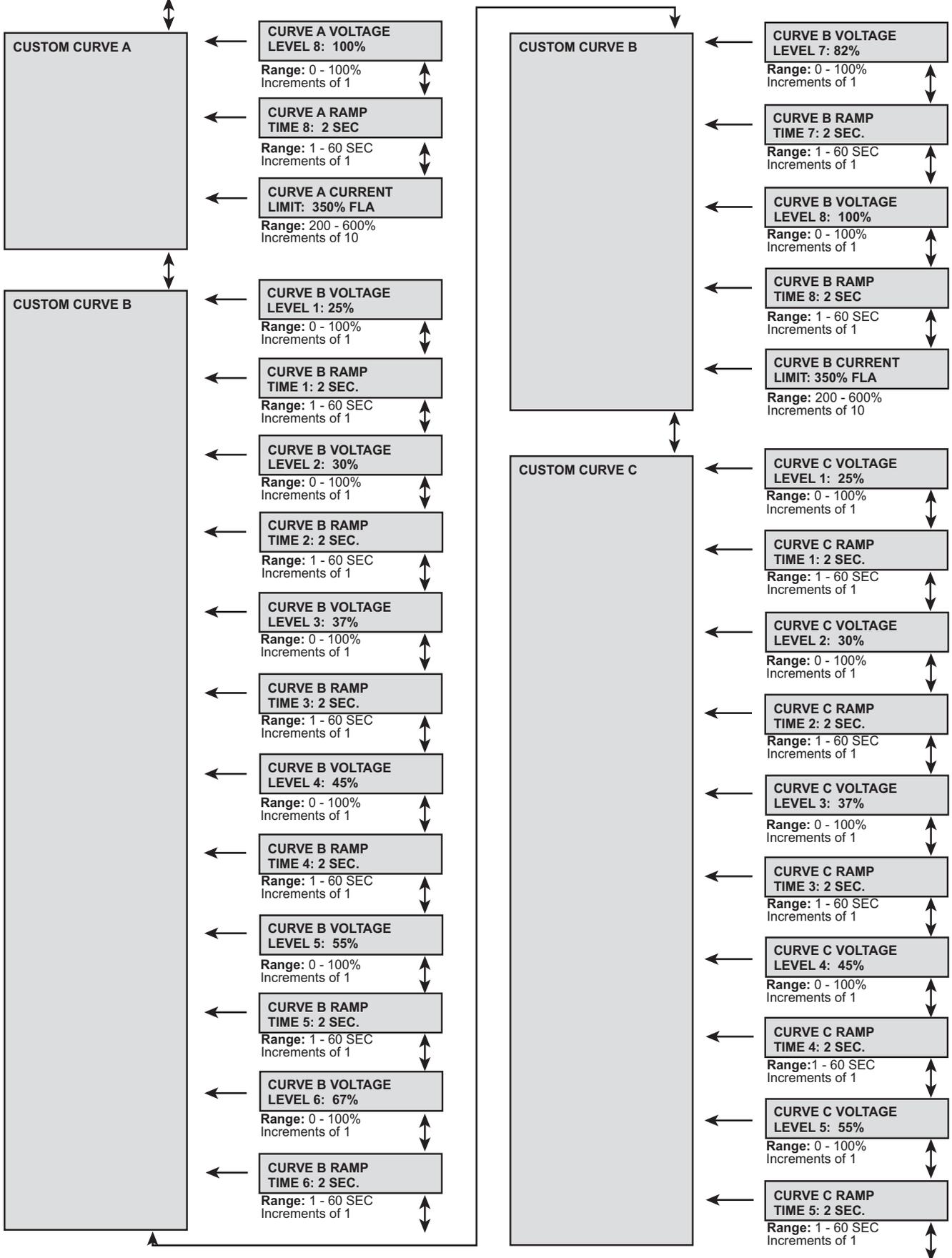
**SP.7 Custom Acceleration Curve (Setpoint Page 7)
(Security Level: 3)**



SP7.1 Setpoint Page 7 allows the user to custom design the acceleration curve (start curve) to the specific application. The user can custom design up to three different curves in the **TX**. Only one curve can be active (enabled) at a time. Each of the three curves allow for eight voltage plotting points, with corresponding ramp times and a current limit setting.
Note: Each successive voltage level must be programmed to a voltage level equal to or greater than the previous level. All eight levels of voltages must be programmed and the eighth level has been preset at 100%.

- If Custom Accel Curve has been set to curve A, B or C on this page, the **TX** will override the Start Control Mode selected in Setpoint Page 2, (even if Start Control Mode in Setpoint Page 2 has not been set to Custom Accel Curve).
Note: Setpoint Page 7 has a security level 3 requirement.

SP.7 Custom Acceleration Curve (Setpoint Page 7)
(Security Level: 3)

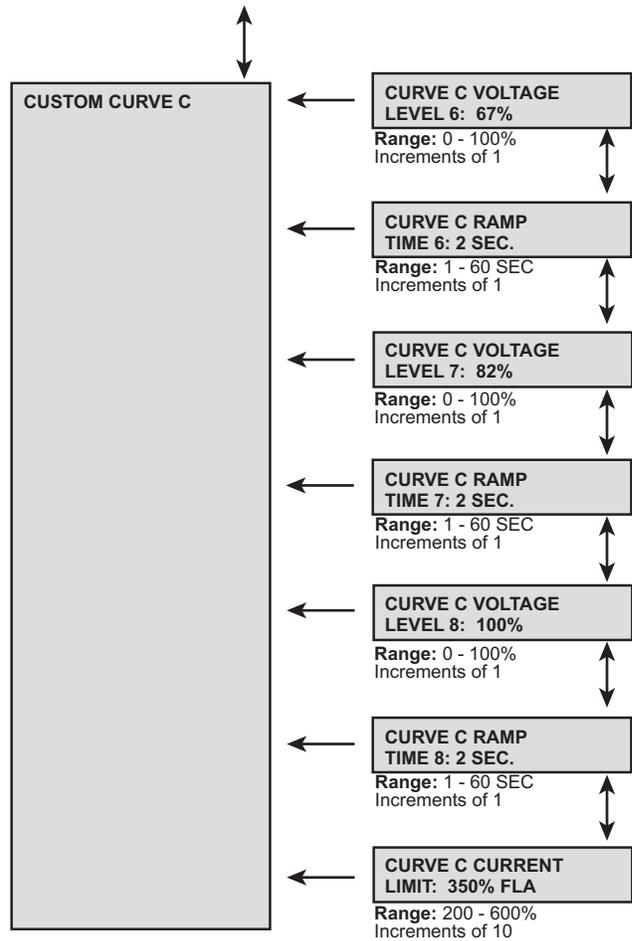


SP.7 Custom Acceleration Curve (Setpoint Page 7)
(Security Level: 3)

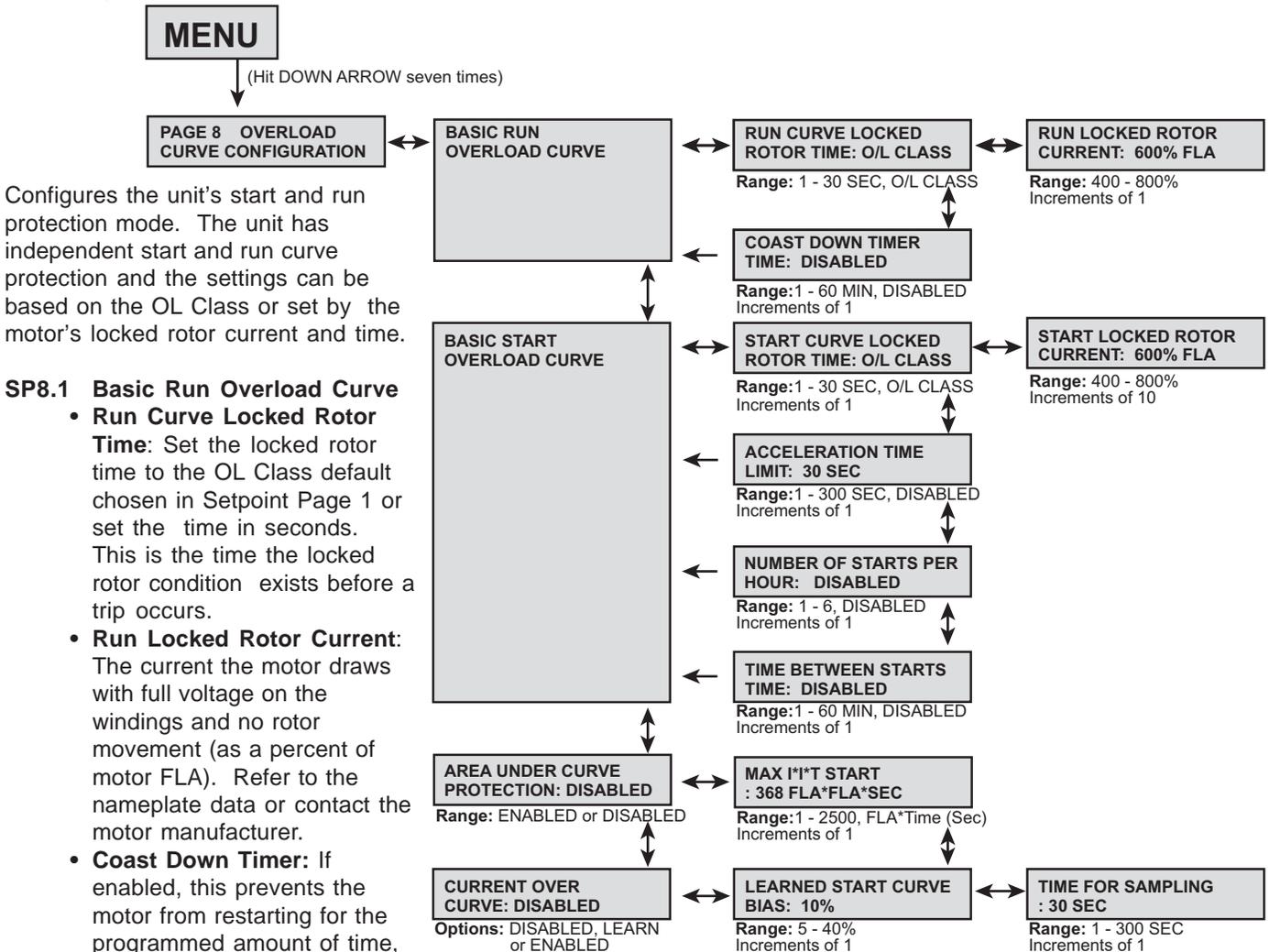
SP7.1 Setpoint Page 7 allows the user to custom design the acceleration curve (start curve) to the specific application. The user can custom design up to three different curves in the **TX**. Only one curve can be active (enabled) at a time. Each of the three curves has eight voltage levels, with corresponding ramp times and a current limit setting.

Note: Each successive voltage level must be programmed to a voltage level equal to or greater than the previous level. All eight levels of voltages must be programmed and the eighth level has been preset at 100%.

- If Custom Accel Curve has been set to curve A, B or C on this page, the **TX** will override the Start Control Mode selected in Setpoint Page 2, (even if Start Control Mode in Setpoint Page 2 has not been set to Custom Accel Curve).
Note: Setpoint Page 7 has a security level 3 requirement.



SP.8 Overload Curve Configuration (Setpoint Page 8)
(Security Level: 3)



Configures the unit's start and run protection mode. The unit has independent start and run curve protection and the settings can be based on the OL Class or set by the motor's locked rotor current and time.

SP8.1 Basic Run Overload Curve

- **Run Curve Locked Rotor Time:** Set the locked rotor time to the OL Class default chosen in Setpoint Page 1 or set the time in seconds. This is the time the locked rotor condition exists before a trip occurs.
- **Run Locked Rotor Current:** The current the motor draws with full voltage on the windings and no rotor movement (as a percent of motor FLA). Refer to the nameplate data or contact the motor manufacturer.
- **Coast Down Timer:** If enabled, this prevents the motor from restarting for the programmed amount of time, after a stop command is given.

SP8.2 Basic Start Overload Curve

- **Start Curve Locked Rotor Time:** The locked rotor time can be set to the OL Class default chosen in Setpoint Page 1 or to a specific time. The overload condition must exist for the programmed amount of time before a trip occurs.
- **Start Locked Rotor Current:** The current the motor draws with full voltage on the windings and no motor movement (as a percent of motor FLA). Refer to the motor nameplate data or contact the motor manufacturer. See Appendix A.
- **Acceleration Time Limit:** If the motor does not enter run mode (reach at speed) within the preset time, the unit trips on acceleration time limit.
- **Number of Starts per hour:** If enabled, this limits the maximum number of starts permitted per hour. This setpoint allows a maximum of 6 starts per hour. Contact motor manufacturer.
- **Time Between Starts:** If enabled, the TX prevents another start attempt until the programmed time has expired.

SP8.3 Area Under Curve Protection: If enabled, this secondary start protection uses both the basic start protection and the area under the curve protection.

- **Max I²T Start:** The maximum I²T allowed during start. If the I²T to start exceeds this number then the TX will generate a trip.

SP8.4 Current Over Curve: Learns the motor's starting characteristics and protects the motor based upon the learned curve. It is useful when commissioning a new motor.

- **Learn:** The unit reads the motor's starting characteristics. Start the motor and allow it to come to full speed. The start feedback enables the motor protection based on the learned start curve.
- **Learned Start Curve Basis:** The maximum allowed deviation above or below the start curve before a trip is generated.
- **Time for Sampling:** The time the TX continues to sample the start curve characteristic during learn the mode.

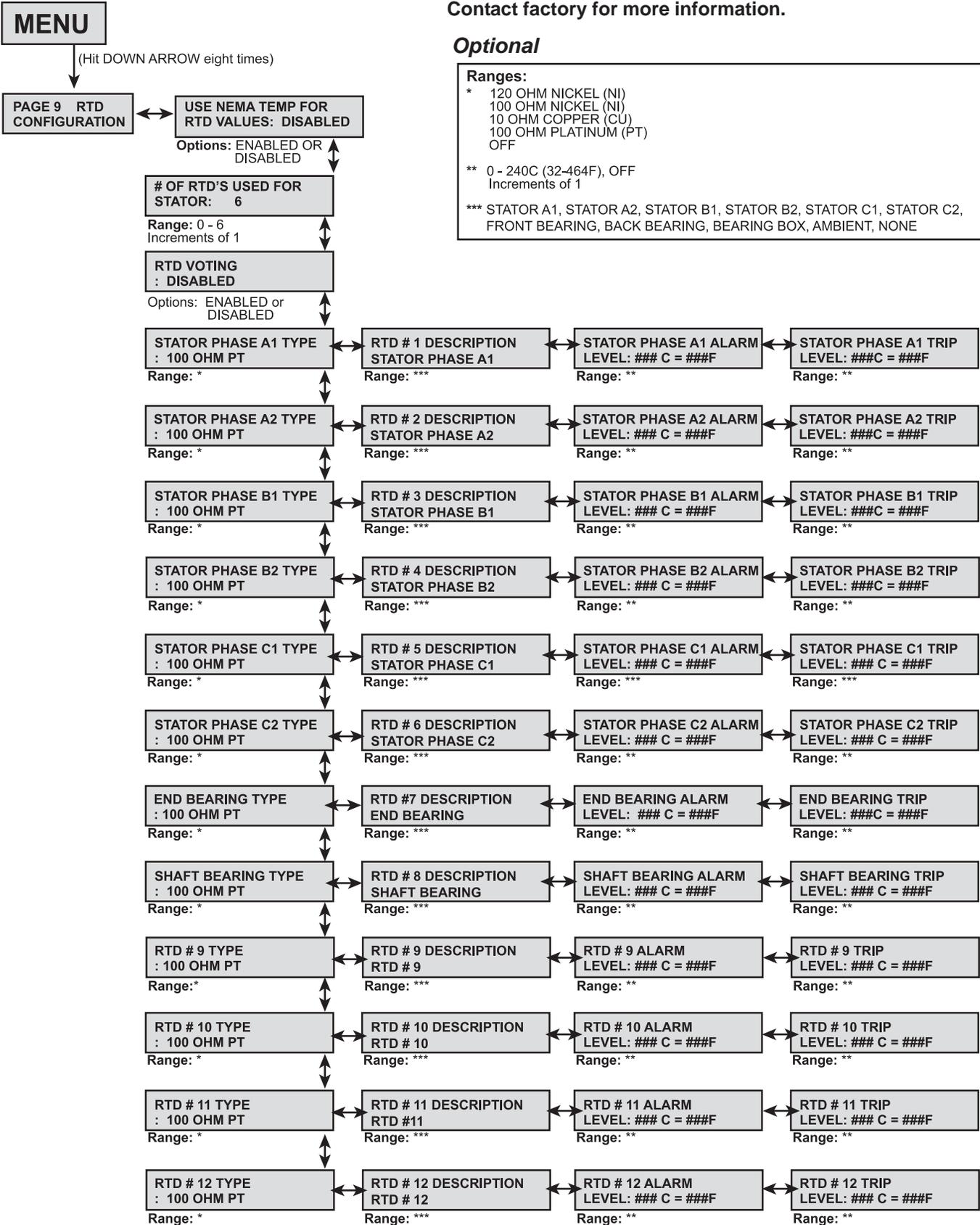
SP.9 RTD Configuration (Setpoint Page 9)
(Security Level: 3)

Please note, this is supplied as an option.
 Contact factory for more information.

Optional

Ranges:

- * 120 OHM NICKEL (NI)
 100 OHM NICKEL (NI)
 10 OHM COPPER (CU)
 100 OHM PLATINUM (PT)
 OFF
- ** 0 - 240C (32-464F), OFF
 Increments of 1
- *** STATOR A1, STATOR A2, STATOR B1, STATOR B2, STATOR C1, STATOR C2,
 FRONT BEARING, BACK BEARING, BEARING BOX, AMBIENT, NONE



**SP.9 RTD Configuration (Setpoint Page 9)
(Security Level: 3)**

The **TX** is available with an optional RTD card that provides 12 programmable RTDs which are individually programmable for type. The available types are 100 ohm platinum, 100 ohm nickel, 120 ohm nickel and 10 ohm copper. Each RTD can be identified with a description name of up to 15 characters (including spacing). Also, each individual RTD has its own alarm and trip level.

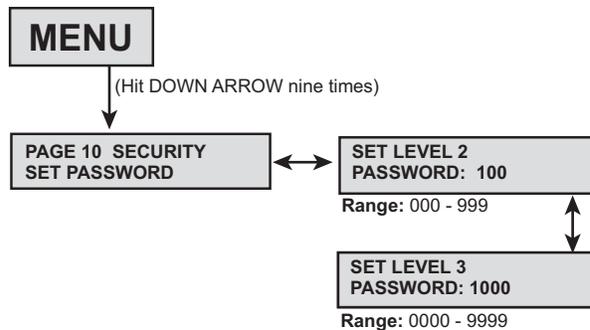
- SP9.1 Use NEMA Temp for RTD Value:** When this setpoint is enabled, the **TX** will use the NEMA design insulation class to limit the maximum allowed range of the alarm and trip level. The maximum allowed temperature range is 240° C or (464°F).
- SP9.2 # Of RTD'S Used for Stator:** Up to six RTDs can be assigned to monitor the stator of the motor.
- SP9.3 RTD Voting:** When this is enabled, the **TX** will not post a trip until 2 RTD's have exceeded the trip level. This prevents nuisance RTD tripping.
- SP9.4** All 12 RTDs are configured in the following manner. The first column is the RTD type, the second column is the RTD description, the third column is the alarm level, and the fourth column is the trip level.
The first six RTDs have been pre-programmed with a description name for the STATOR, with two RTDs per phase. RTDs #1 & #2 have been named STATOR PHASE A1 and A2 respectively. RTDs #3&4 are named STATOR PHASE B1 and B2, RTDs #5&6 are named STATOR PHASE C1 and C2. If other description names are required, press the right arrow button from the RTD Type screen to go the RTD description screen. If no alarm or trip level is required these setpoints can be turned off.

SP.10 Set Password (Setpoint Page 10) (Security Level: 3)

The **TX** has three levels of user programmable setpoint screens. Level one setpoints do not require a password because the data contained in level one is basic nameplate data and starter control. Level two setpoint screens require a three-digit password to configure the protection schemes. Level three setpoint screens require a four-digit password to access the full range of protection and starter schemes.

SP10.1 Set Level 2 Password: This level uses a 3-digit password. The default level 2 password is 100.

SP10.2 Set Level 3 Password: Level three uses a 4-digit password. The default level 3 password is 1000.



SP.11 Communications (Setpoint Page 11)
(Security Level: 3)

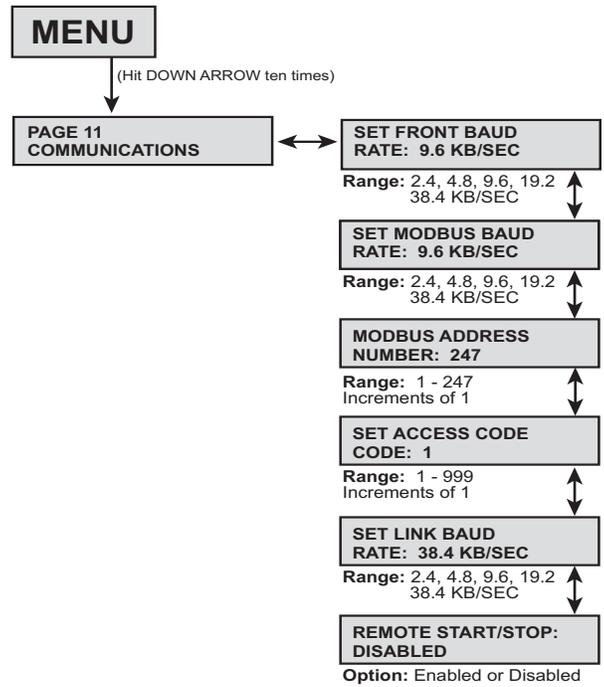
SP11.1 Set Front Baud Rate: Configures the RS232 communications baud rate.

SP11.2 Set Modbus Baud Rate: Configures the modbus communications baud rate.

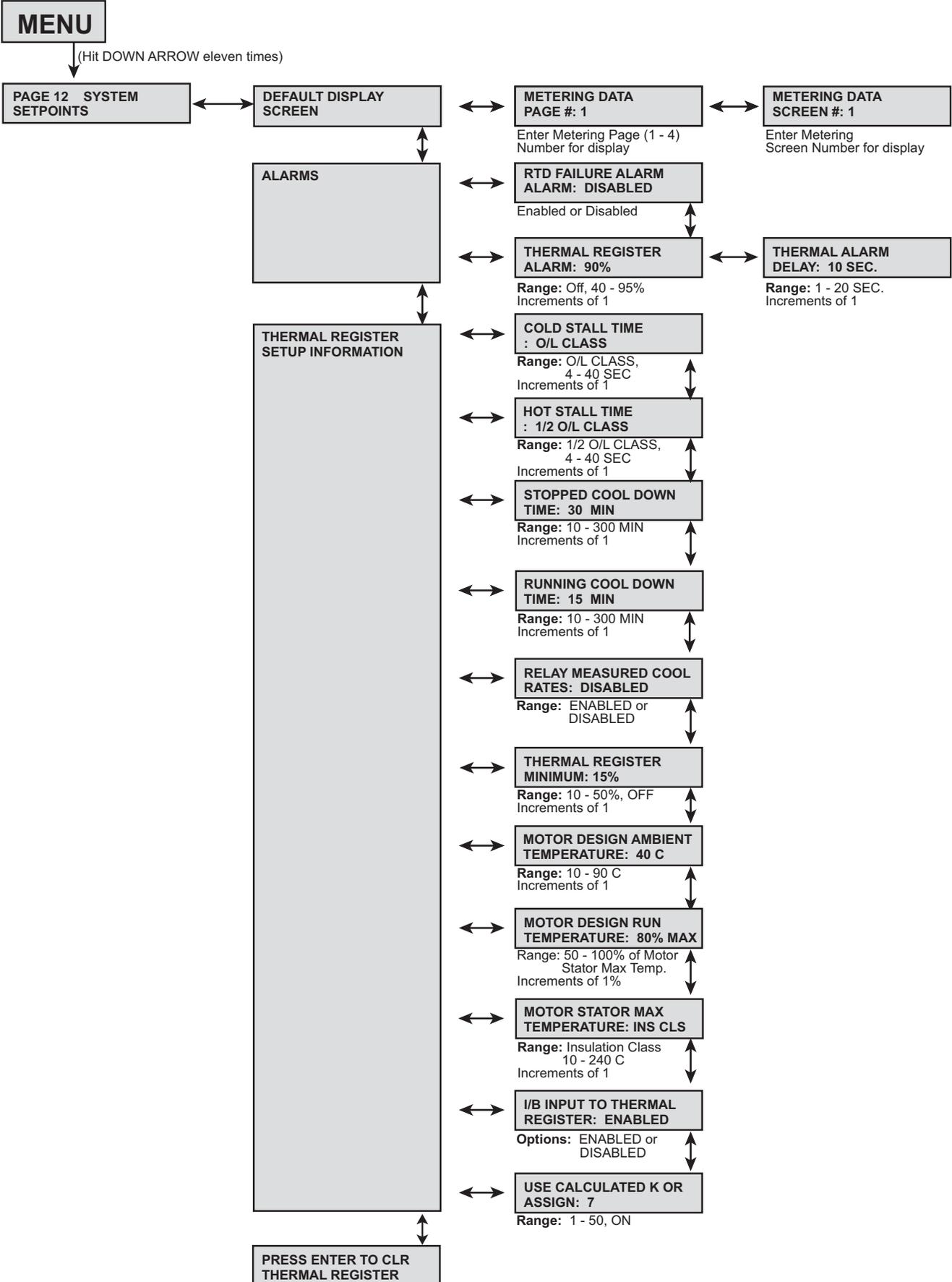
SP11.3 Modbus Address Number: Assigns a Modbus address to the **TX** relay.

SP11.4 Set Access Code: Assigns an access code to the Modbus addressing.

SP11.5 Set Link Baud Rate: Configures the RS422 communications baud rate between the keypad operator and the CPU board. (For applications with remote keypad only.)



SP.12 System Setpoints (Setpoint Page 12)
(Security Level: 3)



SP.12 System Setpoints (Setpoint Page 12) (Security Level: 3)

SP12.1 Default Display Screen: This setpoint group allows the user to choose the default screen the **TX** displays while the motor is running. Select the metering page number (1-3), then select the metering screen number. The range varies depending on the selected page. To display a default screen, program the following two setpoints:

- **Metering Data Page#:** Range is Page 1 - 3.
- **Metering Data Screen#:** If Page 1 is selected as the default page, then Screens 1- 10 are available. If Page 2 Screens 1-29 are available. If Page 3 is selected then Screens 1-6 are available. (See Metering Menu, MP.1, for screen number assignment.)

SP12.2 Alarms: Configures the RTD failure alarm (when RTD option is included) and the thermal register alarm.

- **RTD Failure Alarm:** If enabled, and an RTD shorts or open, an alarm occurs. (Only if RTD option is installed).
- **Thermal Register Alarm:** Sets a level in the thermal register to generate an alarm when the Thermal Register Capacity Used has exceeded this level.
- **Thermal Alarm Delay:** The amount of time that the Thermal Register Used must exceed the setpoint before an alarm condition will occur.

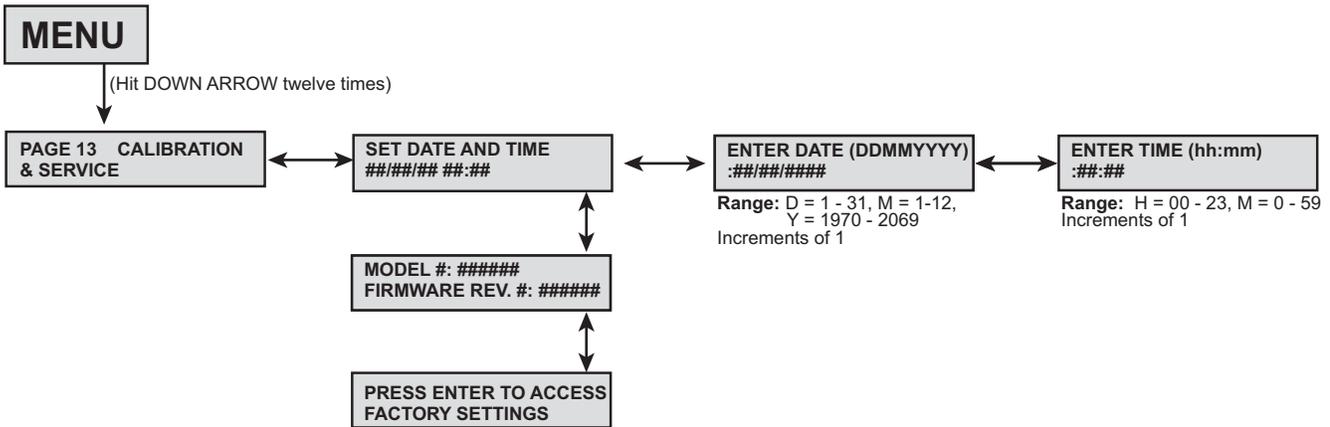
SP12.3 Thermal Register Setup Information: This setpoint group will configure the thermal register and indicate to the **TX** which inputs to use when thermal modeling.

- **Cold Stall Time:** Enter the time from the motor manufacturer's specification sheet or use the time defined by the OL Class. This setpoint is used to define the thermal capacity of the motor.
- **Hot Stall Time:** Enter the amount of time specified by the motor manufacturer or use half of the time defined by the OL Class.
- **Stopped Cool Down Time:** The time the motor requires to cool down after it has stopped. Use only the data provided by the motor manufacturer. This setpoint is used to configure the cooling rate of the thermal register.
- **Running Cool Down Time:** The amount of time the motor requires for cooling down while running. Use only the data provided by the motor manufacturer.
- **Relay Measured Cool Rates:** When the RTD option is supplied, the **TX** can be configured to use the measured cool rates from the RTDs instead of the programmed settings. This setpoint should only be enabled when the RTD option is present.

- **Thermal Register Minimum:** Sets the value in the thermal register which represents a motor running at the nameplate current (with no overheating or negative sequence currents present).
- **Motor Design Ambient Temperature:** Use the data from the motor manufacturer's specifications. When RTD option is supplied, this setpoint will be the base point for the RTD biasing of the Thermal Register.
- **Motor Design Run Temperature:** Use the data from the motor manufacturer's specifications. This setpoint defines the operating temperature rise of the motor at full load amps or 100% load.
- **Motor Stator Max Temperature:** This represents the maximum temperature the stator insulation will withstand. The user may choose to use the temperature setting of the insulation class (selected in Setpoint Page 1) or enter a specific maximum temperature. This value should not exceed the stator's insulation temperature. This maximum temperature represents 100% thermal capacity.
- **I/B Input to Thermal Register:** When enabled it allows the **TX** to use the line current imbalance information to bias the Thermal Register.
- **User Calculated K or Assign:** When the setpoint is set to ON the **TX** will calculate the k constant factor for biasing the thermal register, or the user may choose to assign the k value.

SP12.4 Press Enter to CLR Thermal Register: Allows the level three password user to clear the thermal register for emergency restarts.

SP.13 Calibration & Service (Setpoint Page 13)
(Security Level: Factory Use Only)



SP.13 Calibration & Service (Setpoint Page 13)

Certain screens are displayed for user information only, such as: Current date and time, Model number and Firmware revision number. Setpoint changes in this page will only be accessible to factory personnel.

SP13.1 Set Date and Time: Displays the date and time.

- **Enter Date (DDMMYYYY):** Allows the factory personnel to program the date for the **TX** in the format shown.
- **Enter Time (hh:mm):** Allows the factory personnel to program the time for the **TX**.

SP13.2 Model & Firmware #: Displays the model number and firmware revision in the **TX**.

SP13.3 Press Enter to Access Factory Settings: Available to qualified personnel.

Chapter 6 - Metering Pages

The **TX Series** offers performance metering which gives the user the ability to view information about the motor and the **TX** unit.

6.1 Metering Page List

The following charts list each Metering Page and the functions within that page. The applicable section of the manual is also referenced.

6.1.1 Metering Menu & Data (Metering Page 1)

Metering Page	Description of Display	Screen
Page 1 Metering Menu & Data	Phase A, B, C and Ground Fault	1
	Average current of the % of imbalance and the motor's RPM	2
	Motor load as a percentage of motor FLA	3
	Line frequency and present phase order	4
	Percentage of remaining Thermal Register	5
	Thermal capacity required to start the motor	6
	Average time required to start	7
	Average current during start	8
	Measured I ² T required to start the motor	9
	Amount of time required to start the motor during the last successful start	10

6.1.2 Metering (Metering Page 2)

Metering Page	Description of Display	Screen
Page 2 Metering	Phase A, B, C and Power Factor	1
	Phase A, B, C and Ground Fault	2
	Displays KW and KVA	3
	Displays KVAR and Power Factor	4
	Displays Peak ON and KW Demand	5
	Displays Peak ON and KVA Demand	6
	Displays Peak ON and KVAR Demand	7
	Displays Peak ON and Amps Demand	8
	Clears Demand values	9
	Displays Megawatt hours used	10
	Press enter to clear statistics on MWH values	11

6.1.3 RTD Values (Metering Page 3)

Metering Page	Description of Display	Screen
Page 3 RTD Values	Hottest stator RTD (#1 - 6)	1
	Hottest non-stator RTD (#7 - 12)	2
	Temperature of start phase A1 in °C and °F	3
	Maximum temperature for RTD #1	4
	Same as Screens 3 - 4	5 - 26
	Clear the maximum temperature register (Level 3 password required)	27
	Measured run cool time in minutes	28
	Measured stopped cool time in minutes	29

6.1.4 Status (Metering Page 4)

Metering Page	Description of Display	Screen
Page 4 Status	Current status	1
	Amount of time remaining before an overload trip occurs	2
	Amount of time remaining from a thermal inhibit signal	3
	Coast down time remaining	4
	Amount of time remaining before a start command can be given	5
	Excessive number of starts per hour	6

6.1.5 Event Recorder (Metering Page 5)

Metering Page	Description of Display	Screen
Page 5 Event Recorder	Displays the event with date and time (Up to 60 events)	1
	Displays Phase A, B, C and the Ground Fault at the time of the trip	1A
	Displays Vab, Vbc, Vca and Power Factor at the time of trip	1B

6.1.6 Last Trip (Metering Page 6)

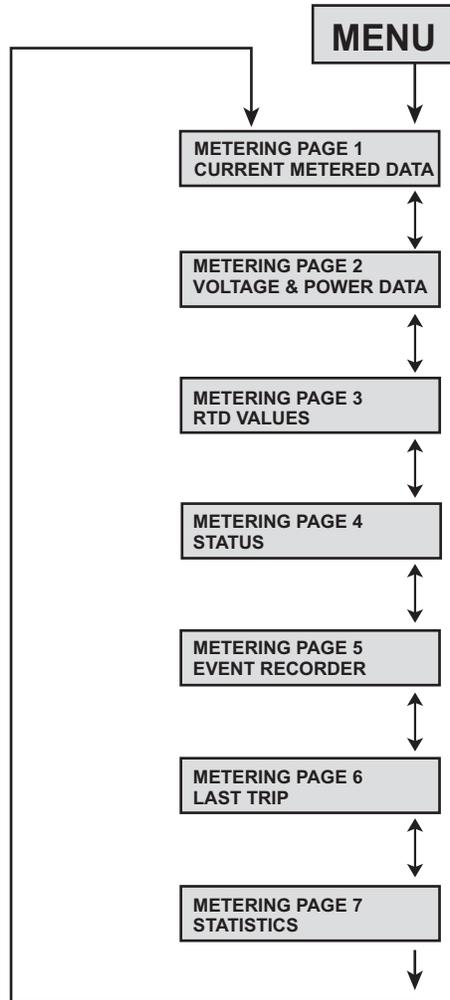
Metering Page	Description of Display	Screen
Page 6 Last Trip	Cause of last trip	1
	Measured phase current	2
	Measured voltage and power factor	3
	Imbalance percentage, the frequency and the kW	4
	Hottest stator RTD temperature	5
	Hottest non-stator RTD temperature	6

6.1.7 Statistics (Metering Page 7)

Metering Page	Description of Display	Screen
Page 7 Statistics	Displays the total Megawatt hours	1
	Accumulated total running hours	2
	Clear the total running hour count	3
	Total number of trips	4
	Number of start and run overload trips since the last statistical data clearing	5
	Number of frequency trips and imbalance trips	6
	Overcurrent trips	7
	Stator and non-stator RTD trips	8
	Ground fault hiset and loset trips	9
	Acceleration time trips	10
	Start under curve trips	11
	Start over curve trips	12
	I ² T start curve trips	13
	Learned start curve trips	14
	Fail shunt trip trips	15
	Phase loss trip trips	16
	Tach accel trip trips	17
	Undervoltage and Overvoltage trips	18
	Power Factor trips	19
	Phase reversal trips	20
	Ext Inp #1	21
	Ext Inp #2	22
	Ext Inp #3	23
	Ext Inp #4	24
	Press enter to clear statistics	25

6.2 Metering Menu

(1) Push MENU key to toggle the screens between Setpoint Menu and Metering Menu and follow the arrow keys to get to different screens.



MP.1 Metering Menu & Data (Metering Page 1)

Displays the basic current metering data:

Screen 1: Phase A, B, C and ground fault current.

Screen 2: Displays the average current of the % of imbalance and the motor's RPM (available with tachometer input)

Screen 3: Displays the motor load in percent of motor FLA.

Screen 4: Displays the line frequency and the present Phase Order.

Screen 5: Displays the percent of the remaining thermal register. In order for the motor to successfully start, the percentage must be greater than the thermal capacity required for a successful start.

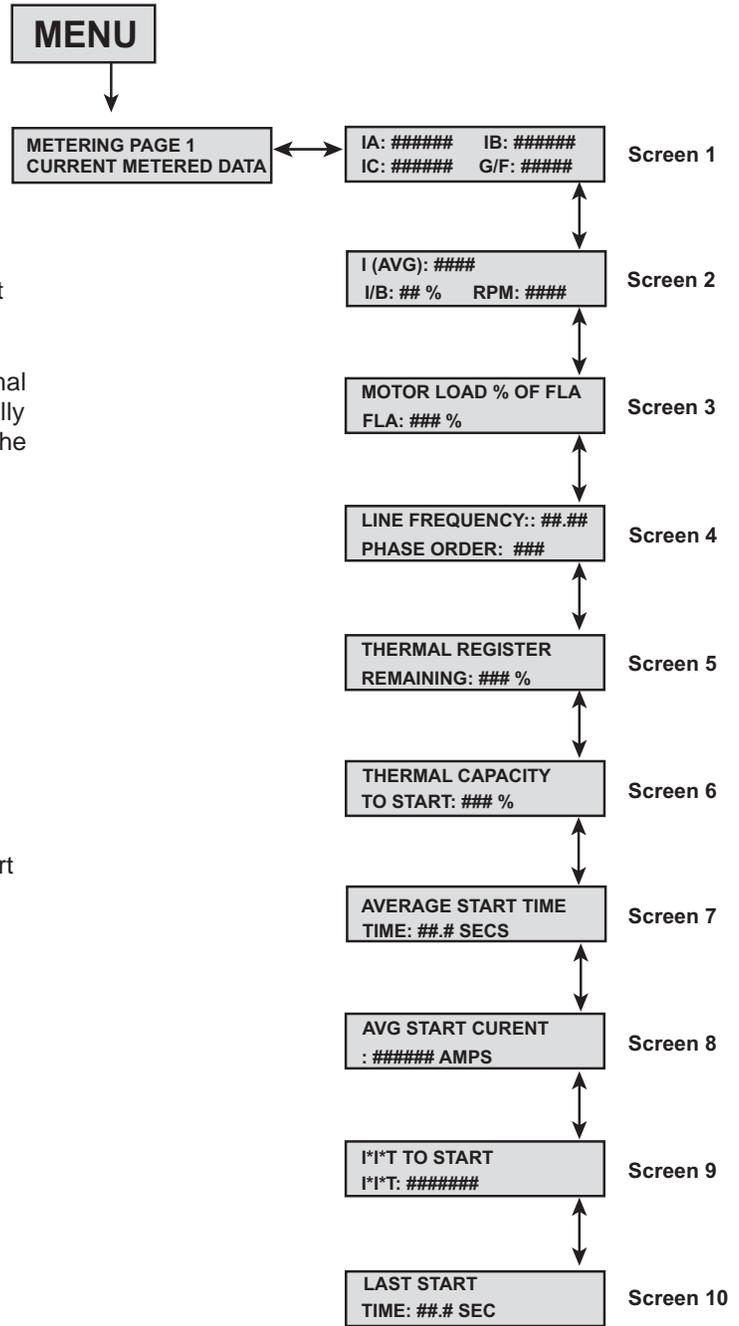
Screen 6: Displays the thermal capacity required to successfully start the motor.

Screen 7: Displays the average time required to start.

Screen 8: Displays the average current during start.

Screen 9: Displays the measured I²T required to start the motor.

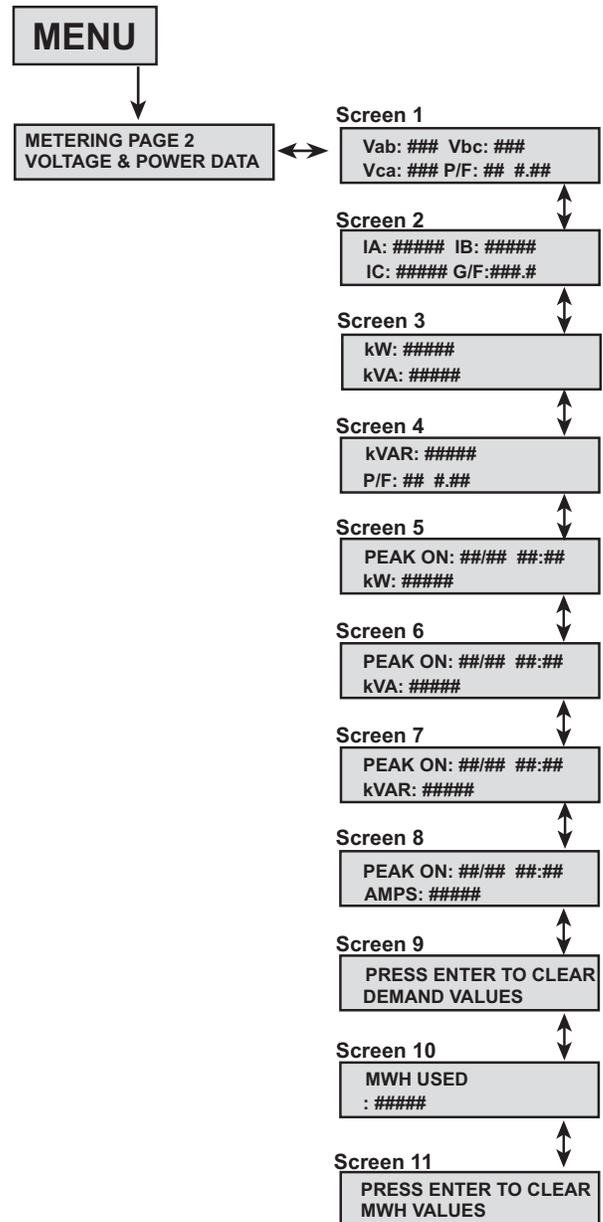
Screen 10: Displays the amount of time required to start the motor during the last successful start.



MP.2 Metering (Metering Page 2)

Displays the **TX Series** statistical voltage metering information.

- Screen 1:** Displays Phase A, B, C and Power Factor.
Note: P/F: N/A Motor stopped
P/F: LG #.## (Lagging)
P/F: LD #.## (Leading)
- Screen 2:** Displays Phase A, B, C and Ground Fault Current.
- Screen 3:** Displays KW and KVA.
- Screen 4:** Displays KVAR and Power Factor.
- Screen 5:** Displays Peak On and KW demand.
- Screen 6:** Displays Peak On and KVA demand.
- Screen 7:** Displays Peak On and KVAR demand.
Note: P/F: N/A Motor stopped
P/F: LG #.## (Lagging)
P/F: LD #.## (Leading)
- Screen 8:** Displays Peak On and Ampsdemand.
- Screen 9:** Clears Demand Values.
- Screen 10:** Displays the Megawatts used per hour.
- Screen 11:** Press Enter to clear statistics on MWH values.



METERING PAGE 3
RTD VALUES

HOTTEST STATOR
RTD#: # @ ### C

Screen 2
HOTTEST NON-STATOR
RTD#: # @ ### C

Screen 3
STATOR PHASE A1
RTD #1: ### C = ### F

Screen 4
MAX TEMP SINCE
CLEAR RTD #1: ### C

Screen 5
STATOR PHASE A2
RTD #2: ### C = ### F

Screen 6
MAX TEMP SINCE
CLEAR RTD #2: ### C

Screen 7
STATOR PHASE B1
RTD #3: ### C = ### F

Screen 8
MAX TEMP SINCE
CLEAR RTD #3: ### C

Screen 9
STATOR PHASE B2
RTD #4: ### C = ### F

Screen 10
MAX TEMP SINCE
CLEAR RTD #4: ### C

Screen 11
STATOR PHASE C1
RTD #5: ### C = ### F

Screen 12
MAX TEMP SINCE
CLEAR RTD #5: ### C

Screen 13
STATOR PHASE C2
RTD #6: ### C = ### F

Screen 14
MAX TEMP SINCE
CLEAR RTD #6: ### C

Screen 15
END BEARING
RTD #7: ### C = ### F

Screen 16
MAX TEMP SINCE
CLEAR RTD #7: ### C

Screen 17
SHAFT BEARING
RTD #8: ### C = ### F

Screen 18
MAX TEMP SINCE
CLEAR RTD #8: ### C

Screen 19
RTD #9
RTD #9: ### C = ### F

Screen 20
MAX TEMP SINCE
CLEAR RTD #9: ### C

Screen 21
RTD #10
RTD #10: ### C = ### F

Screen 22
MAX TEMP SINCE
CLEAR RTD #10: ### C

Screen 23
RTD #11
RTD #11: ### C = ### F

Screen 24
MAX TEMP SINCE
CLEAR RTD #11: ### C

Screen 25
RTD #12
RTD #12: ### C = ### F

Screen 26
MAX TEMP SINCE
CLEAR RTD #12: ### C

Screen 27
PRESS ENTER TO
CLEAR MAX TEMP REGS

Screen 28
MEASURED RUN COOL
TIME: ### MIN

Screen 29
MEASURED STOPPED
COOL TIME: ### MIN

MP.3 RTD Values (Metering Page 3)

Displays the RTD information (when RTD option is supplied)

Screen 1: Displays the hottest stator RTD (#1 - 6 depending upon number of RTDs used for stator).

Screen 2: Displays the hottest non-stator RTD (#7-12 if #1-6 is used for stator).

Screen 3: Displays the temperature of stator phase A1 in °C and °F.

Screen 4: Displays the maximum temperature for RTD #1 since the last command to clear the thermal register.

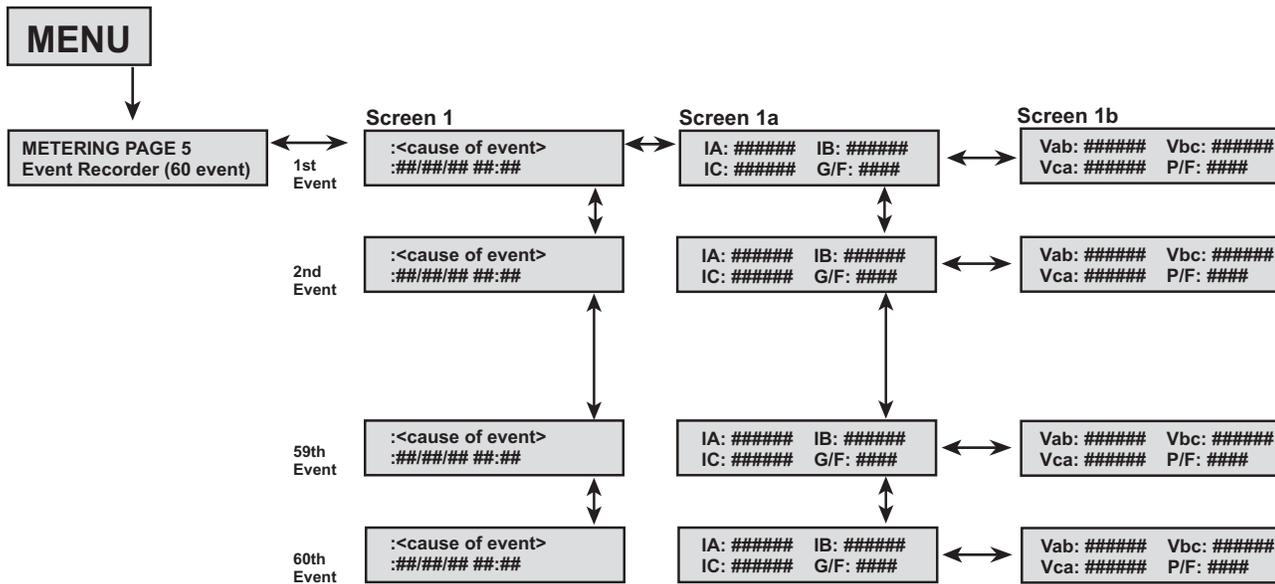
Screen 5 - 26: Same as Screens 3 - 4

Screen 27: Allows the user to clear the maximum temperature register upon entering the setpoint level 3 password.

Screen 28: Displays the measured run cool time in minutes.

Screen 29: Displays the measured stopped cool time in minutes.

MP.5 Event Recorder - 60 Events (Metering Page 5)



All events will be viewed from oldest event in buffer to most recent event.

The events are listed from oldest to most recent.

Screen 1: Displays the event (i.e., Imbalance Trip) with the date and time it occurred.

Screen 1a: Displays the current at Phase A, B, C and the ground fault at the time of the trip.

Screen 1b: Displays the Vab, Vbc, Vca and power factor at the time of trip.

MP.6 Last Trip (Metering Page 6)

Displays the information regarding the last trip.

Screen 1: Displays the cause of the last trip.

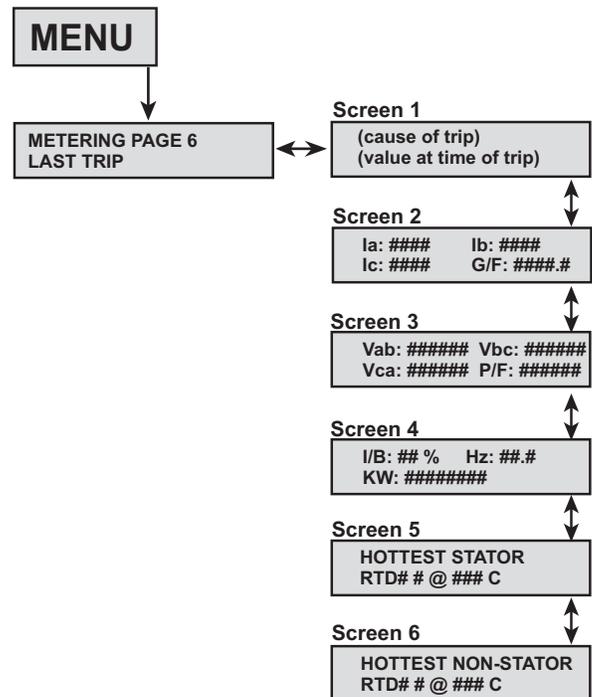
Screen 2: Displays the measured phase current at the time of the trip.

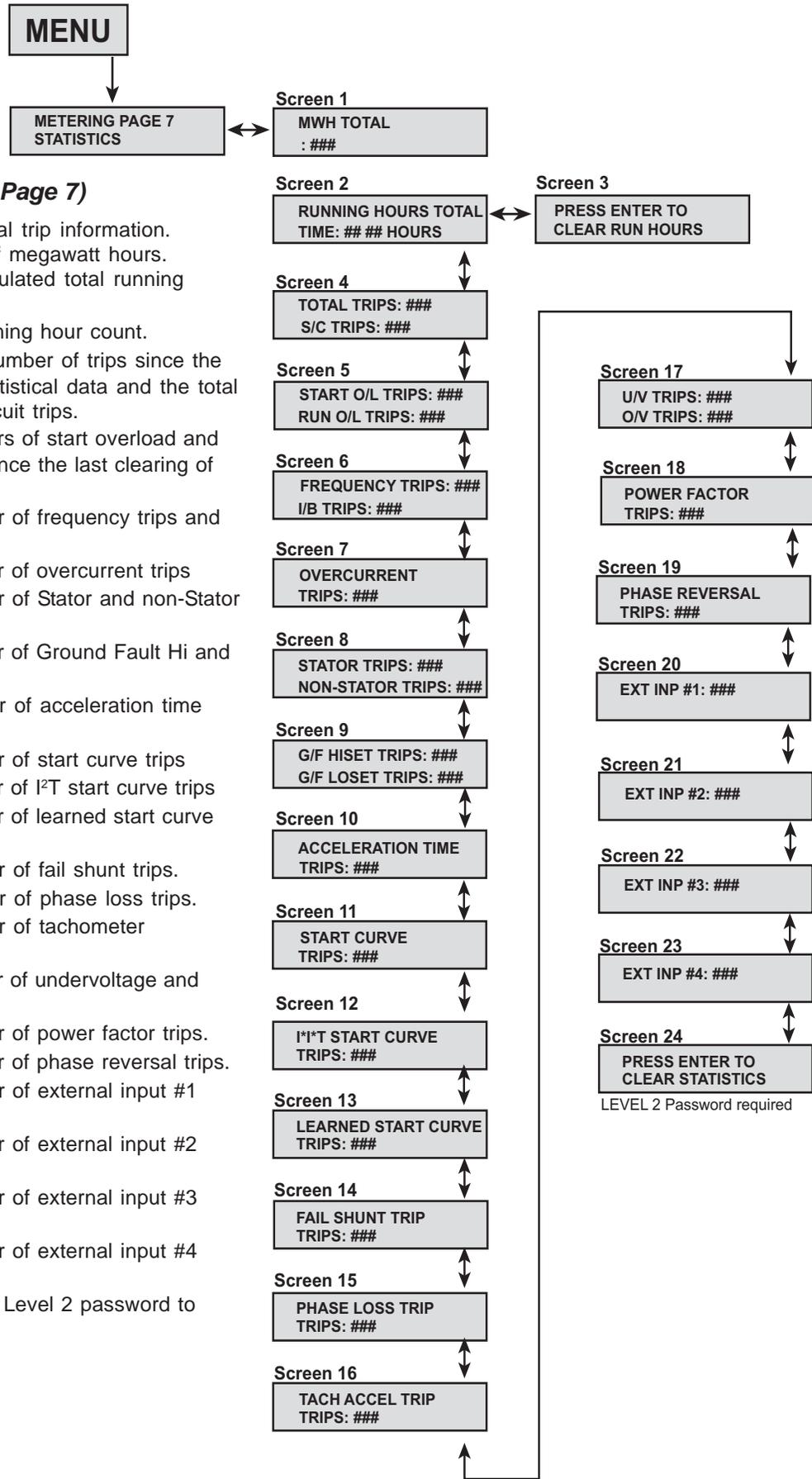
Screen 3: Displays the Vab, Vbc, Vca and power factor at the time of trip.

Screen 4: Displays the imbalance percentage, the frequency and the kW at the time of the trip.

Screen 5: Displays the hottest stator RTD temperature (when RTD option present) at time of the trip.

Screen 6: Displays the hottest non-stator RTD temperature (when RTD option present) at the time of the trip.





MP.7 Statistics (Metering Page 7)

Displays the **TX Series** statistical trip information.

Screen 1: Displays the total of megawatt hours.

Screen 2: Displays the accumulated total running hours.

Screen 3: Clears the total running hour count.

Screen 4: Displays the total number of trips since the last clearing the statistical data and the total number of short circuit trips.

Screen 5: Displays the numbers of start overload and run overload trips since the last clearing of the statistical data.

Screen 6: Displays the number of frequency trips and Imbalance trips.

Screen 7: Displays the number of overcurrent trips

Screen 8: Displays the number of Stator and non-Stator RTD Trips

Screen 9: Displays the number of Ground Fault Hi and Lo Set trips

Screen 10: Displays the number of acceleration time trips.

Screen 11: Displays the number of start curve trips

Screen 12: Displays the number of I²T start curve trips

Screen 13: Displays the number of learned start curve trips.

Screen 14: Displays the number of fail shunt trips.

Screen 15: Displays the number of phase loss trips.

Screen 16: Displays the number of tachometer acceleration trips.

Screen 17: Displays the number of undervoltage and overvoltage trips.

Screen 18: Displays the number of power factor trips.

Screen 19: Displays the number of phase reversal trips.

Screen 20: Displays the number of external input #1 trips.

Screen 21: Displays the number of external input #2 trips.

Screen 22: Displays the number of external input #3 trips.

Screen 23: Displays the number of external input #4 trips.

Screen 24: Requires a Security Level 2 password to clear the statistics.

LEVEL 2 Password required

Chapter 7 - Maintenance and Troubleshooting

The **TX Series** is designed to be a maintenance-free product. However, as with all electronic equipment, the unit should be checked periodically for dirt, moisture or industrial contaminants. These can cause high voltage arc-over, carbon tracking or prevent proper cooling of the SCR heat sinks. All bolts should be checked annually for proper tightness using an accurate torque wrench .

Note: If the unit is installed in a contaminated environment and forced air cooling is used, blower filters must be checked and cleaned regularly to insure proper air flow and cooling of the enclosure.

7.1 - Failure Analysis

When a fault occurs, the LCD will display the fault error and the listed LED and AUX Relay will be lit. Please clear all faults before attempting to restart the unit. **Note:** If the problem persists after the required programming changes have been made, and all corrective action has been taken, please contact the factory for assistance.

Problem	CPU LCD Display	LED	Aux Relay	Possible Cause	Solutions
Short Circuit Trip	SHORT CIRCUIT TRIP	Trip	AUX1	Short circuit or ground fault in motor/cabling	Locate and remove short or ground
				Phase Loss	Repair cause of phase loss
				Branch circuit protection not correctly sized	Verify correct sizing of branch circuit protection
				Faulty main circuit board	Remove power and replace main circuit board.
				Faulty SCRs	Remove power and test SCR(s). Refer to Section 7.1.1 for the SCR testing procedure
Single Phase Trip	SINGLE PHASE TRIP (Check LCD display for possible fault indicators)	Trip	AUX1	Single phase incoming power	Correct problem with incoming power
				Faulty SCRs	Remove power and test SCR(s). Refer to Section 7.1.1 for the SCR testing procedure
Thermostat trips during run	EXTERNAL TRIP ON THERMOSTAT	Trip	AUX1	Fan(s) not functioning (If supplied)	If fans have power, remove power and replace fan(s). If fans do not have power, find cause of power loss and repair.
				Heatsink coated with dirt	Remove power and clean heatsink with high pressure air (80 - 100 psi max clean and dry air)
				Overcurrent on unit	Verify that running current does not exceed unit rating
				Environment temperature over 122° F (ambient temperature for chassis units) or over 104°F (ambient temperature for enclosed version)	Place unit in environment temperature less than 122°F for panel version or less than 104°F for enclosed version.
				Bypass failed to close	Check bypass contactor and wiring
Phase Loss	PHASE LOSS	Trip	AUX1	Loss of 1 or more phases of power from utility or generated power	Check power source
				Blown power fuses	Check for short circuits

Problem	CPU LCD Display	LED	Aux Relay	Possible Cause	Solutions
<i>Overload</i>	OVERLOAD TRIP	Trip	AUX1	Improper programming	Check motor nameplate versus programmed parameters
				Possible load damage or jammed load	Check motor currents
<i>Stall prevention</i>	ACCEL TIME TRIP	Trip	AUX1	Improper setting for motor load condition	Verify current limit setting
				Damaged load	Check for load failure
<i>Under Current Trip</i>	UNDER CURRENT TRIP	Trip	AUX1	Improper programming or unloaded motor	Check setpoint settings
					Check load
<i>Self-test Failure</i>	SELF-TEST FAILURE	Trip	AUX1	Failed CPU or Main Firing Board	Contact factory
				Vibration	Check internal wiring connections
<i>Line Frequency Trip</i>	OVER OR UNDER FREQUENCY TRIP	Trip	AUX1	Generator Power Problem or grid change	Troubleshoot and repair generator
					Contact utilities company
					Main board failure
					Three phase power removed from Main Board
<i>Any Ground Fault Trip (Pending)</i>	GROUND FAULT HI-SET OR LO-SET (Pending)	Trip	AUX1	Improper programming	Check program setpoints
				Any wire going to ground (I.e. stator ground, motor ground, soft start ground)	Check with meggar or Hi-pot motor leads and motor
				High vibration or loose connections	Check internal connections
<i>Motor stopped during run</i>	Check for fault indication	Trip	AUX1	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
<i>Control circuit fuses blow after control power is applied.</i>	None	None	None	Short in control circuit	Remove power, locate and remove this short
				Wrong control voltage	Apply the correct voltage to the control circuit

Problem	CPU LCD Display	LED	Aux Relay	Possible Cause	Solutions
<i>Motor will not start</i>	Any fault indication message	Trip	AUX1	No control voltage applied to control board	Apply control voltage to TB1 pins 1 and 6 on the power board
				Control power transformer failure or CPT fuse failure	Remove power and replace the power transformer or the CPT fuse
				Start circuit wired incorrectly	Remove power and correct the start circuit wiring
				No start command	Apply the start command
				No 3 phase line voltage	Apply 3 phase line voltage to the unit
				Shorted SCR in starter	Remove power and test SCR(s). Refer to Section to 7.1.1 for the SCR testing procedure
				Faulty control logic	Remove power and repair the control logic.
				Failure of main circuit board	Replace the main circuit board
<i>Motor vibrates/ Motor growls while starting or extremely unbalanced motor currents run mode</i>	IMBALANCE TRIP IMBALANCE ALARM	Trip Alarm	AUX1 AUX2	Faulty motor	Check the motor and the motor connections
				Faulty SCRs	Remove power and perform the SCR device checks
				Faulty gate/cathode on SCRs	Remove power and test SCR(s). Refer to Section 7.1.1 for the SCR testing procedure
				Faulty main circuit board	Replace the main circuit board
				Faulty motor/wiring	Troubleshoot and repair/replace wiring
				Faulty main circuit board	Replace the main circuit board

7.2 SCR Testing Procedure



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

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 6 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. 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.

7.3 Replacing SCR Devices

Two types of SCRs are used in the **TX 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.)

7.3.1 Changing an Isolated SCR

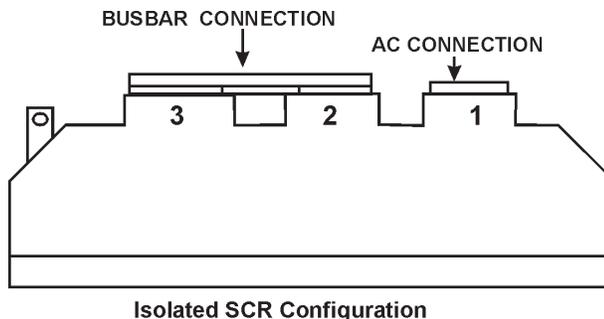
- Remove both line and control power from unit, tag and lock out.



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 mounting surface of the SCR. 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 44 lb/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 78A - 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



7.3.2 Changing a Hockey Puck Type SCR

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



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

- Toshiba uses 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.

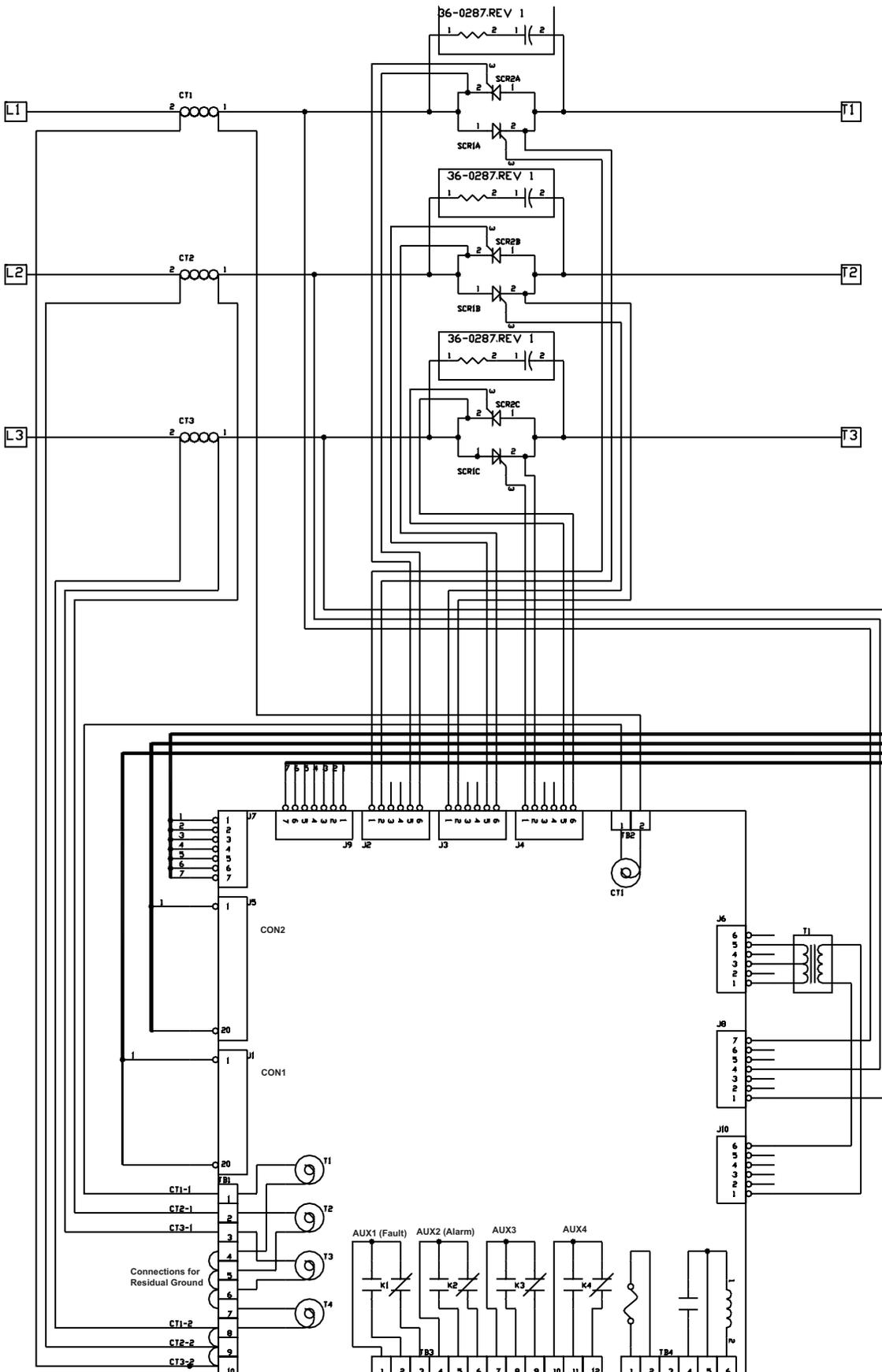
7.4 Replacing the Main Control Board

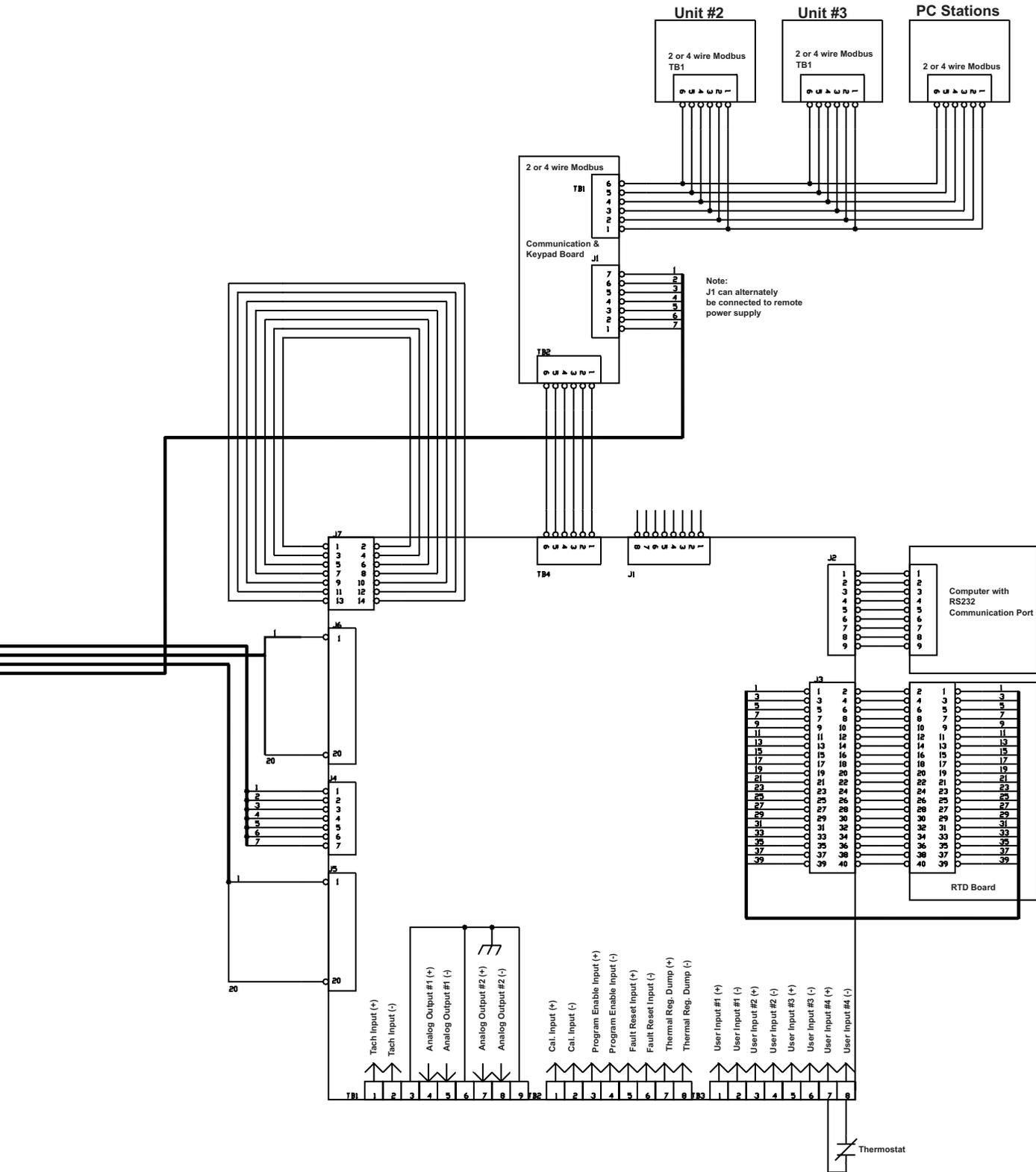
The printed circuit board is not intended to be field repaired. If the board is faulty, the entire board should be replaced using the following procedure:

(See Chapter 6 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 jumpers.
- Remove the mounting screws.
- Remove the old printed circuit board.
- Mount the new printed circuit board.
- Install the mounting screws.
- Set the jumpers 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 program all parameters to values in old board.
- Test

7.5 - Interconnect Drawing





7.6 MAINTENANCE PROGRAM

In order to ensure continued reliable and safe operation of the equipment, a program of periodic maintenance must be established. Operating and environmental conditions will usually dictate the frequency of inspection required. NFPA Publication 70B "Electrical Equipment Maintenance" may be used as a guide for setting up the maintenance program.

DANGER

Contact with energized components can cause severe injury, death and property damage. Turn off and lock-out primary and control circuit power before servicing.

WARNING

Improper maintenance can cause severe injury, death and property damage. Only qualified and authorized persons are to install, operate or service this equipment.

WARNING

Grease is conductive. Do not allow grease or any other substances to contaminate insulating materials. Contaminated insulators can allow a short-circuit or ground fault to occur.

NOTE: Refer to the SAFETY section of this manual for important information.

MAINTENANCE RECORD

Keep a permanent record of all maintenance work. At a minimum, this record should include information on:

- 1) Items inspected
- 2) Reports of any testing
- 3) Equipment condition
- 4) Corrective actions or adjustments
- 5) Date of work
- 6) Comments

The degree of detail of the record will depend somewhat on the operating conditions.

SERVICING EQUIPMENT

For your safety, turn off and lock out main and control circuit power before servicing the starter. Certain minimum safety procedures must be followed:

- 1) Only **qualified personnel** should attempt this service.
- 2) **Never** perform service on or next to exposed components energized with line voltage.

WARNING

Failure to adhere to these safety procedures can result in severe injury, death and property damage.

7.7 DISPOSAL/STORAGE

DISPOSAL

Contact your state environmental agency for details on disposal of electrical components and packaging in your particular area.

STORAGE

If the starter is to be stored for any length of time prior to installation, the following precautions should be taken:

- 1) The original packing should be restored, if possible.
- 2) Do not subject the equipment to moisture or sun rays. Store in cool, clean, and dry location.
- 3) Place a dust cover over the starter packaging to protect against dirt and moisture.
- 4) Store in an upright position.

INSPECTION DURING STORAGE

Routine scheduled inspection is necessary if storage is for an extended period. The unit should be checked for condensation, moisture, corrosion, and vermin.

Prior to installation, the starter should be carefully examined for evidence of physical damage, corrosion, or other deterioration.

The MAINTENANCE section of this manual describes various types of inspections recommended for this starter during the operation period.

Appendix A - Reference Section
Typical Full Load Current for 3 Phase Motors

INDUCTION TYPE SQUIRREL CAGE AND WOUND ROTOR (AMPERES)								SYNCHRONOUS TYPE UNITY POWER FACTOR* (AMPERES)			
HP	115V	200V	208V	230V	460V	575V	2300V	230V	460V	575V	2300V
0.5	4.4	2.5	2.4	2.2	1.1	0.9					
0.75	6.4	3.7	3.5	3.2	1.6	1.3					
1	8.4	4.8	4.6	4.2	2.1	1.7					
1.5	12	6.9	6.6	6	3	2.4					
2	13.6	7.8	7.5	6.8	3.4	2.7					
3		11	10.6	9.6	4.8	3.9					
5		17.5	16.7	15.2	7.6	6.1					
7.5		25.3	24.2	22	11	9					
10		32.2	30.8	28	14	11					
15		48.3	46.2	42	21	17					
20		62.1	59.4	54	27	22					
25		78.2	74.8	68	34	27		53	26	21	
30		92	88	80	40	32		63	32	26	
40		120	114	104	52	41		83	41	33	
50		150	143	130	65	52		104	52	42	
60		177	169	154	77	62	16	123	61	49	12
75		221	211	192	96	77	20	155	78	62	15
100		285	273	248	124	99	26	202	101	81	20
125		359	343	312	156	125	31	253	126	101	25
150		414	396	360	180	144	37	302	151	121	30
200		552	528	480	240	192	49	400	201	161	40
250					302	242	60				
300					361	289	72				
350					414	336	83				
400					477	382	95				
450					515	412	103				
500					590	472	118				

* For 90 and 80 percent power factor, the figures shall be multiplied by 1.1 and 1.25, respectively.

Typical Maximum Allowable Start and Stops per hour

ALLOWABLE STARTS AND STARTING INTERVALS DESIGN A AND B MOTORS									
HP	2 POLE			4 POLE			6 POLE		
	A	B	C	A	B	C	A	B	C
1	15	1.2	75	30	5.8	38	34	15	33
1.5	12.9	1.8	76	25.7	8.6	38	29.1	23	34
2	11.5	2.4	77	23	11	39	26.1	30	35
3	9.9	3.5	80	19.8	17	40	22.4	44	36
5	8.1	5.7	83	16.3	27	42	18.4	71	37
7.5	7	8.3	88	13.9	39	44	15.8	104	39
10	6.2	11	92	12.5	51	46	14.2	137	41
15	5.4	16	100	10.7	75	50	12.1	200	44
20	4.8	21	110	9.6	99	55	10.9	262	48
25	4.4	26	115	8.8	122	58	10	324	51
30	4.1	31	120	8.2	144	60	9.3	384	53
40	3.7	4	130	7.4	189	65	8.4	503	57
50	3.4	49	145	6.8	232	72	7.7	620	64
60	3.2	58	170	6.3	275	85	7.2	735	75
75	2.9	71	180	5.8	338	90	6.6	904	79
100	2.6	92	220	5.2	441	110	5.9	1181	97
125	2.4	113	275	4.8	542	140	5.4	1452	120
150	2.2	133	320	4.5	640	160	5.1	1719	140
200	2	172	600	4	831	300	4.5	2238	265
250	1.8	210	1000	3.7	1017	500	4.2	2744	440

Typical Maximum Locked Rotor Current

NEMA B, C & D

THREE PHASE SQUIRREL CAGE MOTORS NEMA DESIGNS B, C & D						
HP	RATED VOLTAGE					
	200V	230V	460V	575V	2300V	4000V
0.5	23	20	10	8		
0.75	29	25	12	10		
1	34	30	15	12		
1.5	46	40	20	16		
2	57	50	25	20		
3	74	64	32	26		
5	106	92	46	37		
7.5	146	127	63	51		
10	186	162	81	65		
15	267	232	116	93		
20	333	290	145	116		
25	420	365	182	146		
30	500	435	217	174		
40	667	542	290	232		
50	834	725	362	290		
60	1000	870	435	348	87	50
75	1250	1085	542	434	108	62
100	1665	1450	725	580	145	83
125	2085	1815	907	726	181	104
150	2500	2170	1085	868	217	125
200	335	2900	1450	1160	290	167
250	4200	3650	1825	1460	365	210
300	5060	4400	2200	1760	440	253
350	5860	5100	2550	2040	510	293
400	6670	5800	2900	2320	580	333
450	7470	6500	3250	2600	650	374
500	8340	7250	3625	2900	725	417

NEMA E

MAXIMUM LOCKED-ROTOR CURRENTS THREE-PHASE SQUIRREL CAGE MOTORS NEMA DESIGN E						
HP	RATED VOLTAGE (AMPS)					
	200V	230V	460V	575V	2300V	4000V
0.5	23	20	10	8		
0.75	29	25	13	10		
1	35	30	15	12		
1.5	46	40	20	16		
2	58	50	25	20		
3	84	73	37	29		
5	1140	122	61	49		
7.5	210	183	92	73		
10	259	225	113	90		
15	388	337	169	135		
20	516	449	225	180		
25	646	562	281	225		
30	775	674	337	270		
40	948	824	412	330		
50	1185	1030	515	412		
60	1421	1236	618	494	124	71
75	1777	1545	773	618	155	89
100	2154	1873	937	749	187	108
125	2692	2341	1171	936	234	135
150	3230	2809	1405	1124	281	162
200	4307	3745	1873	1498	375	215
250	5391	4688	2344	1875	469	270
300	6461	5618	2809	2247	562	323
350	7537	6554	3277	2622	655	377
400	8614	7427	3745	2996	749	431
450	9691	8427	4214	3371	843	485
500	10767	9363	4682	3745	936	538

Cooling Consideration for Maintaining Ambient Temperature

RATED CURRENT UNITS = AMPS	HEAT GENERATED UNITS = WATTS	MINIMUM CFM UNITS = CFM	MINIMUM EXP. S.S. UNITS = SQ.FT.
48	216	38	54
78	351	62	88
120	540	95	135
180	810	143	203
220	990	174	248
288	1296	228	324
414	1863	328	466
476	2138	376	534
550	2475	436	619
718	3231	569	808
1006	4527	797	1132
1150	5175	911	1294
1250	5625	990	1406

Appendix B - Record of Setpoint Adjustments

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Setting
Page 1 Basic Configuration	Level 1 No Password Required	Motor Full Load Amps (FLA)	Model dependent	50 - 100% of Unit Max Current Rating (Model and Service Factor dependent)	
		Service Factor	1.15	1.00 – 1.3	
		Overload Class	10	O/L Class 5-30	
		NEMA Design	B	A-F	
		Insulation Class	B	A, B, C, E, F, H, K, N, S	
		Line Voltage	480	208 to 600	
		Line Frequency	60	50 or 60 HZ	

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Setting
Page 2 Starter Configuration	Level 1 No Password Required	Start Control Mode	Start Ramp 1	Jog, Start Ramp 1, Start Ramp 2, Custom Accel Curve, Start Disabled, Dual Ramp	
		Jog Voltage	Off	5-75%, Off	
		Start Ramp #1 Type	Voltage	Current, Voltage, Off	
		Initial Voltage #1	20%	0-100%	
		Ramp Time #1	10 sec	0-120 sec	
		Current Limit #1	350% FLA	200-600 %	
		Initial Current #1	200% FLA	0-300%	
		Ramp Time #1	10 sec	0-120 sec	
		Maximum Current #1	350% FLA	200-600 %	
		Start Ramp #2 Type	Off	Current, Voltage, Off	
		Initial Voltage #2	60%	0-100 %	
		Ramp Time #2	10 sec	0-120 sec	
		Current Limit #2	350 % FLA	200-600 %	
		Initial Current #2	200% FLA	0-600 %	
		Ramp Time #2	10 sec	0-120 sec	
		Maximum Current #2	350% FLA	200-600 %	
		Kick Start Type	Off	Voltage or Off	
		Kick Start Voltage	65%	10-100 %	
		Kick Start Time	0.50 sec	0.10-2.00	
		Deceleration	Disabled	Enabled or Disabled	
		Start Deceleration Voltage	60%	0-100 %	
		Stop Deceleration Voltage	30%	0-59 %	
		Deceleration Time	5 sec	1-60 sec	
Timed Output Time	Off	1-1000 sec, Off			
Run Delay Time	1 Sec	1-30 sec, Off			
At Speed Delay Time	1 Sec	1-30 sec, Off			
Bypass Pull-in Current	100% FLA	90 - 300%			

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Setting
Page 3 Phase and Ground Settings	Level 2 Password Protection	Imbalance Alarm Level	15% FLA	5-30 %, Off	
		Imbalance Alarm Delay	1.5 sec	1.0-20.0 sec	
		Imbalance Trip Level	20%	5-30 %, Off	
		Imbalance Trip Delay	2.0 sec	1.0-20.0 sec	
		Undercurrent Alarm Level	Off	10-90 %, Off	
		Undercurrent Alarm Delay	2.0 sec	1.0-60.0 sec	
		Overcurrent Alarm Level	Off	100-300 %, Off	
		Overcurrent Alarm Delay	2.0 sec	1.0-20.0 sec	
		Overcurrent Trip Level	Off	100-300 %, Off	
		Overcurrent Trip Delay	2.0 sec	1.0-20.0 sec	
		Phase Loss Trip	Disabled	Enabled or Disabled	
		Phase Loss Trip Delay	0.1 sec	0-20.0 sec	
		Phase Rotation Detection	Enabled	Enabled Only	
		Phase Rotation	ABC	ABC	
		Ground Fault Alarm Level	Off	5-90 %, Off	
		Ground Fault Alarm Delay	0.1 sec	0.1-20.0 sec	
		Ground Fault Loset Trip Level	Off	5-90 %, Off	
		Ground Fault Loset Trip Delay	0.5 sec	0.1-20 sec	
		Ground Fault Hiset Trip Level	Off	5-90 %, Off	
		Ground Fault Hiset Trip Delay	0.008 sec	0.008-0.250 sec	
		Overvoltage Alarm Level	Off	5 -30%, Off	
		Overvoltage Alarm Delay	1.0 sec	1.0-30.0 sec	
		Overvoltage Trip Level	Off	5-30%, Off	
		Overvoltage Trip Delay	2.0 sec	1.0-30.0 sec	
		Undervoltage Alarm Level	Off	5-30%, Off	
		Undervoltage Alarm Delay	1.0 sec	1.0-30.0 sec	
		Undervoltage Trip Level	Off	5-30%, Off	
		Undervoltage Trip Delay	2.0 sec	1.0-30.0 sec	
		Line Frequency Trip Window	Disabled	0-6 Hz, Disabled	
		Line Frequency Trip Delay	1.0 sec	1.0-20.0 sec	
		P/F Lead P/F Alarm	Off	0.1-1.00, Off	
		P/F Lead Alarm Delay	1.0 sec	1-120 sec	
		P/F Lead P/F Trip	Off	.01-1.00, Off	
		P/F Lead Trip Delay	1.0 sec	1-120 sec	
		P/F Lag P/F Alarm	Off	.01-1.00, Off	
		P/F Lag Alarm Delay	1.0 sec	1-120 sec	
		P/F Lag P/F Trip	Off	.01-1.00, Off	
		P/F Lag Trip Delay	1.0 sec	1-120 sec	
		Power Demand Period	10 min	1 - 60 min	
		KW Demand Alarm Pickup	Off KW	Off, 1-100000	
KVA Demand Alarm Pickup	Off KVA	Off, 1-100000			
KVAR Demand Alarm Pickup	Off KVAR	Off, 1-100000			
Amps Demand Alarm Pickup	Off Amps	Off, 1-100000			

Setpoint Page	Security Level	Description	Factory Setting			Range	Setting
			1st	2nd	3rd		
Page 4 Relay Assignments	Level 2 Password Protection	O/L Trip	Trip Only	None	None	None Trip(AUX1) Alarm(AUX2) AUX3 AUX4	
		I/B Trip	Trip	None	None		
		S/C Trip	Trip Only	None	None		
		Overcurrent Trip	Trip	None	None		
		Stator RTD Trip	Trip	None	None		
		Bearing RTD Trip	Trip	None	None		
		G/F Hi Set Trip	Trip	None	None		
		G/F Lo Set Trip	Trip	None	None		
		Phase Loss Trip	Trip	None	None		
		Accel. Time Trip	Trip Only	None	None		
		Start Curve Trip	Trip Only	None	None		
		Over Frequency Trip	Trip	None	None		
		Under Frequency Trip	Trip	None	None		
		I*T Start Curve	Trip	None	None		
		Learned Start Curve	Trip	None	None		
		Phase Reversal	Trip	None	None		
		Overvoltage Trip	Trip	None	None		
		Undervoltage Trip	Trip	None	None		
		Power Factor Trip	Trip	None	None		
		Tach Accel Trip	Trip	None	None		
		Inhibits Trip	Trip	None	None		
		Shunt Trip	AUX 3	None	None		
		Bypass Discrepancy	None	None	None		
		External Input #1	None	None	None		
		External Input #2	None	None	None		
		Dual Ramp	None	None	None		
		Thermostat	Trip	None	None		
		O/L Warning	Alarm	None	None		
		Overcurrent Alarm	Alarm	None	None		
		Ground Fault Alarm	Alarm	None	None		
		Under Current Alarm	Alarm	None	None		
		Motor Running	None	None	None		
		I/B Alarm	Alarm	None	None		
		Stator RTD Alarm	Alarm	None	None		
		Non-Stator RTD Alarm	Alarm	None	None		
		RTD Failure Alarm	Alarm	None	None		
		Self Test Fail	Trip	None	None		
		Thermal Register	Alarm	None	None		
		U/V Alarm	Alarm	None	None		
		O/V Alarm	Alarm	None	None		
Power Factor Alarm	Alarm	None	None				
KW Demand Alarm	Alarm	None	None				
KVA Demand Alarm	Alarm	None	None				
KVAR Demand Alarm	Alarm	None	None				
Amps Demand Alarm	Alarm	None	None				
Timed Output	None	None	None				
Run Delay Time	None	None	None				
At Speed	AUX4	None	None				

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Setting
Page 5 Relay Configuration	Level 2 Password Protection	Trip (AUX1) Fail-Safe	No	Yes or No	
		Trip (AUX1) Relay Latched	Yes	Yes or No	
		Alarm (AUX2) Fail-Safe	No	Yes or No	
		Alarm (AUX2) Relay Latched	No	Yes or No	
		AUX3 Relay Fail-Safe	No	Yes or No	
		AUX3 Relay Latched	No	Yes or No	
		AUX4 Relay Fail-Safe	No	Yes or No	
		AUX4 Relay Latched	No	Yes or No	

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Setting
Page 6 User I/O Configuration	Level 2 Password Protection	Tachometer Scale Selection	Disabled	Enabled or Disabled	
		Manual Tach Scale 4.0 mA:	0 RPM	0 - 3600	
		Manual Tach Scale 20.0 mA:	2000 RPM	0 - 3600	
		Tach Accel Trip Mode Select	Disabled	Underspeed, Overspeed or Disabled	
		Tach Ramp Time	20 sec	1 - 120	
		Tach Underspeed Trip PT	1650 RPM	0-3600	
		Tach Overspeed Trip PT	1850 RPM	0 - 3600	
		Tach Accel Trip Delay	1 sec	1 - 60	
		Analog Output #1	RMS Current	Off, RPM 0-3600, Hottest Non-Stator RTD 0-200°C, Hottest Stator RTD 0 - 200°C, RMS Current 0 - 7500 A, % Motor Load 0 - 600 %.	
		Analog Output #1 4mA:	0	0-65535	
		Analog Output #1 20mA:	250	0-65535	
		Analog Output #2	% Motor Load	Same As Analog Input #1	
		Analog Output #2 4mA:	0	0-1000%	
		Analog Output #2 20mA:	1000	0-1000%	
		User Programmable External Inputs			
		External Input #1	Disabled	Enabled or Disabled	
		Name Ext. Input #1		User Defined, up to 15 Characters	
		External Input #1	NO	Normally Open or Closed	
		External Input #1	0 sec	0-60 sec	
		External Input #2	Disabled	Enabled or Disabled	
		Name Ext. Input #2		User Defined, up to 15 Characters	
		External Input #2 Type	NO	Normally Open or Closed	
		External Input #2 Time Delay	0 sec	0-60 sec	
		Dual Ramp	Dual Ramp	Enabled or Disabled or Dual Ramp	
		Name Ext. Input #3	Dual Ramp	User Defined, up to 15 Characters	
		Dual Ramp Type	NO	Normally Open or Closed	
		Dual Ramp Time Delay	0 sec	0-60 sec	
Thermostat	Enabled	Enabled or Disabled			
Name Ext. Input #4	Thermostat	User Defined, up to 15 Characters			
Thermostat Type	NC	Normally Open or Closed			
Thermostat Time Delay	1 sec	0-60 sec			

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Setting
Page 7 Custom Acceleration Curve	Level 3 Password Protection	Custom Accel Curve	Disabled	Disabled, Curve A, B, or C	
		Custom Curve A			
		Curve A Voltage Level 1	25%	0-100%	
		Curve A Ramp Time 1	2 sec	1-60 sec	
		Curve A Voltage Level 2	30%	0-100%	
		Curve A Ramp Time 2	2 sec	1-60 sec	
		Curve A Voltage Level 3	37%	0-100%	
		Curve A Ramp Time 3	2 sec	1-60 sec	
		Curve A Voltage Level 4	45%	0-100%	
		Curve A Ramp Time 4	2 sec	1-60 sec	
		Curve A Voltage Level 5	55%	0-100%	
		Curve A Ramp Time 5	2 sec	1-60 sec	
		Curve A Voltage Level 6	67%	0-100%	
		Curve A Ramp Time 6	2 sec	1-60 sec	
		Curve A Voltage Level 7	82%	0-100%	
		Curve A Ramp Time 7	2 sec	1-60 sec	
		Curve A Voltage Level 8	100%	0-100%	
		Curve A Ramp Time 8	2 sec	1-60 sec	
		Curve A Current Limit	350% FLA	200-600%	
		Custom Curve B		Same Programmable Data Points and Ranges as Custom Curve A	
Custom Curve C		Same Programmable Data Points and Ranges as Custom Curve A			
Setpoint Page	Security Level	Description	Factory Setting Default	Range	Setting
Page 8 Overload Curve Configuration	Level 3 Password Protection	Basic Run Overload Curve			
		Run Curve Locked Rotor Time	O/L Class	1-30 sec, O/L Class	
		Run Locked Rotor Current	600% FLA	400-800%	
		Coast Down Timer	Disabled	1-60 Min, Disabled	
		Basic Start Overload Curve			
		Start Curve Locked Rotor Time	O/L Class	1-30 sec, O/L Class	
		Start Locked Rotor Current	600% FLA	400-800%	
		Acceleration Time Limit	30 sec	1-300 sec, Disabled	
		Number of Starts Per Hour	Disabled	1-6, Disabled	
		Time Between Starts Time	Disabled	1-60 Min, Disabled	
		Area Under Curve Protection	Disabled	Enabled or Disabled	
		Max I ² T Start	368 FLA	1-2500 FLA*FLA*sec	
		Current Over Curve	Disabled	Disabled, Learn, Enabled	
		Learned Start Curve Bias	10%	5-40%	
		Time for Sampling	30 sec	1-300 sec	

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Setting
Page 9 RTD Configuration	Level 3 Password Protection	Use NEMA Temp for RTD Values	Disabled	Enabled or Disabled	
		# of RTD Used for Stator	4	0-6	
		RTD Voting	Disabled	Enabled or Disabled	
		Stator Phase A1 Type	Off	120 OHM NI, 100 OHM NI, 100 OHM PT, 10 OHM CU	
		RTD #1 Description	Stator A1	User defined, Up to 15 Characters	
		Stator Phase A1 Alarm Level	Off	0-240C (32-464F), Off	
		Stator Phase A1 Trip Level	Off	0-240C (32-464F), Off	
		Stator Phase A2 Type	Off	Same as Stator Phase A1	
		RTD #2 Description	Stator A2	User defined, Up to 15 Characters	
		Stator Phase A2 Alarm	Off	0-240C (32-464F), Off	
		Stator Phase A2 Trip Level	Off	0-240C (32-464F), Off	
		Stator Phase B1 Type	Off	Same as Stator Phase A1	
		RTD #3 Description	Stator B1	User defined, Up to 15 Characters	
		Stator Phase B1 Alarm Level	Off	0-240C (32-464F), Off	
		Stator Phase B1 Trip Level	Off	0-240C (32-464F), Off	
		Stator Phase B2 Type	Off	Same as Stator Phase A1	
		RTD #4 Description	Stator B2	User defined, Up to 15 Characters	
		Stator Phase B2 Alarm Level	Off	0-240C (32-464F), Off	
		Stator Phase B2 Trip Level	Off	0-240C (32-464F), Off	
		Stator Phase C1 Type	Off	Same as Stator Phase A1	
		RTD #5 Description	Stator C1	User defined, Up to 15 Characters	
		Stator Phase C1 Alarm Level	Off	0-240C (32-464F), Off	
		Stator Phase C1 Trip Level	Off	0-240C (32-464F), Off	
		Stator Phase C2 Type	Off	Same as Stator Phase A1	
		RTD #6 Description	Stator C2	User defined, Up to 15 Characters	
		Stator Phase C2 Alarm Level	Off	0-240C (32-464F), Off	
		Stator Phase C2 Trip Level	Off	0-240C (32-464F), Off	
		End Bearing Type	Off	Same as Stator A1	
		RTD #7 Description	End Bearing	User defined, Up to 15 Characters	
		End Bearing Alarm Level	Off	0-240C (32-464F), Off	
		End Bearing Trip Level	Off	0-240C (32-464F), Off	
		Shaft Bearing Type	Off	Same as Stator Phase A1	
		RTD #8 Description	Shaft Bearing	User defined, Up to 15 Characters	
Shaft Bearing Alarm Level	Off	0-240C (32-464F), Off			
Shaft Bearing Trip Level	Off	0-240C (32-464F), Off			
RTD #9 Type	Off	Same as Stator Phase A1			
RTD #9 Description	User defined	User defined, Up to 15 Characters			
RTD #9 Alarm Level	Off	0-240C (32-464F), Off			
RTD #9 Trip Level	Off	0-240C (32-464F), Off			

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Setting
Page 9 RTD Configuration	Level 3 Password Protection	RTD #10 Type	Off	Same as Stator Phase A1	
		RTD #10 Description	User defined	User defined, Up to 15 Characters	
		RTD #10 Alarm Level	Off	0-240C (32-464F), Off	
		RTD #10 Trip Level	Off	0-240C (32-464F), Off	
		RTD #11 Type	Off	Same as Stator Phase A1	
		RTD #11 Description	User defined	User defined, Up to 15 Characters	
		RTD #11 Alarm Level	Off	0-240C (32-464F), Off	
		RTD #11 Trip Level	Off	0-240C (32-464F), Off	
		RTD #12 Type	Off	Same as Stator Phase A1	
		RTD #12 Description	User defined	User defined, Up to 15 Characters	
		RTD #12 Alarm Level	Off	0-240C (32-464F), Off	
		RTD #12 Trip Level	Off	0-240C (32-464F), Off	

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Setting
Page 10	Level 3	Set Level 2 Password	100	000 – 999 Three Digits	
		Set Level 3 Password	1000	0000 – 9999 Four Digits	

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Setting
Page 11 Communications	Level 3 Password Protection	Set Front Baud Rate	9.6 KB/sec	2.4, 4.8, 9.6, 19.2, 38.4 KB/sec	
		Set Modbus Baud Rate	9.6 KB/sec	2.4, 4.8, 9.6, 19.2, 38.4 KB/sec	
		Modbus Address Number	247	1 – 247	
		Set Access Code	1	1 – 999	
		Set Link Baud Rate	38.4 KB/sec	2.4, 4.8, 9.6, 19.2, 38.4 KB/sec	
		Remote Start/Stop	Disabled	Enabled or Disabled	

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Setting
Page 12 System Setpoints	Level 3 Password Protection	Default Display Screen			
		Metering Data Page #	1	Enter Metering Page (1-4)	
		Metering Data Screen #	1	Enter Metering Screen Page 1(1-10) Page 2 (1-11) Page 3 (1 - 29) Page 4 (1 - 6)	
		Alarms			
		RTD Failure Alarm	Disabled	Enabled or Disabled	
		Thermal Register Alarm	90%	Off, 40-95%	
		Thermal Alarm Delay	10 sec	1-20 sec	
		Thermal Register Setup Info			
		Cold Stall Time	O/L Class	O/L Class (5-30) or 4-40 second time delay	
		Hot Stall Time	½ O/L Class	½ O/L Class, 4-40 sec	
		Stopped Cool Down Time	30 Min	10-300 Min	
		Runing Cool Down Time	15 Min	10-300 Min	
		Relay Measured Cool Rates	Disabled	Enabled or Disabled	
		Thermal Register Minimum	15%	10-50%	
		Motor Design Ambient Temp	40C	10-90C	
		Motor Design Run Temperature	80% Max	50-100% of Motor Stator Max Temp	
		Motor Stator Max Temp	INS CLS	INS CLS, 10-240 C	
		I/B Input to Thermal Register	Enabled	Enabled Only	
		Use Calculated K or Assign	7	1-50, On	
Press Enter to Clr Thermal Register					

Setpoint Page	Security Level	Description	Factory Setting Default	Range	Setting
Page 13 Calibration & Service	FACTORY USE ONLY	Set Date and Time (DDMMYY:HHMM)	FACTORY SET; ###/###/## #:##		
		Enter Date (DDMMYYYY)	FACTORY SET; ###/###/####	D=1-31, M=1-12, Y=1970-2069	
		Enter Time (HH:MM)	FACTORY SET; ##:##	H=00-23, M=0-59	
		Model # Firmware REV. #	FACTORY SET; #####	Display Only, Cannot be changed	
		Press Enter to Access Factory Settings		Available to Qualified Factory Personnel	

Warranty Policy

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.

The total liability of the Company, Toshiba Corporation and their suppliers and subcontractors for any loss, damage or claim, whether in contract, tort (including negligence and liability without fault), or otherwise, arising out of, connected with or resulting from the equipment and parts described in this manual or the performance or breach of any contract for the sale or supply of such equipment and parts, or from the design, manufacture, sale, delivery, resale, installation, technical direction or supervision of installation, inspection, testing, repair, replacement, operation, maintenance or use of any such equipment or part or any service relating thereto furnished by the Company shall not in any event exceed the price allocable to the equipment, part or service which gives claim, loss or damage. In no event, whether as a breach of contract or warranty, alleged negligence, liability without fault, or otherwise, shall the Company, Toshiba Corporation or their suppliers or subcontractors be liable for special or consequential damages, including, without limitation, loss or profits or revenue, loss of equipment described herein or any associated equipment, cost of capital, cost of substitute equipment or parts, facilities or services, down-time costs, labor costs or claims of customers of the purchaser for such damages.

