RediStart™

Solid State Starter

MX^3 Control

RB3, RC3, RX3E Models

User Manual

890034-02-00

December 2006

Motor Starter Card Set:	BIPC-400100-01-03
Software Version 1:	810023-02-01
Software Version 2:	810024-01-01
Gate Driver Card:	300047-01 Rev. 13

BENSHAW®
ADVANCED CONTROLS & DRIVES

Important Reader Notice

Congratulations on the purchase of your new Benshaw RediStart MX^3 Solid State Starter. This manual contains the information to install and program the MX^3 Solid State Starter.

This manual may not cover all of the applications for the RediStart MX^3. Also, it may not provide information on every possible contingency concerning installation, programming, operation, or maintenance specific to the RediStart MX^3 Series Starters.

The content of this manual will not modify any prior agreement, commitment or relationship between the customer and Benshaw. The sales contract contains the entire obligation of Benshaw. The warranty enclosed within the contract between the parties is the only warranty that Benshaw will recognize and any statements contained herein do not create new warranties or modify the existing warranty in any way.

Any electrical or mechanical modifications to Benshaw products without prior written consent of Benshaw will void all warranties and may also void cUL listing or other safety certifications, unauthorized modifications may also result in product damage operation malfunctions or personal injury.

Incorrect handling of the starter may result with an unexpected fault or damage to the starter. For best results on operating the RediStart MX^3 starter, carefully read this manual and all warning labels attached to the starter before installation and operation. Keep this manual on hand for reference.

Do not attempt to install, operate, maintain or inspect the starter until you have thoroughly read this manual and related documents carefully and can use the equipment correctly.
Do not use the starter until you have a full knowledge of the equipment, safety procedures and instructions.
This instruction manual classifies safety instruction levels under "WARNING" and "CAUTION".

⚡ **Electrical Hazard** that could result in injury or death.

⚠ **Caution** that could result in damage to the starter.
Highlight marking an important point in the documentation.

Please follow the instructions of both safety levels as they are important to personal safety.

High Voltage

⚡ Motor control equipment and electronic controllers are connected to hazardous line voltages. When servicing starters and electronic controllers, there may be exposed components with housings or protrusions at or above line potential. Extreme care should be taken to protect against shock.
Stand on an insulating pad and make it a habit to use only one hand when checking components. Always work with another person in case an emergency occurs. Disconnect power before checking controllers or performing maintenance. Be sure equipment is properly grounded. Wear safety glasses whenever working on electronic controllers or rotating machinery.

TRADEMARK NOTICE

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UL is a trademark of Underwriters Laboratories, Incorporated.

Safety Precautions

Electric Shock Prevention

- While power is on or soft starter is running, do not open the front cover. You may get an electrical shock.
- This soft starter contains high voltage which can cause electric shock resulting in personal injury or loss of life.
- Be sure all AC power is removed from the soft starter before servicing.
- Do not connect or disconnect the wires to or from soft starter when power is applied.
- Make sure ground connection is in place.
- Always install the soft starter before wiring. Otherwise, you may get an electrical shock or be injured.
- Operate the switches with dry hands to prevent an electrical shock.
- Risk of Electric Shock - More than one disconnect switch may be required to de-energize the equipment before servicing.

Injury Prevention

- Service only by qualified personnel.
- Make sure power-up restart is off to prevent any unexpected operation of the motor.
- Make certain proper shield installation is in place.
- Apply only the voltage that is specified in this manual to the terminals to prevent damage.

Transportation and Installation

- Use proper lifting gear when carrying products, to prevent injury.
- Make certain that the installation position and materials can withstand the weight of the soft starter. Refer to the installation information in this manual for correct installation.
- If parts are missing, or soft starter is damaged, do not operate the RediStart MX^3.
- Do not stand or rest heavy objects on the soft starter, as damage to the soft starter may result.
- Do not subject the soft starter to impact or dropping.
- Make certain to prevent screws, wire fragments, conductive bodies, oil or other flammable substances from entering the soft starter.

Trial Run

- Check all parameters, and ensure that the application will not be damaged by a sudden start-up.

Emergency Stop

- To prevent the machine and equipment from hazardous conditions if the soft starter fails, provide a safety backup such as an emergency brake.

Disposing of the RediStart MX^3

- Never dispose of electrical components via incineration. Contact your state environmental agency for details on disposal of electrical components and packaging in your area.

Table of Contents

1 Introduction

1 - INTRODUCTION

Using this Manual

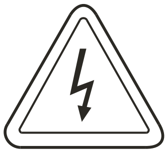
Layout

This manual is divided into 9 sections. Each section contains topics related to the section. The sections are as follows:

- Introduction
- Technical Information
- Installation
- Keypad Operation
- Parameters
- Parameter Descriptions
- Theory of Operation
- Troubleshooting & Maintenance
- Appendices

Symbols

There are 2 symbols used in this manual to highlight important information. The symbols appear as the following:



Electrical Hazard warns of situations in which a high voltage can cause physical injury, death and/or damage equipment.

Caution warns of situations in which physical injury and/damage to equipment may occur by means other than electrical.

Highlight mark an important point in the documentation.

DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

Only qualified personnel familiar with low voltage equipment are to perform work described in this set of instructions.
Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E.
Turn off all power before working on or inside equipment.
Use a properly rated voltage sensing device to confirm that the power is off.
Before performing visual inspections, tests, or maintenance on the equipment, disconnect all sources of electric power.
Assume that circuits are live until they have been completely de-energized, tested, and tagged. Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of backfeeding.
Replace all devices, doors, and covers before turning on power to this equipment.

Failure to follow these instructions will result in death or serious injury.

Benshaw Services

General Information

Benshaw offers its customers the following:

- Start-up services
- On-site training services
- Technical support
- Detailed documentation
- Replacement parts

⌘ **NOTE:** Information about products and services is available by contacting Benshaw, refer to page 4.

Start-Up Services

Benshaw technical field support personnel are available to customers with the initial start-up of the RediStart MX^3. Information about start-up services and fees are available by contacting Benshaw.

On-Site Training Services

Benshaw technical field support personnel are available to conduct on-site training on RediStart MX^3 operations and troubleshooting.

Technical Support

Benshaw technical support personnel are available (at no charge) to answer customer questions and provide technical support over the telephone. For more information about contacting technical support personnel, refer to page 4.

Documentation

Benshaw provides all customers with:

- Operations manual.
- Wiring diagram.

All drawings are produced in AutoCAD© format. The drawings are available on standard CD / DVD or via e-mail by contacting Benshaw.

On-Line Documentation

All RediStart MX^3 documentation is available on-line at **http://www.benshaw.com**.

Replacement Parts

Spare and replacement parts can be purchased from Benshaw Technical Support.

Software Number

This manual pertains to the software version number 1) 810023-02-01.
2) 810024-01-01.

Hardware Number

This manual pertains to the card hardware assembly version number BIPC-400100-01-03.

Publication History

See page 229.

Warranty

Benshaw provides a 1 year standard warranty with its starters. An extension to the 3 year warranty is provided when a Benshaw or Benshaw authorized service technician completes the installation and initial start up. The warranty data sheet must also be signed and returned. The cost of this service is not included in the price of the Benshaw soft starter and will be quoted specifically to each customers needs. All recommended maintenance procedures must be followed throughout the warranty period to ensure validity. This information is also available by going online to register at www.benshaw.com.

Contacting Benshaw

Contacting Benshaw

Information about Benshaw products and services is available by contacting Benshaw at one of the following offices:

Benshaw Inc. Corporate Headquarters
1659 E. Sutter Road
Glenshaw, PA 15116
Phone: (412) 487-8235
Tech Support: (800) 203-2416
Fax: (412) 487-4201

Benshaw Canada Controls Inc.
550 Bright Street East
Listowel, Ontario N4W 3W3
Phone: (519) 291-5112
Tech Support: (877) 236-7429 (BEN-SHAW)
Fax: (519) 291-2595

Benshaw West
14715 North 78th Way, Suite 600
Scottsdale, AZ 85260
Phone: (480) 905-0601
Fax: (480) 905-0757

Benshaw High Point
EPC Division
645 McWay Drive
High Point, NC 27263
Phone: (336) 434-4445
Fax: (336) 434-9682

Benshaw Mobile
CSD Division
5821 Rangeline Road, Suite 202
Theodor, AL 36582
Phone: (251) 443-5911
Fax: (251) 443-5966

Benshaw Pueblo
Trane Division
1 Jetway Court
Pueblo, CO 81001
Phone: (719) 948-1405
Fax: (719) 948-1445

Technical support for the RediStart MX^3 Series is available at no charge by contacting Benshaw's customer service department at one of the above telephone numbers. A service technician is available Monday through Friday from 8:00 a.m. to 5:00 p.m. EST.

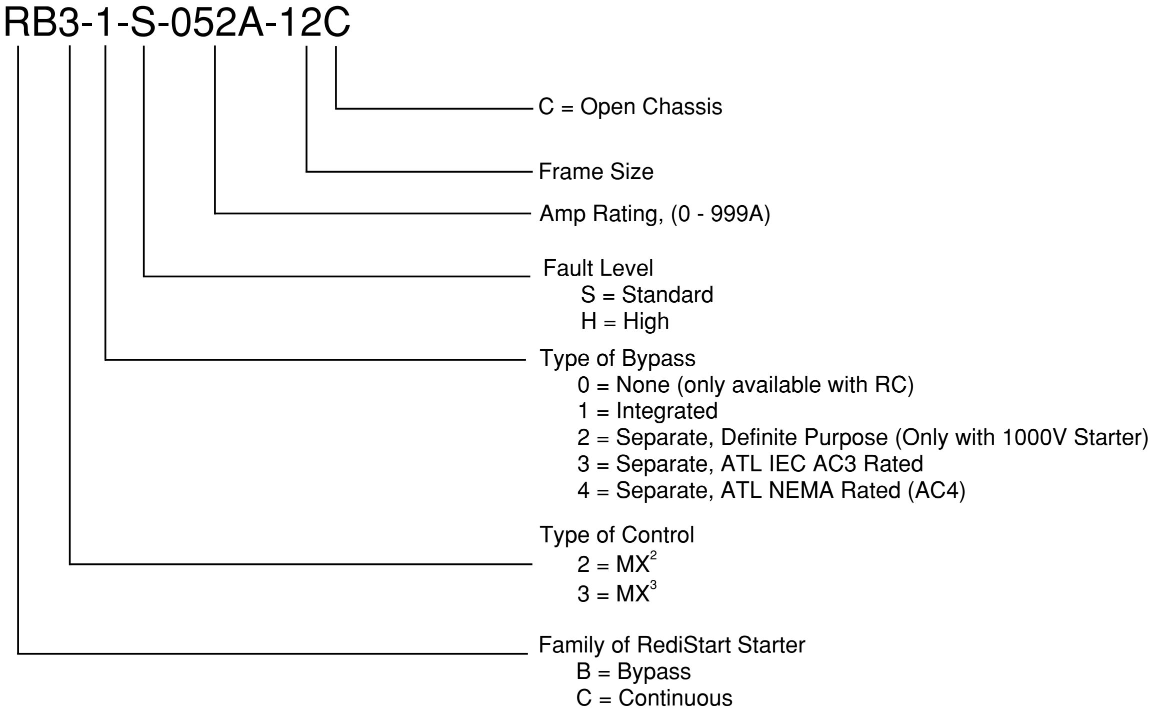
⌘ **NOTE:** An on-call technician is available after normal business hours and on weekends by calling Benshaw and following the recorded instructions.

To help assure prompt and accurate service, please have the following information available when contacting Benshaw:

- Name of Company
- Telephone number where the caller can be contacted
- Fax number of caller
- Benshaw product name
- Benshaw model number
- Benshaw serial number
- Name of product distributor
- Approximate date of purchase
- Voltage of motor attached to Benshaw product
- FLA of motor attached to Benshaw product
- A brief description of the application

Interpreting Model Numbers

Figure 1: RediStart MX^3 Series Model Numbers



1 - INTRODUCTION

General Overview of a Reduced Voltage Starter

General Overview

The RediStart MX^3 motor starter is a microprocessor-controlled starter for single or three-phase motors. The starter can be custom designed for specific applications. A few of the features are:

- Solid state design.
- Reduced voltage starting and soft stopping.
- Closed-loop motor current control, power (kW) control, torque control.
- Programmable motor protection.
- Programmable operating parameters.
- Programmable metering.
- Communications

Each starter can operate within applied line voltage and frequency values of 100VAC to 600VAC (optional 1000VAC) and 23 to 72Hz.

The starter can be programmed for any motor FLA and all of the common motor service factors. It enables operators to control both motor acceleration and deceleration. The RediStart MX^3 can also protect the motor and its load from damage that could be caused by incorrect phase order wiring.

The starter continually monitors the amount of current being delivered to the motor. This protects the motor from overheating or drawing excess current.

Features

The enhanced engineering features of the starter include:

- Multiple frame sizes
- Universal voltage operation
- Universal frequency operation
- Programmable motor overload multiplier
- Controlled acceleration and deceleration
- Phase rotation protection
- Regulated current control
- Electronic motor thermal overload protection
- Electronic over/under current protection
- Single phase protection
- Line-to-line current imbalance protection
- Stalled motor protection
- Programmable metering
- Passcode protected
- Programmable Relays
- Analog output with digital offset and span adjustment
- Analog input with digital offset and span adjustment
- Voltage and Current Accuracy of 3%
- Slow speed (Cyclo Conversion) 1.0 – 40.0% forward and reverse
- Motor winding heater (Anti-Condensation)
- Anti-windmilling brake
- PTC Thermistor
- 99 Event Recorder
- 9 Fault Log
- Real Time Clock
- Zero Sequence Ground Fault
- Backspin Timer
- Starts per Hour
- Time between Starts
- PORT (Power Outage Ride Through)
- 16 RTDs with O/L Biasing
- D.C. Injection Braking (Light or Heavy duty)

2 Technical Specifications

2 - TECHNICAL SPECIFICATIONS

Technical Specifications

2.1 General Information

The physical specifications of the starter vary depending upon its configuration. The applicable motor current determines the configuration and its specific application requirements.
Specifications are subject to change without notice.

This document covers the control electronics and several power sections:

- MX^3 control card set
- RB Power Stacks with Bypass, Integral and Separate
- RC Power Stacks, Continuous operation, NO bypass

Electrical Ratings

2.2 Electrical Ratings

2.2.1 Terminal Points and Functions

Table 1: Terminals

Function	Terminal Block	Terminal Number	Description
Control Power	TB1	G, ground N, 120VAC neutral N, 120VAC neutral L, 120VAC line L, 120VAC line	96 – 144 VAC input, 50/60 Hz 45VA required for control card
Relay 1 (R1)	TB2	NO1:Normally Open Contact RC1:Common NC1: Normally Closed Contact	Relay Output, SPDT form C **NO Contact (resistive)** **NC Contact(resistive)** 5A at 250VAC 3A at 250VAC 5A at 125VAC 3A at 125VAC 5A at 30VDC 3A at 30VDC 1250VA 750VA
Relay 2 (R2)	TB2	NO2: Normally Open Contact RC2: Common Contact NC2: Normally Closed Contact	Relay Output, SPDT form C **NO Contact (resistive)** **NC Contact(resistive)** 5A at 250VAC 3A at 250VAC 5A at 125VAC 3A at 125VAC 5A at 30VDC 3A at 30VDC 1250VA 750VA
Relay 3 (R3)	TB2	NO3: Normally Open Contact RC3: Common Contact NC3: Normally Closed Contact	10A at 250VAC 10A at 125VAC 10A at 30VDC 2500VA
Relay 4 (R4)	J3	R4A: Normally Open Contact R4B: Normally Open Contact	Relay Output, SPST-NO form A **Resistive:** 5A at 250VAC 5A at 125VAC 5A at 30VDC 1250VA
Relay 5 (R5)	J3	R5A: Normally Open Contact R5B: Normally Open Contact	Relay Output, SPST-NO form A **Resistive:** 5A at 250VAC 5A at 125VAC 5A at 30VDC 1250VA
Relay 6 (R6)	J3	R6A: Normally Open Contact R6B: Normally Open Contact	Relay Output, SPST-NO form A **Resistive:** 5A at 250VAC 5A at 125VAC 5A at 30VDC 1250VA

Table 1: Terminals

Function	Terminal Block	Terminal Number	Description
Digital Inputs	TB3	1: Start 2: DI1 3: DI2 4: DI3 5: Common	120VAC digital input 2500V optical isolation 4mA current draw Off: 0-35VAC On: 60-120VAC
Digital Inputs	J6	1: DI4 2: DI5 3: DI6 4: DI7 5: DI8 6: Common	120VAC digital input 2500V optical isolation 4mA current draw Off: 0-35VAC On: 60-120VAC
Serial Comm	TB4	1: B+ 2: A- 3: COM	Modbus RTU serial communication port. RS-485 interface 19.2k baud maximum 2500V Isolation
Analog I/O	TB5	1: Ain Power 2: Ain + 3: Ain - 4: Common 5: Aout 6: Common 7: Shield	Input: Voltage or Current Voltage: 0-10VDC, 67KΩ impedance Current: 0-20mA, 500Ω impedance Output: Voltage or Current Voltage: 0-10VDC, 120mA maximum Current: 0-20mA, 500Ω load maximum
PTC Thermistor Input	J7	1: Motor PTC 2: Motor PTC	Positive Temperature Coefficient Thermistor - Trip resistance 3.5K, ± 300 Ohms. - Reset resistance 1.65K, ± 150 Ohms. - Open terminal voltage is 15V. - PTC voltage at 4Kohms = 8.55V. (>7.5V) - Response time adjustable between 1 and 5 seconds. - Maximum cold resistance of PTC chain = 1500 Ohms.
Zero Sequence Ground Fault	J15	1: CT input 2: CT input	Zero Sequence Ground Fault CT Type: 50:0.025 (2000:1 ratio) Measurement range: 0.1A - 25.0 Amps Accuracy : +/- 3% Burden at 25Amps : 0.0089VA.
Display	RJ45		Door Mounted Display Connector
SCR	J6 to J11	1: Gate 2: Cathode	SCR gate Connections
Phase C.T.	J12	1: CT1+ 2: CT1 3: CT2+ 4: CT2 5: CT3+ 6: CT3	Phase CT Connector

Wire Gauge

The terminals can support 1- 14 AWG wire or 2-16 AWG wires or smaller.

Torque Rating

The terminals on the control cards have a torque rating of 5.0-inch lb. or 0.56Nm. This MUST be followed or damage will occur to the terminals.

⌘ **NOTE:** Refer to Control Card Layouts starting on page 41.

2.2.2 Measurements and Accuracies

Table 2: Measurements and Accuracies

Internal Measurements	
CT Inputs	Conversion: True RMS, Sampling @ 1.562kHz Range: 1-6400A
Line Voltage Inputs	Conversion: True RMS, Sampling @ 1.562kHz Range: 100VAC to 1000VAC, 23 to 72 Hz
Metering	
Current	0 – 40,000 Amps ± 3%
Voltage	0 – 1250 Volts ± 3%
Watts	0 – 9,999 MW ± 5%
Volts-Amps	0 – 9,999 MVA ± 5%
Watt-Hours	0 – 10,000 MWh ± 5%
PF	-0.01 to +0.01 (Lag & Lead) ± 5%
Line Frequency	23 – 72 Hz ± 0.1 Hz
Ground Fault	5 – 100% FLA ± 5% (Machine Protection)
Zero Seq GF	0.1 – 25.0 Amps ± 3%
Run Time	± 3 seconds per 24 hour period
Analog Input	Accuracy ± 3% of full scale (10 bit)
Analog Output	Accuracy ±2% of full scale (12 bit)
	⌘ **NOTE:** Percent accuracy is percent of full scale of the given ranges, Current = Motor FLA, Voltage = 1000V, Watts/Volts-Amps/Watt-Hours = Motor & Voltage range

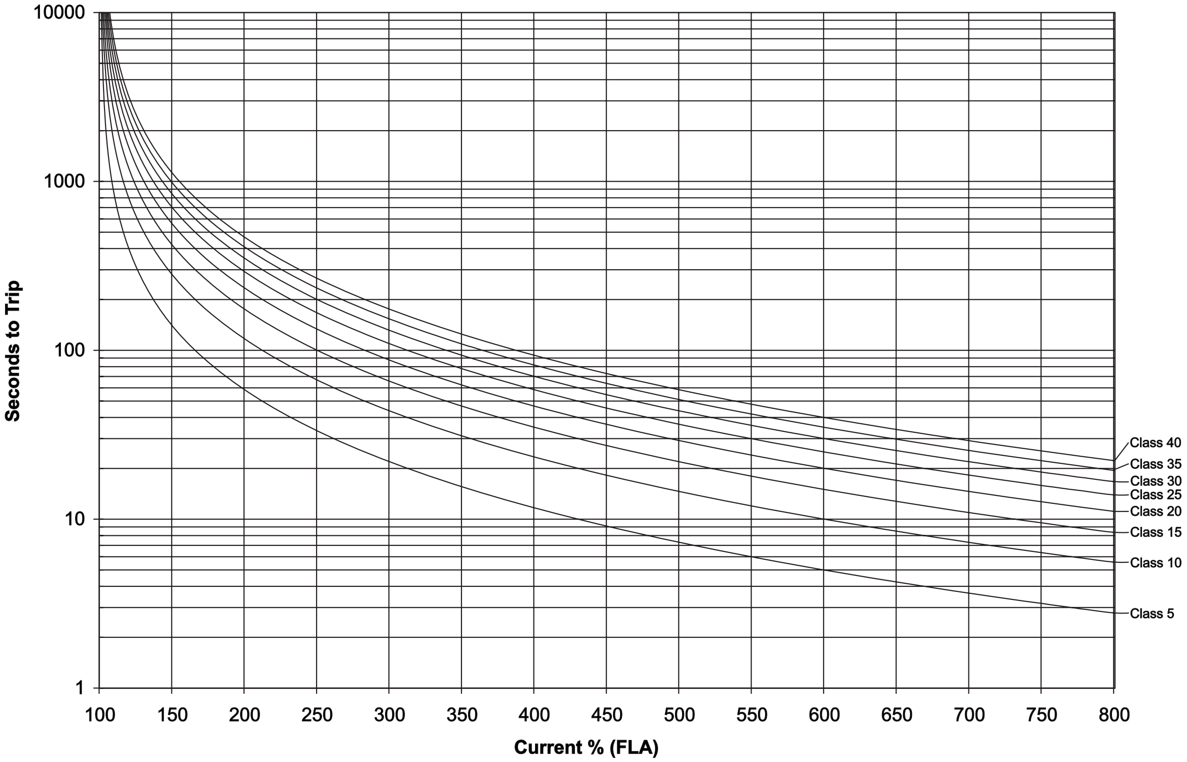
2.2.3 List of Motor Protection Features

- ANSI 14 – Speed Switch and Tachometer Trip
- ANSI 19 – Reduced Voltage Start
- ANSI 27 / 59 – Adjustable over/under voltage protection (Off or 1 to 40%, time 0.1 to 90.0 sec. in 0.1 sec. intervals, independent over and under voltage levels)
- ANSI 37 – Undercurrent detection (Off or 5 to 100% and time 0.1 to 90.0 sec. in 0.1 sec. intervals)
- ANSI 38 – Bearing RTD
  Other RTD
  Open RTD Alarm
- ANSI 46 – Current imbalance detection (Off or 5 to 40%)
- ANSI 47 – Phase rotation (selectable ABC, CBA, Insensitive, or Single Phase)
- ANSI 48 – Adjustable up-to-speed / stall timer (1 to 900 sec. in 1 sec. intervals)
- ANSI 49 – Stator RTD
- ANSI 50 – Instantaneous electronic overcurrent trip
- ANSI 51 – Electronic motor overload (Off, class 1 to 40, separate starting and running curves available)
- ANSI 51 – Overcurrent detection (Off or 50 to 800% and time 0.1 to 90.0 sec. in 0.1 sec. intervals)
- ANSI 51G – Residual Ground fault detection (Off or 5 to 100% of motor FLA)
  Zero Sequence Ground Fault Detection (Off, 0.1 - 25Amps)
- ANSI 66 – Starts/Hour & Time Between Starts
  Restart Block (Backspin Timer)
- ANSI 74 – Alarm relay output available
- ANSI 81 – Over / Under Frequency
- ANSI 86 – Overload lockout
- Single Phase Protection
- Shorted SCR detection
- Mechanical Jam

2.2.4 Solid State Motor Overload

The MX^3 control has an advanced I^2t electronic motor overload (OL) protection function. For optimal motor protection the MX^3 control has forty standard NEMA style overload curves available for use. Separate overloads can be programmed, one for acceleration and another for normal running operation. The overloads can be individual, the same or completely disabled if necessary. The MX^3 motor overload function also implements a NEMA based current imbalance overload compensation, RTD Biasing, user adjustable hot and cold motor compensation and user adjustable exponential motor cooling.

Figure 2: Commonly Used Overload Curves



The motor overload will NOT trip when the current is less than motor Full Load Amps (FLA) * Service Factor (SF).

The motor overload "pick up" point current is at motor Full Load Amps (FLA) * Service Factor (SF).

The motor overload trip time will be reduced when there is a current imbalance present.

⌘ **NOTE:** Refer to Theory of Operation, Chapter 7 in section 7.1 for more motor overload details and a larger graph.

Refer to http://www.benshaw.com/olcurves.html for an automated overload calculator.

2.2.5 CT Ratios

Table 3: CT Ratios

CT Ratio	Minimum FLA (A rms)	Maximum FLA (A rms)
72:1 (4 wraps 288:1)	4	16
96:1 (3 wraps 288:1)	5	21
144:1 (2 wraps 288:1)	8	32
288:1	15	64
864:1	45	190
2640:1	135	590
3900:1	200	870
5760:1	295	1285
8000:1	410	1800
14400:1 (CT-CT combination)	740	3200
28800:1 (CT-CT combination)	1475	6400
For the following CT Ratios, consult factory.		
50:5	11	45
150:5	33	135
250:5	55	225
800:5	176	720
2000:5	440	1800
5000:5	1100	4500

2.2.6 Optional RTD Module Specifications

The starter has the option of operating with up to two Benshaw SPR-100P remote RTD modules.

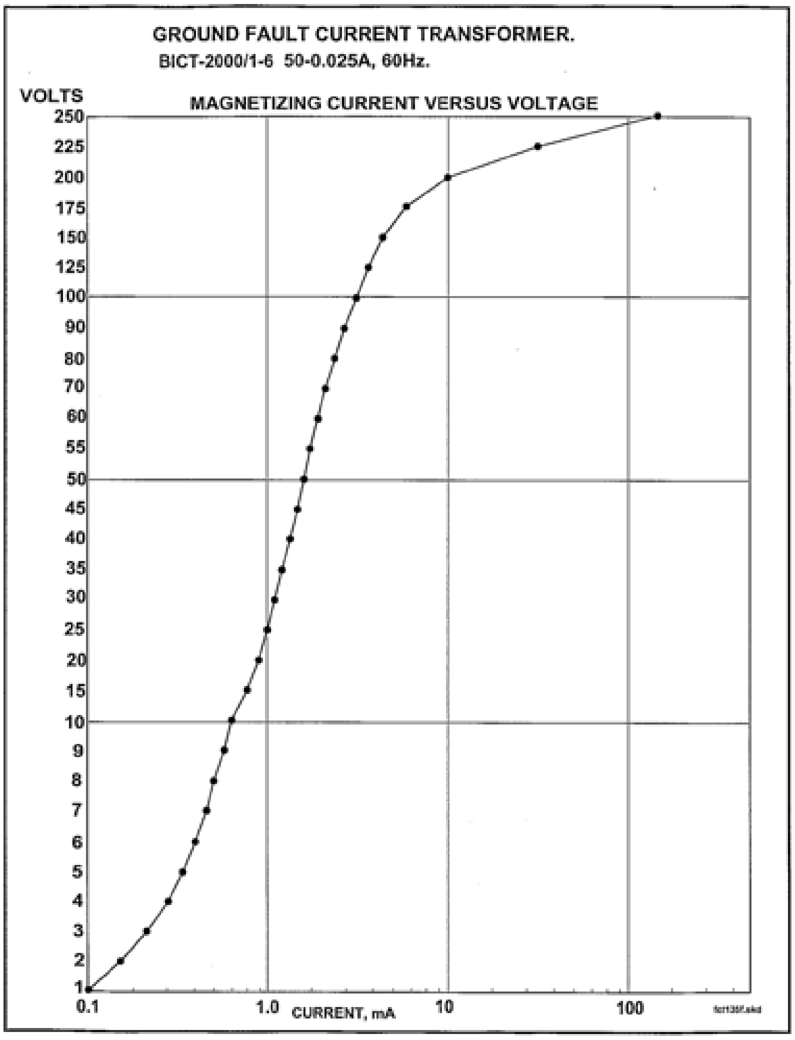
Table 4: Remote RTD Module Specifications

Model Number	SPR-100P
RTD Type	100Ω Platinum, 3 lead
TCR (α)	0.00385 Ω/Ω/°C (DIN 43760)
Maximum Lead Resistance	25Ω per lead
Recommended Lead Resistance	Less than 16Ω per lead
Shorted Lead Detection	< 60Ω
Open Lead Detection	> 260Ω
RTD Sensing Current	10 mA DC
RTD Sensing Voltage	10V DC maximum
Range	0 to 200 °C (32 to 392 °F)
Resolution	1 °C (1.8 °F)
Accuracy	±1.0% full scale (±2 °C or ±3.6 °F)
Sampling Rate	1 RTD per second
Number of RTDs	8
Input Voltage	24 Volts DC ± 20%, 2.5W
Communication Type	Modbus RTU, RS-485, 19.2Kbps
Modbus® Addresses	16 to 23
Operating Environment	-40 to 60 °C (-40 to 140 °F), up to 95% R.H., non-condensing
Terminal Strips	Accepts one or two stranded copper wires of the same size from 12 to 30 AWG
Dimensions	5 ½" W x 3 ½" H x 2 ¼" D
Listing	cUL

2.2.7 Zero Sequence Ground Fault CT

The Benshaw BICT 2000/1-6 CT has the following excitation curve.

Figure 3: BICT2000/1-6 Excitation Curve



Starter Power Ratings

2.3 Starter Power Ratings

Each RB3 model starter is rated for three different starting duties. For example, a starter can operate a:

300HP motor for a standard duty start (350% for 30 seconds)

Or

200HP for a heavy duty start (500% for 30 seconds)

Or

150HP motor for a class 30 start (600% for 30 seconds)

Or

450HP motor when connected to the inside delta of a motor for a class 10 start (350% for 30 seconds)

2.3.1 Standard Duty (350% for 30 sec) Ratings

Table 5: Standard Duty Horsepower Ratings

Standard Duty (350% current for 30 seconds, 115% Continuous)						
MODEL NUMBER	**NOMINAL AMPS**	**HORSEPOWER RATING**				
		200-208V	**230-240V**	**380-400V**	**440-480V**	**575-600V**
RB3-1-S-027A-11C	27	7.5	10	15	20	25
RB3-1-S-040A-11C	40	10	15	25	30	40
RB3-1-S-052A-12C	52	15	20	30	40	50
RB3-1-S-065A-12C	65	20	25	40	50	60
RB3-1-S-077A-13C	77	25	30	40	60	75
RB3-1-S-096A-13C	96	30	40	50	75	100
RB3-1-S-125A-14C	125	40	50	75	100	125
RB3-1-S-156A-14C	156	50	60	75	125	150
RB3-1-S-180A-14C	180	60	75	100	150	200
RB3-1-S-180A-15C	180	60	75	100	150	200
RB3-1-S-240A-15C	240	75	100	150	200	250
RB3-1-S-302A-15C	302	100	125	150	250	300
RB3-1-S-361A-16C	361	125	150	200	300	400
RB3-1-S-414A-17C	414	150	150	250	350	400
RB3-1-S-477A-17C	477	150	200	300	400	500
RB3-1-S-515A-17C	515	200	200	300	450	500
RB3-1-S-590A-18C	590	200	250	350	500	600
RB3-1-S-720A-19C	720	250	300	400	600	700
RB3-1-S-838A-20C	838	300	350	500	700	800

⌘ **NOTE:** Do not exceed Class 10 overload setting.

2.3.2 Heavy Duty (500% current for 30 sec) Ratings

Table 6: Heavy Duty Horsepower Ratings

Heavy Duty (500% current for 30 seconds, 125% Continuous)						
MODEL NUMBER	**NOMINAL AMPS**	**HORSEPOWER RATING**				
		200-208V	**230-240V**	**380-400V**	**440-480V**	**575-600V**
RB3-1-S-027A-11C	24	7.5	10	15	20	25
RB3-1-S-040A-11C	40	10	15	25	30	40
RB3-1-S-052A-12C	54	15	20	30	40	50
RB3-1-S-065A-12C	54	15	20	30	40	50
RB3-1-S-077A-13C	54	15	20	30	40	50
RB3-1-S-096A-13C	96	30	40	50	75	100
RB3-1-S-125A-14C	125	40	50	75	100	125
RB3-1-S-156A-14C	125	40	50	75	100	125
RB3-1-S-180A-14C	125	40	50	75	100	125
RB3-1-S-180A-15C	180	60	75	100	150	200
RB3-1-S-240A-15C	215	60	75	125	150	200
RB3-1-S-302A-15C	215	60	75	125	150	200
RB3-1-S-361A-16C	252	75	100	150	200	250
RB3-1-S-414A-17C	372	125	150	200	300	400
RB3-1-S-477A-17C	372	125	150	200	300	400
RB3-1-S-515A-17C	372	125	150	200	300	400
RB3-1-S-590A-18C	551	200	200	300	450	500
RB3-1-S-720A-19C	623	200	250	350	500	600
RB3-1-S-838A-20C	623	200	250	350	500	600

⌘ **NOTE:** Do not exceed Class 20 overload setting.

2.3.3 Severe Duty (600% current for 30 sec) Ratings

Table 7: Severe Duty Horsepower Ratings

Severe Duty (600% current for 30 seconds 125% Continuous)						
MODEL NUMBER	NOMINAL AMPS	HORSEPOWER RATING				
		200-208V	230-240V	380-400V	440-480V	575-600V
RB3-1-S-027A-11C	24	5	7.5	10	15	20
RB3-1-S-040A-11C	40	10	10	20	30	40
RB3-1-S-052A-12C	45	10	15	25	30	40
RB3-1-S-065A-12C	45	10	15	25	30	40
RB3-1-S-077A-13C	45	10	15	25	30	40
RB3-1-S-096A-13C	77	25	30	40	60	75
RB3-1-S-125A-14C	105	30	40	60	75	100
RB3-1-S-156A-14C	105	30	40	60	75	100
RB3-1-S-180A-14C	105	30	40	60	75	100
RB3-1-S-180A-15C	180	50	60	100	125	150
RB3-1-S-240A-15C	180	50	60	100	125	150
RB3-1-S-302A-15C	180	50	60	100	125	150
RB3-1-S-361A-16C	210	60	75	125	150	200
RB3-1-S-414A-17C	310	100	125	150	250	300
RB3-1-S-477A-17C	310	100	125	150	250	300
RB3-1-S-515A-17C	310	100	125	150	250	300
RB3-1-S-590A-18C	515	150	200	300	450	500
RB3-1-S-720A-19C	515	150	200	300	450	500
RB3-1-S-838A-20C	515	150	200	300	450	500

⌘ **NOTE:** Do not exceed Class 30 overload setting.

2.3.4 Inside Delta Connected Standard Duty (350% for 30 sec) Ratings

Table 8: Inside Delta Standard Duty Horsepower Ratings

INSIDE DELTA Std Duty (350% start for 30 seconds 115% Continuous)						
MODEL NUMBER	NOMINAL AMPS	HORSEPOWER RATING				
		200-208V	220-240V	380-415V	440-480V	575-600V
RB3-1-S-125A-14C	180	60	75	100	150	200
RB3-1-S-156A-14C	240	75	100	150	200	250
RB3-1-S-180A-14C	279	75	100	150	200	250
RB3-1-S-180A-15C	279	75	100	150	200	250
RB3-1-S-240A-15C	361	125	150	200	300	400
RB3-1-S-302A-15C	414	150	150	250	350	400
RB3-1-S-361A-16C	515	200	150	250	450	400
RB3-1-S-414A-17C	590	200	250	350	500	600
RB3-1-S-477A-17C	720	250	300	400	600	700
RB3-1-S-515A-17C	800	250	300	500	600	700
RB3-1-S-590A-18C	838	300	350	500	700	800
RB3-1-S-720A-19C	1116	300	350	700	900	800
RB3-1-S-838A-20C	1300	400	500	800	1000	1200

⌘ **NOTE:** Do not exceed Class 10 overload setting.

2.3.5 RB3 Power Stack Ratings and Protection Requirements

Model Number	Nominal Current (A)	115% Current Rating (A)	Nominal Current (A) Inside Delta	115% Current (A) Inside Delta	Unit Withstand Rating (KA) Std. Fault[5]	Unit Withstand Rating (KA) High. Fault[5]	Connection Type		Allowable Fuse Class	Maximum Fuse Size Current (A)	Maximum Circuit Breaker Trip Rating (A)	Running Watt Loss, After Bypassed (W)
							Line	Load				
RB_1_027A11C	27	31	-	48	5	5	Power Block[1]	Bus Tab[3]	J/T/RK1/RK5	45/70*	60/100*	49
RB_1_040A11C	40	46	-	71	5	5	Power Block[1]	Bus Tab[3]	J/T/RK1/RK5	70/100*	100/150*	49.8
RB_1_052A12C	52	60	-	93	10	10	Power Block[2]	Bus Tab[3]	J/T/RK1/RK5	90/125*	125/200*	51
RB_1_065A12C	65	75	-	116	10	10	Power Block[2]	Bus Tab[3]	J/T/RK1/RK5	110/175*	150/250*	53.7
RB_1_077A13C	77	89	-	137	10	10	Bus Tab[3]	Bus Tab[3]	J/T/RK1/RK5	125/200*	175/300*	56
RB_1_096A13C	96	110	-	171	10	10	Bus Tab[3]	Bus Tab[3]	J/T/RK1/RK5	150/250*	225/350*	59
RB_1_125A14C	125	144	194	223	18	30	Bus Tab[4]	Bus Tab[4]	J/T/RK1/RK5	200/300*	300/450*	62
RB_1_156A14C	156	179	242	278	18	30	Bus Tab[4]	Bus Tab[4]	J/T/RK1/RK5	250/400*	350/600*	66
RB_1_180A14C	180	207	279	321	18	30	Bus Tab[4]	Bus Tab[4]	J/T/RK1/RK5	300/450*	450/700*	71
RB_1_180A15C	180	207	279	321	30	65	Bus Tab[4]	Bus Tab[4]	J/T/RK1/RK5	300/450*	450/700*	71
RB_1_240A15C	240	276	372	428	30	65	Bus Tab[4]	Bus Tab[4]	J/T/RK1/RK5	400/600*	600/900*	75
RB_1_302A15C	302	347	468	538	30	65	Bus Tab[4]	Bus Tab[4]	J/T/RK1/RK5/L	500/800*	700/1100*	82
RB_1_361A16C	361	415	560	643	30	65	Bus Tab[4]	Bus Tab[4]	J/T/RK1/RK5/L	600/900*	900/1300*	92
RB_1_414A17C	414	476	642	738	42	65	Bus Tab[4]	Bus Tab[4]	L/T	700/1100*	1000/1600*	103
RB_1_477A17C	477	549	739	850	42	65	Bus Tab[4]	Bus Tab[4]	L/T	800/1200*	1200/1800*	120
RB_1_515A17C	515	592	798	918	42	65	Bus Tab[4]	Bus Tab[4]	L	900/1300*	1300/2000*	140
RB_1_590A18C	590	679	915	1052	42	65	Bus Tab[4]	Bus Tab[4]	L	1000/1600*	1400/2000*	165
RB_1_720A18C	720	828	1116	1283	42	65	Bus Tab[4]	Bus Tab[4]	L	1200/1800*	1800/2500*	205
RB_1_838A19C	838	964	1299	1494	42	65	Bus Tab[4]	Bus Tab[4]	L	1400/2000*	2000/3000*	245

* Rating for Inside Delta Application

1 Power Block wire size #12-#4awg

2 Power Block wire size #10-#1awg

3 Bus Tab with 1 hole ¼" diameter

4 Bus Tab with NEMA 2 hole pattern ½" diameter ¾" apart as defined by NEMA Standard CC1

5 For higher kAIC ratings, consult factory

2.3.6 Power Stack Input Ratings with Protection Requirements for Separate Bypass

Model Number	Nominal Current (A)	115% Current Rating (A)	Nominal Current (A) Inside Delta	115% Current (A) Inside Delta	AC3 Unit Withstand Fault Rating (KA) 5	NEMA (AC4) Unit Withstand Fault Rating (KA) 5	Connection Type		Allowable Fuse Class	Maximum Fuse Size Current (A)	Maximum Circuit Breaker Trip Rating (A)	Running Watt Loss, After Bypassed (W)
							Line	Load				
RB_2_027A11C	27	31	-	-	5	5	Power Block[1]	Bus Tab[3]	J/T/RK1/RK5	45/70*	60/100*	49
RB_2_040A11C	40	46	-	-	5	10	Power Block[1]	Bus Tab[3]	J/T/RK1/RK5	70/100*	100/150*	49.8
RB_2_052A12C	52	60	-	-	5	10	Power Block[2]	Bus Tab[3]	J/T/RK1/RK5	90/125*	125/200*	51
RB_2_065A12C	65	75	-	-	10	10	Power Block[2]	Bus Tab[3]	J/T/RK1/RK5	110/175*	150/250*	53.7
RB_2_077A13C	77	89	-	-	10	10	Bus Tab[3]	Bus Tab[3]	J/T/RK1/RK5	125/200*	175/300*	56
RB_2_096A13C	96	110	-	-	10	10	Bus Tab[3]	Bus Tab[3]	J/T/RK1/RK5	150/250*	225/350*	59
RB_2_125A14C	125	144	194	223	10	10	Bus Tab[4]	Bus Tab[4]	J/T/RK1/RK5	200/300*	300/450*	62
RB_2_156A14C	156	179	242	278	10	18	Bus Tab[4]	Bus Tab[4]	J/T/RK1/RK5	250/400*	350/600*	66
RB_2_180A14C	180	207	279	321	10	18	Bus Tab[4]	Bus Tab[4]	J/T/RK1/RK5	300/450*	450/700*	71
RB_2_180A15C	180	207	279	321	10	18	Bus Tab[4]	Bus Tab[4]	J/T/RK1/RK5	300/450*	450/700*	71
RB_2_240A15C	240	276	372	428	18	18	Bus Tab[4]	Bus Tab[4]	J/T/RK1/RK5	400/600*	600/900*	75
RB_2_302A15C	302	347	468	538	18	30	Bus Tab[4]	Bus Tab[4]	J/T/RK1/RK5/L	500/800*	700/1100*	82
RB_2_361A16C	361	415	560	643	30	30	Bus Tab[4]	Bus Tab[4]	J/T/RK1/RK5/L	600/900*	900/1300*	92
RB_2_414A17C	414	476	642	738	30	30	Bus Tab[4]	Bus Tab[4]	L/T	700/1100*	1000/1600*	103
RB_2_477A17C	477	549	739	850	30	30	Bus Tab[4]	Bus Tab[4]	L/T	800/1200*	1200/1800*	120
RB_2_515A17C	515	592	798	918	30	30	Bus Tab[4]	Bus Tab[4]	L	900/1300*	1300/2000*	140
RB_2_590A18C	590	679	915	1052	30	30	Bus Tab[4]	Bus Tab[4]	L	1000/1600*	1400/2000*	165
RB_2_720A18C	720	828	1116	1283	30	30	Bus Tab[4]	Bus Tab[4]	L	1200/1800*	1800/2500*	205
RB_2_838A19C	838	964	1299	1494	Consult Factory	Consult Factory	Bus Tab[4]	Bus Tab[4]	L	1400/2000*	2000/3000*	245

* Rating for Inside Delta Application

1 Power Block wire size #12-#4awg

2 Power Block wire size #10-#1awg

3 Bus Tab with 1 hole ¼" diameter

4 Bus Tab with NEMA 2 hole pattern ½" diameter ¾" apart as defined by NEMA Standard CC1

5 For higher kAIC ratings, consult factory

2.3.7 Power Stack Input Ratings with Protection Requirements for RC No Bypass

Model Number	Nominal Current (A)	125% Current	Unit Withstand Fault Rating (kA)^4	Connection Type		Current Limiting Circuit Breaker Protected Rating			Current Limiting Circuit Breaker Protected Rating			Running Watt Loss, After Bypassed (W)
				Line	Load	Allowable Fuse Class	Maximum Fuse Current (A)	Short Circuit Rating	Catalog Number	Trip Plug	Short Circuit Rating	
RC_ 0 _027A11C	27	33.75	42	Power Block^1	Power Block^1	J/600V AC T/RK1	40 60	100kA 50kA	CED63B	60A	42kA	110
RC_ 0 _040A11C	40	50	42	Power Block^1	Power Block^1	J/600V AC T/RK1	60 100	100kA 50kA	CED63B	60A	42Ka	145
RC_ 0 _052A12C	52	65	42	Power Block^2	Power Block^1	J/600V AC T/RK1	60 100	100kA 50kA	CED63B	100A	42kA	175
RC_ 0 _065A12C	65	81	42	Power Block^2	Power Block^1	J/600V AC T/RK1	225	100kA	CED63B	100A	42kA	210
RC_ 0 _077A13C	77	96	42	Power Block^1	Power Block^1	J/600V AC T/RK1	225	100kA	CED63B	125A	42kA	240
RC_ 0 _096A13C	96	120	42	Power Block^1	Power Block^1	J/600V AC T/RK1	225	100kA	CFD63B	225A	42kA	285
RC_ 0 _124A33C	124	155	42	Power Block^1	Power Block^1	J/600V AC T/RK1	225	100kA	CFD63B	225A	42kA	360
RC_ 0 _125A14C	125	155	42	Bus Tab	Bus Tab	J/600V AC T/RK1	350	100kA	CFD63B	225A	42kA	360
RC_ 0 _156A14C	156	195	42	Bus Tab	Bus Tab	J/600V AC T/RK1	400	100kA	CFD63B	225A	65kA	435
RC_ 0 _180A15C	180	2225	42	Bus Tab	Bus Tab	J/600V AC T/RK1	400	100kA	CFD63B	250A	65kA	495
RC_ 0 _240A15C	240	300	42	Bus Tab	Bus Tab	J/600V AC T/RK1	600	100kA	CFD63B	400A	65kA	645
RC_ 0 _302A15C	302	377	42	Bus Tab	Bus Tab	J/600V AC T/RK1	800	100kA	CFD63B	400A	65kA	800
RC_ 0 _361A16C	361	421	42	Bus Tab	Bus Tab	J/600V AC T/RK1	800	100kA	CJD63B CLD63b	400A 600A	65kA	950
RC_ 0 _477A17C	477	596	42	Bus Tab	Bus Tab	J/600V AC T/RK1	800	100kA	CJD63B CLD63b	400A 600A	65kA	1240
RC_ 0 _590A18C	590	737	42	Bus Tab	Bus Tab	L	1400	100kA	CND63B CND63b	800A 1200a	85kA	1520
RC_ 0 _720A18C	720	900	42	Bus Tab	Bus Tab	L	1600	100kA	CND63B CND63b	800A 1200A	85kA	1845
RC_ 0 _840A19C	840	1050	85	Bus Tab	Bus Tab	L	1600	100kA	CND63B CND63b	800A 1200A	85kA	2145
RC_ 0 _960A19C	960	1200	85	Bus Tab	Bus Tab	L	1600 2000	100kA 50kA	HPD63F160	1200 – 1600A	85kA	2445
RC_ 0_1200KA19C	1200	1440	85	Bus Tab	Bus Tab	L	1600 2000	100kA 50kA	HPD63F160	1200 – 1600A	85kA	3045

1 Power Block wire size #6 awg max

2 Power Block wire size #2 awg max

3 Power Block wire size #2/0 max

4 For higher kAIC ratings, consult factory

2.3.8 RB3 Starter Control Power Requirements

Table 9: RB3 Starter CPT VA Requirements

Model Number	Power Required (VA)	Recommended Min. TX size	Model Number	Power Required (VA)	Recommended Min. TX size
RB3-1-S-027A-11C	74	75	RB3-1-S-240A-15C	243	250
RB3-1-S-040A-11C	74	75	RB3-1-S-302A-15C	243	250
RB3-1-S-052A-12C	111	125	RB3-1-S-361A-16C	243	250
RB3-1-S-065A-12C	111	125	RB3-1-S-414A-17C	441	450
RB3-1-S-077A-13C	111	125	RB3-1-S-477A-17C	441	450
RB3-1-S-096A-13C	111	125	RB3-1-S-515A-17C	441	450
RB3-1-S-125A-14C	131	150	RB3-1-S-590A-18C	441	450
RB3-1-S-156A-14C	243	250	RB3-1-S-720A-19C	441	450
RB3-1-S-180A-14C	243	250	RB3-1-S-838A-20C	243	250

2.3.9 RC3 Starter Control Power Requirements

Table 10: RC3 Starter CPT VA Requirements

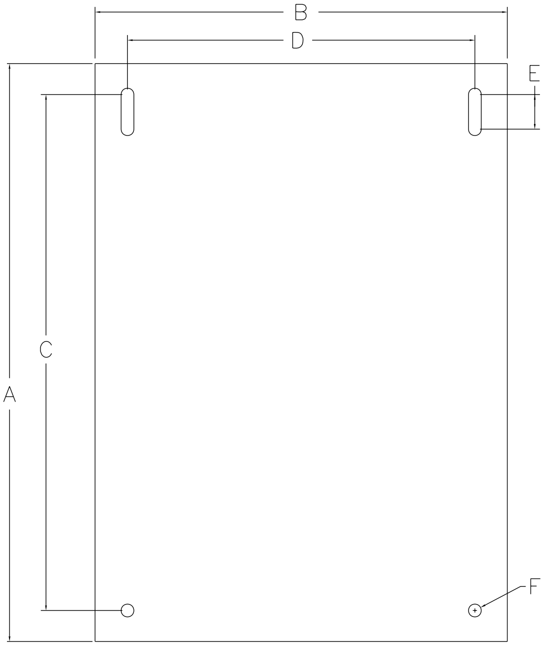
Model Number	Power Required (VA)	Recommended Min. TX size	Model Number	Power Required (VA)	Recommended Min. TX size
RC3-1-S-027A-31C	45	75	RC3-1-S-240A-35C	123	150
RC3-1-S-040A-31C	45	75	RC3-1-S-302A-35C	123	150
RC3-1-S-052A-31C	45	75	RC3-1-S-361A-35C	201	250
RC3-1-S-065A-32C	45	75	RC3-1-S-414A-35C	150	200
RC3-1-S-077A-32C	45	75	RC3-1-S-477A-35C	225	350
RC3-1-S-096A-33C	45	75	RC3-1-S-590A-35C	225	350
RC3-1-S-124A-33C	45	75	RC3-1-S-720A-36C	225	350
RC3-1-S-125A-34C	123	150	RC3-1-S-840A-19C	225	350
RC3-1-S-156A-34C	123	150	RC3-1-S-960A-20C	225	350
RC3-1-S-180A-34C	123	150	RC3-1-S-1200A-37C	285	350

Mechanical Drawings

2.4 Dimensions

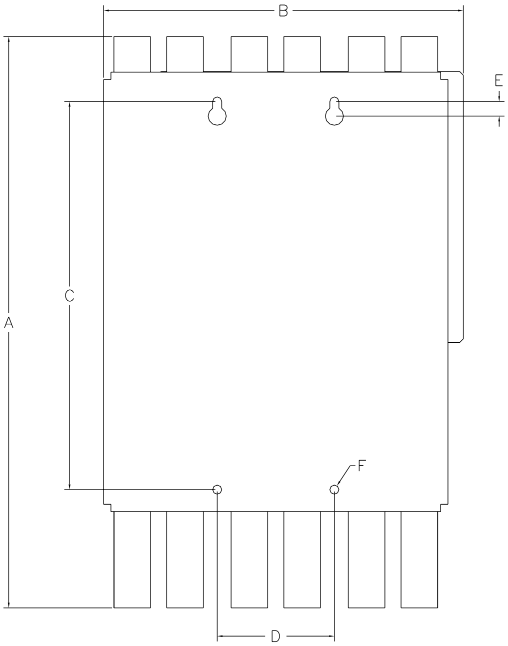
2.4.1 RB3 Chassis with Integral Bypass

Figure 4: RB3 - 96A, 830A



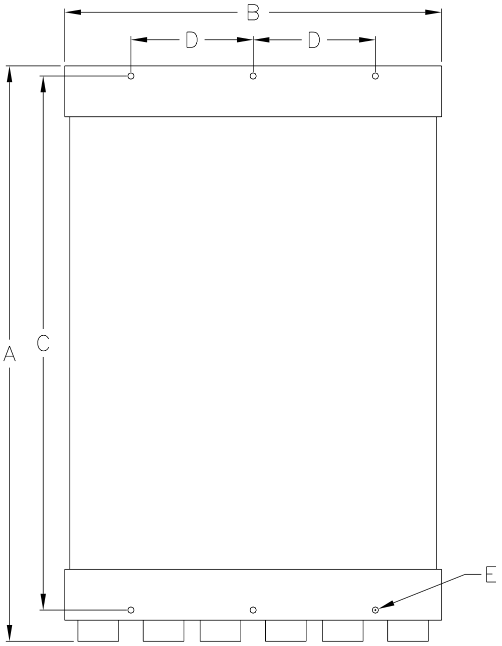
Model	A	B	C	D	E	F
RB3 27-65A	14	10	12.5	8.43	0.84	0.31
RB3 77-96A	15	10	13.5	8.43	0.84	0.31
RB3 838A	27.75	26.6	23.5	8.7	N/A	0.31

Figure 5: RB3 125 - 361A



Model	A	B	C	D	E	F
RB3 125A	19.5	12.27	13.25	4	0.5	0.31
RB3 156-180A	21.25	12.27	15.25	4	0.5	0.31
RB3 180-302A	22.75	12.27	16.75	4	0.5	0.31
RB3 361A	23.87	13.09	18.63	4.31	0.5	0.31

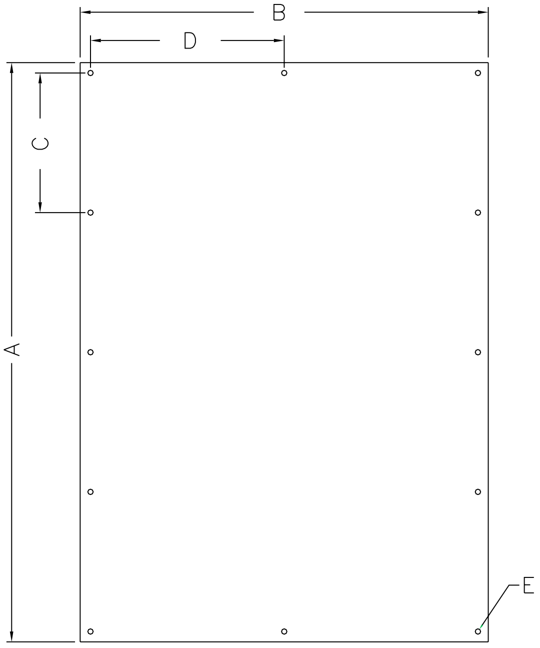
Figure 6: RB3 414 - 838A



Model	A	B	C	D	E	F
RB3 414-590A	28.29	18.5	26.25	6	N/A	0.31
RB3 720A	30.04	18.5	28	6	N/A	0.31
RB3 838A	27.75	26.6	23.5	8.7	N/A	0.31

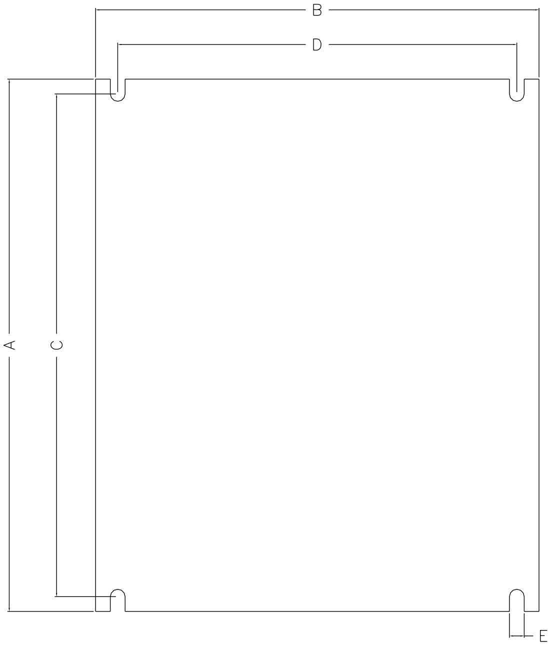
2.4.2 RC3 Chassis with no Bypass

Figure 7: RC3 0 - 124A



Model	A	B	C	D	E
RC3 27-52A	14	9.875	3.375	4.69	8-32 TAP
RC3 65-77A	18	10	4.375	4.75	¼-20 TAP
RC3 96-124A	27	10	5.313	4.75	¼-20 TAP

Figure 8: RC3 156 - 590A



Model	A	B	C	D	E
RC3 156-180A	18	15	17	13.5	0.3
RC3 240A	24	15	23	13.5	0.5
RC3 302-361A	28	17.25	27	15.75	0.5
RC3 477A	28	20	27	18.5	0.5
RC3 590A	35	20	34	18.5	0.5

Environmental Conditions

2.5 Environmental Conditions

Table 11: Environmental Ratings

Operating Temperatures	-10°C to +40°C (14°F to 104°F)enclosed -10°C to +50°C (14°F to 122°F)open
Storage Temperatures	-20°C to +70°C (-4°F to 155°F)
Humidity	0% to 95% non condensing
Altitude	1000m (3300ft) without derating
Maximum Vibration	5.9m/s^2 (19.2ft/s^2) [0.6G]
Cooling	RC (Natural convection) RB (Bypassed)

Altitude Derating

2.6 Altitude Derating

Benshaw's starters are capable of operating at altitudes up to 3,300 feet (1000 meters) without requiring altitude derating. Table 12 provides the derating percentage to be considered when using a starter above 3,300 feet (1000 meters).

Table 12: Altitude Derating

Altitude		Percent Derating (Amps)
3300 Feet	1006 meters	0.0%
4300 Feet	1311 meters	3.0%
5300 Feet	1615 meters	6.0%
6300 Feet	1920 meters	9.0%
7300 Feet	2225 meters	12.0%
8300 Feet	2530 meters	15.0%
9300 Feet	2835 meters	18.0%

Real Time Clock

2.7 Real Time Clock

The MX^3 comes with a real time clock. The user can enter the actual time and the starter will use this time when it logs faults in the fault recorder as well as events in the event recorder. This can help with troubleshooting. The system clock does not recognize daylight savings time.
Accuracy: +- 1 minute per month
Range: 1/1/1972 to 1/1/2107 with automatic leap year compensation.

Approvals

2.8 Approvals

MX^3 Control Card set is UL, cUL Recognized

Certificate of Compliance

2.9 Certificate of Compliance

CE Mark, See Appendix E on page 208.

3 Installation

Before You Start

3.1 Before You Start

3.1.1 Installation Precautions

Inspection

Before storing or installing the RediStart MX^3 Series Starter, thoroughly inspect the device for possible shipping damage. Upon receipt:

- Remove the starter from its package and inspect exterior for shipping damage. If damage is apparent, notify the shipping agent and your sales representative.
- Open the enclosure and inspect the starter for any apparent damage or foreign objects. Ensure that all of the mounting hardware and terminal connection hardware is properly seated, securely fastened, and undamaged.
- Ensure all connections and wires are secured.
- Read the technical data label affixed to the starter and ensure that the correct horsepower and input voltage for the application has been purchased.

The numbering system for a chassis is shown below.

General Information

Installation of some models may require halting production during installation. If applicable, ensure that the starter is installed when production can be halted long enough to accommodate the installation. Before installing the starter, ensure:

- The wiring diagram (supplied separately with the starter) is correct for the required application.
- The starter is the correct current rating and voltage rating for the motor being started.
- All of the installation safety precautions are followed.
- The correct power source is available.
- The starter control method has been selected.
- The connection cables have been obtained (lugs) and associated mounting hardware.
- The necessary installation tools and supplies are procured.
- The installation site meets all environmental specifications for the starter NEMA/CEMA rating.
- The motor being started has been installed and is ready to be started.
- Any power factor correction capacitors (PFCC) are installed on the power source side of the starter and not on the motor side.

Failure to remove power factor correction or surge capacitors from the load side of the starter will result in serious damage to the starter that will not be covered by the starter warranty. The capacitors must be connected to the line side of the starter. The up-to-speed (UTS) contact can be used to energize the capacitors after the motor has reached full speed.

3.1.2 Safety Precautions

To ensure the safety of the individuals installing the starter, and the safe operation of the starter, observe the following guidelines:

- Ensure that the installation site meets all of the required environmental conditions (Refer to Site Preparation, page 29).
- LOCK OUT ALL SOURCES OF POWER.
- Install circuit disconnecting devices (i.e., circuit breaker, fused disconnect or non-fused disconnect) if they were not previously installed by the factory as part of the package.
- Install short circuit protection (i.e., circuit breaker or fuses) if not previously installed by the factory as part of the package.
- Consult Power Ratings for the fault rating on pages 19-21.
- Follow all NEC (National Electrical Code) and/or C.S.A. (Canadian Standards Association) standards or Local Codes as applicable.
- Remove any foreign objects from the interior of the enclosure, especially wire strands that may be left over from installation wiring.
- Ensure that a qualified electrician installs wiring.
- Ensure that the individuals installing the starter are wearing ALL protective eyewear and clothing.
- Ensure the starter is protected from debris, metal shavings and any other foreign objects.

The opening of the branch circuit protective device may be an indication that a fault current has been interrupted. To reduce the risk of electrical shock, current carrying parts and other components of the starter should be inspected and replaced if damaged.

Installation Considerations

3.2 Installation Considerations

3.2.1 Site Preparation

General Information

Before the starter can be installed, the installation site must be prepared. The customer is responsible for:

- Providing the correct power source
- Providing the correct power protection
- Selecting the control mechanism
- Obtaining the connection cables, lugs and all other hardware
- Ensuring the installation site meets all environmental specifications for the enclosure NEMA rating
- Installing and connecting the motor

Power Cables

The power cables for the starter must have the correct NEC/CSA current rating for the unit being installed. Depending upon the model, the power cables can range from a single #14 AWG conductor to four 750 MCM cables. (Consult local and national codes for selecting wire size).

Site Requirements

The installation site must adhere to the applicable starter NEMA/CEMA rating. For optimal performance, the installation site must meet the appropriate environmental and altitude requirements.

3.2.2 EMC Installation Guidelines

General	In order to help our customers comply with European electromagnetic compatibility standards, Benshaw Inc. has developed the following guidelines.
Attention	This product has been designed for Class A equipment. Use of the product in domestic environments may cause radio interference, in which case the installer may need to use additional mitigation methods.
Enclosure	Install the product in a grounded metal enclosure.
Grounding	Connect a grounding conductor to the screw or terminal provided as standard on each controller. Refer to layout/power wiring schematic for grounding provision location.
Wiring	Refer to Wiring Practices on page 31.
Filtering	To comply with Conducted Emission Limits (CE requirement), a high voltage (1000V or greater) 0.1 uF capacitor should be connected from each input line to ground at the point where the line enters the cabinet.

3.2.3 Use of Power Factor Capacitors

Power factor correction capacitors and surge capacitors CAN NOT be connected between the starter and the motor. These devices can damage the SCRs during ramping. These devices appear like a short circuit to the SCR when it turns on, which causes a di/dt level greater than the SCR can handle. If used, power factor correction capacitors or surge capacitors must be connected ahead of the starter and sequenced into the power circuit after the start is completed. A programmable relay can be configured as an up-to-speed (UTS) relay and then used to pull-in a contactor to connect the capacitors after the motor has reached full speed.

⌘ **NOTE:** If the motor manufacturer supplies surge capacitors they must be removed before starting.

3.2.4 Use of Electro-Mechanical Brakes

If an electro-mechanical brake is used with the starter, it must be powered from the line side of the starter to ensure full voltage is applied to the brake during a start so it will properly release. A programmable relay can be configured as a run relay and then used to pull-in a contactor to power the brake whenever the starter is providing power to the motor.

3.2.5 Reversing Contactor

If the application requires a reversing contactor, it should be connected on the output side (load) of the soft starter. The contactor must be closed before starting the soft starter. The soft starter must be off before switching the direction of the reversing contactor. The reversing contactor must never be switched while the soft starter is operating.

Mounting Considerations

3.3 Mounting Considerations

3.3.1 Bypassed Starters

Provisions should be made to ensure that the average temperature inside the enclosure never rises above 50°C. If the temperature inside the enclosure is too high, the starter can be damaged or the operational life can be reduced.

3.3.2 Non-Bypassed Starters

Provisions should be made to ensure that the temperature inside the enclosure never rises above 50°C. If the temperature inside the enclosure is too high, the starter can be damaged or the operational life can be reduced. As a general rule of thumb, the following ventilation guidelines can be followed.

Table 13: Ventilation Requirements

Current Range	Bottom of Enclosure	Top of Enclosure
< 200 amps	Fans or grills depending on enclosure size	
200 to 300 amps	2 x 4” grills (12 sq. in.)	2 x 4” grills (12 sq.in.)
301 to 400 amps	1 x 4” fan (115 cfm)	2 x 4” grills (12 sq.in.)
401 to 600 amps	2 x 4” fan (230 cfm)	2 x 6” grills (28 sq.in.)
601 to 700 amps	2 x 6” fan (470 cfm)	2 x 6” grills (28 sq.in.)
> 700 amps	Consult factory	Consult Factory

The starter produces 4 watts of heat per amp of current and 26 square inches of enclosure surface is required per watt of heat generation. Contact Benshaw and ask for the enclosure sizing technical note for more information concerning starters in sealed enclosures. Benshaw supplies starters under 124 amps non-bypassed, with the heat sink protruding from the back of the enclosure. This allows a small enclosure size while still maintaining the cooling capability of the starter.

Wiring Considerations

3.4 Wiring Considerations

3.4.1 Wiring Practices

When making power and control signal connections, the following should be observed:

- Never connect input AC power to the motor output terminals T1/U, T2/V, or T3/W.
- Power wiring to the motor must have the maximum possible separation from all other wiring. Do not run control wiring in the same conduit; this separation reduces the possibility of coupling electrical noise between circuits. Minimum spacing between metallic conduits containing different wire groups should be three inches (8cm).
- Minimum spacing between different wiring groups in the same tray should be six inches.
- Wire runs outside an enclosure should be run in metallic conduit or have shielding/armor with equivalent attenuation.
- Whenever power and control wiring cross it should be at a 90 degrees angle.
- Different wire groups should be run in separate conduits.
- With a reversing application, the starter must be installed in front of the reversing contactors.

⌘ **NOTE:** Local electrical codes must be adhered to for all wiring practices.

3.4.2 Considerations for Control and Power Wiring

Control wiring refers to wires connected to the control terminal strip that normally carry 24V to 115V and Power wiring refers to wires connected to the line and load terminals that normally carries 200VAC - 600VAC respectively. Select power wiring as follows:

- Use only UL or CSA recognized wire.
- Wire voltage rating must be a minimum of 300V for 230VAC systems and 600V (Class 1 wire) for 460VAC and 600VAC systems.
- Grounding must be in accordance with NEC, CEC or local codes. If multiple starters are installed near each other, each must be connected to ground. Take care to not form a ground loop. The grounds should be connected in a STAR configuration.
- Wire must be made of copper and rated 60/75°C for units 124 Amps and below. Larger amp units may use copper or aluminum wire. Refer to NEC table 310-16 or local codes for proper wire selection.

3.4.3 Considerations for Signal Wiring

Signal wiring refers to the wires connected to the control terminal strip that are low voltage signals, below 15V.

- Shielded wire is recommended to prevent electrical noise interference from causing improper operation or nuisance tripping.
- Signal wire rating should carry as high of a voltage rating as possible, normally at least 300V.
- Routing of signal wire is important to keep as far away from control and power wiring as possible.

3.4.4 Meggering a Motor

If the motor needs to be meggered, remove the motor leads from the starter before conducting the test. Failure to comply may damage the SCRs and WILL damage the control board, which WILL NOT be replaced under warranty.

3.4.5 High Pot Testing

If the starter needs to be high pot tested, perform a DC high pot test. The maximum high point voltage must not exceed 2.0 times rated RMS voltage + 1000VAC (High pot to 75% of Factory). Failure to comply WILL damage the control board, which WILL NOT be replaced under warranty. An example to find the high point voltage is (2.0 * rated RMS voltage + 1000) * 0.75.

Power and Control Drawings for Bypassed and Non Bypassed Power Stacks

3.5 Power and Control drawings for Bypassed and Non Bypassed Power Stacks

Figure 9: Power Schematic for RB3 Low HP

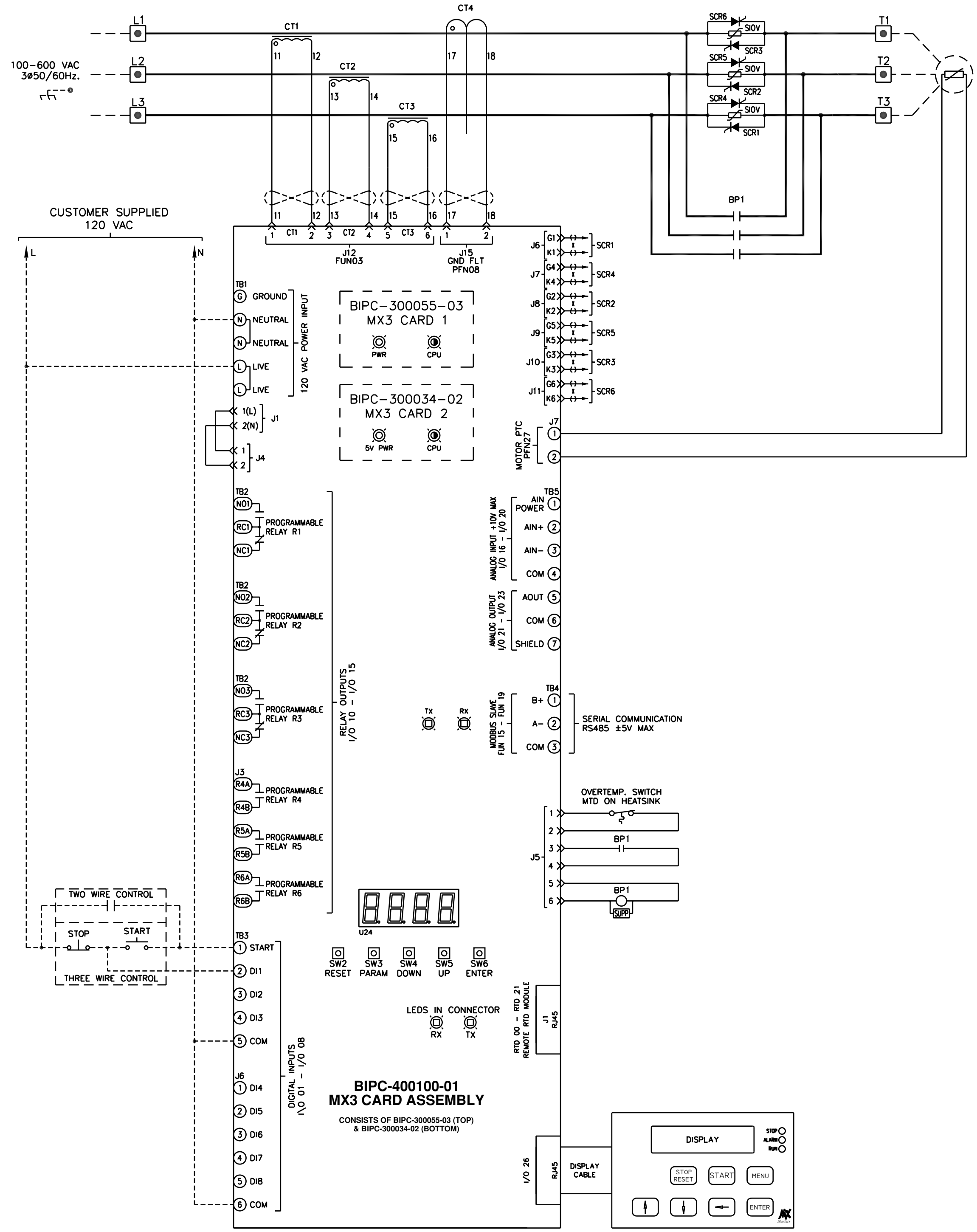


Figure 10: Power Schematic for RB3 High HP

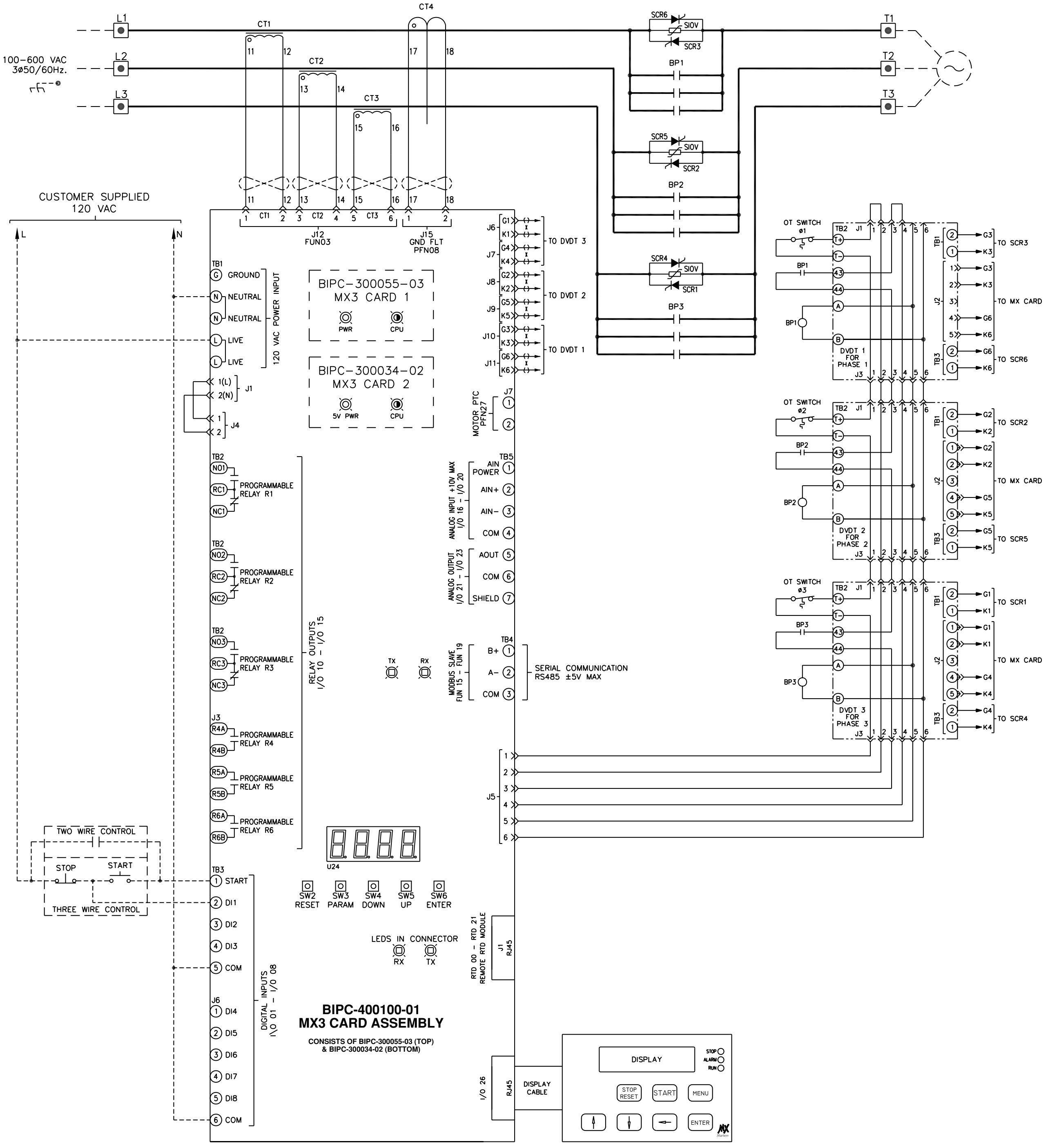
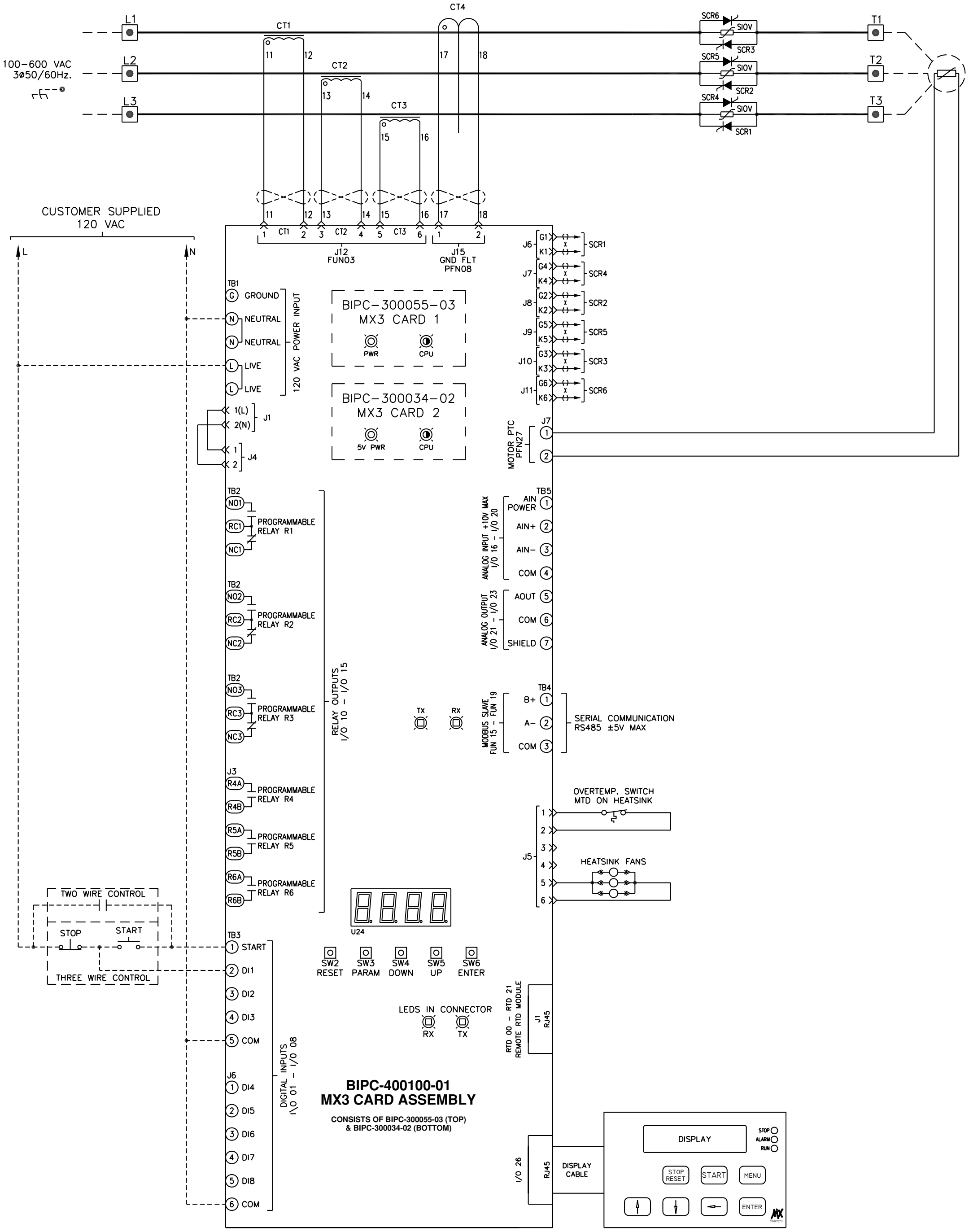


Figure 11: Power Schematic for RC3



3.6 Power Wiring

3.6.1 Recommended Incoming Line Protection

Fuses or Circuit Breaker, refer to pages 19 - 21.

Input Line Requirements
The input line source needs to be an adequate source to start the motor, generally 2 times the rating of the motor FLA. (This may not apply in some cases such as being connected to a generator).

3.6.2 Recommended Wire Gauges

The wire gauge selection is based on the FLA of the motor. Refer to NEC table 310-16 or CEC Part 1, Table 2 or local code requirements for selecting the correct wire sizing. Ensure appropriate wire derating for temperature is applied. If more than three current carrying conductors are in one conduit, ensure NEC table 310.15(B)(2) or CEC Part 1 Table 5C is adhered to. In some areas local codes may take precedence over the NEC. Refer to your local requirements.

3.6.3 Power Wire Connections

Attach the motor cables:

- Use the T1, T2 and T3 terminals. Use lugs/crimps or terminals. (Lugs and Crimps are to be provided by the user)

Attach the power source cables:

- Use the L1, L2 and L3 terminals. Use lugs/crimps or terminals (Lugs and Crimps are to be provided by the user).

3.6.4 Motor Lead Length

The standard starter can operate a motor with a maximum of 2000 feet of properly sized cable between the “T” leads of the starter and that of the motor. For wire runs greater than 2000 feet contact Benshaw Inc. for application assistance. If shielded cable is used, consult factory for recommended length.

3.6.5 Compression Lugs

The following is a list of the recommended crimp-on wire connectors manufactured by Penn-Union Corp. for copper wire.

Table 14: Single Hole Compression Lugs

Wire Size	Part #	Wire Size	Part #
1/0	BLU-1/0S20	500 MCM	BLU-050S2
2/0	BLU-2/0S4	600 MCM	BLU-060S1
3/0	BLU-3/0S1	650 MCM	BLU-065S5
4/0	BLU-4/0S1	750 MCM	BLU-075S
250 MCM	BLU-025S	800 MCM	BLU-080S
300 MCM	BLU-030S	1000 MCM	BLU-100S
350 MCM	BLU-035S	1500 MCM	BLU-150S
400 MCM	BLU-040S4	2000 MCM	BLU-200s
450 MCM	BLU-045S1		

Table 15: Two Hole Compression Lugs

Wire Size	Part #	Wire Size	Part #
1/0	BLU-1/0D20	500 MCM	BLU-050D2
2/0	BLU-2/0D4	600 MCM	BLU-060D1
3/0	BLU-3/0D1	650 MCM	BLU-065D5
4/0	BLU-4/0D1	750 MCM	BLU-075D
250 MCM	BLU-025D	800 MCM	BLU-080D
300 MCM	BLU-030D	1000 MCM	BLU-100D
350 MCM	BLU-035D	1500 MCM	BLU-150D
400 MCM	BLU-040D4	2000 MCM	BLU-200D
450 MCM	BLU-045D1		

3.6.6 Torque Requirements for Power Wiring Terminations

Table 16: Slotted Screws and Hex Bolts

Wire size installed in conductor		Tightening torque, pound-inches (N-m)							
		Slotted head NO. 10 and larger				Hexagonal head-external drive socket wrench			
AWG or kcmil	(mm^2)	Slot width-0.047 inch (1.2mm) or less and slot length ¼ inch (6.4mm) or less		Slot width-over 0.047 inch (1.2mm) or slot length – over ¼ inch (6.4mm) or less		Split- bolt connectors		Other connectors	
18 – 10	(0.82 – 5.3)	20	(2.3)	35	(4.0)	80	(9.0)	75	(8.5)
8	(8.4)	25	(2.8)	40	(4.5)	80	(9.0)	75	(8.5)
6 – 4	(13.3 – 21.2)	35	(4.0)	45	(5.1)	165	(18.6)	110	(12.4)
3	(26.7)	35	(4.0)	50	(5.6)	275	(31.1)	150	(16.9)
2	(33.6)	40	(4.5)	50	(5.6)	275	(31.1)	150	(16.9)
1	(42.4)	—	—	50	(5.6)	275	(31.1)	150	(16.9)
1/0 – 2/0	(53.5 – 64.4)	—	—	50	(5.6)	385	(43.5)	180	(20.3)
3/0 – 4/0	(85.0 – 107.2)	—	—	50	(5.6)	500	(56.5)	250	(28.2)
250 – 350	(127 – 177)	—	—	50	(5.6)	650	(73.4)	325	(36.7)
400	(203)	—	—	50	(5.6)	825	(93.2)	375	(36.7)
500	(253)	—	—	50	(5.6)	825	(93.2)	375	(42.4)
600 – 750	(304 – 380)	—	—	50	(5.6)	1000	(113.0)	375	(42.4)
800 – 1000	(406 – 508)	—	—	50	(5.6)	1100	(124.3)	500	(56.5)
1250 – 2000	(635 – 1010)	—	—	—	—	1100	(124.3)	600	(67.8)

⌘ **NOTE** – For a value of slot width or length not corresponding to those specified above, the largest torque value associated with the conductor size shall be marked. Slot width is the nominal design value. Slot length is measured at the bottom of the slot.

DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

Only qualified personnel familiar with low voltage equipment are to perform work described in this set of instructions.
Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E.
Turn off all power before working on or inside equipment.
Use a properly rated voltage sensing device to confirm that the power is off.
Before performing visual inspections, tests, or maintenance on the equipment, disconnect all sources of electric power.
Assume that circuits are live until they have been completely de-energized, tested, and tagged. Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of backfeeding.
Replace all devices, doors, and covers before turning on power to this equipment.

Failure to follow these instructions will result in death or serious injury.

Table 17: Tightening Torque for Inside Hex Screws

Socket size across flats		Tightening torque	
inches	**(mm)**	**Pound-inches**	**(N-m)**
1/8	(3.2)	45	(5.1)
5/32	(4.0)	100	(11.3)
3/16	(4.8)	120	(13.6)
7/32	(5.6)	150	(16.9)
1/4	(6.4)	200	(22.6)
5/16	(7.9)	275	(31.1)
3/8	(9.5)	275	(42.4)
1/2	(12.7)	500	(56.5)
9/16	(14.3)	600	(67.8)
⌘ **NOTE** – For screws with multiple tightening means, the largest torque value associated with the conductor size shall be marked. Slot length shall be measured at the bottom of the slot.			

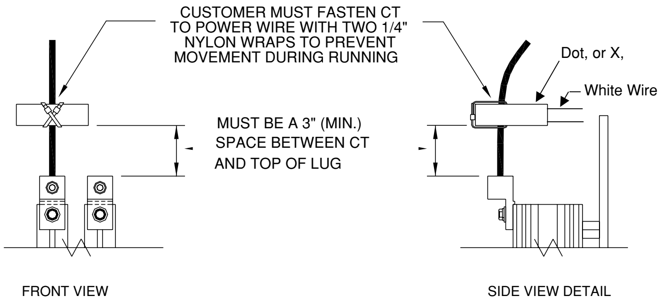
Current Transformers

3.7 Current Transformers

3.7.1 CT Mounting

For starters larger than 124 amps, the CTs are shipped loose from the power stack and need to be mounted on the power wiring. Thread the motor or incoming lead through the CT with the polarity mark towards the line side. (The polarity marks may be a white or yellow dot, an “X” on the side of the CT, or the white wire.) Each phase has its own CT. The CT must then be attached to the power wiring, at least three inches from the power wire lugs, using two tie-wraps.

Figure 12: Typical CT Mounting



3.7.2 CT Polarity

The CT has a polarity that must be correct for the starter to correctly measure Watts, kW Hours, Power Factor, and for the Power and TruTorque motor control functions to operate properly.

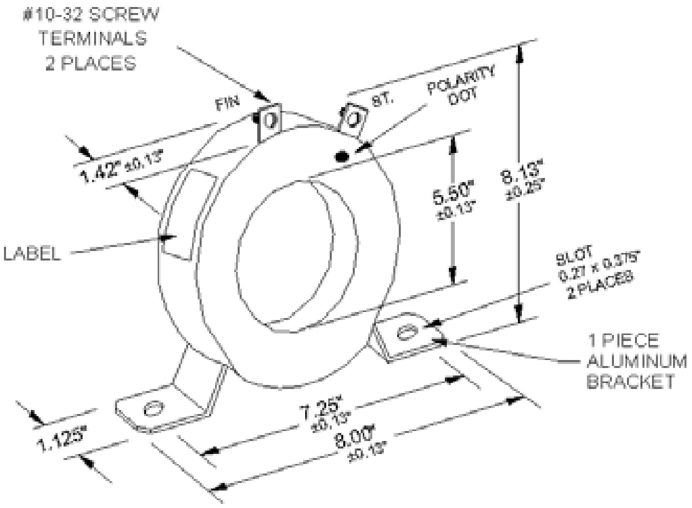
Each CT has a dot on one side of the flat surfaces. This dot, normally white in color, must be facing in the direction of the line.

CT1 must be on Line L1, CT2 must be on Line L2, CT3 must be on Line L3.

3.7.3 Zero Sequence Ground Fault Current Transformer

The Zero Sequence Ground Fault CT can be installed over the three phase conductors for sensitive ground current detection or for use with high resistance grounded systems.

Figure 13: BICT 2000/1-6 Mechanical Dimensions



The correct installation of the current transformer on the motor leads is important. The shield ground wire should also be passed through the CT window if the motor conductors use shielded cable. Otherwise, capacitive coupling of the phase current into the cable shield may be measured as ground fault current. See figure below for proper installation.

Figure 14: Zero Sequence CT Installation Using Unshielded Cable

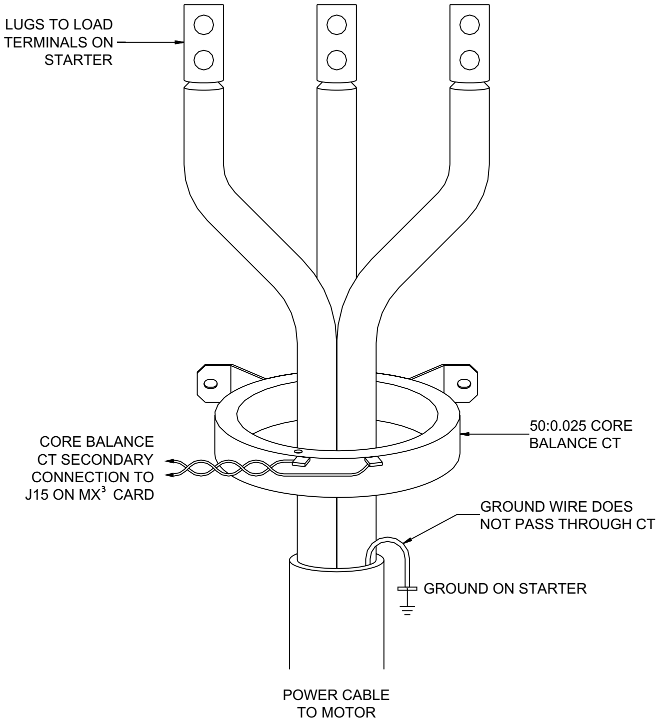
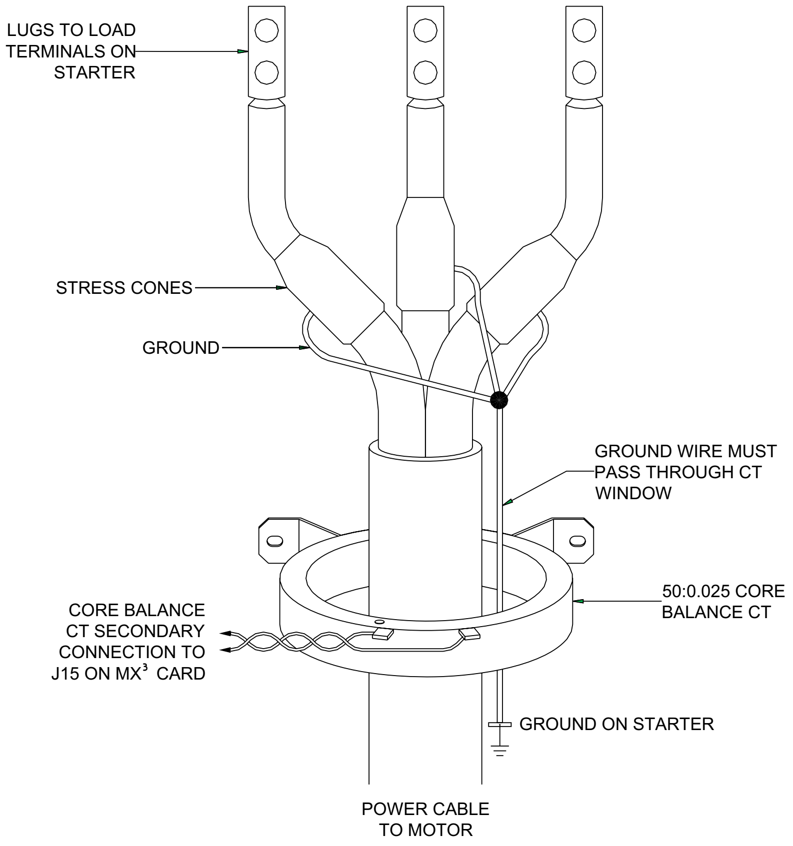
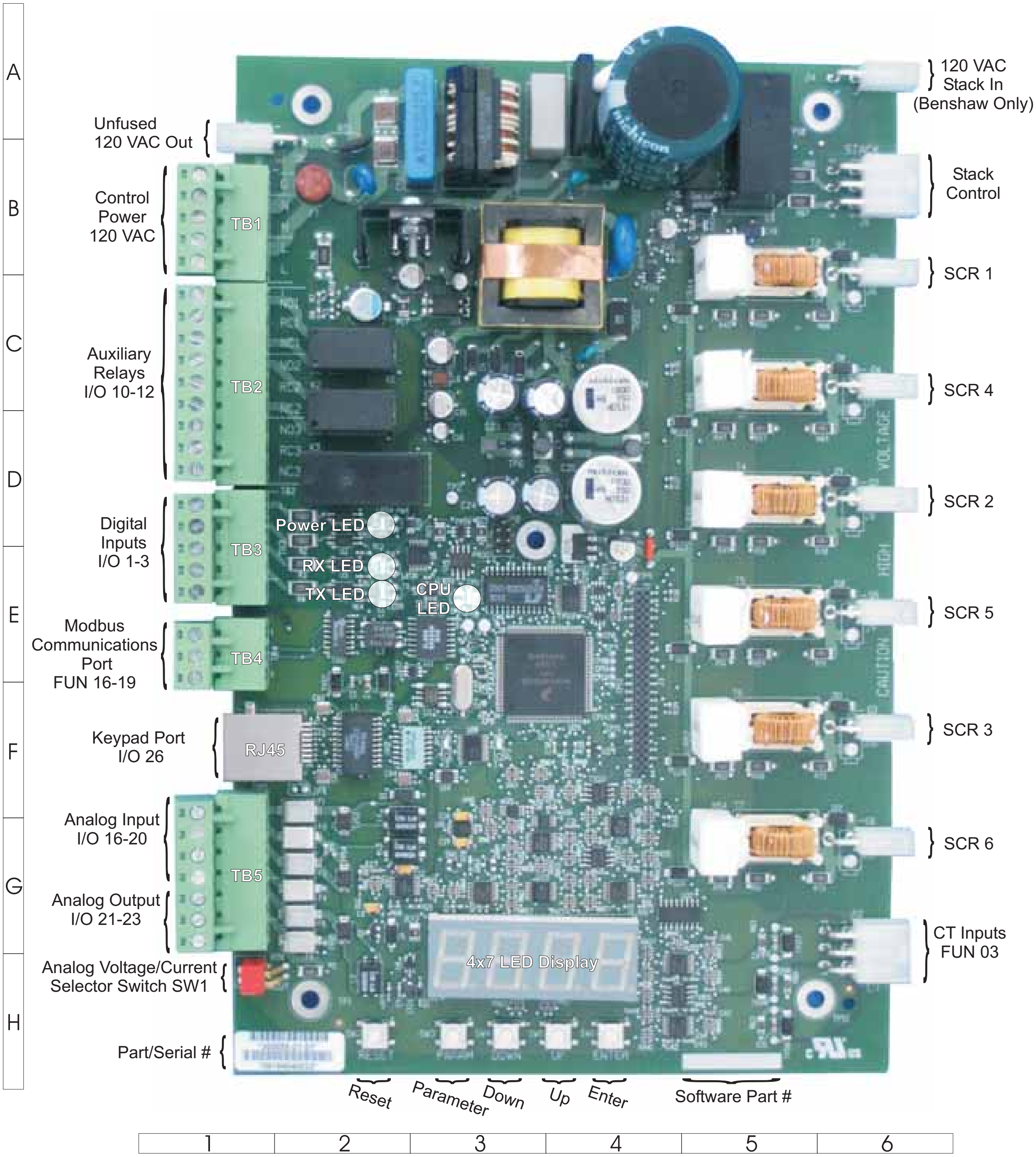


Figure 15: Zero Sequence CT Installation Using Shielded Cable



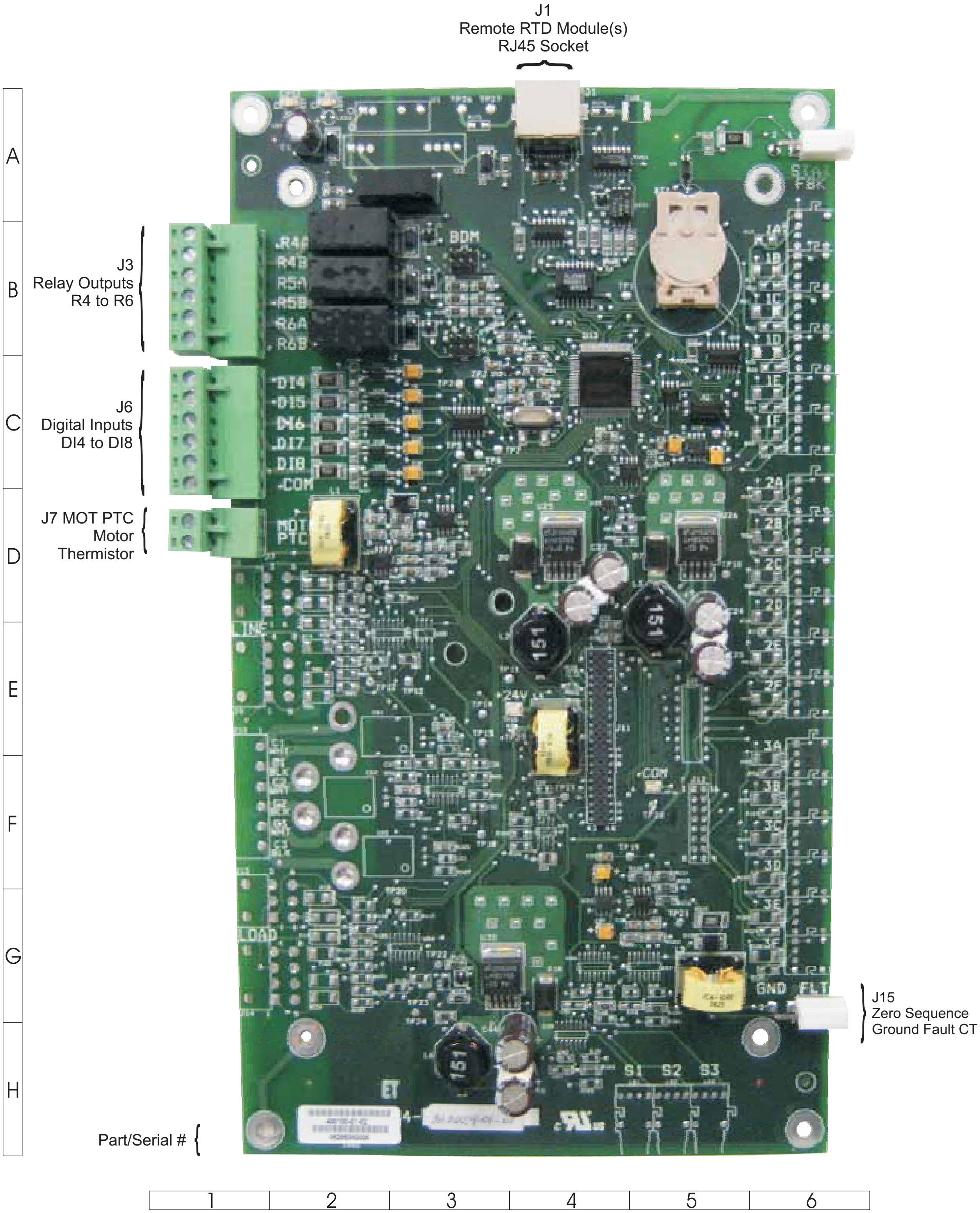
3.8 Control Card Layout

Figure 16: Control Card Layout



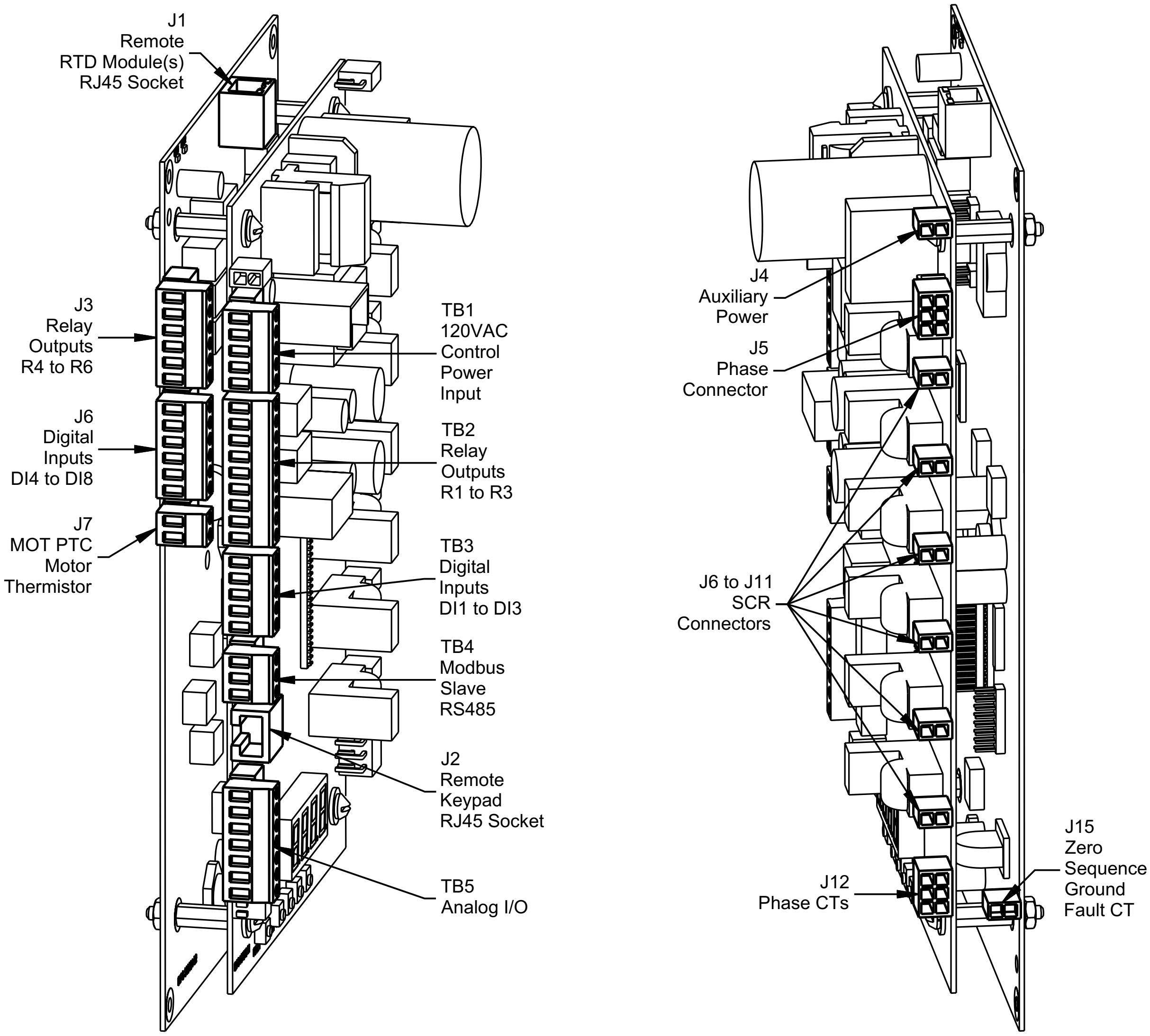
3.9 I/O Card Layout

Figure 17: I/O Card Layout



3.10 Terminal Block Layout

Figure 18: Terminal Block Layout



Control Wiring

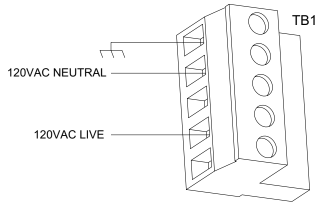
3.11 Control Wiring

3.11.1 Control Power

The 120VAC control power is supplied to TB1. The connections are as follows:

1 - Ground
2 - Neutral
3 - Neutral
4 - Line (120VAC)
5 - Line (120VAC)

Figure 19: Control Power Wiring Example



3.11.2 Output Relays

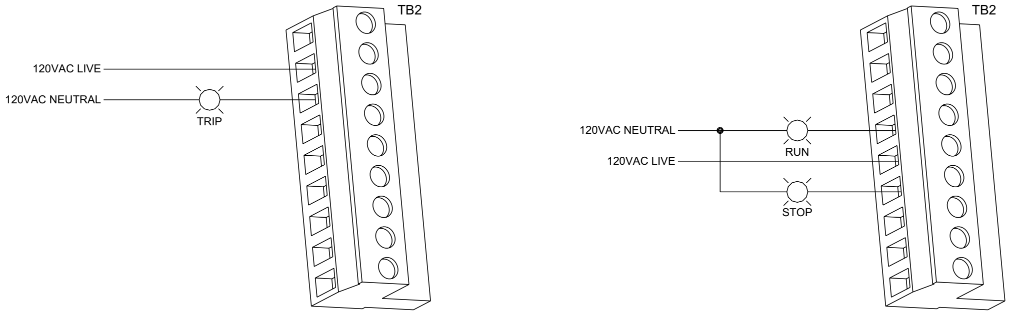
TB2 is for output relays R1, R2 and R3. These relays connect as follows:

1 - NO1: Relay 1 normally open
2 - RC1: Relay 1 common
3 - NC1: Relay 1 normally closed
4 - NO2: Relay 2 normally open
5 - RC2: Relay 2 common
6 - NC2: Relay 2 normally closed
7 - NO3: Relay 3 normally open
8 - RC3: Relay 3 common
9 - NC3: Relay 3 normally closed

Terminal block J3 is for output relays R4, R5 and R6. These relays connect as follows:

1 - R4A: Relay 4 common
2 - R4B: Relay 4 open
3 - R5A: Relay 5 common
4 - R5B: Relay 5 open
5 - R6A: Relay 6 common
6 - R6B: Relay 6 open

Figure 20: Relay Wiring Examples



TRIP PILOT LIGHT
(RELAY 1 SET TO FLFS - FAULT FAILSAFE)

RUN & STOPPED PILOT LIGHT
(RELAY 2 SET TO RUN)

See Also Relay Output Configuration (I/O 10-15) on page 112.

3.11.3 Digital Input

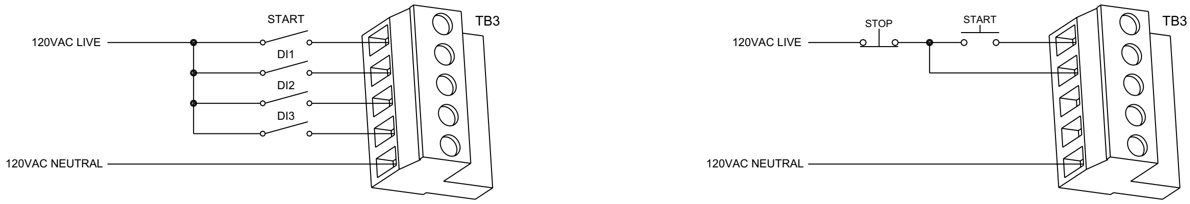
TB3 is for digital inputs Start, DI1, DI2 and DI3. These digital inputs use 120VAC. These digital inputs connect as follows:

1 - Start: Start Input
2 - DI1: Digital Input 1
3 - DI2: Digital Input 2
4 - DI3: Digital Input 3
5 - Com: 120VAC neutral

Terminal block J6 is for digital inputs DI4 to DI8. These digital inputs use 120VAC. These digital inputs connect as follows:

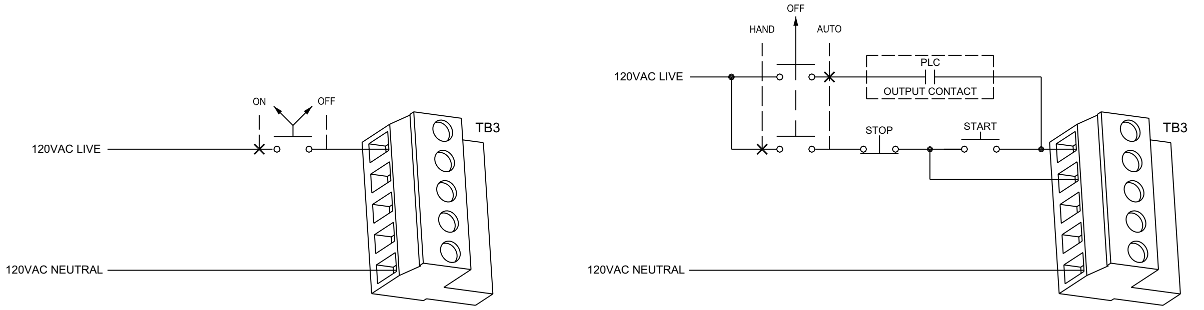
1 - DI4: Digital input 4
2 - DI5: Digital input 5
3 - DI6: Digital input 6
4 - DI7: Digital input 7
5 - DI8: Digital input 8
6 - Com: 120VAC neutral

Figure 21: Digital Input Wiring Examples



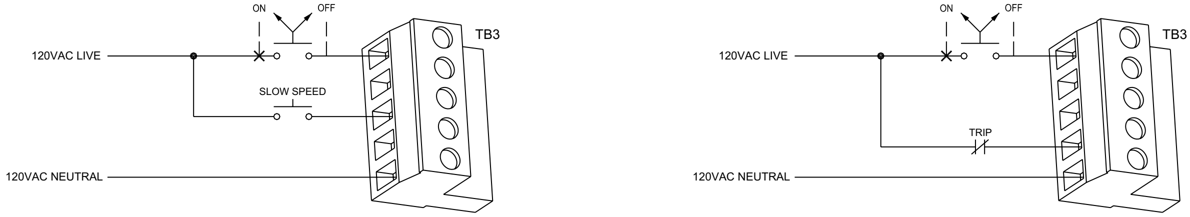
DIGITAL INPUT WIRING

3-WIRE START / STOP BUTTONS
(DI1 SET TO STOP)



2-WIRE ON / OFF SELECTOR SWITCH

HAND / OFF / AUTO SELECTOR SWITCH
(DI1 SET TO STOP)



SLOW SPEED CONTROL BUTTON
(DI2 SET TO SSPD - SLOW SPEED)

EXTERNAL TRIP INPUT
(DI3 SET TO FL - FAULT LOW)

See Also Digital Input Configuration (I/O 01-08) on page 111.

3.11.4 Analog Input

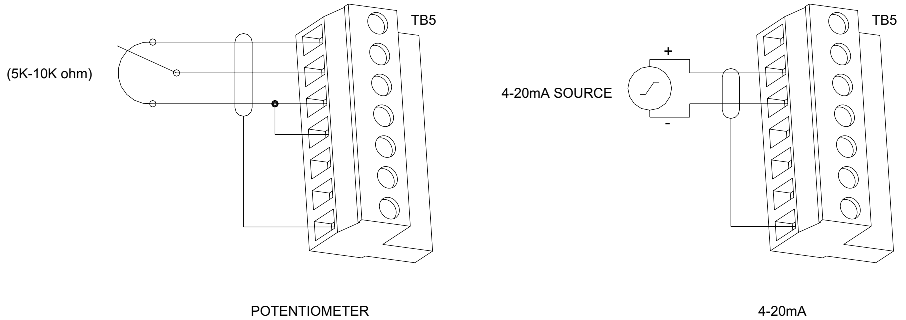
The analog input can be configured for voltage or current loop. The input is shipped in the voltage loop configuration unless specified in a custom configuration. Below TB5 is SW1-1. When the switch is in the on position, the input is current loop. When off, it is a voltage input. The control is shipped with the switch in the off position.

⌘ **NOTE:** The analog input is a low voltage input, maximum of 15VDC. The input will be damaged if control power (115VAC) or line power is applied to the analog input.

The terminals are as follows:

1 : +10VDC Power (for POT)
2 : + input
3 : - input
4 : common
7 : shield

Figure 22: Analog Input Wiring Examples



See Also	Analog Input (I/O 16-20) on page 113. Starter Type parameter (FUN07) on page 128. Theory of Operation section 7.11, Phase Control on page 173. Theory of Operation section 7.12, Current Follower on page 175.

3.11.5 Analog Output

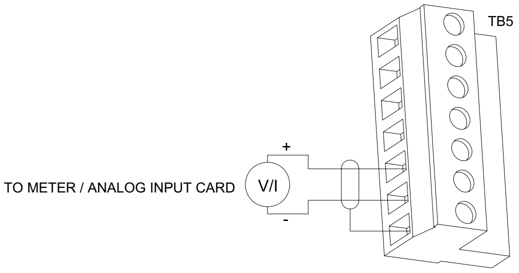
The analog output can be configured for Voltage or Current loop. The output is shipped in the Voltage loop configuration unless specified in a custom configuration. Below TB5 is SW1-2. When the switch is in the off position, the output is current. When on, it is a Voltage loop output. The control is shipped with the Switch on.

⌘ **NOTE:** The analog output is a low voltage output, maximum of 15VDC. The output will be damaged if control power (115VAC) or line power is applied to the analog output.

The terminals are as follows:

5 - analog output
6 - common
7 - shield

Figure 23: Analog Output Wiring Example

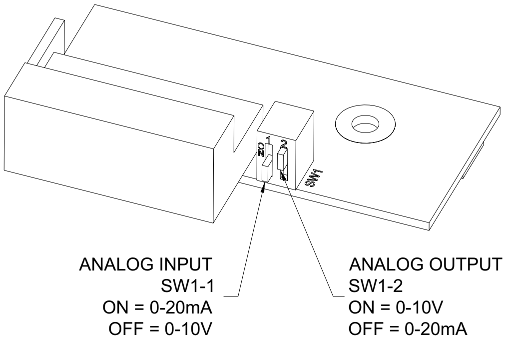


See Also	Analog Output (I/O 21-23) on page 116.

3.11.6 SW1 DIP Switch

The SW1 DIP switch on the card changes the analog input and analog output between 0-10V or 0-20mA. The picture below shows how to adjust the switch to select the desired signal.

Figure 24: SW1 DIP Switch Settings

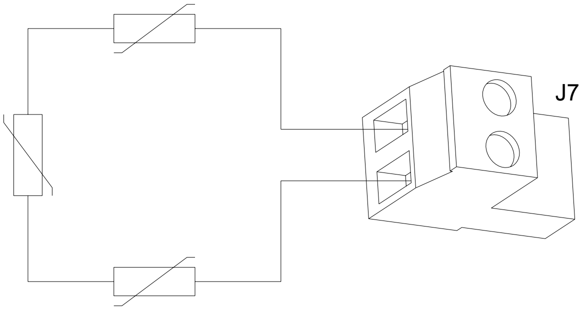


3.11.7 Motor PTC

Terminal block J7 is for a PTC (positive temperature co-efficient) motor thermistor. This input is designed to use standard DIN 44081 or DIN 44082 thermistors. The specifications of the input are as follows;
- Trip resistance 3.5K, ± 300 Ohms.
- Reset resistance 1.65K, ± 150 Ohms.
- Open terminal voltage is 15V.
- PTC voltage at 4Kohms = 8.55v. (>7.5V)
- Response time adjustable between 1 and 5 seconds.
- Maximum cold resistance of PTC chain = 1500 Ohms.

An example of the thermistor wiring is shown below.

Figure 25: PTC Thermistor Wiring



See Also Motor PTC Trip Time (PFN27) on page 104.

3.11.8 RTD Module Connector

Connector J1 is for the connection of Benshaw Remote RTD Modules. These modules can be mounted at the motor to reduce the length of the RTD leads. The connector is a standard RJ-45. The wires connect as follows;
4 - B(+)
5 - A(-)
8 - common

Remote LCD Keypad/Display

3.12 Remote LCD Keypad/Display

The display has a NEMA 13 / IP65 service rating. The display is available in 2 versions, a small display as P/N KPMX3SLCD and large display as P/N KPMX3LLCD.

3.12.1 Remote Display

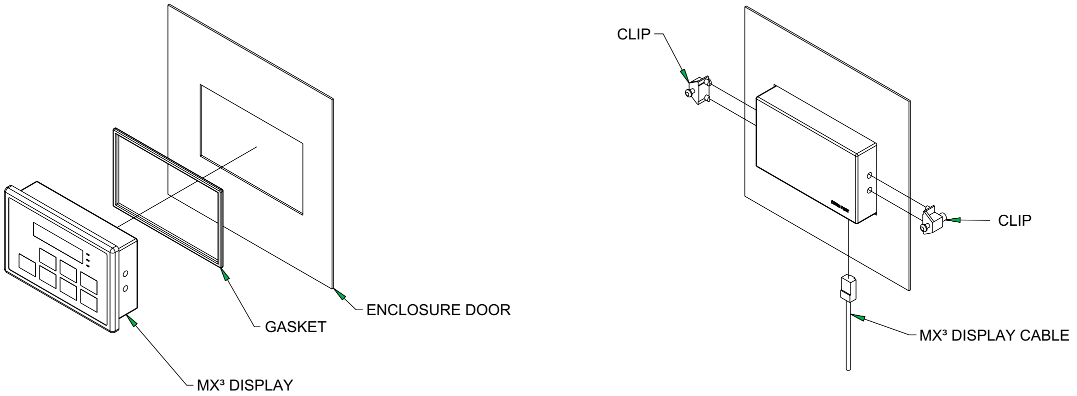
The LCD keypad is mounted remotely from the MX^3 Control via a straight through display cable which connects between the MX^3 RJ45 terminal and remote display's RJ45 terminal.

3.12.2 Installing Display

The remote display is installed as follows:

- Install the gasket onto the display
- Insert the display through the door cutout
- Insert the mounting clips into the holes in each side of the display
- Tighten the mounting clips until they hold the display securely in place. Torque requirements for the display screen is 0.7 NM (6.195 in lbs)
- Plug the cable into the display connector on the MX^3 card. See figure 16 – control card layout on page 41 for the connector location
- Route the cable through the enclosure to the display. Observe the wiring considerations as listed in section 3.4.3 on page 31
- Plug the other end of the cable into the LCD display

Figure 26: Mounting Remote Keypads



3.12.3 Display Cutout

Figure 27: Small Display Keypad Mounting Dimensions
Part # : KPMX3SLCD

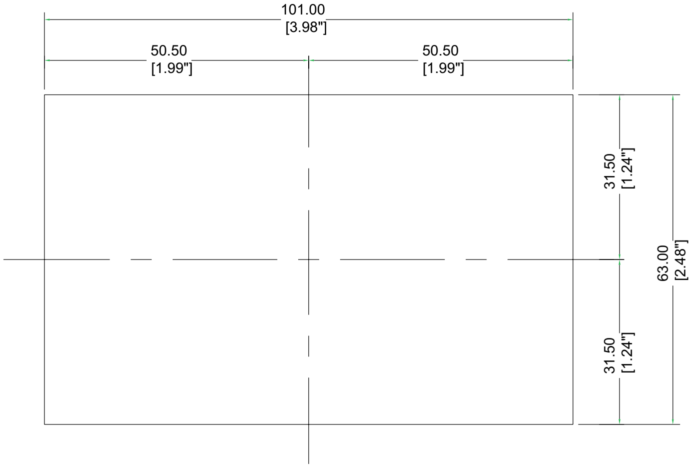
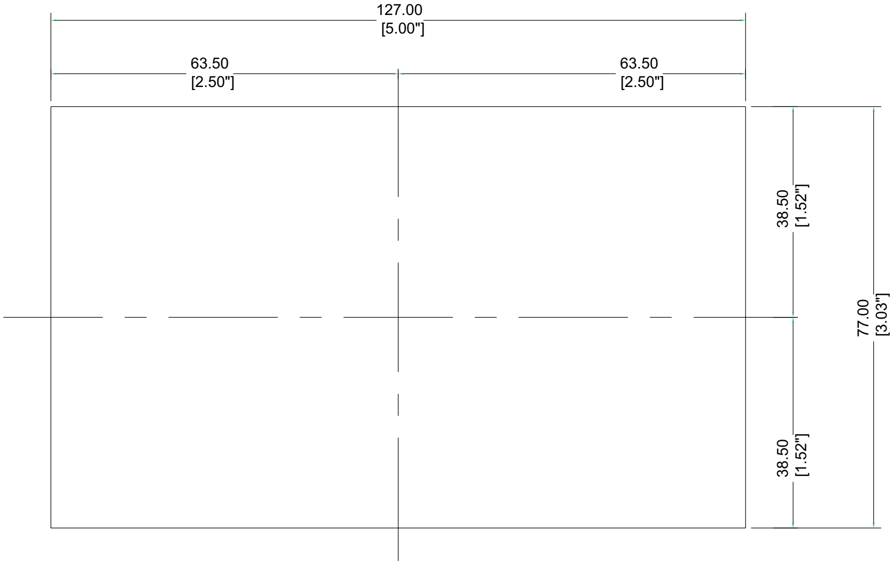


Figure 28: Large Display Keypad Mounting Dimensions
Part # : KPMX3LLCD



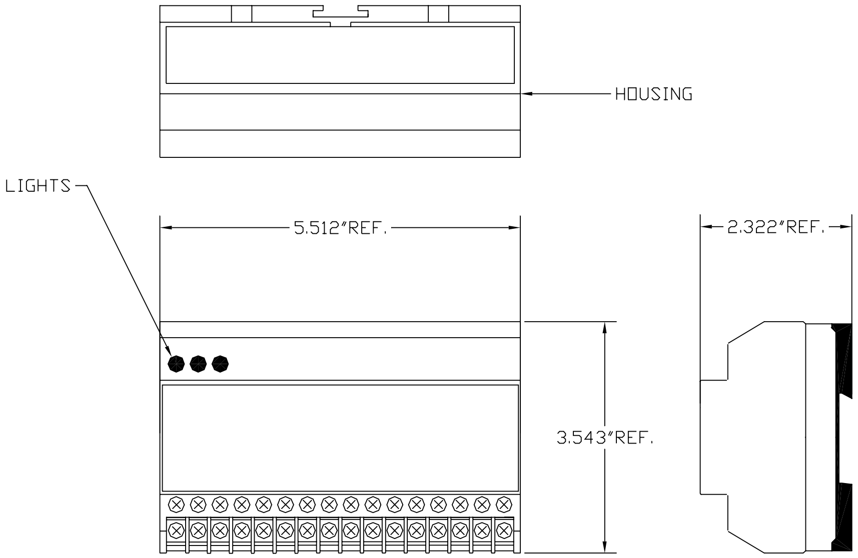
RTD Module Installation

3.13 RTD Module Installation

3.13.1 Location

The mounting location for the Remote RTD Module should be chosen to give easy access to the RTD wiring, control terminals and indicator LEDs as well as providing a location to mount the power supply. The Remote RTD Module is specifically designed to be mounted close to the equipment it is monitoring. This eliminates long RTD wire lengths which save time and money on installation and wiring. The Benshaw Remote RTD Module is designed to mount on industry standard 35mm wide by 7.5mm deep DIN rail.

Figure 29: Remote RTD Module Mechanical Layout



3.13.2 Modbus Address

Set the rotary switch on the top of the Remote RTD Module to the desired Modbus address. Up to 2 modules can be connected to the MX^3 starter. The address set by the rotary switch must match the setting in RTD 01 or RTD 02. For example, setting both the rotary switch and RTD 01 to 16 would make the connected module be module #1. The connected RTDs would then represent #1 to #8 in the RTD programming.

3.13.3 Power Connections

The 24VDC power source is connected to the following terminals.

- 24VDC-: Negative connection to 24VDC power supply
- 24VDC+: Positive connection to 24VDC power supply
- "⏚": Chassis ground connection

3.13.4 RS-485 Communication

The RS-485 communications wiring should use shielded twisted pair cable. The shield should only be terminated at one end. The connections are as follows:

MX RJ45	Module	Description
pin 5	A(-)	RS-485 negative communications connection.
pin 4	B(+)	RS-485 positive communications connection.
pin 8	Com	RS-485 common connection.

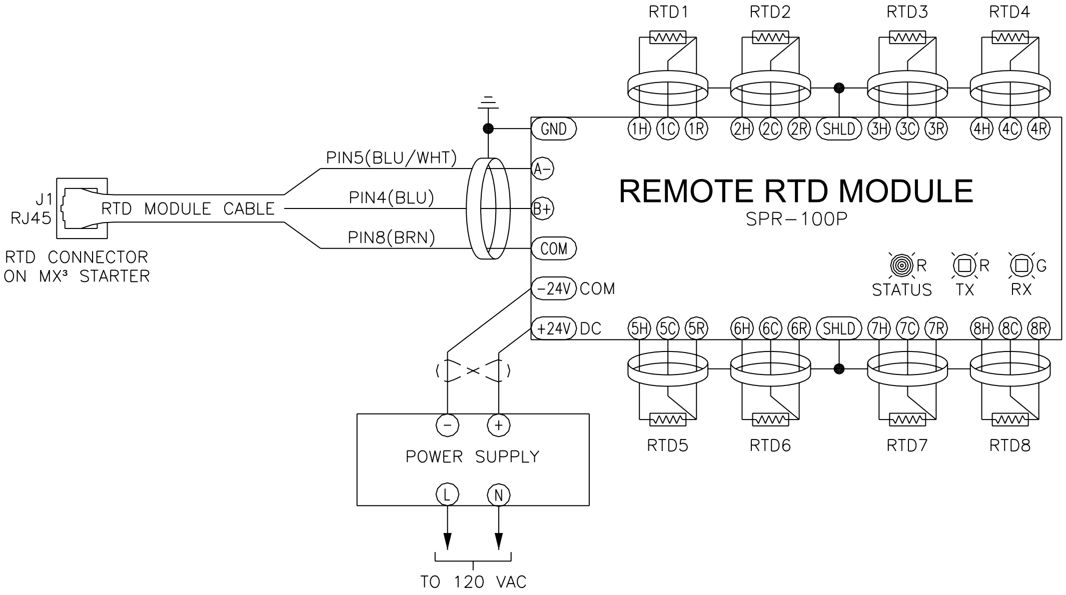
3.13.5 RTD Connections

Each Remote RTD Module has connections for up to 8 RTDs. The terminals for the RTD wires are as follows:

- R- RTD return wire
- C- RTD compensation wire
- H- RTD hot wire

Each RTD is connected to the three terminals with the common number. For example, RTD number 5 connects to the terminals numbered 5R, 5C and 5H.

Figure 30: Remote RTD Module Wiring



3.13.6 RTD Temperature vs. Resistance

Temperature		100Ω Pt (DIN 43760)	°C	°F	100Ω Pt
°C	°F		100	212	138.50
-50	-58	80.13	110	230	142.29
-40	-40	84.27	120	248	146.06
-30	-22	88.22	130	266	149.82
-20	-4	92.16	140	284	153.58
-10	14	96.09	150	302	157.32
0	32	100.00	160	320	161.04
10	50	103.90	170	338	164.76
20	68	107.79	180	356	168.47
30	86	111.67	190	374	172.46
40	104	115.54	200	392	175.84
50	122	119.39	210	410	179.51
60	140	123.24	220	428	183.17
70	158	127.07	230	446	186.82
80	176	130.89	240	464	190.45

4 Keypad Operation

4 - KEYPAD OPERATION

Introduction

4.1 Introduction

The MX^3 has a 2x16 character, back-lit LCD display/keypad that may be mounted remotely from the MX^3 control card. The remote LCD keypad has menu, enter, up, down, left, start and stop/reset keys.

The display has keys such as [START], [STOP], and a [LEFT] arrow for moving the cursor around in the LCD display. Status indicators provide additional information for the starter operation. Extended parameters are also added.

The remote keypad is NEMA 13 / IP65 when mounted directly on the door of an enclosure with the correct gasket.

Figure 31 - Remote LCD Keypad

Description of the LEDs on the Keypad

4.2 Description of the LEDs on the Keypad

The keypad provides three LED indicators in addition to the 2x16 character display. The LEDs provide starter status information.

Table 18: Remote Keypad LED Functions

LED	State	Indication
STOP	On	Stopped
	Flashing	Faulted
RUN	On	Running and up-to-speed
	Flashing	Running and not up-to-speed (ramping, decelerating, braking etc).
ALARM	Flashing	Alarm condition exists. If condition persists, a fault occurs.

⌘ **NOTE:** By default, the [STOP] key is always active, regardless of selected control source (Local Source and Remote Source parameters). It may be disabled though using the Keypad Stop Disable (I/O26) parameter. For more information refer to the Keypad Stop Disable (I/O26) parameter on page 119.

Description of the Keys on the Remote LCD Keypad

4.3 Description of the Keys on the Remote LCD Keypad

Table 19: Function of the Keys on the LCD Keypad

Key	Function
start	• This key causes the starter to begin the start sequence. The direction is dependent on wiring and phase selection. • In order for this key to work, the Local Source (QST04) parameter must be set to "Keypad".
⇧	• Increase the value of a numeric parameter. • Select the next value of an enumerated parameter. • It scrolls forward through a list of parameters within a group (when the last parameter is displayed, it scrolls to the beginning of the list). • When a list of faults is displayed, it moves from one fault to the next. • When a list of events is displayed, it moves from one event to the next. • When the starter is in the Operate Mode, pressing [UP] allows you to change which group of meter values is monitored.
⇩	• Decrease the value of a numeric parameter. • Select the previous value of an enumerated parameter. • It scrolls backward through a list of parameters within a group (when the first parameter is displayed, it scrolls to the end of the list). • When a list of faults is displayed, it moves from one fault to the previous fault. • When a list of events is displayed, it moves from one event to the previous event. • When the starter is in the Operate Mode, pressing [Down] allows you to change which group of meter values is monitored.
⇦	• When editing a numeric parameter, the [LEFT] arrow key moves the cursor one digit to the left. If cursor is already at the most significant digit, it returns to the least significant digit on the right. • When in Menu mode, the [LEFT] arrow allows groups to be scrolled through in the opposite direction of the [MENU] Key.
enter	• Stores the change of a value. • When in Fault History, [ENTER] key scrolls through information logged when a fault occurred. • When in Event History, [ENTER] key scrolls through information logged when an event occurred. • When an alarm condition exists, [ENTER] scrolls through all active alarms.
menu	• [MENU] scrolls between the operate screen and the available parameter groups. • When viewing a parameter, pressing [MENU] jumps to the top of the menu. • When a parameter is being edited and [MENU] is pressed, the change is aborted and the parameter's old value is displayed.
stop reset	• The [STOP/RESET] key halts the operation of the starter (Stop Key). • If a fault has occurred, the [STOP] key is used to clear the fault (Reset Key). • The [STOP/RESET] key always halts the operation of the starter if the control source is set to "Keypad". If the control source (QST 04/QST 05) is not set to "Keypad", [STOP] key may be disabled using the Keypad Stop Disable (I/O26) parameter.

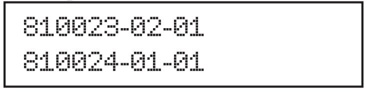
Alphanumeric Display

4.4 Alphanumeric Display

The remote LCD keypad and display uses a 32-character alphanumeric LCD display. All starter functions can be accessed by the keypad. The keypad allows easy access to starter programming with parameter descriptions on the LCD display.

4.4.1 Power Up Screen

On power up, the MX and I/O software part numbers are displayed for five seconds. Pressing any key immediately changes the display to the operate screen.



```
810023-02-01
810024-01-01
```

4.4.2 Operate Screen

The operate screen is the main screen. The Operate screen is used to indicate the status of the starter, if it's running, what state it's in, and display the values of Meter 1 and Meter 2, which are selectable.

The Operate Screen is divided into five sections.

- Sections A and B display status information
- Sections C and D display the meters selected by the Meter 1 and 2 parameters, see FUN 01, 02
- Section S displays the source for the start command

Figure 32: Operate Screen

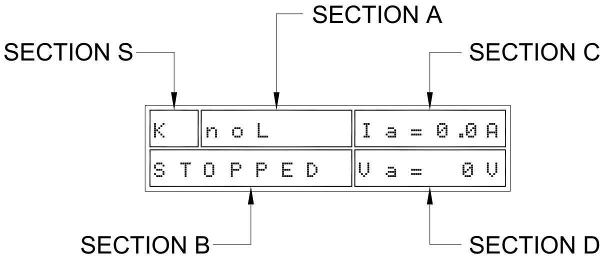


Table 20: Operate Screen Section A

Display	Description
NoL	L1, L2, L3 not present
Ready	Starter ready to run
Alarm	A fault condition is present. If it continues, a fault occurs
Run	Starter is running

Table 21: Operate Screen Section B

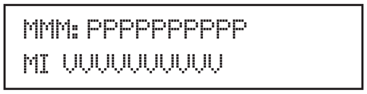
Display	Description
Stopped	Starter is stopped and no Faults
Fault	Starter tripped on a Fault
Heater	Starter is on and heating motor
Kick	Starter is applying kick current to the motor
Accel	Starter is accelerating the load
Kick 2	Starter is applying kick current to the motor in Ramp 2
Accel 2	Starter is accelerating the load in Ramp 2
Run	Starter is in Run mode and Ramp Time has expired
UTS	Starter is Up To Speed
Control	Phase Control or Current Follower mode
Decel	Starter is decelerating the load
Wye	In Wye-delta control indicates motor is accelerating in Wye mode
Slow Spd Fwd	Preset slow speed forward
Slow Spd Rev	Preset slow speed reverse
Braking	DC Injection Braking.
PORT	Power Outage Ride Through

Table 22: Operate Screen Section S

Display	Description
K	Keypad Control
T	Terminal Block Wiring Control
S	Serial Communication Connection Control

4.4.3 Parameter Group Screens

From the operate screen, the parameter group screens are accessed by pressing either the menu or the left arrow keys. The parameter group screens display the different parameter groups; QST, CFN, PFN, I/O, RTD, FUN, FL1, E01.



```
MMM:PPPPPPPPPP
MI VVVVVVVVVV
```

MMM: = Parameter Group
MI: = Menu Index
PPP: = Parameter Name
VVV: = Parameter Value and Units
Refer to Chapter 5 for a listing of the parameters and their ranges.

4.4.4 Meter Pages

Although any meter may be viewed by changing the two meter parameters (FUN 01, FUN 02), there are 19 “Meter Pages” that are easily accessed to view all of the meter information. These meter pages are scrolled through by pressing the [UP] or [DOWN] down arrows from the operate screen.

```
Current I2= 0.0A
I1= 0.0  I3= 0.0A
```

```
Voltage V2=   0V
V1=   0 V3=   0V
```

```
MWattHour=    0
kWattHour=    0
```

```
Watts     =   0
VA        =   0
```

```
Motor PF  =0.00
vars      =   0
```

```
TruTorque =   0%
Power     =   0%
```

```
Overload  =   0%
CurrImbal = 0.0%
```

```
RS Gnd Cur=   0%
ZS Gnd Cur= 0.0A
```

```
Lst St Tim= xx.xs
Pk St Cur = xx.xA
```

```
Frequency = 0.0H
Phase     =noL
```

```
Run Days  =   xxxx
RunHours  =xx:xx
```

```
Analog In  = 0.0%
Analog Out= 0.0%
```

```
Starts      =xxxxx
```

```
Temps   Ts= ---
To= ---  Tb= ---
```

```
1= Off  3= Off
2= Off  4= Off
```

```
5= Off  7= Off
6= Off  8= Off
```

```
9= Off  11= Off
10=Off  12= Off
```

```
13= Off  15= Off
14=Off  16= Off
```

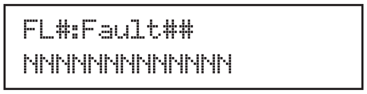
```
    hh:mm:ssA/P
    dd/mm/yy
```

⌘ **NOTE:**

Run Hours	00:00 – 23:59
Run Days	0 – 2730 days or 7.5 years
kWatt Hours	0 – 999
MWatt Hours	0 – 9999
Starts	0 – 65535
RS Gnd Cur	% motor FLA

4.4.5 Fault Log Screen

Information regarding each fault is available through the remote MX^3 LCD display.



```
FL#:Fault##
NNNNNNNNNNNNN
```

FL _: = Fault Log Number. FL1 is the most recent fault and FL9 is the oldest fault.
Fault _ _ = Fault Code
NNN… = Fault Name, or the condition when the fault occurred.

Press [MENU] until you get to the FL1 parameter.

Pressing the [UP] and [DOWN] keys navigates through older and newer faults in the log.

When you get to your fault on the screen begin pressing the [ENTER] key repeatedly. This will rotate through the steps below to show the conditions the starter was in when the fault occurred.

Enter Step	
1	Fault Description.
2	Status when the fault occurred, Run, Stopped, Accel. etc.
3	The L1 current at the time of the fault.
4	The L2 current at the time of the fault.
5	The L3 current at the time of the fault.
6	L1-2 voltage at the time of the fault.
7	L2-3 voltage at the time of the fault.
8	L3-1 voltage at the time of the fault.
9	kW at the time of the fault.
10	Frequency at the time of the fault.
11	Run time since last run time reset.

4.4.6 Fault Screen

When a Fault occurs, the main screen is replaced with a fault screen. The screen shows the fault number and the name of the fault. The main status screen is not shown until the fault is reset.

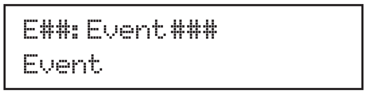
When a fault occurs, the STOP LED flashes.

```
Fault##
FaultName
```

⌘ **NOTE**: For a list of the Faults, refer to Appendix C - Fault Codes on page 205.

4.4.7 Event Recorder

An event is anything that changes the present state of the starter. Examples of events include a start, a stop, an overload alarm or a fault. The event recorder stores the last 99 events.



```
E##:Event###
Event
```

Press [MENU] until you get to the E01 parameter.

Pressing [UP] or [DOWN] will scroll through the last 99 events and displays the event or fault code on top, and the event or fault that changed the starter's state on the bottom.

Pressing [ENTER] gives the starter state condition at the time of event.

Press [ENTER] again to give you the time of the event.

Press [ENTER] again to give you the date that the event occurred.

⌘ **NOTE**: After pressing [ENTER] you can shift through all the different starter states, times and dates by using the [UP] and [DOWN] arrows.

4.4.8 Lockout Screen

When a lockout is present, one of the following screens will be displayed. The main status screen is not shown until the lockout is cleared.

The overload lockout displays the overload content and the time until reset if an overload occurs.

```
Overload Lockout 96%
      XX:XX
```

The stack over temperature lockout will be displayed if a stack over temperature is detected.

```
Stack Overtemp
Lockout
```

The control power lockout will be displayed if the control power is not within specifications.

```
Control Power
Lockout
```

The disconnect open lockout will be displayed if a digital input is programmed to "disconnect" and the input is not on.

```
Disconnect Open
Lockout
```

The time between starts lockout displays the time until the next start is allowed when PFN21 is programmed.

```
Time btw Starts
Lockout XX:XX
```

The backspin timer lockout displays the time until the next restart when PFN20 is programmed.

```
Backspin Timer
Lockout XX:XX
```

The starts per hour lockout displays the time until the next start is allowed when PFN22 is programmed.

```
Starts per Hour
Lockout XX:XX
```

The motor PTC lockout is displayed when the motor thermistor is overheated or defective.

```
Motor PTC
Lockout
```

The RTD lockout displays the hottest RTD that tripped the starter.

```
RTD Lockout
RTD##= XXXC
```

The communications loss is displayed when the starter loses communication with the remote RTD modules.

```
RTD Lockout
RTD##commloss
```

The open lockout is displayed when the RTD module senses an open RTD.

```
RTD Lockout
RTD##= Open
```

The short lockout is displayed when the RTD module senses a shorted RTD.

```
RTD Lockout
RTD##= Sort
```

⌘ **NOTE:** XX:XX is the time remaining until the lockout releases.

4.4.9 Alarm Screen

When an alarm is present, the word “Alarm” is displayed on the operate screen. Pressing the [ENTER] key displays more information about the alarm.

```
Alarm##
Alarm Name
```

Procedure for Setting Data

4.5 Procedure for Setting Data

Select a parameter that is to be changed. To change Motor FLA from 10 Amps to 30 Amps:

From the main screen:

```
TReady Ia= 0.0A
Stopped Va= 480V
```

Press [MENU] key and the display shows QST: (Quick Start) screen.

```
QST:Jump Code
00  1
```

Press [UP] key once to Motor FLA (QST 01).

```
QST:Motor FLA
01  10Amp
```

Press [ENTER] key once, the cursor starts to flash in the one’s place.

```
QST:Motor FLA
01  10Amp
```

Press [LEFT] key once, the cursor flashes in the ten’s place.

```
QST:Motor FLA
01  10Amp
```

Press [UP] arrow to increase the value, for a value of 30, press twice.

```
QST:Motor FLA
01  30Amp
```

Press [ENTER] to store the value.

```
QST:Motor FLA
01  30Amp
```

Press [UP] arrow to change another parameter in QST.
Press [MENU] to change another parameter in another group.
Press [LEFT] arrow to go back to the main screen.

Jump Code

4.6 Jump Code

At the beginning of each parameter group, there is a Jump Code parameter. By changing the value of this parameter and pressing [ENTER], you can jump directly to any parameter within that group.

Restoring Factory Parameter Settings

4.7 Restoring Factory Parameter Settings

Go to the FUN group by pressing [MENU]. Scroll through to FUN 22- Miscellaneous Commands and press [ENTER]. Now set to "Factory Rst" and press [ENTER]. The display will return to None but the parameters will be reset to the factory defaults.

Below is a list of the minimum parameters that will need to be set again.

FUN 05 (Rated RMS Voltage)
FUN 03 (CT Ratio)
I/O 01 - 08 (Digital Inputs)
I/O 10 - 15 (Relay Outputs)

⌘ NOTE: You must consult the wiring schematic for digital inputs and relay output configuration.

Resetting a Fault

4.8 Resetting a Fault

To reset from a fault condition, press [RESET].

Emergency Overload Reset

4.9 Emergency Overload Reset

To perform an emergency overload reset, press [RESET] and [DOWN] buttons together. This sets the motor overload content to 0.

LED Display

4.10 LED Display

The card mounted LED display can be used to access most of the parameters when the standard remote mounted display is not connected. The LED parameter numbers (Pxx) are shown in the parameter table. See chapter 5.

5

Parameter Groups

Introduction

5.1 Introduction

The MX^3 incorporates a number of parameters that allow you to configure the starter to meet the special requirements of your particular application.

The parameters are divided into groups of related functionality, and within the groups the parameters are identified by a short, descriptive name. They are numbered by the group name followed by an index within the group.

This chapter lists all of the parameters and their possible values.

5.2 LCD Display Parameters

The parameters are subdivided into six groups. The groups are **QST** (Quick Start), **CFN** (Control Functions), **PFN** (Protection Functions), **I/O** (Input/Output Functions), **RTD** (Resistance Temperature Device), **FUN** (Function), **FL1**(Fault Log) and **E01** (Event Recorder).

The Quick Start Group provides a collection of the parameters that are most commonly changed when commissioning a starter. Many of the parameters in the Quick Start group are duplicates of the same parameters in other groups.

The following shows the menu structure for the LCD display as well as the text that is displayed for the parameters on the display.

If the LCD is not connected, most parameters shown on the LED display will turn on when LCD is unplugged.

5.2.1 Quick Start Group

Group	LED	Display	Description	Setting Range	Units	Default	Page
QST 00		Jump Code	Jump to Parameter	1 to 9		1	72
QST 01	P1	Motor FLA	Motor FLA	1 to 6400	RMS Amps	10	72
QST 02	P2	Motor SF	Motor Service Factor	1.00 to 1.99		1.15	73
QST 03	P3	Running OL	Motor Overload Class Running	Off, 1 to 40		10	73
QST 04	P4	Local Src	Local Source	Keypad Terminal Serial		Terminal	74
QST 05	P5	Remote Src	Remote Source				74
QST 06	P6	Init Cur 1	Initial Current 1	50 to 600	%FLA	100	75
QST 07	P7	Max Cur 1	Maximum Current 1	100 to 800	%FLA	600	76
QST 08	P8	Ramp Time 1	Ramp Time 1	0 to 300	Seconds	15	76
QST 09	P9	UTS Time	Up To Speed Time/Transition time	1 to 900	Seconds	20	77

5.2.2 Control Function Group

Group	LED	Display	Parameter	Setting Range	Units	Default	Page
CFN 00		Jump Code	Jump to Parameter	1 to 27		1	77
CFN 01	P10	Start Mode	Start Mode	Voltage Ramp Current Ramp TT Ramp Power Ramp Tach Ramp		Current Ramp	78
CFN 02	P8	Ramp Time 1	Ramp Time 1	0 to 300	Seconds	15	78
CFN 03	P6	Init Cur 1	Initial Motor Current 1	50 to 600	%FLA	100	79
CFN 04	P7	Max Cur 1	Maximum Motor Current 1	100 to 800	%FLA	600	79
CFN 05	P24	Ramp Time 2	Ramp Time 2	0 to 300	Seconds	15	80
CFN 06	P22	Init Cur 2	Initial Motor Current 2	50 to 600	%FLA	100	80
CFN 07	P23	Max Cur 2	Maximum Motor Current 2	100 to 800	%FLA	600	80
CFN 08	P11	Init V/T/P	Initial Voltage/Torque/Power	1 to 100	%	25	81
CFN 09	P12	Max T/P	Maximum Torque/Power	10 to 325	%	105	81
CFN 10		Accel Prof	Acceleration Ramp Profile	Linear Squared S-Curve		Linear	83
CFN 11	P13	Kick Lvl 1	Kick Level 1	Off, 100 to 800	%FLA	Off	84
CFN 12	P14	Kick Time 1	Kick Time 1	0.1 to 10.0	Seconds	1.0	84
CFN 13	P25	Kick Lvl 2	Kick Level 2	Off, 100 to 800	%FLA	Off	85
CFN 14	P26	Kick Time 2	Kick Time 2	0.1 to 10.0	Seconds	1.0	85
CFN 15	P15	Stop Mode	Stop Mode	Coast Volt Decel TT Decel DC Brake		Coast	85
CFN 16	P16	Decel Begin	Decel Begin Level	100 to 1	%	40	86
CFN 17	P17	Decel End	Decel End Level	99 to 1	%	20	87
CFN 18	P18	Decel Time	Decel Time	1 to 180	Seconds	15	87
CFN 19		Decel Prof	Decel Ramp Profile	Linear Squared S-Curve		Linear	88
CFN 20	P19	Brake Level	DC Brake Level	10 to 100	%	25	88
CFN 21	P20	Brake Time	DC Brake Time	1 to 180	Seconds	5	89
CFN 22	P21	Brake Delay	DC Brake Delay	0.1 to 3.0	Seconds	0.2	89
CFN 23	P27	SSpd Speed	Slow Speed	Off, 1 – 40	%	Off	90
CFN 24	P28	SSpd Curr	Slow Speed Current Level	10 to 400	% FLA	100	90
CFN 25	P29	SSpd Timer	Slow Speed Time/Limit	Off, 1 to 900	Seconds	10	91
CFN 26	P30	SSpd Kick Curr	Slow Speed Kick Level	Off, 100 to 800	% FLA	Off	91
CFN 27	P31	SSpd Kick T	Slow Speed Kick Time	0.1 to 10.0	Seconds	1.0	92

5.2.3 Protection Group

Group	LED	Display	Parameter	Setting Range	Units	Default	Page
PFN 00		Jump Code	Jump to parameter	1 - 35		1	92
PFN 01	P32	Over Cur Lvl	Over Current Trip Level	Off, 50 - 800	%FLA	Off	92
PFN 02	P33	Over Cur Time	Over Current Trip Delay Time	Off, 0.1 - 90.0	Seconds	0.1	93
PFN 03	P34	Undr Cur Lvl	Under Current Trip Level	Off, 5 - 100	%FLA	Off	93
PFN 04	P35	Undr Cur Time	Under Current Trip Delay Time	Off, 0.1 - 90.0	Seconds	0.1	94
PFN 05	P36	Cur Imbl Lvl	Current Imbalance Trip Level	Off, 5 - 40	%	15	94
PFN 06		Cur Imbl Time	Current Imbalance Trip Time	0.1 - 90	Seconds	10	95
PFN 07	P37	Resid GF Lvl	Residual Ground Fault Trip Level	Off, 5 - 100	%FLA	Off	96
PFN 08		ZS GF Lvl	Zero Sequence Ground Fault Trip Level	Off, 1.0 - 25	Amps	Off	97
PFN 09		Gnd Flt Time	Ground Fault Trip Time	0.1 - 90.0	Seconds	3.0	98
PFN 10	P38	Over Vlt Lvl	Over Voltage Trip Level	Off, 1 - 40	%	Off	98
PFN 11	P39	Undr Vlt Lvl	Under Voltage Trip Level	Off, 1 - 40	%	Off	99
PFN 12	P40	Vlt Trip Time	Over/Under Voltage Trip Delay Time	0.1 - 90.0	Seconds	0.1	99
PFN 13		Ph Loss Time	Phase Loss Trip Time	0.1 - 5.0	Seconds	0.2	100
PFN 14		Over Frq Lvl	Over Frequency Trip Level	24 - 72	Hz	72	100
PFN 15		Undr Frq Lvl	Under Frequency Trip Level	23 - 71	Hz	23	100
PFN 16		Frq Trip Time	Frequency Trip Time	0.1 - 90.0	Seconds	0.1	101
PFN 17		PF Lead Lvl	PF Lead Trip Level	Off, -0.80 lag to +0.01 lead		Off	101
PFN 18		PF Lag Lvl	PF Lag Trip Level	Off, -0.01 lag to +0.80 lead		Off	101
PFN 19		PF Trip Time	PF Trip Time	0.1 - 90.0	Seconds	10.0	101
PFN 20		Backspin Time	Backspin Timer	Off, 1 - 180	Minutes	Off	102
PFN 21		Time Btw St	Time Between Starts	Off, 1 - 180	Minutes	Off	102
PFN 22		Starts/Hour	Starts per Hour	Off, 1 - 6		Off	102
PFN 23	P41	Auto Reset	Auto Fault Reset Time	Off, 1 - 900	Seconds	Off	102
PFN 24	P42	Auto Rst Lim	Auto Fault Reset Count Limit	Off, 1 - 10		Off	103
PFN 25	P43	Ctrl Flt En	Controlled Fault Stop	Off, On		On	103
PFN 26		Speed Sw Time	Speed Switch Trip Time	Off, 1 - 250	Seconds	Off	104
PFN 27		M PTC Time	Motor PTC Trip Time	Off, 1 - 5	Seconds	Off	104
PFN 28	P44	Indep S® OL	Independent Starting/Running Overload	Off, On		Off	105
PFN 29	P45	Starting OL	Motor Overload Class Starting	Off, 1 - 40		10	106
PFN 30		Running OL	Motor Overload Class Running	Off, 1 - 40		10	106
PFN 31	P46	OL H© Ratio	Motor Overload Hot/Cold Ratio	0 - 99	%	60	107
PFN 32	P47	OL Cool Time	Motor Overload Cooling Time	1.0 - 999.9	Minutes	30	108
PFN 33		OL Alarm Lvl	Motor OL Alarm Level	1 - 100	%	90	108
PFN 34		OL Lock Lvl	Motor OL Lockout Level	1 - 99	%	15	109
PFN 35		OL Lock Calc	Motor OL Auto Lockout Level	Off, Auto		Off	110

5.2.4 I/O Group

Group	LED	Display	Parameter	Setting Range	Units	Default	Page
I/O 00		Jump Code	Jump to parameter	1 to 27		1	110
I/O 01	P48	DI 1 Config	Digital Input #1 Configuration	Off Stop Fault High Fault Low Fault Reset Disconnect Inline Cnfrm Bypass Cnfrm E OL Reset Local/Remote Heat Disable Heat Enable Ramp Select Slow Spd Fwd Slow Spd Rev Brake Disable Brake Enable Speed Sw NO Speed Sw NC		Stop	111
I/O 02	P49	DI 2 Config	Digital Input #2 Configuration			Off	
I/O 03	P50	DI 3 Config	Digital Input #3 Configuration			Off	
I/O 04		DI 4 Config	Digital Input #4 Configuration			Off	
I/O 05		DI 5 Config	Digital Input #5 Configuration			Off	
I/O 06		DI 6 Config	Digital Input #6 Configuration			Off	
I/O 07		DI 7 Config	Digital Input #7 Configuration			Off	
I/O 08		DI 8 Config	Digital Input #8 Configuration			Off	
I/O 09	P51	Dig Trp Time	Digital Fault Input Trip Time	0.1 to 90.0	Seconds	0.1	112
I/O 10	P52	R1 Config	Relay Output #1 Configuration	Off Fault FS Fault NFS Running UTS Alarm Ready Locked Out Overcurrent Undercurrent OL Alarm Shunt FS Shunt NFS Ground Fault Energy Saver Heating Slow Spd Slow Spd Fwd Slow Spd Rev Braking Cool Fan Ctl PORT Tach Loss		Fault FS	112
I/O 11	P53	R2 Config	Relay Output #2 Configuration			Off	
I/O 12	P54	R3 Config	Relay Output #3 Configuration			Off	
I/O 13		R4 Config	Relay Output #4 Configuration			Off	
I/O 14		R5 Config	Relay Output #5 Configuration			Off	
I/O 15		R6 Config	Relay Output #6 Configuration			Off	
I/O 16	P55	Ain Trp Type	Analog Input Trip Type	Off Low Level High Level		Off	113
I/O 17	P56	Ain Trp Lvl	Analog Input Trip Level	0 to 100	%	50	114
I/O 18	P57	Ain Trp Tim	Analog Input Trip Delay Time	0.1 to 90.0	Seconds	0.1	114
I/O 19	P58	Ain Span	Analog Input Span	1 to 100	%	100	115
I/O 20	P59	Ain Offset	Analog Input Offset	0 to 99	%	0	116
I/O 21	P60	Aout Fctn	Analog Output Function	Off 0 – 200% Curr 0 – 800% Curr 0 – 150% Volt 0 – 150% OL 0 – 10 kW 0 – 100 kW 0 – 1 MW 0 – 10 MW 0 – 100% Ain 0 – 100% Firing Calibration		Off	116
I/O 22	P61	Aout Span	Analog Output Span	1 to 125	%	100	117
I/O 23	P62	Aout Offset	Analog Output Offset	0 to 99	%	0	118
I/O 24	P63	Inline Confg	Inline Configuration	Off, 1.0 to 10.0	Seconds	3.0	118
I/O 25	P64	Bypas Fbk Tim	Bypass / 2M Confirm	0.1 to 5.0	Seconds	2.0	118
I/O 26	P65	Kpd Stop	Keypad Stop Disable	Enabled, Disabled		Enabled	119
I/O 27	P66	Auto Start	Power On Start Selection	Disabled Power Fault Power and Fault		Disabled	119

5.2.5 RTD Group

Group	Display	Parameter	Setting Range	Units	Default	Page
RTD 00	Jump Code	Jump to Parameter	1 - 29		1	120
RTD 01	RTDMod1 Addr	RTD Module #1 Address	Off, 16 - 23		Off	120
RTD 02	RTDMod2 Addr	RTD Module #2 Address				120
RTD 03	RTD1 Group	RTD1 Group	Off Stator Bearing Other		Off	120
RTD 04	RTD2 Group	RTD2 Group				
RTD 05	RTD3 Group	RTD3 Group				
RTD 06	RTD4 Group	RTD4 Group				
RTD 07	RTD5 Group	RTD5 Group				
RTD 08	RTD6 Group	RTD6 Group				
RTD 09	RTD7 Group	RTD7 Group				
RTD 10	RTD8 Group	RTD8 Group				
RTD 11	RTD9 Group	RTD9 Group				
RTD 12	RTD10 Group	RTD10 Group				
RTD 13	RTD11 Group	RTD11 Group				
RTD 14	RTD12 Group	RTD12 Group				
RTD 15	RTD13 Group	RTD13 Group				
RTD 16	RTD14 Group	RTD14 Group				
RTD 17	RTD15 Group	RTD15 Group				
RTD 18	RTD16 Group	RTD16 Group				
RTD 19	Stator Alrm	Stator Alarm Level	1 - 200	°C	200	121
RTD 20	Bearing Alrm	Bearing Alarm Level			200	121
RTD 21	Other Alrm	Other Alarm Level			200	121
RTD 22	Stator Trip	Stator Trip Level			200	122
RTD 23	Bearing Trip	Bearing Trip Level			200	122
RTD 24	Other Trip	Other Trip Level			200	122
RTD 25	RTD Voting	RTD Voting	Disabled, Enabled		Disabled	123
RTD 26	RTD Biasing	RTD Motor OL Biasing	Off, On		Off	123
RTD 27	RTD Bias Min	RTD Bias Minimum Level	0 - 198	°C	40	124
RTD 28	RTD Bias Mid	RTD Bias Mid Point Level	1 - 199	°C	130	124
RTD 29	RTD Bias Max	RTD Bias Maximum Level	105 - 200	°C	155	124

5.2.6 Function Group

Group	LED	Display	Parameter	Setting Range	Units	Default	Page
FUN 00		Jump Code	Jump to Parameter	1 to 24		1	125
FUN 01	P71	Meter 1	Meter 1	Ave Current L1 Current L2 Current L3 Current Curr Imbal Ground Fault Ave Volts L1-L2 Volts L2-L3 Volts L3-L1 Volts Overload Power Factor Watts VA vars kW hours MW hours Phase Order Line Freq Analog Input Analog Output Run Days Run Hours Starts TruTorque % Power % Pk Accel Cur Last Start T Zero Seq GF Stator Temp Bearing Temp Other Temp All Temp		Ave Current	125
FUN 02		Meter 2	Meter 2			Ave Volts	
FUN 03	P78	CT Ratio	CT Ratio	72:1, 96:1, 144:1, 288:1, 864:1, 2640:1, 3900:1, 5760:1, 8000:1, 14400:1, 28800:1, 50:5, 150:5, 250:5, 800:5, 2000:5, 5000:5		288:1	126
FUN 04	P77	Phase Order	Input Phase Sensitivity	Insensitive ABC CBA Single Phase		Insens.	126
FUN 05	P76	Rated Volts	Rated RMS Voltage	100, 110, 120, 200, 208, 220, 230, 240, 350, 380, 400, 415, 440, 460, 480, 500, 525, 575, 600, 660, 690, 800, 1000, 1140, 2200, 2300, 2400, 3300, 4160, 4600, 4800, 6000, 6600, 6900, 10.00K, 11.00K, 11.50K, 12.00K 12.47K, 13.20K, 13.80K	RMS Voltage	480	126
FUN 06	P75	Motor PF	Motor Rated Power Factor	-0.01 (Lag) to 1.00 (Unity)		-0.92	127
FUN 07	P74	Starter Type	Starter Type	Normal Inside Delta Wye-Delta Phase Ctl Curr Follow ATL		Normal	128
FUN 08	P73	Heater Level	Heater Level	Off, 1 to 40	%FLA	Off	128

Group	LED	Display	Parameter	Setting Range	Units	Default	Page
FUN 09	P72	Energy Saver	Energy Saver	Off, On	Seconds	Off	129
FUN 10		PORT Flt Tim	P.O.R.T. Fault Time	Off, 0.1 - 90.0	Seconds	Off	129
FUN 11		PORT Byp Tim	P.O.R.T. Bypass Hold Time	Off, 0.1 - 5.0	Seconds	Off	130
FUN 12		PORT Recover	P.O.R.T. Recovery Method	Voltage Ramp, Fast Recover, Current Ramp, Curr Ramp 2, Ramp Select, Tach Ramp		Fast Recover	130
FUN 13		Tach FS Lvl	Tachometer Full Speed Voltage	1.00 - 10.00	Volts	5.00	130
FUN 14		Tach Los Tim	Tachometer Loss Time	0.1 - 90.0	Seconds	1.5	130
FUN 15		Tach Los Act	Tachometer Loss Action	Fault Current TruTorque KW		Fault	131
FUN 16	P70	Com Drop #	Communication Address	1 to 247		1	131
FUN 17	P69	Com Baud rate	Communication Baud Rate	1200, 2400, 4800, 9600, 19200	bps	19200	131
FUN 18	P68	Com Timeout	Communication Timeout	Off, 1 to 120	Seconds	Off	132
FUN 19	P71	Com Parity	Communications Byte Framing	Even, 1 Stop Bit Odd, 1 Stop Bit None, 1 Stop Bit None, 2 Stop Bit		Even, 1 Stop	132
FUN 20	P80	Software 1	Software Part Number 1	Display Only			132
FUN 21		Software 2	Software Part Number 2	Display Only			133
FUN 22	P67	Misc Command	Miscellaneous Commands	None Reset RT Reset kWh Reflash Mode Store Parameters Load Parameters Factory Reset Std BIST Powered BIST		None	133
FUN 23		T/D Format	Time and Date Format	mm/dd/yy 12h mm/dd/yy 24h yy/mm/dd 12h yy/mm/dd 24h dd/mm/yy 12h dd/mm/yy 24h		mm/dd/yy 12h	134
FUN 24		Time	Time			Present Time	134
FUN 25		Date	Date			Present Date	134
FUN 26		Passcode	Passcode			Off	135

5.2.7 Fault Log Group (FL1 - FL9)

Group	Fault Number	Fault Description	Starter State	I1	I2	I3	V1	V2	V3	KW	Hz	Run Time	Page # 135 228

5.2.8 Event Log Group (E01 - E99)

Group	Event Number	Event Description	Condition	Time	Date	Page # 135 228

6 Parameter Description

Parameter Descriptions

6.1 Parameter Descriptions

The detailed parameter descriptions in this chapter are organized in the same order as they appear on the LCD display.

Each parameter has a detailed description that is displayed with the following format.

Parameter Name MMM__

LCD Display

```
MMM: Parameter
MI    Value
```

Range

Parameter Value (Default: Constant)

OR

LCD
Keypad

Description The description of the function.

See Also Cross references to related parameters or other chapters.

Jump to Parameter QST 00

LCD Display

```
QST: Jump Code
00         1
```

Description By changing the value of this parameter and pressing [ENTER], you can jump directly to any parameter within the group.

Motor FLA QST 01

LCD Display

```
QST: Motor FLA
01       10Amp
```

Range 1 – 6400 Amps RMS **(Default 10A)**

Description The Motor FLA parameter configures the motor full load amps, and is obtained from the nameplate on the attached motor.

If multiple motors are connected, the FLA of each motor must be added together for this value.

⌘ **NOTE:** Incorrectly setting this parameter prevents proper operation of the motor overload protection, motor over current protection, motor undercurrent protection, ground fault protection and acceleration control.

Motor Service Factor QST 02

LCD Display:

```
QST:  Motor SF
02     1.15
```

Range

1.00 – 1.99 **(Default 1.15)**

Description

The Motor Service Factor parameter should be set to the service factor of the motor. The service factor is used for the overload calculations. If the service factor of the motor is not known, then the service factor should be set to 1.00.

⌘ **NOTE:** The NEC (National Electrical Code) does not allow the service factor to be set above 1.40. Check with other local electrical codes for their requirements.

The National Electrical Code, article 430 Part C, allows for different overload multiplier factors depending on the motor and operating conditions. NEC section 430-32 outlines the allowable service factor for different motors.

See Also

Theory of Operation section 7.2, Motor Service Factor on page 147.

Motor Running Overload Class QST 03

LCD Display:

```
QST: Running OL
03        10
```

Range

Off, 1 – 40 **(Default 10)**

Description

The Motor Running Overload Class parameter sets the class of the electronic overload for starting and running if the Independent Starting / Running Overload parameter is set to "Off". If separate starting versus running overload classes are desired, set the Independent S/R OL (PFN28) parameter to "On".

The starter stores the thermal overload value as a percentage value between 0 and 100%, with 0% representing a “cold” overload and 100% representing a tripped overload.

When the parameter is set to "Off", the electronic overload is disabled in all states, starting and running. A separate motor overload protection device must be supplied.

⌘ **NOTE:** Care must be taken not to damage the motor when turning the running overload class off or setting a high value.

⌘ **NOTE:** Consult motor manufacturer data to determine the correct motor overload settings.

See Also

Independent Starting/Running Overload (PFN28) on page 105.
Motor Starting Overload Class (PFN29) on page 106.
Motor Overload Hot/Cold Ratio (PFN31) on page 107.
Motor Overload Cooling Time (PFN32) on page 108.
Motor OL Alarm Level (PFN33) on page 108.
Motor OL Lockout Level (PFN34) on page 109.
Motor OL Auto Lockout Level (PFN35) on page 110.
Relay Output Configuration (I/O 10-15) on page 112.
Theory of Operation section 7.1, Solid State Motor Overload Protection on page 138.

Local Source QST 04

LCD Display

```
QST: Local Src
04  Terminal
```

Range

LCD	Description
Keypad	The start/stop control is from the keypad.
Terminal	The start/stop control is from the terminal strip inputs. **(Default)**
Serial	The start/stop Fault High control is from the network.

Description

The MX^3 can have three sources of start and stop control; Terminal, Keypad and Serial. Two parameters, (QST04 - Local Source) and (QST05 - Remote Source), select the source of the start and stop control.

If a digital input is programmed as Local / Remote, then that input selects the control source. When the input is low, the local source is used. When the input is high, the remote source is used. If no digital input is programmed as Local/Remote, then the local/remote bit in the starter control Modbus register selects the control source. The default value of the bit is Local (0).

⌘ **NOTE:** By default, the Stop key is always enabled, regardless of selected control source. It may be disabled though using the Keypad Stop Disable (I/O26) parameter on page 119.

See Also

Remote Source (QST05) on page 74.
Digital Input Configuration (I/O 01-08) on page 111.
Keypad Stop Disable (I/O26) on page 119.
Communication Address (FUN16) on page 131.
Communication Baud Rate (FUN17) on page 131.
Communication Timeout (FUN18) on page 132.

Remote Source QST 05

LCD Display

```
QST: Remote Src
05  Terminal
```

Range

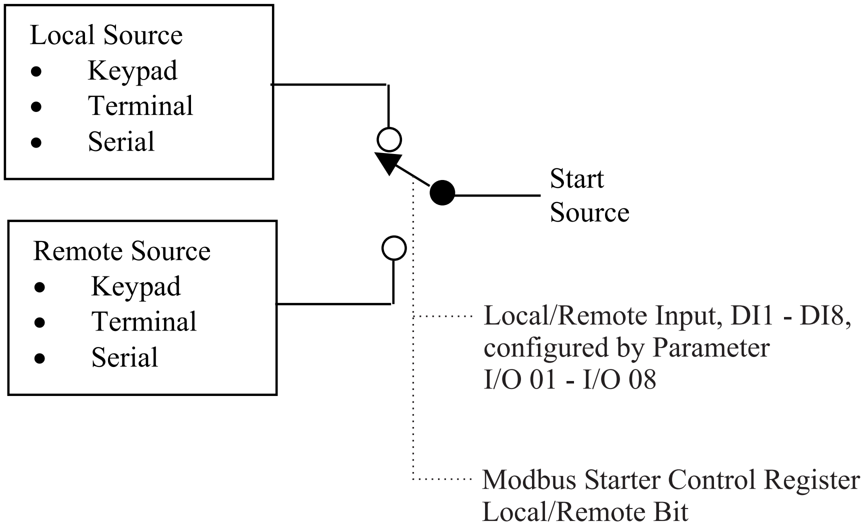
LCD	Description
Keypad	The start/stop control is from the keypad.
Terminal	The start/stop control is from the terminal strip inputs. **(Default)**
Serial	The start/stop control is from the network.

Description

The MX^3 can have three sources of start and stop control; Terminal, Keypad and Serial. Two parameters, (QST04 - Local Source) and (QST05 - Remote Source), select the sources of the start and stop control.

If a digital input is programmed as Local / Remote, then that input selects the control source. When the input is low, the local source is used. When the input is high, the remote source is used. If no digital input is programmed as Local/Remote, then the local/remote bit in the Modbus starter control register selects the control source. The default value of the bit is Local (0).

Figure 33: Local Remote Source



See Also

Local Source parameter (QST04) on page 74.
Digital Input Configuration parameters (I/O 01 - 08) on page 111.
Keypad Stop Disable parameter (I/O26) on page 119.
Communication Address parameter (FUN16) on page 131.
Communication Baud Rate parameter (FUN17) on page 131.
Communication Timeout parameter (FUN18) on page 132.

Initial Current 1 QST 06

LCD Display

```
QST: Init Cur 1
06     100%
```

Range

50 – 600 % of FLA **(Default 100%)**

Description

The Initial Current 1 parameter is set as a percentage of the Motor FLA (QST01) parameter setting. The Initial Current 1 parameter sets the current that is initially supplied to the motor when a start is commanded. The initial current should be set to the level that allows the motor to begin rotating within a couple of seconds of receiving a start command.

To adjust the initial current setting, give the starter a run command. Observe the motor to see how long it takes before it begins rotating and then stop the unit. For every second that the motor doesn't rotate, increase the initial current by 20%. Typical loads require an initial current in the range of 50% to 175%.

If the motor does not rotate within a few seconds after a start command, the initial current should be increased. If the motor accelerates too quickly after a start command, the initial current should be decreased.

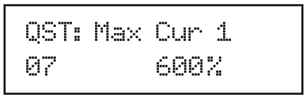
The Initial Current 1 parameter must be set to a value that is lower than the Maximum Current 1 parameter setting.

See Also

Start Mode (CFN01) on page 78.
Ramp Time 1 (QST08 / CFN02) on page 78.
Maximum Current 1 (QST07 / CFN04) on page 79.
Kick Level 1 (CFN11) on page 84.
Kick Time 1 (CFN12) on page 84.
Theory of Operation section 7.3.1, Current Ramp Settings, Ramps and Times on page 148.

Maximum Current 1 QST 07

LCD Display



```
QST: Max Cur 1
07      600%
```

Range

100 – 800 % of FLA **(Default 600%)**

Description

The Maximum Current 1 parameter is set as a percentage of the Motor FLA (QST01) parameter setting. This parameter performs two functions. It sets the current level for the end of the ramp profile, as well as the maximum current that is allowed to reach the motor after the ramp is completed.

If the ramp time expires before the motor has reached full speed, the starter holds the current at the maximum current level until either the UTS timer expires; the motor reaches full speed, or the overload trips.

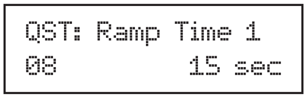
Typically, the maximum current is set to 600% unless the power system or load dictates the setting of a lower maximum current.

See Also

Up To Speed Time (QST09) on page 77.
Start Mode (CFN01) on page 78.
Ramp Time 1 (QST08 / CFN02) on page 78.
Initial Current 1 (QST06 / CFN03) on page 79.
Kick Level 1 (CFN11) on page 84.
Kick Time 1 (CFN12) on page 84.
Theory of Operation section 7.3.1, Current Ramp Settings, Ramps and Times on page 148.

Ramp Time 1 QST 08

LCD Display



```
QST: Ramp Time 1
08         15 sec
```

Range

0 – 300 seconds **(Default 15)**

Description

The Ramp Time 1 parameter is the time it takes for the starter to allow the current, voltage, torque or power (depending on the start mode) to go from its initial to the maximum value. To make the motor accelerate faster, decrease the ramp time. To make the motor accelerate slower, increase the ramp time.

A typical ramp time setting is from 15 to 30 seconds.

If the ramp time expires before the motor reaches full speed, the starter maintains the maximum current level until either the motor reaches full speed, the UTS timer expires, or the motor thermal overload trips.

⌘ **NOTE**: Setting the ramp time to a specific value does not necessarily mean that the motor will take this time to accelerate to full speed. The motor and load may achieve full speed before the ramp time expires if the application does not require the set ramp time and maximum current to reach full speed. Alternatively, the motor and load may take longer than the set ramp time to achieve full speed.

See Also

Up To Speed Time (QST09) on page 77.
Start Mode (CFN01) on page 78.
Initial Current 1 (QST06 / CFN03) on page 79.
Maximum Current 1 (QST07 / CFN04) on page 79.
Kick Level 1 (CFN11) on page 84.
Kick Time 1 (CFN12) on page 84.
Theory of Operation section 7.3.1, Current Ramp Settings, Ramps and Times on page 148.

Up To Speed Time QST 09

LCD Display

```
QST: UTS Time
09       20sec
```

Range 1 – 300 seconds **(Default 20)**

Description The Up To Speed Time parameter sets the maximum acceleration time to full speed that the motor can take. A stalled motor condition is detected if the motor does not get up-to-speed before the up-to-speed timer expires. The motor is considered up-to-speed once the current stabilizes below 175 percent of the FLA value and the ramp time expires.

⌘ **NOTE:** During normal acceleration ramps, the up-to-speed timer has to be greater than the sum of the highest ramp time in use and the kick time. The up-to-speed timer does not automatically change to be greater than the ramp time. If a ramp time greater than the up-to-speed timer is set, the starter will declare an up-to-speed fault every time a start is attempted.

⌘ **NOTE:** When the Start Mode parameter (CFN01) is set to "Voltage Ramp", the UTS timer acts as an acceleration kick. When the UTS timer expires, full voltage is applied to the motor. This feature can be used to reduce motor oscillations if they occur near the end of an open loop voltage ramp start.

⌘ **NOTE:** When the starter type parameter (FUN07) is set to "Wye-Delta", the UTS timer is used as the transition timer. When the UTS timer expires, the transition from Wye starting mode to Delta running mode takes place if it has not already occurred.

Fault Code 01 - Up to Speed Fault is declared when a stalled motor condition is detected.

See Also

Start Mode (CFN01) on page 78.
Ramp Time 1 (QST08 / CFN02) on page 78.
Ramp Time 2 (CFN05) on page 80.
Kick Time 1 (CFN12) on page 84.
Kick Time 2 (CFN14) on page 85.
Starter Type (FUN07) on page 128.
Theory of Operation section 7.3, Acceleration Control on page 148.
Theory of Operation section 7.8, Wye-Delta on page 168.

Jump to Parameter CFN 00

LCD Display

```
CFN:Jump Code
00        1
```

Description By changing the value of this parameter and pressing [ENTER], you can jump directly to any parameter within the group.

Start Mode CFN 01

LCD Display

```
CFN: Start Mode
01  Current Ramp
```

Range

LCD	Description
Voltage Ramp	Open Loop Voltage acceleration ramp.
Current Ramp	Current control acceleration ramp. **(Default)**
TT Ramp	TruTorque control acceleration ramp.
Power Ramp	Power (kW) control acceleration ramp.
Tach Ramp	Tachometer control acceleration ramp.

Description

The Start Mode parameter allows the selection of the optimal starting ramp profile based on the application.

The closed loop current control acceleration ramp is ideal for starting most general-purpose motor applications. Ex: crushers, ball mills, reciprocating compressors, saws, centrifuges, and most other applications.

The closed loop TruTorque control acceleration ramp is suitable for applications that require a minimum of torque transients during starting or for consistently loaded applications that require a reduction of torque surges during starting. Ex: centrifugal pumps, fans, and belt driven equipment.

The closed loop power control acceleration ramp is ideal for starting applications using a generator or other limited capacity source.

In addition to the basic motor and starter setup variables, the following needs to be done to use the tachometer feedback control ramp:
1. Connect a tachometer with appropriate DC output voltage and correct polarity to the MX^3 power card input (TB5-2(+input), TB5-3(-input)).
2. The start mode (CFN01) is to be selected as Tach Ramp.
3. Program Tachometer Full Speed Voltage (FUN13).
4. Program Tachometer Loss Time (FUN14).
5. Program Tachometer Loss Action (FUN15).
6. Set the Initial Current Level (CFN03) to the desired current limit.
7. Set the Maximum Current Level (CFN04) to the desired maximum current limit.

See Also

Initial Voltage/Torque/Power (CFN08) on page 81.
Maximum Torque/Power (CFN09) on page 81.
Acceleration Ramp Profile (CFN10) on page 83.
Theory of Operation section 7.3, Acceleration Control on page 148.

Ramp Time 1 CFN 02

LCD Display

```
CFN: Ramp Time 1
02        15sec
```

Range

0 – 300 seconds **(Default 15)**

Description

The Ramp Time 1 parameter is the time it takes for the starter to allow the current, voltage, torque or power (depending on the start mode) to go from its initial to the maximum value. To make the motor accelerate faster, decrease the ramp time. To make the motor accelerate slower, increase the ramp time.

A typical ramp time setting is from 15 to 30 seconds.

If the ramp time expires before the motor reaches full speed, the starter maintains the maximum current level until either the motor reaches full speed, the UTS timer expires, or the motor thermal overload trips.

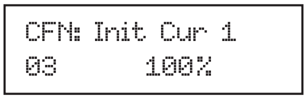
⌘ **NOTE**: Setting the ramp time to a specific value does not necessarily mean that the motor will take this time to accelerate to full speed. The motor and load may achieve full speed before the ramp time expires if the application does not require the set ramp time and maximum current to reach full speed. Alternatively, the motor and load may take longer than the set ramp time to achieve full speed.

See Also

Up To Speed Time (QST09) on page 77.
Start Mode (CFN01) on page 78.
Initial Current 1 (QST06 / CFN03) on page 79.
Maximum Current 1 (QST07 / CFN04) on page 79.
Kick Level 1 (CFN11) on page 84.
Kick Time 1 (CFN12) on page 84.
Theory of Operation section 7.3.1, Current Ramp Settings, Ramps and Times on page 148.

Initial Current 1 CFN 03

LCD Display



```
CFN: Init Cur 1
03      100%
```

Range

50 – 600 % of FLA **(Default 100%)**

Description

The Initial Current 1 parameter is set as a percentage of the Motor FLA (QST01) parameter setting. The Initial Current 1 parameter sets the current that is initially supplied to the motor when a start is commanded. The initial current should be set to the level that allows the motor to begin rotating within a couple of seconds of receiving a start command.

To adjust the initial current setting, give the starter a run command. Observe the motor to see how long it takes before it begins rotating and then stop the unit. For every second that the motor doesn't rotate, increase the initial current by 20%. Typical loads require an initial current in the range of 50% to 175%.

If the motor does not rotate within a few seconds after a start command, the initial current should be increased. If the motor takes off too quickly after a start command, the initial current should be decreased.

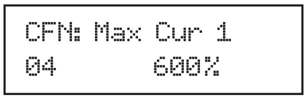
The Initial Current 1 parameter must be set to a value that is lower than the Maximum Current 1 parameter setting.

See Also

Start Mode (CFN01) on page 78.
Ramp Time 1 (QST08 / CFN02) on page 78.
Maximum Current 1 (QST07 / CFN04) on page 79.
Kick Level 1 (CFN11) on page 84.
Kick Time 1 (CFN12) on page 84.
Theory of Operation section 7.3.1, Current Ramp Settings, Ramps and Times on page 148.

Maximum Current 1 CFN 04

LCD Display



```
CFN: Max Cur 1
04       600%
```

Range

100 – 800 % of FLA **(Default 600%)**

Description

The Maximum Current 1 parameter is set as a percentage of the Motor FLA (QST01) parameter setting and performs two functions. It sets the current level for the end of the ramp profile. It also sets the maximum current that is allowed to reach the motor after the ramp is completed.

If the ramp time expires before the motor has reached full speed, the starter holds the current at the maximum current level until either the UTS timer expires; the motor reaches full speed, or the overload trips.

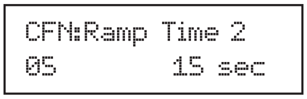
Typically, the maximum current is set to 600% unless the power system or load dictates the setting of a lower maximum current.

See Also

Up To Speed Time (QST09) on page 77.
Start Mode (CFN01) on page 78.
Ramp Time 1 (QST08 / CFN02) on page 78.
Initial Current 1 (QST06 / CFN03) on page 79.
Kick Level 1 (CFN11) on page 84.
Kick Time 1 (CFN12) on page 84.
Theory of Operation section 7.3.1, Current Ramp Settings, Ramps and Times on page 148.

Ramp Time 2 CFN 05

LCD Display



```
CFN:Ramp Time 2
05        15 sec
```

Range

0 – 300 seconds **(Default 15)**

Description

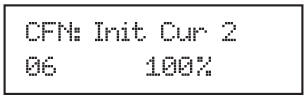
The Ramp Time 2 parameter sets the time it takes for the starter to allow the current to go from the initial current to the maximum current when the second ramp is active. Refer to the Ramp Time 1 (QST08 / CFN02) for description of operation.

See Also

Ramp Time 1 (QST08 / CFN02) on page 78.
Digital Input Configuration (I/O 01-08) on page 111.
Theory of Operation section 7.3.1, Current Ramp Settings, Ramp and Times on page 148.
Theory of Operation section 7.3.7, Dual Acceleration Ramp Control on page 154.

Initial Current 2 CFN 06

LCD Display



```
CFN: Init Cur 2
06      100%
```

Range

50 – 600 % of FLA **(Default 100%)**

Description

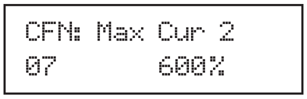
The Initial Current 2 parameter is set as a percentage of the Motor FLA (QST01) parameter setting when the second ramp is active. Refer to the Initial Current 1 (CFN03) for description of operation.

See Also

Initial Current 1 (CFN03) on page 79.
Digital Input Configuration (I/O 01-08) on page 111.
Theory of Operation section 7.3.1, Current Ramp Settings, Ramps and Times on page 148.
Theory of Operation section 7.3.7, Dual Acceleration Ramp Control on page 154.

Maximum Current 2 CFN 07

LCD Display



```
CFN: Max Cur 2
07       600%
```

Range

100 – 800 % of FLA **(Default 600%)**

Description

The Maximum Current 2 parameter is set as a percentage of the Motor FLA (QST01) parameter setting, when the second ramp is active. Refer to the Maximum Current 1 (CFN 04) for description of operation.

See Also

Maximum Current 1 (CFN04) on page 79.
Digital Input Configuration (I/O 01-08) on page 111.
Theory of Operation section 7.3.1, Current Ramp Settings, Ramps and Times on page 148.
Theory of Operation section 7.3.7, Dual Acceleration Ramp Control on page 154.

Initial Voltage/Torque/Power CFN08

LCD Display

```
CFN: Init V/T/P
08       25%
```

Range

1 – 100 % of Voltage/Torque/Power **(Default 25%)**

Description

Start Mode (CFN01) set to Open Loop Voltage Acceleration:
This parameter sets the starting point for the voltage acceleration ramp profile. A typical value is 25%. If the motor starts too quickly or the initial current is too high, reduce this parameter. If the motor does not start rotating within a few seconds after a start is commanded, increase this parameter.

Start Mode (CFN01) set to Current Control Acceleration:
Not used when the Start Mode parameter is set to Current control acceleration. Refer to the Initial Current 1 parameter (CFN03) to set the initial current level.

Start Mode (CFN01) set to TruTorque Control Acceleration:
This parameter sets the initial torque level that the motor produces at the beginning of the starting ramp profile. A typical value is 10% to 20%. If the motor starts too quickly or the initial torque level is too high, reduce this parameter. If the motor does not start rotating within a few seconds after a start is commanded, increase this parameter. If the value is set too low a “No Current at Run” fault may occur during acceleration.

⌘ **NOTE**: It is important that the FUN06 - Rated Power Factor parameter is set properly so that the actual initial torque level is the value desired.

Start Mode (CFN01) set to (kW) Power Control Acceleration:
This parameter sets the initial motor power (KW) level that will be achieved at the beginning of the starting ramp profile. A typical value is 10% to 30%. If the motor starts too quickly or the initial power level is too high, reduce this parameter. If the motor does not start rotating within a few seconds after a start is commanded, increase this parameter. If the value is set too low a “No Current at Run” fault may occur during acceleration.

⌘ **NOTE:** It is important that the FUN06 - Rated Power Factor parameter is set properly so that the actual initial power level is the value desired.

See Also

Start Mode (CFN01) on page 78.
Ramp Time 1 (CFN02) on page 78.
Initial Current 1 (CFN03 / QST06) on page 79.
Maximum Torque/Power (CFN09) on page 81.
Rated Power Factor (FUN06) on page 127.
Theory of Operation section 7.3, Acceleration Control on page 148.

Maximum Torque/Power CFN 09

LCD Display

```
CFN:  Max T/P
09      105%
```

Range

10 – 325 % of Torque/Power **(Default 105%)**

Description

Start Mode (CFN01) set to Open Loop Voltage Acceleration:
Not used when the Start Mode parameter is set to open-loop voltage acceleration. When in open loop voltage acceleration mode, the final voltage ramp value is always 100% or full voltage.

Start Mode (CFN01) set to Current Control Acceleration:
Not used when the Start Mode parameter is set to current control acceleration mode. Refer to the Maximum Current 1 parameter (CFN04) to set the maximum current level.

Start Mode (CFN01) set to TruTorque Control Acceleration:
This parameter sets the final or maximum torque level that the motor produces at the end of the acceleration ramp time. For a loaded motor, the maximum torque value initially should be set to 100% or greater. If the maximum torque value is set too low, the motor may not produce enough torque to reach full speed and may stall. On lightly loaded motors, this parameter may be reduced below 100% to produce smoother starts.

⌘ **NOTE:** It is important that the FUN06 - Rated Power Factor parameter is set properly so that the desired maximum torque level is achieved.

Start Mode (CFN01) set to Power Control Acceleration:
This parameter sets the final or maximum power (KW) consumption level that will be achieved at the end of the ramp time. For a loaded motor, the maximum power value initially should be set to 100% or greater. If the maximum power level is set too low, the motor may not produce enough torque to reach full speed and may stall. On lightly loaded motors, this parameter may be reduced below 100% to provide for smoother starts.

⌘ **NOTE**: It is important that the FUN06 - Rated Power Factor parameter is set properly so that the actual maximum power level is achieved.

See Also

Start Mode (CFN01) on page 78.
Ramp Time 1 (CFN02 / QST08) on page 78.
Initial Current 1 (CFN03 / QST06) on page 79.
Maximum Current 1 (QST07 / CFN04) on page 79.
Initial Voltage/Torque/Power (CFN08) on page 81.
Rated Power Factor (FUN06) on page 127.
Theory of Operation section 7.3, Acceleration Control on page 148.

Acceleration Ramp Profile CFN 10

LCD Display

```
CFN: Accel Prof
10  Linear
```

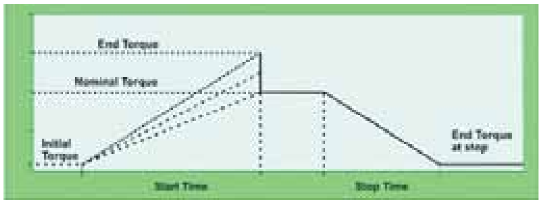
Range

Linear **(Default)**
Square
S-Curve

Description

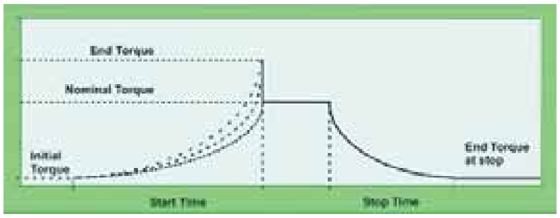
Linear – The linear profile linearly increases the control reference (voltage, current, torque, power, speed) from the initial acceleration ramp value to the final acceleration ramp value. The linear profile is the default profile and is recommended for most acceleration and deceleration situations.

Linear



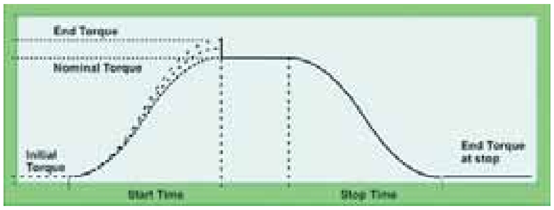
Squared – The squared profile increases the control reference (voltage, current, torque, power, speed) in a squared manner. A squared acceleration profile can be useful when using TruTorque control on a load with a squared torque characteristic (such as pumps, and fans). A squared torque profile can provide a more linear speed profile during acceleration and deceleration.

Squared



S–Curve – The S-curve profile slowly increases the control reference's rate of change at the beginning of the ramp profile and an slowly decreases the rate of change of the reference at the end of the ramp profile. This profile can be useful when using closed loop tach control to smooth the starting and ending of the acceleration profile. It can also be useful with other types of control methods that require extra smooth starts.

S-Curve



See Also

Start Mode (CFN01) on page 78.

Kick Level 1 CFN 11

LCD Display

```
CFN: Kick Lvl 1
11   Off
```

Range

Off, 100 – 800% of FLA **(Default Off)**

Description

The Kick Level 1 parameter sets the current level that precedes any ramp when a start is first commanded. The kick current is only useful on motor loads that are hard to get rotating but then are much easier to move once they are rotating. An example of a load that is hard to get rotating is a ball mill. The ball mill requires a high torque to get it to rotate the first quarter turn (90°). Once the ball mill is past 90°of rotation, the material inside begins tumbling and it is easier to turn.

The kick level is usually set to a low value and then the kick time is adjusted to get the motor rotating. If the kick time is set to more than 2.0 seconds without the motor rotating, increase the kick current by 100% and re-adjust the kick time.

See Also

Start Mode parameter on (CFN01) on page 78.
Kick Time 1 parameter on (CFN12) on page 84.
Theory of Operation section 7.3.2, Programming A Kick Current on page 149.

Kick Time 1 CFN 12

LCD Display

```
CFN:Kick Time 1
12      1.0sec
```

Range

0.1 – 10.0 seconds **(Default 1.0)**

Description

The Kick Time 1 parameter sets the length of time that the kick current level (CFN11) is applied to the motor.

The kick time adjustment should begin at 0.5 seconds and be adjusted by 0.1 or 0.2 second intervals until the motor begins rotating. If the kick time is adjusted above 2.0 seconds without the motor rotating, start over with a higher kick current setting.

⌘ **NOTE:** The kick time adds to the total start time and must be accounted for when setting the UTS time.

See Also

Up To Speed parameter (QST09) on page 77.
Start Mode parameter (CFN01) on page 78.
Kick Level 1 (CFN11) on page 84.
Theory of Operation section 7.3.2, Programming A Kick Current on page 149.

Kick Level 2 CFN 13

LCD Display

```
CFN: Kick Lvl 2
13   Off
```

Range Off, 100 – 800% of FLA **(Default Off)**

Description The Kick Level 2 parameter sets the current level that precedes any ramp when a start is first commanded when the second ramp is active. Refer to the Kick Level 1 parameter on page 84 for description of operation.

Kick Time 2 CFN 14

LCD Display

```
CFN:Kick Time 2
14       1.0sec
```

Range 0.1 – 10.0 seconds **(Default 1.0)**

Description The Kick Time 2 parameter sets the length of time that the kick current level (CFN11) is applied to the motor when the second ramp is active. Refer to the Kick Time 1 parameter on page 84 for description of operation.

See Also

Kick Level 1 parameter (CFN11) on page 84.
Digital Input Configuration (I/O 01 - 08) parameters on page 111.
Theory of Operation section 7.3.2, Programming A Kick Current on page 149.
Theory of Operation section 7.3.7, Dual Acceleration Ramp Control on page 154.

Stop Mode CFN 15

LCD Display

```
CFN: Stop Mode
15  Coast
```

Range

LCD	Description
Coast **(Default)**	Coast to Stop
Volt Decel	Open Loop Voltage Deceleration
TT Decel	TruTorque Deceleration
DC Brake	D.C. Braking

Description

Coast:
A coast to stop should be used when no special stopping requirements are necessary; Example: crushers, balls mills, centrifuges, belts, conveyor. The bypass contactor is opened before the SCRs stop gating to reduce wear on the contactor contacts.

Voltage Decel:
In this mode, the starter linearly phases-back the SCRs based on the parameters Decel Begin Level, Decel End Level, and Decel Time.

TruTorque Decel:
In this mode, the starter linearly reduces the motor torque based on the Decel End Level and Decel Time.

DC Brake:
In this mode the starter provides D.C. injection for frictionless braking of a three phase motor.

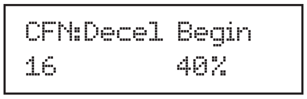
⌘ **NOTE:** The MX^3 stops the motor when any fault occurs. Depending on the application, it may be desirable for the motor to be stopped in a controlled manner (Voltage Decel, TT Decel or D.C. Braking) instead of being allowed to coast to a stop when this occurs. This may be achieved by setting the Controlled Fault Stop (PFN 25) parameter to On. Be aware however that not all fault conditions allow for a controlled fault stop.

See Also

Decel Begin Level parameter (CFN16) on page 86.
Decel End Level parameter (CFN17) on page 87.
Decel Time parameter (CFN18) on page 87.
Deceleration Ramp Profile (CFN19) on page 88.
DC Brake Level (CFN20) on page 88.
DC Brake Time (CFN21) on page 89.
DC Brake Delay (CFN22) on page 89.
Controlled Fault Stop Enable (PFN25) on page 103.
Digital Input Configuration(I/O 01 - 08) on page 111.
Relay Output Configuration (I/O 10 - 15) on page 112.
Theory of Operation section 7.4, Deceleration Control on page 157.
Theory of Operation section 7.5, Braking Controls on page 159.

Decel Begin Level CFN 16

LCD Display



```
CFN:Decel Begin
16        40%
```

Range

1 – 100% of phase angle firing **(Default 40%)**

Description

Stop Mode (CFN15) set to Voltage Deceleration:
The voltage deceleration profile utilizes an open loop S-curve voltage ramp profile. The Decel Begin Level parameter sets the initial or starting voltage level when transferring from running to deceleration. The deceleration beginning level is not a precise percentage of actual line voltage, but defines a point on the S-curve deceleration profile.

A typical voltage decel begin level setting is between 30% and 40%. If the motor initially surges (oscillates) when a stop is commanded, decrease this parameter value. If there is a sudden drop in motor speed when a stop is commanded, increase this parameter value.

Stop Mode (CFN15) set to TruTorque Deceleration:
Not used when the Stop Mode parameter is set to TruTorque Decel. The TruTorque beginning deceleration level is automatically calculated based on the motor load at the time the stop command is given.

⌘ **NOTE:** It is important that the FUN06 - Rated Power Factor parameter is set properly so that the actual deceleration torque levels are the levels desired.

See Also

Stop Mode parameter (CFN15) on page 85.
Decel End Level parameter (CFN17) on page 87.
Decel Time parameter (CFN18) on page 87.
Controlled Fault Stop Enable parameter (PFN25) on page 103.
Rated Power Factor parameter (FUN06) on page 127.
Theory of Operation section 7.4, Deceleration Control on page 157.

Decel End Level CFN 17

LCD Display

```
CFN: Decel End
17        20%
```

Range 1 – 99 % of phase angle firing **(Default 20%)**

Description

Stop Mode (CFN15) set to Voltage Deceleration:
The voltage deceleration profile utilizes an open loop S-curve voltage ramp profile. The Decel End Level parameter sets the ending voltage level for the voltage deceleration ramp profile. The deceleration ending level is not a precise percentage of actual line voltage, but defines an ending point on the S-curve deceleration profile.

A typical voltage decel end level setting is between 10% and 20%. If the motor stops rotating before the deceleration time has expired, increase this parameter value. If the motor is still rotating when the deceleration time has expired, decrease this parameter value. If the value is set too low a “No Current at Run” fault may occur during deceleration.

⌘ **NOTE:** The deceleration end level cannot be set greater than the decel begin level.

Stop Mode (CFN15) set to TruTorque Deceleration:
The decel end level parameter sets the ending torque level for the TruTorque deceleration ramp profile.

A typical TruTorque decel end level setting is between 10% and 20%. If the motor stops rotating before the deceleration time has expired, increase this parameter value. If the motor is still rotating when the deceleration time has expired, decrease this parameter value.

See Also

Stop Mode parameter (CFN15) on page 85.
Decel Begin Level parameter (CFN16) on page 86.
Decel Time parameter (CFN18) on page 87.
Controlled Fault Stop Enable parameter (PFN25) on page 103.
Theory of Operation section 7.4, Deceleration Control on page 157.

Decel Time CFN 18

LCD Display

```
CFN: Decel Time
18        15sec
```

Range 1 – 180 seconds **(Default 15)**

Description

The Decel Time parameter sets the time that the deceleration profile is applied to the motor and sets the slope of the deceleration ramp profile. When in voltage decel mode, this time sets the time to ramp from the initial decel level to the final decel level.

⌘ **NOTE**: If the motor is not up to speed when a stop is commanded, the voltage decel profile begins at the lower of either the decel begin level setting or at the motor voltage level when the stop is commanded. Although the profile may be adjusted, the deceleration time remains the same.

When in the TruTorque deceleration mode, the decel time sets the time between when a stop is commanded and when the decel end torque level is applied.

If the motor stops rotating before the decel time expires, decrease the decel time parameter. If the motor is still rotating when the decel time expires, increase the decel time parameter.

A typical decel time is 20 to 40 seconds.

⌘ **NOTE:** Depending on the motor load and the decel parameter settings, the motor may or may not be fully stopped at the end of the deceleration time.

See Also

Stop Mode parameter (CFN15) on page 85.
Decel Begin Level parameter (CFN16) on page 86.
Decel End Level parameter (CFN17) on page 87.
Controlled Fault Stop parameter (PFN25) on page 103.
Theory of Operation section 7.4, Deceleration Control on page 157.

Decel Ramp Profile CFN 19

LCD Display

```
CFN: Decel Prof
19  Linear
```

Range

Linear **(Default)**
Squared
S-Curve

Description

See Accel Prof (CFN10) for details on page 83.

See Also

Stop Mode (CFN15) on page 85.

DC Brake Level CFN 20

LCD Display

```
CFN:Brake Level
20        25%
```

Range

10 – 100 % of available brake torque **(Default 25%)**

Description

When the Stop Mode (CFN15) is set to "DC brake", the DC Brake Level parameter sets the level of DC current applied to the motor during braking. The desired brake level is determined by the combination of the system inertia, system friction, and the desired braking time. If the motor is braking too fast the level should be reduced. If the motor is not braking fast enough the level should be increased. Refer to Nema MG1, Parts 12 and 20 for maximum load inertia's. (It is required that a PTC Thermistor or RTD MUST be installed to protect the motor.)

DC Brake Function Programming Steps:

1. The DC Brake function may be enabled by setting the stop mode (CFN15) to DC Brake.

2. Once this function is enabled, a relay output configuration (I/O 10 - 15) must be used to control the DC brake contactor or 7th SCR gate drive card during braking. It is recommended to use Relay R3 - (I/O12) because it is a higher rated relay.

⌘ **NOTE:** Standard duty braking
- For load inertia's less than 6 x motor inertia.

⌘ **NOTE:** Heavy duty braking
- For NEMA MG1 parts 12 and 20 maximum load inertia's.

⌘ **NOTE:** When DC injection braking is utilized, discretion must be used when setting up the DC Brake Level. Motor heating during DC braking is similar to motor heating during starting. Even though the Motor OL is active (if not set to "Off") during DC injection braking, excessive motor heating could still result if the load inertia is large or the brake level is set too high. Caution must be used to assure that the motor has the thermal capacity to handle braking the desired load in the desired period of time without excessive heating.

⌘ **NOTE:** Consult motor manufacturer for high inertia applications.

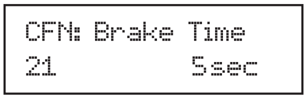
⌘ **NOTE:** Not to be used as an emergency stop. When motor braking is required even during a power outage an electro mechanical brake must be used.

See Also

Stop Mode parameter (CFN15) on page 85.
DC Brake Time parameter (CFN21) on page 89.
DC Brake Delay parameter (CFN22) on page 89.
Controlled Fault Stop Enable parameter (PFN25) on page 103.
Digital Input parameters (I/O 01 - 08) on page 111.
Theory of Operation section 7.1, Solid State Motor Overload Protection, on page 138.
Theory of Operation section 7.5.1, DC Injection Braking Control, on page 160.

DC Brake Time CFN 21

LCD Display



```
CFN: Brake Time
21        5sec
```

Range

1 – 180 Seconds **(Default 5)**

Description

When the Stop Mode (CFN15) is set to "DC brake", the DC Brake Time parameter sets the time that DC current is applied to the motor. The required brake time is determined by the combination of the system inertia, system friction, and the desired braking level. If the motor is still rotating faster than desired at the end of the brake time increase the brake time if possible. If the motor stops before the desired brake time has expired decrease the brake time to minimize unnecessary motor heating.

See Also

Motor Running Overload Class parameter (QST03) on page 73.
Stop Mode parameter (CFN15) on page 85.
DC Brake Level parameter (CFN20) on page 88.
DC Brake Delay parameter (CFN22) on page 89.
Controlled Fault Stop Enable parameter (PFN25) on page 103.
Theory of Operation section 7.5.9, DC Injection Braking Control, on page 164.

DC Brake Delay CFN 22

LCD Display

```
CFN:Brake Delay
22       0.2sec
```

Range

0.1 – 3.0 Seconds **(Default 0.2)**

Description

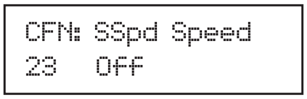
When the Stop Mode (CFN15) is set to "DC brake", the DC Brake Delay time is the time delay between when a stop is commanded and the DC braking current is applied to the motor. This delay allows the residual magnetic field and motor counter EMF to decay before applying the DC braking current. If a large surge of current is detected when DC braking is first engaged increase the delay time. If the delay before the braking action begins is too long then decrease the delay time. In general, low horsepower motors can utilize shorter delays while large horsepower motor may require longer delays.

See Also

Stop Mode parameter (CFN15) on page 85.
DC Brake Level parameter (CFN20) on page 88.
DC Brake Time parameter (CFN21) on page 89.
Theory of Operation section 7.5.9, DC Injection Braking Control, on page 164.

Preset Slow Speed CFN 23

LCD Display



```
CFN: SSpd Speed
23   Off
```

Range Off, 1.0% – 40.0 % **(Default Off)**

Description

The Preset Slow Speed parameter sets the speed of motor operation. When set to "Off", slow speed operation is disabled.

Slow speed operation is commanded by programming one of the digital inputs to either Slow Speed Forward or Slow Speed Reverse. Energizing the Slow Speed Input when the starter is idle will initiate slow speed operation.

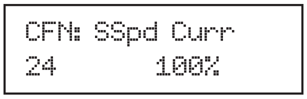
⌘ **NOTE:** When the motor is operating at slow speeds its cooling capacity can be greatly reduced. Therefore, the running time of the motor at a given current level is dependant on the motor's thermal capacity. Although the Motor OL is active (if not set to "Off") during slow speed operation, it is recommended that the motor temperature be monitored when slow speed is used for long periods of time.

See Also

Slow Speed Current Level parameter (CFN24) on page 90.
Slow Speed Time Limit parameter (CFN25) on page 94.
Motor PTC Trip Time (PFN27) on page 104.
Digital Input Configuration parameters (I/O 01 - 08) on page 111.
Relay Output Configuration parameter (I/O 10 - 15) on page 112.
Theory of Operation section 7.6, Slow Speed Operation on page 164.

Preset Slow Speed Current Level CFN 24

LCD Display



```
CFN: SSpd Curr
24       100%
```

Range 10 – 400 % FLA **(Default 100%)**

Description

The Preset Slow Speed Current Level parameter selects the level of current applied to the motor during slow speed operation. The parameter is set as a percentage of motor full load amps (FLA). This value should be set to the lowest possible current level that will properly operate the motor.

⌘ **NOTE:** When the motor is operating at slow speeds its cooling capacity can be greatly reduced. Therefore, the running time of the motor at a given current level is dependant on the motor's thermal capacity. Although the Motor OL is active (if not set to "Off") during slow speed operation, it is recommended that the motor temperature be monitored when slow speed is used for long periods of time.

See Also

Motor Running Overload Class parameter (QST03) on page 73.
Slow Speed Time Limit parameter (CFN25) on page 94.
Motor PTC Trip Time (PFN27) on page 104.
Theory of Operation section 7.6 , Slow Speed Operation on page 164.

Slow Speed Time Limit CFN 25

LCD Display

```
CFN: SSpd Timer
25       10sec
```

Range

Off, 1 – 900 Seconds **(Default 10)**

Description

The Slow Speed Time Limit parameter sets the amount of time that continuous operation of slow speed may take place. When this parameter is set to "Off", the timer is disabled. This parameter can be used to limit the amount of slow speed operation to protect the motor and/or load.

⌘ **NOTE:** The Slow Speed Time Limit includes the time used for the Slow Speed Kick if kick is enabled.

⌘ **NOTE:** The Slow Speed Time Limit resets when the motor is stopped. Therefore, this timer does not prevent the operator from stopping slow speed operation and re-starting the motor, which can result in the operation time of the motor being exceeded.

⌘ **NOTE:** When the motor is operating at slow speeds, its cooling capacity can be greatly reduced. Therefore, the running time of the motor at a given current level is dependant on the motor's thermal capacity. Although the Motor OL is active (if not set to "Off") during slow speed operation it is recommended that the motor temperature be monitored if slow speed is used for long periods of time.

See Also

Motor Running Overload Class parameter (QST03) on page 73.
Slow Speed Current Level parameter (CFN24) on page 90.
Motor PTC Trip Time (PFN27) on page 104.
Theory of Operation section 7.6, Slow Speed Operation on page 164.

Slow Speed Kick Level CFN 26

LCD Display

```
CFN:SSpd Kick Cu
26   Off
```

Range

Off, 100 – 800 % FLA **(Default Off)**

Description

The Slow Speed Kick Level sets the short-term current level that is applied to the motor to accelerate the motor for slow speed operation. If set to "Off" the Slow Speed Kick feature is disabled. Slow speed kick can be used to "break loose" difficult to start loads while keeping the normal slow speed current level at a lower level.

This parameter should be set to a midrange value and then the Slow Speed Kick Time (PFN27) should be increased in 0.1 second intervals until the kick is applied long enough to start the motor rotating. If the motor does not start rotating then increase the Slow Speed Kick Level and begin adjusting the kick time from 1.0 seconds again.

If the motor initially accelerates too fast then reduce the Slow Speed Kick Level and/or reduce the Slow Speed Kick Time.

See Also

Kick Level 1 parameter (CFN11) on page 83.
Slow Speed Kick Time parameter (CFN27) on page 91.
Motor PTC Trip Time (PFN27) on page 104.
Theory of Operations section 7.6, Slow Speed Operation on page 164.

Slow Speed Kick Time CFN 27

LCD Display

```
CFN:SSpd Kick T
27       1.0sec
```

Range 0.1 – 10.0 seconds **(Default 1.0)**

Description The Slow Speed Kick Time parameter sets the length of time that the Slow Speed Kick current level (CFN26) is applied to the motor at the beginning of slow speed operation. After the Slow Speed Kick Level is set, the Slow Speed Kick Time should be adjusted so that the motor starts rotating when a slow speed command is given.

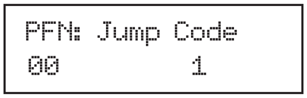
If the motor initially accelerates too fast then reduce the Slow Speed Kick Level and/or reduce the Slow Speed Kick Time.

See Also

Preset Slow Speed (CFN23) on page 90.
Slow Speed Kick Level parameter (CFN26) on page 91.
Motor PTC Trip Time (PFN27) on page 104.
Theory of Operations section 7.6, Slow Speed Operation on page 164.

Jump to Parameter PFN 00

LCD Display

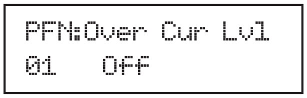


```
PFN: Jump Code
00         1
```

Description By changing the value of this parameter and pressing [ENTER], you can jump directly to any parameter within the group.

Over Current Trip Level PFN 01

LCD Display



```
PFN:Over Cur Lvl
01   Off
```

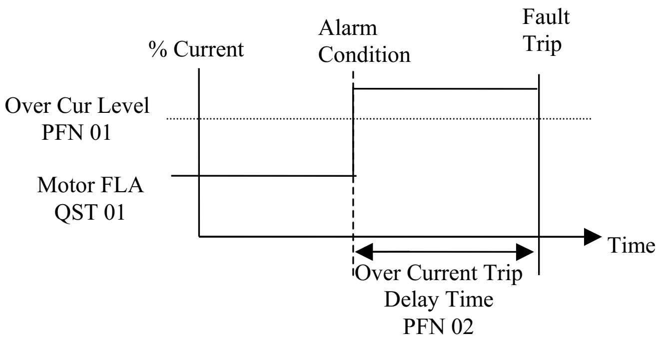
Range Off, 50 – 800 % of FLA **(Default Off)**

Description

If the MX^3 detects a one cycle, average current that is greater than the level defined, an over current alarm condition exists and any relays programmed as alarm will energize. The over current timer starts a delay time. If the over current still exists when the delay timer expires, the starter Over Current Trips (F31) any relay programmed as fault relay changes state.

The Over Current Trip is only active in the UTS state, Energy Saver state, Current follower or while in the Phase Control mode.

A relay can be programmed to change state when an over current alarm condition is detected.



See Also

Over Current Time parameter (PFN02) on page 93.
Auto Reset parameter (PFN23) on page 102.
Controlled Fault Stop Enable parameter (PFN25) on page 103.
Relay Output Configuration parameters (I/O 10 - 15) on page 112.

Over Current Trip Delay Time PFN 02

LCD Display

```
PFN:Over Cur Tim
02       0.1 sec
```

Range

Off, 0.1 – 90.0 seconds **(Default 0.1)**

Description

The Over Current Trip Delay Time parameter sets the period of time that the motor current must be greater than the Over Current Trip Level (PFN01) parameter before an over current fault and trip occurs.

If "Off" is selected, the over current timer does not operate and the starter does not trip. It energizes any relay set to Over current until the current drops or the starter trips on an overload.

A shear pin function can be implemented by setting the delay to its minimum value.

See Also

Over Current Level parameter (PFN01) on page 92.
Auto Reset parameter (PFN23) on page102.
Controlled Fault Stop Enable parameter (PFN25) on page 103.
Relay Output Configuration parameters (I/O 10 - 15) on page 112.

Under Current Trip Level PFN 03

LCD Display

```
PFN:Undr Cur Lvl
03   Off
```

Range

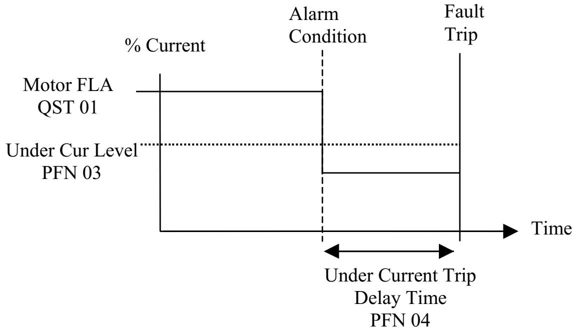
Off, 5 – 100 % of FLA **(Default Off)**

Description

If the MX^3 detects a one cycle, average current that is less than the level defined, an under current alarm condition exists and any relays programmed as alarm will energize. The under current timer starts a delay time. If the under current still exists when the delay time expires, the starter Under Current Trips (F34) and any relay programmed as fault relay changes state.

The Under Current Trip is only active in the UTS state, Energy Saver state, Current follower or while in the Phase Control mode.

A relay can be programmed to change state when an under current alarm condition is detected.



See Also

Under Current Time parameter (PFN04) on page 94.
Auto Reset parameter (PFN23) on page 102.
Controlled Fault Stop Enable parameter (PFN25) on page 103.
Relay Output Configuration parameters (I/O 10 - 15) on page 112

Under Current Trip Delay Time PFN 04

LCD Display

```
PFN:Undr Cur Tim
04       0.1 sec
```

Range

Off, 0.1 – 90.0 seconds **(Default 0.1)**

Description

The Under Current Trip Delay Time parameter sets the period of time that the motor current must be less than the Under Current Level (PFN03) parameter before an under current fault and trip occurs.

If "Off" is selected, the under current timer does not operate and the starter does not trip. It energizes any relay set to "Under Current" until the current rises.

See Also

Under Current Level parameter (PFN03) on page 93.
Auto Reset parameter (PFN23) on page 102.
Controlled Fault Stop Enable parameter (PFN25) on page 103.
Relay Output Configuration parameters (I/O 10 - 15) on page 112.

Current Imbalance Trip Level PFN 05

LCD Display

```
PFN:Cur Imbl Lvl
05        15%
```

Range

Off, 5 – 40 % **(Default 15%)**

Description

The Current Imbalance Trip Level parameter sets the imbalance that is allowed before the starter shuts down. The current imbalance must exist for the Current Imbalance Delay Trip Time (PFN06) before a fault occurs.

At average currents less than or equal to full load current (FLA), the current imbalance is calculated as the percentage difference between the phase current that has the maximum deviation from the average current (Imax) and the FLA current.

The equation for the current imbalance if running at current <=FLA:

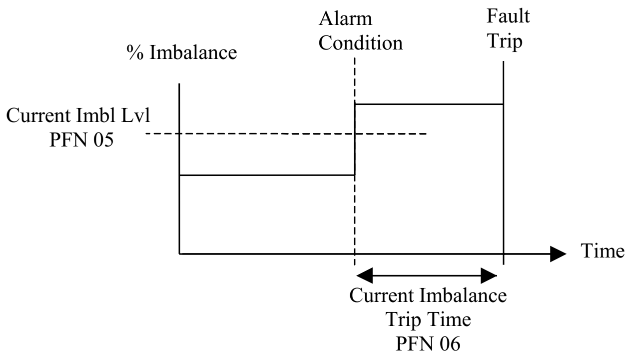
$$\% imbalance = \frac{(Iave - Imax)}{FLA} \times 100\%$$

At average currents greater than full load current (FLA), the current imbalance for each phase is calculated as the percentage difference between the phase current that has the maximum deviation from the average current (Imax) and the average current (Iave).

The equation for the current imbalance if running at current > FLA:

$$\% imbalance = \frac{(Iave - Imax)}{Iave} \times 100\%$$

If the highest calculated current imbalance is greater than the current imbalance level for the Current Imbalance Delay Trip Time (PFN06), the starter shuts down the motor and declares a Fault 37 (Current Imbalance).

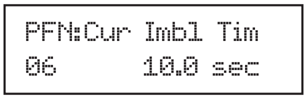


See Also

Current Imbalance Trip Time (PFN06) on page 95.
Auto Reset parameter (PFN23) on page 102.
Controlled Fault Stop Enable parameter (PFN25) on page 103.

Current Imbalance Trip Time PFN 06

LCD Display



```
PFN:Cur Imbl Tim
06      10.0 sec
```

Range 0.1 – 90.0 seconds **(Default 10.0)**

Description The Current Imbalance Trip Time parameter sets the time that the current imbalance must be greater than the percent imbalance parameter (PFN05) before a trip Fault 37 will occur.

See Also Current Imbalance Trip Level (PFN05) on page 94.

Residual Ground Fault Trip Level PFN 07

LCD Display

```
PFN:Resid GF Lvl
07   Off
```

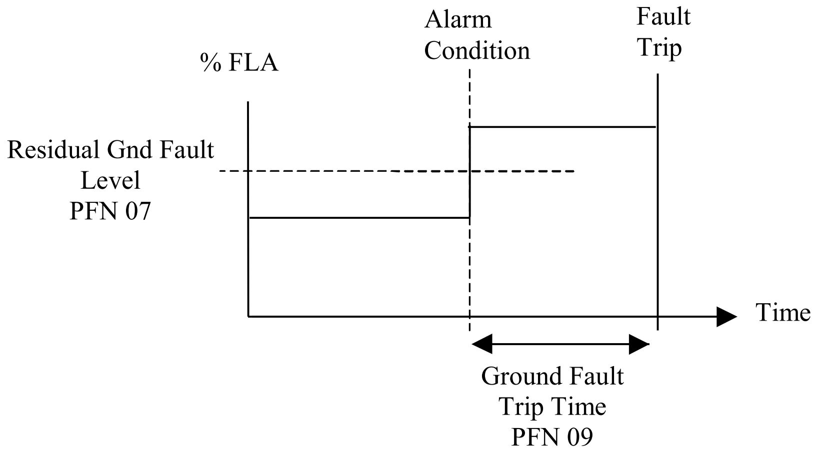
Range Off, 5 – 100 % FLA **(Default Off)**

Description The Residual Ground Fault Trip Level parameter sets a ground fault current trip or indicate level that can be used to protect the system from a ground fault condition. The starter monitors the instantaneous sum of the three line currents to detect the ground fault current.

Ground Fault Trip: The MX^3 will trip with a ground fault indication if:

- No other fault currently exists.
- Ground fault current is equal to or greater than the GF Trip Level for a time period greater than the GF Trip Delay (PFN09).

Once the starter recognizes a ground fault condition, it shuts down the motor and declares a Fault 38 (Ground Fault).



If a programmable relay (I/O 10-15) is set to "GROUND FAULT", the starter energizes the relay when the condition exists.

A typical value for the ground fault current setting is 10% to 20% of the full load amps of the motor.

⌘ **NOTE:** This type of protection is meant to provide machine ground fault protection only. It is not meant to provide human ground fault protection.

⌘ **NOTE:** The MX^3 residual ground fault protection function is meant to detect ground faults on solidly grounded systems. Use on a high impedance or floating ground power system may impair the usefulness of the MX^3 residual ground fault detection feature.

⌘ **NOTE:** Due to uneven CT saturation effects and motor and power system variations, there may be small values of residual ground fault currents measured by the MX^3 during normal operation.

See Also

Ground Fault Trip Time (PFN09) on page 98.
Auto Reset parameter (PFN23) on page 102.
Controlled Fault Stop Enable parameter (PFN25) on page 103.
Relay Output Configuration parameters (I/O 10 - 15) on page 112.

Zero Sequence Ground Fault Trip Level PFN 08

LCD Display

```
PFN: ZS GF Lvl
08   Off
```

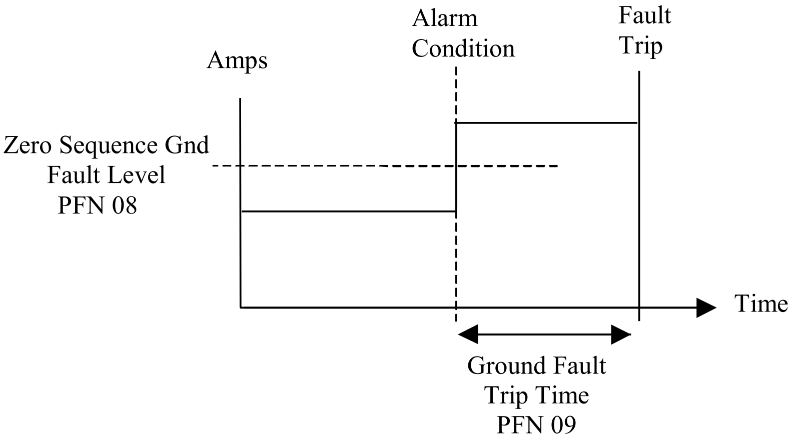
Range Off, 1.0 – 25.0 amps **(Default Off)**

Description The Zero Sequence Ground Fault Trip Level parameter sets a ground fault current trip or alarm level that can be used to protect the system from a ground fault condition. In isolated or high impedance-grounded systems, core-balanced current sensors are typically used to detect low level ground faults caused by insulation breakdowns or entry of foreign objects. Detection of such ground faults can be used to interrupt the system to prevent further damage, or to alert the appropriate personnel to perform timely maintenance.

Ground Fault Trip: The MX^3 will trip with a ground fault indication if:

- No other fault currently exists.
- Ground fault current is equal to or greater than the GF Trip Level for a time period greater than the GF Trip Delay (PFN09).

Once the starter recognizes a ground fault condition, it will shut down the motor and display a fault F38-Ground Fault.



If a programmable relay (I/O 10 - 15) is set to "GROUND FAULT", the starter energizes the relay when the condition exists.

⌘ **NOTE:** The MX^3 zero sequence ground fault detection consists of installing a Cat. No BICT-2000/1-6 (50: 0.025 amps) core balance current transformer to terminal J15 Gnd Flt located on the I/O card. See Control Card layout starting on page 41.

See Also Ground Fault Trip Time (PFN09) on page 98.
Auto Reset parameter (PFN23) on page 102.
Controlled Fault Stop (PFN25) on page 103.
Relay Outputs (I/O 10 - 15) on page 112.

Ground Fault Trip Time PFN 09

LCD Display

```
PFN:Gnd Flt Time
09       3.0 sec
```

Range

0.1 – 90.0 seconds **(Default 3.0)**

Description

The Ground Fault Trip Time parameter can be set from 0.1 to 90.0 seconds in 0.1 second intervals.

See Also

Residual Ground Fault Trip Level (PFN07) on page 96.
Zero Sequence Ground Fault Trip Level (PFN08) on page 97.

Over Voltage Trip Level PFN 10

LCD Display

```
PFN:Over Vlt Lvl
10   Off
```

Range

Off, 1 – 40 % **(Default Off)**

Description

If the MX^3 detects a one cycle input phase voltage that is above the over voltage level, the over/under voltage alarm is shown and the voltage trip timer begins counting. The delay time must expire before the starter faults.

⌘ **NOTE**: For the over voltage protection to operate correctly, the rated voltage parameter (FUN05) must be set correctly.

⌘ **NOTE:** The voltage level is only checked when the starter is running.

See Also

Under Voltage Level parameter (PFN11) on page 99.
Voltage Trip Time parameter (PFN12) on page 99.
Auto Reset parameter (PFN23) on page 102.
Controlled Fault Stop Enable parameter (PFN25) on page 103.
Rated Voltage parameter (FUN05) on page 126.

Under Voltage Trip Level PFN 11

LCD Display

```
PFN:Undr Vlt Lvl
11   Off
```

Range

Off, 1 – 40 % **(Default Off)**

Description

If the MX^3 detects a one cycle input phase voltage that is below the under voltage level, the over/under voltage alarm is shown and the voltage trip timer begins counting. The delay time must expire before the starter faults.

⌘ **NOTE:** For the under voltage protection to operate correctly, the Rated Voltage parameter (FUN05) must be set correctly.

⌘ **NOTE**: The voltage level is only checked when the starter is running.

See Also

Over Voltage Level parameter (PFN10) on page 98.
Voltage Trip Time parameter (PFN12) on page 99.
Auto Reset parameter (PFN23) on page 102.
Controlled Fault Stop Enable parameter (PFN25) on page 103.
Rated Voltage parameter (FUN05) on page 126.

Over/Under Voltage Trip Delay Time PFN 12

LCD Display

```
PFN:Vlt Trip Tim
12    0.1 sec
```

Range

0.1 – 90.0 seconds **(Default 0.1)**

Description

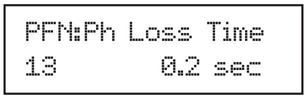
The Voltage Trip Time parameter sets the period of time that either an over voltage or under voltage condition must exist before a fault occurs.

See Also

Over Voltage Level parameter (PFN10) on page 98.
Under Voltage Level parameter (PFN11) on page 99.
Auto Reset parameter (PFN23) on page 102.
Controlled Fault Stop Enable parameter (PFN25) on page 103.

Phase Loss Trip Time PFN 13

LCD Display



```
PFN:Ph Loss Time
13       0.2 sec
```

Range 0.1 – 5.0 seconds **(Default 0.2)**

Description The Phase Loss Trip Time parameter sets the delay time on Fault 27: "Phase Loss." This fault detects a loss of proper phase timing even when the phasing remains valid; example: loss of line when the motor back generates a voltage. This allows a much faster detection than low line or no current at run faults.

Over Frequency Trip Level PFN 14

LCD Display

```
PFN:Over Frq Lvl
14        72 Hz
```

Range 24 – 72 Hz **(Default 72)**

Description The Over Frequency Trip Level parameter sets the highest line frequency that the starter will operate on.

When operating on line power, the default setting will usually suffice. If the application is speed sensitive, or the line power is suspect, the Over Frequency Trip Level parameter can be set to the highest acceptable frequency. When operating on generator power, the Over Frequency Trip Level parameter should be set to the highest acceptable frequency. This will ensure that a generator problem will not cause unnecessarily large fluctuations in the speed of the motor.

The frequency must be above the over frequency trip level setting for the Frequency Trip Time (PFN16) parameter before the starter will recognize a high frequency condition. Once a high frequency condition exists, the starter will shut down and display a Fault 13: "High Freq Trip."

See Also Under Frequency Trip Level (PFN15) on page 100.
Frequency Trip Time (PFN16) on page 101.

Under Frequency Trip Level PFN 15

LCD Display

```
PFN:Undr Frq Lvl
15        23 Hz
```

Range 23 – 71 Hz **(Default 23)**

Description The Under Frequency Trip Level parameter sets the lowest line frequency that the starter will operate on.

When operating on line power, the default setting will usually suffice. If the application is speed sensitive, or the line power is suspect, the Under Frequency parameter can be set to the lowest acceptable frequency. When operating on generator power, the Under Frequency parameter should be set to the lowest acceptable frequency. This will ensure that a generator problem will not cause unnecessarily large fluctuations in the speed of the motor.

The frequency must be below the under frequency setting for the Frequency Trip Time (PFN16) parameter before the starter will recognize an under frequency condition. Once an under frequency condition exists, the starter will shut down and display a Fault 12: "Low Freq Trip."

See Also Over Frequency Trip Level (PFN14) on page 100.
Frequency Trip Time (PFN16) on page 101.

Frequency Trip Time PFN 16

LCD Display

```
PFN:Frq Trip Tim
16       0.1 sec
```

Range 0.1 – 90.0 seconds **(Default 0.1)**

Description The Frequency Trip Time parameter sets the time that the line frequency must go above the Over Frequency Trip Level (PFN14) or below the Under Frequency Trip Level (PFN15) parameter before a high or low frequency fault will occur.

See Also Over Frequency Level (PFN14) on page 100.
Under Frequency Level (PFN15) on page 100.

PF Lead Trip Level PFN 17

LCD Display

```
PFN:PF Lead Lvl
17   Off
```

Range Off, - 0.80 lag to +0.01 lead **(Default Off)**

Description The amount of power factor lead, before the specified PF Trip Time (PFN19) Fault 35 will occur.

See Also Power Factor Lag Trip Level (PFN18) on page 101.
Power Factor Trip Time (PFN19) on page 101.

PF Lag Trip Level PFN 18

LCD Display

```
PFN:PF Lag Lvl
18  Off
```

Range Off, - 0.01 lag to +0.80 lead **(Default Off)**

Description The amount of power factor lag, before the specified PF Trip Time (PFN19) Fault 36 will occur.

See Also Power Factor Lead Trip Level (PFN17) on page 101.
Power Factor Trip Time (PFN19) on page 101.

PF Trip Time PFN 19

LCD Display

```
PFN:PF Trip Time
19      10.0 sec
```

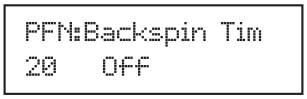
Range 0.1 – 90.0 seconds **(Default 10.0)**

Description The amount of time that the power factor lead level (PFN17) or lag level (PFN18) conditions must exist beyond the window (PFN19) before a trip will occur.

See Also Power Factor Lead Trip Level (PFN17) on page 101.
Power Factor Lag Trip Level (PFN18) on page 101.

Backspin Timer PFN 20

LCD Display



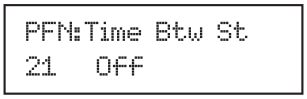
```
PFN:Backspin Tim
20   Off
```

Range Off, 1 – 180 minutes **(Default Off)**

Description The Backspin Timer parameter sets the minimum time between a stop and the next allowed start. If the starter is stopped and a time has been set, the starter will display a backspin lockout and the time until the next allowed start in the bottom right of the display.

Time Between Starts PFN 21

LCD Display



```
PFN:Time Btw St
21   Off
```

Range Off, 1 – 180 minutes **(Default Off)**

Description The Time Between Starts parameter sets the minimum allowed time between starts. Once a start command has been given, the next start cannot be performed until this time has expired. If the starter is stopped and the time between starts has yet to expire, the starter will display a time btw starts lockout and the time until the next start is allowed in the bottom right of the display.

⌘ **NOTE:** The TBS timer is not activated by a PORT restart.

Starts per Hour PFN 22

LCD Display

```
PFN:Starts/Hour
22   Off
```

Range Off, 1 – 6 **(Default Off)**

Description The Starts per Hour parameter will set the number of allowed starts in one hour. If the starter has been stopped and the number of starts given in the last hour has exceeded this setting, the starter will display a starts per hour lockout and the time until the next start is allowed in the bottom right of the display.

⌘ **NOTE:** The Starts/Hour counter does not increment on a PORT restart.

Auto Fault Reset Time PFN 23

LCD Display

```
PFN: Auto Reset
23   Off
```

Range Off, 1 – 900 seconds **(Default Off)**

Description

The Auto Fault Reset Time parameter sets the time delay before the starter will automatically reset a fault. For the list of faults that may be auto reset, refer to Appendix B - Fault Codes.

⌘ **NOTE:** A start command needs to be initiated once the timer resets the fault.

See Also

Appendix C - Fault Codes on page 205.
Auto Reset Limit parameter (PFN23) on page 103.

Auto Fault Reset Count Limit PFN 24

LCD Display

```
PFN:Auto Rst Lim
24   Off
```

Range

Off, 1 – 10 **(Default Off)**

Description

The Auto Reset Count Limit parameter sets the number of times that an auto fault reset may be performed. Once the number of auto reset counts have been exceeded, the starter will lockout until a manual fault reset is performed.

If less than the maximum number of auto resets occur and the starter does not fault for 15 minutes after the last auto fault reset occurred, the counter will be set back to zero. The auto reset counter is also set back to zero when a manual fault reset occurs.

See Also

Auto Reset parameter (PFN23) on page 102.

Controlled Fault Stop Enable PFN 25

LCD Display

```
PFN:Ctrl Flt En
25    On
```

Range

Off – On **(Default On)**

Description

A Controlled Fault Stop Enable can occur if this parameter is "On". The controlled stop will occur before the starter trips. During a controlled fault stop, the action selected by the Stop Mode parameter is performed before the starter is tripped. This prevents the occurrence of water hammer etc. in sensitive systems when a less than fatal fault occurs.

⌘ **NOTE:** All relays except the UTS relay are held in their present state until the stop mode action has been completed.

⌘ **NOTE:** Only certain faults can initiate a controlled fault stop. Some faults are considered too critical and cause the starter to stop immediately regardless of the Controlled Fault Stop Enable parameter.

Refer to Appendix C - Fault Codes to determine if a fault may perform a controlled stop.

See Also

Stop Mode parameter (CFN15) on page 85.
Appendix C - Fault Codes on page 205.

Speed Switch Trip Time PFN 26

LCD Display

```
PFN:Speed Sw Tim
26   Off
```

Range

Off, 1 – 250 seconds **(Default Off)**

Description

When using the Speed Switch Trip Time protection, the starter will start monitoring the zero speed input as soon as a run command is given and will recognize a stalled motor if the zero speed time has elapsed before the zero speed signal is removed. The zero speed input requires a high (Speed Sw NC) or low (Speed Sw NO) signal to indicate the zero speed condition to a digital input (I/O 01 - I/O 08).

Fault Code 04 - Speed Switch Timer will be displayed when a stalled motor condition is detected.

See Also

Digital Inputs (I/O 01 - 08) on page 111.

Motor PTC Trip Time PFN 27

LCD Display

```
PFN:M PTC Time
27  Off
```

Range

Off, 1 – 5 seconds **(Default Off)**

Description

The soft starter has the capability to monitor a PTC (Positive Temperature Coefficient) thermistor signal from the motor. The thermistors will provide a second level of thermal protection for the motor. There is no PTC input required when set to "Off".

⌘ **NOTE:** A motor PTC Fault #F05 occurs if resistance exceeds 3.5K ohm (+/- 300 ohms). The starter is locked out until the resistance drops below 1.65K ohm (+/- 150 ohms).

⌘ **NOTE:** Open terminals will give a F05 fault immediately if this parameter is not set to "Off". The input is designed for DIN44081 and DIN44082 standard thermistors.

Independent Starting/Running Overload PFN 28

LCD Display

```
PFN:Indep S/R OL
28   Off
```

Range

Off – On **(Default Off)**

Description

If “Off”
When this parameter is “Off” the overload defined by the Motor Running Overload Class parameter (QST03) is active in all states.

If “On”
When this parameter is “On”, the starting and running overloads are separate with each having their own settings. The starting overload class (PFN29) is used during motor acceleration and acceleration kick. The running overload class (PFN30) is used during all other modes of operation.

If both the running overload and the starting overload classes are set to "Off", then the existing accumulated motor OL% is erased and no motor overload is calculated in any state.

If the starting overload class is set to "Off" and the running overload class is set to "On", then the I^2t motor overload does NOT accumulate during acceleration kick and acceleration ramping states. However, the existing accumulated OL% remains during starting and the hot/cold motor compensation is still active. The OL% is capped at 99% during starting.

Although there is really no reason to do so, the starting overload class could be set to "On" and the running overload class set to "Off".

See Also

Motor Running Overload Class parameter (PFN30) on page 106.
Motor Starting Overload Class parameter (PFN29) on page 106.
Motor Overload Hot/Cold Ratio parameter (PFN31) on page 107.
Motor Overload Cooling Time parameter (PFN32) on page 108.
Theory of Operation section 7.1.9, Separate Starting and Running Motor Overload Settings on page 144.

Motor Starting Overload Class PFN 29

LCD Display

```
PFN:Starting OL
29        10
```

Range Off, 1 – 40 **(Default 10)**

Description The Motor Starting Overload Class parameter sets the class of the electronic overload when starting. The starter stores the thermal overload value as a percentage value between 0 and 100%, with 0% representing a “cold” overload and 100% representing a tripped overload.

The starting overload class is active during Kicking and Ramping when the Independent Starting/Running Overload parameter is set to “On”.

When the Motor Starting Overload Class parameter is set to "Off", the electronic overload is disabled while starting the motor.

⌘ **NOTE**: Care must be taken not to damage the motor when turning the starting overload class off or setting to a high value.

⌘ **NOTE:** Consult motor manufacturer data to determine the correct motor OL settings.

See Also

Independent Starting/Running Overload parameter (PFN28) on page 105.
Motor Running Overload Class parameter (PFN30) on page 106.
Motor Overload Hot/Cold Ratio parameter (PFN31) on page 107.
Motor Overload Cooling Time parameter (PFN32) on page 108.
Relay Output Configuration parameters (I/O 10-15) on page 112.
Theory of Operation section 7.1, Solid State Motor Overload Protection on page 138.

Motor Running Overload Class PFN 30

LCD Display:

```
PFN: Running OL
30        10
```

Range Off, 1 – 40 **(Default 10)**

Description The Motor Running Overload Class parameter sets the class for starting and running if the parameter is set to "Off". If separate starting versus running overload classes are desired, set the parameter to "On".

The motor running overload class parameter sets the class of the electronic overload when up to speed and stopping. The starter stores the thermal overload value as a percentage value between 0 and 100%, with 0% representing a “cold” overload and 100% representing a tripped overload. See section 7.1, for the overload trip time versus current curves on page 138.

When the parameter is set to "Off", the electronic overload is disabled when up to speed and a separate motor overload protection device must be supplied.

⌘ **NOTE:** Care must be taken not to damage the motor when turning the running overload class off or setting a high value.

⌘ **NOTE:** Consult motor manufacturer data to determine the correct motor overload settings.

See Also

Independent Starting/Running Overload parameter (PFN28) on page 105.
Motor Starting Overload Class parameter (PFN29) on page 106.
Motor Overload Hot/Cold Ratio parameter (PFN31) on page 107.
Motor Overload Cooling Time parameter (PFN32) on page 108.
Relay Output Configuration parameter (I/O 10-15) on page 112.
Theory of Operation section 7.1, Solid State Motor Overload Protection on page 138.

Motor Overload Hot/Cold Ratio PFN 31

LCD Display

```
PFN:OL H/C Ratio
31        60 %
```

Range 0 – 99% **(Default 60%)**

Description

The Motor Overload Hot/Cold Ratio parameter defines the steady state overload content (OL_{SS}) that is reached when the motor is running with a current less than full load current (FLA) * Service Factor (SF). This provides for accurate motor overload protection during a “warm” start.

The steady state overload content is calculated by the following formula.

$$OL_{ss} = \text{OL H/C Ratio} \times \frac{\text{Current}}{\text{FLA}} \quad \frac{1}{\text{Current Imbalance Derate Factor}}$$

The rise or fall time for the overload to reach this steady state is defined by the Motor Overload Cooling Time (PFN32) parameter.

The default value of 60% for Motor Overload Hot/Cold Ratio parameter is typical for most motors. A more accurate value can be derived from the hot and cold locked rotor times that are available from most motor manufacturers using the following formula.

$$\text{OL H/C Ratio} = \left(1 - \frac{\text{Max Hot Locked Rotor Time}}{\text{Max Cold Locked Rotor Time}}\right) \text{x } 100\%$$

⌘ **NOTE**: Consult motor manufacturer data to determine the correct motor overload settings.

See Also

Independent Starting/Running Overload parameter (PFN28) on page 105.
Motor Running Overload Class parameter (PFN30) on page 106.
Motor Starting Overload Class parameter (PFN29) on page 106.
Motor Overload Cooling Time parameter (PFN32) on page 108.
Relay Output Configuration parameters (I/O 10-15) on page 112.
Theory of Operation section 7.1.6, Hot/Cold Motor Overload Compensation on page 141.

Motor Overload Cooling Time PFN 32

LCD Display

```
PFN:OL Cool Tim
32      30.0 min
```

Range 1.0 – 999.9 minutes **(Default 30.0)**

Description The Motor Overload Cooling Time parameter is the time to cool from 100% to less than (<) 1%. When the motor is stopped, the overload content reduces exponentially based on Motor Overload Cooling Time parameter.

Refer to the following equation:

$$\text{OL Content} = \text{OL Content when Stopped} * e^{\frac{5}{CoolingTime}t}$$

So, a motor with a set cooling time of 30 minutes (1800 sec) with 100% accumulated OL content cools to <1% OL content in 30 minutes.

⌘ **NOTE**: Consult motor manufacturer data to determine the correct motor cooling time.

See Also

Independent Starting/Running Overload parameter (PFN28) on page 105.
Motor Running Overload Class parameter (PFN30) on page 106.
Motor Starting Overload Class parameter (PFN29) on page 106.
Motor Overload Hot/Cold Ratio parameter (PFN31) on page 107.
Theory of Operation section 7.1.10, Motor Cooling While Stopped on page 145.
Theory of Operation section 7.1.11, Motor Cooling While Running on page 146.

Motor OL Alarm Level PFN 33

LCD Display

```
PFN:OL Alarm Lvl
33        90 %
```

Range 1 – 100% **(Default 90%)**

Description An overload alarm condition is declared when the accumulated motor overload content reaches the programmed OL Alarm Level. An output relay can be programmed to change state when a motor overload alarm condition is present to warn of an impending motor overload fault.

See Also

Relay Output Configuration parameters (I/O 10-15) on page 112.
Theory of Operation 7.1, Solid State Overload Protection on page 138.

Motor OL Lockout Level PFN 34

LCD Display

```
PFN:OL Lock Lvl
34        15 %
```

Range	1 – 99% **(Default 15%)**
Description	After tripping on an overload, restarting is prevented and the starter is "locked out" until the accumulated motor overload content has cooled below the programmed motor OL Lockout Level.
See Also	Theory of Operation 7.1, Solid State Motor Overload Protection on page 138.

Motor OL Auto Lockout Level PFN 35

LCD Display

```
PFN:OL Lock Calc
35   Off
```

Range

Off, Auto **(Default Off)**

Description

The MX^3 has the capability to automatically calculate a motor OL lockout release level. This level shall be calculated so that the OL lockout is cleared when there is enough OL content available to start the motor without tripping the OL. This prevents the motor from being started if the O/L will trip during the start.

The value shall be calculated based on OL content used for the past four (4) successful motor starts. A factor of 1.25 shall be applied as a safety margin.

Example:

The OL content used for the past 4 starts were 30%, 29%, 30%, 27%

Average OL content used is 29% (using integer math).

Multiply result by 1.25 -> 36%

The new calculated motor OL lockout release level will be 100% - 36% -> 64%

The starting OL% content shall be latched when a start command is given. A value for OL content used during a start shall only be added to the list if the motor start fully completes the start (i.e. the starter reaches up to speed).

⌘ **NOTE:** This feature should not be used on systems where the starting load varies greatly from start to start.

⌘ **NOTE:** The OL does not have to reach 100% for the lockout to occur.

See Also

Motor OL Lockout Level (PFN34) on page 109.
Theory of Operation 7.1, Solid State Motor Overload Protection on page 138.

Jump to Parameter I/O 00

LCD Display

```
I/O: Jump Code
00         1
```

Description

By changing the value of this parameter and pressing [ENTER], you can jump directly to any parameter within the group.

Digital Input Configuration I/O 01 - I/O 08

LCD Display

```
I/O:DI 1 Config
01  Stop
```

```
I/O:DI 2 Config
02  Off
```

```
I/O:DI 3 Config
03  Off
```

```
I/O:DI 4 Config
04  Off
```

```
I/O:DI 5 Config
05  Off
```

```
I/O:DI 6 Config
06  Off
```

```
I/O:DI 7 Config
07  Off
```

```
I/O:DI 8 Config
08  Off
```

Range

LCD	Description
Off	Off, Not Assigned, Input has no function. **(Default DI02 -DI08)**
Stop	Stop Command for 3-wire control. **(Default DI 1)**
Fault High	Fault High, Fault when input is asserted, 120V applied. See (I/O 09)
Fault Low	Fault Low, Fault when input is de-asserted, 0V applied. See (I/O 09)
Fault Reset	Reset when input asserted, 120V applied.
Disconnect	Disconnect switch monitor.
Inline Cnfrm	Inline contactor feedback.
Bypass Cnfrm	Bypass/2M, bypass contactor feedback, 2M contactor feedback in full voltage or Wye-delta.
E OL Reset	Emergency Motor Overload content reset. After an OL trip has occurred. Reset when input asserted, 120V applied.
Local/Remote	Local/Remote control source, Selects whether the Local Source parameter or the Remote Source parameter is the control source. Local Source is selected when input is de-asserted, 0V applied. Remote Source selected when input asserted, 120V applied.
Heat Disable	Heater disabled when input asserted, 120V applied.
Heat Enable	Heater enabled when input asserted, 120V applied.
Ramp Select	Ramp 2 is enabled when input asserted, 120V applied.
Slow Spd Fwd	Operate starter in slow speed forward mode.
Slow Spd Rev	Operate starter in slow speed reverse mode.
Brake Disabl	Disable DC injection braking.
Brake Enabl	Enable DC injection braking.
Speed Sw NO	Speed Switch Normally Open, 0V applied. See (PFN26) on page 104.
Speed Sw NC	Speed Switch Normally Closed, 120V applied. See (PFN26) on page 104.

Description

I/O parameters 1 - 3 configure which features are performed by the DI 1 to DI 3 terminals.
I/O parameters 4 - 8 configure which features are performed by the DI 4 to DI 8 terminals.

See Also

Local Source parameter (QST04) on page 74.
Remote Source parameter (QST05) on page 74.
Digital Fault Input Trip Time (I/O09) on page 112.
Bypass Feedback Time parameter (I/O25) on page 118.
Heater Level parameter (FUN08) on page 128.
Theory of Operation section 7.1.12, Emergency Motor Overload Reset on page 146.
Theory of Operation section 7.3.7, Dual Acceleration Ramp Control on page 154.
Theory of Operation section 7.8, Wye-Delta Operation on page 168.
Theory of Operation section 7.13, Start/Stop Control with a Hand/Off/Auto Selector Switch on page 176.

Digital Fault Input Trip Time I/O 09

LCD Display

```
I/O:Din Trp Time
09      0.1 sec
```

Range 0.1 – 90.0 Seconds **(Default 0.1)**

Description: The Digital Fault Input Trip Time parameter sets the length of time the digital input must be high or low before a trip occurs. This delay time only functions for fault high and fault low.

See Also Digital Input Configuration parameter on page 111.

Relay Output Configuration I/O 10 - I/O 15

LCD Display

```
I/O: R1 Config
10 FaultFS
```

```
I/O: R2 Config
11  Off
```

```
I/O: R3 Config
12  Off
```

```
I/O: R4 Config
13  Off
```

```
I/O: R5 Config
14  Off
```

```
I/O: R6 Config
15  Off
```

Range

LCD	Description
Off	Off, Not Assigned. May be controlled over Modbus **(Default: R - 2, 3, 4, 5, 6)**
Fault FS	Faulted – Fail Safe operation. Energized when no faults present, de-energized when faulted. **(Default R1)**
Fault NFS	Faulted– Non Fail Safe operation. Energized when faulted.
Running	Running, starter running, voltage applied to motor.
UTS	Up to Speed, motor up to speed or transition to for Wye/Delta Operation.
Alarm	Alarm, any alarm condition present.
Ready	Ready, starter ready for start command.
Locked Out	Locked Out.
OverCurrent	Over Current Alarm, over current condition detected.
UnderCurrent	Under Current Alarm, under current condition detected.
OL Alarm	Overload Alarm.
Shunt FS	Shunt Trip Relay – Fail Safe operation, energized when no shunt trip. fault present, de-energized on shunt trip fault.
Shunt NFS	Shunt Trip Relay – Non Fail Safe operation, de-energized when no shunt trip fault present, energized on shunt trip fault.
Ground Fault	A Ground Fault trip has occurred.
Energy Saver	Operating in Energy Saver Mode.
Heating	Motor Heating, starter applying heating pulses to motor.
Slow Spd	Starter operating in slow speed mode.
Slow Spd Fwd	Starter operating in slow speed forward mode.
Slow Spd Rev	Starter operating in slow speed reverse mode.
Braking	Starter is applying DC brake current to motor.
Cool Fan Ctl	Heatsink fan control.
PORT	Energized when the starter is in the Power Outage Ride Through mode.
Tach Loss	Energized when the starter has faulted on a Tachometer Loss of Signal Fault.

Description Parameters I/O 10-12 configure which functions are performed by the R1 to R3 relays located on MX^3 card.

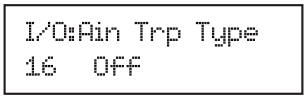
Parameters I/O 13-15 configure which functions are performed by the R4 to R6 relays located on I/O card.

See Also

Up To Speed Time parameter (QST09) on page 78.
Over Current Level parameter (PFN01) on page 92.
Under Current Level parameter (PFN03) on page 93.
Residual Ground Fault Level parameter (PFN07) on page 96.
Inline Configuration parameter (I/O24) on page 118.
Heater Level parameter (FUN08) on page 128.
Energy Saver parameter (FUN09) on page 129.
Theory of Operation section 7.1 , Motor Overload Operation on page 138.
Theory of Operation section 7.8, Wye-Delta Operation on page 168.
Theory of Operation section 7.9, Across The Line (Full Voltage Starter) on page 171.
Appendix C - Fault Codes on page 205.

Analog Input Trip Type I/O 16

LCD Display



```
I/O:Ain Trp Type
16   Off
```

	LCD	Description
Range	Off	Off, Disabled. **(Default)**
	Low Level	Low, Fault if input signal below preset trip level.
	High Level	High, Fault if input signal above preset trip level.

Description

The analog input is the reference input for a starter configured as a Phase Controller or Current Follower. In addition, the Analog Input Trip parameter allows the user to set a "High" or "Low" comparator based on the analog input. If the type is set to "Low", then a fault occurs if the analog input level is below the trip level for longer than the trip delay time. If the type is set to "High", then a fault occurs if the analog input level is above the trip level for longer than the trip delay time. This function is only active when the motor is running.

This feature can be used in conjunction with using the analog input as a reference for a control mode in order to detect an open 4-20mA loop providing the reference. Set the Analog Input Trip Type parameter to"Low" and set the Analog Trip Level parameter to a value less than (<) 20%.

See Also

Analog Input Trip Level parameter (I/O17) on page 114.
Analog Input Trip Time/Level parameter (I/O18) on page 114.
Analog Input Span parameter (I/O19) on page 115.
Analog Input Offset parameter (I/O20) on page 116.
Starter Type parameter (FUN07) on page 128.
Theory of Operation section 7.11, Phase Control on page 173.
Theory of Operation section 7.12, Current Follower on page 175.

Analog Input Trip Level I/O 17

LCD Display

```
I/O:Ain Trp Lvl
17       50 %
```

Range 0 – 100% **(Default 50%)**

Description The Analog Input Trip Level parameter sets the analog input trip or fault level.

This feature can be used to detect an open 4-20mA loop by setting the Analog Input Trip Type (I/O16) parameter to "Low" and setting the Analog Input Trip Level (I/O17) parameter to a value less than (<) 20%.

⌘ **NOTE:** The analog input trip level is NOT affected by the Analog Input Offset or Analog Input Span parameter settings. Therefore, if the trip level is set to 10% and the Analog Input Trip Type parameter is set to "Low", a fault occurs when the analog input signal level is less than (<) 1V or 2mA regardless of what the Analog Input and Analog Input Span parameters values are set to.

See Also
Analog Input Trip Type parameter (I/O16) on page 113.
Analog Input Span parameter (I/O19) on page 115.
Analog Input Offset parameter (I/O20) on page 116.

Analog Input Trip Delay Time I/O 18

LCD Display

```
I/O:Ain Trp Tim
18      0.1 sec
```

Range 0.1 – 90.0 seconds **(Default 0.1)**

Description The Analog Input Trip Delay Time parameter sets the length of time the analog input trip level must be exceeded before a trip occurs.

See Also
Analog Input Trip Type parameter (I/O16) on page 113.
Analog Input Trip Level parameter (I/O17) on page 114.
Analog Input Span parameter (I/O19) on page 115.
Analog Input Offset parameter (I/O20) on page 116.

Analog Input Span I/O 19

LCD Display

```
I/O: Ain Span
19      100 %
```

Range 1 – 100% **(Default 100%)**

Description The analog input can be scaled using the Analog Input Span parameter.

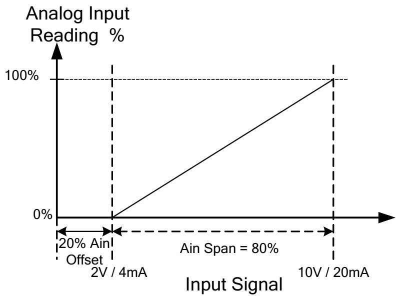
Examples:
For a 0-10V input or 0-20mA input, a 100% Analog Input Span setting results in a 0% input reading with a 0V input and a 100% input reading with a 10V input.

For a 0-5V input, a 50% Analog Input Span setting results in a 0% input reading with a 0V input and a 100% input reading with a 5V input.

For a 4-20mA input, a 80% Analog Input Span setting and a 20% Analog Input Offset setting results in a 0% input reading at 4mA and a 100% input reading at 20mA.

⌘ **NOTE:** Input signal readings are clamped at a 100% maximum.

Example: 4ma = 0% input, 20ma = 100% input



See Also

Analog Input Trip Level parameter (I/O17) on page 114.
Analog Input Trip Time parameter (I/O18) on page 114.
Analog Input Offset parameter (I/O20) on page 116.
Starter Type parameter (FUN07) on page 128.
Theory of Operation section 7.11, Phase Control on page 173.
Theory of Operation section 7.12, Current Follower on page 175.

Analog Input Offset I/O 20

LCD Display

```
I/O: Ain Offset
20         0 %
```

Range 0 – 99% **(Default 0%)**

Description The analog input can be offset so that a 0% reading can occur when a non-zero input signal is being applied.

Example: Input level of 2V (4mA) => 0% input. In this case the Analog Input Offset parameter should be set to 20% so that the 2v (4mA) input signal results in a 0% input reading.

⌘ **NOTE:** For a 4-20mA input, set the Analog Input Span to 80% and the Analog Input Offset to 20%.

⌘ **NOTE:** The measured input reading is clamped at 0% minimum.

See Also

Analog Input Trip Level parameter (I/O17) on page 114.
Analog Input Trip Time parameter (I/O18) on page 114.
Analog Input Span parameter (I/O19) on page 115.
Starter Type parameter (FUN07) on page 128.
Theory of Operation section 7.11, Phase Control on page 173.
Theory of Operation section 7.12, Current Follower on page 175.

Analog Output Function I/O 21

LCD Display

```
I/O: Aout Fctn
21  Off
```

Range

LCD	Description
Off	Off, Disabled **(Default)**
0 – 200% Curr	Based on per cycle RMS values.
0 – 800% Curr	Based on per cycle RMS values.
0 – 150% Volt	Based on per cycle RMS values.
0 – 150% OL	Motor Thermal Overload.
0 – 10 kW	Based on filtered V and I values.
0 – 100 kW	Based on filtered V and I values.
0 – 1 MW	Based on filtered V and I values.
0 – 10 MW	Based on filtered V and I values.
0 – 100% Ain	The output value takes into account the inputs span and offset settings.
0 – 100% Firing	Output Voltage to Motor, based on SCR firing angle.
Calibration	Calibration, full (100%) output.

Description The Analog Output Function parameter selects the function of the analog output. The available analog output function selections and output scaling are shown below. The analog output is updated every 25msec.

See Also

Analog Output Span parameter (I/O22) on page 116.
Analog Output Offset parameter (I/O23) on page 118.
Theory of Operation section 7.11, Phase Control on page 173.
Theory of Operation section 7.12, Current Follower on page 175.

Analog Output Span I/O 22

LCD Display

```
I/O: Aout Span
22      100 %
```

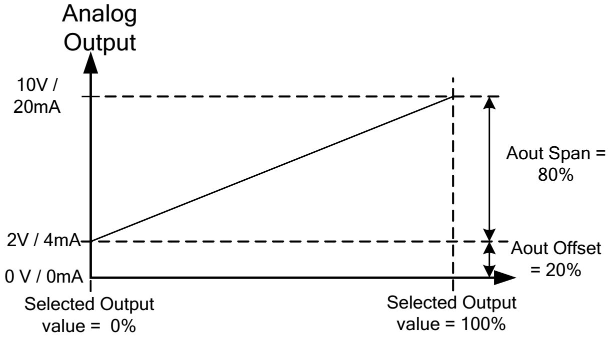
Range 1 – 125% **(Default 100%)**

Description The analog output signal can be scaled using the Analog Output Span parameter. For a 0-10V output or 0-20mA output, a 100% scaling outputs the maximum voltage (10V) or current (20mA) when the selected output function requests 100% output. A scale of 50% outputs 50% voltage/current when the analog output function requests a 100% output.

⌘ **NOTE:** For a 4-20mA output, set the Analog Output Span to 80% and the Analog Output Offset to 20%.

⌘ **NOTE:** The output does not exceed 100% (10V or 20mA).

Example: 0% output => 4mA, 100% output => 20ma



See Also Analog Output Offset parameter (I/O23) on page 118.

Analog Output Offset I/O 23

LCD Display

```
I/O:Aout Offset
23         0 %
```

Range 0 – 99% **(Default 0%)**

Description The analog output signal can be offset using the Analog Output Offset parameter. A 50% offset outputs a 50% output (5V in the 10V case) when 0% is commanded. If the selected variable requests 100% output, the span should be reduced to (100 minus offset) so that a 100% output request causes a 100% output voltage (x% offset + (100-x)%span)=100%.

⌘ **NOTE:** For a 4-20mA output, set the Analog Output Span to 80% and the Analog Output Offset to 20%.

See Also Analog Output Span parameter (I/O22) on page 117.

Inline Configuration I/O 24

LCD Display

```
I/O:Inline Confg
24      3.0 sec
```

Range Off, 0 – 10.0 seconds **(Default 3.0)**

Description The Inline Configuration parameter controls the behavior of the No Line warning, No Line fault, and the Ready relay function.

If the Inline Configuration parameter is set to "Off", then the MX^3 assumes that there is no Inline contactor and that line voltage should be present while stopped. If no line is detected, then a No Line alarm condition exists and the ready condition does not exist. If a start is commanded, then a No Line fault is declared.

If the Inline Configuration parameter is set to a "time delay", then the MX^3 assumes that there is an Inline contactor and that line voltage need not be present while stopped. If no line is detected, then the No Line alarm condition does not exist and the ready condition does exist. If a start is commanded and there is no detected line voltage for the time period defined by this parameter, then a “noL” (No Line) fault is declared.

In order to control an inline contactor, program a relay as a Run relay.

⌘ **NOTE:** This fault is different than over/under voltage since it detects the presence of NO line.

See Also Relay Output Configuration parameters (I/O 10-15) on page 112.

Bypass Feedback Time I/O 25

LCD Display

```
I/O:Bpas Fbk Tim
25      2.0 sec
```

Range 0.1 – 5.0 seconds **(Default 2.0)**

Description The starter contains a built in dedicated bypass feedback input that is enabled when the dedicated stack relay is factory programmed to "bypass". The programmable inputs DI 1, DI 2, DI 3, DI4, DI5, DI6, DI7 or DI8 may also be used to monitor an auxiliary contact from the bypass contactor(s) or in the case of a wye-delta starter the 2M contactor. The digital input is expected to be in the same state as the UTS relay. If it is not, the MX^3 trips on Fault 48 (Bypass Fault).

The Bypass Confirmation input must be different from the UTS relay for the time period specified by this parameter before a fault is declared. There is no alarm associated with this fault.

See Also

Digital Input Configuration parameters (I/O 01-08) on page 111.
Theory of Operation section 7.8, Wye-Delta Operation on page 168.

Keypad Stop Disable I/O 26

LCD Display

```
I/O:Keypad Stop
26  Enabled
```

Range

LCD	Description
Disabled	Keypad Stop does not stop the starter.
Enabled	Keypad Stop does stop the starter. **(Default)**

Description

If "Disabled"
When this parameter is set to "Disabled", the keypad [STOP] button is de-activated. This should be done with caution, as the [STOP] will not stop the starter.

If the keypad is selected as local or remote control sources, the [STOP] key cannot be disabled.

If "Enabled"
When this parameter is set to "Enabled", the keypad stop button is enabled and stops the starter regardless of the selected control source (keypad, terminal or serial).

See Also

Local Source parameter (QST04) on page 74.
Remote Source parameter (QST05) on page 74.

Auto Start Selection I/O 27

LCD Display

```
I/O: Auto Start
27  Disabled
```

Range

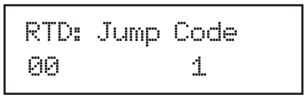
LCD	Description
Disabled	When Disabled, the Start input must always transition from low to high for a start to occur. **(Default)**
Power	When set to Power, a start will occur if the Start input is high while control power is applied.
Fault	When set to Fault, a start will occur if the Start input is high when a fault is reset.
Power, Fault	When set to Power and Fault, a start will occur if the Start input is high while control power is applied, and a start will occur if the Start input is high when a fault is reset.

Description

The Auto Start Selection parameter determines whether or not a transition from low to high is required on the Start input for a start to occur after either a power up or a fault reset. This applies to lockout conditions being cleared as well. The behavior for a lockout clearing is the same as for a fault being reset.

Jump to Parameter RTD 00

LCD Display

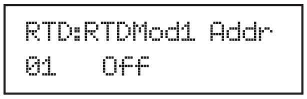


```
RTD: Jump Code
00        1
```

Description By changing the value of this parameter and pressing [ENTER], you can jump directly to any parameter within the group.

RTD Module #1 Address RTD 01

LCD Display



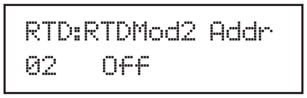
```
RTD:RTDMod1 Addr
01   Off
```

Range Off, 16 to 23 **(Default Off)**

Description The module #1 address parameter has to be set to the Modbus address of the first RTD module attached to the soft-starter. The address of the RTD module can be verified by checking the rotary switch on the top of the RTD module.

RTD Module #2 Address RTD 02

LCD Display



```
RTD:RTDMod2 Addr
02   Off
```

Range Off, 16 to 23 **(Default Off)**

Description The module #2 address parameter has to be set to the Modbus address of the second RTD module attached to the soft-starter. The address of the RTD module can be verified by checking the rotary switch on the top of the RTD module. Ensure that module #2 is not set to the same address as module #1.

RTD Group RTD 03 - RTD 18

LCD Display

```
RTD:RTD 1 Group
03   Off
```

```
RTD:RTD ? Group
??   Off
```

(? = RTD number)
(?? = menu index number)

Range

LCD	Description
Off	RTD channel not read.
Stator	RTD included in Stator metering group.
Bearing	RTD included in Bearing metering group.
Other	RTD acts independently.

Description

Each of the 16 available RTD input channels has a parameter to assign that RTD channel to a grouping.

⌘ **NOTE:** RTD 1 – 8 is on module 1.
RTD 9 – 16 is on module 2.

Stator Alarm Level RTD 19

LCD Display

```
RTD:Stator Alrm
19       200 C
```

Range

1 – 200 ^{O}C **(Default 200 ^{O}C)**

Description

The Stator Alarm Level parameter selects its Alarm temperature level. When an RTD in this group reaches Alarm level an alarm condition will be declared. This parameter sets the alarm level for any RTD set to "Stator".

⌘ **NOTE:** Consult motor manufacturer.

Bearing Alarm Level RTD 20

LCD Display

```
RTD:Bearing Alrm
20       200 C
```

Range

1 – 200 ^{O}C **(Default 200 ^{O}C)**

Description

The Bearing Alarm Level parameter selects its Alarm temperature level. When an RTD in this group reaches Alarm level an alarm condition will be declared. This parameter sets the alarm level for any RTD set to "Bearing".

⌘ **NOTE:** Consult motor manufacturer.

Other Alarm Level RTD 21

LCD Display

```
RTD:Other Alrm
21      200 C
```

Range

1 – 200 ^{O}C **(Default 200 ^{O}C)**

Description

The Other Alarm Level parameter selects its Alarm temperature level. When an RTD in this group reaches Alarm level an alarm condition will be declared. This parameter sets the alarm level for any RTD set to "Other".

⌘ **NOTE:** Consult motor manufacturer.

Stator Trip Level RTD 22

LCD Display

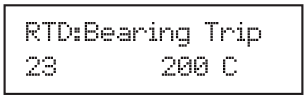
```
RTD:Stator Trip
22       200 C
```

Range 1 – 200 ^{o}C **(Default 200 ^{o}C)**

Description This parameter sets the stator trip temperature when a trip will occur. Fault delay time is 1 second.

Bearing Trip Level RTD 23

LCD Display



```
RTD:Bearing Trip
23       200 C
```

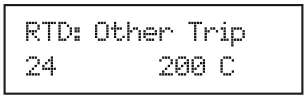
Range 1 – 200 ^{o}C **(Default 200 ^{o}C)**

Description This parameter sets the bearing trip temperature when a trip will occur. Fault delay time is 1 second.

⌘ **NOTE:** Consult motor manufacturer.

Other Trip Level RTD 24

LCD Display



```
RTD: Other Trip
24       200 C
```

Range 1 – 200 ^{o}C **(Default 200 ^{o}C)**

Description This parameter sets the other trip temperature when a trip will occur. Fault delay time is 1 second.

RTD Voting RTD 25

LCD Display

```
RTD: RTD Voting
25  Disabled
```

Range Disabled, Enabled **(Default Disabled)**

Description RTD Trip voting can be enabled for extra reliability in the event of a RTD malfunction. When RTD voting is enabled, two (2) RTDs in one assigned group will need to exceed their trip temperature before a fault is declared.

⌘ **NOTE:** If there is only one RTD assigned to a group the RTD voting will be disabled.

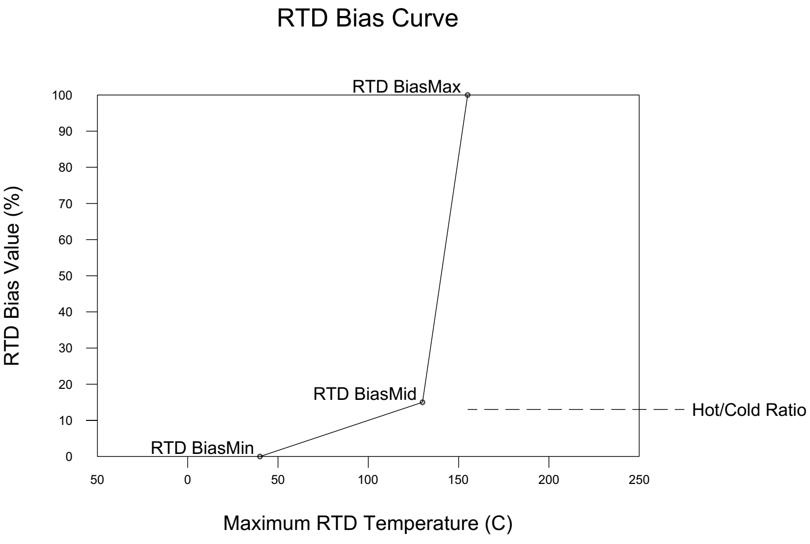
RTD Motor OL Biasing RTD 26

LCD Display

```
RTD:RTD Biasing
26   Off
```

Range Off, On **(Default Off)**

Description When RTDs are present, active, and assigned to the stator group and when RTD biasing is enabled the stator RTD measurements will effect the motor OL content. RTD biasing works together with the I^2t thermal model of the motor. In the RTD biasing case a three point approximation of motor overload capacity based on the highest measured stator RTD temperature is used. If the RTD motor overload capacity calculation exceeds the I^2t based calculation then the RTD biasing value will be used. If the I^2t value is higher then the I^2t value will be used.



<u>**Setpoints**</u>
RTD27 = Bias Minimum Level Setpoint
RTD28 = Bias Midpoint Level Setpoint
RTD29 = Bias Maximum Level Setpoint

See Also RTD Biasing OL group in section 7.1.7, on page 143.

RTD Bias Minimum Level RTD 27

LCD Display

```
RTD:RTD Bias Min
27       40 C
```

Range	0 – 198 °C **(Default 40 °C)**
Description	Typically set to ambient conditions. (40 °C)
See Also	RTD Biasing OL group in section 7.1.7 on page 143.

RTD Bias Midpoint Level RTD 28

LCD Display

```
RTD:RTD Bias Mid
28      130 C
```

Range	1 – 199 °C **(Default 130 °C)**
Description	Typically set at the rated motor running temperature. ⌘ **NOTE:** Consult motor manufacturer for information.
See Also	RTD Biasing OL group in section 7.1.7, on page 143.

RTD Bias Maximum Level RTD 29

LCD Display

```
RTD:RTD Bias Max
29      155 C
```

Range	105 – 200 °C **(Default 155 °C)**
Description	The stator insulation maximum temperature rating. ⌘ **NOTE:** Consult motor manufacturer for information.
See Also	RTD Biasing OL group in section 7.1.7, on page 143.

Jump to Parameter FUN 00

LCD Display

```
FUN: Jump Code
00         1
```

Description

By changing the value of this parameter and pressing [ENTER], you can jump directly to any parameter within the group.

Meter FUN 01, 02

LCD Display

```
FUN:  Meter 1
01  AveCurrent
```

```
FUN:  Meter 2
02  Ave Volts
```

Range

LCD	Description
Ave Current	Average current. **(Default Meter 1)**
L1 Current	Current in phase 1.
L2 Current	Current in phase 2.
L3 Current	Current in phase 3.
Curr Imbal	Current Imbalance %.
Ground Fault	Residual Ground Fault % FLA.
Ave Volts	Average Voltage L-L RMS. **(Default Meter 2)**
L1-L2 Volts	Voltage in, L1 to L2 RMS.
L2-L3 Volts	Voltage in, L2 to L3 RMS.
L3-L1 Volts	Voltage in, L3 to L1 RMS.
Overload	Thermal overload in %.
Power Factor	Motor power factor.
Watts	Motor real power consumed.
VA	Motor apparent power consumed.
vars	Motor reactive power consumed.
kW hours	Kilo-watt-hour used by the motor, wraps at 1,000.
MW hours	Mega-watt-hour used by the motor, wraps at 10,000.
Phase Order	Phase Rotation.
Line Freq	Line Frequency.
Analog In	Analog Input %.
Analog Out	Analog Output %.
Run Days	Running time in days, wraps at 2,730 days.
Run Hours	Running time in Hours and Minutes, wraps at 24:00.
Starts	Number of Starts, wraps at 65,536.
TruTorque %	TruTorque %.
Power %	Power %.
Pk accel Curr	Peak starting current.
Last Start T	Last starting duration.
Zero Seq GF	Zero sequence ground fault.
Stator Temp	Highest Stator temperature.
Bearing Temp	Highest Bearing temperature.
Other Temp	Highest Other temperature.
All Temp	Highest of all temperatures.

Description

Parameters FUN 01 and FUN 02 configure which meters are displayed on the two lines of the main display screen.

CT Ratio FUN 03

LCD Display

```
FUN:  CT Ratio
03    288:1
```

Range

72:1, 96:1, 144:1, 288:1, 864:1, 2640:1, 3900:1, 5760:1, 8000:1, 14400:1, 28800:1, 50:5, 150:5, 250:5, 800:5, 2000:5, 5000:5 **(Default 288:1)**

Description

The CT Ratio parameter must be set to match the CTs (current transformers) supplied with the starter. This allows the starter to properly calculate the current supplied to the motor.

Only Benshaw supplied CTs can be used on the starter. The CTs are custom 0.2 amp secondary CTs specifically designed for use on the MX^3 starter. The CT ratio is then normalized to a 1A secondary value. The supplied CT ratio can be confirmed by reading the part number on the CT label. The part number is of the form BICTxxx1M, where xxx is the CT primary and the 1 indicates the normalized 1 amp.

⌘ **NOTE:** It is very important that the CT ratio is set correctly. Otherwise, many starter functions will not operate correctly.

Input Phase Sensitivity FUN 04

LCD Display

```
FUN:Phase Order
04  Insensitive
```

Range

LCD	Description
Insensitive	Runs with any three phase sequence. **(Default)**
ABC	Only runs with ABC phase sequence.
CBA	Only runs with CBA phase sequence.
Single phase	Single Phase.

Description

The Phase Order parameter sets the phase sensitivity of the starter. This can be used to protect the motor from a possible change in the incoming phase sequence. If the incoming phase sequence does not match the set phase rotation, the starter displays an alarm while stopped and faults if a start is attempted.

Rated RMS Voltage FUN 05

LCD Display

```
FUN:Rated Volts
05   480    Vlt
```

Range

100, 110, 120, 200, 208, 220, 230, 240, 350, 380, 400, 415, 440, 460, 480, 500, 525, 575, 600, 660, 690, 800, 1000, 1140, 2200, 2300, 2400, 3300, 4160, 4600, 4800, 6000, 6600, 6900, 10.00K, 11.00K, 11.50K, 12.00K, 12.47K, 13.20K, 13.80K **(Default 480)**

Description

The Rated Voltage parameter sets the line voltage that is used when the starter performs Over and Under line voltage calculations. This value is the supply voltage, NOT the motor utilization voltage.

⌘ **NOTE:** Settings above 1140V are for medium voltage applications.

⌘ **NOTE:** The rated RMS voltage must be set properly in order for the starter to operate properly.

See Also

Over Voltage Level parameter (PFN10) on page 98.
Under Voltage Level parameter (PFN11) on page 99.
Voltage Trip Time parameter (PFN12) on page 99.
Meter parameter (FUN01, FUN02) on page 125.

Motor Rated Power Factor FUN 06

LCD Display

```
FUN: Motor PF
06     -0.92
```

Range

-0.01 lag – 1.00 unity **(Default –0.92)**

Description

The Motor Rated Power Factor parameter sets the motor power factor value that is used by the MX^3 starter for TruTorque and Power control calculations and metering calculations.

If TruTorque or Power acceleration and/or deceleration control is used, it is very important to properly set this parameter to the motor's full load rated power factor (usually available on the motor nameplate or from the motor manufacturer). For a typical induction motor, this value is between 0.80 and 0.95.

If the motor rated power factor is not available from either the motor nameplate or the motor manufacturer, the value can be obtained by viewing the power factor meter.

With the motor running at full name plate current, view the power factor meter by pressing the [UP] arrow key until the Motor PF meter is displayed using the LCD display.

The meter value can be entered into the Rated Power Factor parameter.

See Also

Meter parameters (FUN01, FUN02) on page 125.
Theory of Operation section 7.3.3, TruTorque Acceleration Control Settings and Times on page 149.
Theory of Operation section 7.3.4, Power Control Acceleration Settings and Times on page 151.

Starter Type FUN 07

LCD Display

```
FUN:Starter Type
07  Normal
```

Range

LCD	Description
Normal	Normal Reduced Voltage Soft Starter RVSS. **(Default)**
Inside Delta	Inside Delta, RVSS.
Wye-Delta	Wye Delta.
Phase Ctl	Open Loop Phase control using external analog input reference.
Curr Follow	Closed Loop Current follower using external analog input reference.
ATL	Across the line (Full Voltage).

Description

The MX^3 has been designed to be the controller for many control applications; Solid State Starter, both Normal (outside Delta) and Inside Delta, and electro mechanical starters, Wye Delta, Across the line full voltage starter, Phase Control/Voltage Follower, Current Follower. In each case, the MX^3 is providing the motor protection and the necessary control for these applications.

⌘ **NOTE:** For single phase operation, select Normal for the Starter Type parameter, and Single Phase for the phase order parameter (FUN04).

See Also

Input Phase Sensitivity parameter (FUN04) on page 126.
Theory of Operation section 7.7.2 , Inside Delta Connected Starter using the MX^3 on page 167.
Theory of Operation section 7.8, Wye-Delta Operation on page 168.
Theory of Operation section 7.11, Phase Control on page 173.
Theory of Operation section 7.12, Current Follower on page 175.

Heater Level FUN 08

LCD Display

```
FUN:Heater Level
08   Off
```

Range

Off, 1 – 40% FLA **(Default Off)**

Description

The Heater Level parameter sets the level of D.C. current that reaches the motor when the motor winding heater/anti-windmilling brake is enabled. The motor winding heater/anti-windmilling brake can be used to heat a motor in order to prevent internal condensation or it can be used to prevent a motor from rotating.

⌘ **NOTE:** The motor can still slowly creep when the anti-windmilling brake is being used. If the motor has to be held without rotating, a mechanical means of holding the motor must be used.

The motor winding heater/anti-windmilling brake operation may be controlled by a digital input and by a heater disable bit in the starter control Modbus register. There are two methods of using the digital inputs, either the input is an enable or disable.

Enabled: When the DI 1, 2, 3, 4, 5, 6, 7, 8 inputs are programmed as Heat Enable Inputs, the input may be used to control when heating/anti-windmilling is applied. The Heater Level parameter must be set, the starter stopped and this input must be high for heating to occur.

Disabled: When the DI 1,2, 3, 4, 5, 6, 7, 8 inputs are programmed as Heat Disable Inputs, the input may be used to control when heating/anti-windmilling is applied. The Heater / Anti-Windmill Level parameter must be set and this input must be low for heating to occur.

If no digital inputs are programmed as heater enabled or disabled and HEATER LEVEL is programmed greater than 0, the heater is applied at all times when the motor is stopped.

The level of D.C. current applied to the motor during this operation needs to be monitored to ensure that the motor is not overheated. The current level should be set as low as possible and then slowly increased over a long period of time. While this is being done, the temperature of the motor should be monitored to ensure it is not overheating.

The motor should be labeled as being live even when not rotating.

The heater feature should not be used to dry out a wet motor.

⌘ **NOTE:** When in single phase mode, the heater function is disabled.

⌘ **NOTE:** When this function is "on", all of the other parameters cannot be programmed until this parameter is turned "off".

Energy Saver FUN 09

LCD Display

```
FUN:Energy Saver
09   Off
```

Range On – Off **(Default Off)**

Description The Energy Saver parameter lowers the voltage applied to a lightly loaded motor. It continues to lower the voltage until it finds the point where the current reaches its lowest stable level and then regulates the voltage around this point. If the load on the motor increases, the starter immediately returns the output of the starter to full voltage.

⌘ **NOTE:** This function does not operate if a bypass contactor is used.

⌘ **NOTE:** In general, Energy Saver can save approximately 1000 watts per 100 HP. Consult Benshaw for further detail.

P.O.R.T. Fault Time FUN 10

LCD Display

```
FUN:PORT Flt Tim
10   Off
```

Range Off, 0.1 – 90.0 seconds **(Default Off)**

Description The purpose of PORT is to not fault when all line power has been lost and to wait for a predetermined amount of time for power to return. There is the capability to hold the bypass contactor (if present) in for a given amount of time. Then when power returns, PORT shall perform a controlled restart of the motor to prevent current and/or torque spikes from occurring. The starter will enter PORT when the line voltage drops below the undervoltage trip level if enabled, or 30% below rated voltage when undervoltage protection is not enabled.

⌘ **NOTE:** For PORT to operate it is assumed that an UPS (Uninterruptible Power Supply) will supply the MX^3 control power. Also the MX^3 run command needs to be held active during the power outage otherwise the MX^3 will perform a normal stop.

P.O.R.T. Bypass Hold Time FUN 11

LCD Display

```
FUN:PORT Byp Tim
11   Off
```

Range Off, 0.1 – 5.0 seconds **(Default Off)**

Description When a power outage event is detected and the PORT Bypass Hold Timer is enabled, the starter will hold the Bypass contactor in for a user selectable amount of time. When the time expires the starter shall open the bypass.

P.O.R.T. Recovery Method FUN 12

LCD Display

```
FUN:PORT Recover
12  Fast Recover
```

Range

LCD	**Description**
Fast Recover	Current acceleration ramp from 100% FLA -> 800% FLA with a ramp time of 1 second. **(Default)**
Current Ramp	Current acceleration ramp using the Ramp#1 user parameter settings.
Current Ramp 2	Current acceleration ramp using the Ramp#2 user parameter settings.
Ramp Select	Current acceleration ramp using the appropriate current ramp selected by the RAMP Select digital input.
Tach Ramp	Speed controlled acceleration ramp. Ramp starts at motor speed measured at start of recovery and accelerates motor at same slope (acceleration rate) as a normal tachometer start from zero speed would do.

Description The PORT Recovery parameter sets how the starter will re-accelerate the motor when power returns.

Tachometer Full Speed Voltage FUN 13

LCD Display

```
FUN:Tach FS Lvl
13      5.00 Vlt
```

Range 1.00 – 10.00 V in 0.01 volt increments **(Default 5.00V)**

Description The Tachometer Full Speed Voltage parameter sets the tachometer input voltage at full speed. This value should be set at full (unloaded) motor speed.
Ex. A tachometer rated at 0.0033 volts-per-rpm is mounted on a 4-pole 1800 rpm motor. Therefore, the FS Volts should be set to: 0.0033 * 1800 = 5.94 volts.

Tachometer Loss Time FUN 14

LCD Display

```
FUN:Tach Los Tim
14       1.5 sec
```

Range 0.1 – 90.0 seconds **(Default 1.5)**

Description

The Tachometer Loss Time is the allowable time the starter will operate when a tachometer signal is lost. If the signal is lost, the starter will perform the action set by the Tach Loss Action parameter.

⌘**NOTE:** Nuisance tachometer loss faults at start can be prevented by setting the initial current parameter to a value that allows the motor to begin rotating soon after a start is commanded.

Tachometer Loss Action FUN 15

LCD Display

```
FUN:Tach Los Act
15  Fault
```

Range

LCD	Description
Fault	The starter will shutdown and indicate a tachometer loss fault.
Current Acceleration	If the tachometer signal is lost the starter will fault. However the start mode parameter will be set to Current control acceleration so that when the fault is reset the starter will start in Current control mode.
TruTorque Accel	If the tachometer signal is lost the starter will fault. However the start mode parameter will be set to TruTorque control acceleration so that when the fault is reset the starter will start in Current control mode.
KW (Power)	If the tachometer signal is lost the starter will fault. However the start mode parameter will be set to KW (Power) so that when the fault is reset the starter will start in Current control mode.

Description

If the tachometer detects the feedback signal is not valid one of the above actions will be taken depending on the value of the Tach Loss Action user parameter.

Communication Address FUN 16

LCD Display

```
FUN: Com Drop #
16         1
```

Range

1 – 247 **(Default 1)**

Description

The Communication Address parameter sets the starter's address for Modbus communications.

See Also

Local Source parameter (QST04) on page 74.
Remote Source parameter (QST05) on page 74.
Communication Baud Rate parameter (FUN17) on page 131.
Communication Timeout parameter (FUN18) on page 132.
Communication Byte Framing parameter (FUN19) on page 132.

Communication Baud Rate FUN 17

LCD Display

```
FUN:Com Baudrate
17  19200
```

Range

1200, 2400, 4800, 9600, 19200 bps **(Default 19200)**

Description

The Communication Baud Rate parameter sets the baud rate for Modbus communications.

See Also

Local Source parameter (QST04) on page 74.
Remote Source parameter (QST05) on page 74.
Communication Address parameter (FUN16) on page 131.
Communication Timeout parameter (FUN18) on page 132.
Communication Byte Framing parameter (FUN19) on page 132.

Communication Timeout FUN 18

LCD Display

```
FUN:Com Timeout
18   Off
```

Range

Off, 1 – 120 seconds **(Default Off)**

Description

The Communication Timeout parameter sets the time that the starter continues to run without receiving a valid Modbus request. If a valid Modbus request is not received for the time that is set, the starter declares an F82 (Modbus Time Out). The starter performs a controlled stop.

See Also

Local Source parameter (QST04) on page 74.
Remote Source parameter (QST05) on page 74.
Stop Mode parameter (CFN15) on page 85.
Controlled Fault Stop Enable parameter (PFN25) on page 103.
Communication Address parameter (FUN16) on page 131.
Communication Baud Rate parameter (FUN17) on page 131.

Communication Byte Framing FUN 19

LCD Display

```
FUN: Com Parity
19  Even, 1 Stop
```

Range

Even, 1 Stop **(Default)**
Odd, 1 Stop
None, 1 Stop
None, 2 Stop

Description

The Communication Byte Framing parameter sets both the parity and number of stop bits.

See Also

Communication Address parameter (FUN16) on page 131.
Communication Baud Rate parameter (FUN17) on page 131.
Communication Timeout parameter (FUN18) on page 132.

Software Version 1 FUN 20

LCD Display

```
FUN: Software 1
20  810023-02-01
```

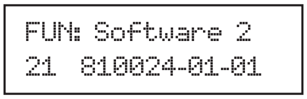
Description

This parameter shows the software version 1.

The software version is also displayed on power up.

Software Version 2 FUN 21

LCD Display



```
FUN: Software 2
21  810024-01-01
```

Description

This parameter shows the software version 2.

The software version is also displayed on power up.

Miscellaneous Commands FUN 22

LCD Display

```
FUN:Misc Command
22  None
```

Range

LCD	Description
None	No commands **(Default)**
Reset RT	Reset Run Time Meter
Reset kWh	Reset kWh/MWh Meters
Reflash Mode	Activate Reflash Mode
Store Parms	The current parameter values are stored in non-volatile memory
Load Parms	All parameter are retrieved from non-volatile memory
Factory Rst	All parameters are restored to the factory defaults
Std BIST	Built In Self Test with no line voltage applied to the starter.
Powered BIST	Built In Self Test with line voltage applied to the starter.

Description

The Miscellaneous Commands parameter is used to issue various commands to the MX^3 starter.

The Reset Run Time command resets the user run time meters back to zero (0).

The Reset kWh command resets the accumulated kilowatt-hour and megawatt-hour meters back to zero (0).

The Reflash Mode command puts the MX^3 into a reflash program memory mode. The reflash mode can only be entered if the MX^3 starter is idle. When the reflash mode is entered, the MX^3 waits to be programmed. The onboard LED display shows “FLSH”. The remote display is disabled after entering reflash mode. The MX^3 does not operate normally until reflash mode is exited. Reflash mode may be exited by cycling control power.

The Store Parameters command allows the user to copy the parameters into non-volatile memory as a backup. If changes are being made, store the old set of parameters before any changes are made. If the new settings do not work, the old parameter values can be loaded back into memory.

The Load Parameters command loads the stored parameters into active memory.

The Factory Reset command restores all parameters to the factory defaults. The default values can be found in chapter 5.

The standard BIST command will put the starter into the unpowered BIST test. See section 8.6.1 on page 195.

The powered BIST command will put the starter into a powered BIST test. See section 8.6.2 on page 197.

Time and Date Format FUN 23

LCD Display

```
FUN: T/D Format
23  mm/dd/yy 12h
```

	LCD
Range	mm/dd/yy 12h mm/dd/yy 24h yy/mm/dd 12h yy/mm/dd 24h dd/mm/yy 12h dd/mm/yy 24h

Description Sets the date display format and 12 hour or 24 hour time display.

⌘ **NOTE:** The system clock does not recognize daylight savings time.

Time FUN 24

LCD Display

```
FUN:   Time
24    hh/mm/ss
```

Description Sets the present time.

See Also Time and Date parameter (FUN 23).

Date FUN 25

LCD Display

```
FUN:   Date
25   mm/dd/yy
```

Description Sets the present date.

See Also Time and Date parameter (FUN 23).

Passcode FUN 26

LCD Display

```
FUN: Passcode
26   Off
```

Description

The MX^3 provides a means of locking parameter values so that they may not be changed. Once locked, the parameters values may be viewed on the display, but any attempt to change their values by pressing the [UP] or [DOWN] keys is ignored.

Viewing the Passcode parameter indicates whether or not the parameters are locked. If they are locked, the Passcode parameter displays "On". If they are not locked, the Passcode parameter displays "Off".

To lock the parameters, press the [ENTER] key while viewing the Passcode parameter. This allows entry of a 4-digit number. Press the [UP] or [DOWN] keys and [ENTER] for each of the four digits. After entering the fourth digit, the number is stored as the passcode and the parameters are locked.

Once parameters are locked, the same 4-digit number must be re-entered into the Passcode parameter in order to unlock them. Any other 4-digit number entered will be ignored.

⌘ **NOTE:** To re-establish password protection after it has been cleared, the password must be entered again.

Fault Log FL1 - 9

LCD Display

```
FL1: Last Fault #
Fault Name
```

Range

FL1 – FL9

Description

When a fault occurs, the fault number is logged in non-volatile memory. The most recent fault is in FL1 and the oldest fault is in FL9.

Pressing [ENTER] toggles through the Starter data recorded at the time of the fault. See section 4.4.5 for more information.

See Also

Appendix C - Fault Codes on page 205.

Event Recorder E01 - E99

Range

E01 – E99

Description

An event is anything that changes the present state of the starter. Some examples of events would be an operation fault, a Start command, or a Stop command. The event recorder stores the last 99 events. When an event occurs, the event number is logged in non-volatile memory. The most recent event is in E01 and the oldest event is in E99.

See Also

Appendix A – Event Codes on page 202.
Appendix C – Fault Codes on page 205.

LCD Display

The first screen displayed in the event recorder gives the starter state on the second line of the screen. See below;

```
E01: Event #??
Stop Complete
```

Pressing [ENTER] will now display the starter state at the time of the event on the bottom line of the screen. See below;

```
E01: Event #??
      Fault
```

Pressing [ENTER] for a 2nd time will display the time of the event on the bottom line of the screen. See below;

```
E01: Event #??
 hh:mm:ss
```

Pressing [ENTER] for a 3rd time will display the date of the event on the bottom line of the screen. See below;

```
E01: Event #??
 mm/dd/yy
```

Pressing [ENTER] again returns to the first display screen.

See Also

Appendix A - Event Codes on Page 202.

7 Theory of Operation

Motor Overload

7.1 Solid State Motor Overload Protection

7.1.1 Overview

The MX^3 contains an advanced I^2t electronic motor overload (OL) protection function. For optimal motor protection, the MX^3 has forty standard NEMA style overload curves (in steps of one) available for use. Separate overload classes can be programmed for acceleration and for normal running operation and individually or completely disabled if necessary. The MX^3 motor overload function also implements a NEMA based current imbalance overload compensation, adjustable hot and cold motor compensation, and adjustable exponential motor cooling.

CAUTION: If the MX^3 motor overload protection is disabled during any mode of operation, external motor overload protection must be provided to prevent motor damage and/or the risk of fire in the case of a motor overload.

7.1.2 Setting Up The MX^3 Motor Overload

Motor overload protection is easily configured through seven parameters (please refer to the descriptions of each parameter in chapter 6 of this manual for additional parameter information):

1. Motor FLA (QST01)
2. Motor Service Factor (QST02)
3. Motor Running Overload Class (PFN30)
4. Motor Starting Overload Class (PFN29)
5. Independent Starting/Running Overload (PFN28)
6. Motor Overload Hot/Cold Ratio (PFN31)
7. Motor Overload Cooling Time (PFN32)

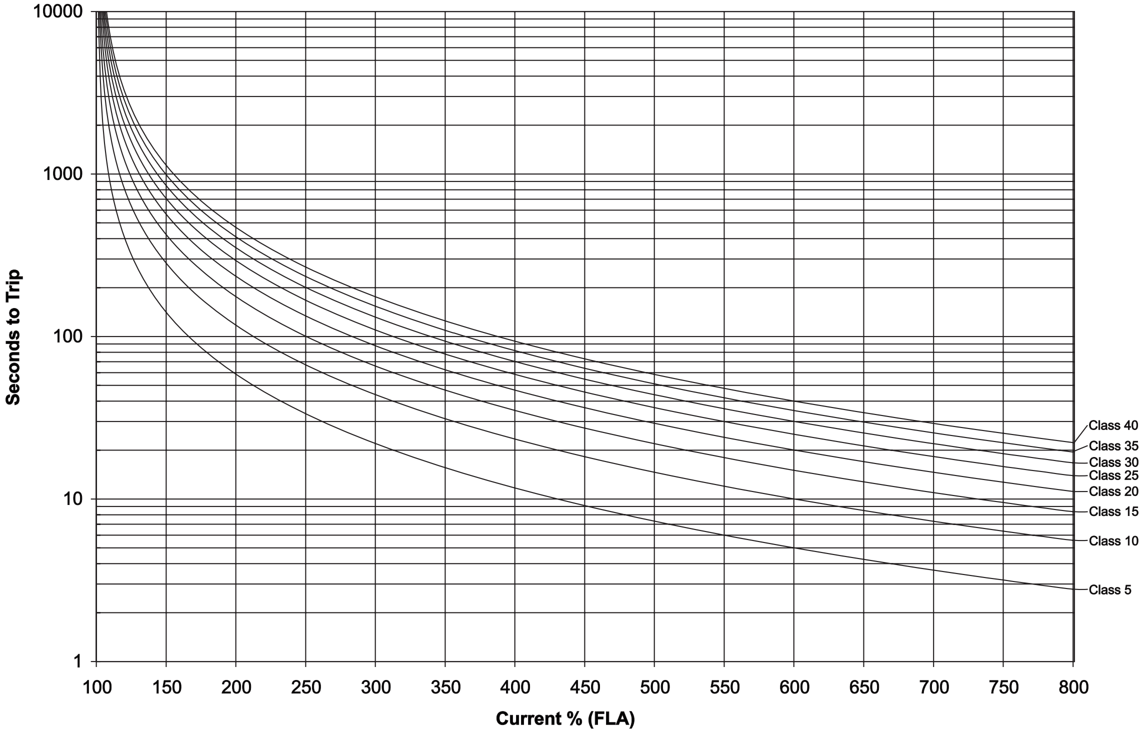
The Motor FLA and Service Factor parameter settings define the motor overload "pickup" point. For example, if the motor service factor is set to 1.00, the motor overload begins accumulating or incrementing when the measured motor current is >100% FLA (100% * 1.00). The overload will NOT trip if the motor current is <100%. If the motor service factor is set to 1.15, the overload starts accumulating content when the motor current >115% FLA (100% * 1.15). The overload will NOT trip if the measured motor current is <115% of rated FLA.

The available overload classes are based on the trip time when operating at 600% of rated motor current. For example, a Class 10 overload trips in 10 seconds when the motor is operating at 600% rated current; a Class 20 overload trips in 20 seconds when the motor is operating at 600% rated current.

The equation for the MX^3 standard overload curves after the "pick-up" point has been reached is:

$$\text{Time to Trip (seconds)} = \frac{35\,\text{seconds} * \text{Class}}{\left(\dfrac{\text{Measured Current} * \dfrac{1}{\text{Current Imbal Derate Factor}}}{\text{Motor FLA}}\right)^2 - 1}$$

Figure 34: Commonly Used Overload Curves



⌘ **NOTE:** In some cases the power stack rating may determine what motor overload settings are available. Each power stack is designed to support specific motor overload classes. The RB3 power stack is designed for class 10 duty without derating. Refer to the RB3 horsepower rating tables in chapter 2 for the specific RB3 overload capabilities. Also, in certain heavy duty DC braking applications, the overload settings may be limited to protect the motor from potential damage during braking.

Visit the web at www.benshaw.com for an automated overload calculator.

7.1.3 Motor Overload Operation

Overload Heating

When the motor is operating in the overloaded condition (motor current greater than FLAxSF), the motor overload content accumulates based on the starter's operating mode at a rate established by the overload protection class chosen. The accumulated overload content can be viewed on the display or over the communications network.

Overload Alarm

An overload alarm condition is declared when the accumulated motor overload content reaches the Motor OL Alarm Level (PFN33). An output relay can be programmed to change state when a motor overload alarm condition is present to warn of an impending motor overload fault.

Overload Trip

The MX^3 starter trips when the motor overload content reaches 100%, protecting the motor from damage. The starter first performs the defined deceleration or DC braking profile before stopping the motor if the controlled fault stop feature of the MX^3 is enabled. The motor overload trip time accuracy is ± 0.2 seconds or ± 3% of total trip time.

Overload Start Lockout

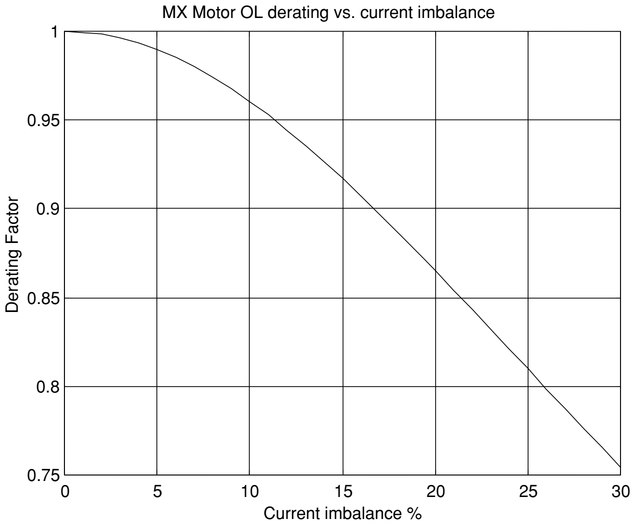
After tripping on an overload, restarting is prevented and the starter is "locked out" until the accumulated motor overload content has cooled below the Motor OL Lockout Level (PFN34).

7.1.4 Current Imbalance / Negative Sequence Current Compensation

The MX^3 motor overload calculations automatically compensate for the additional motor heating which results from the presence of unbalanced phase currents. There can be significant negative sequence currents present in the motor when a current imbalance is present,. These negative sequence currents have a rotation opposite the motor rotation and are typically at two times the line frequency. Due to the negative sequence currents opposite rotation and higher frequency, these currents can cause a significant increase in rotor heating.

The overload curves provided by a motor manufacturer are based on balanced motor operation. Therefore, if a current imbalance is present, the MX^3 motor overload compensates for the additional heating effect by accumulating overload content faster and tripping sooner to protect the motor. The current imbalance compensation also adjusts the Hot / Cold motor protection as described in section 7.1.6 . The MX^3 derating factor is based on NEMA MG-1 14.35 specifications and is shown in Figure 35.

Figure 35: Overload Derating for Current Imbalance



7.1.5 Harmonic Compensation

The MX^3 motor overload calculation automatically compensates for the additional motor heating that can result from the presence of harmonics. Harmonics can be generated by other loads connected to the supply such as DC drives, AC variable frequency drives, arc lighting, uninterruptible power supplies, and other similar loads.

7.1.6 Hot / Cold Motor Overload Compensation

If a motor has been in operation for some time, it will have heated up to some point. Therefore, there is typically less overload content available in the case where a motor is restarted immediately after it has been running when compared to the situation where a motor has been allowed to cool down before restarting. The MX^3 provides adjustable hot motor overload compensation to fully protect the motor in these cases.

If the hot and cold maximum locked rotor times are provided, the MX^3 Hot/Cold Ratio parameter value can be calculated as follows:

$$\text{OL H/C Ratio} = \left(1 - \frac{\text{Max Hot Locked Rotor Time}}{\text{Max Cold Locked Rotor Time}}\right) \text{x}\, 100\%$$

If no motor information is available, a Hot/Cold ratio value of 60% is usually a good starting point.

The MX^3 adjusts the actual motor overload content based on the programmed Hot/Cold Ratio set point and the present running current of the motor so that the accumulated motor overload content accurately tracks the thermal condition of the motor. If the motor current is constant, the overload content eventually reaches a steady state value. This value is derived as follows:

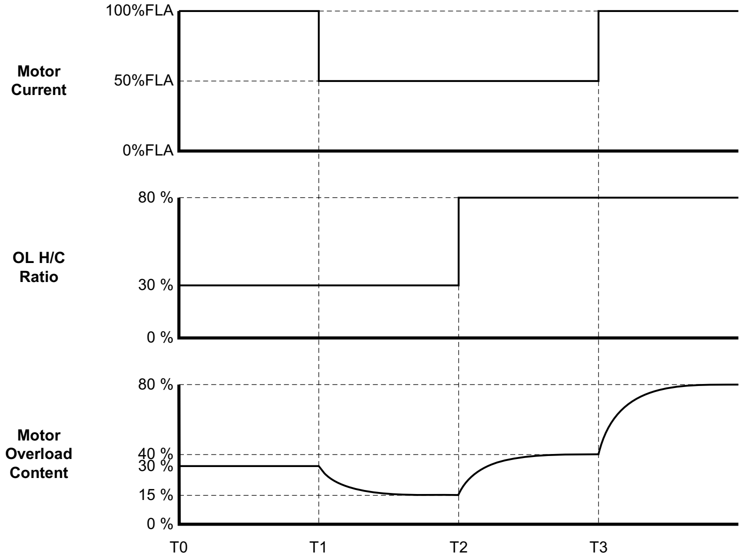
$$\text{OL}_{\text{ss}} = \text{OL H/C Ratio} \times \frac{\text{Current}}{\text{FLA}} \times \frac{1}{\text{Current Imbalance Derate Factor}}$$

The running OL content is also adjusted based on the derating factor due to the presence of any current imbalances , harmonics and or RTD Biasing.

If the existing motor overload content is less than the calculated running OL content, the motor overload exponentially increases the overload content until the appropriate running overload content level is achieved. If the existing motor overload content is greater than the calculated running OL content level, the overload exponentially cools down or decreases to the appropriate running overload content level. The rate of the running motor overload heating or cooling is controlled by the Motor Overload Cooling Time (PFN32) parameter.

The following diagram illustrates how the current and the Motor Overload Hot/Cold Ratio (PFN31) parameter determine the steady state overload content. It assumes there is no current imbalance.

Figure 36: Motor Overload H/C Ratio Example



At time T0, the motor current is 100%FLA and the OL H© Ratio is set at 30%. It is assumed that the motor has been running for some time and the motor overload content has reached a steady state value of 30% (30% H/C Ratio x 100% FLA = 30%).

At time T1, the motor current drops to 50%FLA. The motor overload content exponentially cools to a new steady state value of 15% (30% H/C Ratio x 50% FLA = 15%).

At time T2, the OL H© Ratio is set to 80%. The motor overload content exponentially rises to a new steady state value of 40% (80% H/C Ratio x 50% FLA = 40%).

At time T3 the motor current rises back up to 100%FLA. The motor overload content exponentially rises to a new steady state value of 80% (80% H/C Ratio x 100% FLA= 80%).

7.1.7 RTD Overload Biasing

The RTD biasing calculates a motor thermal value based on the highest stator RTD measurement. The motor thermal overload content is set to this calculated value if this calculated value is higher than the motor thermal overload content. The RTD biasing is calculated as follows:

Max measured stator RTD temp < RTD Bias Min Level (RTD27)

$$BiasOL\% = 0$$

RTD Bias Min Level (RTD27) < Max measured stator RTD temp < RTD Bias Mid Point Level (RTD28)

$$BiasOL\% = \frac{RTD\,\mathrm{max} - MinBiasTemp}{MidBiasTemp - MinBiasTemp} \times Hot\_Cold\_Ratio$$

RTD Bias Mid Point Level (RTD28) < Max measured stator RTD temp < RTD Bias Max Level (RTD29)

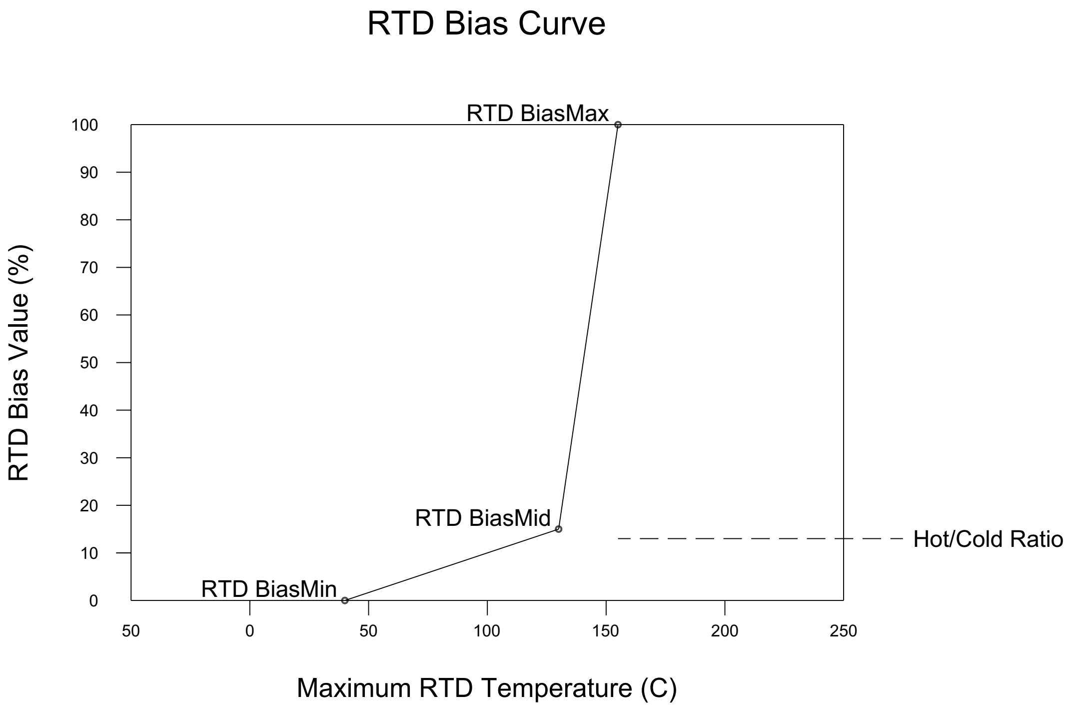
$$BiasOL\% = \left[\frac{RTD\,\mathrm{max} - MidBiasTemp}{MaxBiasTemp - MidBiasTemp} \times (99.9\% - hot\_cold\_ratio)\right] + hot\_cold\_ratio$$

RTD Bias Max Level (RTD29) < Max measured stator RTD temp

$$BiasOL\% = 99.9\%$$

The RTD Biasing levels are generally set by using the motor data as follows:
RTD Bias Min Level (RTD27): This parameter is typically programmed to the ambient temperature rating of the motor.
RTD Bias Mid Level (RTD28): This parameter is typically programmed to the temperature rise rating of the motor.
RTD Bias Max Level (RTD29): This parameter is typically programmed to insulation rating of the motor.

Figure 37: RTD Bias Curve



7.1.8 Overload Auto Lockout

This feature prevents an overload trip during the motor start due to insufficient thermal capacity. It will automatically calculate the overload content required to start the motor. It will lockout the starter if there is not enough overload content available. The release value calculated is based on OL content used for the past four (4) successful motor starts. A factor of 1.25 is applied as a safety margin.

Example:

The OL content used for the past 4 starts were 30%, 29%, 30%, 27%.
step 1 (30+29+30+27) / 4 = 29%
step 2 29% * 1.25 = 36%.
step 3 100% - 36% = 64% Therefore 64% is the calculated OL Lockout release level.

7.1.9 Separate Starting and Running Motor Overload Settings

If desired, separate overload classes can be programmed for use during starting and during running. The motor overload protection may also be disabled during starting or during normal running. In order to enable separate overload settings the Independent Starting/Running Overload (PFN28) parameter needs to be set "to On" to allow independent overload operation. Once set to "On", the individual Motor Starting Overload Class (PFN29) and Motor Running Overload Class (PFN30) parameters can be set to either "Off" or the desired overload class settings.

The Motor Starting Overload Class (PFN29) parameter value is used for the motor overload calculations when the starter is starting the motor (kick mode, acceleration, and running before up-to-speed has been declared). Once the motor has reached full speed and during deceleration or braking, the Motor Running Overload Class (PFN30) is used for the motor overload calculations. As the motor protection curves shift from the acceleration curve to the running curve, the accumulated overload content is retained to provide a seamless transition from one mode of operation to the other.

Disabling the Starting OL function or using a higher OL class for the Starting OL can be useful on extremely high inertial loads such as large centrifuges or high friction loads that require very long starting periods.

⌘ **NOTE**: When the Independent Starting/Running Overload (PFN28) parameter is set to "Off", the running OL is used at all times.

⌘ **NOTE:** The Hot/Cold motor compensation is still active when either the starting or running overload is disabled. Therefore the motor overload content may still slowly increase or decrease depending on the measured motor current. However if the motor overload is disabled, the motor overload content is limited to a maximum of 99%. Therefore, a motor overload trip can not occur.

CAUTION: When both overloads are disabled, the accumulated overload content is set to zero (0%) and the starter does not provide any motor overload protection. External motor overload protection must be provided to prevent motor damage and/or the risk of fire in the case of a motor overload.

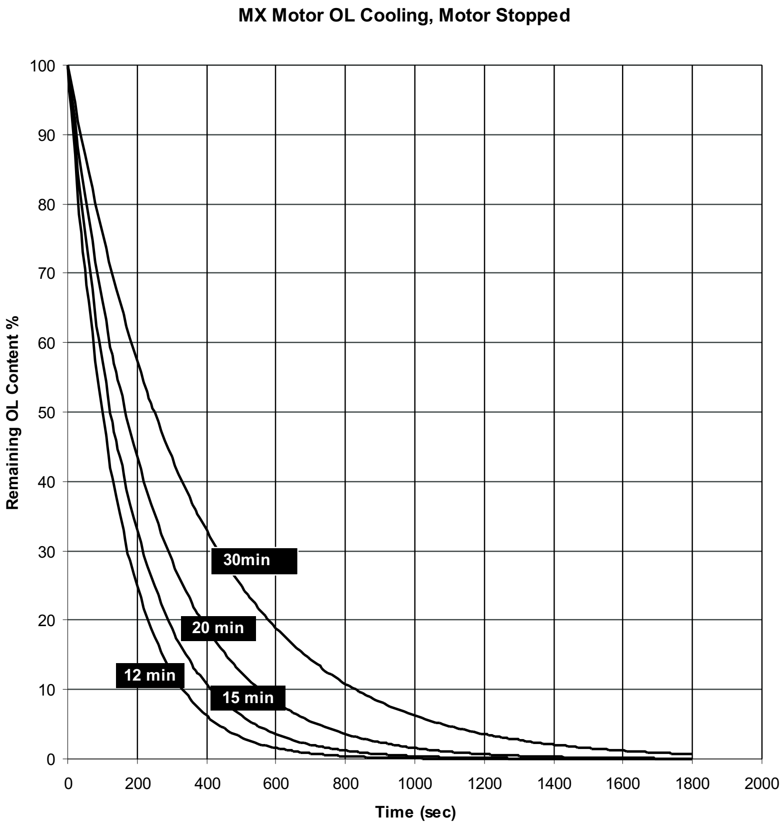
7.1.10 Motor Cooling While Stopped

The Motor Overload Cooling Time (PFN32) parameter is used to adjust the cooling rate of the motor overload. When the motor is stopped and cooling, the accumulated motor overload content is reduced in an exponential manner.

$$\text{OL Content} = \text{OL Content when Stopped} * e^{\frac{5}{CoolingTime}t}$$

When the motor is stopped, the motor overload cools as shown in the following Figure 38.

Figure 38: Motor Cooling While Stopped Curves



If the motor manufacturer does not specify the motor cooling time, the following approximations for standard TEFC cast iron motors based on frame size can be used:

Frame Size	Cooling Time
180	30 min
280	60 min
360	90 min
400/440	120 min
500	180 min
Larger frames	Consult Manufacturer

For motors less than 300hp, another approximation based on allowable motor starts per hour can also be used to set an initial value of the Motor Overload Cooling Time (PFN32) parameter:

$$\text{Motor Cooling Time (minutes)} \approx \frac{\text{60 minutes}}{\text{Starts per hour}}$$

⌘ **NOTE:** The Motor Overload Cooling Time (PFN32) parameter is defined as the time that it takes for the motor to cool from 100% overload content to less than 1% overload content. Sometimes a motor manufacturer may provide a cooling time constant (t or tau) value. In these cases, the Motor Overload Cooling Time (PFN32) parameter should be set to five (5) times the specified time constant value.

7.1.11 Motor Cooling While Running

When the motor is running, the Motor Overload Cooling Time (PFN32) parameter and the Motor Overload Hot/Cold Ratio (PFN31) parameter settings control the motor OL content. If the motor overload content is above the steady state OL running level (See section 7.1.6, Hot / Cold Motor Overload Compensation for more details) the motor OL exponentially cools to the appropriate steady state OL level. When the motor is running, the cooling time is adjusted based on the measured current level and current imbalance level at which the motor is operating.

$$\text{Cooling Time Running} = \text{Cooling Time Stopped} * \frac{\text{Measured Running Current}}{\text{Motor FLA}} * \frac{1}{\text{Current Imbalance Derate Factor}}$$

In all cases, the running motor cooling time is shorter (motor will cool faster) than when the motor is stopped. The faster cooling results because it is assumed that when a motor is running, cooling air is being applied to the motor.

7.1.12 Emergency Motor Overload Reset

The MX^3 has an emergency motor overload reset feature that allows the user to override the overload starter lockout. This resets the motor overload content to 0%. It does not reset the overload fault.

To perform an emergency overload reset, simultaneously press the [RESET] and [DOWN] buttons on the keypad. An emergency overload reset may also be performed by applying 120 Volts to a digital input that is configured as an emergency overload reset input or by setting the emergency overload reset bit in the starter control Modbus register.

CAUTION: This feature should only be used in an emergency. Before an emergency reset is performed the cause of the motor overload should be investigated to ensure that the motor is capable of restarting without causing undesired motor or load damage. When the emergency motor overload reset is used, the accumulated motor overload content is reset back to zero (0%). Therefore, the MX^3 motor protection functions may not be able to fully protect the motor from damage during a restart after performing an emergency motor overload reset.

Motor Service Factor

7.2 Motor Service Factor

General

The Motor Service Factor (QST02) parameter should be set to the service factor of the motor. The service factor is used to determine the "pick up" point for the overload calculations. If the service factor of the motor is not known then the service factor should be set to 1.00.

⌘ **NOTE:** The NEC (National Electrical Code) does not allow the service factor to be set above 1.40. Check with other local electrical codes for their requirements.

The National Electrical Code, article 430 Part C, allows for different overload multiplier factors depending on the motor and operating conditions. NEC section 430-32 outlines the allowable service factor for different motors as follows:

Motor Overload Multiplier

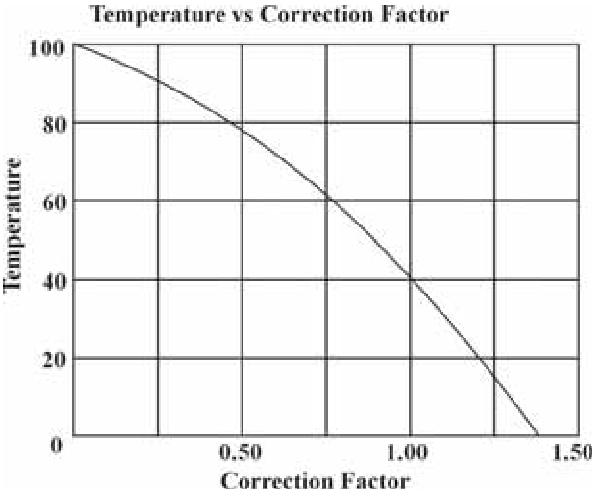
Service factor 1.15 or more	1.25
Motor temp. rise 40°C or less	1.25
All others	1.15

NEC section 430-34 permits further modifications if the service factor is not sufficient to start the motor:

Motor Overload Multiplier

Service factor 1.15 or more	1.40
Motor temp. rise 40°C or less	1.40
All others	1.30

Although the NEC does not address the effect of the ambient temperature of the motor location, guidance can be derived by examining NEC limits. If the motor is operating in an ambient temperature that is less than 40°C, then the overload multiplier can be increased while still protecting the motor from exceeding its maximum designed temperature. The following curve gives the ambient temperature versus the correction factor.



Example: If a motor operates at 0°C, then a 1.36 correction factor could be applied to the overload multiplier. This could give a theoretical overload multiplier of 1.36 x 1.25 or 1.70. The highest legal NEC approved value of overload multiplier is 1.40, so this could be used.

Acceleration Control

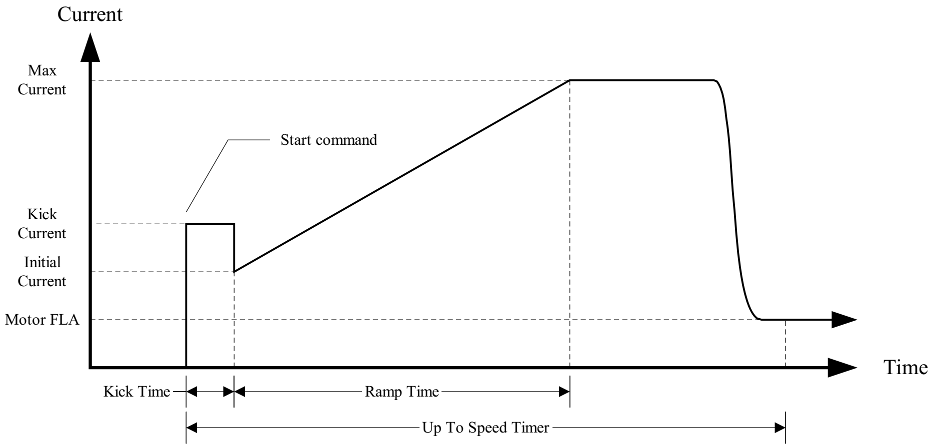
7.3 Acceleration Control

7.3.1 Current Ramp Settings, Ramps and Times

General

The current ramp sets how the motor accelerates. The current ramp is a linear increase in current from the initial setting to the maximum setting. The ramp time sets the speed of this linear current increase. The following figure shows the relationships of these different ramp settings.

Figure 39: Current Ramp



Initial Current

The initial current should be set to the level that allows the motor to begin rotating within a couple of seconds of receiving a start command.

To adjust the initial current setting, give the starter a run command. Observe the motor to see how long it takes before it begins rotating and then stop the unit. For every second that the motor doesn't rotate, increase the initial current by 20%. Typical loads require an initial current in the range of 50% to 175%.

Maximum Current

For most applications, the maximum current can be left at 600%. This ensures that enough current is applied to the motor to accelerate it to full speed.

The maximum current can also be set to a lower current limit. This is usually done to limit the voltage drop on the power system or to limit the torque the motor produces to help prevent damage to the driven load.

⌘ **NOTE:** The motor may achieve full speed at any time during the current ramp. This means that the maximum current setting may not be reached. Therefore, the maximum current setting is the most current that could ever reach the motor, and not necessarily the maximum current that reaches the motor.

⌘ **NOTE:** When setting a current limit, the motor must be monitored to ensure that the current is high enough to allow the motor to reach full speed under worst case load conditions.

Ramp Time

The ramp time is the time it takes for the current to go from the initial current to the maximum current. To make the motor accelerate faster, decrease the ramp time. To make the motor accelerate slower, increase the ramp time.

If the ramp time expires before the motor reaches full speed, the starter maintains the maximum current level until either the motor reaches full speed, the Up to Speed time expires, or the motor thermal overload trips.

⌘ **NOTE:** Setting the ramp time to a specific value does not necessarily mean that the motor will take this time to accelerate to full speed. The motor and load may achieve full speed before the ramp time expires if the application does not require the set ramp time and maximum current to reach full speed. Alternatively, the motor and load may take longer than the set ramp time to achieve full speed.

7.3.2 Programming A Kick Current

General

The kick current sets a constant current level that is applied to the motor before the ramp begins. The kick current is only useful on motor loads that are hard to get rotating but then are much easier to move once they are rotating. An example of a load that is hard to get rotating is a ball mill. The ball mill requires a high torque to get it to rotate the first quarter turn (90°). Once the ball mill is past 90° of rotation, the material inside begins tumbling and it is easier to turn.

Kick Level

The kick current parameter is usually set to a low value and then the kick time is adjusted to get the motor rotating. If the kick time is set to more than 2.0 seconds without the motor rotating, increase the kick current by 100% and re-adjust the kick time.

Kick Time

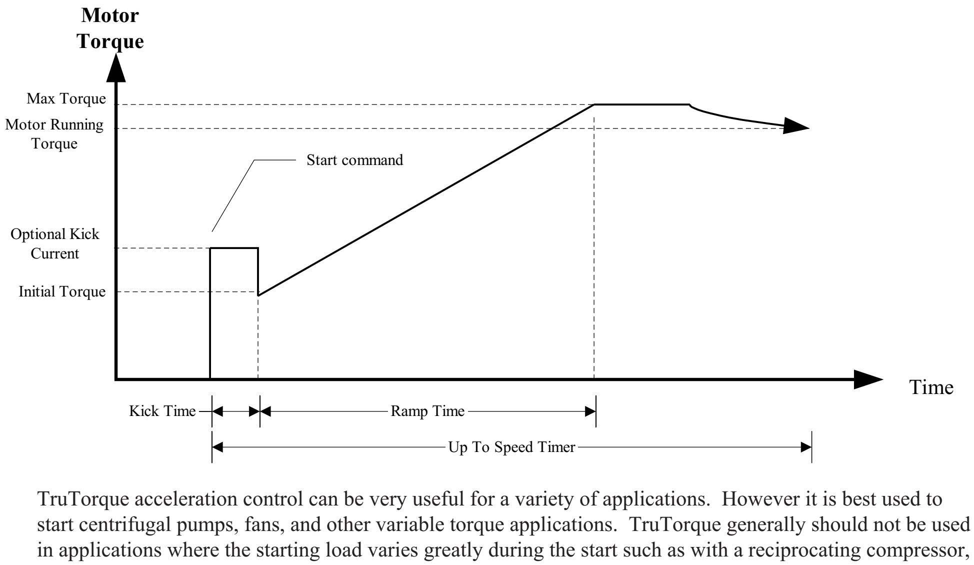
The kick time adjustment should begin at 0.5 seconds and be adjusted by 0.1 or 0.2 second intervals until the motor begins rotating. If the kick time is adjusted above 2.0 seconds without the motor rotating, start over with a higher kick current setting.

7.3.3 TruTorque Acceleration Control Settings and Times

General

TruTorque acceleration control is a closed loop torque based control. The primary purpose of TruTorque acceleration control is to smoothly start motors and to reduce the torque surge that can occur as an AC induction motor comes up to speed. This torque surge can be a problem in applications such as pumps and belt driven systems. In pumping applications, this torque surge can result in a pressure peak as the motor comes up to speed. In most situations this small pressure peak is not a problem. However in selected cases, even a small pressure rise can be highly undesirable. In belt driven applications, TruTorque can prevent the slipping of belts as the motor reaches full speed.

Figure 40: TruTorque Ramp



TruTorque acceleration control can be very useful for a variety of applications. However it is best used to start centrifugal pumps, fans, and other variable torque applications. TruTorque generally should not be used in applications where the starting load varies greatly during the start such as with a reciprocating compressor, where the starting load is very low, or where the starting load varies greatly from one start to another. TruTorque control is not recommended for the starting of AC synchronous motors.

Initial Torque

This parameter (CFN08) sets the initial torque level that the motor produces at the beginning of the starting ramp profile. A typical value is 10% to 20%. If the motor starts too quickly or the initial motor torque is too high, reduce this parameter. If the motor does not start rotating within a few seconds after a start is commanded, increase this parameter. If the value is set too low a "No Current at Run" fault may occur.

Maximum Torque

This parameter (CFN09) sets the final or maximum torque level that the motor produces at the end of the acceleration ramp time. For a loaded motor, the maximum torque value initially should be set to 100% or greater. If the maximum torque value is set too low, the motor may not produce enough torque to reach full speed and may stall. On lightly loaded motors, this parameter may be reduced below 100% to produce smoother starts.

If the motor can be started by using the default TruTorque acceleration parameter values or another ramp profile, the Maximum Torque level can be determined more precisely so that the motor comes up to speed in approximately the preset ramp time. In this case, while the motor is running fully loaded, display the TruTorque percent (TT%) meter on the display. Record the value displayed. The Maximum Torque level should then be set to the recorded full load value of TT% plus an additional 10%. Restart the motor with this value to verify correct operation.

⌘ **NOTE:** When setting the Maximum Torque value, the motor must be monitored to ensure that the torque level is high enough to allow the motor to reach full speed under worst-case load conditions.

⌘ **NOTE:** Depending on loading, the motor many achieve full speed at any time during the TruTorque ramp. This means that the Maximum Torque level many never be achieved. Therefore, the maximum torque level is the maximum TruTorque level that is permitted. However the motor torque may not necessarily reach this value during all starts.

Ramp Time

When in TruTorque acceleration mode, the ramp time setting is the time it takes for the torque to go from the initial torque setting to the maximum torque setting. To make the motor accelerate faster, decrease the ramp time. To make the motor accelerate slower, increase the ramp time.

If the ramp time expires before the motor reaches full speed, the starter maintains the Maximum Torque level until either the motor reaches full speed, UTS timer expires, or the motor thermal overload protection trips.

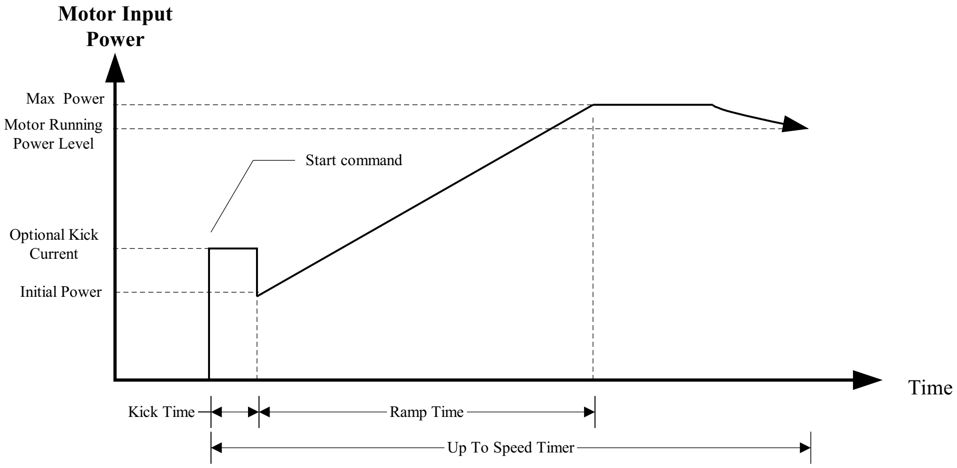
⌘ **NOTE:** Setting the ramp time to a specific value does not necessarily mean that the motor takes that exact amount of time to accelerate to full speed. The motor and load may achieve full speed before the ramp time expires if the load does not require the set ramp time or set torque level to reach full speed. Alternately, the motor and load may take longer than the set ramp time to achieve full speed depending on the parameter settings and load level.

7.3.4 Power Control Acceleration Settings and Times

General

Power control is a closed loop power based acceleration control. The primary purpose of Power controlled acceleration is to control and limit the power (kW) drawn from the power system and to reduce the power surge that may occur as an AC induction motor comes up to speed. This power surge can be a problem in applications that are operated on generators or other limited or "soft" power systems. Power control also reduces the torque surge that can also occur as an AC induction motor comes up to speed.

Figure 41: Power Ramp



Power control acceleration can be very useful for a variety of applications. Power control generally should not be used in applications where the starting load varies greatly during the start such as with a reciprocating compressor. Power control is not recommended for starting of AC synchronous motors.

Initial Power

This parameter (CFN08) sets the initial power level that the motor draws at the beginning of the starting ramp profile. A typical value is usually 10% to 30%. If the motor starts too quickly or the initial power level is too high, reduce this parameter. If the motor does not start rotating within a few seconds after a start is commanded, increase this parameter. If this value is set too low a "No Current at Run" fault may occur.

Maximum Power

This parameter (CFN09) sets the final or maximum power level that the motor produces at the end of the acceleration ramp. For a loaded motor, the maximum power level initially should be set to 100% or greater. If the maximum power level value is set too low, the motor may not produce enough torque to reach full speed and may stall. On lightly loaded motors, this parameter may be reduced below 100% to produce smoother starts.

If the motor can be started by using the default Power acceleration parameter values or the Current control ramp, the Maximum Power level can be determined more precisely so that the motor comes up to speed in approximately the preset ramp time. In this case, while the motor is running fully loaded, display the Power percent (KW%) meter on the display. Record the value displayed. The Maximum Power level should then be set to the recorded full load value of KW% plus an additional 5% to 10%. Restart the motor with this value to verify correct operation.

⌘ **NOTE:** When setting the Maximum Power level, the motor must be monitored to ensure that the starting power is high enough to allow the motor to reach full speed under worst case load conditions.

⌘ **NOTE**: Depending on loading, the motor may achieve full speed at any time during the Power ramp. This means that the Maximum Power level may not be reached. Therefore, the maximum power level is the maximum power level that is permitted. However, the motor power may not necessarily reach this value during all starts.

Ramp Time

When in Power acceleration mode, the ramp time setting is the time it takes for the power to go from the initial power setting to the maximum power setting. To make the motor accelerate faster, decrease the ramp time. To make the motor accelerate slower, increase the ramp time.

If the ramp time expires before the motor reaches full speed, the starter maintains the Maximum Power level until either the motor reaches full speed, the UTS timer expires, or the motor thermal overload protection trips.

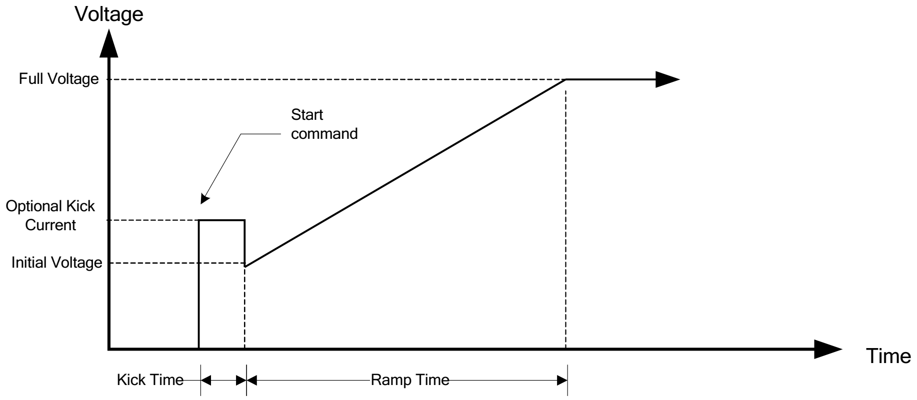
⌘ **NOTE:** Setting the ramp time to a specific value does not necessarily mean that the motor takes that exact amount of time to accelerate to full speed. The motor and load may achieve full speed before the ramp time expires if the load does not require the set ramp time or set power level to reach full speed. Alternately, the motor and load may take longer than the set ramp time to achieve full speed depending on the parameter settings and load level.

7.3.5 Open Loop Voltage Ramps and Times

General

The open loop voltage ramp provides soft starting of a motor by increasing the voltage applied to motor from the Initial Voltage setting to full (100%) line voltage. The ramp time sets the speed at which the voltage is increased. Because this is an open loop control profile, the motor current during starting tends to be reduced; however, the current is not limited to any particular level. This starting mode (old), is not commonly used except in special circumstances. In most applications, the use of one of the other closed loop starting profiles is recommended.

Figure 42: Voltage Ramp



Initial Voltage

This parameter sets the initial voltage level that is applied to the motor. To adjust the starting voltage level, give the starter a run command and observe the motor operation. If the motor starts too quickly reduce the initial voltage level. If the motor does not start rotating immediately or starts too slowly then increase the initial voltage level until the motor just starts to rotate when a start command is given. If the initial voltage level is set too low, a Fault 39 - No Current at Run may occur. In this case increase the initial voltage level to permit more current to initially flow to the motor.

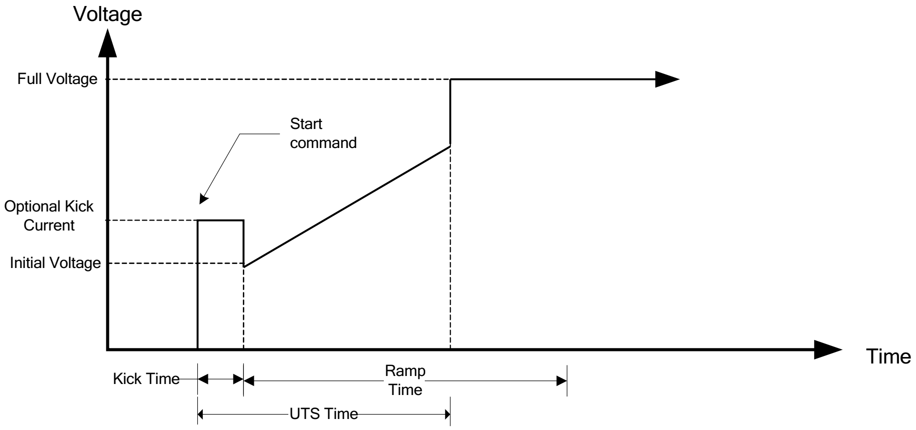
Ramp Time

The ramp time setting is the time that it takes for the applied voltage to go from the initial voltage level to the full voltage (100%) level. To make the motor accelerate faster, decrease the ramp time. To make the motor accelerate slower, increase the ramp time.

UTS Timer

When the start mode is set to open-loop voltage ramp acceleration, the UTS Timer acts as an acceleration kick. When the UTS timer expires, full voltage is applied to the motor. This feature can be used to reduce motor surging that may occur near the end of an open loop voltage ramp start. If a surge occurs near the end of the ramp, set the UTS timer to expire at this time and restart the motor. If the surge still occurs, set the UTS time to a lower time until the surging subsides. If motor surging continues to be a problem, it is recommended that one of the other standard MX^3 closed-loop starting profiles be used.

Figure 43: Effect of UTS Timer on Voltage Ramp



7.3.6 Tachometer Ramp Selection

Description

The Tachometer control ramp profile provides a method to linearly ramp the speed of the system. When this control mode is selected, the starter uses a tachometer to provide speed feedback to the starter. This mode is commonly used on conveyor belt applications where a smooth controlled start is necessary under various load conditions to prevent belt breakage, lifting, or excessive stretching. The Tachometer controller consists of an inner PID current loop and an outer PI speed control loop.

⌘ **NOTE:** The maximum current limit will override the speed control loop if necessary. If the Maximum Current level is not set high enough or the load is too great, the MX^3 starter will limit the motor current to this maximum level. When current limiting occurs, the speed profile will no longer be linear and the motor(s) will take longer to accelerate to full speed. Therefore, if current limiting is undesirable, this parameter must be set higher than the peak starting current during a linear speed ramp start.

Tachometer Requirements

In addition to the basic motor and starter setup variables, the following needs to done to use the tachometer feedback control ramp:

1. Connect a tachometer with appropriate DC output voltage and correct polarity to the MX^3 power card input (TB5-2 (+ positive) & TB5-3 (- negative)) .

2. The tachometer feedback Start Mode (CFN01) is selectable as “Tach Ramp” from the Starter Modes menu.

3. Program the appropriate variables in the Tachometer Setup menu.
   FUN13- Tachometer Full Speed Voltage on page 130.
   FUN14- Tachometer Loss Time on page 130.
   FUN15- Tachometer Loss Action on page 131.

4. Set the Initial Current (QST06/CFN03) level to the desired starting current.

5. Set the Maximum Current (QST07/CFN04) level to the desired maximum current limit.

7.3.7 Dual Acceleration Ramp Control

General

Two independent current ramps and kick currents may be programmed. The use of two different starting profiles can be very useful with applications that have varying starting loads such as conveyors that can start either loaded or unloaded.

The Current Ramp 1 profile is programmed using the parameters Initial Current 1, Maximum Current 1, and Ramp Time 1. The Current Ramp 2 is programmed using the parameters Initial Current 2, Maximum Current 2, and Ramp Time 2. Kick Current 1 profile is programmed using the parameters Kick Level 1 and Kick Time 1. Kick Current 2 profile is programmed using the parameters Kick Level 2 and Kick Time 2.

7.3.8 Acceleration Ramp Selection

Current Ramp 2 and Kick Current 2 starting profiles are selected by programming a digital input to the Ramp Select function and then energizing that input by applying 120 Volts to it. When a digital input is programmed to Ramp Select, but de-energized, Current Ramp 1 and Kick Current 1 are selected. When no digital inputs are programmed to the Ramp Select function the Ramp 1 profile is used.

The Ramp Select input only affects the starting profile when using a current ramp profile and during a kick. The Ramp Select input does not affect the TruTorque ramp, Power ramp, or the Voltage ramp profile (unless kicking is enabled at the beginning of those ramps).

The following table summarizes which parameters affect the starting profile when a digital input is programmed to the Ramp Select function and that input is either energized or de-energized.

Ramp Modes

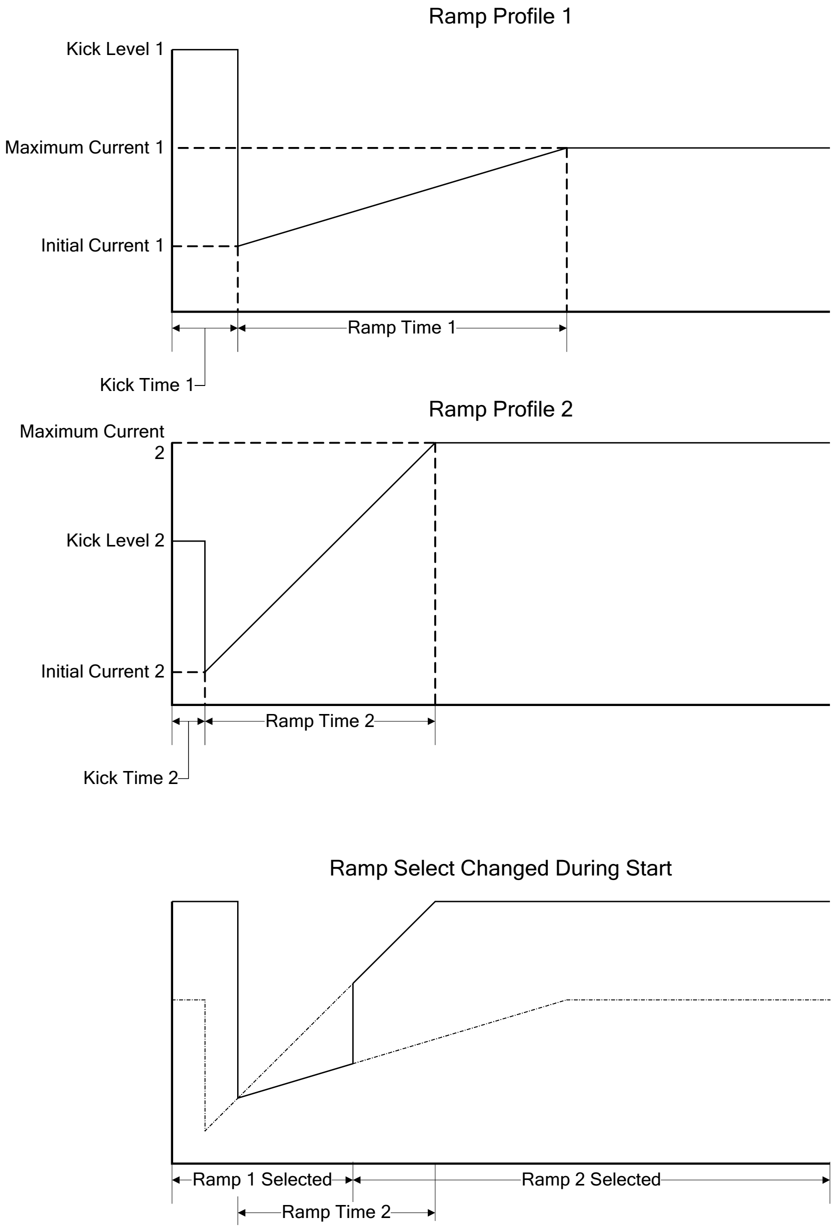
	Ramp Select De-energized	**Ramp Select Energized**
Current Ramp	Initial Current 1	Initial Current 2
	Maximum Current 1	Maximum Current 2
	Ramp Time 1	Ramp Time 2
	Kick Level 1	Kick Level 2
	Kick Time 1	Kick Time 2
TruTorque Ramp	Initial Voltage/Torque/Power	
	Maximum Torque/Power	
	Ramp Time 1	
	Kick Level 1	Kick Level 2
	Kick Time 1	Kick Time 2
Power (KW) Ramp	Initial Voltage/Torque/Power	
	Maximum Torque/Power	
	Ramp Time 1	
	Kick Level 1	Kick Level 2
	Kick Time 1	Kick Time 2
Voltage Ramp	Initial Voltage/Torque/Power	
	Ramp Time 1	
	Kick Level 1	Kick Level 2
	Kick Time 1	Kick Time 2
Tachometer Ramp	Initial Current 1	Initial Current 2
	Maximum Current 1	Maximum Current 2
	Ramp Time 1	Ramp Time 2
	Kick Level 1	Kick Level 2
	Kick Time 1	Kick Time 2

7.3.9 Changing Ramp Profiles

The selected ramp profile may be changed during starting by changing the Ramp Select input. When the Ramp Select input changes during ramping, control switches to the other profile as if it were already in progress. It does not switch to the beginning of the other profile. Refer to the following example below:

⌘ **NOTE:** Once the motor has achieved an up-to-speed status (UTS), changes to the Ramp Select input have no effect on the motor operation.

Figure 44: Changing Ramps During Acceleration Example



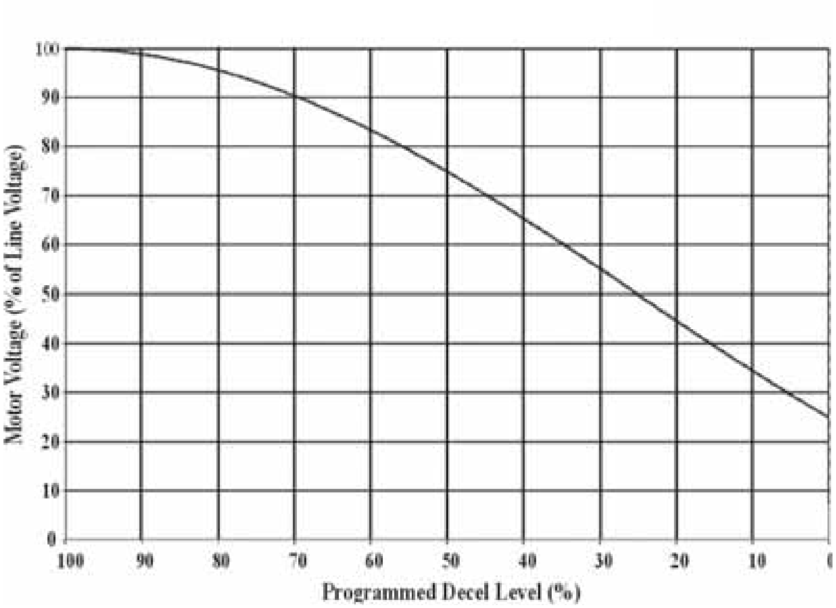
7.4 Deceleration Control

7.4.1 Voltage Control Deceleration

Overview

The deceleration control on the MX^3 uses an open loop voltage ramp. The MX^3 ramps the voltage down to decelerate the motor. The curve shows the motor voltage versus the decel setting.

Figure 45: Motor Voltage Versus Decel Level



Beginning Level

This sets the starting voltage of the deceleration ramp. Most motors require the voltage to drop to around 60% or lower before any significant deceleration is observed. Therefore, a good first setting for this parameter is 35%.

To adjust this parameter, it is necessary to observe the motor operation as soon as a stop is commanded. If the motor hunts (speed oscillations) at the beginning of the deceleration, then lower the parameter by 5%. If the motor has a big drop in speed as soon as a stop is commanded, then raise the parameter by 5%.

Some motors are very sensitive to the adjustment of this parameter. If a 5% adjustment changes the motor from hunting to dropping in speed, then a smaller change of 1% or 2% may be necessary.

Ending Level

This sets the final voltage for the deceleration ramp. In most cases, this parameter can be set to 10% and the decel time can be used to adjust the deceleration rate. If the motor is coming to a stop too quickly or if the starter continues to apply current to the motor after the motor has stopped, this parameter can be increased in 5% increments to fix this.

Decel Time

The decel time sets how quickly the motor decelerates. Usually a time of 30 seconds is a good starting point. To make the motor take longer to decelerate, increase this parameter or to make the motor decelerate quicker, decrease this parameter.

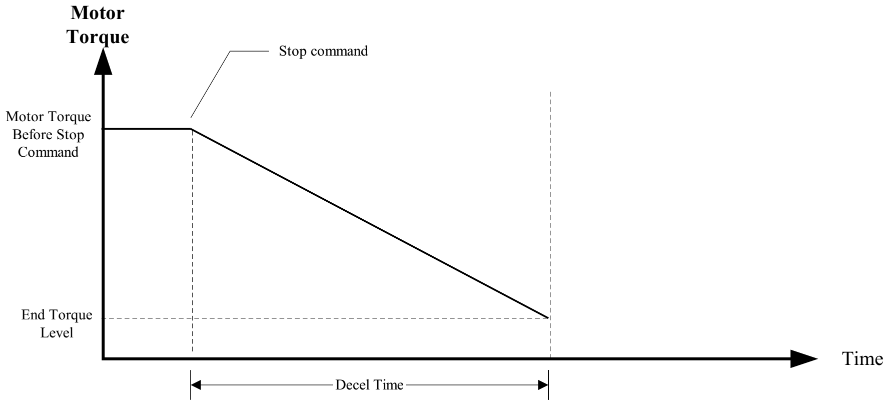
⌘ **NOTE:** Deceleration control provides a smoother stop. However, the motor will take longer to stop than if it was just allowed to coast to stop.

7.4.2 TruTorque Deceleration

Overview

TruTorque deceleration control is a closed loop deceleration control. This allows TruTorque deceleration to be more consistent in cases of changing line voltage levels and varying motor load conditions. TruTorque deceleration is best suited to pumping and compressor applications where pressure surges, such as water hammer, must be eliminated. The MX^3 linearly reduces the motor's torque to smoothly decelerate the motor and load. TruTorque deceleration is very easy to use with only two parameters to set.

Figure 46: TruTorque Deceleration



Ending Level

The Decel End Level parameter sets the ending torque level for the TruTorque deceleration ramp profile.

A typical TruTorque decel end level setting is between 10% and 20%. If the motor stops rotating before the deceleration time has expired, increase this parameter value. If the motor is still rotating when the deceleration time has expired, decrease this parameter value.

Decel Time

The decel time sets the ramp time between the motor torque level when stop was commanded and the decel end torque level.

If the motor stops rotating before the decel time has expired, decrease the decel time parameter. If the motor is still rotating when the decel time expires, increase the decel time parameter.

7.5 Braking Controls

Overview

When the Stop Mode parameter is set to DC Brake, the MX^3 starter provides DC injection braking for fast and non friction braking of a three-phase motor. The MX^3 starter applies a controlled DC current to the motor in order to induce a stationary magnetic field that then exerts a braking torque on the motor's rotating rotor. The braking current level and braking time required depends on the motor characteristics, the load inertia, and the friction in the system.

The MX^3 starter supports two different levels of DC injection braking:
1. Standard Duty Brake - For less than 6 x motor inertia.
2. Heavy Duty Brake - For NEMA specified inertia and two motor current feedback methods:
   a) Standard Current Transformers (CTs)
   b) Optional Hall Effect Current Sensor (LEM)

The optional Hall Effect Current sensor can be used when a more precise measurement of braking current is necessary. This can occur if the DC injection braking is applied when the source supply has a very high short circuit capability (very stiff) or in special instances when more precise braking current control is required. The appropriate brake type and feedback method is preset from the factory. Please consult Benshaw for more information if changes need to be made.

Maximum Load Inertia

The following table shows maximum load inertia, NEMA MG1 parts 12 and 20. It is recommended a thermistor or RTD be installed to protect the motor from overheating.

	Speed - RPM						
	3600	**1800**	**1200**	**900**	**720**	**600**	**514**
HP	**Inertia (lb-ft2)**						
2	2.4	11	30	60	102	158	228
3	3.5	17	44	87	149	231	335
5	5.7	27	71	142	242	375	544
71/2	8.3	39	104	208	356	551	798
10	11	51	137	273	467	723	1048
15	16	75	200	400	685	1061	1538
20	21	99	262	525	898	1393	2018
25	26	122	324	647	1108	1719	2491
30	31	144	384	769	1316	2042	2959
40	40	189	503	1007	1725	2677	3881
50	49	232	620	1241	2127	3302	4788
60	58	275	735	1473	2524	3819	5680
75	71	338	904	1814	3111	4831	7010
100	92	441	1181	2372	4070	6320	9180
125	113	542	1452	2919	5010	7790	11310
150	133	640	1719	3456	5940	9230	-
200	172	831	2238	4508	7750	12060	-
250	210	1017	2744	5540	9530	14830	-
300	246	1197	3239	6540	11270	-	-
350	281	1373	3723	7530	-	-	-
400	315	1546	4199	8500	-	-	-
450	349	1714	4666	9460	-	-	-
500	381	1880	5130	-	-	-	-
600	443	2202	6030	-	-	-	-
700	503	2514	-	-	-	-	-
800	560	2815	-	-	-	-	-

7.5.1 DC Injection Braking, Standard Duty

The MX^3 Standard Duty Braking allows up to approximately 250% FLA current to be applied to the motor. The MX^3 Standard Duty package consists of an extra braking contactor that shorts motor terminals 2 and 3 together while braking, as DC current is applied by the MX^3 starter to provide moderate braking torque.

CAUTION: Contactor MUST NOT short phase T1 and phase T3.

⌘ **NOTE:** Contactor sizing requires AC1 contactor rating (Motor FLA / 1.6). The three contacts must be paralleled.

7.5.2 DC Injection Braking, Heavy Duty

The MX^3 Heavy Duty Braking allows up to 400% FLA current to be applied to the motor for maximum braking performance. The MX^3 Heavy Duty braking package includes a freewheel current path between phases 1 and 3 that consists of a fuse and a 7th SCR with gating card. In combination with the applied DC current from the MX^3 starter, the freewheeling current path greatly enhances available braking torque. When Braking, the stop must be counted as another motor start when looking at the motor starts per hour limit.
⌘ **NOTE:** Semi-Conductor Fuse and 7th SCR supplied by Benshaw.

7.5.3 Braking Output Relay

To utilize DC injection braking, one of the user output Relays needs to be programmed as a Braking relay. (Refer to the Relay Output Configuration parameters on page 112 for more information). The output of a Braking relay is needed to control the contactor and/or 7th SCR gating control card used during braking.

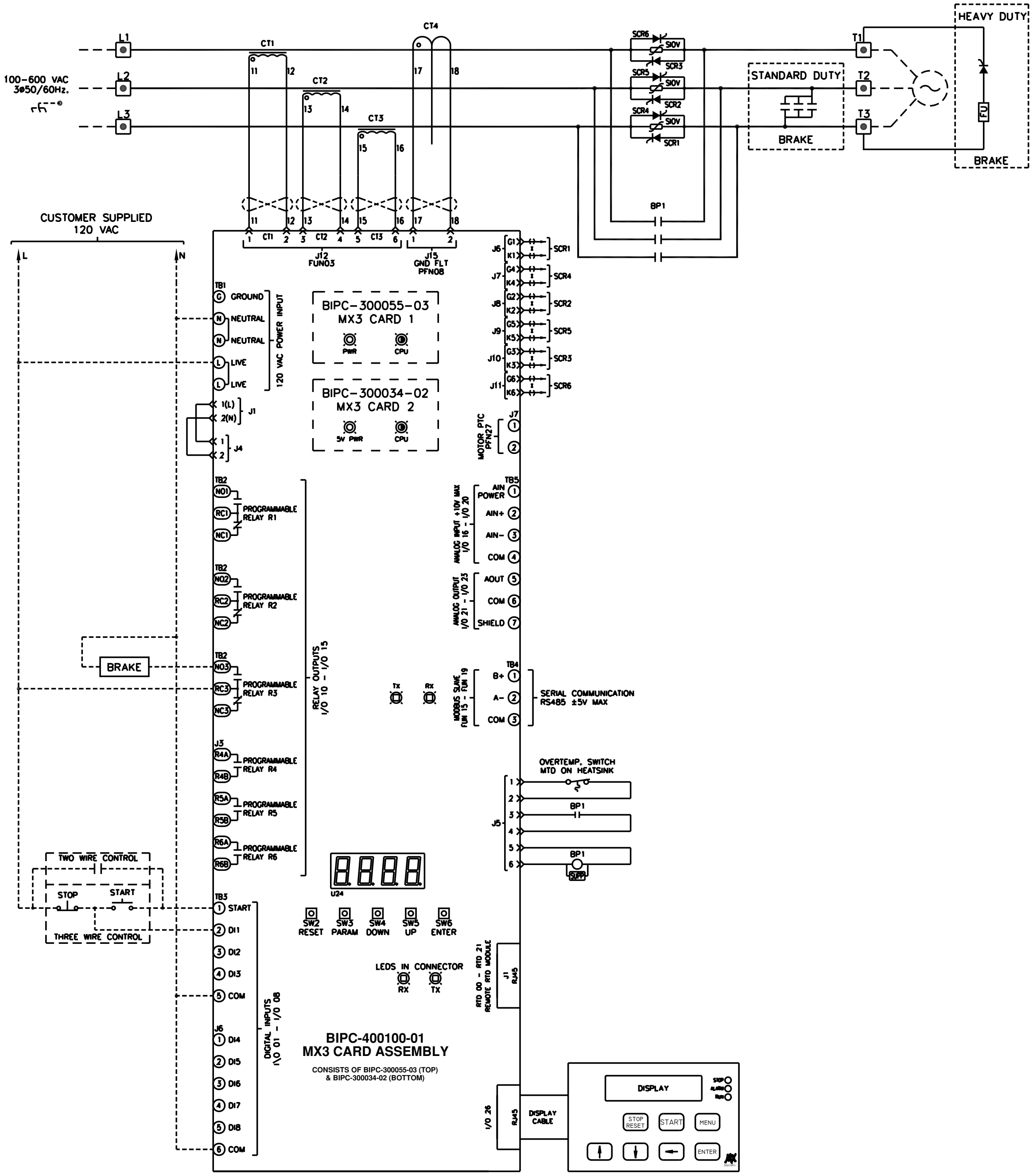
⌘ **NOTE:** Verify that the correct output relay is programmed to Braking and that the wiring of this relay is correct. Damage to the starter can result if the braking relay is not programmed and/or wired properly.

7.5.4 Stand Alone Overload Relay for emergency ATL (Across The Line) Operation

Due to the currents being drawn on Line 1 and Line 3 for braking, this stand alone overload relay will cause nuisance current imbalance trips. For a solution consult factory.

7.5.5 DC Injection Brake Wiring Example

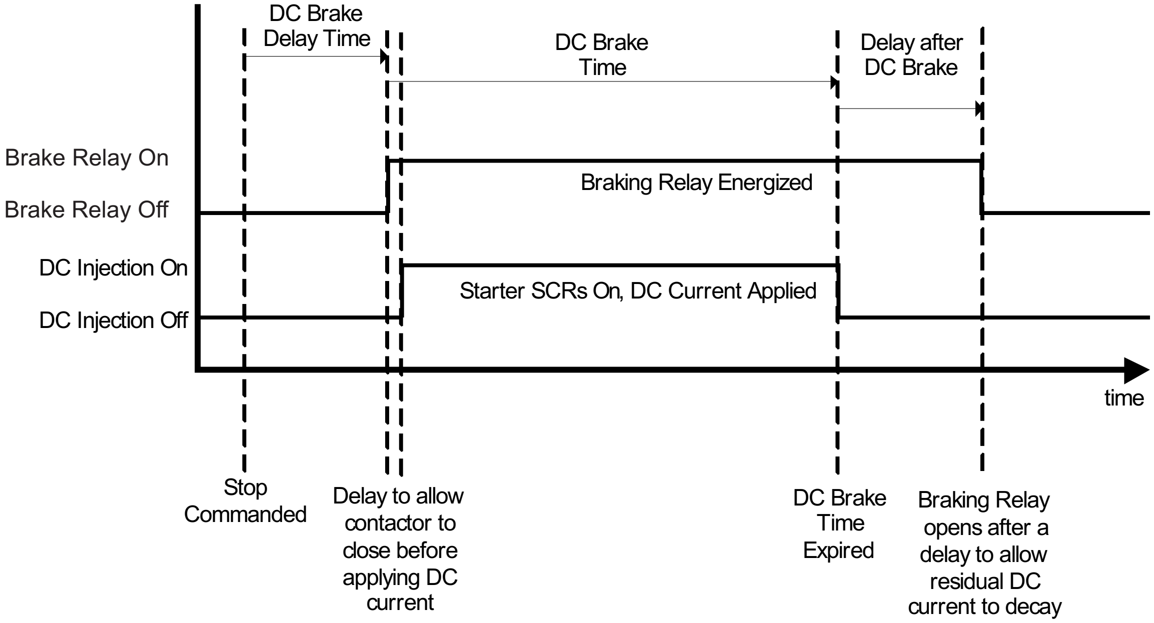
Figure 47: DC Injection Brake Wiring Example



7.5.6 DC Brake Timing

The MX^3 DC injection brake timing is shown below:

Figure 48: DC Injection Brake Timing



After the DC Brake Time has expired, the Braking Relay is held energized to allow the DC current to decay before opening the freewheel path. This delay prevents a contactor (if used) from having to open significant DC current which greatly prolongs the life of the contactor. This delay time is based on motor FLA, the larger the motor the longer the delay time. The delay after DC brake time is approximately:

Motor FLA	Delay after DC Brake Time
10 A	0.4 seconds
100 A	0.8 seconds
500 A	2.3 seconds
1000 A	4.3 seconds

Motor Overload Calculations During DC Injection Braking

During DC braking the MX^3 Solid State Motor Overload Protection is fully active. During braking the Running Motor overload setting is used. The MX^3 adjusts the overload calculations based on whether Standard Duty or Heavy Duty braking is used. The overload calculations are also adjusted based on whether the standard Current Transformers (CTs) are used for current feedback or if the optional Hall Effect Current sensor is used for current feedback.

⌘ **NOTE:** Discretion must be used when DC injection braking. Motor heating during DC injection braking is similar to motor heating during starting. Although the Motor OL is active (if it has not been intentionally disabled), excessive rotor heating could still result if the load inertia is very large, braking level is high, or the brake time is set too long. Caution must be used to assure that the motor has the thermal capacity to brake the desired load in the desired period of time without excessive heating.

7.5.7 DC Injection Brake Enable and Disable Digital Inputs

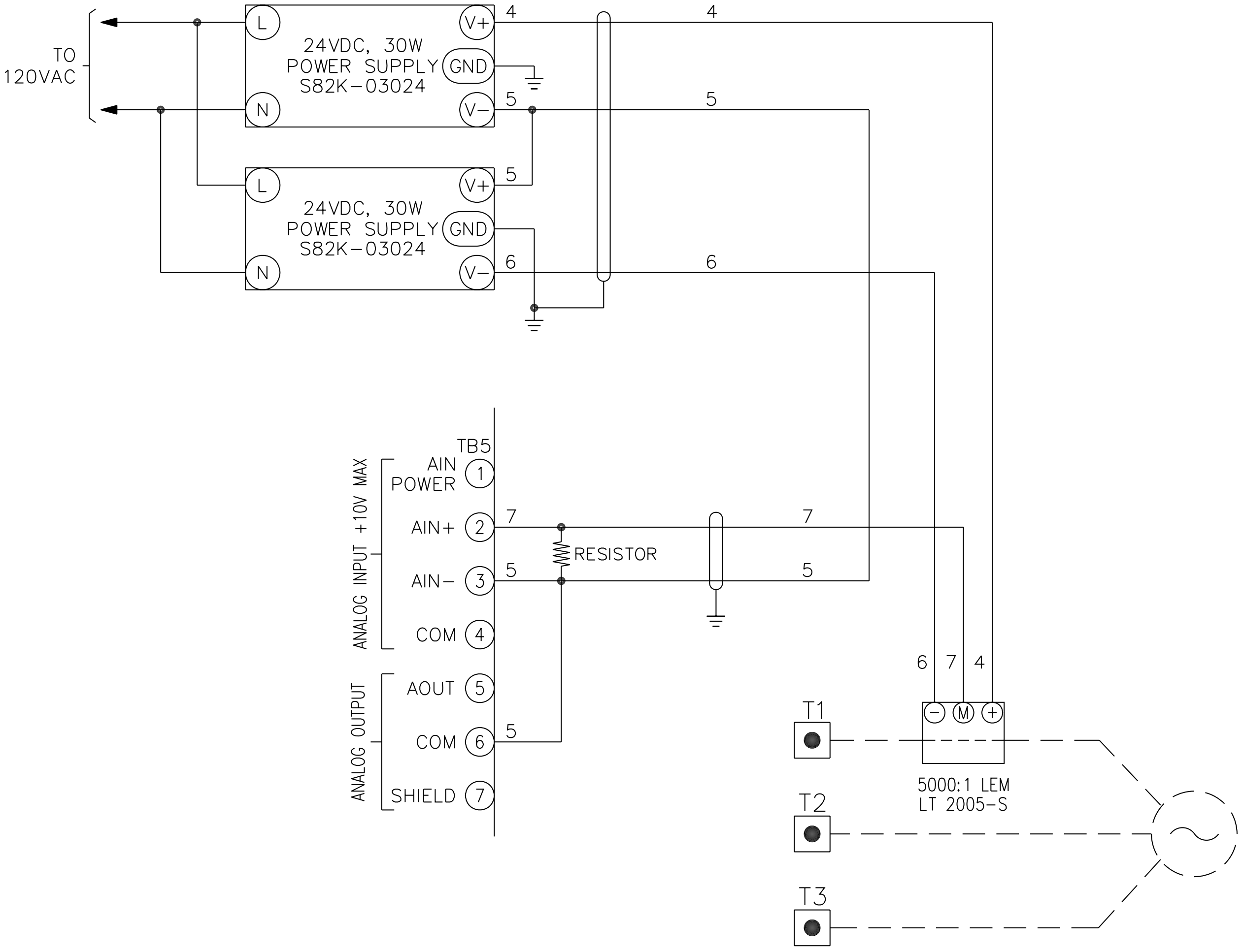
Digital inputs can be programmed to either a Brake enable or a Brake Disable. In the Brake Enable case the digital input must be energized for DC braking to occur. The braking will immediately stop if the brake enable is de-energized.

In the Brake Disable case, DC braking will occur unless the Brake Disable digital input is energized. DC braking will cease if the brake disable is energized.

Once DC Braking is stopped due to a digital input state change, no further DC braking will take place and the starter will return to the idle state.

7.5.8 Use of Optional Hall Effect Current Sensor

The Hall Effect Current Sensor should be located on Phase 1 of the motor output wiring. The sensor should be located so that the sensor measures both the applied DC current from the starter as well as the freewheel current. The sensor is connected to the analog input of the MX^3 card along with a burden resistor. The analog input must be set to be a 0-10V voltage input for correct operation. The sensor scaling and burden resistance are factory selected. Please consult factory if changes to either the sensor scaling or burden resistance is required.



⌘ **NOTE:** Hall effect current sensor must be used when load inertia exceeds motor manufactures recommended specifications.

7.5.9 DC Injection Braking Parameters

Brake Level:	The DC Brake Level parameter sets the level of DC current applied to the motor during braking. The desired brake level is determined by the combination of the system inertia, system friction, and the desired braking time. If the motor is braking too fast the level should be reduced. If the motor is not braking fast enough the level should be increased.
Brake Time:	The DC Brake Time parameter sets the time that DC current is applied to the motor. The desired brake time is determined by the combination of the system inertia, system friction, and the desired braking level. If the motor is still rotating faster than desired at the end of the brake time increase the brake time if possible. If the motor stops before the desired brake time has expired decrease the brake time to minimize unnecessary motor heating.
Brake Delay:	The DC Brake Delay Time is the time delay between when a stop is commanded and the DC braking current is applied to the motor. This delay allows the residual magnetic field and motor counter EMF to decay before applying the DC braking current. If a large surge of current is detected when DC braking is first engaged increase the delay time. If the delay before the braking action begins is too long then decrease the delay time. In general, low horsepower motors can utilize shorter delays while large horsepower motor may require longer delays.

Slow Speed Cyclo Converter

7.6 Slow Speed Cyclo Converter

The MX^3 Soft Starter implements a patented Slow Speed algorithm that can be used to rotate a three-phase AC motor, with control of the stator current, at speeds less than the rated synchronous speed of the motor. The algorithm is used with a standard three-phase six-switch SCR based soft starter. The advantages of the MX^3 starter algorithm over other "jogging" techniques are that: the low speed motor rotation is done without any additional hardware such as additional mechanical contactors and/or extra SCRs, the peak phase currents are reduced compared with other jogging techniques, motor heating is minimized, and higher shaft torque can be generated.

7.6.1 Operation

Slow speed forward and reverse operation is achieved by energizing a digital input that has been programmed to either Slow Speed Forward or Slow Speed Reverse (refer to the Digital Input Configuration parameters on page 111 for more information). The active control source (Local Source or Remote Source) must be set to terminal. Slow Speed Start/Stop control is not available from the LCD keypad. The starter must be in the idle state in order to enter slow speed operation.

Relay outputs can be programmed to energize during slow speed operation (refer to the Relay Output Configuration parameters on page 112 for more information). This feature can be used to disable mechanical brakes or energize clutches during slow speed operation.

Motor Overload Calculations During Slow Speed Operation
During Slow Speed Operation the MX^3 Solid State Motor Overload Protection is fully active. During slow speed operation the Running Motor overload setting is used.

⌘ **NOTE:** When the motor is operating at slow speeds its cooling capacity can be greatly reduced. Therefore the running time of the motor at a given current level is dependant on the motor's thermal capacity. Although the Motor OL is active (if it has not been intentionally disabled) during slow speed operation it is recommended that the motor temperature be monitored if slow speed is used for long periods of time.

7.6.2 Slow Speed Cyclo Converter Parameters

Slow Speed:	The Slow Speed parameter selects the speed of motor operation when slow speed is selected. When set to "Off", slow speed operation is disabled.
Slow Speed Current Level:	The Slow Speed Current Level parameter selects the level of current applied to the motor during slow speed operation. The parameter is set as a percentage of motor full load amps (FLA). This value should be set to the lowest possible current level that will properly operate the motor.
Slow Speed Time Limit:	The Slow Speed Time Limits parameter sets the amount of time that continuous operation of slow speed may take place. When this parameter is set to "Off" the timer is disabled. This parameter can be used to limit the amount of continuous slow speed operation to protect the motor and/or load. ⌘ **NOTE:** The Slow Speed Time Limit includes the time used for the Slow Speed Kick if kick is enabled. ⌘ **NOTE:** The Slow Speed Time Limit resets when the motor is stopped. This timer does not prevent the operator from stopping and re-starting the motor which can result in the slow speed operation time of the motor being exceeded.
Slow Speed Kick Level:	The Slow Speed Kick Level sets the short-term current level that is applied to the motor to accelerate the motor for slow speed operation. The Slow Speed Kick feature is disabled if it is set to "Off". Slow Speed Kick can be used to "break loose" difficult to start loads while keeping the operating slow speed current level lower. This parameter should be set to a midrange value and then the Slow Speed Kick Time should be increased in 0.1 second intervals until the kick is applied long enough to start the motor rotating. If the motor does not start rotating with the set Slow Speed Kick Level increase the level and begin adjusting the kick time from 1.0 seconds again. If the motor initially accelerates too fast then reduce the Slow Speed Kick Level and/or reduce the Slow Speed Kick Time.
Slow Speed Kick Time:	The Slow Speed Kick Time parameter sets the length of time that the Slow Speed Kick current level is applied to the motor at the beginning of slow speed operation. After the Slow Speed Kick Level is set, the Slow Speed Kick Time should be adjusted so that the motor starts rotating when a slow speed command is given. If the motor initially accelerates too fast then reduce the Slow Speed Kick Level and/or reduce the Slow Speed Kick Time.

Inside Delta Connected Starter

7.7 Inside Delta Connected Starter

There are differences between a line connected soft starter as shown in Figure 49 and the inside delta connected soft starter as shown in Figure 50 that need to be considered.

By observation of Figure 50, access to all six stator-winding terminals is required for an inside delta application. For a 12-lead motor, all 12 stator terminals must be accessible. In the line connected soft starter of Figure 49, access to only three leads of the stator windings of the motor is required.

One failed SCR on any phase of the inside delta soft starter results in a single-phase condition. A shunt trip circuit breaker is recommended to protect the motor in this case. A programmable relay can be configured as a shunt trip relay and can be used to trip the breaker. When certain faults occur, the shunt trip relay energizes.

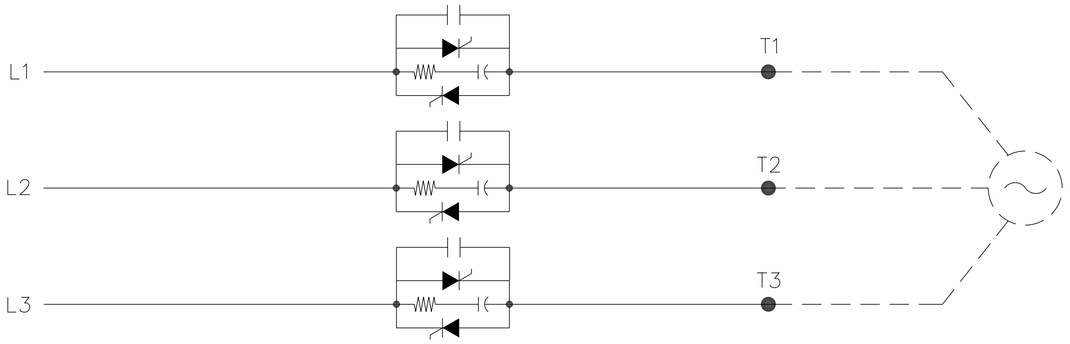
The SCR control for an inside delta application is different than the SCR control for a standard soft starter. The Starter Type parameter needs to be properly set so that the SCRs are gated correctly.

If a circuit breaker is the only means to disconnect the soft starter and motor from the line, then one leg of the motor leads in the inside delta soft starter is always electrically live when the circuit breaker is closed. This requires caution to ensure these leads of the motor are not exposed to personnel.

7.7.1 Line Connected Soft Starter

In Figure 49, the power poles of the soft starter are connected in series with the line. The starter current equals the line current.

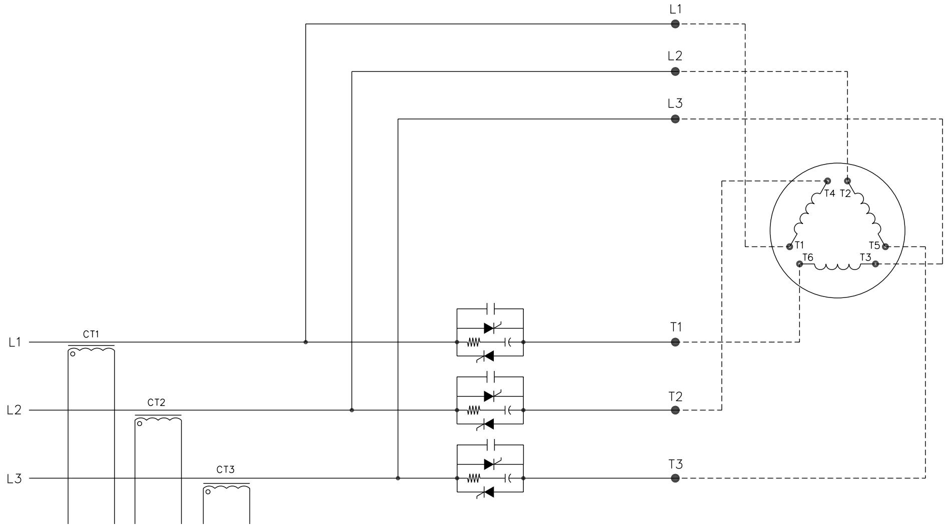
Figure 49: Typical Motor Connection



7.7.2 Inside Delta Connected Starter

An inside delta connected soft starter is shown in Figure 50, where the power poles are connected in series with the stator windings of a delta connected motor.

Figure 50: Typical Inside Delta Motor Connection



NOTE: Current Transformers MUST be installed to measure the full line current and never installed so they measure the current inside the delta connection.

For an inside delta connected motor, the starter current is less than the line current by a factor of 1.55 (FLA/1.55). By comparison of Figure 49 and Figure 50, the most obvious advantage of the inside delta starter is the reduction of current seen by the soft starter. The soft starter can be downsized by a factor of 1.55, providing significant savings in cost and size of the starter.

An inside delta soft starter can also be considered for motors with more than 6 leads, including 12 lead dual voltage motors.

NEMA and IEC use different nomenclature for motor terminal markings, for 3 and 6 leaded motors.
NEMA labels motors leads, 1,2,3,4,5,6,
IEC labels motor leads, U1, V1, W1, U2, V2, W2

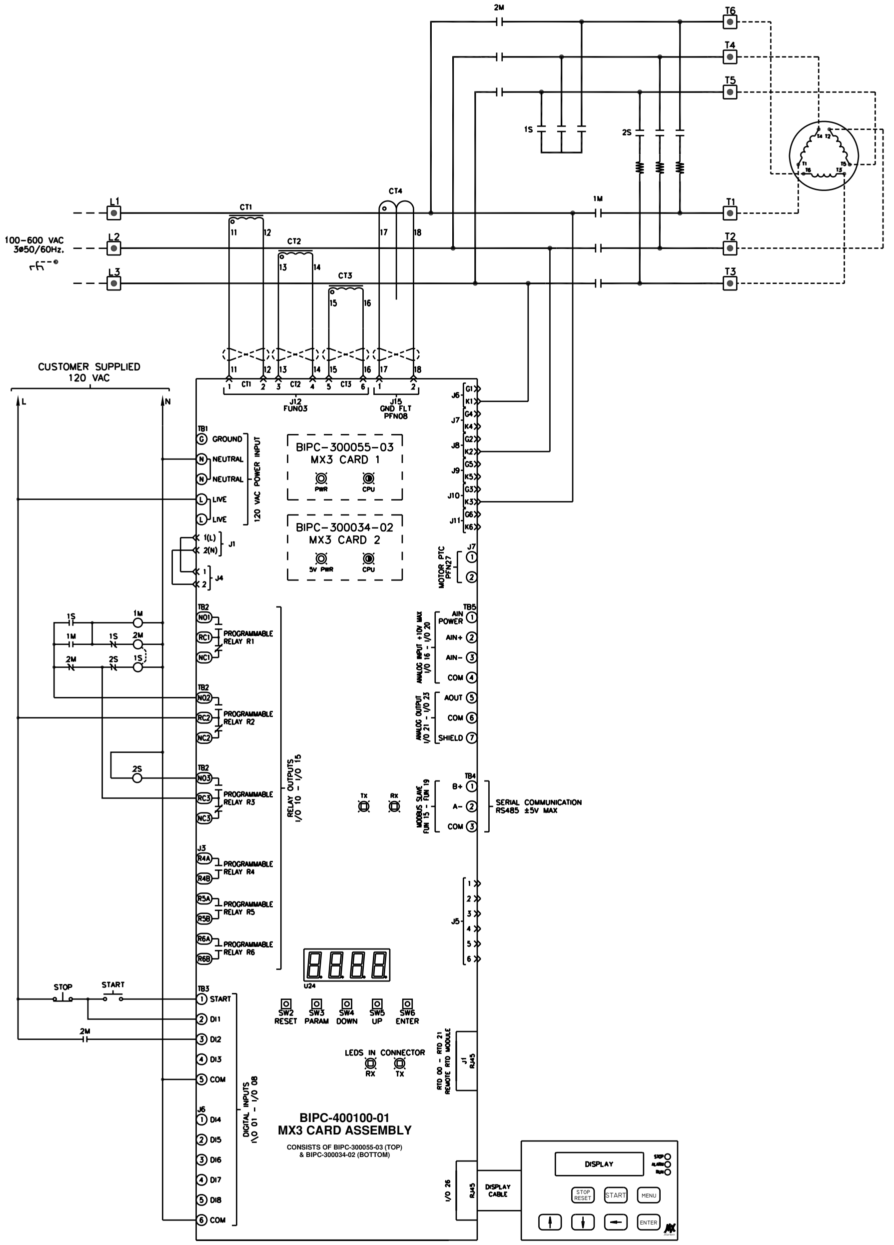
Wye Delta Starter

7.8 Wye Delta Starter

When the Starter Type parameter is set to Wye-Delta, the MX^3 is configured to operate an electro mechanical Wye-Delta (Star-Delta) starter. When in Wye-Delta mode, all MX^3 motor and starter protective functions except bad SCR detection and power stack overload, are available to provide full motor and starter protection.

A typical closed transition Wye-Delta starter schematic is shown in the figure below.

Figure 51: Wye Delta Motor Connection to the MX^3



The MX^3 utilizes an intelligent Wye to Delta transition algorithm. During starting, if the measured motor current drops below 85% of FLA and more than 25% of the Up To Speed timer setting has elapsed, then a Wye to Delta transition occurs. The intelligent transition algorithm prevents unnecessarily long motor starts which reduces motor heating. If a Wye to Delta transition has not already occurred, a transition always occurs when the complete Up To Speed Time expires.

The MX^3 can operate two configurations of Wye-Delta starters, open transition and closed transition. An open transition starter momentarily disconnects the motor from the input line during the transition from Wye to Delta operating mode. A closed transition starter uses resistors that are inserted during the transition so that the motor is never completely disconnected from the input line. The presence of the resistors in a closed transition starter smooths the transition. A typical closed transition Wye-Delta starter schematic is shown in Figure 51 on page 168.

The closed transition resistors generally are sized to be in the circuit for a short period of time. To protect the resistors from over heating, one input should be programmed as a Bypass/2M contact feedback input and the Bypass/2M confirm parameter must be set.

For the Wye-Delta starter mode to operate properly one output relay needs to be programmed to the RUN output function and another output relay needs to be programmed to the UTS output function. (Refer to the Relay Output Configuration parameters on page 112 for more information).

Based on the typical closed transition schematic shown in Figure 51, when a start command is given, the starter enters the Wye starting mode by energizing the relay programmed as RUN.

The transition to Wye (Starting) mode occurs as follows:

1. Start command is given to the starter.
2. The RUN relay is energized which energizes the 1S contactor.
3. When the 1S contactor pulls in, the 1M contactor is energized.

The MX^3 starter remains in the Wye mode until either:

1. The start command is removed.
2. The Up To Speed Time expires.
3. The measured motor current is less than 85% of FLA and more than 25% of the Up To Speed Timer setting has elapsed.
4. A fault occurs.

When the Up To Speed Time expires, the starter changes from Wye starting mode to the Delta or normal running mode by energizing the relay programmed as UTS. In Delta mode, the RUN and UTS relays are both energized and the motor is connected in the normal running Delta configuration.

The transition to Delta (Run) mode occurs as follows:

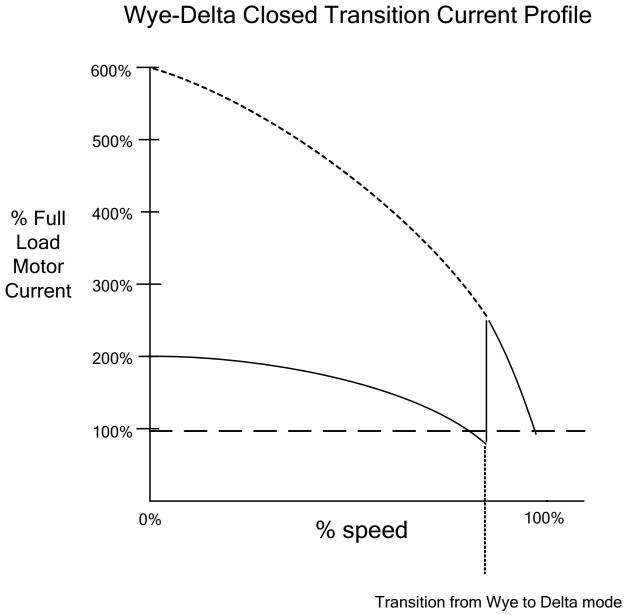
1. The UTS relay is energized which energizes the 2S contactor.
2. When the 2S contactor pulls in, resistors are inserted in the circuit and the 1S contactor is de-energized.
3. When the 1S contactor drops out the 2M contactor is energized.
4. When the 2M contactor is pulled in, feedback can be sent to the MX^3 control card to confirm that the transition sequence to Delta is complete.

The starter remains in the Delta or running mode until the start command is removed or a fault occurs.

Usually the MX^3 intelligent Wye to Delta transition algorithm provides an optimal transition point that minimizes the transient current and torque surges that can occur. However, the Wye to Delta transition will occur when the Up To Speed Time parameter has expired. In order to reduce the current surge during the transition from Wye to Delta mode, the Up To Speed Time parameter should be adjusted so that the transition occurs as close to full speed as possible within the constraints of the load. If the Up To Speed Time is set too short the starter will transition too soon and a large current and torque surge will occur. If the Up To Speed Time is set too long, the motor may not have sufficient torque to continue accelerating when in Wye mode and may stop accelerating at a low speed until the transition to Delta mode occurs. If this occurs, the start is unnecessarily prolonged and motor heating is increased.

A typical closed transition Wye-Delta starting current profile is shown in Figure 52.

Figure 52: Wye Delta Profile



A digital input can be programmed as a 2M contactor feedback input. This input provides verification that the 2M contactor has fully closed preventing operation when the transition resistors are still connected in the motor circuit. The use of this feedback is recommended to prevent the overheating of the transition resistors if the 2M contactor does not close properly. The 2M confirmation trip time can be adjusted by modifying the Bypass Feedback Time parameter.

⌘ **NOTE**: When in Wye-Delta mode, the acceleration ramp, kick, and deceleration settings have no effect on motor operation.

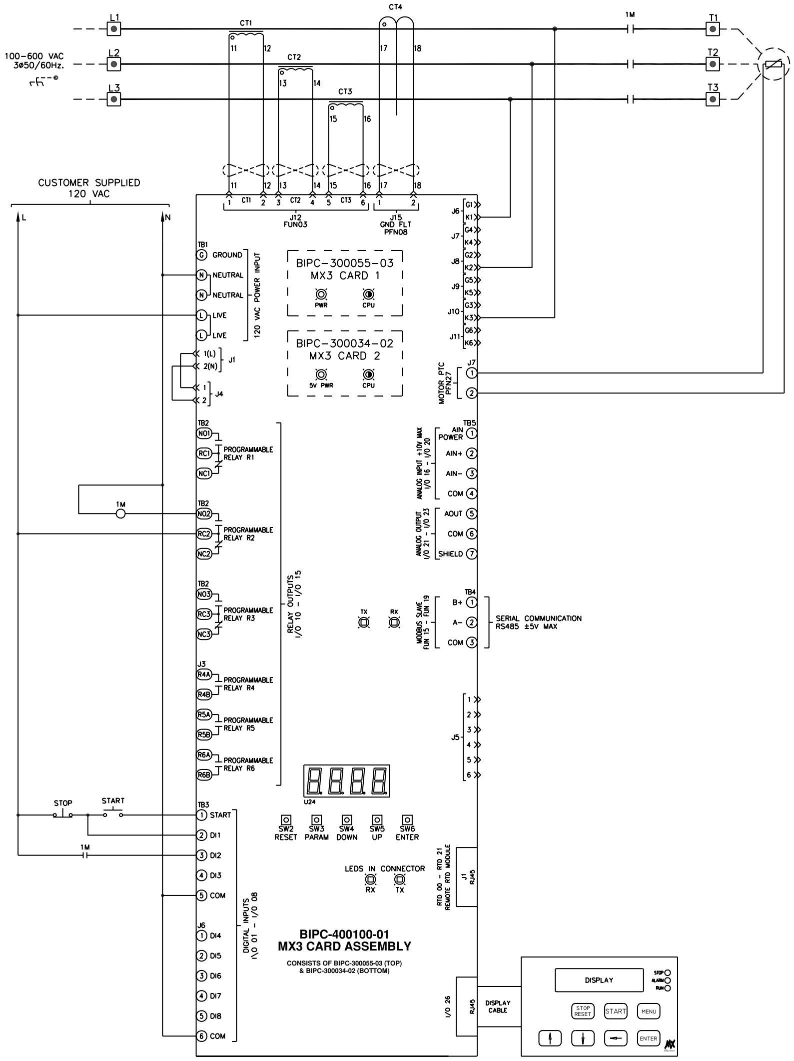
⌘ **NOTE:** When in Wye-Delta mode, the SCR gate outputs are disabled.

7.9 Across The Line (Full Voltage Starter)

When the Starter Type parameter is set to ATL, the MX^3 is configured to operate an electro mechanical full voltage or across-the-line (ATL) starter.

In the ATL configuration, the MX^3 assumes that the motor contactor (1M) is directly controlled by an output relay that is programmed to RUN. Therefore, when a start command is given, the RUN programmed relay energizes the motor contactor, which applies power to the motor. When the MX^3 determines that the motor is at full speed, the up-to-speed (UTS) condition is indicated by energizing the UTS programmed relays. When configured as an ATL starter, all MX^3 motor and starter protective functions, except bad SCR detection and power stack overload, are available to provide full motor and starter protection.

Figure 53: A Typical ATL Starter Schematic with the MX^3



⌘ **NOTE:** When in ATL mode, the acceleration ramp, kick, and deceleration parameter settings have no effect on motor operation.

⌘ **NOTE:** When in ATL mode, the SCR gate outputs are disabled.

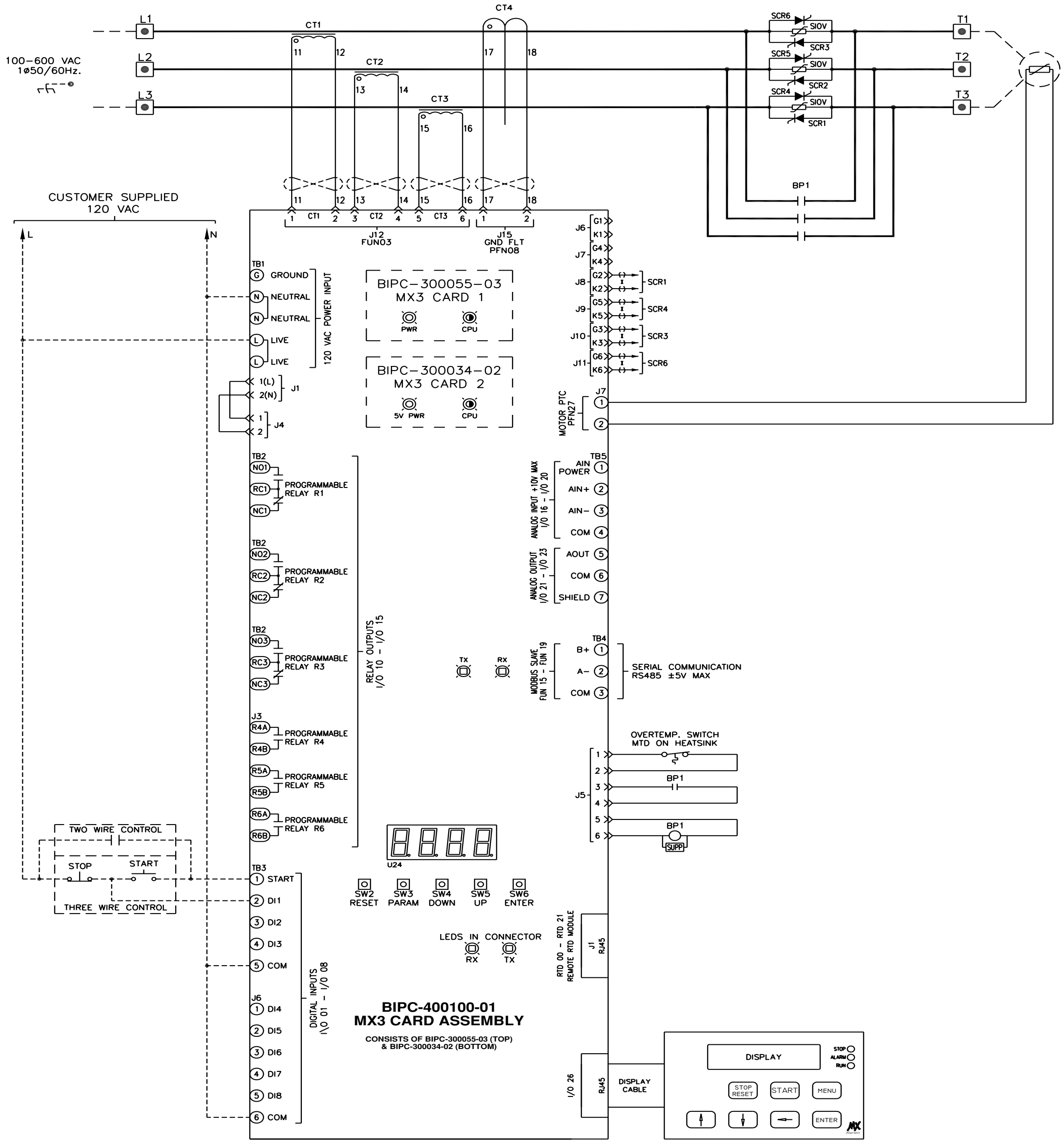
Single Phase Soft Starter

7.10 Single Phase Soft Starter

There are times a single phase motor may need to be started using a soft starter. This can be accomplished with any 3 phase starter with the following modifications to the starter.

- Connect Line power to terminals L1 and L3.
- Remove gate leads from J8 and J9 and tie off so the leads will not touch anything.
- Remove gate leads from J6 and reinstall to J8, from J7 and reinstall to J9,
- Change Input Phase Sensitivity, FUN04 to "SPH" Single Phase.
- Connect motor to terminals T1 and T3.

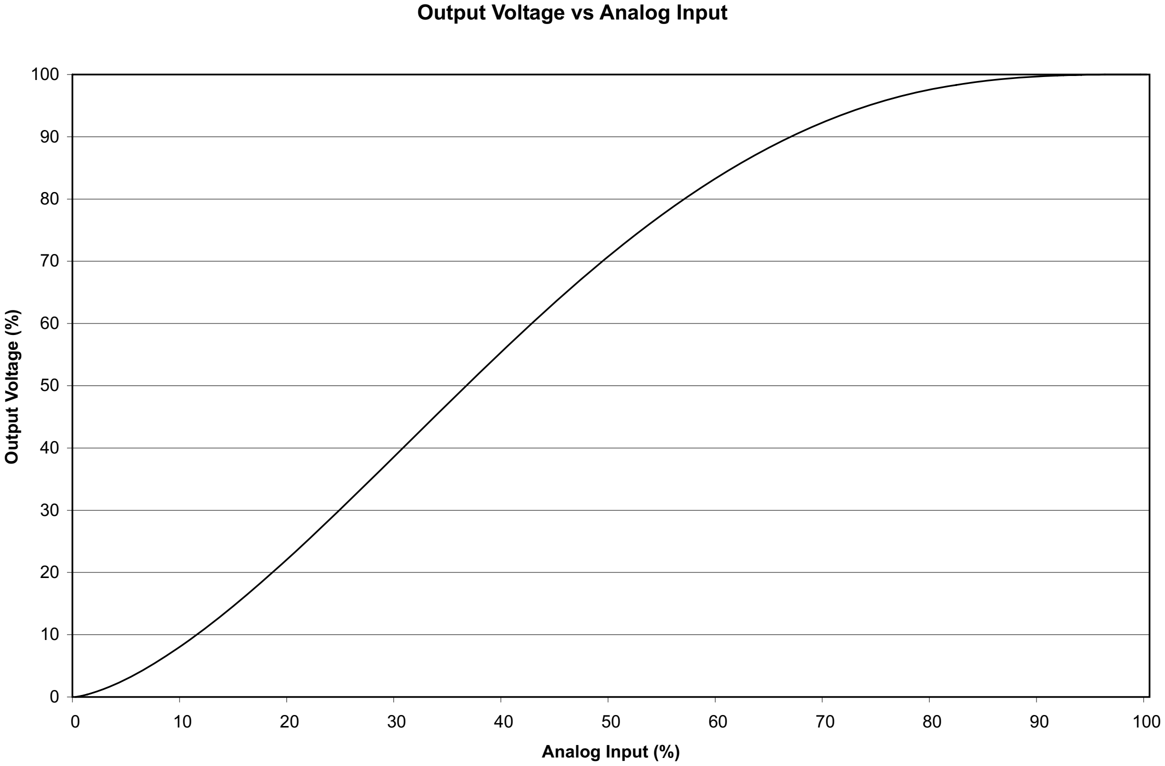
Figure 54: Power Schematic for RB3 Integral Bypass Power Stack for Single Phase Operation



7.11 Phase Control

When the Starter Type parameter (FUN07) is set to Phase Control, the MX^3 is configured to operate as a phase controller or voltage follower. This is an open loop control mode. When a start command is given, the RUN programmed relays energize. The firing angles of the SCRs are directly controlled based on voltage or current applied to the Analog Input.

Figure 55: Phase Control Mode



A reference input value of 0% results in no output. A reference input value of 100% results in full (100%) output voltage. The actual input voltage / current that results in a given output can be adjusted through the use of the Analog Input Offset and the Analog Input Span parameters.

⌘ **NOTE:** The power stack must be rated for continuous non-bypassed duty in order to operate in Phase Control mode continuously, NO BYPASS.

⌘ **NOTE:** When operating in Phase Control mode, the acceleration ramp, kick, and deceleration settings have no effect on operation.

⌘ **NOTE:** When in Phase Control mode the following motor / starter protective functions are available:

- Current Imbalance
- Over Current
- Current while Stopped
- Under Current
- Over Voltage
- Under Voltage
- Motor OL
- Residual Ground Fault
- Instantaneous Over Current (IOC)
- Phase Rotation
- Phase Loss
- Under Frequency
- Over Frequency

7.11.1 Phase Controller:

Phase control can be used to directly control the voltage applied to motors, resistive heaters, etc. When in Phase Control mode, the phase angle of the SCRs, and hence the voltage applied, is directly controlled based on the analog input signal. The MX^3 reference command can be generated from any 0-10V, 0-20mA or similar source, such as a potentiometer, another MX^3 or an external controller such as a PLC.

7.11.2 Master/Slave Starter Configuration:

In the master / slave configuration, one "master" starter can directly control the output of one or more "slave" starters. To utilize the master / slave configuration, one starter needs to be defined as the "master" starter. The Starter Type parameter of the "master" starter should be configured appropriately as a Soft Starter (normal or ID), Phase Controller or Current Follower. If configured as a soft starter, the acceleration and deceleration profiles need to be configured for proper operation.

To configure a master / slave application:

1. The analog output of the master MX^3 control card needs to be connected to the analog input(s) of the slave card(s).

2. The master MX^3 analog output needs to be configured. Set the Analog Output Function parameter to option 10 or "0 - 100% firing". The Analog Output Span parameter should be set to provide a 0-10V or 0-20 milliamp output to the slave starter(s). Adjust analog output jumper (JP1) to provide either a voltage or a current output. Set the slave MX^3 Starter Type parameter to Phase Control and verify that the Analog Input Offset and Analog Input Span parameters are set to accept the master signal.

3. The slave MX^3 needs to be provided with a start command from the master MX^3. A RUN programmed relay from the master MX^3 can be used to provide the start command to the slaves. The slave(s) Control Source parameters (Local Source and Remote Source) settings need to be set appropriately.

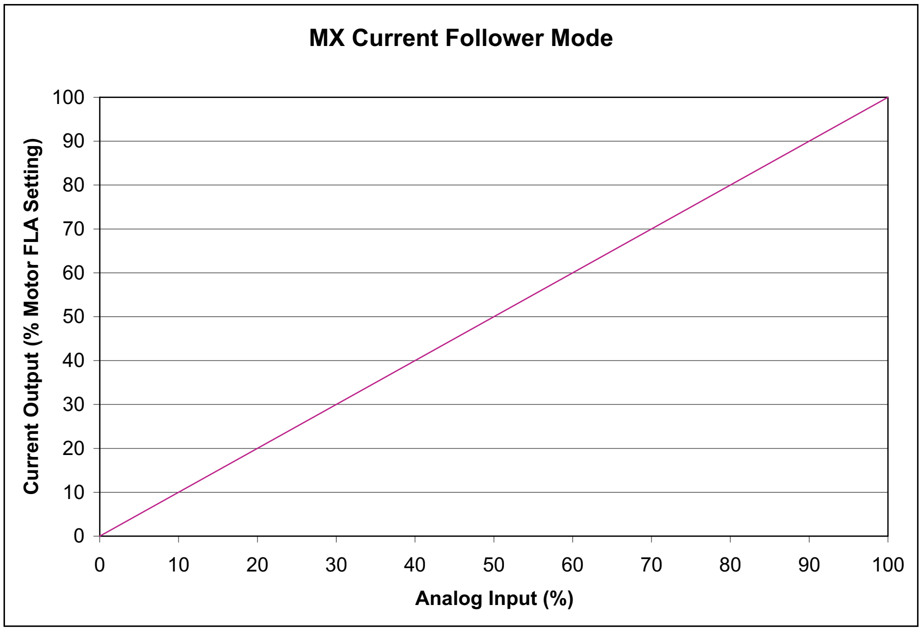
4. The slave MX^3 analog input(s) needs to be configured for the appropriate voltage or current input signal type. Set the analog input jumper (SWI-1) to the desired input type.

For additional master/slave application information, consult the factory.

7.12 Current Follower

When the Starter Type parameter (FUN 07) is set to Current Follower, the MX^3 is configured to operate as a Closed Loop current follower. Current Follower mode can be used to control the current applied to motors, resistive heaters, etc. The Current Follower mode uses the analog input to receive the desired current command and controls the SCRs to output the commanded current. The MX^3 reference command can be generated from any 0-10V, 0-20mA or 4-20mA source such as a potentiometer, another MX^3 or an external controller such as a PLC.

Figure 56: Current Follower Mode



A reference input value of 0% results in no output. A reference input value of 100% results in a current output equal to the Motor FLA setting. The actual voltage or current input that results in a given output can be adjusted through the use of the Analog Input Offset and Analog Input Span parameters.

⌘ **NOTE:** The power stack must be rated for continuous non-bypassed duty in order to operate in Current Follower mode.

⌘ **NOTE:** When operating in Current Follower mode, the acceleration ramp, kick, and deceleration settings have no effect on operation.

⌘ **NOTE:** The following motor / starter protective functions are available when in Current Follower mode:

- Current Imbalance
- Over Current
- Under Current
- Over Voltage
- Under Voltage
- Over Frequency
- Under Frequency
- Phase Loss
- Phase Rotation
- Current while Stopped
- Motor OL
- Residual Ground Fault
- Instantaneous Over Current (IOC)

Start/Stop Control with a Hand/Off/Auto Selector Switch

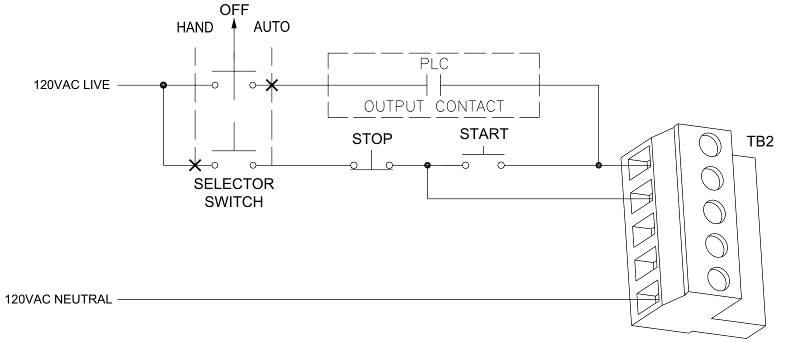
7.13 Start/Stop Control with a Hand/Off/Auto Selector Switch

Often times, a switch is desired to select between local or "Hand" mode and remote or "Auto" mode. In most cases, local control is performed as 3-wire logic with a normally open, momentary contact Start pushbutton and a normally closed, momentary contact Stop pushbutton, while remote control is performed as 2-wire logic with a "Run Command" contact provided by a PLC.

The MX^3 can perform both 2-wire start/stop logic and 3-wire start/stop logic. With 2-wire logic, the starter starts when a run command is applied to the Start input. It continues to run until the run command is removed from the Start input. With 3-wire logic, the starter starts when a start command is momentarily applied to the Start input and continues to run until an input programmed as a Stop input goes low.

The MX^3 automatically determines whether to use 2-wire logic or 3-wire logic by the presence of a high level on a Stop input. If there is an input programmed as a Stop input, and that input is high when the Start input goes high, then 3-wire start/stop logic is used. Otherwise, 2-wire start/stop logic is used. This feature eliminates the need for external logic relays often used to "seal in" the momentary Start and Stop pushbuttons, creating a 2-wire logic signal. The key is to have the Stop input be high when the Hand/Off/Auto switch is in the Hand position, but be low when the switch is in the Auto position. The following wiring diagram illustrates a possible implementation. In this example, DI 1 on the MX^3 is programmed as a Stop input.

Figure 57: Example of Start/Stop with a Hand/Off/Auto Selector Switch



When the Hand/Off/Auto selector switch is in the Hand position, current flows to the Stop push button contact and to the Stop input on the MX^3. If the Stop is not pressed and the Start push button is pressed the starter starts. This is a typical 3-wire control. The seal for the Start push button input is accomplished in software. When the stop is pressed, the starter stops.

When the Hand/Off/Auto selector switch is in the Auto position, current flows to the user supplied run contact, but the Stop input remains low. When the user supplied run contact closes, and the stop input is low (no power applied) the starter is in 2-wire control.

CAUTION: It is important that the Stop push button be wired in front of the Start push button, otherwise the starter could be started when the Stop bush button is pressed and the Start button is pressed.

Simplified I/O Schematics

7.14 Simplified I/O Schematics

Figure 58: Digital Input Simplified Schematic

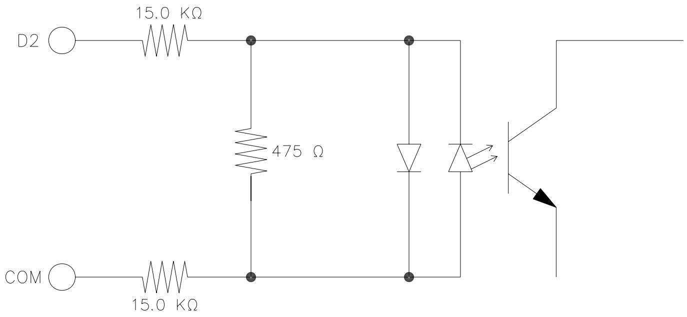


Figure 59: Analog Input Simplified Schematic

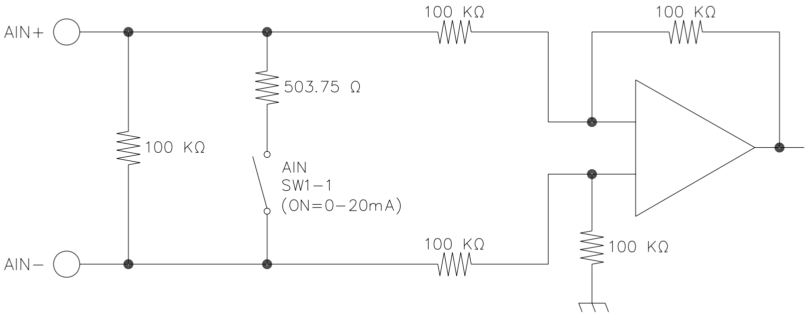
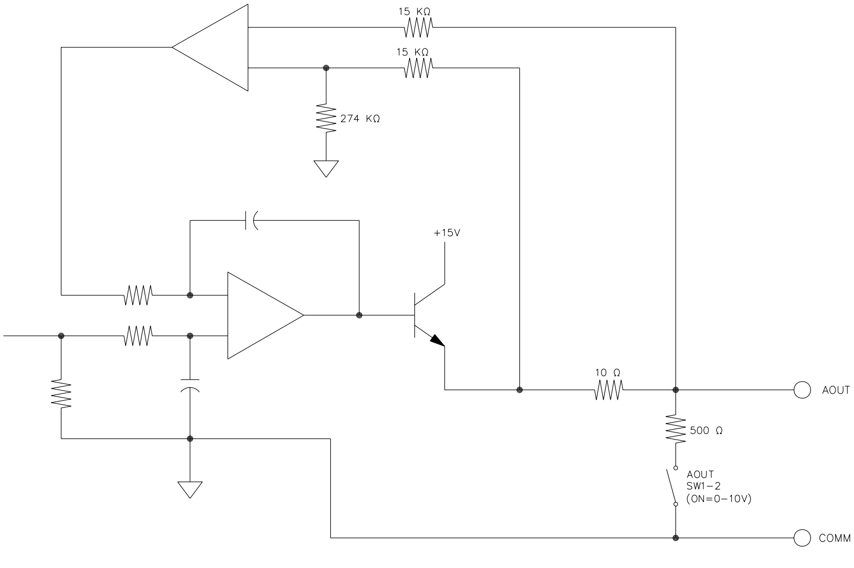


Figure 60: Analog Output Simplified Schematic



Remote Modbus Communications

7.15 Remote Modbus Communications

The MX^3 starter provides Modbus RTU to support remote communication.

The communication interface is RS-485, and allows up to 247 slaves to be connected to one master (with repeaters when the number of drops exceeds 31). Please refer to Figures 62 and 61 for connection diagrams.

7.15.1 Supported Commands

The MX^3 supports the following Modbus commands:

- Read Holding Registers (03 hex)
- Read Input Registers (04 hex)
- Preset Single Register (06 hex)
- Preset Multiple Registers (10 hex)

Up to 64 registers may be read or written with a single command.

7.15.2 Modbus Register Addresses

The Modbus specification defines holding registers to begin at 40001 and input registers to begin at 30001. Holding registers may be read and written. Input registers may only be read.

In the MX^3, the register maps are identical for both the holding registers and the input registers. For example, the Motor FLA (QST 01) parameter is available both in holding register 40101 and in input register 30101. This is why the register addresses in the Modbus Register Map are listed with both numbers (e.g. 30101/40101).

7.15.3 Cable Specifications

Good quality twisted, shielded communications cable should be used when connecting to the Modbus port on the MX^3. The cable should contain two twisted pairs and have an overall shield. Use one pair of conductors for the A(-) and B(+) signals. Use the other pair of conductors for the Common signal. The cable should adhere to the following specifications.

- Conductors: 2 twisted pair
- Impedance: 100 Ohm to 120 Ohm
- Capacitance: 16 pF/ft or less
- Shield: Overall shield or individual pair shields

Examples of cables that meet these specifications are Belden part number 9842 and Alpha Wire part number 6412.

7.15.4 Terminating Resistors

The MX^3 does not have a terminating resistor for the end of the trunk line. If a terminating resistor is required, the resistor must be wired to the terminal block.

The purpose of terminating resistors is to eliminate signal reflections that can occur at the end of a network trunk line. In general, terminating resistors are not needed unless the bit rate is very high, or the network is very long. In fact, terminating resistors place a large load on the network and may reduce the number of drops that may be placed on the network.

The maximum baudrate of 19,200 supported by the MX^3 is not high enough to warrant a terminating resistor unless the network is extremely long (3,000 feet or more). A terminating resistor should only be installed on the MX^3 if signal reflection is known to be a problem and only if the MX^3 is at the end of the network. Terminating resistors should never be installed on nodes that are not at the end of the network.

7.15.5 Grounding

RS-485 buses with isolated nodes are most immune to noise when the bus is not connected to earth ground at any point. If electrical codes require that the bus be connected to earth ground, then the Common signal should be connected to earth ground at one point and one point only. If the Common signal is connected to earth ground at more than one point, then significant currents can flow through the Common signal when earth ground potentials are different at those points. This can cause damage to devices attached to the bus.

7.15.6 Shielding

The shield should be continuous from one end of the trunk to the other. The shield must be tied to the RS-485 Common signal at one point and one point only. If the shield is not tied to Common at any point or is tied to Common at more than one point, then its effectiveness at eliminating noise is greatly reduced.

7.15.7 Wiring

Figure 62 shows the wiring of TB4 to a Modbus-485 Network. If the starter is the end device in the network, a 120Ω, 1/4W terminating resistor may be required. Please refer to Figure 61 for wire and termination practices.

Figure 62: TB4 Connector

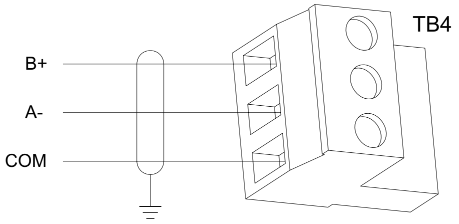
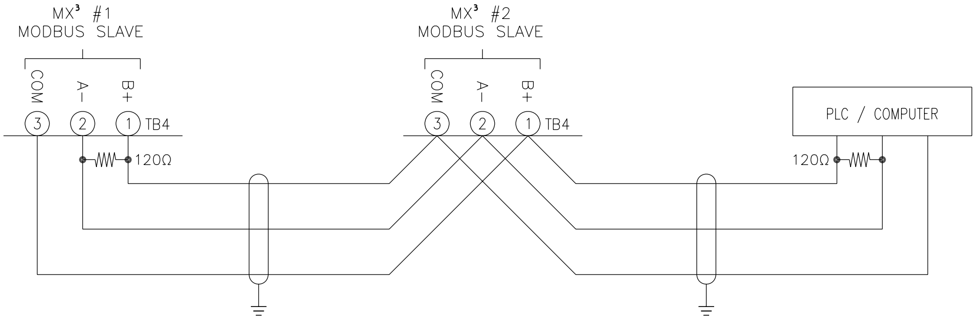


Figure 61: Modbus Network Wiring Example



NOTES:

8

Troubleshooting & Maintenance

8 - TROUBLESHOOTING & MAINTENANCE

Safety Precautions

8.1 Safety Precautions

For safety of maintenance personal as well as others who might be exposed to electrical hazards associated with maintenance activities, the safety related work practices of NFPA 70E, Part II, should always be followed when working on electrical equipment. Maintenance personnel must be trained in the safety practices, procedures, and requirements that pertain to their respective job assignments.

WARNING: To avoid shock hazard, disconnect main power before working on controller/starter, motor or control devices such as start/stop pushbuttons. Procedures which require parts of the equipment to be energized during troubleshooting, testing, etc, must be performed by properly qualified personnel, using appropriate work practices and precautionary measures as specified in NFPA70, Part II.

CAUTION: Disconnect the controller/starter from the motor before measuring insulation resistance (IR) of the motor windings. Voltages used for insulation resistance testing can cause failure of SCR's. Do not make any measurements on the controller with an IR tester (megger).

Preventative Maintenance

8.2 Preventative Maintenance

8.2.1 General Information

Preventative maintenance performed on a regular basis will help ensure that the starter continues to operate reliably and safely. The frequency of preventative maintenance depends upon the type of maintenance and the installation site's environment.

⌘ **NOTE:** A trained technician should always perform preventative maintenance.

8.2.2 Preventative Maintenance

During Commissioning:
- Torque all power connections during commissioning. This includes factory wired equipment.
- Check all of the control wiring in the package for loose connections.
- If fans are installed, ensure proper operation.

One month after the starter has been put in operation:
- Re-torque all power connections. This includes factory wired equipment.
- Inspect the cooling fans to ensure proper operation.

After the first month of operation:
- Re-torque all power connections every year.
- Clean any accumulated dust from the starter using a clean source of compressed air.
- Inspect the cooling fans every three months to ensure proper operation.
- Clean or replace any air vent filters on the starter every three months.

⌘ **NOTE:** If mechanical vibrations are present at the installation site, inspect the electrical connections more frequently.

8.3 General Troubleshooting Charts

The following troubleshooting charts can be used to help solve many of the more common problems that may occur.

8.3.1 Motor does not start, no output to motor

Condition	Cause	Solution
Display Blank, CPU Heartbeat LED on MX^3 board not blinking.	Control voltage absent.	Check for proper control voltage input. Verify fuses and wiring.
	MX^3 control board problem.	Consult factory.
Fault Displayed.	Fault Occurred.	See fault code troubleshooting table for more details.
Start command given but nothing happens.	Start/Stop control input problems.	Verify that the start/stop wiring and start input voltage levels are correct.
	Control Source parameters (QST 04-05) not set correctly.	Verify that the parameters are set correctly.
NOL or No Line is displayed and a start command is given, it will fault in F28.	No line voltage has been detected by the MX^3 when a start command is given.	Check input supply for inline contactor, open disconnects, open fuses, open circuit breakers, or disconnected wiring.
		Verify that the SCR gate wires are properly connected to the MX^3 control board.
		On medium voltage systems, verify wiring of the voltage feedback measurement circuit.
		See fault code troubleshooting table for more details.

8.3.2 During starting, motor rotates but does not reach full speed

Condition	Cause	Solution
Fault Displayed.	Fault Occurred.	See fault code troubleshooting table for more details.
Display shows Accel or Run.	Maximum Motor Current setting (QST07) set too low.	Review acceleration ramp settings.
	Motor loading too high and/or current not dropping below 175% FLA indicating that the motor has not come up to speed.	Reduce load on motor during starting.
	Motor FLA (QST01) or CT ratio (FUN03) parameter set incorrectly.	Verify that Motor FLA and CT ratio parameters are set correctly.
	Abnormally low line voltage.	Fix cause of low line voltage.
	A mechanical or supplemental brake is still engaged.	Verify that any external brakes are disengaged.
Motor Hums before turning.	Initial current to low.	Increase initial current.
	FLA or CT incorrect.	Verify FLA and CTs settings.

8.3.3 Starter not accelerating as desired

Condition	Cause	Solution
Motor accelerates too quickly.	Ramp time 1 (QST08) too short.	Increase ramp time.
	Initial current (QST06) set too high.	Decrease Initial current.
	Maximum current (QST07) set too high.	Decrease Maximum current.
	Kick start current (CFN11) too high.	Decrease or turn off Kick current.
	Kick start time (CFN12) too long.	Decrease Kick time.
	Motor FLA (QST01) or CT ratio (FUN03) parameter set incorrectly.	Verify that Motor FLA and CT ratio parameters are set correctly.
	Starter Type parameter (FUN07) set incorrectly.	Verify that Starter Type parameter is set correctly.
Motor accelerates too slowly.	Maximum Motor Current setting (QST07) set too low.	Review acceleration ramp settings.
	Motor loading too high.	Reduce load on motor during starting.
	Motor FLA (QST01) or CT ratio (FUN03) parameter set incorrectly.	Verify that Motor FLA and CT ratio parameters are set correctly.
	Abnormally low line voltage.	Fix cause of low line voltage.
	Ramp time to long.	Decrease ramp time.

8.3.4 Starter not decelerating as desired

Condition	Cause	Solution
Motor stops too quickly.	Decel Time (CFN18) set too short.	Increase Decel Time.
	Decel Begin and End Levels (CFN16 and CFN17) set improperly.	Increase Decel Begin and/or Decel End levels.
Decel time seems correct but motor surges (oscillates) at beginning of deceleration cycle.	Decel Begin Level (CFN16) set too high.	Decrease Decel Begin Level until surging is eliminated.
Decel time seems correct but motor stops before end of deceleration cycle.	Decel End Level (CFN17) set too low.	Increase Decel End Level until motor just stops at the end of the deceleration cycle.
Water hammer still occurs at end of cycle.	Decel End Level (CFN17) set too high.	Decrease Decel End Level until water hammer is eliminated.
	Decel Time (CFN18) too short.	If possible, increase Decel Time to decelerate system more gently.
Motor speed drops sharply before decel.	Decel begin level (CFN16) too low.	Increase the Decel Begin Level until drop in speed is eliminated.

8.3.5 Motor stops unexpectedly while running

Condition	**Cause**	**Solution**
Fault Displayed.	Fault Occurred.	See fault code troubleshooting table for more details.
Ready Displayed.	Start command lost.	Verify start command input signal is present or serial communications start command is present.
		Check any permissive that may be wired into the run command. (Start/Stop)
Display Blank, Heartbeat LED on MX^3 card not blinking.	Control voltage absent.	Check for proper control voltage input. Verify wiring and fuses.
	MX^3 control card problem.	Consult factory.

8.3.6 Metering incorrect

Condition	Cause	Solution
Power Metering not reading correctly.	CTs installed or wired incorrectly.	Verify correct CT wiring and verify that the CTs are installed with all the White dots towards the input line side. CT1=L1 CT2=L2 CT3=L3
	CT ratio parameter (FUN03) set incorrectly.	Verify that the CT ratio parameter is set correctly.
PF Meter not reading correctly.	CTs installed or wired incorrectly.	Verify correct CT wiring and verify that the CTs are installed with all the White dots towards the input line side.
Motor Current or Voltage meters fluctuating with steady load.	Energy Saver active.	Turn off Energy Saver if not desired.
	Loose connections.	Shut off all power and check all connections.
	SCR fault.	Verify that the SCRs gate leads are connected properly and the SCRs are ok.
	Load actually is not steady.	Verify that the load is actually steady and that there are not mechanical issues.
	Other equipment on same power feed causing power fluctuations and/or distortion.	Fix cause of power fluctuations and/or distortion.
Voltage Metering not reading correctly.	In medium voltage systems, Rated Voltage parameter (FUN05) set incorrectly.	Verify that Rated Voltage parameter is set correctly.
Current Metering not reading correctly.	CT ratio parameter (FUN03) set incorrectly.	Verify that the CT ratio parameter is set correctly.
	CTs installed or wired incorrectly.	Verify correct CT wiring and verify that the CTs are installed with all the White dots towards the input line side.CT1=L1 CT2=L2 CT3=L3
Residual Ground Fault Current Metering not reading correctly.	CT ratio parameter (FUN03) set incorrectly.	Verify that the CT ratio parameter is set correctly.
	CTs installed or wired incorrectly.	Verify correct CT wiring and verify that the CTs are installed with all the White dots towards the input line side.CT1=L1 CT2=L2 CT3=L3
Zero Sequence GF Metering not reading correctly.	CT installed or wired incorrectly.	Verify CT Installation.

8.3.7 Other Situations

Condition	Cause	Solution
Motor Rotates in Wrong Direction.	Phasing incorrect.	If input phasing correct, exchange any two output wires.
		If input phasing incorrect, exchange any two input wires.
Erratic Operation.	Loose connections.	Shut off all power and check all connections.
Motor Overheats.	Motor overloaded.	Reduce motor load.
	Too many starts per hour.	Allow for adequate motor cooling between starts. Set Hot/Cold ratio higher or lengthen cooling time.
	High ambient temperature.	Reduce ambient temperature or provide for better cooling. Set OL class lower to compensate for ambient temperature.
	Acceleration time too long.	Reduce starting load and/or review acceleration ramp settings.
	Incorrect motor OL settings.	Review and correct motor OL settings.
	Motor cooling obstructed/damaged.	Remove cooling air obstructions. Check motor cooling fan.
Starter cooling fans do not operate. (When Present)	Fan power supply lost.	Verify fan power supply, check fuses.
	Fan wiring problem.	Check fan wiring.
	Fan failure.	Replace fan.
Analog Output not functioning properly.	Voltage/Current output switch(SW1-2) not set correctly.	Set SW1-2 to give correct output.
	Wiring problem.	Verify output wiring.
	Analog Output Function parameter (I/O21) set incorrectly.	Verify that the Analog Output Function parameter is set correctly.
	Analog Output Offset and/or Span parameters (I/O23 and I/O22) set incorrectly.	Verify that the Analog Output Span and Offset parameters are set correctly.
	Load on analog output too high.	Verify load on analog output meets the MX^3 analog output specifications.
	Ground loop or noise problems.	Verify correct grounding of analog output connection to prevent noise and/or ground loops from affecting output.
Remote Keypad does not operate correctly.	Keypad cable not plugged in properly or cable is damaged.	Verify that the remote keypad cable has not been damaged and that it is properly seated at both the keypad and the MX^3 control card.
	Remote display damaged.	Replace remote display.
Cannot change parameters.	Passcode is set.	Clear Passcode.
	Starter is running.	Stop Starter.
	Modbus is overriding.	Stop communications.
	Heater Level (FUN08) parameter is "On".	Turn Heater Level (FUN08) parameter to "Off".

Fault Code Table

8.4 Fault Code Table

The following is a list of possible faults that can be generated by the MX^3 starter control.

Fault Code	Description	Detailed Description of Fault / Possible Solutions
F01	UTS Time Limit Expired	Motor did not achieve full speed before the UTS timer (QST09) expired.
		Check motor for jammed or overloaded condition.
		Verify that the combined kick time (CFN12) and acceleration ramp time (QST08) is shorter than the UTS timer (QST09) setting.
		Evaluate acceleration ramp settings. The acceleration ramp settings may be too low to permit the motor to start and achieve full speed. If so, revise acceleration ramp settings to provide more motor torque during starting.
		Evaluate UTS timer setting and, if acceptable, increase UTS timer setting (QST09).
F02	Motor OL	Check motor for mechanical failure, jammed, or overloaded condition.
		Verify the motor thermal overload parameter settings (QST03 and PFN28 to PFN35,) and motor service factor setting (QST02).
		Verify that the motor FLA (QST01) and CT ratio (FUN03) settings are correct.
		If motor OL trip occurs during starting, review acceleration ramp profile settings.
		Verify that there is not an input line power quality problem or excessive line distortion present.
		Verify that PF caps, if installed, are ahead of CTs.
		Reset overload when content falls below Motor OL Lockout Level (PFN34).
F03	Slow Speed Timer	Increase Slow Speed Timer (CFN25).
F04	Speed Switch Time Limit Expired	Increase Speed Switch Time (PFN 26).
		Accelerate motor faster.
F05	Motor PTC Overtemperature	Verify PTC thermistor specifications.
		Allow motor to cool, this will reset motor PTC thermistors.
		Check motor cooling fan.
		Clean debris off of motor.
		Reduce Overload.
		Reduce high ambient.
F06	Stator RTD Overtemperature	Verify Stator RTD specifications.
		Allow motor to cool.
		Check motor cooling fan.
		Clean debris off of motor.
		Reduce Overload.
		Reduce high ambient.
F07	Bearing RTD Overtemperature	Verify Bearing RTD specifications.
		Replace bearings.
		Reduce load on bearings.
		Reduce high ambient.
		Reduce high vibrations.
F08	Other RTD Overtemperature	Verify Other RTD specifications
		Reduce load.
		Reduce high ambient.

Fault Code	Description	Detailed Description of Fault / Possible Solutions
F10	Phase Rotation Error, not ABC	Input phase rotation is not ABC and Input Phase Sensitivity parameter (FUN04) is set to ABC only.
		Verify correct phase rotation of input power. Correct wiring if necessary.
		Verify correct setting of Input Phase Sensitivity parameter (FUN04).
F11	Phase Rotation Error, not CBA	Input phase rotation is not CBA and Input Phase Sensitivity parameter (FUN04) is set to CBA only.
		Verify correct phase rotation of input power. Correct wiring if necessary.
		Verify correct setting of Input Phase Sensitivity parameter (FUN04).
F12	Low Line Frequency	Line frequency below Under Freq Trip (PFN15).
		Verify input line frequency.
		If operating on a generator, check generator speed governor for malfunctions.
		Check input supply for open fuses or open connections.
		Line power quality problem / excessive line distortion.
F13	High Line Frequency	Line frequency above Over Freq Trip (PFN14).
		Verify input line frequency.
		If operating on a generator, check generator speed governor for malfunctions.
		Line power quality problem / excessive line distortion.
F14	Input power not single phase	Three-phase power has been detected when the starter is expecting single-phase power.
		Verify that input power is single phase.
		Verify that single-phase power is connected to the L1 and L2 inputs. Correct wiring if necessary.
		Verify that the SCR gate wires are properly connected to the MX^3 control card.
F15	Input power not three phase	Single-phase power has been detected when the starter is expecting three-phase power.
		Verify that input power is three phase. Correct wiring if necessary.
		Verify that the SCR gate wires are properly connected to the MX^3 control card.
		On medium voltage systems, verify wiring of the voltage feedback measurement circuit.
F21	Low Line L1-L2	Low voltage below the Under voltage Trip Level parameter setting (PFN11) was detected for longer than the Over/Under Voltage Trip delay time (PFN12).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (FUN05) is set correctly.
		Check input supply for open fuses or open connections.
		On medium voltage systems, verify wiring of the voltage measurement circuit.
F22	Low Line L2-L3	Low voltage below the Under voltage Trip Level parameter setting (PFN11) was detected for longer than the Over/Under Voltage Trip delay time (PFN12).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (FUN05) is set correctly.
		Check input supply for open fuses or open connections.
		On medium voltage systems, verify wiring of the voltage feedback measurement circuit.

Fault Code	Description	Detailed Description of Fault / Possible Solutions
F23	Low Line L3-L1	Low voltage below the Under voltage Trip Level parameter setting (PFN11) was detected for longer than the Over/Under Voltage Trip delay time (PFN12).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (FUN05) is set correctly.
		Check input supply for open fuses or open connections.
		On medium voltage systems, verify wiring of the voltage feedback measurement circuit.
F24	High Line L1-L2	High voltage above the Over voltage Trip Level parameter setting (PFN10) was detected for longer than the Over/Under Voltage Trip delay time (PFN12).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (FUN05) is set correctly.
		Line power quality problems/ excessive line distortions.
F25	High Line L2-L3	High voltage above the Over voltage Trip Level parameter setting (PFN10) was detected for longer than the Over/Under Voltage Trip delay time (PFN12).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (FUN05) is set correctly.
		Line power quality problems/ excessive line distortions.
F26	High Line L3-L1	High voltage above the Over voltage Trip Level parameter setting (PFN10) was detected for longer than the Over/Under Voltage Trip delay time (PFN12).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (FUN05) is set correctly.
		Line power quality problems/ excessive line distortions.
F27	Phase Loss	The MX^3 has detected the loss of one or more input or output phases when the starter was running. Can also be caused by line power dropouts.
		Check input supply for open fuses.
		Check power supply wiring for open or intermittent connections.
		Check motor wiring for open or intermittent connections.
		On medium voltage systems, verify wiring of the voltage feedback measurement circuit.
		Check Gate and Cathode connections to MX^3 card.
F28	No Line	No input voltage was detected for longer than the Inline Configuration time delay parameter setting (I/O24) when a start command was given to the starter.
		If an inline contactor is being used, verify that the setting of the Inline Configuration time delay parameter (I/O24) allows enough time for the inline contactor to completely close.
		Check input supply for open disconnects, open fuses, open circuit breakers or disconnected wiring.
		Verify that the SCR gate wires are properly connected to the MX^3 control card.
		On medium voltage systems, verify wiring of the voltage feedback measurement circuit.
F29	PORT Timeout	PORT fault timer timed out before line power returned.
		Extend PORT fault time parameter (FUN10) if possible.
F30	I.O.C. (Instantaneous Over current)	During operation, the MX^3 detected a very high level of current in one or more phases.
		Check motor wiring for short circuits or ground faults.
		Check motor for short circuits or ground faults.
		Check if power factor or surge capacitors are installed on the motor side of the starter.
		Verify that the motor FLA (QST01) and CT ratio (FUN03) settings are correct.

Fault Code	Description	Detailed Description of Fault / Possible Solutions
F31	Over current	Motor current exceeded the Over Current Trip Level setting (PFN01) for longer than the Over Current Trip Delay Time setting (PFN02).
		Check motor for a jammed or an overload condition.
F34	Undercurrent	Motor current dropped under the Under Current Trip Level setting (PFN03) for longer than the Under Current Trip Delay time setting (PFN04).
		Check system for cause of under current condition.
F35	Power Factor Leading	The motor power factor went above the PF leading trip level.
		Verify loading of motor.
		On synchronous motors, verify field supply current.
F36	Power Factor Lagging	The motor power factor went below the PF lagging trip level.
		Verify loading of motor.
		On synchronous motors, verify field supply current.
F37	Current Imbalance	A current imbalance larger than the Current Imbalance Trip Level parameter setting (PFN05) was present for longer than the curr imbal trip time (PFN06).
		Check motor wiring for cause of imbalance. (Verify dual voltage and 6 lead motors for correct wiring configuration).
		Check for large input voltage imbalances that can result in large current imbalances.
		Check motor for internal problems.
F38	Ground Fault	Ground current above the Ground Fault Trip level setting (PFN07 / PFN08) has been detected for longer than the delay time (PFN09) setting.
		Check motor wiring for ground faults.
		Check motor for ground faults.
		Megger motor and cabling (disconnect from starter before testing).
		Verify that the motor FLA (QST01) and CT ratio (FUN03) settings are correct.
		Verify that the CTs are installed with all the White dots towards the input line.
		In Single phase applications, verify that only two CTs are being used; that they are installed with all the White dots or Xs in the correct direction; and that the CTs are connected to the L1 and L3 CT inputs on the MX^3 control card.
F39	No Current at Run	Motor current went below 10% of FLA while the starter was running.
		Verify Motor Connections.
		Verify the CT wiring to the MX^3 control card.
		Verify that the motor FLA (QST01) and CT ratio (FUN03) settings are correct.
		Check if load is still connected to starter.
		Check if motor may have been driven by the load (a regeneration condition).
		Check Gate and Cathode connections to MX^3 for loose connections.
		Check for inline contactor or disconnect.
F40	Shorted / Open SCR	A shorted or open SCR condition has been detected.
		Verify that all SCR gate leads wires are properly connected at the SCR devices and the MX^3 control card.
		Check all SCRs with ohmmeter for shorts.
		Verify that the Input Phase Sensitivity parameter setting (FUN04) is correct.
		Verify that the Starter Type parameter setting (FUN07) is correct.
		Verify the motor wiring. (Verify dual voltage motors for correct wiring configuration).

Fault Code	Description	Detailed Description of Fault / Possible Solutions
F41	Current at Stop	Motor current was detected while the starter was not running.
		Examine starter for shorted SCRs.
		Examine bypass contactor (if present) to verify that it is open when starter is stopped.
		Verify that the motor FLA (QST01) and CT ratio (FUN03) settings are correct.
F46	Disconnect Open	A signal on the disconnect digital input (I/O01 - I/O08) was not present when a start was commanded.
		Verify that disconnect feedback wiring is correct.
		Verify that disconnect is not faulty.
F47	Stack Protection Fault (stack thermal overload)	The MX^3 electronic power stack OL protection has detected an overload condition.
		Check motor for jammed or overloaded condition.
		Verify that the CT ratio (FUN03) is correct.
		Motor load exceeds power stack rating. Consult factory
F48	Bypass /2M Contactor Fault	A digital input has been programmed as a Bypass/2M Contactor Feedback input and an incorrect bypass feedback has been detected for longer than the Bypass Confirm time parameter setting (I/O25).
		Verify that the bypass/2M contactor coil and feedback wiring is correct.
		Verify that the relay connected to the bypass/2M contactor(s) is programmed as the UTS function (I/O10 - I/O15).
		Verify that the bypass/2M contactor power supply is present (J4).
		Verify that the appropriate Digital Input Configuration parameter (I/O 01 -08) has been programmed correctly.
		Verify that the bypass contactor(s) are not damaged or faulty.
F49	Inline Contactor Fault	The in-line contactor did not close.
		Check wiring to coil of contactor.
		Check feedback wiring from auxiliary contactor to digital input (I/O 01 - 08).
		Check in-line fault delay (I/O24).
F50	Control Power Low	Low control power (below 90V) has been detected while running.
		Verify that the control power input level is correct, especially during starting when there may be significant line voltage drop.
		Check control power transformer tap setting (if available).
		Check control power transformer fuses (if present).
		Check wiring between control power source and starter.
F51	Current Sensor Offset Error	Indicates that the MX^3 control card self-diagnostics have detected a problem with one or more of the current sensor inputs.
		Verify that the motor FLA (QST01) and CT ratio (FUN03) are correct.
		Verify that no actual current is flowing through any of the starter’s CTs when the starter is not running.
		Consult factory if fault persists.
F53	Tachometer Signal Loss	No tachometer signal detected during start or run.
		Verify tachometer wiring and level of signal.
		Verify tachometer Full Speed Voltage (FUN13) setting.
		Extend Tachometer Loss Time (FUN14) to allow time for motor to start turning.
		Increase Initial Current to make sure motor starts turning immediately after the start command is given.

Fault Code	Description	Detailed Description of Fault / Possible Solutions
F54	BIST Fault	The Build In Self Test was cancelled.
		The disconnect (if present) was closed during standard BIST testing.
		Line voltage and/or phase current was detected during standard BIST testing.
		During powered BIST testing the disconnect was opened during testing.
		During powered BIST testing line voltage was lost during testing.
F55	BIST CT Fault	During powered BIST testing the starter detected that one or more CTs are located on the incorrect phases or one or more CT's polarities are reversed.
		Verify CT wiring, positioning and direction.
F56	RTD Open or Shorted	An open or shorted RTD was detected.
		Verify the condition and wiring of the RTD.
F60	External Fault on DI#1 Input	DI # 01 - 08 (I/O 01 - 08) has been programmed as a fault type digital input and the input indicates a fault condition is present.
F61	External Fault on DI#2 Input	
F62	External Fault on DI#3 input	
F63	External Fault on DI#4 input	
F64	External Fault on DI#5 input	
F65	External Fault on DI#6 input	
F66	External Fault on DI#7 input	
F67	External Fault on DI#8 input	Increase Digital Fault Input Trip Time (I/O09).
F71	Analog Input Level Fault Trip.	Based on the Analog Input parameter settings, the analog input level has either exceeded or dropped below the Analog Input Trip Level setting (I/O17) for longer than the Analog Input Trip Delay time (I/O18).
		Measure value of analog input to verify correct reading.
		Verify settings of all Analog Input parameters (I/O16 - I/O20).
		Verify correct positioning of input switch (SW1-1) (Voltage or Current) on the MX^3 control card.
		Verify correct grounding of analog input connection to prevent noise or ground loops from affecting input.
F80	RTD Module Communications Fault	Communications with the RTD module(s) has been lost.
		Verify RS-485 wiring between RTD module(s) and MX^3 card set.
		Verify RTD module 24VDC power supply.
		Verify that the RTD module(s) are set to the same address as the MX^3 module address parameters RTD01 and RTD02.
F81	Keypad Communication Fault	Indicates that communication has been lost with the remote keypad. (This fault normally occurs if the remote keypad is disconnected while the MX^3 control card is powered up.
		Verify that the remote keypad cable has not been damaged and that its connectors are firmly seated at both the keypad and the MX^3 control card.
		Route keypad cables away from high power and/or high noise areas to reduce possible electrical noise pickup.
F82	Modbus Timeout Fault	Indicates that the starter has lost serial communications. Fault occurs when the starter has not received a valid serial communications within the Communication Timeout parameter (FUN18) defined time.
		Verify communication parameter settings (FUN16 - FUN19).
		Check wiring between the remote network and the MX^3 control card.
		Examine remote system for cause of communication loss.

Fault Code	Description	Detailed Description of Fault / Possible Solutions
F84	MX^3 to I/O Card Communication Fault (Interboard fault)	Communication between the two MX^3 cards has been lost.
		Verify that both cards are mounted together and that the mounting hardware is not loose.
		Verify that no foreign matter is located between the two boards.
		Consult factory if fault persists.
F85	I/O Card SW version Fault	Typically occurs when attempting to run a version of application software that is incompatible with the bottom I/O card. Verify that the software is a correct version for the I/O card being used. Consult factory for more details.
F86	I/O Card Current Offset Error	Indicates that the I/O card self-diagnostics have detected a problem with the zero sequence ground fault input.
		If no zero sequence ground fault CT is connected to input, verify that parameters ZS GF Lvl (PFN08) is turned "Off".
		Verify that no current is flowing through the zero sequence ground fault CT.
		Consult factory is fault persists.
F87	I/O Card Error	I/O card has detected a problem with the Real Time Clock operation. Consult factory.
F88	I/O Card Error	I/O card has detected an internal CPU problem. Consult factory.
F89	I/O Card SW Watchdog	I/O card has detected an internal software problem. Consult factory.
F90	I/O Card Error	I/O card has detected an internal CPU problem. Consult factory.
F91	I/O Card Program EPROM Checksum	I/O card has detected an internal CPU problem. Consult factory.
F94	CPU Error – SW Fault	Typically occurs when attempting to run a version of control software that is incompatible with the MX^3 control card hardware being used. Verify that the software is a correct version for the MX^3 control card being used. Consult factory for more details.
		Fault can also occur if the MX^3 control has detected an internal software problem. Consult factory.
F95	CPU Error – Parameter EEPROM Checksum Fault	The MX^3 found the non-volatile parameter values to be corrupted. Typically occurs when the MX^3 is re-flashed with new software.
		Perform a Factory Parameter reset and then properly set all parameters before resuming normal operation.
		If fault persists after performing a Factory Parameter reset, consult factory.
F96	CPU Error	The MX^3 has detected an internal CPU problem. Consult factory.
F97	CPU Error – SW Watchdog Fault	The MX^3 has detected an internal software problem. Consult factory.
F98	CPU Error	The MX^3 has detected an internal CPU problem. Consult factory.
F99	CPU Error – Program EPROM Checksum Fault	The non-volatile program memory has been corrupted.
		Consult factory. Control software must be reloaded in to the MX^3 control card before normal operation can resume.

SCR Testing

8.5 SCR Testing

8.5.1 Resistance

The SCRs in the starter can be checked with a standard ohmmeter to determine their condition.

Remove power from the starter before performing these checks.

- Check from L to T on each phase. The resistance should be over 50k ohms.
- Check between the gate leads for each SCR (red and white twisted pair).
  The resistance should be from 8 to 50 ohms.

⌘ **NOTE:** The resistance measurements may not be within these values and the SCR may still be good. The checks are to determine if an SCR is shorted "L" to "T" of if the gate in an SCR is shorted or open. An SCR could also still be damaged even though the measurements are within the above specifications.

8.5.2 Voltage

When the starter is running, the operation of the SCRs can be confirmed with a voltmeter.

Extreme caution must be observed while performing these checks since the starter has lethal voltages applied while operating.

While the starter is running and up to speed, use an AC voltmeter, check the voltage from "L" to "T" of each phase. The voltage should be less than 1.5 Volts. If the starter has a bypass contactor, the voltage drop should be less than 0.3 volts.

Using a DC voltmeter, check between the gate leads for each SCR (red and white twisted pair). The voltage should between 0.5 and 2.0 volts.

8.5.3 Integral Bypass (RB3)

A voltage check from "L" to "T" of each phase of the RediStart starter should be preformed every 6 months to confirm the bypass contactors are operating correctly.

Extreme caution must be observed while performing these checks since the starter has lethal voltages applied while operating.

While the starter is running and Up to Speed, use an AC voltmeter; check the voltage from "L" to "T" of each phase. The voltage drop across the contactor contacts should be less than 300mV. The bypass should be serviced if the voltage drop is greater that 300mV. It may be necessary to clean the contact tips or replace the contactor.

Built-In Self Test Functions

8.6 Built In Self Test Functions

The MX^3 has two built in self test (BIST) modes. The first test is the standard self test and is used to test many of the basic functions of the starter without line voltage being applied. The second test is a line powered test that is used to verify the current transformer's locations and connections and to test for shorted SCRs/power poles, open or non-firing SCRs/power poles, and ground fault conditions.

8.6.1 Standard BIST Tests

(FUN 22 - Std BIST):

The standard BIST tests are designed to be run with no line voltage applied to the starter. In selected low voltage systems where a disconnect switch is used, the Disconnect Switch must be opened before starting the standard tests. Standard BIST mode can be entered by entering the appropriate value into the Miscellaneous Command (FUN22) user parameter.

CAUTION: In order to prevent backfeeding of voltage through the control power transformer (if used), control power must be carefully applied to the MX^3 control card and contactors so that self testing can occur safely. In low voltage applications, the user must verify that the applied test control power cannot be fed backwards through the system. "Run/Test" isolation switches, test power plugs, and wiring diagrams are available from Benshaw.

CAUTION: In low voltage systems with an inline/isolation contactor. Before the inline test is performed verify that no line voltage is applied to the line side of the inline contactor. Otherwise when the inline test is performed the inline contactor will be energized, applying line voltage to the starter, and a BIST test fault will occur.

The standard BIST tests comprise of:

Step 1 **LCD Display**
Go to parameter (FUN22) - misc commands and press [ENTER].
Press [UP] button until it reads "Std BIST" and press [ENTER].

Std BIST test will commence.

```
FUN: Misc commands
22   Std BIST
```

⌘ **NOTE:** Designed to run with no line voltage applied.

Step 2– RUN relay test and Inline Feedback Test:

In this test, the RUN assigned relays are cycled on and off once and the feedback from an inline contactor is verified. In order to have a valid inline contactor feedback, a digital input needs to be set to Inline Confirm and the input needs to be wired to an auxiliary contact of the inline contactor. The feedback is checked in both the open and closed state. If the feedback does not match the state of the RUN relay within the amount of time set by the Inline Config (I/O24) parameter an “Inline” fault will occur.

```
BIST Mode
Inline Closed
```

```
BIST Mode
Inline Open
```

⌘ **NOTE:** If no digital input is assigned as an Inline Confirm input this test will always pass.

⌘ **NOTE:** If the Inline Config (I/O24) parameter on page 118 is set to "Off" this test will be skipped.

Step 3 – UTS relay test and Bypass Feedback Test:

In this test, the dedicated bypass relay (if assigned) and UTS assigned relays are cycled on and off once and the feedback from a bypass contactor is verified. In order to have a valid bypass contactor feedback, the dedicated bypass confirm input and any other inputs set to bypass confirm needs to be wired to an auxiliary contact of the bypass contactor. The feedback is checked in both the open and closed state. If the feedback does not match the state of the UTS relay within the amount of time set by the Bypass Feedback (I/O25) parameter a “Bypass/2M Fault” will occur.

```
BIST Mode
Bypass Closed
```

```
BIST Mode
Bypass Open
```

⌘ **NOTE**: If the dedicated bypass relay is set to "fan" and if no digital input are assigned as a Bypass Confirm input this test will always pass.

Step 4 – Sequential SCR gate firing (L1+, L1-, L2+, L2-, L3+, L3-):

In this test the SCR gate outputs are sequentially fired starting with the L1+ device(s) and ending with the L3- device(s). This test can be used to verify that the SCR gate leads are connected properly. The gate voltage can be verified using a DC voltage meter or oscilloscope. The voltage on each red and white wire pair should be between 0.5VDC and 2.0VDC.

This test will check all 6 gates separately. The order the BIST will check the gates is as follows: Gate 6, Gate 3, Gate 5, Gate 2, Gate 4, Gate 1. The question mark (?) in the display below refers to which gate is being fired up.

```
BIST Mode
Gate ? on
```

Step 5 – Simultaneous SCR gate firing:

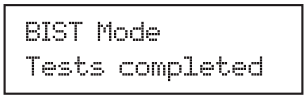
In this test the SCR gate outputs are simultaneously fired (all gates on). This test can be used to verify that the SCR gate leads are connected properly. The gate voltage can be verified using a DC voltage meter or oscilloscope. The voltage on each red and white wire pair should be between 0.5VDC and 2.0VDC.

Pressing [ENTER] on the keypad at any time will abort the current test in progress and proceed to the next BIST test.

During the standard BIST tests if line voltage or phase current is detected, the MX^3 will immediately exit BIST mode and declare a “BIST Abnormal Exit” fault.

```
BIST Mode
All Gates on
```

Step 6



```
BIST Mode
Tests completed
```

8.6.2 Powered BIST Tests

(FUN 22 - Powered BIST):

The powered BIST tests are designed to be run with normal line voltage applied to the starter and a motor connected. Powered BIST verifies that the power poles are good, no ground faults exist, CTs are connected and positioned correctly and that the motor is connected. Powered BIST mode can be entered by entering the appropriate value into the Miscellaneous Command (FUN22) user parameter.

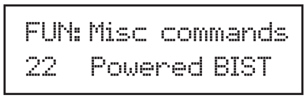
⌘ **NOTE:** The powered BIST test is only for use with SCR based reduced voltage soft starters. Powered BIST can not be used with wye-delta or ATL types of starters.

⌘ **NOTE:** The motor wiring MUST be fully connected before starting the powered BIST tests. Also the motor must be at rest (stopped). Otherwise the powered BIST tests will not function correctly.

⌘ **NOTE:** Before using the powered BIST test function, the following MX^3 user parameters MUST be set for correct operation of the powered BIST test: Motor FLA (QST01), CT Ratio (FUN03), Phase Order (FUN04), Rated Voltage (FUN05), and Starter Type (FUN07).

The powered BIST tests comprise of:

Step 1 **LCD Display**
Go to FUN22- misc commands and press [ENTER].
Increment up to "Powered BIST" and press [ENTER].
Powered BIST test will commence.



```
FUN:Misc commands
22  Powered BIST
```

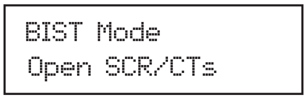
Step 2– Shorted SCR and Ground Fault Test:

In this test each power pole is energized individually. If current flow is detected, the MX^3 controller attempts to differentiate whether it is a shorted SCR/shorted power pole condition or a ground fault condition and either a "Bad SCR Fault" or "Ground Fault" will occur.

```
BIST Mode
Shorted SCR/GF
```

Step 3– Open SCR and Current Transformer (CT) Test

In this test, a low-level closed-loop controlled current is selectively applied to various motor phases to verify that the motor is connected, all SCRs are turning on properly, and that the CTs are wired and positioned properly. If current is detected on the wrong phase then a "BIST CT Fault" fault will be declared. If an open motor lead, open SCR, or non-firing SCR is detected then a "Bad SCR Fault" will occur.



```
BIST Mode
Open SCR/CTs
```

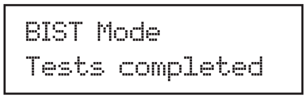
⌘ **NOTE:** When this test is in progress audible humming or buzzing maybe heard from the motor.

Pressing [ENTER] on the keypad at any time will abort the current test in progress and proceed to the next BIST test.

⌘ **NOTE**: If line voltage is lost during the powered tests a "BIST Abnormal Exit" fault will occur.

⌘ **NOTE:** The powered BIST tests will verify that the input phase order is correct. If the measured phase order is not the same as the Phase Order (FUN04) parameter a phase order fault will occur.

Step 4



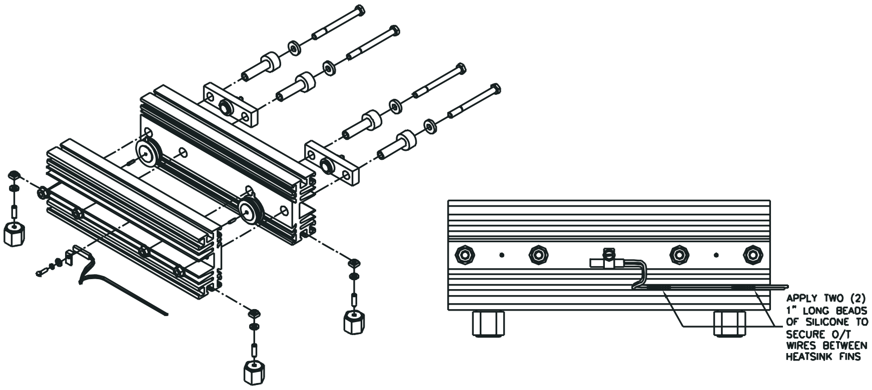
```
BIST Mode
Tests completed
```

SCR Replacement

8.7 SCR Replacement

This section is to help with SCR replacements on stack assemblies. Please read prior to installation.

8.7.1 Typical Stack Assembly



APPLY TWO (2) 1" LONG BEADS OF SILICONE TO SECURE O/T WIRES BETWEEN HEATSINK FINS

8.7.2 SCR Removal

To remove the SCR from the heatsink, loosen the two bolts (3) on the loader bar side of the clamp. Do not turn on the nuts (5). The nuts have a locking ridge that sink into the aluminum heatsink. Do ¼ turns until the SCR comes loose. Remove the SCRs from the heatsink.

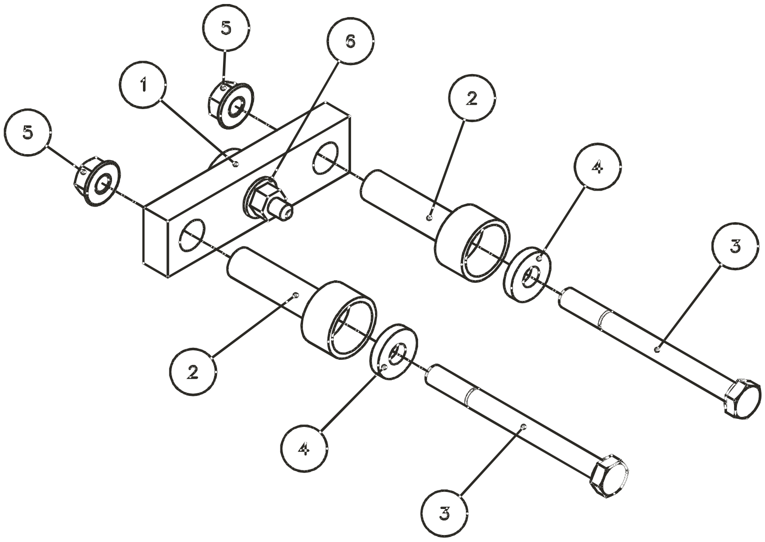
⌘ **NOTE:** Do not loosen nut on indicator washer (6). This will change the clamping pressure of the clamp and the clamp will be defective.

8.7.3 SCR Installation

- Coat the faces of the SCRs to be installed with a thin layer of EJC (Electrical Joint Compound).
- Place the SCRs onto the dowel pins. The top SCR will have the cathode to the left and the bottom SCR will have the cathode to the right. The SCR symbol has a triangle that points to the cathode.
- Finger tighten nuts on the bolts.

8.7.4 SCR Clamp

Below is an exploded view of a typical SCR clamp. Refer to the Clamp Parts List on page 199 for names of the parts being used.



SCR CLAMP PARTS

Item #	Quantity	Description
1	1	Loader Bar
2	2	Insulator cup
3	2	Bolt
4	2	Washer
5	2	Serrated nut (larger style clamp has 1 support bar)
6	1 or 2	Indicator Washer – Quantity dependant on style of clamp

8.7.5 Tightening Clamp

Finger tighten the clamp. Ensure both bolts are tightened an equal amount so that the loader bar (item 1) is square in the heatsink. Tighten the bolts equally in 1/8 turn increments until the indicator washer(s) (item 6), which are under the nut(s) in the center of the loader bar, becomes loose indicating the clamp is tight. On the loader bars with two indicator washers, it may be necessary to tighten or loosen one side of the clamp to get both indicator washers free.

8.7.6 Testing SCR

After the SCRs have been replaced, conduct the resistance test as defined in Section 8.5.

NOTES:

Appendices

Event Codes

** **Event Number 1 through 99** - See starter fault listing for description of faults. The event log will only indicate that a fault of a given fault code occurred and a time stamp when it occurred.

Event Number	Event	Event Number	Event
1 through 99 **	Starter Faults	170	PORT Entered due to low voltage
		171	PORT Entered due to low current
101	Start Commanded	172	PORT Bypass contactor opened
102	Slow Speed Commanded	173	PORT Power returned
103	System UTS	174	PORT Recovery complete
104	Energy Saver Entered		
105	Energy Saver Exited	180	Parameter Defaults Loaded
106	System Stop Commanded	181	Time Set / Changed
107	System Stop Complete	182	User Passcode Enabled
		183	User Passcode Disabled
110	Motor OL Warning	184	Factory Control Password Accessed
111	Motor OL Lockout Activated	185	Event Log Cleared
112	Motor OL Lockout Expired	186	User Run Time Reset
113	Stack OL Warning	187	User KWh meters Reset
114	Stack OL Lockout Activated	188	Reflash Mode Entered
115	Stack OL Lockout Expired	190	System Powered Up
116	Emergency OL Reset Performed	191	System Powered Down
117	RTD Stator Warning	192	Low Control Power Detected when Stopped
118	RTD Bearing Warning	193	Standard BIST Entered
119	RTD Other Warning	194	Powered BIST Entered
		195	BIST Passed
140	Disconnect Opened		
141	Disconnect Closed		

Alarm Codes

The following is a list of all MX alarm codes. The alarm codes correspond to associate fault codes. In general, an alarm indicates a condition that if continued, will result in the associated fault.

Alarm Code	Description	Notes
A02	Motor Overload Alarm	This occurs when the motor thermal content reaches the Motor OL Alarm Level (PFN33). The MX^3 trips when it reaches 100%. The alarm continues until the overload trip lockout is reset.
A05	Motor PTC Alarm	This occurs when the Motor PTC thermistor input indicates that the motor is overheated but before the fault trip time has expired.
A06	Stator RTD Alarm	This occurs when a RTD assigned to the Stator group reaches its alarm level.
A07	Bearing RTD Alarm	This occurs when a RTD assigned to the Bearing group reaches its alarm level.
A08	Other RTD Alarm	This occurs when a RTD assigned to the other group reaches its alarm level.
A10	Phase Rotation not ABC	This alarm exists while the MX^3 is stopped, line voltage is detected and phase sensitivity parameter is set to ABC. If a start is commanded, a Fault 10 occurs.
A11	Phase Rotation not CBA	This alarm exists while the MX^3 is stopped, line voltage is detected and phase sensitivity parameter is set to CBA. If a start is commanded, a Fault 11 occurs.
A12	Low Line Frequency	This alarm exists when the MX^3 has detected a line frequency below the user defined low line frequency level. The alarm continues until either the line frequency changes to be in range or the fault delay timer expires.
A13	High Line Frequency	This alarm exists when the MX^3 has detected a line frequency above the user defined high line frequency level. The alarm continues until either the line frequency changes to a valid frequency or the fault delay timer expires.
A14	Input power not single phase	This alarm exists while the MX^3 is stopped, set to single phase mode, and line voltage is detected that is not single phase. If a start is commanded, a Fault 14 occurs.
A15	Input power not three phase	This alarm exists while the MX^3 is stopped, set to a three-phase mode, and single-phase line voltage is detected. If a start is commanded, a Fault 15 occurs.
A21	Low Line L1-L2	This alarm exists while the MX^3 is stopped and low line voltage is detected. If a start is commanded, a Fault 21 may occur.
A22	Low Line L2-L3	This alarm exists while the MX^3 is stopped and low line voltage is detected. If a start is commanded, a Fault 22 may occur.
A23	Low Line L3-L1	This alarm exists while the MX^3 is stopped and low line voltage is detected. If a start is commanded, a Fault 23 may occur.
A24	High Line L1-L2	This alarm exists while the MX^3 is stopped and high line voltage is detected. If a start is commanded, a Fault 24 may occur.
A25	High Line L2-L3	This alarm exists while the MX^3 is stopped and high line voltage is detected. If a start is commanded, a Fault 25 may occur.
A26	High Line L3-L1	This alarm exists while the MX^3 is stopped and high line voltage is detected. If a start is commanded, a Fault 26 may occur.
A27	Phase Loss	This alarm exists while the MX^3 is running and a phase loss condition is detected, but the delay for the fault has not yet expired. When the delay expires, a Fault 27 occurs.
A28	No Line	This alarm exists while the MX^3 needs to be synchronized or is trying to sync to the line and no line is detected.

Alarm Code	Description	Notes
A29	P.O.R.T. Timeout	This alarm exists while the MX^3 is in Power Outage Ride Through mode and it is waiting for line power to return. When the PORT fault delay expires a Fault 29 shall occur.
A31	Over current	This alarm exists while the MX^3 is running and the average current is above the defined threshold, but the delay for the fault has not yet expired. When the delay expires, a Fault 31 occurs.
A34	Undercurrent	This alarm exists while the MX^3 is running and the average current is below the defined threshold, but the delay for the fault has not yet expired. When the delay expires, a Fault 34 occurs.
A35	Power Factor Leading	This alarm exists while the MX^3 is running and the measured PF is leading the defined threshold, but the delay for the fault has not yet expired. When the delay expires, a Fault 35 occurs.
A36	Power Factor Lagging	This alarm exists while the MX^3 is running and the measured PF is lagging the defined threshold, but the delay for the fault has not yet expired. When the delay expires, a Fault 36 occurs.
A37	Current Imbalance	This alarm exists while the MX^3 is running and a current imbalance above the defined threshold is detected, but the delay for the fault has not yet expired. When the delay expires, a Fault 37 occurs.
A38	Ground Fault	This alarm exists while the MX^3 is running and a ground current above the defined threshold is detected, but the delay for the fault has not yet expired. When the delay expires, a Fault 38 occurs.
A47	Stack Overload Alarm	This occurs when the stack thermal rises above 105%.
A53	Tachometer Signal Loss	This occurs when a non-valid or tachometer input signal is detected. The alarm shall exist until a valid tachometer feedback signal is detected or the fault delay timer has expired. When the delay expires, a Fault 53 shall occur.
A60	External Alarm on DI 1 Input	This alarm shall exist if DI 1 is programmed as a fault, is in the fault state, but the fault timer has not yet expired. When the timer expires a Fault 60 shall occur.
A61	External Alarm on DI 2 Input	This alarm shall exist if DI 2 is programmed as a fault, is in the fault state, but the fault timer has not yet expired. When the timer expires a Fault 61 shall occur.
A62	External Alarm on DI 3 Input	This alarm shall exist if DI 3 is programmed as a fault, is in the fault state, but the fault timer has not yet expired. When the timer expires a Fault 62 shall occur.
A63	External Alarm on DI 4 Input	This alarm shall exist if DI 4 is programmed as a fault, is in the fault state, but the fault timer has not yet expired. When the timer expires a Fault 63 shall occur.
A64	External Alarm on DI 5 Input	This alarm shall exist if DI 5 is programmed as a fault, is in the fault state, but the fault timer has not yet expired. When the timer expires a Fault 64 shall occur.
A65	External Alarm on DI 6 Input	This alarm shall exist if DI 6 is programmed as a fault, is in the fault state, but the fault timer has not yet expired. When the timer expires a Fault 65 shall occur.
A66	External Alarm on DI 7 Input	This alarm shall exist if DI 7 is programmed as a fault, is in the fault state, but the fault timer has not yet expired. When the timer expires a Fault 66 shall occur.
A67	External Alarm on DI 8 Input	This alarm shall exist if DI 8 is programmed as a fault, is in the fault state, but the fault timer has not yet expired. When the timer expires a Fault 67 shall occur.
A71	Analog Input Level Trip Alarm	This alarm exists if the analog input exceeds the defined threshold, but the delay for the fault has not yet expired. When the delay expires, a Fault 71 occurs.

Fault Codes

Fault Code	Description	Controlled Fault Stop	Shunt Trip Fault	Auto-Reset Allowed
F00	No fault	-	-	-
F01	UTS Time Limit Expired	Y	N	Y
F02	Motor Thermal Overload Trip	Y	N	Y
F03	Slow Speed Time Limit Expired	N	N	N
F04	Speed Switch Time Limit Expired	Y	N	Y
F05	Motor PTC Overtemperature	Y	N	Y
F06	Stator RTD Overtemperature	Y	N	Y
F07	Bearing RTD Overtemperature	Y	N	Y
F08	Other RTD Overtemperature	Y	N	Y
F10	Phase Rotation Error, not ABC	N	N	Y
F11	Phase Rotation Error, not CBA	N	N	Y
F12	Low Line Frequency	N	N	Y
F13	High Line Frequency	N	N	Y
F14	Input power not single phase	N	N	Y
F15	Input power not three phase	N	N	Y
F21	Low Line L1-L2	Y	N	Y
F22	Low Line L2-L3	Y	N	Y
F23	Low Line L3-L1	Y	N	Y
F24	High Line L1-L2	Y	N	Y
F25	High Line L2-L3	Y	N	Y
F26	High Line L3-L1	Y	N	Y
F27	Phase Loss	N	N	Y
F28	No Line	N	N	Y
F29	PORT Timeout	N	N	Y
F30	Instantaneous over current (I.O.C.)	N	Y	N
F31	Overcurrent	Y	N	Y
F34	Undercurrent	Y	N	Y
F35	Power Factor Leading	Y	N	Y
F36	Power Factor Lagging	Y	N	Y
F37	Current Imbalance	Y	N	Y
F38	Ground Fault	N	Y	Y
F39	No Current at Run	N	N	Y
F40	Shorted / Open SCR	N	Y	N
F41	Current at Stop	N	Y	N
F46	Disconnect Fault	N	Y	N
F47	Stack Overtemperature / P.S Failure	N	N	Y
F48	Bypass/2M Contactor Fault	Y	N	N
F49	Inline Contactor Fault	Y	N	N
F50	Control Power Low	N	N	Y
F51	Current Sensor Offset Error	N	Y	N
F53	Tachometer Signal Loss	Y	N	N
F54	BIST Fault	N	N	N
F55	BIST CT Fault	N	N	N
F56	RTD Open or Shorted	Y	N	N
F60	External Fault on DI 1 Input	N	N	Y
F61	External Fault on DI 2 Input	N	N	Y
F62	External Fault on DI 3 Input	N	N	Y
F63	External Fault on DI 4 Input	Y	N	Y

Fault Code	Description	Controlled Fault Stop	Shunt Trip Fault	Auto-Reset Allowed
F64	External Fault on DI 5 Input	Y	N	Y
F65	External Fault on DI 6 Input	Y	N	Y
F66	External Fault on DI 7 Input	Y	N	Y
F67	External Fault on DI 8 Input	Y	N	Y
F71	Analog Input #1 Level Fault Trip	Y	N	Y
F80	RTD Module Communication Fault	Y	N	N
F81	Keypad Communication Fault	Y	N	N
F82	Modbus Timeout Fault	Y	N	Y
F84	MX to I/O Card Communication Fault	N	N	N
F85	I/O Card Software version Fault	N	N	N
F86	I/O Card Current Offset Error	N	N	N
F87	I/O Card Error	N	N	N
F88	I/O Card Error	N	N	N
F89	I/O Card Software Watchdog	N	N	N
F90	I/O Card Error	N	N	N
F91	I/O Card Program EPROM Checksum Fault	N	N	N
F94	CPU Error – Software fault	N	N	N
F95	CPU Error – Parameter EEPROM Checksum Fault	N	N	N
F96	CPU Error	N	Y	N
F97	CPU Error - Software Watchdog	N	Y	N
F98	CPU Error	N	N	N
F99	CPU Error – Program EPROM Checksum Fault	N	N	N

Options and Accessories

	Description	Part Number	Size
1)	LCD Display (small)	KPMX3SLCD	H=63mm(2.48"), W=101mm(4")
2)	LCD Display (large)	KPMX3LLCD	H=77mm(3.03"), W=127mm(5")
3)	LCD display cable	RI-100008-00 RI-100009-00	3' or 1 meter 6' or 2 meters
4)	Remote RTD Module	SPR-100P	
5)	Zero Sequence Ground Fault CT	CT-2000/1-6 (CT100001-01)	
6)	Communication Modules	-consult factory	

Spare Parts

	Description	Part Number	Size	Quantity
1)	LCD Display	small = KPMX3SLCD	H=63mm (2.48"), W=101mm (4")	
		large = KPMX3LLCD	H=77mm (3.03"), W=127mm (5")	
2)	LCD Display Cable	short = RI-100008-00 long = RI-100009-00	3' or 1m 6' or 2m	
3)	Remote RTD	SPR-100P		
4)	Cooling Fans		4" – 6"	
5)	Stack O/T Switch			3
6)	Current Transformer (CTs)	CT288:1 CT864:1 CT2640:1 CT5760:1	288:1 864:1 2640:1 5760:1	
7)	Zero Sequence CT	CT-2000/1-6 (CT100001-01)		
8)	MX^3 Assembly	PC-400100-01-02		
9)	DV/DT Board	PC-300048-01-02		3
10)	SCRs	BISCR5016x BISCR10016x BISCR13216x BISCR16116x BISCR25016x		3 / Starter
		BISCR66018x BISCR88018x BISCR150018x		6 / Starter
11)	Contactors	RSC-9-6AC120 RSC-12-6AC120 RSC-18-6AC120 RSC-22-6AC120 RSC-32-6AC120 RSC-40-6AC120 RSC-50-6AC120 RSC-75-6AC120 RSC-85-6AC120 RSC-85/4-6AC-120 RSC-100-4120 RSC-125-4120 RSC-150-4120 RSC-180-4120 RSC-220-4120 RSC-300-4120 RSC-400-4120 RSC-600-4120 RSC-800-4120		

APPENDIX E - EU DECLARATION OF CONFORMITY

EU Declaration of Conformity

According to the EMC – Directive 89/336/EEC as Amended by 92/31/EEC and 93/68/EEC

Product Category: Motor Controller

Product Type: Reduced Voltage Solid State Motor Controller

Model Number:

RB3-1-S-027A-11C	RB3-1-S-096A-13C	RB3-1-S-240A-15C	RB3-1-S-515A-17C
RB3-1-S-040A-11C	RB3-1-S-125A-14C	RB3-1-S-302A-15C	RB3-1-S-590A-18C
RB3-1-S-052A-12C	RB3-1-S-156A-14C	RB3-1-S-361A-16C	RB3-1-S-720A-19C
RB3-1-S-065A-12C	RB3-1-S-180A-14C	RB3-1-S-414A-17C	RB3-1-S-838A-20C
RB3-1-S-077A-13C	RB3-1-S-180A-15C	RB3-1-S-477A-17C	
RC3-1-S-096A-13C	RC3-1-S-240A-15C	RC3-1-S-515A-17C	
RC3-1-S-125A-14C	RC3-1-S-302A-15C	RC3-1-S-590A-18C	
RC3-1-S-156A-14C	RC3-1-S-361A-16C	RC3-1-S-720A-19C	
RC3-1-S-180A-14C	RC3-1-S-414A-17C	RC3-1-S-838A-20C	
RC3-1-S-180A-15C	RC3-1-S-477A-17C		

Manufacturer's Name: Benshaw, Inc.

Manufacturer's Address:
1659 East Sutter Road
Glenshaw, PA 15116
United States of America

The before mentioned products comply with the following EU directives and Standards:

Safety: UL 508 Standard for Industrial Control Equipment covering devices for starting, stopping, regulating, controlling, or protecting electric motors with ratings of 1500 volts or less.

Electromagnetic Compatibility:
EN 50081-2 Emissions Radiated/Conducted
EN 55011/05.98+A1:1999
EN 50082-2 Immunity/Susceptibility which includes:
EN 61000-4-2 Electrostatic Discharge
EN 61000-4-3 Radiated RF
EN 61000-4-4 Electrical Fast Transient/Burst
EN 61000-4-6 Injected Currents

The products referenced above are for the use of control of the speed of AC motors. The use in residential and commercial premises (Class B) requires an optional EMC series filter. Via internal mechanisms and Quality Control, it is verified that these products conform to the requirements of the Directive and applicable standards.

Glenshaw, PA USA - 1 October 2003

Neil Abrams
Quality Control
Manager

Modbus Register Map

Following is the Modbus Register Map. Note that all information may be accessed either through the Input registers (30000 addresses) or through the Holding registers (40000 addresses).

Absolute Register Address	Description	Range	Units
30020/40020	Starter Control	Bit Mask: Bit 0: Run/Stop Bit 1: Fault Reset Bit 2: Emergency Overload Reset Bit 3: Local/Remote Bit 4: Heat Disable Bit 5: Ramp Select Bit 10: Relay 6 Bit 11: Relay 5 Bit 12: Relay 4 Bit 13: Relay 3 Bit 14: Relay 2 Bit 15: Relay 1	–
30021/40021	Starter Status	Bit Mask: Bit 0: Ready Bit 1: Running Bit 2: UTS Bit 3: Alarm Bit 4: Fault Bit 5: Lockout	–
30022/40022	Input Status	Bit Mask: Bit 0: Start Bit 1: DI 1 Bit 2: DI 2 Bit 3: DI 3 Bit 4: DI 4 Bit 5: DI 5 Bit 6: DI 6 Bit 7: DI 7 Bit 8: DI 8	–
30023/40023	Alarm Status 1	Bit Mask: Bit 0: “A OL” – Motor overload Bit 1: "A 5" – Motor PTC Bit 2: "A 6" – Stator RTD Bit 3: "A 7" – Bearing RTD Bit 4: "A 8" – Other RTD Bit 5: “A 10” – Phase rotation not ABC Bit 6: “A 11” – Phase rotation not CBA Bit 7: “A 12” – Low Line Frequency Bit 8: “A 13” – High Line Frequency Bit 9: “A 14” – Phase rotation not 1PH Bit 10: “A 15” – Phase rotation not 3PH Bit 11: “A 21” – Low line L1-L2 Bit 12: “A 22” – Low line L2-L3 Bit 13: “A 23” – Low line L3-L1 Bit 14: “A 24” – High line L1-L2 Bit 15: “A 25” – High line L2-L3	–
30024/40024	Alarm Status 2	Bit 0: “A 26” – High line L3-L1 Bit 1: “A 27” – Phase loss Bit 2: “noL” – No line Bit 3: “A 29” – PORT Timeout Bit 4: “A 31” – Overcurrent Bit 5: “A 34” – Undercurrent Bit 6: “A 35” – PF Too Leading Bit 7: “A 36” – PF Too Lagging Bit 8: “A 37” – Current imbalance Bit 9: “A 38” – Ground fault Bit 10: “A 47” – Stack overtemperature Bit 11: “A 53” – Tach Loss Bit 12: “A 60” – DI 1 Bit 13: “A 61” – DI 2 Bit 14: “A 62” – DI 3 Bit 15: “A 63” – DI 4	–

Absolute Register Address	Description	Range	Units
30025/40025	Alarm Status 3	Bit 0: “A 64” – DI 5 Bit 1: “A 65” – DI 6 Bit 2: “A 66” – DI 7 Bit 3: “A 67” – DI 8 Bit 4: “A 71” – Analog Input Trip	–
30026/40026	Lockout Status	Bit 0: Motor overload Bit 1: Motor PTC Bit 2: RTD Stator Bit 3: RTD Bearing Bit 4: RTD Other Bit 5: Disconnect open Bit 6: Stack overtemperature Bit 7: Control power Bit 8: RTD Open/Short Bit 9: Time between starts Bit 10: Backspin Bit 11: Starts per hour Bit 12: RTD Comm Loss	–
30027/40027	Present Fault Code		
30028/40028	Average Current		A_{rms}
30029/40029	L1 Current		A_{rms}
30030/40030	L2 Current		A_{rms}
30031/40031	L3 Current		A_{rms}
30032/40032	Current Imbalance		0.1 %
30033/40033	Residual Ground Fault Current		% FLA
30034/40034	Zero Sequence Ground Fault Current		0.1 Arms
30035/40035	Average Voltage		V_{rms}
30036/40036	L1-L2 Voltage		V_{rms}
30037/40037	L2-L3 Voltage		V_{rms}
30038/40038	L3-L1 Voltage		V_{rms}
30039/40039	Motor Overload		%
30040/40040	Power Factor	-99 to +100 (in 16-bit two’s compliment signed format)	0.01
30041/40041	Watts (lower 16 bits)	(in 32-bit unsigned integer format)	W
30042/40042	Watts (upper 16 bits)		
30043/40043	VA (lower 16 bits)	(in 32-bit unsigned integer format)	VA
30044/40044	VA (upper 16 bits)		
30045/40045	vars (lower 16 bits)	(in 32-bit two’s compliment signed integer format)	var
30046/40046	vars (upper 16 bits)		
30047/40047	kW hours (lower 16 bits)	(in 32-bit unsigned integer format)	kWh
30048/40048	kW hours (upper16 bits)		
30049/40049	Phase Order	0: no line 1: ABC 2: CBA 3: SPH	–
30050/40050	Line Frequency	230 – 720, or 0 if no line	0.1 Hz
30051/40051	Analog Input %	-1000 to +1000 (in 16-bit two’s compliment signed format)	0.1 %
30052/40052	Analog Output %	0 – 1000	0.1 %
30053/40053	Running Time	0 – 65535	hours
30054/40054	Running Time	0 – 59	minutes
30055/40055	Starts		–
30056/40056	TruTorque %		%
30057/40057	Power %		%

Absolute Register Address	Description	Range	Units
30058/40058	Peak Starting Current		A_{rms}
30059/40059	Last Starting Duration		0.1 Sec
30060/40060	Hottest Stator RTD Temperature	0 - 200	°C
30061/40061	Hottest Bearing RTD Temperature	0 - 200	°C
30062/40062	Hottest Other RTD Temperature	0 - 200	°C
30063/40063	RTD 1 Temperature	0 - 200	°C
30064/40064	RTD 2 Temperature	0 - 200	°C
30065/30065	RTD 3 Temperature	0 - 200	°C
30066/40066	RTD 4 Temperature	0 - 200	°C
30067/40067	RTD 5 Temperature	0 - 200	°C
30068/40068	RTD 6 Temperature	0 - 200	°C
30069/40069	RTD 7 Temperature	0 - 200	°C
30070/40070	RTD 8 Temperature	0 - 200	°C
30071/40071	RTD 9 Temperature	0 - 200	°C
30072/40072	RTD 10 Temperature	0 - 200	°C
30073/40073	RTD 11 Temperature	0 - 200	°C
30074/40074	RTD 12 Temperature	0 - 200	°C
30075/40075	RTD 13 Temperature	0 - 200	°C
30076/40076	RTD 14 Temperature	0 - 200	°C
30077/40077	RTD 15 Temperature	0 - 200	°C
30078/40078	RTD 16 Temperature	0 - 200	°C
30079/40079	RTDs Enabled	Bit Mask: Each of the sixteen (16) bits represents an RTD. A 1 indicates the RTD is enabled. Bit 0 represents RTD 1. Bit 15 represents RTD 16.	–
30080/40080	RTDs Assigned as Stator	Bit Mask: Each of the sixteen (16) bits represents an RTD. A 1 indicates the RTD is assigned to the stator group.	–
30081/40081	RTDs Assigned as Bearing	Bit Mask: Each of the sixteen (16) bits represents an RTD. A 1 indicates the RTD is assigned to the bearing group.	–
30082/40082	RTDs Assigned as Other	Bit Mask: Each of the sixteen (16) bits represents an RTD. A 1 indicates the RTD is assigned to the other group.	–
30083/40083	RTDs with Open Leads	Bit Mask: Each of the sixteen (16) bits represents an RTD. A 1 indicates the RTD has an open lead.	–
30084/40084	RTDs with Shorted Leads	Bit Mask: Each of the sixteen (16) bits represents an RTD. A 1 indicates the RTD has shorted leads.	–
30085/40085	Remaining Lockout Time		Sec
30086/40086	Date/Time (lower 16 bits)	(in 32-bit unsigned integer format)	Sec
30087/40087	Date/Time (upper 16 bits)		
30101/40101	Motor FLA	1 – 6400	A_{rms}
30102/40102	Motor Service Factor	100 – 199	0.01
30103/40103	Independent Start/Run Motor Overloads	0: Disabled 1: Enabled	–
30104/40104	Motor Overload Running Enable	0: Disabled 1: Enabled	–

Absolute Register Address	Description	Range	Units
30105/40105	Motor Overload Running Class	1 – 40	–
30106/40106	Motor Overload Starting Enable	0: Disabled 1: Enabled	–
30107/40107	Motor Overload Starting Class	1 – 40	–
30108/40108	Motor Overload Hot/Cold Ratio	0 – 99	%
30109/40109	Motor Overload Cooling Time	10 – 9999	0.1 Min
30110/40110	Local Source	0: Keypad 1: Terminal 2: Serial	–
30111/40111	Remote Source		
30112/40112	Start Mode	0: Open Loop Voltage Ramp 1: Closed Loop Current Ramp 2: TruTorque Ramp 3: Power Ramp 4: Tach Ramp	–
30113/40113	Initial Motor Current 1	50 – 600	% FLA
30114/40114	Maximum Motor Current 1	100 – 800	% FLA
30115/40115	Ramp Time 1	0 – 300	Sec
30116/40116	Initial Motor Current 2	50 – 600	% FLA
30117/40117	Maximum Motor Current 2	100 – 800	% FLA
30118/40118	Ramp Time 2	0 – 300	Sec
30119/40119	UTS Time	1 – 900	Sec
30120/40120	Initial V/T/P	1 – 100	%
30121/40121	Max T/P	10 – 325	%
30122/40122	Stop Mode	0: Coast 1: Voltage Decel 2: TruTorqu Decel 3: DC Brake	–
30123/40123	Decel Begin Level	100 – 1	%
30124/40124	Decel End Level	99 – 1	%
30125/40125	Decel Time	1 – 180	Sec
30126/40126	DC Brake Level	10 – 100	%
30127/40127	DC Brake Time	1 – 180	Sec
30128/40128	DC Brake Delay	1 – 30	100 mSec
30129/40129	Kick Enable 1	0: Disabled 1: Enabled	–
30130/40130	Kick Current Level 1	100 – 800	% FLA
30131/40131	Kick Time 1	1 – 100	100 mSec
30132/40132	Kick Enable 2	0: Disabled 1: Enabled	–
30133/40133	Kick Current Level 2	100 – 800	% FLA
30134/40134	Kick Time 2	1 – 100	100 mSec
30135/40135	Slow Speed Enable	0: Disabled 1: Enabled	–

Absolute Register Address	Description	Range	Units
30136/40136	Slow Speed	0: 1.0 1: 1.5 2: 1.6 3: 1.7 4: 1.9 5: 2.0 6: 2.5 7: 2.6 8: 2.8 9: 2.9 10: 3.1 11: 3.3 12: 3.5 13: 3.8 14: 4.2 15: 4.5 16: 5.0 17: 5.5 18: 6.2 19: 7.1 20: 8.3 21: 9.1 22: 10.0 23: 11.1 24: 12.5 25: 14.3 26: 16.7 27: 20.0 28: 25.0 29: 33.3 30: 37.5 31: 40.0	%
30137/40137	Slow Speed Current Level	10 – 400	% FLA
30138/40138	Slow Speed Time Limit Enable	0: Disabled 1: Enabled	–
30139/40139	Slow Speed Time Limit	1 – 900	Sec
30140/40140	Slow Speed Kick Enable	0: Disabled 1: Enabled	–
30141/40141	Slow Speed Kick Level	100 – 800	% FLA
30142/40142	Slow Speed Kick Time	1 – 100	100 mSec

Absolute Register Address	Description	Range	Units
30143/40143	Rated RMS Voltage	0: 100 1: 110 2: 120 3: 200 4: 208 5: 220 6: 230 7: 240 8: 350 9: 380 10: 400 11: 415 12: 440 13: 460 14: 480 15: 500 16: 525 17: 575 18: 600 19: 660 20: 690 21: 800 22: 1000 23: 1140 24: 2200 25: 2300 26: 2400 27: 3300 28: 4160 29: 4600 30: 4800 31: 6000 32: 6600 33: 6900 34: 10000 35: 11000 36: 11500 37: 12000 38: 12470 39: 13200 40: 13800	Vrms
30144/40144	Input Phase Sensitivity	0: Ins 1: ABC 2: CBA 3: SPH	–
30145/40145	Motor Rated Power Factor	1 – 100	–
30146/40146	Overcurrent Enable	0: Disabled 1: Enabled	–
30147/40147	Overcurrent Level	50 – 800	% FLA
30148/40148	Overcurrent Delay Time Enable	0: Disabled 1: Enabled	–
30149/40149	Overcurrent Delay Time	1 – 900	100 mSec
30150/40150	Undercurrent Trip Enable	0: Disabled 1: Enabled	–
30151/40151	Undercurrent Trip Level	5 – 100	% FLA
30152/40152	Undercurrent Trip Delay Time Enable	0: Disabled 1: Enabled	–
30153/40153	Undercurrent Trip Delay Time	1 – 900	100 mSec
30154/40154	Current Imbalance Trip Enable	0: Disabled 1: Enabled	–
30155/40155	Current Imbalance Trip Level	5 – 40	%

Absolute Register Address	Description	Range	Units
30156/40156	Residual Ground Fault Trip Enable	0: Disabled 1: Enabled	–
30157/40157	Residual Ground Fault Trip Level	5 – 100	% FLA
30158/40158	Over Voltage Trip Enable	0: Disabled 1: Enabled	–
30159/40159	Over Voltage Trip Level	1 – 40	%
30160/40160	Under Voltage Trip Enable	0: Disabled 1: Enabled	–
30161/40161	Under Voltage Trip Level	1 – 40	%
30162/40162	Over/Under Voltage Delay Time	1 – 900	100 mSec
30163/40163	Digital Input Trip Delay Time	1 – 900	100 mSec
30164/40164	Auto Fault Reset Enable	0: Disabled 1: Enabled	–
30165/40165	Auto Fault Reset Delay Time	1 – 900	Sec
30166/40166	Auto Fault Reset Count Enable	0: Disabled 1: Enabled	–
30167/40167	Auto Fault Reset Count	1 – 10	–
30168/40168	Controlled Fault Stop	0: Disabled 1: Enabled	–
30169/40169	DI 1 Configuration	0: Off 1: Stop 2: Fault High 3: Fault Low 4: Fault Reset 5: Disconnect 6: Inline Feedback (F49) 7: Bypass / 2M Feedback (F48) 8: Emergency Motor OL Reset 9: Local / Remote Control Source 10: Heat Disable 11: Heat Enable 12: Ramp Select 13: Slow Speed Forward 14: Slow Speed Reverse 15: DC Brake Disable 16: DC Brake Enable 17: Speed Switch Normally Open 18: Speed Switch Normally Closed	–
30170/40170	DI 2 Configuration		
30171/40171	DI 3 Configuration		
30172/40172	R1 Configuration	0: Off 1: Fault Fail Safe 2: Fault Non Fail Safe 3: Running 4: Up To Speed 5: Alarm 6: Ready 7: Locked Out 8: Over Current Alarm 9: Under Current Alarm 10: Overload Alarm 11: Shunt Trip Fail Safe 12: Shunt Trip Non Fail Safe 13: Faulted on Ground Fault 14: In Energy Saver Mode 15: Heating 16: Slow Speed 17: Slow Speed Forward 18: Slow Speed Reverse 19: DC Braking 20: Cooling Fan 21: PORT 22: Tach Loss	–
30173/40173	R2 Configuration		
30174/40174	R3 Configuration		
30175/40175	Analog Input Trip Enable	0: Disabled 1: Enabled	–

Absolute Register Address	Description	Range	Units
30176/40176	Analog Input Trip Type	0: Low – Fault below preset level 1: High – Fault above preset level	–
30177/40177	Analog Input Trip Level	0 – 100	%
30178/40178	Analog Input Trip Delay Time	1 – 900	100 mSec
30179/40179	Analog Input Span	1 – 100	%
30180/40180	Analog Input Offset	0 – 99	%
30181/40181	Analog Output Function	0: Off (no output) 1: 0 – 200% Current 2: 0 – 800% Current 3: 0 – 150% Voltage 4: 0 – 150% Overload 5: 0 – 10kW 6: 0 – 100kW 7: 0 – 1MW 8: 0 – 10MW 9: 1 – 100% Analog Input 10: 0 – 100% Firing 11: Calibration (full output)	–
30182/40182	Analog Output Span	1 – 125	%
30183/40183	Analog Output Offset	0 – 99	%
30184/40184	Inline Enable	0: Disabled 1: Enabled	–
30185/40185	Inline Delay Time	10 – 100	100 mSec
30186/40186	Bypass Feedback Time	1 – 50	100 mSec
30187/40187	Keypad Stop	0: Disabled 1: Enabled	–
30188/40188	Modbus Timeout Enable	0: Disabled 1: Enabled	–
30189/40189	Modbus Timeout	1 – 120	Sec
30190/40190	CT Ratio (x:1)	0: 72:1 1: 96:1 2: 144:1 3: 288:1 4: 864:1 5: 2640:1 6: 3900:1 7 5760:1 8: 8000:1 9: 14400:1 10: 28800:1 11: 50:5 12: 150:5 13: 250:5 14: 800:5 15: 2000:5 16: 5000:5	–
30191/40191	Auto Start	0: Disabled 1: Start after power applied 2: Start after fault reset 3: Starter after power applied and after fault reset	–
30192/40192	Energy Saver Enable	0: Disabled 1: Enabled	–
30193/40193	Heater / Anti-Windmill Enable	0: Disabled 1: Enabled	–
30194/40194	Heater / Anti-Windmill Level	1 – 40	% FLA
30195/40195	Starter Type	0: Normal (Outside Delta) 1: Inside Delta 2: Wye-Delta 3: Phase Controller 4: Current Follower 5: Across the Line (Full Voltage)	–

Absolute Register Address	Description	Range	Units
30196/40196	LED Display Meter	0: Status 1: Ave Current 2: L1 Current 3: L2 Current 4: L3 Current 5: Current Imbalance % 6: Residual Ground Fault 7: Ave. Volts 8: L1-L2 Volts 9: L2-L3 Volts 10: L3-L1 Volts 11: Overload 12: Power Factor 13: Watts 14: VA 15: vars 16: kW hours 17: MW hours 18: Phase Order 19: Line Frequency 20: Analog Input 21: Analog Output 22: Running Days 23: Running Hours 24: Starts 25: TruTorque % 26: Power % 27: Peak Starting Current 28: Last Starting Duration 29: Zero Sequence Ground Current 30: Hottest Stator RTD Temperature 31: Hottest Bearing RTD Temperature 32: Hottest Other RTD Temperature 33: Hottest RTD Temperature	–
30197/40197	LCD Display Meter 1	1: Ave Current 2: L1 Current 3: L2 Current 4: L3 Current 5: Current Imbalance % 6: Residual Ground Current 7: Ave. Volts 8: L1-L2 Volts 9: L2-L3 Volts 10: L3-L1 Volts 11: Overload 12: Power Factor 13: Watts 14: VA 15: vars 16: kW hours 17: MW hours 18: Phase Order 19: Line Frequency 20: Analog Input 21: Analog Output 22: Running Days 23: Running Hours 24: Starts 25: TruTorque % 26: Power % 27: Peak Starting Current 28: Last Starting Duration 29: Zero Sequence Ground Current 30: Stator RTD Temperature 31: Bearing RTD Temperature 32: Other RTD Temperature 33: Hottest RTD Temperature	–
30198/40198	LCD Display Meter 2		

Absolute Register Address	Description	Range	Units
30199/40199	Misc. Commands	0: None 1: Reset Run Time 2: Reset kWh 3: Enter Reflash Mode 4: Store Parameters 5: Load Parameters 6: Factory Reset 7: Standard BIST 8: Powered BIST	–
30221/40221	Acceleration Profile	0: Linear 1: Squared 2: S-Curve	–
30222/40222	Deceleration Profile		–
30223/40223	PORT Bypass Enable	0: Disabled 1: Enabled	–
30224/40224	PORT Bypass Delay Time	1 – 50	100 mSec
30225/40225	PORT Recovery Method	0: Voltage Ramp 1: Fast Recover 2: Current Ramp 3: Current Ramp 2 4: Ramp Select 5: Tach Ramp	–
30226/40226	Tachometer Full Speed Voltage	100 – 1000	10 mV
30227/40227	Tachometer Loss Delay Time	1 – 900	100 mSec
30228/40228	Tachometer Loss Action	0: Fault 1: Closed Loop Current Ramp 2: TruTorque Ramp 3: Power Ramp	–
30229/40229	Time/Date Format	0: MM/DD/YY, 12 Hour 1: MM/DD/YY, 24 Hour 2: YY/MM/DD, 12 Hour 3: YY/MM/DD, 24 Hour 4: DD/MM/YY, 12 Hour 5: DD/MM/YY, 24 Hour	–
30230/40230	Current Imbalance Delay Time	1 – 900	100 mSec
30231/40231	Zero Sequence Ground Fault Trip Enable	0: Disabled 1: Enabled	-
30232/40232	Zero Sequence Ground Fault Trip Level	10 – 250	100 mArms
30233/40233	Ground Fault Delay Time	1 – 900	100 mSec
30234/40234	Phase Loss Delay Time	1 – 50	100 mSec
30235/40235	Over Frequency Trip Level	24 – 72	Hz
30236/40236	Under Frequency Trip Level	23 – 71	Hz
30237/40237	Over/Under Frequency Delay Time	1 – 900	100 mSec
30238/40238	Power Factor Leading Trip Enable	0: Disabled 1: Enabled	–
30239/40239	Power Factor Leading Trip Level	80 – 99 =-0.80 to -0.99 lag 100 – 120 =-1.00 to +0.80 lead	–
30240/40240	Power Factor Lagging Trip Enable	0: Disabled 1: Enabled	–
30241/40241	Power Factor Lagging Trip Level	1 – 99 = -0.01 to -0.99 lag 100 – 120 =1.00 to +0.80 lead	–
30242/40242	Power Factor Delay Time	1 – 900	100 mSec
30243/40243	Backspin Timer Enable	0: Disabled 1: Enabled	–
30244/40244	Backspin Time	1 – 180	Min
30245/40245	Time Between Starts Enable	0: Disabled 1: Enabled	–
30246/40246	Time Between Starts	1 – 180	Min
30247/40247	Starts per Hour Enable	0: Disabled 1: Enabled	–
30248/40248	Starts per Hour	1 – 6	–

Absolute Register Address	Description	Range	Units
30249/40249	Speed Switch Enable	0: Disabled 1: Enabled	–
30250/40250	Speed Switch Delay Time	1 – 250	Sec
30251/40251	Motor PTC Enable	0: Disabled 1: Enabled	–
30252/40252	Motor PTC Delay Time	1 – 5	Sec
30253/40253	PORT Trip Enable	0: Disabled 1: Enabled	–
30254/40254	PORT Trip Delay Time	1 – 900	100 mSec
30255/40255	Motor Overload Alarm Level	1 – 100	%
30256/40256	Motor Overload Lockout Level	1 – 99	%
30257/40257	Motor Overload Auto Lockout Calculation	0: Disabled 1: Enabled	–
30258/40258	Motor Overload RTD Biasing Enable	0: Disabled 1: Enabled	–
30259/40259	Motor Overload RTD Biasing Min	0 – 198	°C
30260/40260	Motor Overload RTD Biasing Mid	1 – 199	°C
30261/40261	Motor Overload RTD Biasing Max	105 – 200	°C
30262/40262	DI4 Configuration	Same as DI 1 through DI 3 configuration in register 30169/40169	–
30263/40263	DI5 Configuration		
30264/40264	DI6 Configuration		
30265/40265	DI7 Configuration		
30266/40266	DI8 Configuration		
30267/40267	R4 Configuration	Same as R1 through R3 configuration in register 30172/40172	–
30268/40268	R5 Configuration		
30269/40269	R6 Configuration		
30270/40270	RTD Module 1 Enable	0: Disabled 1: Enabled	–
30271/40271	RTD Module 1 Address	16 – 23	–
30272/40272	RTD Module 2 Enable	0: Disabled 1: Enabled	–
30273/40273	RTD Module 2 Address	16 – 23	–
30274/40274	RTD 1 Group	0: Off 1: Stator 2: Bearing 3: Other	–
30275/40275	RTD 2 Group		
30276/40276	RTD 3 Group		
30277/40277	RTD 4 Group		
30278/40278	RTD 5 Group		
30279/40279	RTD 6 Group		
30280/40280	RTD 7 Group		
30281/40281	RTD 8 Group		
30282/40282	RTD 9 Group		
30283/40283	RTD 10 Group		
30284/40284	RTD 11 Group		
30285/40285	RTD 12 Group		
30286/40286	RTD 13 Group		
30287/40287	RTD 14 Group		
30288/40288	RTD 15 Group		
30289/40289	RTD 16 Group		
30290/40290	RTD Stator Alarm Level	1 – 200	°C
30291/40291	RTD Bearing Alarm Level		
30292/40292	RTD Other Alarm Level		
30293/40293	RTD Stator Alarm Level		
30294/40294	RTD Bearing Trip Level		
30295/40295	RTD Other Trip Level		

Absolute Register Address	Description	Range	Units
30296/40296	RTD Voting Enable	0: Disabled 1: Enabled	–
30601/40601 to 30609/40609	Fault Code (newest fault) to Fault Code (oldest fault)	Refer to page 205	–
30611/40611 to 30619/40619	System States**:** The state that the starter was in when the fault has occurred.	0: Initializing 1: Locked Out 2: Faulted 3: Stopped 4: Heating 5: Kicking 6: Ramping 7: Slow Speed 8: Not UTS 9: UTS (up to speed) 10: Phase Control / Current Follower 11: Decelerating 12: Braking 13: Wye 14: PORT 15: BIST 16: Shorted SCR Test 17: Open SCR Test	–
30621/40621 to 30629/40629	L1 Currents: The current that the load is drawing from Line 1 when the fault has occurred.		Arms
30631/40631 to 30639/40639	L2 Currents: The current that the load is drawing from Line 2 when a fault occurs.		Arms
30641.40649 to 30649/40649	L3 Currents: The current that the load is drawing from Line 3 when a fault occurs.		Arms
30651/40651 to 30659/40659	L1 – L2 Voltages: The line voltage that is present between lines 1 and 2 when a fault occurs.		Vrms
30661/40661 to 30669/40669	L2 – L3 Voltages: The line voltage that is present between lines 2 and 3 when a fault occurs.		Vrms
30671/40671 to 30679/40679	L3 – L1 Voltages: The line voltage that is present between lines 3 and 1 when a fault occurs.		Vrms
30681/40681 to 30689/40689	Kilowatts: The power that the load is drawing when a fault occurs.		KW
30691/40691 to 30699/40699	Line Periods: The line period (1/frequency) that is present when a fault occurs.		microseconds
30701/40701 to 30709/40709	Run Time Hours: The value of the running time meter when a fault occurs.		Hours
30711/40711 to 30719/40719	Run Time Counts: The value of the running time meter when a fault occurs. The running counts provides more resolution than the running time hours.	Resets to 0 each time the running time hours increments (at 35 999)	10 counts/sec
30801/40801 (newest) to 30899/40899 (oldest)	Event Codes: Bit 15 indicates whether a record is an event or fault. A 1 indicates fault and a 0 indicates an event. The remaining 15 bits contain the code.	Refer to page 202	
30901/40901 (newest) to 30999/40999 (oldest)	The system state when the event or fault occurred may be read.	Refer to address 30611 – 30619	
31001/41001 to 31198/41198	Time and Date Stamp	2 registers= 32 bit unsigned integer / event. seconds since Jan 1, 1972. 12am	

Starter Control Register:

Bit 0 – Run/Stop	0: Stop 1: Start
Bit 1 – Fault Reset	0: No action 1: Fault Reset
Bit 2 –Emergency Overload Reset	0: No action 1: Emergency Overload Reset
Bit 3 –Local/Remote	0: Local 1: Remote
Bit 4 –Heat Disabled	0: Heater Enabled 1: Heater Disabled
Bit 5 –Ramp Select	0: Ramp 1 1: Ramp 2
Bit 10 – Relay 6	0: Energize(d) 1: De-energize(d)
Bit 11 – Relay 5	Same as above
Bit 12 – Relay 4	Same as above
Bit 13 – Relay 3	Same as above
Bit 14 – Relay 2	Same as above
Bit 15 – Relay 1	Same as above

The control source must be serial for the starter to be started through Modbus. The Run/Stop bit must transition from 0 to 1 for a start to occur. If the starter stops due to a fault, the action of the starter depends on the state of the Auto Start parameter (I/O27).

The fault reset bit must transition from 0 to 1 for a fault to be reset.

If any of the programmed digital inputs are programmed as Local/Remote inputs, then the local/remote bit has no effect.

When the relays are programmed as “OFF”, the relay bits may be written in order to control the relays. When the relays are programmed for any function other than “OFF” (Fault, Run, UTS for example), then the relay bits may be read to determine the state of the relays.

Starter Status Register:

Bit 0 – Ready	0: Initializing or Faulted and Decelerating or Faulted and Braking or Faulted and Stopped or Lockout 1: Otherwise
Bit 1 – Running	0: Not Running 1: Running
Bit 2 –UTS	0: Not UTS 1: UTS
Bit 3 –Alarm	0: No alarm conditions 1: 1 or more alarm conditions
Bit 4 –Fault	0: No Fault Condition 1: Fault Condition
Bit 5 –Lockout	0: Start or Fault Reset not locked out. 1: Start or Fault Reset locked out. Possible causes are: Overload Lockout State

Watts, VA, vars, and kW hour Registers:
Meter registers present 32 bit meters in two consecutive 16 bit registers. The least significant 16 bits are in the first register followed by the most significant 16 bits in the second register.

Reading the least significant register latches data into the most significant register so that the data remains synchronized between the two.

Parameter Registers:
For those parameters that can be set either to “Off”, or some value within a range (many of the protection parameters, for example) there are two Modbus registers. One is an “enable” register, and the other sets the value within the range.

APPENDIX G - PARAMETER TABLES

Parameter Table

Following is the parameter table for both the LED and LCD Display. The last column is a convenient place to write down parameter settings.

Quick Start Group

LED	LCD	Parameter	Setting Range	Units	Default	Page	Setting
P1	QST 01	Motor FLA	1 – 6400	RMS Amps	10	72	
P2	QST 02	Motor Service Factor	1.00 – 1.99		1.15	73	
P3	QST 03	Motor Running Overload Class	Off, 1 – 40		10	73	
P4	QST 04	Local Source	Keypad Terminal Serial		Terminal	74	
P5	QST 05	Remote Source				74	
P6	QST 06	Initial Motor Current 1	50 – 600	%FLA	100	75	
P7	QST 07	Maximum Motor Current 1	100 – 800	%FLA	600	76	
P8	QST 08	Ramp Time 1	0 – 300	Seconds	15	76	
P9	QST 09	UTS Time / Transition Time	1 – 900	Seconds	20	77	

Control Function Group

Group	LED	Display	Parameter	Setting Range	Units	Default	Page	Setting
CFN 00		Jump Code	Jump to Parameter	1 to 25		1		
CFN 01	P10	Start Mode	Start Mode	Voltage Ramp Current Ramp TT Ramp Power Ramp Tach Ramp		Current Ramp	78	
CFN 02	P8	Ramp Time 1	Ramp Time 1	0 to 300	Seconds	15	78	
CFN 03	P6	Init Cur 1	Initial Motor Current 1	50 to 600	%FLA	100	79	
CFN 04	P7	Max Cur 1	Maximum Motor Current 1	100 to 800	%FLA	600	79	
CFN 05	P24	Ramp Time 2	Ramp Time 2	0 to 300	Seconds	15	80	
CFN 06	P22	Init Cur 2	Initial Motor Current 2	50 to 600	%FLA	100	80	
CFN 07	P23	Max Cur 2	Maximum Motor Current 2	100 to 800	%FLA	600	80	
CFN 08	P11	Init V/T/P	Initial Voltage/Torque/Power	1 to 100	%	25	81	
CFN 09	P12	Max T/P	Maximum Torque/Power	10 to 325	%	105	81	
CFN 10		Accel Prof	Acceleration Ramp Profile	Linear Squared S-Curve		Linear	83	
CFN 11	P13	Kick Lvl 1	Kick Level 1	Off, 100 to 800	%FLA	Off	84	
CFN 12	P14	Kick Time 1	Kick Time 1	0.1 to 10.0	Seconds	1.0	84	
CFN 13	P25	Kick Lvl 2	Kick Level 2	Off, 100 to 800	%FLA	Off	85	
CFN 14	P26	Kick Time 2	Kick Time 2	0.1 to 10.0	Seconds	1.0	85	
CFN 15	P15	Stop Mode	Stop Mode	Coast Volt Decel TT Decel DC Brake		Coast	85	
CFN 16	P16	Decel Begin	Decel Begin Level	100 to 1	%	40	86	
CFN 17	P17	Decel End	Decel End Level	99 to 1	%	20	87	
CFN 18	P18	Decel Time	Decel Time	1 to 180	Seconds	15	87	
CFN 19		Decel Prof	Decel Ramp Profile	Linear Squared S-Curve		Linear	88	
CFN 20	P19	Brake Level	DC Brake Level	10 to 100	%	25	88	
CFN 21	P20	Brake Time	DC Brake Time	1 to 180	Seconds	5	89	

Group	LED	Display	Parameter	Setting Range	Units	Default	Page	Setting
CFN 22	P21	Brake Delay	DC Brake Delay	0.1 to 3.0	Seconds	0.2	89	
CFN 23	P27	SSpd Speed	Slow Speed	Off, 1 – 40	%	Off	90	
CFN 24	P28	SSpd Curr	Slow Speed Current Level	10 to 400	% FLA	100	90	
CFN 25	P29	SSpd Timer	Slow Speed Timer	Off, 1 to 900	Seconds	10	91	
CFN 26	P30	SSpd Kick Curr	Slow Speed Kick Level	Off, 100 to 800	% FLA	Off	91	
CFN 27	P31	SSpd Kick T	Slow Speed Kick Time	0.1 to 10.0	Seconds	1.0	92	

Protection Function Group

Group	LED	Display	Parameter	Setting Range	Units	Default	Page	Setting
PFN 00		Jump Code	Jump to parameter	1 - 35		1		
PFN 01	P32	Over Cur Lvl	Over Current Trip Level	Off, 50 - 800	%FLA	Off	92	
PFN 02	P33	Over Cur Time	Over Current Trip Delay Time	Off, 0.1 - 90.0	Seconds	0.1	93	
PFN 03	P34	Undr Cur Lvl	Under Current Trip Level	Off, 5 - 100	%FLA	Off	93	
PFN 04	P35	Undr Cur Time	Under Current Trip Delay Time	Off, 0.1 - 90.0	Seconds	0.1	94	
PFN 05	P36	Cur Imbl Lvl	Current Imbalance Trip Level	Off, 5 - 40	%	15	94	
PFN 06		Cur Imbl Time	Current Imbalance Trip Time	0.1 - 90	Seconds	10	95	
PFN 07	P37	Resid GF Lvl	Residual Ground Fault Trip Level	Off, 5 - 100	%FLA	Off	96	
PFN 08		ZS GF Lvl	Zero Sequence Ground Fault Trip Level	Off, 1.0 - 25	Amps	Off	97	
PFN 09		Gnd Flt Time	Ground Fault Trip Time	0.1 - 90.0	Seconds	3.0	98	
PFN 10	P38	Over Vlt Lvl	Over Voltage Trip Level	Off, 1 - 40	%	Off	98	
PFN 11	P39	Undr Vlt Lvl	Under Voltage Trip Level	Off, 1 - 40	%	Off	99	
PFN 12	P40	Vlt Trip Time	Over/Under Voltage Trip Delay Time	0.1 - 90.0	Seconds	0.1	99	
PFN 13		Ph Loss Time	Phase Loss Trip Time	0.1 - 5.0	Seconds	0.2	100	
PFN 14		Over Frq Lvl	Over Frequency Trip	24 - 72	Hz	72	100	
PFN 15		Undr Frq Lvl	Under Frequency Trip	23 - 71	Hz	23	100	
PFN 16		Frq Trip Time	Frequency Trip Time	0.1 - 90.0	Seconds	0.1	101	
PFN 17		PF Lead Lvl	PF Lead Trip Level	Off, -0.80 lag to +0.01 lead		Off	101	
PFN 18		PF Lag Lvl	PF Lag Trip Level	Off, -0.01 lag to +0.80 lead		Off	101	
PFN 19		PF Trip Time	PF Trip Time	0.1 - 90.0	Seconds	10.0	101	
PFN 20		Backspin Time	Backspin Timer	Off, 1 - 180	Minutes	Off	102	
PFN 21		Time Btw St	Time Between Starts	Off, 1 - 180	Minutes	Off	102	
PFN 22		Starts/Hour	Starts per Hour	Off, 1 - 6		Off	102	
PFN 23	P41	Auto Reset	Auto Fault Reset Time	Off, 1 - 900	Seconds	Off	102	
PFN 24	P42	Auto Rst Lim	Auto Fault Reset Count Limit	Off, 1 - 10		Off	103	
PFN 25	P43	Ctrl Flt En	Controlled Fault Stop	Off, On		On	103	
PFN 26		Speed Sw Time	Speed Switch Trip Time	Off, 1 - 250	Seconds	Off	104	
PFN 27		M PTC Time	Motor PTC Trip Time	Off, 1 - 5	Seconds	Off	104	
PFN 28	P44	Indep S® OL	Independent Starting/Running Overload	Off, On		Off	105	
PFN 29	P45	Starting OL	Motor Overload Class Starting	Off, 1 - 40		10	106	
PFN 30		Running OL	Motor Overload Class Running	Off, 1 - 40		10	106	
PFN 31	P46	OL H© Ratio	Motor Overload Hot/Cold Ratio	0 - 99	%	60	107	

Group	LED	Display	Parameter	Setting Range	Units	Default	Page	Setting
PFN 32	P47	OL Cool Time	Motor Overload Cooling Time	1.0 - 999.9	Minutes	30	108	
PFN 33		OL Alarm Lvl	Motor OL Alarm Level	1 - 100	%	90	108	
PFN 34		OL Lock Lvl	Motor OL Lockout Level	1 - 99	%	15	109	
PFN 35		OL Lock Calc	Motor OL Auto Lockout Level	Off, Auto		Off	110	

I/O Group

Group	LED	Display	Parameter	Setting Range	Units	Default	Page	Setting
I/O 00		Jump Code	Jump to parameter	1 to 19		1		
I/O 01	P48	DI 1 Config	Digital Input #1 Configuration	Off Stop Fault High Fault Low Fault Reset Disconnect Inline Cnfrm Bypass Cnfrm E OL Reset Local/Remote Heat Disable Heat Enable Ramp Select Slow Spd Fwd Slow Spd Rev Brake Disable Brake Enable Speed Sw NO Speed Sw NC		Stop	111	
I/O 02	P49	DI 2 Config	Digital Input #2 Configuration			Off		
I/O 03	P50	DI 3 Config	Digital Input #3 Configuration			Off		
I/O 04		DI 4 Config	Digital Input #4 Configuration			Off		
I/O 05		DI 5 Config	Digital Input #5 Configuration			Off		
I/O 06		DI 6 Config	Digital Input #6 Configuration			Off		
I/O 07		DI 7 Config	Digital Input #7 Configuration			Off		
I/O 08		DI 8 Config	Digital Input #8 Configuration			Off		
I/O 09	P51	Dig Trp Time	Digital Fault Input Trip Time	0.1 to 90.0	Seconds	0.1	112	
I/O 10	P52	R1 Config	Relay Output #1Configuration	Off Fault FS Fault NFS Running UTS Alarm Ready Locked Out Overcurrent Undercurrent OL Alarm Shunt FS Shunt NFS Ground Fault Energy Saver Heating Slow Spd Slow Spd Fwd Slow Spd Rev Braking Cool Fan Ctl PORT Tach Loss		Fault FS	112	
I/O 11	P53	R2 Config	Relay Output #2 Configuration			Off		
I/O 12	P54	R3 Config	Relay Output #3 Configuration			Off		
I/O 13		R4 Config	Relay Output #4 Configuration			Off		
I/O 14		R5 Config	Relay Output #5 Configuration			Off		
I/O 15		R6 Config	Relay Output #6 Configuration			Off		
I/O 16	P55	Ain Trp Type	Analog Input Trip Type	Off Low Level High Level		Off	113	
I/O 17	P56	Ain Trp Lvl	Analog Input Trip Level	0 to 100	%	50	114	
I/O 18	P57	Ain Trp Tim	Analog Input Trip Delay Time	0.1 to 90.0	Seconds	0.1	114	
I/O 19	P58	Ain Span	Analog Input Span	1 to 100	%	100	115	
I/O 20	P59	Ain Offset	Analog Input Offset	0 to 99	%	0	116	

Group	LED	Display	Parameter	Setting Range	Units	Default	Page	Setting
I/O 21	P60	Aout Fctn	Analog Output Function	Off 0 – 200% Curr 0 – 800% Curr 0 – 150% Volt 0 – 150% OL 0 – 10 kW 0 – 100 kW 0 – 1 MW 0 – 10 MW 0 – 100% Ain 0 – 100% Firing Calibration		Off	116	
I/O 22	P61	Aout Span	Analog Output Span	1 to 125	%	100	117	
I/O 23	P62	Aout Offset	Analog Output Offset	0 to 99	%	0	118	
I/O 24	P63	Inline Confg	Inline Configuration	Off, 1.0 to 10.0	Seconds	3.0	118	
I/O 25	P64	Bypas Fbk Tim	Bypass / 2M Confirm	0.1 to 5.0	Seconds	2.0	118	
I/O 26	P65	Kpd Stop	Keypad Stop Disable	Enabled, Disabled		Enabled	119	
I/O 27	P66	Auto Start	Power On Start Selection	Disabled, Power, Fault, Power and Fault		Disabled	119	

RTD Group

Group	Display	Parameter	Setting Range	Units	Default	Page	Setting
RTD 00	Jump Code	Jump to Parameter	1 - 29		1		
RTD 01	RTD Mod1 Addr	RTD Module #1 Address	Off, 16 - 23		Off	120	
RTD 02	RTD Mod2 Addr	RTD Module #2 Address				120	
RTD 03	RTD1 Group	RTD1 Group	Off Stator Bearing Other		Off	120	
RTD 04	RTD2 Group	RTD2 Group					
RTD 05	RTD3 Group	RTD3 Group					
RTD 06	RTD4 Group	RTD4 Group					
RTD 07	RTD5 Group	RTD5 Group					
RTD 08	RTD6 Group	RTD6 Group					
RTD 09	RTD7 Group	RTD7 Group					
RTD 10	RTD8 Group	RTD8 Group					
RTD 11	RTD9 Group	RTD9 Group					
RTD 12	RTD10 Group	RTD10 Group					
RTD 13	RTD11 Group	RTD11 Group					
RTD 14	RTD12 Group	RTD12 Group					
RTD 15	RTD13 Group	RTD13 Group					
RTD 16	RTD14 Group	RTD14 Group					
RTD 17	RTD15 Group	RTD15 Group					
RTD 18	RTD16 Group	RTD16 Group					

Group	Display	Parameter	Setting Range	Units	Default	Page	Setting
RTD 19	Stator Alrm	Stator Alarm Level	1 - 200	°C	200	121	
RTD 20	Bearing Alrm	Bearing Alarm Level			200	121	
RTD 21	Other Alrm	Other Alarm Level			200	121	
RTD 22	Stator Trip	Stator Trip Level			200	122	
RTD 23	Bearing Trip	Bearing Trip Level			200	122	
RTD 24	Other Trip	Other Trip Level			200	122	
RTD 25	RTD Voting	RTD Voting	Disabled Enabled		Disabled	123	
RTD 26	RTD Biasing	RTD Motor OL Biasing	Off, On		Off	123	
RTD 27	RTD Bias Min	RTD Bias Minimum Level	0 - 198	°C	40	124	
RTD 28	RTD Bias Mid	RTD Bias Mid Point Level	1 - 199	°C	130	124	
RTD 29	RTD Bias Max	RTD Bias Maximum Level	105 - 200	°C	155	124	

Function Group

Number	LED	Display	Parameter	Setting Range	Units	Default	Page	Setting
FUN 00		Jump Code	Jump to parameter	1 to 24		1		
FUN 01	P71	Meter 1	Meter 1	Ave Current L1 Current L2 Current L3 Current Curr Imbal Ground Fault Ave Volts L1-L2 Volts L2-L3 Volts L3-L1 Volts Overload Power Factor Watts VA vars kW hours MW hours Phase Order Line Freq Analog Input Analog Output Run Days Run Hours Starts TruTorque % Power % Pk Accel Cur Last Start T Zero Seq GF Stator Temp Bearing Temp Other Temp All Temp		Ave Current	125	
FUN 02		Meter 2	Meter 2			Ave Volts		
FUN 03	P78	CT Ratio	CT Ratio	72:1, 96:1, 144:1, 288:1, 864:1, 1320:1, 2640:1, 2880:1, 3900:1, 5760:1, 8000:1, 14400:1, 28800:1, 50:5, 150:5, 250:5, 800:5, 2000:5, 5000:5		288:1	126	

Number	LED	Display	Parameter	Setting Range	Units	Default	Page	Setting
FUN 04	P77	Phase Order	Input Phase Sensitivity	Insensitive ABC CBA Single Phase		Insens.	126	
FUN 05	P76	Rated Volts	Rated RMS Voltage	100, 110, 120, 200, 208, 220, 230, 240, 350, 380, 400, 415, 440, 460, 480, 500, 525, 575, 600, 660, 690, 1000, 1140, 2200, 2300, 2400, 3300, 4160, 4600, 4800, 6000, 6600, 6900, 10000, 11000, 11500, 12000, 12470, 13200, 13800	RMS Voltage	480	126	
FUN 06	P75	Motor PF	Motor Rated Power Factor	-0.01 (Lag) to 1.00 (Unity)		-0.92	127	
FUN 07	P74	Starter Type	Starter Type	Normal Inside Delta Wye-Delta Phase Ctl Curr Follow ATL		Normal	128	
FUN 08	P73	Heater Level	Heater Level	Off, 1 to 40	%FLA	Off	128	
FUN 09	P72	Energy Saver	Energy Saver	Off, On	Seconds	Off	129	
FUN 10		PORT Flt Tim	P.O.R.T. Fault Time	Off, 0.1 - 90.0	Seconds	Off	129	
FUN 11		PORT Byp Tim	P.O.R.T. Bypass Hold Time	Off, 0.1 - 5.0	Seconds	Off	130	
FUN 12		PORT Recover	P.O.R.T. Recovery Method	Voltage Ramp Fast Recover Current Ramp Curr Ramp 2 Ramp Select Tach Ramp		Fast Recover	130	
FUN 13		Tach FS Lvl	Tachometer Full Speed Voltage	1.00 - 10.00	Volts	5.00	130	
FUN 14		Tach Los Tim	Tachometer Loss Time	0.1 - 90.0	Seconds	1.5	130	
FUN 15		Tach Los Act	Tachometer Loss Action	Fault Current TruTorque KW		Fault	131	
FUN 16	P70	Com Drop #	Communication Address	1 to 247		1	131	
FUN 17	P69	Com Baud rate	Communication Baud Rate	1200 2400 4800 9600 19200	bps	19200	131	
FUN 18	P68	Com Timeout	Communication Timeout	Off, 1 to 120	Seconds	Off	132	
FUN 19	P71	Com Parity	Communications Byte Framing	Even, 1 Stop Bit Odd, 1 Stop Bit None, 1 Stop Bit None, 2 Stop Bit		Even, 1 Stop	132	
FUN 20	P80	Software 1	Software Part Number 1	Display Only			132	
FUN 21		Software 2	Software Part Number 2	Display Only			133	
FUN 22	P67	Misc Command	Miscellaneous Commands	None Reset RT Reset kWh Reflash Mode Store Parameters Load Parameters Factory Reset Std BIST Powered BIST		None	133	

Number	LED	Display	Parameter	Setting Range	Units	Default	Page	Setting
FUN 23		T/D Format	Time and Date Format	mm/dd/yy 12h mm/dd/yy 24h yy/mm/dd 12h yy/mm/dd 24h dd/mm/yy 12h dd/mm/yy 24h		mm/dd/yy 12h	134	
FUN 24		Time	Time			Present Time	134	
FUN 25		Date	Date			Present Date	134	
FUN 26		Passcode	Passcode			Off	135	

Fault Group

Group	Fault Number	Fault Description	Starter State	I1	I2	I3	V1	V2	V3	kW	Hz	Run Time
FL1												
FL2												
FL3												
FL4												
FL5												
FL6												
FL7												
FL8												
FL9												

Event Group

Group	Event/Fault #	Event/Fault Description	Condition	Time	Date
E01					
E02					
E_					
E_					
E_					
E_					
E_					
E_					
E_					
E_					
E_					
E_					
E_					
E_					
E98					
E99					

Publication History;

Revision	Date	ECO#
00	12/15/06	Initial Release

BENSHAW
ADVANCED CONTROLS & DRIVES

BENSHAW
615 Alpha Drive
Pittsburgh, PA 15238
Phone: (412) 968-0100
Fax: (412) 968-5415

BENSHAW Canada
550 Bright Street
Listowel, Ontario N4W 3W3
Phone: (519) 291-5112
Fax: (519) 291-2595