PUBLICATION #890023-01-02

BENSHAW
ADVANCED CONTROLS & DRIVES

RediStart
Solid State Starter
Software Manual
MX Control

The Leader In

Solid State Motor Control

Technology

TRADEMARK NOTICE

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Modbus is a registered trademark of Schneider Electric.
UL is a trademark of Underwriters Laboratories, Incorporated

WARNING

1. This starter contains hazardous voltage that can cause electric shock resulting in personal injury or loss of life.
2. Before servicing, be sure all AC power is removed from the starter and the motor has stopped spinning
3. Wait at least 1 minute after turning off the AC power for the bus capacitor to discharge on the control card.
4. Do not connect or disconnect the wires to or from the starter when power is applied.
5. Ensure shielded cables are discharged.

WARNING

1. Service only by qualified personnel.
2. Make sure ground connection is in place.
3. Make certain proper shield installation is in place.

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Using This Manual

1.1 Using this manual

Layout

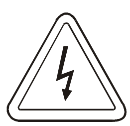
This manual is divided into 10 sections. Each section contains topics related to the section.

The sections are as follows:

1. Introduction
2. Control Card
3. Keypad Operation
4. Parameters
5. Parameter Descriptions
6. Applications
7. Troubleshooting
8. Theory of Operation
9. Technical Information
10. Appendices

Symbols

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



Warning: Electrical Hazard that could result in injury or death.

Caution: Could result in damage to the starter.

Highlight: Marking an important point in the documentation.

Using This Manual

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 Contacting Benshaw on page 4.

Start-Up Services

Benshaw technical field support personnel are available to do startup and conduct on-site training on the starter operations and troubleshooting.

On-Site Training Services

Benshaw technical field support personnel are available to conduct on-site training on the 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 Contacting Benshaw on page 4.

Documentation

Benshaw provides all customers with:

- Parameter Configuration Manual, Publication # 890023-01-xx
- Hardware Manual, Publication # 890023-02-xx
- Quick Start Reference Guide for LED Display, Publication # 890023-03-xx
- Quick Start Reference Guide for LCD Display, Publication # 890023-04-xx
- Drawing: Enclosed product has wiring diagrams of associated control devices found within the enclosure.

On-line Documentation

All documentation is available on-line at http://www.benshaw.com.

Replacement Parts

Spare and replacement parts can be purchased from Benshaw.

Software Number

This manual pertains to the software version numbers 810018-01-12, 810018-01-13, 810018-02-00

Publication History

Refer to the Revision History in the appendices.

1 – INTRODUCTION

Contacting Benshaw

1.2 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
United States of America
Phone: (412) 487-8235
Fax: (412) 487-4201

Benshaw Canada Controls Inc.
550 Bright Street East
Listowel, Ontario N4W 3W3
Canada
Phone: (519) 291-5112
Fax: (519) 291-2595

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

E –Mail: usatechsupport@benshaw.com
cantechsupport@benshaw.com

Technical support for MX starters 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:

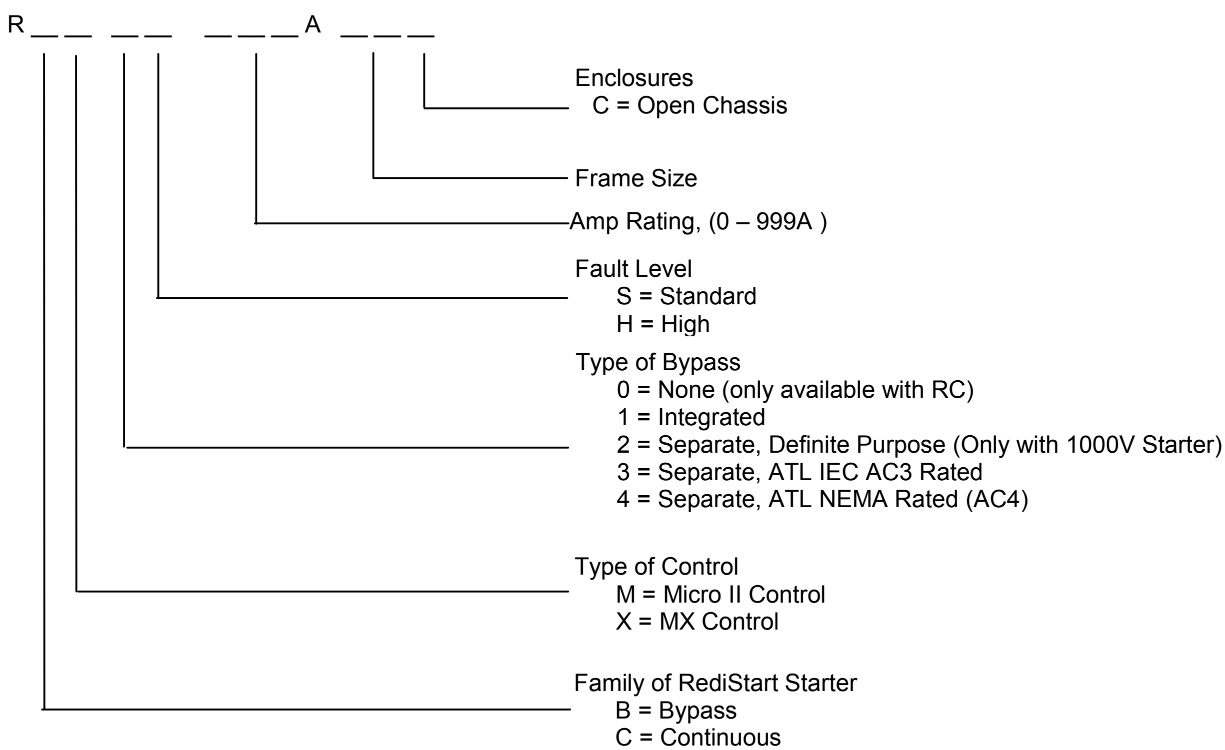
- Name of company
- Telephone number where the caller can be contacted
- Fax number of caller
- Benshaw product name
- Benshaw model number
- Benshaw serial number
- Name of product distributor
- Approximate date of purchase
- System Voltage
- FLA of motor attached to Benshaw product
- A brief description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

Interpreting Model Numbers

1.3 Inspection

Before storing or installing the RediStart starter with MX control, 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 starter numbering system for a chassis is:



Example of the model Number: RBX-1S-361A-14C

A RediStart starter with bypass, MX control, Integrated Bypass, Standard Fault, 361 Amp unit, Frame 14, open Chassis

1 – INTRODUCTION

General Overview

1.4 General Overview of a Reduced Voltage Starter

The RediStart MX motor starter is a microprocessor-controlled starter for single or three-phase induction 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 control, torque control.
- Programmable motor protection.
- Programmable operating parameters.
- Programmable metering.

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. It 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. The starter automatically stops the motor if the Phase to Phase line current is not within acceptable ranges or if the current is lost in a line.

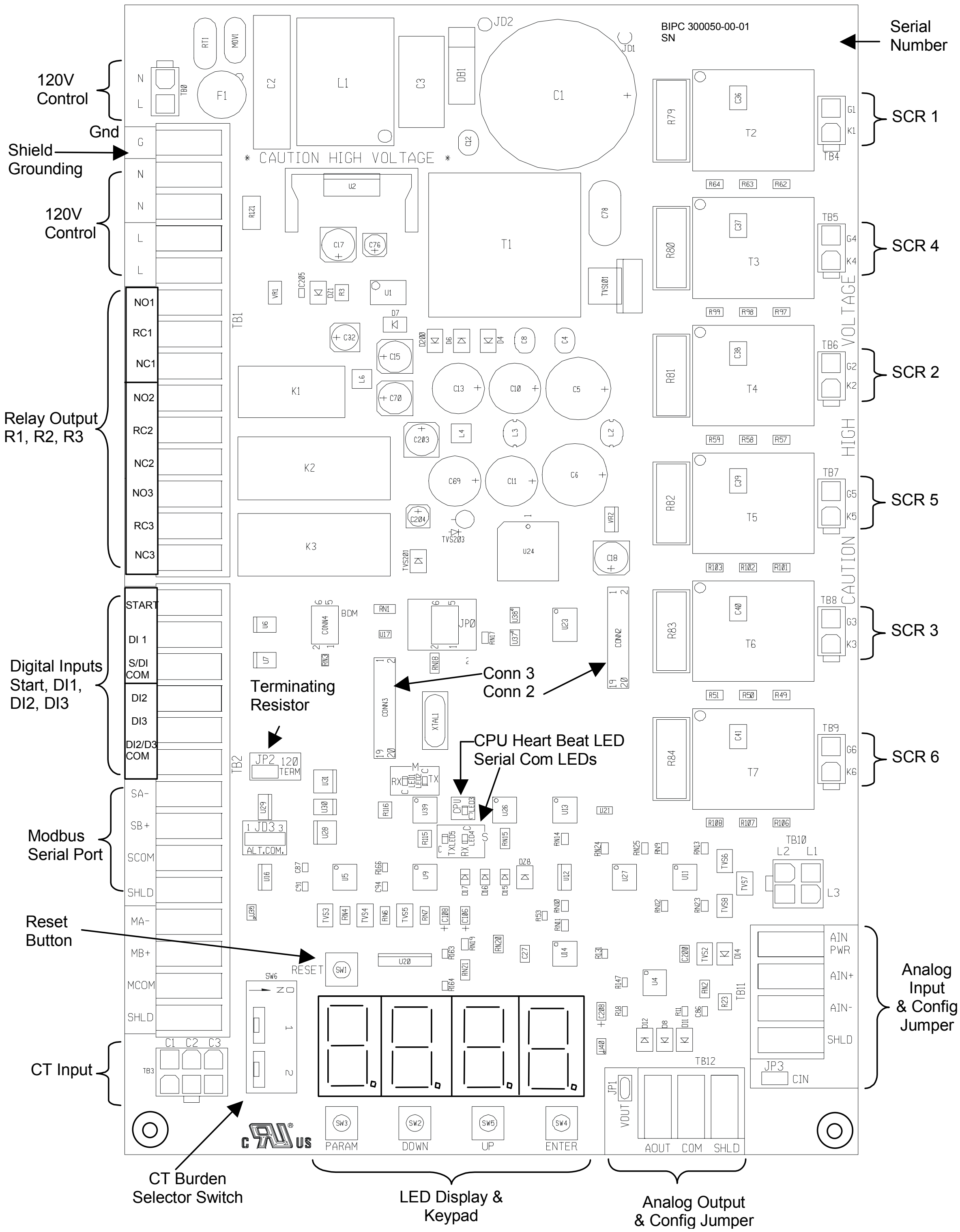
Features The enhanced engineering features of the starter include:

- 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

2 Control Card

2 – CONTROL CARD

Figure 1 – Control Card Layout



2.1 Control Card Setup

2.1.1 CT Ratio Scaling

The motor current signal scaling is set according to the motor size and the application specified when the starter is ordered. To ensure accurate operation, the motor current signal must be correctly scaled for the motor (and its application) being controlled by the starter. Motor current signal scaling may have to be changed if:

- Motor size has been changed from the original specification.

- Motor load has been changed from the original application.

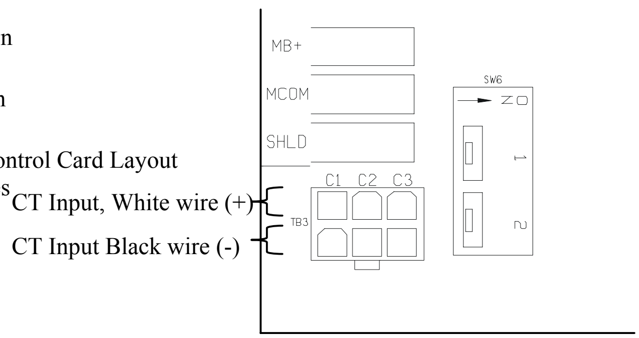
Motor current signal scaling is accomplished by verifying the current transformer ratio as supplied with the starter and then selecting the correct DIP switch setting from the chart on the following page for the current transformer ratio. The DIP switches are:

Figure 2 – CT Inputs and CT switches

- ON in the RIGHT position

- OFF in the LEFT position

- Refer to for Figure 1 – Control Card Layout actual location of switches



NOTE: The applicable ratio is stamped on each CT. Adjust the DIP switches only when there is no current being supplied to the motor, or the switches could be damaged.

NOTE: See the CT Ratio parameter on page 83.

2.1.2 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.

The CT can be placed either before or after the starter. In specific applications, like Inside Delta and a starter with a DC brake, the CTs must be before the starter.

CT1 must be on Line L1 (R), CT2 must be on Line L2 (S), and CT3 must be on Line L3 (T).

2.1.3 Confirm Switch Settings

To verify or change the motor current signal scaling:

- Compare the CT ratio stamped on each CT to the CT ratio listed on the wiring diagram supplied with the starter to ensure the correct CTs are installed.

- Inspect the control card to ensure that the DIP switches are in the correct positions for the applicable CT ratio and the motor full-load Amps (FLA).

2 – CONTROL CARD

Table 1 – CT Ratios and Burden Switch Settings

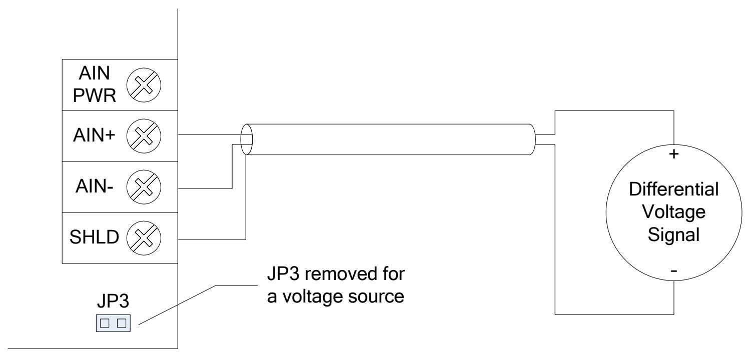
CT Ratio	Minimum FLA (A rms)	Maximum FLA (A rms)	Switch 6 Position 1	Switch 6 Position 2
72 (4 wraps 288:1)	2	3	Off	Off
	3	4	Off	On
	4	9	On	Off
	9	16	On	On
96 (3 wraps 288:1)	3	4	Off	Off
	4	5	Off	On
	5	12	On	Off
	12	21	On	On
144 (2 wraps 288:1)	4	7	Off	Off
	7	8	Off	On
	8	18	On	Off
	18	32	On	On
288	8	14	Off	Off
	14	16	Off	On
	16	36	On	Off
	36	64	On	On
864	24	42	Off	Off
	42	50	Off	On
	50	108	On	Off
	108	190	On	On
1320 (2 wraps 2640)	37	64	Off	Off
	64	76	Off	On
	76	165	On	Off
	165	290	On	On
2640	73	128	Off	Off
	128	151	Off	On
	151	330	On	Off
	330	590	On	On
2880	73	140	Off	Off
	140	165	Off	On
	165	361	On	Off
	361	640	On	On
3900	105	190	Off	Off
	190	225	Off	On
	225	490	On	Off
	490	870	On	On
5760	160	280	Off	Off
	280	330	Off	On
	330	720	On	Off
	720	1280	On	On
8000	223	390	Off	Off
	390	465	Off	On
	465	1000	On	Off
	1000	1800	On	On
14400 Mult. CT-CT Combinations	400	700	Off	Off
	700	840	Off	On
	840	1800	On	Off
	1800	3200	On	On
28800 Mult. CT-CT Combinations	800	1400	Off	Off
	1400	1680	Off	On
	1680	3600	On	Off
	3600	6400	On	On

2.1.4 Configuring the Analog Input

The analog input can be configured for Voltage or Current loop. The input is shipped in the Current Loop configuration unless specified in a custom configuration. Next to the analog input terminal block is JP3. When the jumper is installed, the input is a current loop. When removed, it is a voltage input. The control card is shipped with the jumper JP3 installed.

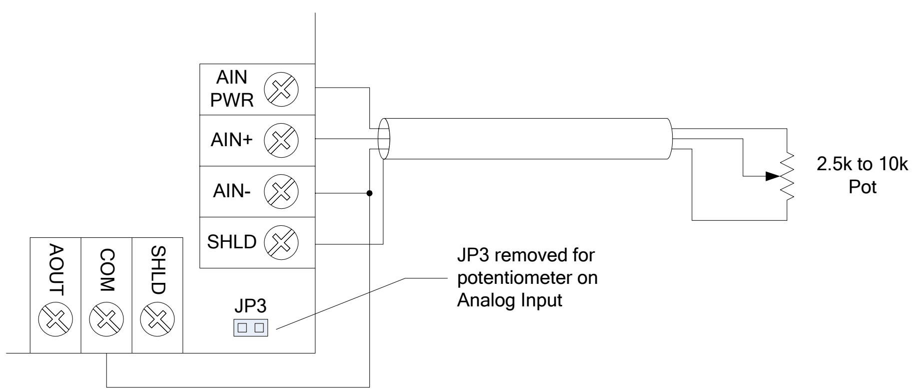
The analog input accepts a true differential signal through the AIN+ and AIN- terminals.

Figure 3 – Wiring Example of a Differential Voltage Analog Input



If the analog input is to be connected to a potentiometer, it may be powered by the AIN PWR terminal and must be grounded to the COM terminal on the analog output terminal block. The potentiometer may be 2.5k to 10k Ohms.

Figure 4 – Wiring Example of a Potentiometer on the Analog Input



NOTE: The analog output signal common also serves as the analog input signal common.

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.

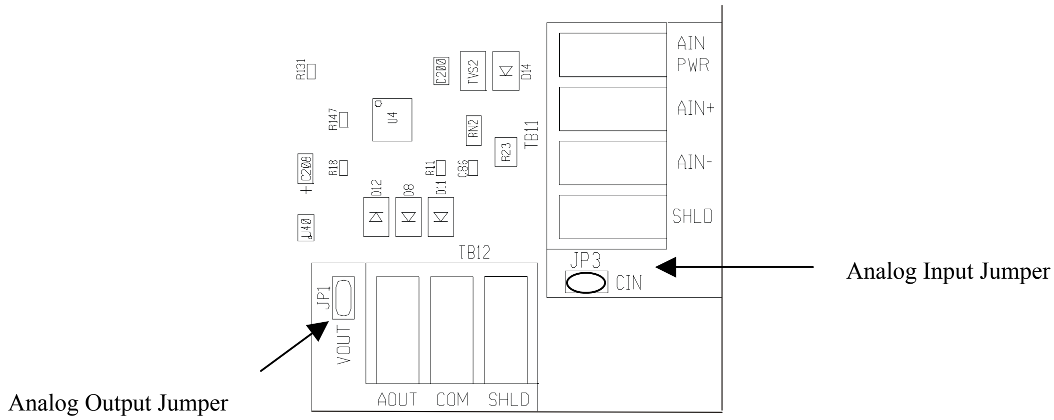
2.1.5 Configuring the Analog Output

The analog output can be configured for Voltage or Current loop. The output is shipped in the Voltage configuration unless specified in a custom configuration. Next to the analog output terminal block is JP1. When the jumper is installed, the output is Voltage. When removed, it is a current loop output. The control card is shipped with the jumper installed.

NOTE: The analog output single common also serves as the analog input single common.

2 – CONTROL CARD

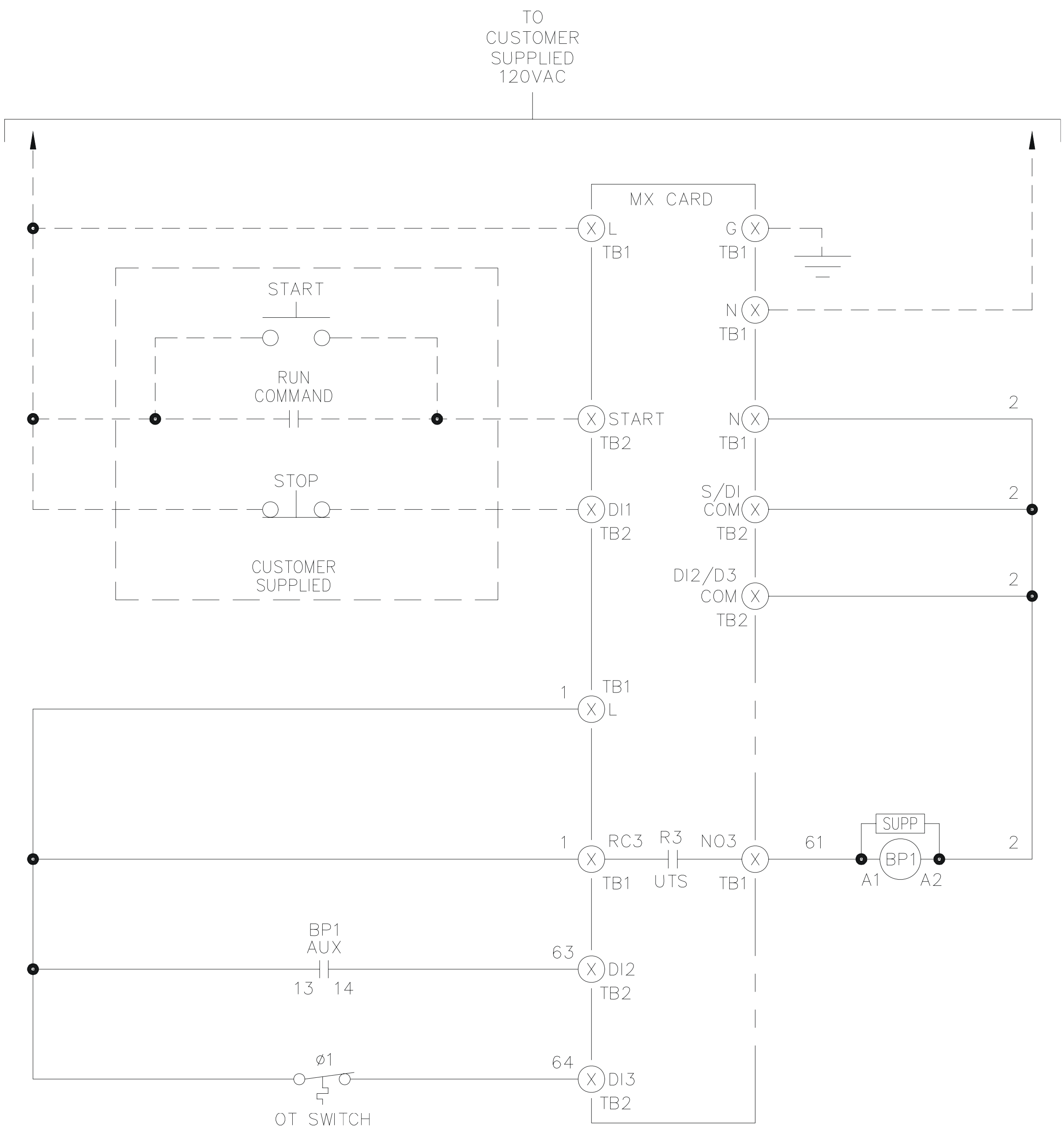
Figure 5 – MX Control Card Analog Jumper Placement



2.2 Basic Control Wiring Drawing

Digital inputs DI1, DI2, DI3 and relay outputs R1, R2, R3 are pre-programmed. This wiring diagram illustrates a 3-wire start/stop control by programming DI1 as a stop input. 2-wire start/stop control can be implemented by just using the start input. Refer to sections 5 & 6 for configuring the Digital and Analog input and output in software.

Figure 6 – Basic Wiring Diagram



3 Keypad Operation

3 – KEYPAD OPERATION

LED Keypad and Display

3.1 Introduction

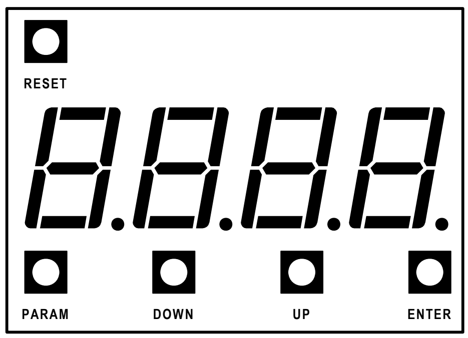
The MX provides a comprehensive set of parameters to allow the use of the reduced voltage solid state starter in nearly any industrial application. While the starter can meet the requirements of many applications right out of the box, customization of parameter values to better suit your particular application is easily accomplished with the standard, on-board, 4-digit, 7-segment LED display/keypad.

Optionally, a 2x16 character, back-lit LCD display/keypad may be added. This optional keypad may be mounted remotely from the MX control card. The remote LCD keypad has the same keys as the standard display with several additional keys including start and stop keys for operation of the starter from the keypad. When the remote LCD keypad is connected, the local display is disabled.

3.2 Standard Keypad and Display

The LED display provides information on starter operation and programming. The 4-digit, 7-segment display shows starter meter outputs and programming data. Special symbols provide further information about the starter operation (see the following section).

Figure 7 – Standard Keypad and Display



3.2.1 Viewing and Changing Parameters for the Standard Keypad

3.2.1.1 Viewing Parameter Values

Parameter view mode can be entered by:

1. At the default meter display, press the **PARAM** key to enter parameter mode. "P 1" is displayed to indicate Parameter 1.
2. Use the **UP** and **DOWN** keys to scroll through the available parameters.
3. Pressing the **UP** key from "P 1" advances to parameter "P 2".
4. Pressing the **DOWN** key from "P 1" wraps around to the highest parameter.
5. The value of the parameter can be viewed by pressing the **ENTER** key.
6. To view another parameter without changing/saving the parameter, press the **PARAM** key to return to the parameter number display.

To return to the default meter display either:

1. Press the **PARAM** key while in the parameter number display mode.
2. Wait 60 seconds and the display returns to the default meter display.

3.2.1.2 Changing Parameter Values

Parameter change mode can be entered by:

1. At the default meter display, press the **PARAM** key to enter parameter mode.
2. Use the **UP** and **DOWN** keys to scroll through the available parameters.
3. The value of the parameter can be viewed by pressing the **ENTER** key.
4. When viewing the parameter value, the parameter can be changed by using the **UP** and **DOWN** keys.
5. To store the new value, press the **ENTER** key. When the **ENTER** key is pressed the value is saved and the display goes back to parameter # “P_”.

To exit parameter change mode without saving the new parameter value either:

1. Press the **PARAM** key to return to the parameter number display.
2. Wait 60 seconds and the display returns to the default meter display.

3.2.2 Special Messages Displayed

In addition to being able to view and change parameters, various special messages may be displayed during different conditions. Here is a summary of the possible special messages.

noL	No Line	AbC	Phase order meter showing ABC
rdY	Ready	CbA	Phase order meter showing CBA
Acc	Accelerating or Kicking	SPH	Phase order meter showing Single Phase
Acc2	Accelerating or Kicking with ramp 2	oxxx	xxx = overload content.
utS	Up to Speed	P xx	xx = Parameter code.
run	Run – Done with Accel ramp but not yet Up to Speed.	A xx	xx = Alarm code. If the condition persists, a fault occurs.
dcL	Decelerating Motor	F xx	xx = Fault code.
A OL	Overload Alarm – The motor overload level is between 90% and 100%.	ioc	Instantaneous Overcurrent
F OL	Overload Fault – The motor overload level has reached 100%.	dFLt	Default – Flashes when parameter defaults are loaded.
L OL	Overload Lockout – A start is not allowed until the motor overload level cools below 15%.	HEAt	Heater/Anti-windmill Mode
		ES	Energy Saver
L CP	Control Power Lockout – A start is not allowed because the control power is too low.	FLSH	In reflash mode
		Prog	In reflash mode, programming
		rEAd	In reflash mode, verifying
LOC	Lock out State	donE	In reflash mode, complete

The following sections provide more detail for some of the conditions that cause special messages to be displayed.

3.2.2.1 Power Up

The software version is displayed as a series of blinking digits once power has been applied to the MX. If the parameters were being reset on power up, “dFLt” is flashed on the display for three seconds, and then the software version is displayed.

3.2.2.2 Stopped

When the starter is not in the run mode, the display shows the status condition of the starter, such as “rdY” (ready), “L OL” (Overload Lockout), “noL” (No Line).

LED Keypad and Display

3.2.2.3 Running

When running, the display shows the selected meter function. The following meters can be selected using the Meter display parameter.

Avg. RMS current	Avg. Voltage (RMS)	KW	Line Frequency	TruTorque %
Phase 1 RMS current	L1-L2 Voltage (RMS)	KVA	Analog Input %	Power %
Phase 2 RMS current	L2-L3 Voltage (RMS)	VARS	Analog Output %	
Phase 3 RMS current	L3-L1 Voltage (RMS)	KWh	Running Time Days	
Current Imbalance %	Overload %	MWh	Running Time Hours	
GF Current (% FLA)	Power Factor	Phase Rotation	Starts	

3.2.2.4 Alarm Condition

When an alarm condition exists, the display alternates between displaying the selected meter and the alarm code. The alarm code is displayed as "A XX", where XX is the alarm code.

- When a thermal overload alarm condition exists, "A OL" is displayed.
- When a no line alarm condition exists, "noL" is displayed.

When the starter is stopped, the selected meter is not displayed.

3.2.2.5 Lockout Condition

When a lockout condition exists, the display shows the lockout code. The lockout code is displayed as "L XX": where XX is the lockout code. Following are the defined lockout conditions and their codes:

- When a motor thermal overload lockout condition exists, "L OL" is displayed.
- When a power stack thermal overload lockout condition exists, "L Ot" is displayed.
- When a low control power lockout condition exists, "L CP" is displayed.

When there are multiple lockout codes, each is displayed at 2 second intervals.

3.2.2.6 Faulted Condition

When a fault condition exists, the display shows the fault code. The exceptions to this are as follows:

- When the fault is thermal overload trip, "F OL" is displayed.
- When the fault is Instantaneous Overcurrent, "ioc" is displayed.

3.2.3 Quick Meters

Although any meter may be viewed by changing the meter parameter, there are 3 "Quick Meters" that are always available with a single key press. When the starter is in the normal display mode, the display may be toggled between the information currently displayed and the following quick meters.

Status Meter Toggle between the programmed meter display and the starter operational status display (rdY, run, utS, dcL, etc) by pressing the **ENTER** key.

Overload Meter Toggle between the programmed meter display and the overload content by pressing the **DOWN** key. The overload is displayed as "oXXX" where XXX is the overload content. For example, when the overload content is 76 percent, it is displayed as "o 76".

Phase Order Meter Toggle between the programmed meter display and the phase order by pressing the **UP** key. The phase order is displayed as "AbC" or "CbA".

3.2.4 Restoring Factory Parameter Settings

To restore ALL parameters to the factory default settings, press and hold the **PARAM** and **ENTER** pushbutton switch on power up. The display blinks "dFLt". Parameters unique to the motor starter applications need to be set again to appropriate values before motor operation.

3.2.5 Resetting a Fault

To reset from a fault condition, press **RESET**.

3.2.6 Emergency Thermal Reset

To perform an emergency thermal reset, press **RESET** and **DOWN.** This sets the motor thermal overload content to 0.

3 – KEYPAD OPERATION

Remote LCD Keypad and Display

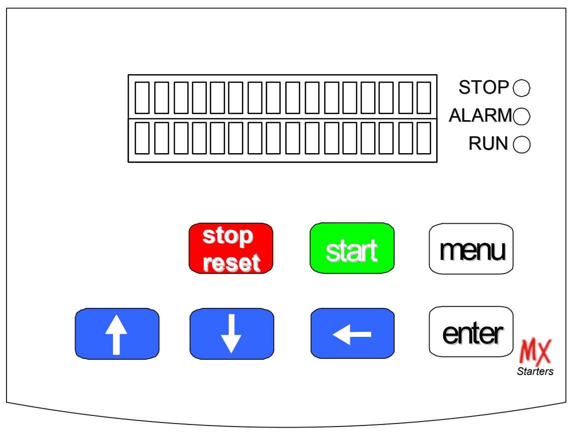
3.3 2x16 Remote LCD Keypad

Like the standard keypad, the remote LCD keypad has the same basic functions with enhancements that allow using plain text instead of codes and a menu structure instead of a straight line of parameters.

Additional keys have been added, such as “start”, “stop”, and a “left arrow” for moving the cursor around in the LCD display. Status indicators have been added, providing additional information for the starter operation.

The remote keypad and display are connected to the MX control card via a 1 or 2 meter (3 or 6ft) cable. The remote keypad is NEMA 1, 12, and 3R when mounted directly on a panel or the door of an enclosure with the correct gasket. If the bezel and keypad are used, a NEMA 4 rating can be obtained. A keypad kit may be ordered from Benshaw if the starter was not originally ordered with one. Part numbers are MX-1M-RKP-00 (includes a 1 meter cable) and MX-2M-RKP-00 (includes a 2 meter cable). Refer to the hardware manual for mounting instructions.

Figure 8 – Remote LCD Keypad



3.3.1 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 2 – 2x16 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, decelling, brake, 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 parameter. For more information refer to page 77.

3.3.2 Description of the Keys on the Remote LCD Keypad

The **UP** arrow, **DOWN** arrow, **ENTER** and **MENU** keys on the LCD keypad perform the same functions as the **UP**, **DOWN**, **ENTER** and **PARAM** keys on the standard keypad. Three keys have been added, with one of the keys serving a dual function.

Start Key

The **START** key allows the starter to be started from the keypad. In order for this key to work, the Local Source parameter must be set to Keypad (as opposed to terminal). Refer to section 5, Parameter Descriptions.

Stop/Reset Key

When the starter is in a faulted condition, the **STOP/RESET** key is used to reset the fault. When the starter is running, the **STOP/RESET** key causes the starter to stop.

Left Arrow

When changing a numerical parameter, the **LEFT** arrow key can be pressed to move the cursor to the next significant digit. When navigating through the parameter group screens, the **MENU** key progresses to the next group and the **LEFT** arrow key moves back to the previous group.

Table 3 – Description of the Keys on the Remote LCD Keypad

start	This key causes the starter to begin the start sequence. The direction is dependent on wiring and phase selection.
⇧	• Increase the value of a numeric parameter. • Select the next value of an enumerated parameter. • It scrolls forward through a list of parameter groups or parameters within a group (When the last group or 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 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 parameter groups or parameters within a group (When the first group or 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 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 scrolls 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.
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 is not set to the keypad, the stop key may be disabled using the Keypad Stop Disable parameter.

Remote LCD Keypad and Display

3.3.3 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.

Power UP Screen

On power up, the software part number is displayed for a few seconds. Pressing any key immediately changes the display to the operate screen.

```
Software PN
  810018-01-00
```

NOTE: The software part number may be different than that shown above.

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.

```
SSAAAAAACCCCCCCC
BBBBBBBBDDDDDDDD
```

The Operate Screen is divided into four sections.

- Sections A and B display status information
- Section C and D displays the meter selected by the Meter 1 and 2 parameters.
- Section SS displays the source for the start command.

Table 4 – 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 to occurs
Run	Starter is running

Table 5 – Operate Screen Section B

Display	Function
Stopped	Starter is stopped and no Faults
Lockout	Starter is in the Lockout condition
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 Load
Kick 2	Starter is applying kick current to the motor
Accel 2	Starter is Accelerating Load
Run	Starter is in Run mode
UTS	Starter is Up To Speed
Control	Phase Control or Current Follower mode
Decel	Starter is Decelerating Load
Wye	In Wye-delta control indicates motor is accelerating in Wye mode

Table 6 – Operate Screen Section SS

K	Keypad
T	Terminal Block Wiring
S	Serial Communication Connection

3.3.4 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, FUN, FL_.

```
MMM: PPPPPPPPPPP
MI   VVVVVVVVVVV
```

MMM: = Parameter Group
MI: = Menu Index
PPP: = Parameter Name
VVV: = Parameter Value and Units

Refer to Section 4 for a listing of the parameters and their ranges.

3.3.5 Meter Pages

Although any meter may be viewed by changing the two meter parameters, there are 11 "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** arrows from the operate screen.

```
Current I2=   0A
I1=   0 I3    0A
```

```
Voltage V2= 480V
V1= 480 V3= 480V
```

```
MWatt Hour=   1
kWatt Hour= 356
```

```
Motor PF  =0.00
VARS      =   0
```

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

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

```
Curr Imbal= 0.0%
```

```
Overload  =  12%
Gnd Curr  =   0%
```

```
Frequency =60.0H
Phase     =AbC
```

```
Run Days  =xxxx
Run Hours =xx:xx
```

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

```
Starts    =xxxxx
```

Remote LCD Keypad and Display

Note:	Run Hours	00:00 – 23:59
	Run days	0 – 2730 or 7.5 years
	kWatt Hours	0 – 999
	MWatt Hours	0 – 9999
	Starts	0 – 65535

3.3.6 Fault Log Screen

Pressing the **MENU OR** the **LEFT** arrow keys repeatedly cycles through all of the Parameter Groups either forward or reverse. More information regarding each fault is available through the remote LCD display than is available through the standard LED display.

```
FL_: Fault__
NNNNNNNNNNNNNN
```

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

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

Repeatedly pressing the **ENTER** key rotates through 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 average current at the time of the fault
4	The average voltage at the time of the fault
5	The line frequency at the time of the fault

3.3.7 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 Number
Fault Name
```

NOTE: For a list of the Faults, refer to Appendix B – Fault Codes on page 148.

3.3.8 Lockout Screen

When a lockout is present, the word "Lockout" is displayed on the operate screen. Pressing the **ENTER** key displays more information about the Lockout.

```
Lockout
Overload  = 115%
```

```
Lockout
Control Power
```

Remote LCD Keypad and Display

3.3.9 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 Number
Alarm Name
```

3.3.10 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:

```
T Ready Ia= 0.0A
Stopped Va=    V
```

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         10 Amp
```

Press **ENTER** key once, the cursor starts to flash in the one's place.

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

Press **LEFT** key once, the cursor flashes in the ten's place.

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

Press **UP** arrow to increase the value, for a value of 30, pressed twice.

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

Press **ENTER** to store the value.

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

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.

3.3.11 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.

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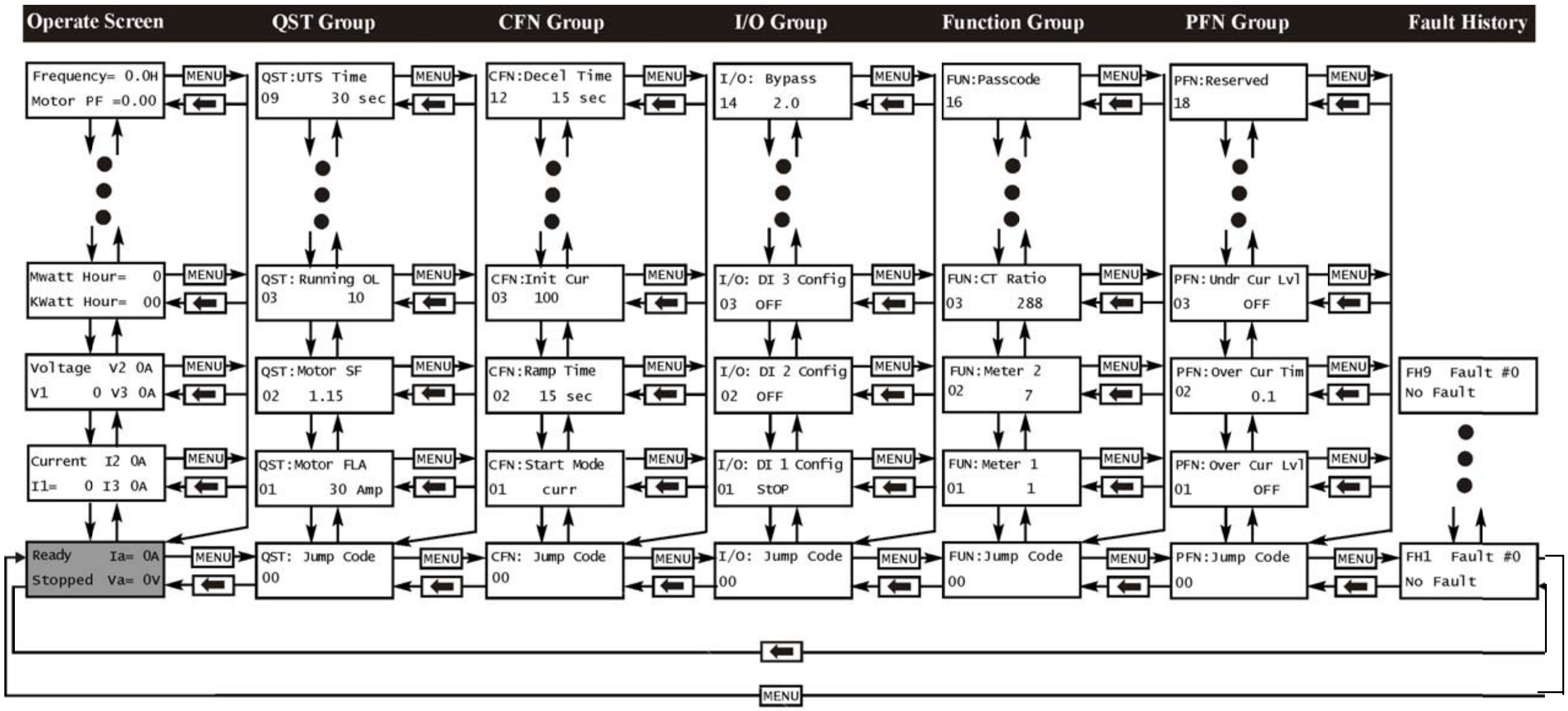

In any of the parameter groups, the user can jump to a specific parameter code by following these steps:

- Select a parameter group that requires a change.
- At the beginning of each program group the menu will read [Jump Code]. Press the [MENU] key.
- Enter the code number of the parameter needed to be changed then press [ENTER].
- There is no jump code for [Operate Screen]

4 Parameters

4 – PARAMETERS

4.1 Introduction

The MX incorporates a large number of parameters that allow you to configure the starter to meet the special requirements of your particular application. The parameters are organized two ways, depending on the display being used. When the standard, on-board LED display is used, the parameters are in a single group and numbered P1, P2, P3… etc.

When the remote LCD display is used, 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. Section 4.3 lists the parameters in the order in which they appear on the LED display. Section 4.4 lists them in the order in which they appear on the LCD display. The following table is a cross-reference between the two.

4.2 LED and LCD Display Parameters Cross Reference

Parameter Number	Group		Page #
P1	QST 01	Motor FLA	41
P2	QST 02	Motor Service Factor	41
P3	QST 03	Motor Running Overload Class	42
P4	QST 04	Local Source	43
P5	QST 05	Remote Source	44
P6	QST 06	Initial Current 1	45
P7	QST 07	Maximum Current 1	46
P8	QST 08	Ramp Time 1	47
P9	QST 09	Up To Speed Time	48
P10	CFN 01	Start Mode	49
P8	CFN 02	Ramp Time 1	47
P6	CFN 03	Initial Current 1	45
P7	CFN 04	Maximum Current 1	46
P11	CFN 08	Initial Voltage/Torque/Power	50
P12	CFN 09	Maximum Torque/Power	51
P13	CFN 10	Kick Level 1	52
P14	CFN 11	Kick Time 1	52
P15	CFN 14	Stop Mode	53
P16	CFN 15	Decel Begin Level	54
P17	CFN 16	Decel End Level	55
P18	CFN 17	Decel Time	56
P19	CFN 06	Initial Current 2	56
P20	CFN 07	Maximum Current 2	57
P21	CFN 05	Ramp Time 2	57
P22	CFN 12	Kick Level 2	57
P23	CFN 13	Kick Time 2	58
P24	PFN 01	Over Current Level	58
P25	PFN 02	Over Current Time	59
P26	PFN 03	Under Current Level	60
P27	PFN 04	Under Current Time	60
P28	PFN 05	Current Imbalance Level	61
P29	PFN 06	Ground Fault Level	62
P30	PFN 07	Over Voltage Level	63
P31	PFN 08	Under Voltage Level	63
P32	PFN 09	Voltage Trip Time	64
P33	PFN 10	Auto Reset	64
P34	PFN 11	Controlled Fault Stop Enable	64
P35	PFN 12	Independent Starting/Running Overload	65
P36	PFN 13	Motor Starting Overload Class	66
P3	PFN 14	Motor Running Overload Class	42
P37	PFN 15	Motor Overload Hot/Cold Ratio	67
P38	PFN 16	Motor Overload Cooling Time	68
P39	I/O 01	DI 1 Configuration	69
P40	I/O 02	DI 2 Configuration	69
P41	I/O 03	DI 3 Configuration	69
P42	I/O 04	R1 Configuration	70
P43	I/O 05	R2 Configuration	70
P44	I/O 06	R3 Configuration	70
P45	I/O 07	Analog Input Trip Type	71
P46	I/O 08	Analog Input Trip Level	72
P47	I/O 09	Analog Input Trip Time	72
P48	I/O 10	Analog Input Span	73
P49	I/O 11	Analog Input Offset	74
P50	I/O 12	Analog Output Function	74
P51	I/O 13	Analog Output Span	75
P52	I/O 14	Analog Output Offset	75
P53	I/O 15	Inline Configuration	76
P54	I/O 16	Bypass Feedback Time	76
P55	I/O 17	Keypad Stop Disable	77
P56	PFN 17	Reserved	
P57	PFN 18	Reserved	
P58	FUN 15	Miscellaneous Commands	78
P59	FUN 12	Communication Timeout	78
P60	FUN 11	Communication Baud Rate	79
P61	FUN 10	Communication Drop Number	79
P62	FUN 09	Energy Saver	79
P63	FUN 08	Heater Level	80
P64	FUN 07	Starter Type	81
P65	FUN 06	Rated Power Factor	82
P66	FUN 05	Rated Voltage	82
P67	FUN 04	Phase Order	83
P68	FUN 03	CT Ratio	83
P69	FUN 01	Meter	84
NA	FUN 02	Meter 2	84
P70	FUN 13	Starter Model Number	84
P71	FUN 14	Software Part Number	85
P72	FUN 16	Passcode	86
P73	FL1	Fault Log	87

4.3 LED Display Parameters

Number	Parameter	Setting Range	Units	Default	Page
P1	Motor FLA	1 – 6400	RMS Amps	10	41
P2	Motor Service Factor	1.00 – 1.99		1.15	41
P3	Motor Running Overload Class	OFF, 1 – 40		10	42
P4	Local Source	PAd: Keypad tEr Terminal SEr: Serial		tEr	43
P5	Remote Source				44
P6	Initial Current 1	50 – 600	%FLA	100	45
P7	Maximum Current 1	100 – 800	%FLA	600	46
P8	Ramp Time 1	0 – 300	Seconds	15	47
P9	Up To Speed Time	1 – 900	Seconds	20	48
P10	Start Mode	oLrP: Voltage Ramp curr: Current Ramp tt: TT Ramp Pr: Power Ramp		curr	49
P11	Initial Voltage/Torque/Power	1 – 100	%	25	50
P12	Maximum Torque/Power	10 – 325	%	105	51
P13	Kick Level 1	OFF, 100 – 800	%FLA	OFF	52
P14	Kick Time 1	0.1 – 10.0	Seconds	1.0	52
P15	Stop Mode	CoS Coast SdcL Volt Decel tdcL TT Decel		CoS	53
P16	Decel Begin Level	100 – 1	%	40	54
P17	Decel End Level	99 – 1	%	20	55
P18	Decel Time	1 – 180	Seconds	15	56
P19	Initial Current 2	50 – 600	%FLA	100	56
P20	Maximum Current 2	100 – 800	%FLA	600	57
P21	Ramp Time 2	0 – 300	Seconds	15	57
P22	Kick Level 2	OFF, 100 – 800	%FLA	OFF	57
P23	Kick Time 2	0.1 – 10.0	Seconds	1.0	58
P24	Over Current Level	OFF, 50 – 800	%FLA	OFF	58
P25	Over Current Time	OFF, 0.1 – 90.0	Seconds	0.1	59
P26	Under Current Level	OFF, 5 – 100	%FLA	OFF	60
P27	Under Current Time	OFF, 0.1 – 90.0	Seconds	0.1	60
P28	Current Imbalance Level	OFF, 5 – 40	%	15	61
P29	Ground Fault Level	OFF, 5 – 100	%FLA	OFF	62
P30	Over Voltage Level	OFF, 1 – 40	%	OFF	63
P31	Under Voltage Level	OFF, 1 – 40	%	OFF	63
P32	Voltage Trip Time	0.1 – 90.0	Seconds	0.1	64
P33	Auto Reset	OFF, 1–900	Seconds	OFF	64
P34	Controlled Fault Stop Enable	OFF, On		On	64
P35	Independent Starting/Running Overload	OFF, On		OFF	65
P36	Motor Starting Overload Class	OFF, 1 – 40		10	66
P37	Motor Overload Hot/Cold Ratio	0 – 99	%	60	67
P38	Motor Overload Cooling Time	1.0 – 999.9	Minutes	30.0	68

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Number	Parameter	Setting Range	Units	Default	Page
P39	DI 1 Configuration	OFF: Off		StOP	69
P40	DI 2 Configuration			byP	
P41	DI 3 Configuration			FL	
P42	R1 Configuration	OFF: Off FLFS: Fault (fail safe) FLnF: Fault (non fail safe) run: Running utS: UTS AL: Alarm rdyr: Ready LOC: Locked Out OC: Over Current UC: Under Current OLA: OL Alarm ShFS: Shunt Trip (fail safe) ShnF: Shunt Trip (non fail safe) GfLt: Ground Fault ES: Energy Saver HEAt: Heating		FLFS	70
P43	R2 Configuration			run	
P44	R3 Configuration			utS	
P45	Analog Input Trip Type	OFF: Disabled Lo: Low Level Hi: High Level		OFF	71
P46	Analog Input Trip Level	0 – 100	%	50	72
P47	Analog Input Trip Time	0.1 – 90.0	Seconds	0.1	72
P48	Analog Input Span	1 – 100	%	100	73
P49	Analog Input Offset	0 – 99	%	0	74
P50	Analog Output Function	0: OFF (no output) 1: 0 – 200% Curr 2: 0 – 800% Curr 3: 0 – 150% Volt 4: 0 – 150% OL 5: 0 – 10 kW 6: 0 – 100 kW 7: 0 – 1 MW 8: 0 – 10 MW 9: 0 – 100% Ain 10: 0 – 100% Firing 11: Calibration		0	74
P51	Analog Output Span	1 – 125	%	100	75
P52	Analog Output Offset	0 – 99	%	0	75
P53	Inline Configuration	OFF, 1.0 –10.0	Seconds	3.0	76
P54	Bypass Feedback Time	0.1 – 5.0	Seconds	2.0	76
P55	Keypad Stop Disable	Enabled, Disabled		Enabled	77
P56	Reserved				
P57	Reserved				

Number	Parameter	Setting Range	Units	Default	Page
P58	Miscellaneous Commands	0: None 1: Reset Run Time 2: Reset KWh/MWh 3: Enter Reflash mode 4 Store Parameters 5 Load Parameters 6: Factory Reset		0	78
P59	Communication Timeout	OFF, 1 – 120	Seconds	OFF	78
P60	Communication Baud Rate	1.2, 2.4, 4.8, 9.6, 19.2	Kbps	9.6	79
P61	Communication Drop Number	1 – 247		1	79
P62	Energy Saver	OFF, On		OFF	79
P63	Heater Level	OFF, 1 – 25	%FLA	OFF	80
P64	Starter Type	nor: Normal Id: Inside Delta y-d: Wye-Delta PctL: Phase Control cFol: Current Follow AtL: ATL		nor	81
P65	Rated Power Factor	-0.01 (Lag)–1.00 (Unity)		-0.92	82
P66	Rated 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, 10.00 (10000), 11.00 (11000), 11.50 (11500), 12.00 (12000), 12.47 (12470), 13.20 (13200), 13.80 (13800)	RMS Voltage	480	82
P67	Phase Order	InS Insensitive AbC ABC CbA CBA SPH Single Phase		InS	83
P68	CT Ratio	72, 96, 144, 288, 864, 1320, 2640, 2880, 3900, 5760, 8000, 14.4 (14400), 28.8 (28800)		288	83

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Number	Parameter	Setting Range	Units	Default	Page
P69	Meter	0: Status 1: Ave Current 2: L1 Current 3: L2 Current 4: L3 Current 5: Curr Imbal 6: 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 Freq 20: Analog Input 21: Analog Output 22: Run Days 23: Run Hours 24: Starts 25: TruTorque % 26: Power %		1	84
P70	Starter Model Number	Model Dependent			84
P71	Software Part Number	Display Only			85
P72	Passcode			Off	86
P73	Fault Log				87

4.4 LCD Display Parameters

The 2x16 display has the same parameters available as the LED display, with the exception of two meter parameters instead of one since two meters may be displayed on the main screen. The parameters are subdivided into five groups. The groups are **QST** (Quick Start), **CFN** (Control Functions), **I/O** (Input/Output Functions), **PFN** (Protection Functions) and **FUN** (Function).

The Quick Start Group provides a collection of the parameters most commonly needed to be 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.

4.4.1 Quick Start Group

Group	Display	Description	Setting Range	Units	Default	Page
QST 00	Jump Code	Jump to parameter	1 – 9		1	
QST 01	Motor FLA	Motor FLA	1– 6400	RMS Amps	10	41
QST 02	Motor SF	Motor Service Factor	1.00 – 1.99		1.15	41
QST 03	Running OL	Motor Running Overload Class	Off, 1 – 40		10	42
QST 04	Local Src	Local Source	Keypad Terminal Serial		Terminal	43
QST 05	Remote Src	Remote Source				44
QST 06	Init Cur	Initial Current 1	50 – 600	%FLA	100	45
QST 07	Max Cur	Maximum Current 1	100 – 800	%FLA	600	46
QST 08	Ramp Time	Ramp Time 1	0 – 300	Seconds	15	47
QST 09	UTS Time	Up To Speed Time	1 – 900	Seconds	20	48

4.4.2 Control Function Group

Group	Display	Description	Setting Range	Units	Default	Page
CFN 00	Jump Code	Jump to parameter	1 – 17		1	
CFN 01	Start Mode	Start Mode	Voltage Ramp Current Ramp TT Ramp Power Ramp		Current Ramp	49
CFN 02	Ramp Time 1	Ramp Time 1	0 – 300	Seconds	15	47
CFN 03	Init Cur 1	Initial Current 1	50 – 600	%FLA	100	45
CFN 04	Max Cur 1	Maximum Current 1	100 – 800	%FLA	600	46
CFN 05	Ramp Time 2	Ramp Time 2	0 – 300	Seconds	15	57
CFN 06	Init Cur 2	Initial Current 2	50 – 600	%FLA	100	56
CFN 07	Max Cur 2	Maximum Current 2	100 – 800	%FLA	600	57
CFN 08	Init V/T/P	Initial Voltage/Torque/Power	1 – 100	%	25	50
CFN 09	Max T/P	Maximum Torque/Power	10 – 325	%	105	51
CFN 10	Kick Lvl 1	Kick Level 1	Off, 100 – 800	%FLA	Off	52
CFN 11	Kick Time 1	Kick Time 1	0.1 – 10.0	Seconds	1.0	52
CFN 12	Kick Lvl 2	Kick Level 2	Off, 100 – 800	%FLA	Off	57
CFN 13	Kick Time 2	Kick Time 2	0.1 – 10.0	Seconds	1.0	58
CFN 14	Stop Mode	Stop Mode	Coast Volt Decel TT Decel		Coast	53
CFN 15	Decel Begin	Decel Begin Level	100 – 1	%	40	54
CFN 16	Decel End	Decel End Level	50 – 1	%	20	55
CFN 17	Decel Time	Decel Time	1 – 180	Seconds	15	56

4.4.3 Protection Group

Group	Display	Description	Setting Range	Units	Default	Page
PFN 00	Jump Code	Jump to parameter	1 – 18		1	
PFN 01	Over Cur Lvl	Over Current Level	Off, 50 – 800	%FLA	Off	58
PFN 02	Over Cur Tim	Over Current Time	Off, 0.1 – 90.0	Seconds	0.1	59
PFN 03	Undr Cur Lvl	Under Current Level	Off, 5 – 100	%FLA	Off	60
PFN 04	Undr Cur Tim	Under Current Time	Off, 0.1 – 90.0	Seconds	0.1	60
PFN 05	Cur Imbl Lvl	Current Imbalance Level	Off, 5 – 40	%	15	61
PFN 06	Gnd Flt Lvl	Ground Fault Level	Off, 5 – 100	%FLA	Off	62
PFN 07	Over Vlt Lvl	Over Voltage Level	Off, 1 – 40	%	Off	63
PFN 08	Undr Vlt Lvl	Under Voltage Level	Off, 1 – 40	%	Off	63
PFN 09	Vlt Trip Tim	Voltage Trip Time	0.1 – 90.0	Seconds	0.1	64
PFN 10	Auto Reset	Auto Reset	Off, 1 – 900	Seconds	Off	64
PFN 11	Ctrl Flt En	Controlled Fault Stop Enable	Off, On		On	64
PFN 12	Indep S/R OL	Independent Starting/Running Overload	Off, On		Off	65
PFN 13	Starting OL	Motor Starting Overload Class	Off, 1 – 40		10	66
PFN 14	Running OL	Motor Running Overload Class	Off, 1 – 40		10	42
PFN 15	OL H/C Ratio	Motor Overload Hot/Cold Ratio	0 – 99	%	60	67
PFN 16	OL Cool Tim	Motor Overload Cooling Time	1.0 – 999.9	Minutes	30.0	68
PFN 17	Reserved	Reserved				
PFN 18	Reserved	Reserved				

4.4.4 I/O Group

Group	Display	Description	Setting Range	Units	Default	Page
I/O 00	Jump Code	Jump to parameter	1 – 17		1	
I/O 01	DI 1 Config	DI 1 Configuration	Off Stop Fault High Fault Low Fault Reset Bypass Cnfrm E OL Reset Local/Remote Heat Disable Heat Enable Ramp Select		Stop	69
I/O 02	DI 2 Config	DI 2 Configuration			Bypass Cnfrm	
I/O 03	DI 3 Config	DI 3 Configuration			Fault Low	
I/O 04	R1 Config	R1 Configuration	Off Fault FS (Fail Safe) Fault NFS (Non Fail Safe) Running UTS Alarm Ready Locked Out Overcurrent Undercurrent OL Alarm Shunt Trip FS Shunt Trip NFS Ground Fault Energy Saver Heating		Fault FS	70
I/O 05	R2 Config	R2 Configuration			Running	
I/O 06	R3 Config	R3 Configuration			UTS	
I/O 07	Ain Trp Type	Analog Input Trip Type	Off Low Level High Level		Off	71
I/O 08	Ain Trp Lvl	Analog Input Trip Level	0 – 100	%	50	72
I/O 09	Ain Trp Tim	Analog Input Trip Time	0.1 – 90.0	Seconds	0.1	72
I/O 10	Ain Span	Analog Input Span	1 – 100	%	100	73
I/O 11	Ain Offset	Analog Input Offset	0 – 99	%	0	74
I/O 12	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	74
I/O 13	Aout Span	Analog Output Span	1 – 125	%	100	75
I/O 14	Aout Offset	Analog Output Offset	0 – 99	%	0	75
I/O 15	Inline Confg	Inline Configuration	Off, 1.0 – 10.0	Seconds	3.0	76
I/O 16	Bypas Fbk Tim	Bypass Feedback Time	0.1 – 5.0	Seconds	2.0	76
I/O 17	Kpd Stop Dis	Keypad Stop Disable	Enabled, Disabled		Enabled	77

4.4.5 Function Group

Group	Display	Description	Setting Range	Units	Default	Page
FUN 00	Jump Code	Jump to parameter	1 – 16		1	
FUN 01	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 %		Ave Current	84
FUN 02	Meter 2	Meter 2			Ave Volts	
FUN 03	CT Ratio	CT Ratio	72, 96, 144, 288, 864, 1320, 2640, 2880, 3900, 5760, 8000, 14400, 28800		288	83
FUN 04	Phase Order	Phase Order	Insensitive ABC CBA Single Phase		Insens.	83
FUN 05	Rated Volts	Rated 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	82
FUN 06	Motor PF	Rated Power Factor	-0.01 (Lag) – 1.00 (Unity)		-0.92	82
FUN 07	Starter Type	Starter Type	Normal Inside Delta Wye-Delta Phase Ctl Curr Follow ATL		Normal	81
FUN 08	Heater Level	Heater Level	Off, 1 – 25	%FLA	Off	80
FUN 09	Energy Saver	Energy Saver	Off, On		Off	79
FUN 10	Com Drop #	Communication Drop Number	1 – 247		1	79
FUN 11	Com Baudrate	Communication Baud Rate	1200 2400 4800 9600 19200	bps	9600	79

Group	Display	Description	Setting Range	Units	Default	Page
FUN 12	Com Timeout	Communication Timeout	Off, 1 – 120	Seconds	Off	78
FUN 13	Starter MN	Starter Model Number	Model Dependent			84
FUN 14	Software PN	Software Part Number	Display Only			85
FUN 15	Misc Command	Miscellaneous Commands	None Reset RT Reset kWh Reflash Mode Factory Reset Store Parameters Load Parameters		None	78
FUN 16	Passcode	Passcode			Off	86

4.4.6 Fault Group

Group	Description	Setting Range	Display
FL1	Last Fault (newest)	Display Only	Fault #
FL2	Previous Fault	Display Only	Fault #
FL3	Previous Fault	Display Only	Fault #
FL4	Previous Fault	Display Only	Fault #
FL5	Previous Fault	Display Only	Fault #
FL6	Previous Fault	Display Only	Fault #
FL7	Previous Fault	Display Only	Fault #
FL8	Previous Fault	Display Only	Fault #
FL9	Previous Fault (oldest)	Display Only	Fault #

5 Parameter Descriptions

5 – PARAMETER DESCRIPTIONS

The detailed parameter descriptions in this chapter are organized in the same order as they appear on the LED display. If the remote LCD display is being used, the table in chapter 4 beginning on page 33 can be used to find the page number of the parameter in this chapter.

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

P__	Parameter Name	MMM ___

LCD Display

```
MMM:Parameter
 MI Value
```

Range Parameter Value **(Default ___)**

Description The description of the function

Options

LED	LCD
EEE	Keypad

See Also Cross references to related parameters or other chapters

In the above format, the header box for the parameter contains the P number (as it appears in the menu on the LED display), the parameter name and the parameter group number (as it appears in the menu on the LCD display).

The **LCD Display** section shows an example of what actually appears on the LCD display. The parameter group (represented above by "MMM") and the (possibly abbreviated) parameter name are shown on the first line. The parameter group number (represented above by "MI" for "menu index") and the parameter's value and units are shown on the second line.

Some parameters appear in two different menus of the LCD display. This is mostly the case for those parameters that are in the Quick Start Group. In this case, both LCD menu groups are listed in the header box and two example LCD displays are shown.

For some parameters, the **Range** section is enough to describe the parameter. For others, there may be an additional **Options** section to describe each of the options that a parameter may be set to. The form that the options take may be different for the LED and LCD displays, so this section shows how the options appear on both displays.

The **See Also** section lists cross references to other parameters that may be related as well as references to further detail in other chapters.

P1 Motor FLA QST 01

LCD Display

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

Range Model dependent, 1 to 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.

P2 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 8.2, Motor Service Factor, on page 117

P3	Motor Running Overload Class	QST 03, PFN 14

LCD Display

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

```
PFN: Running OL
14        10
```

Range

OFF, 1– 40 **(Default 10)**

Description

The Motor Running Overload Class parameter sets the class 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 Starting/Running Overload 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 8.1, Solid State Motor Overload Protection for the overload trip time versus current curves.

When the Motor Running Overload Class 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 on page 65
Motor Starting Overload Class parameter on page 66
Motor Overload Hot/Cold Ratio parameter on page 67
Motor Overload Cooling Time parameter on page on page 68
Relay Output Configuration parameter on page 70
Theory of Operation section 8.1, Solid State Motor Overload Protection, on page 110

P4	Local Source	QST 04

LCD Display

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

Range PAd, tEr, SEr **(Default tEr)**

Description The MX can have three sources of start and stop control; Terminal, Keypad and Serial. Two parameters, Local Source and Remote Source, select the source of the start and stop control.

If a digital input is programmed as "L-r" (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 "L-r", then the local/remote bit in the starter control Modbus register selects the control source. The default value of the bit is Local (0).

Options

LED	LCD	
PAd	Keypad	When selected, the start/stop control is from the keypad.
tEr	Terminal	When selected, the start/stop control is from the terminal strip inputs.
SEr	Serial	When selected, the start/stop control is from the network.

See Also

Remote Source parameter on page 44
Digital Input Configuration parameters on page 69
Keypad Stop Disable parameter on page 77
Communication Timeout parameter on page 78
Communication Baud Rate parameter on page 79
Communication Drop Number parameter on page 79

NOTE: By default, the Stop key is always active, regardless of selected control source. It may be disabled though using the Keypad Stop Disable parameter.

P5	Remote Source	QST 05

LCD Display

```
QST:Remote SRC
05  Terminal
```

Range PAd, tEr, SEr **(Default tEr)**

Description The MX can have three sources of start and stop control; Terminal, Keypad and Serial. Two parameters, Local Source and Remote Source, select the source of the start and stop control.

If a digital input is programmed as "L-r" (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 "L-r", then the local/remote bit in the starter control Modbus register selects the control source. The default value of the bit is Local (0).

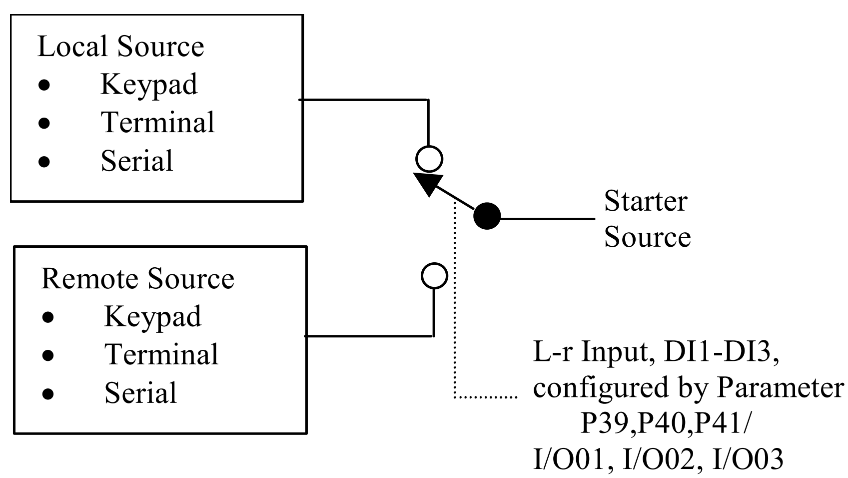
Options

LED	LCD	
PAd	Keypad	When selected, the start/stop control is from the keypad.
tEr	Terminal	When selected, the start/stop control is from the terminal strip inputs.
SEr	Serial	When selected, the start/stop control is from the network.

See Also

Local Source parameter on page 43
Digital Input Configuration parameters on page 69
Keypad Stop Disable parameter on page 77
Communication Timeout parameter on page 78
Communication Baud Rate parameter on page 79
Communication Drop Number parameter on page 79

Figure 9 – Local Remote Source



P6	Initial Current 1	QST 06, CFN 03

LCD Display

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

```
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 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

Maximum Current 1 parameter on page 46
Ramp Time 1 parameter on page 47
Kick Level 1 parameter on page 52
Kick Time 1 parameter on page 52
Start Mode parameter on page 49
Theory of Operation section 8.3.1, Current Ramp Settings, Ramps and Times, on page 118

P7	Maximum Current 1	QST 07, CFN 04

LCD Display

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

```
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 parameter setting. The Maximum Current 1 parameter 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 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 Initial Current 1 parameter on page 45
Ramp Time 1 parameter on page 47
Up To Speed Time parameter on page 48
Kick Level 1 parameter on page 52
Kick Time 1 parameter on page 52
Start Mode parameter on page 49
Theory of Operation section 8.3.1, Current Ramp Settings, Ramps and Times, on page 118

P8	Ramp Time 1	QST 08, CFN02

LCD Display

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

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

Range 0 – 300 seconds **(Default 15 seconds)**

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

Initial Current 1 parameter on page 45
Maximum Current 1 parameter on page 46
Up To Speed Time parameter on page 48
Kick Level 1 parameter on page 52
Kick Time 1 parameter on page 52
Start Mode parameter on page 49
Theory of Operation section 8.3.1, Current Ramp Settings, Ramps and Times, on page 118

P9	Up To Speed Time	QST 09

LCD Display

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

Range

1– 900 Seconds **(Default 20 sec)**

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. This allows the programming of a maximum acceleration time for the motor. 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 is set to Open-Loop 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 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.

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

See Also

Ramp Time 1 parameter on page 47
Kick Time 1 parameter on page 52
Ramp Time 2 parameter on page 57
Kick Time 2 parameter on page 58
Start Mode parameter on page 49
Starter Type parameter on page 81
Application section 6.2.1, Wye Delta, on page 91
Theory of Operation section 8.3, Acceleration Control, on page 118

P10	Start Mode	CFN 01

LCD Display

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

Range OLrP, Curr, tt, Pr **(Default Curr)**

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

Options

LED	LCD	
OLrP:	Voltage Ramp	Open Loop Voltage acceleration ramp
Curr:	Current Ramp	Current control acceleration ramp. The closed loop current control acceleration ramp is ideal for starting most general-purpose motor applications. Examples: crushers, ball mills, reciprocating compressors, saws, centrifuges, and most other applications.
tt:	TT Ramp	TruTorque control acceleration ramp. 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. Examples: centrifugal pumps, fans, and belt driven equipment.
Pr:	Power Ramp	Power (kW) control acceleration ramp. The closed loop power control acceleration ramp is ideal for starting applications using a generator or other limited capacity source.

See Also

Initial Current 1 parameter on page 45
Maximum Current 1 parameter on page 46
Ramp Time 1 parameter on page 47
Kick Level 1 parameter on page 52
Kick Time 1 parameter on page 52
Initial Voltage/Torque/Power parameter on page 50
Theory of Operation section 8.3, Acceleration Control, on page 118

P11	Initial Voltage/Torque/Power	CFN 08

LCD Display

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

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

Description Start Mode set to Open Loop Voltage Acceleration:

When the Start Mode parameter is 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 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 to set the initial current level.

Start Mode set to TruTorque Control Acceleration:

When the Start Mode parameter is set to TruTorque 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 Rated Power Factor parameter is set properly so that the actual initial torque level is the value desired.

Start Mode set to Power Control Acceleration:

When the Start Mode parameter is set to Power controlled 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 Rated Power Factor parameter is set properly so that the actual initial power level is the value desired.

See Also

Maximum Torque/Power parameter on page 51
Initial Current 1 parameter on page 45
Ramp Time 1 parameter on page 47
Start Mode parameter on page 49
Rated Power Factor parameter on page 82
Theory of Operation section 8.3, Acceleration Control, on page 118

P12	Maximum Torque/Power	CFN 09

LCD Display

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

Range

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

Description

Start Mode 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 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 to set the maximum current level.

Start Mode set to TruTorque Control Acceleration:

When the Start Mode parameter is set to TruTorque 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 Rated Power Factor parameter is set properly so that the desired maximum torque level is achieved.

Start Mode set to Power Control Acceleration:

When the Start Mode parameter is set to Power controlled 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 Rated Power Factor parameter is set properly so that the actual maximum power level is achieved.

See Also

Initial Voltage/Torque/Power parameter on page 50
Maximum Current 1 parameter on page 46
Ramp Time 1 parameter on page 47
Start Mode parameter on page 49
Rated Power Factor parameter on page 82
Theory of Operation section 8.3, Acceleration Control, on page 118

P13 Kick Level 1 CFN 10

LCD Display

```
CFN:  Kick Lvl 1
10   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

Kick Time 1 parameter on page 52
Start Mode parameter on page 49
Theory of Operation section 8.3.2, Programming A Kick Current, on page 119

P14 Kick Time 1 CFN 11

LCD Display

```
CFN: Kick Time 1
11       1.0 sec
```

Range

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

Description

The Kick Time 1 parameter sets the length of time that the kick current level 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

Kick Level 1 parameter on page 52
Start Mode parameter on page 49
Up To Speed Time parameter on page 48
Theory of Operation section 8.3.2, Programming A Kick Current, on page 119

P15	Stop Mode	CFN 14

LCD Display

```
CFN: Stop Mode
14   Coast
```

Range

CoS, SdcL, tdcL (**Default CoS**)

Description

The Stop Mode parameter allows for the most suitable stop of the motor based on the application.

Options

LED	LCD	
CoS	Coast	Coast: A coast to stop should be used when no special stopping requirements are necessary; Example: crushers, balls mills, centrifuges, belts, conveyor. In Low Voltage systems, the bypass contactor is opened before the SCRs stop gating to reduce wear on the contactor contacts. (Default)
SdcL	Voltage Decel	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.
tdcL	TT Decel	TruTorque Decel: In this mode, the starter linearly reduces the motor torque based on the Decel End Level and Decel Time.

Note: The MX 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 or TT Decel) instead of being allowed to coast to a stop when this occurs. This may be achieved by setting the Controlled Fault Stop Enable parameter to On. Be aware however that not all fault conditions allow for a controlled fault stop.

See Also

Decel Begin Level parameter on page 54
Decel End Level parameter on page 55
Decel Time parameter on page 56
Controlled Fault Stop Enable parameter on page 64
Theory of Operation section 8.4, Deceleration Control, on page 127

P16	Decel Begin Level	CFN 15

LCD Display

```
CFN:Decel Begin
15        40 %
```

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

Description

Stop Mode set to Voltage Deceleration:

The voltage deceleration profile utilizes an open loop S-curve voltage ramp profile. When the Stop Mode parameter is set to Voltage Decel, 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 set to TruTorque Deceleration:

Not used when the Stop Mode parameter is set to TruTorque Decel, the decel begin level has no effect on the deceleration profile. 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 Rated Power Factor parameter is set properly so that the actual deceleration torque levels are the levels desired.

See Also

Stop Mode parameter on page 53
Decel End Level parameter on page 55
Decel Time parameter on page 56
Controlled Fault Stop Enable parameter on page 64
Rated Power Factor parameter on page 82
Theory of Operation section 8.4, Deceleration Control, on page 127

P17 Decel End Level CFN 16

LCD Display

```
CFN:  Decel End
16        20 %
```

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

Description

Stop Mode set to Voltage Deceleration:

The voltage deceleration profile utilizes an open loop S-curve voltage ramp profile. When the Stop Mode parameter is set to Voltage Decel, 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.

Note: The deceleration end level can not be set greater than the decel begin level.

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.

Stop Mode set to TruTorque Deceleration:

When the Stop Mode parameter is set to TruTorque Decel, 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 on page 53
Decel Begin Level parameter on page 54
Decel Time parameter on page 56
Controlled Fault Stop Enable parameter on page 64
Theory of Operation section 8.4, Deceleration Control, on page 127

P18 Decel Time CFN 17

LCD Display

```
CFN: Decel Time
17        15 sec
```

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

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 between applying the initial decel level to the application of 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.

Refer to section 8.4, Deceleration Control page 127,

See Also

Stop Mode parameter on page 53
Decel Begin Level parameter on page 54
Decel End Level parameter on page 55
Controlled Fault Stop Enable parameter on page 64
Theory of Operation section 8.4, Deceleration Control, on page 127

P19 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 parameter setting when the second ramp is active. Refer to the Initial Current 1 parameter for description of operation.

See Also

Initial Current 1 parameter on page 45
Digital Input Configuration parameters on page 69
Theory of Operation section 8.3.1, Current Ramp Settings, Ramps and Times, on page 118
Theory of Operation section 8.3.6, Dual Acceleration Ramp Control, on page 125

P20	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 parameter setting, when the second ramp is active. Refer to the Maximum Current 1 for description of operation.

See Also

Maximum Current 1 parameter on page 46
Digital Input Configuration parameters on page 69
Theory of Operation section 8.3.1, Current Ramp Settings, Ramps and Times, on page 118
Theory of Operation section 8.3.6, Dual Acceleration Ramp Control, on page 125

P21	Ramp Time 2	CFN 05

LCD Display

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

Range 0 – 300 seconds **(Default 15 seconds)**

Description The Ramp Time 2 parameter 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 parameter for description of operation.

See Also

Ramp Time 1 parameter on page 47
Digital Input Configuration parameters on page 69
Theory of Operation section 8.3.1, Current Ramp Settings, Ramps and Times, on page 118
Theory of Operation section 8.3.6, Dual Acceleration Ramp Control, on page 125

P22	Kick Level 2	CFN 12

LCD Display

```
CFN:  Kick Lvl 2
12   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 for description of operation.

See Also

Kick Level 1 parameter on page 52
Digital Input Configuration parameters on page 69
Theory of Operation section 8.3.2, Programming A Kick Current, on page 119
Theory of Operation section 8.3.6, Dual Acceleration Ramp Control, on page 125

P23	Kick Time 2	CFN 13

LCD Display

```
CFN: Kick Time 2
13       1.0 sec
```

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

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

See Also
Kick Time 1 parameter on page 52
Digital Input Configuration parameters on page 69
Theory of Operation section 8.3.2, Programming A Kick Current, on page 119
Theory of Operation section 8.3.6, Dual Acceleration Ramp Control, on page 125

P24	Over Current Level	PFN 01

LCD Display

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

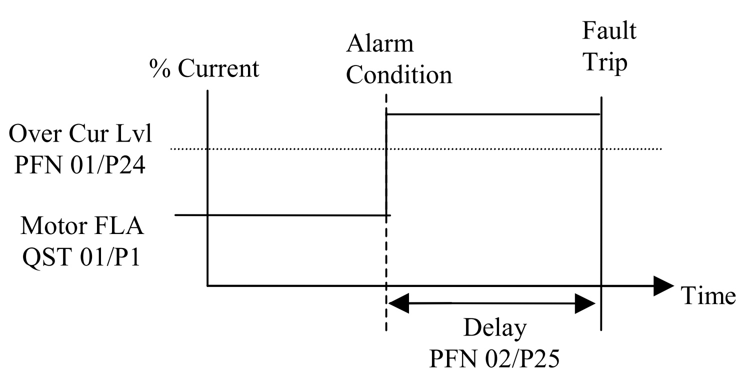
Range OFF, 50 – 800 % of FLA **(Default OFF)**

Description If the starter detects a one cycle, average RMS current that is greater than the level defined, an over current alarm condition exists and the alarm relay energizes if defined. 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) and the fault relay de-energizes.

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 on page 59
Relay Output Configuration parameters on page 70
Auto Reset parameter on page 64
Controlled Fault Stop Enable parameter on page 64



P25	Over Current Time	PFN 02

LCD Display

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

Range

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

Description

The Over Current Time parameter sets the period of time that the motor current must be greater than the Over Current Level 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 Overcurrent 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 on page 58
Relay Output Configuration parameters on page 70
Auto Reset parameter on page 64
Controlled Fault Stop Enable parameter on page 64

P26	Under Current Level	PFN 03

LCD Display

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

Range

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

Description

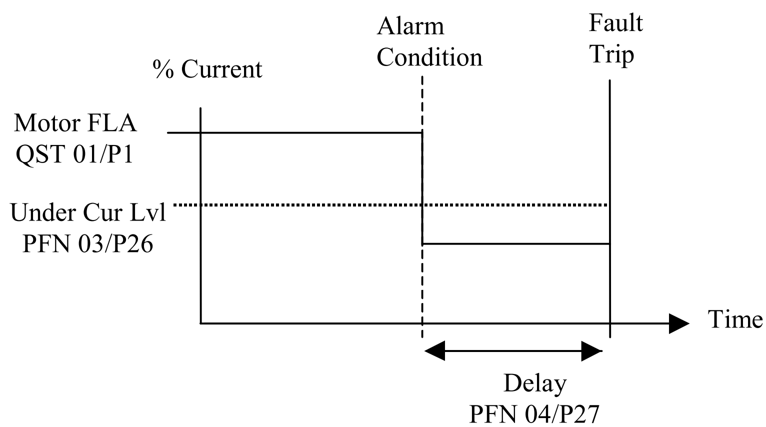
If the MX detects a one cycle, average RMS current that is less than the level defined, an under current alarm condition exists and the alarm relay energizes, if defined. The under current timer starts a delay time. If the under current still exists when the delay time expires, the starter Under Current Trips (F34) and the fault relay de-energizes.

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 on page 60
Relay Output Configuration parameters on page 70
Auto Reset parameter on page 64
Controlled Fault Stop Enable parameter on page 64



P27	Under Current Time	PFN 04

LCD Display

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

Range

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

Description

The Under Current Time parameter sets the period of time that the motor current must be less than the Under Current Level 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 Undercurrent until the current rises.

See Also

Under Current Level parameter on page 60
Relay Output Configuration parameters on page 70
Auto Reset parameter on page 64
Controlled Fault Stop Enable parameter on page 64

P28	Current Imbalance Level	PFN 05

LCD Display

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

Range

OFF, 5 – 40 % **(Default 15%)**

Description

The Current Imbalance Level parameter sets the imbalance that is allowed before the starter shuts down. The current imbalance must exist for 10 seconds before a fault occurs.

At average currents less than or equal to 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 FLA current.

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

$$\% \text{ imbalance} = \frac{(\text{I ave} - \text{I max})}{\text{FLA}} \text{ x } 100\%$$

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).

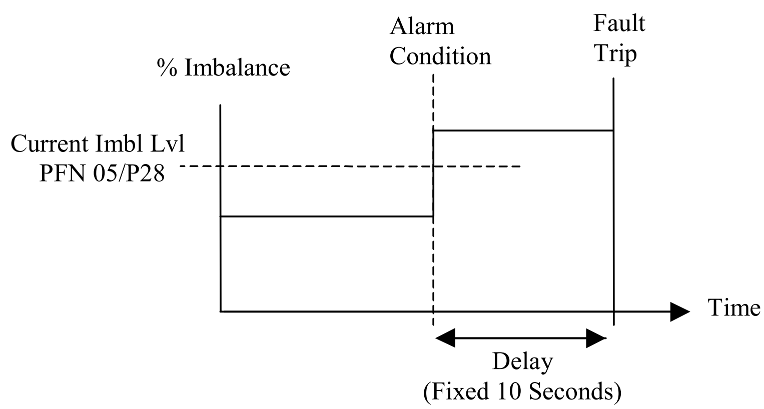
The equation for the current imbalance if running at current > FLA:

$$\% \text{ imbalance} = \frac{(\text{I ave} - \text{I max})}{\text{I ave}} \text{ x } 100\%$$

If the highest calculated current imbalance is greater than the current imbalance level for 10 seconds, the starter shuts down the motor and declares a Fault 37 (Current Imbalance).

See Also

Auto Reset parameter on page 64
Controlled Fault Stop Enable parameter on page 64



P29	Ground Fault Level	PFN 06

LCD Display

```
PFN:Gnd Flt Lvl
06   Off
```

Range

OFF, 5 – 100 % FLA **(Default OFF)**

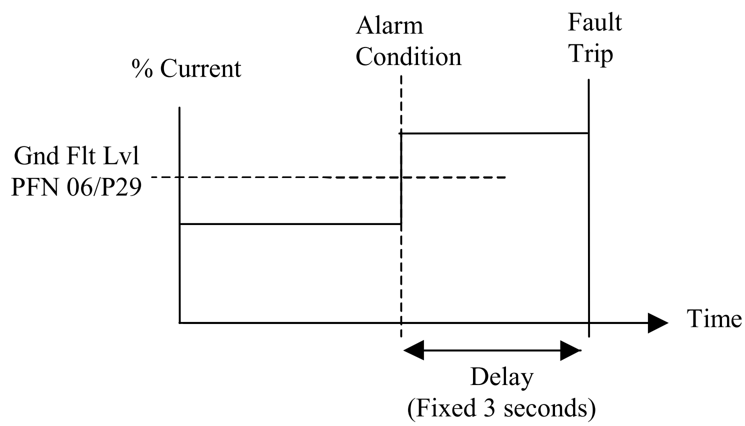
Description

The Ground Fault 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.

The ground fault current has to remain above the ground fault level for 3 seconds before the starter recognizes a ground fault condition. Once the starter recognizes a ground fault condition, it shuts down the motor and declares a Fault 38 (Ground Fault).

If a programmable relay is set to ground fault (GND), 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 is often referred to as residual ground fault protection. 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 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 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 during normal operation.

See Also

Relay Output Configuration parameters on page 70
Auto Reset parameter on page 64
Controlled Fault Stop Enable parameter on page 64

P30 Over Voltage Level PFN 07

LCD Display

```
PFN:Over Vlt Lvl
07   Off
```

Range

OFF, 1 – 40 % **(Default OFF)**

Description

If the MX detects for one cycle of any of the individual input phase voltages (rms) 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. The over voltage condition and the phase on which occurred is displayed.

NOTE: For the over voltage protection to operate correctly, the Rated Voltage parameter must be set correctly.

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

See Also

Rated Voltage parameter on page 82
Under Voltage Level parameter on page 63
Voltage Trip Time parameter on page 64
Auto Reset parameter on page 64
Controlled Fault Stop Enable parameter on page 64

P31 Under Voltage Level PFN 08

LCD Display

```
PFN:Undr Vlt Lvl
08   Off
```

Range

OFF, 1 – 40 % **(Default OFF)**

Description

If the MX detects for one cycle of any of the individual input phase voltages (rms) 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. The under voltage condition and the phase on which it occurred is displayed.

NOTE: For the under voltage protection to operate correctly, the Rated Voltage parameter must be set correctly.

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

See Also

Rated Voltage parameter on page 82
Over Voltage Level parameter on page 63
Voltage Trip Time parameter on page 64
Auto Reset parameter on page 64
Controlled Fault Stop Enable parameter on page 64

P32	Voltage Trip Time	PFN 09

LCD Display

```
PFN:Vlt Trip Tim
09       0.1 sec
```

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

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 on page 63
Under Voltage Level parameter on page 63
Auto Reset parameter on page 64
Controlled Fault Stop Enable parameter on page 64

P33	Auto Reset	PFN 10

LCD Display

```
PFN: Auto Reset
10   Off
```

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

Description The Auto Reset parameter sets the time delay after a fault occurred and before the starter can automatically reset the fault. For the list of fault 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 B – Fault Codes on page 148

P34	Controlled Fault Stop Enable	PFN 11

LCD Display

```
PFN:Ctrl Flt En
11    On
```

Range OFF – On **(Default On)**

Description If a fault condition occurs that permits a controlled fault stop and the Controlled Fault Stop Enable parameter is ON, then a controlled fault stop occurs. 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 stop immediately regardless of the Controlled Fault Stop Enable parameter.

Refer to Appendix B – Fault Codes to determine if a fault may perform a controlled stop.

See Also Stop Mode parameter on page 53
Appendix B – Fault Codes on page 148

P35	Independent Starting/Running Overload	PFN 12

LCD Display

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

Range

OFF – On **(Default OFF)**

Description

If "OFF"

When this parameter is "OFF" the overload defined by the Motor Running Overload Class parameter 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 is used during motor acceleration and acceleration kick. The running overload class 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 exponential heating and cooling function during all other states. However, 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 on page 42
Motor Starting Overload Class parameter on page 66
Motor Overload Hot/Cold Ratio parameter on page 67
Motor Overload Cooling Time parameter on page 68
Theory of Operation section 8.1.7, Separate Starting and Running Motor Overload Settings, on page 114

P36	Motor Starting Overload Class	PFN 13

LCD Display

```
PFN:Starting OL
13         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, and the Independent Starting/Running Overload is “ON”, 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 on page 65
Motor Running Overload Class parameter on page 42
Motor Overload Hot/Cold Ratio parameter on page 67
Motor Overload Cooling Time parameter on page 68
Relay Output Configuration parameters on page 70
Theory of Operation section 8.1, Solid State Motor Overload Protection, on page 110

P37	Motor Overload Hot/Cold Ratio	PFN 15

LCD Display

```
PFN:OL H/C Ratio
15        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.

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

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

Motor Overload Cooling Time parameter on page 68
Independent Starting/Running Overload parameter on page 65
Motor Running Overload Class parameter on page 42
Motor Starting Overload Class parameter on page 66
Relay Output Configuration parameters on page 70
Theory of Operation section 8.1.6, Hot / Cold Motor Overload Compensation, on page 113
Theory of Operation section 8.1.4, Current Imbalance / Negative Sequence Current Compensation, on page 112

P38	Motor Overload Cooling Time	PFN 16

LCD Display

```
PFN:OL Cool Tim
16      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 overload setting.

See Also

Motor Overload Hot/Cold Ratio parameter on page 67
Independent Starting/Running Overload parameter on page 65
Motor Running Overload Class parameter on page 42
Motor Starting Overload Class parameter on page 66
Theory of Operation section 8.1.8, Motor Cooling While Stopped, on page 115
Theory of Operation section 8.1.9, Motor Cooling While Running, on page 116

P39, P40, P41	Digital Input Configuration	I/O 01, I/O 02, I/O 03

LCD Display

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

```
I/O:DI 2 Config
02  Bypass Cnfrm
```

```
I/O:DI 3 Config
03  Fault Low
```

Description

I/O parameters 1 – 3 configure which functions are performed by the D1 to D3 terminals.

Options

LED	LCD	
OFF	OFF	OFF, Not Assigned, Input has no function
StOP	Stop	Command a Stop to remove the software seal in for 3-wire control **(Default DI 1)**
FH	Fault High	Fault High, Fault when input is asserted, 120V applied.
FL	Fault Low	Fault Low, Fault when input is de-asserted, 0V applied **(Default DI 3)**
Fr	Fault Reset	Fault Reset, Reset when input asserted, 120V applied.
byP	Bypass Cnfrm	Bypass/2M, bypass contactor feedback, 2M contactor feedback in full voltage or Wye-delta **(Default DI 2)**
EoLr	EOL Reset	Emergency Motor Overload content reset. After an OL trip has occurred Reset when input asserted, 120V applied.
L-r	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.
hdIS	Heat Disable	Heat Disable, Heater disabled when input asserted, 120V applied.
hEn	Heat Enabled	Heat Enabled, Heater enabled when input asserted, 120V applied.
rSEL	Ramp Select	Ramp 2 selection, Ramp 2 is enabled when input asserted, 120V applied.

See Also

Bypass Feedback Time parameter on page 76
Local Source parameter on page 43
Remote Source parameter on page 44
Heater Level parameter on page 80
Application section 6.2.1, Wye Delta, on page 91
Theory of Operation section 8.1.10, Emergency Motor Overload Reset, on page 116
Theory of Operation section 8.5, Wye-Delta Operation, on page 129
Theory of Operation section 8.3.6, Dual Acceleration Ramp Control, on page 125
Theory of Operation section 8.9, Start/Stop Control with a Hand/Off/Auto Selector Switch, on page 135

P42, P43, P44	Relay Output Configuration	I/O 04, I/O 5, I/O 06

LCD Display

```
I/O: R1 Config
04  Fault FS
```

```
I/O: R2 Config
05  Running
```

```
I/O: R3 Config
06  UTS
```

Description

I/O parameters 1 – 3 configure which functions are performed by the R1 to R3 relays

Options

LED	LCD	
OFF	Off	OFF, Not Assigned, Output has no function or may be controlled over Modbus
FLFS	Fault FS	Faulted – Fail Safe operation, energized when no faults present, de-energized when faulted **(Default R1)**
FLnF	Fault NFS	Faulted– Non Fail Safe operation, de-energized when no faults present, energized when faulted
run	Running	Running, starter running, voltage applied to motor **(Default R2)**
utS	UTS	Up to Speed, motor up to speed **(Default R3)** or transition to for Wye/Delta Operation
AL	Alarm	Alarm, any alarm condition present
rdyr	Ready	Ready, starter ready for start command
LOC	Locked Out	Locked Out
OC	Over Current	Over Current Alarm, over current condition detected.
UC	Under Current	Under Current Alarm, under current condition detected.
OLA	OL Alarm	Overload Alarm
ShFS	Shunt FS	Shunt Trip Relay – Fail Safe operation, energized when no shunt trip fault present, de-energized on shunt trip fault.
ShnF	Shunt NFS	Shunt Trip Relay – Non Fail Safe operation, de-energized when no shunt trip fault present, energized on shunt trip fault
GfLt	Ground Fault	A Ground Fault trip has occurred.
ES	Energy Saver	Operating in Energy Saver Mode.
HEAt	Heating	Motor Heating, starter applying heating pulses to motor.

See Also

Up To Speed Time parameter on page 48
Over Current Level parameter on page 58
Under Current Level parameter on page 60
Ground Fault Level parameter on page 62
Inline Configuration parameter on page 76
Heater Level parameter on page 80
Energy Saver parameter on page 79
Application section 6.1, Application Consideration between Line Connected and Inside Delta Connected Soft Starter, on page 90
Application section 6.2.1, Wye Delta, on page 91
Application section 6.2.4, Across The Line (Full Voltage Starter), on page 94
Theory of Operation section 8.1.3, Motor Overload Operation, on page 112
Theory of Operation section 8.5, Wye-Delta Operation, on page 129
Appendix B – Fault Codes, on page 148

P45 Analog Input Trip Type I/O 07

LCD Display

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

Range

OFF, Lo, Hi **(Default Off)**

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 Type 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 Input Trip Level parameter to a value less than (<) 20%.

Options

LED	LCD	
OFF	Disabled	OFF, Disabled (Default)
Lo	Low Level	Low, Fault if input signal below preset trip level
Hi	High Level	High, Fault if input signal above preset trip level

See Also

Analog Input Trip Level parameter on page 72
Analog Input Trip Time parameter on page 72
Analog Input Span parameter on page 73
Analog Input Offset parameter on page 74
Starter Type parameter on page 81
Section 2.1.4, Configuring the Analog Input, on page 11
Application section 6.2.2, Phase Control, on page 93
Application section 6.2.3, Current Follower, on page 93
Theory of Operation section 8.6, Phase Control, on page 131
Theory of Operation section 8.7, Current Follower, on page 133

P46	Analog Input Trip Level	I/O 08

LCD Display

```
I/O:Ain Trp Lvl
08        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 parameter to LOW and setting the Analog Input Trip Level 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 Offset and Analog Input Span parameters values are set to.

See Also
Analog Input Trip Type parameter on page 71
Analog Input Trip Time parameter on page 72
Analog Input Span parameter on page 73
Analog Input Offset parameter on page 74

P47	Analog Input Trip Time	I/O 09

LCD Display

```
I/O:Ain Trp Tim
09       0.1 sec
```

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

Description The Analog Input Trip 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 on page 71
Analog Input Trip Level parameter on page 72
Analog Input Span parameter on page 73
Analog Input Offset parameter on page 74

P48	Analog Input Span	I/O 10

LCD Display

```
I/O: Ain Span
10       100 %
```

Range 0 – 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.

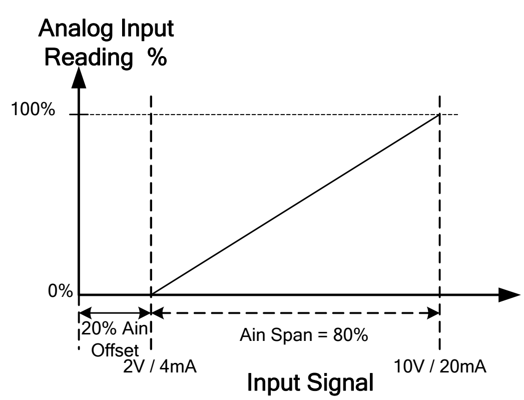
For a 4-20mA input, a 80% Analog Input Span setting and a 20% Analog Input Offset setting results in a 0% input reading at 4mA and a 100% input reading at 20mA.

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

See Also

Analog Input Trip Level parameter on page 72
Analog Input Trip Time parameter on page 72
Analog Input Offset parameter on page 74
Starter Type parameter on page 81
Section 2.1.4, Configuring the Analog Input, on page 11
Theory of Operation section 8.6, Phase Control, on page 131
Theory of Operation section 8.7, Current Follower, on page 133

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



P49	Analog Input Offset	I/O 11

LCD Display

```
I/O:Ain Offset
11         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 on page 72
Analog Input Trip Time parameter on page 72
Analog Input Span parameter on page 73
Starter Type parameter on page 81
Section 2.1.4, Configuring the Analog Input, on page 11
Theory of Operation section 8.6, Phase Control, on page 131
Theory of Operation section 8.7, Current Follower, on page 133

P50	Analog Output Function	I/O 12

LCD Display

```
I/O: Aout Fctn
12         0
```

Range 0 – 11, **(Default 0/OFF)**

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.

Options

LED	LCD	
0	OFF	OFF, Disabled (Default)
1	0 – 200% Curr	Based on per cycle RMS values
2	0 – 800% Curr	Based on per cycle RMS values
3	0 – 150% Volt	Based on per cycle RMS values
4	0 – 150% OL	Motor Thermal Overload
5	0 – 10 kW	Based on filtered V and I values
6	0 – 100 kW	Based on filtered V and I values
7	0 – 1 MW	Based on filtered V and I values
8	0 – 10 MW	Based on filtered V and I values
9	0 – 100% Ain	The output value takes into account the inputs span and offset settings
10	0 – 100% Firing	Output Voltage to Motor, based on SCR firing angle
11	Calibration	Calibration, full (100%) output

See Also

Analog Output Span parameter on page 75
Analog Output Offset parameter on page 75
Section 2.1.5, Configuring the Analog Output, on page 11
Theory of Operation section 8.6, Phase Control, on page 131
Theory of Operation section 8.7, Current Follower, on page 133

P51	Analog Output Span	I/O 13

LCD Display

```
I/O: Aout Span
13       100 %
```

Range 0 – 125% **(Default 100%)**

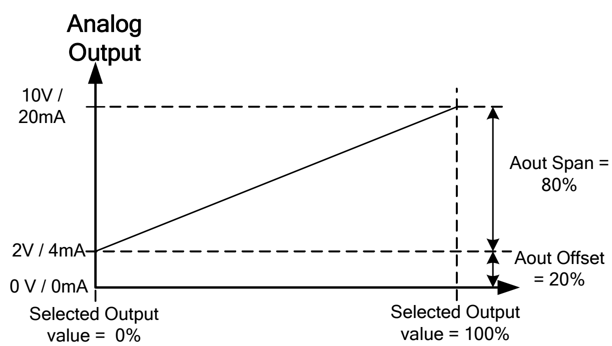
Description The analog output signal can be scaled using the Analog Output Span parameter. For a 0-10V output or 0-20mA output, a 100% scaling outputs the maximum voltage (10V) or current (20mA) when the selected output function requests 100% output. A scale of 50% outputs 50% voltage/current when the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

See Also Analog Output Offset parameter on page 75

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



P52	Analog Output Offset	I/O 14

LCD Display

```
I/O:Aout Offset
14         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 on page 75

P53	Inline Configuration	I/O 15

LCD Display

```
I/O:Inline Confg
15       3.0 sec
```

Range OFF, 0 – 10.0 seconds **(Default 3.0 sec)**

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 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 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 the Inline Configuration parameter, then a "noL" (No Line) fault is declared.

In order to control an inline contactor, program a relay as a Running relay. This is the default function for R2.

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

See Also Relay Output Configuration parameters on page 70

P54	Bypass Feedback Time	I/O 16

LCD Display

```
I/O:Bpas Fbk Tim
16       2.0 sec
```

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

Description The programmable inputs DI 1, DI 2 or DI 3 may 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 trips on Fault 48 (Bypass Fault).

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

NOTE: A digital input needs to be programmed to Bypass/2M for this function to operate.

See Also Digital Input Configuration parameters on page 69
Application section 6.2.1, Wye Delta, on page 91
Theory of Operation section 8.5, Wye-Delta Operation, on page 129

P55	Keypad Stop Disable	I/O 17

LCD Display

```
I/O:Kpd Stop Dis
17       Enabled
```

Range Enabled – Disabled **(Default Enabled)**

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 regardles off the selected control source (keypad, terminal or serial).

Option

LED	LCD	
Off	Disabled	Keypad Stop does not stop the starter
On	Enabled	Keypad Stop does stop the starter **(Default Enabled)**

See Also

Local Source parameter on page 43
Remote Source parameter on page 44

P58	Miscellaneous Commands	FUN 15

LCD Display

```
FUN:Misc Command
15   None
```

Range 0 – 6 **(Default 0)**

Description The Miscellaneous Commands parameter is used to issue various commands to the MX starter.

The Reset Run Time command resets the user run time meters back to zero (0).

The Reset kWh command resetsthe accumulated kilowatt-hour and megawatt-hour meters back to zero (0).

The Reflash Mode command puts the MX into a reflash program memory mode. The reflash mode can only be entered if the MX starter is idle. When the reflash mode is entered, the MX waits to be programmed. The onboard LED display shows "FLSH". The remote display is disabled after entering reflash mode. The MX does not operate normally until reflash mode is exited. Reflash mode may be exited by cycling control power.

The Store 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 command loads the stored parameters into active memory.

The Factory Reset command restores all parameters to the factory defaults. These can be found section 4.

Options

LED	LCD	
0	None	No commands
1	Reset Run Time	Reset Run Time Meter
2	Reset kWh/MWh	Reset kWh/MWh Meters
3	Reflash Mode	Activate Reflash Mode
4	Store Parm	The current parameter values are stored in non-volatile memory
5	Load Parm	All parameter are retrieved from non-volatile memory
6	Factory Rst	All parameters are restored to the factory defaults

P59	Communication Timeout	FUN 12

LCD Display

```
FUN:Com Timeout
12   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

Stop Mode parameter on page 53
Local Source parameter on page 43
Remote Source parameter on page 44
Controlled Fault Stop Enable parameter on page 64
Communication Drop Number parameter on page 79
Communication Baud Rate parameter on page 79

P60 Communication Baud Rate FUN 11

LCD Display

```
FUN:Com Baudrate
11    9600
```

Range 1.2, 2.4, 4.8, 9.6, 19.2 Kbps **(Default 9.6)**

Description The Communication Baud Rate parameter sets the baud rate for Modbus communications.

See Also
Local Source parameter on page 43
Remote Source parameter on page 44
Communication Drop Number parameter on page 79
Communication Timeout parameter on page 78

P61 Communication Drop Number FUN 10

LCD Display

```
FUN: Com Drop #
10         1
```

Range 1 – 247 **(Default 1)**

Description The Communication Drop Number parameter sets the starter's address for Modbus communications.

See Also
Local Source parameter on page 43
Remote Source parameter on page 44
Communication Baud Rate parameter on page 79
Communication Timeout parameter on page 78

P62 Energy Saver FUN 09

LCD Display

```
FUN:Energy Saver
09   Off
```

Range On – Off **(Default OFF)**

Description The energy saver feature 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 once the motor is up to speed.

NOTE: In general, Energy Saver can save approximately 1000 watts per 100 HP. Consult Benshaw for further detail.

P63	Heater Level	FUN 08

LCD Display

```
FUN:Heater Level
08   Off
```

Range

OFF, 1 –25% 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 using the digital inputs, either the input is an enable or disable.

Enabled: When the DI 1, DI 2 or DI 3 inputs are programmed as Heat Enable Inputs, the input may be used to control when heating/anti-windmilling is applied. The Heater / Anti-Windmill Level parameter must be set, the starter stopped and this input must be high for heating to occur.

Disabled: When the DI 1, DI 2 or DI 3 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, the heater is applied at all times when the motor is stopped.

The level of DC 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.

See Also

Digital Input Configuration parameters on page 69

P64	Starter Type	FUN 07

LCD Display

```
FUN:Starter Type
07   Normal
```

Range

nor,Id,y-d, PctL, cFol, AtL **(Default nor)**

Description

The MX has been designed to be the controller for many control applications; Solid State Starter, both Normal (outside Delta) and Inside Delta, and electromechanical starters, Wye Delta, Across the line full voltage starter, Phase Control/Voltage Follower, Current Follower. In each case, the MX is providing the motor protection and the necessary control for these applications.

Options

LED	LCD	
nor	Normal	Normal (Outside Delta), Reduced Voltage Soft Starter RVSS (**Default**)
Id	Inside Delta	Inside Delta, RVSS
y-d	Wye-Delta	Wye Delta
PctL	Phase Control	Open Loop Phase control / voltage follower using external input reference.
cFol	Current Follow	Closed Loop Current follower using external input reference.
AtL	ATL	Across the line (Full Voltage)

NOTE: For single phase operation, select Normal for the Starter Type parameter, and Single Phase for the phase order parameter

See Also

Phase Order parameter on page 83
Application section 6.2, Other Applications using the MX, on page 91
Theory of Operation section 8.5, Wye-Delta Operation, on page 129
Theory of Operation section 8.6, Phase Control, on page 131
Theory of Operation section 8.7, Current Follower, on page 133
Theory of Operation section 8.8, Across The Line / Full Voltage Operation, on page 134

P65	Rated Power Factor	FUN 06

LCD Display

```
FUN:Rated PF
06   -0.92
```

Range -0.01 to 1.00 **(Default –0.92)**

Description The Rated Power Factor parameter sets the motor power factor value that is used by the MX 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 either by setting the LED display's Meter parameter to PF, or 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 on page 84
Theory of Operation section 8.3.3, TruTorque Acceleration Control Settings and Times, on page 119
Theory of Operation section 8.3.4, Power Control Acceleration Settings and Times, on page 121

P66	Rated 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, 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. When applied to medium voltage, (2200 and above) the voltage must be set correctly for the starter to function properly.

See Also Over Voltage Level parameter on page 63
Under Voltage Level parmater on page 63
Voltage Trip Time parameter on page 64

P67 Phase Order FUN 04

LCD Display

```
FUN:Phase Order
04   Insensitive
```

Range InS, AbC, CbA, SPH **(Default InS)**

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.

Options

LED	LCD	
InS	Insensitive	Runs with any three phase sequence
AbC	ABC	Only runs with ABC phase sequence
CbA	CBA	Only runs with CBA phase sequence
SPH	Single phase	Single Phase

P68 CT Ratio FUN 03

LCD Display

```
FUN: CT Ratio
03  288
```

Range 72, 96, 144, 288, 864, 1320, 2640, 2880, 3900, 5760, 8000, 14.4K, 28.8K **(Default 288)**

Description The CT ratio 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 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 and burden switches are set correctly. Otherwise, many starter functions will not operate correctly.

See Also Table 1 – CT Ratios and Burden Switch Settings on page 10

P69	Meter	FUN 01, FUN02

LCD Display

```
FUN:  Meter 1
01   Ave Current
```

```
FUN:  Meter 2
02   Ave Volts
```

Range 0 – 25 **(Default 1 for meter 1, 7 for meter 2)**

Description For the LED display, parameter P69 configures which single meter is displayed on the main screen. For the LCD display, parameters FUN 01and FUN 02 configure which meters are displayed on the two lines of the main display screen.

Options

LED	LCD	
0	Status	Running State (LED meter only)
1	Ave Current	Average current (Default meter 1)
2	L1 Current	Current in phase 1
3	L2 Current	Current in phase 2
4	L3 Current	Current in phase 3
5	Cur Imbal	Current Imbalance %
6	Ground Fault	Residual Ground Fault % FLA
7	Ave Volts	Average Voltage L-L RMS (Default meter 2)
8	L1-L2 Volts	Voltage in, L1 to L2 RMS
9	L2-L3 Volts	Voltage in, L2 to L3 RMS
10	L3-L1 Volts	Voltage in, L3 to L1 RMS
11	Overload	Thermal overload in %
12	Power Factor	Motor power factor
13	Watts	Motor real power consumed
14	VA	Motor apparent power consumed
15	VARS	Motor reactive power consumer
16	kW hours	Kilo-watt-hour used by the motor, wraps at 1,000
17	MW hours	Mega-watt-hour used by the motor, wraps at 10,000
18	Phase Order	Phase Rotation
19	Line Freq	Line Frequency
20	Analog Input	Analog Input %
21	Analog Output	Analog Output %
22	Run Days	Running time in days, wraps at 2,730 days
23	Run Hours	Running time in Hours and Minutes, wraps at 24:00
24	Starts	Number of Starts, wraps at 65,536
25	TruTorque %	TruTorque %
26	Power %	Power %

P70	Starter Model Number	FUN 13

LCD Display

```
FUN: Starter MN
13  None
```

Description The Starter Model Number parameter configures the thermal protection of the starter power stack. This information is useful for future service reasons. If calling Benshaw for service, this number should be recorded so it can be provided to the service technician.

P71	Software Part Number	FUN 14

LCD Display

```
FUN:Software PN
14  810018-01-xx
```

Description

The Software Part Number parameter displays the software version. When calling Benshaw for service, this number should be recorded so it can be provided to the service technician.

In addition to view the software version with this parameter, the software version is also displayed on power up. On the LED display, the software version is flashed one character at a time on power up. On the LCD display, the software PN is fully displayed on power up.

P72	Passcode	FUN 16

LCD Display

```
FUN:  Passcode
16   Off
```

Description

The MX supports a 4-digit passcode. When the passcode is set, parameters may not be changed.

When a passcode is set and an attempt is made to change a parameter through the display/keypad, the **UP** and **DOWN** keys simply have no effect. When a passcode is set and an attempt is made to change a parameter through Modbus, the MX returns an error response with an exception code of 03 (Illegal Data Value) to indicate that the register can not be changed.

LED Display

The following steps must be performed to set a passcode using the LED Display:

1. At the default meter display, press the **PARAM** key to enter the parameter mode.
2. Press the **UP** or **DOWN** keys to get to the passcode parameter.
3. Press the **ENTER** key. "Off" is displayed to indicate that no passcode is currently set.
4. Press the **UP** or **DOWN** keys and **ENTER FOR** each digit to be defined, select a value from 0000 to 9999 starting at the most significant digit.
5. Press the **ENTER** key to set the passcode.

The following steps must be performed to clear a passcode.

1. At the default meter display, press the **PARAM** key to enter the parameter mode.
2. Press the **UP** or **DOWN** keys to get to the passcode parameter.
3. Press the **ENTER** key. "On" is displayed to indicate that a passcode is presently set.
4. Press the **UP** or **DOWN** keys and **ENTER** after each digit to select the previously set passcode value.
5. Press the **ENTER** key. The passcode is then cleared.

LCD Display

The following steps must be performed to set a passcode using the LCD Display:

1. At the default meter display, press the **MENU** key to enter the Menu mode.
2. Press the **UP** or **DOWN** keys to get to the **FUN** parameters.
3. Press the **ENTER** key
4. Press the **UP** or **DOWN** keys to get to the **FUN 16**.
5. Press the **ENTER** key. "Off " is displayed to indicate that no passcode is currently set.
6. Press the **UP** or **DOWN** keys and **ENTER** for each digit to be defined, select a value from 0000 to 9999 starting at the most significant digit Press the **ENTER** key to set the passcode.

The following steps must be performed to clear a passcode.

1. At the default meter display, press the **MENU** key to enter the menu mode.
2. Press the **UP** or **DOWN** keys to get to the **FUN** parameter.
6. Press the **ENTER** key
7. Press the **UP** or **DOWN** keys to get to the **FUN 16**.
3. Press the **ENTER** key. "On" is displayed to indicate that a passcode is presently set.
4. Press the **UP** or **DOWN** keys and **ENTER** after each digit to select the previously set passcode value.
5. Press the **ENTER** key. The passcode is then cleared.

NOTE: To re-establish password protection after it has been cleared, the password must be entered again.

P73	Fault Log	FL1

LCD Display

```
FL1:Last Fault #
Fault Name
```

Range

1–9

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.

If the starter is equipped with an LCD display, pressing "ENTER" toggles through the Starter Conditions, Avg. Line Current, Avg. Line Voltage, and Line Frequency at the time of the fault.

See Also

Appendix B – Fault Codes on page 148

6 Applications

6 – APPLICATIONS

Line Connected Motor

6.1 Application Consideration between Line Connected and Inside Delta Connected Soft Starter

There are differences between a line connected soft starter as shown in Figure 10 and the inside delta connected soft starter as shown in Figure 11 that need to be understood.

By observation of Figure 11, 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 10, 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. Refer to Appendix B – Fault Codes, for those faults that cause a shunt trip.

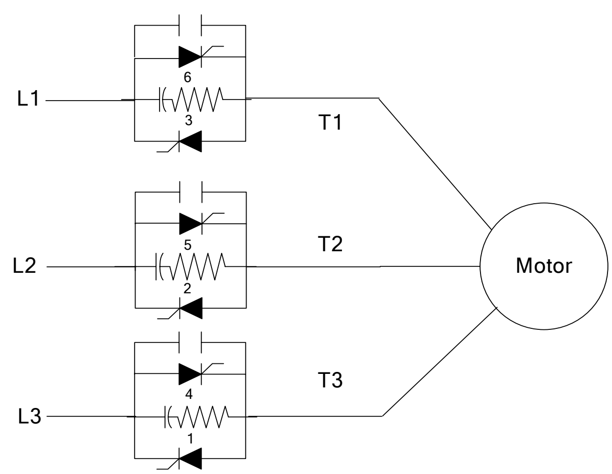
The SCR control for an inside delta application is different than the SCR control for a standard soft starter. The Starter Type parameter needs to be properly set so that the SCRs are gated correctly.

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.

6.1.1 Line Connected Soft Starter

In Figure 10, the power poles of the soft starter are connected in series with the line. The starter draws line current (L1, L2, L3).

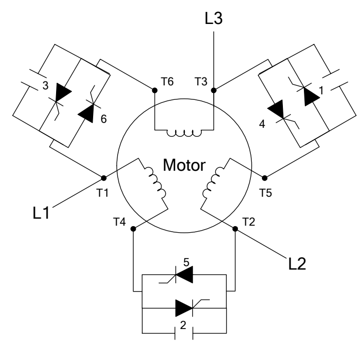
Figure 10 – Typical Motor Connection



6.1.2 Inside Delta Connection

An inside delta soft starter is shown in Figure 11, where the power poles are connected in series with the stator windings of a delta connected motor.

Figure 11 – Typical Inside Delta Motor Connection



For an Inside Delta connected motor, the inside winding's average SCR current is less than that of the outside average line current by a factor of 1.55 (FLA/1.55). By comparison of Figure 10 and Figure 11, the most obvious advantage of the inside delta starter is the reduction of current seen by the soft starter. The soft starter current rating 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

6.2 Other Applications using the MX

The MX has been designed to be the controller for other motor control applications, such as Wye Delta, Across the line full voltage starter, Phase Control/Voltage Follower and Current Follower. In each case, the MX is providing the motor protection and the necessary control for these applications.

6.2.1 Wye Delta

When the Starter Type parameter is set to Wye-Delta, the MX is configured to operate an electromechanical Wye-Delta (Star-Delta) starter. When in Wye-Delta mode, all MX motor and starter protective functions, except bad SCR detection and power stack overload, are available to provide full motor and starter protection. The Up To Speed Time parameter sets the time when the Wye to Delta transition occurs during starting.

The MX can operate two configurations of Wye-Delta starters, open transition and closed transition.

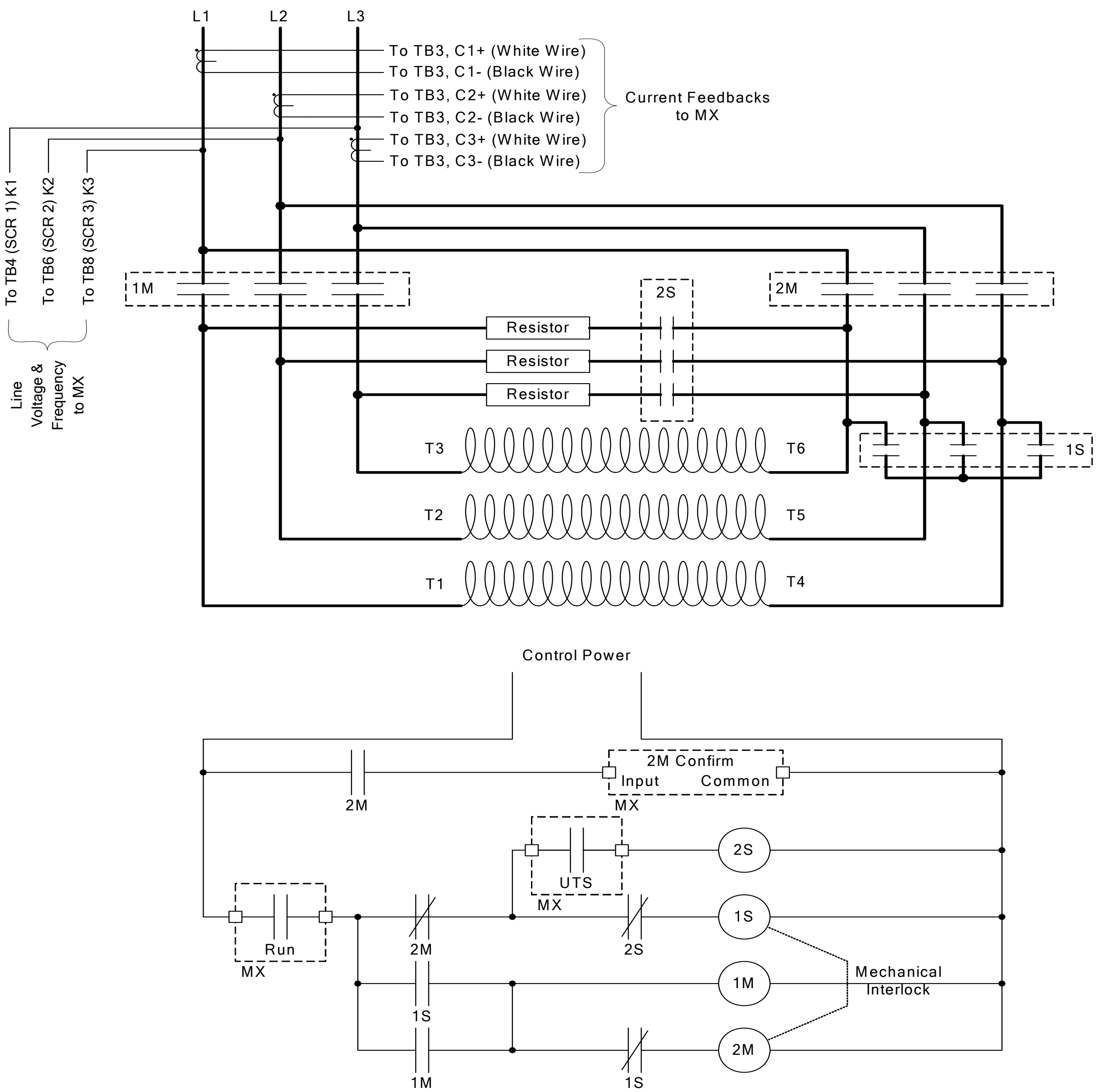
An open transition starter momentarily disconnects the motor from the input line during the transition from Wye to Delta operating mode.

A closed transition starter uses resistors that are inserted during the transition so that the motor is never completely disconnected from the input line.

Wye Delta Starter

The presence of these resistors in a closed transition starter smoothes the transition from Wye to Delta operation mode. A typical closed transition Wye-Delta starter schematic is shown in the following figure

Figure 12 – Wye Delta Motor Connection to the MX



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.

For operation of the Wye-Delta and its transitions from a start to a completed run, refer to Section 8.5, Wye-Delta Operation.

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.

6.2.2 Phase Control

When the Starter Type parameter is set to Phase Control, the MX is configured to operate as a phase controller / voltage follower. This is an open loop control mode. The firing angles of the SCRs are directly controlled based on voltage or current applied to the Analog Input. A reference-input value of 0% results in no output. A reference-input value of 100% results in full (100%) output voltage. 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. The Phase Control mode has many uses. Two typical applications are use in master/slave starter configurations and as a basic phase controller.

Phase Controller:

When in Phase Control mode, the MX can function as a general 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 measured analog input signal. The MX's reference command can be generated from any 0-10V, 0-20mA, 4-20mA source such as a potentiometer, another MX, or an external controller such as a PLC.

The Phase control mode can only be used on continuous/fan cooled starters. The bypassed starter does not have the thermal capacity to continuously operate at rated amps in phase control mode and the bypass contactor is not used. Use the RC power stack.

Master/Slave (Lead/Follower) 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 Control, or Current Follower. If configured as a soft starter, the acceleration and deceleration profiles need to be configured for proper operation.

The analog output of the "master" starter should be set to 0-100% firing and connected to the analog input(s) of the "slave" starter(s). "Slaves" should have their Starter Type parameters set to Phase control.

Note: The power stack must be rated for continuous non-bypassed duty in order to operate properly in Phase Control mode.

6.2.3 Current Follower

When the Starter Type parameter is set to Current Follower, the MX 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's reference command can be generated from any 0-10V, 0-20mA, 4-20mA source such as a potentiometer, another MX, or an external controller such as a PLC. When a start command is given, the RUN programmed relay output energizes and the SCRs are gated on.

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 paramter 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.

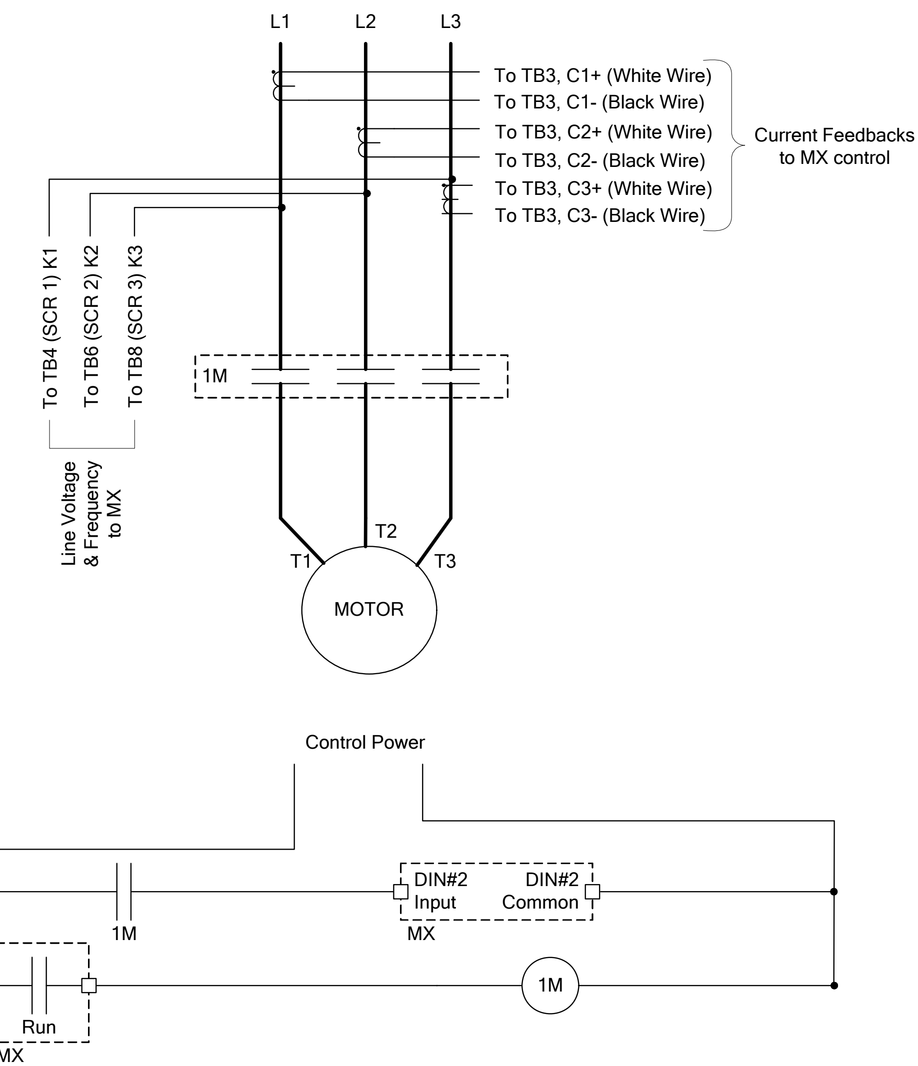
Across The Line Starter

6.2.4 Across The Line (Full Voltage Starter)

When the Starter Type parameter is set to ATL, the MX is configured to operate an electromechanical full voltage or across-the-line (ATL) starter.

In the ATL configuration, the MX assumes that the motor contactor (1M) is directly controlled by a digital output relay that is programmed for the RUN function. Therefore, when a start command is given, the RUN programmed relay energizes the motor contactor, which applies power to the motor. When the MX has determined that the motor has reached full speed, the up-to-speed (UTS) condition is indicated by energizing the UTS programmed relays. When configured as an ATL starter, all MX motor and starter protective functions, except bad SCR detection and power stack overload, are available to provide full motor and starter protection.

Figure 13 – A typical ATL Starter Schematic with the MX



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.

7 Troubleshooting

7 – TROUBLESHOOTING

7.1 General Troubleshooting Charts

The following troubleshooting charts can be used to help solve many of the more common problems that may occur.

7.1.1 Motor does not start, no output to motor

Condition	Cause	Solution
Display Blank, CPU Heartbeat LED on MX card not blinking.	Control voltage absent.	Check for proper control voltage input. Verify fuses and wiring.
	MX control card 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 (P4/QST04 and P5/QST05) not set correctly.	Verify that the parameters are set correctly.
noL or No Line is displayed and a start command is given. A Fault 28 occurs.	The MX control card has not detected line voltage when given a start.	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 control card.
		On medium voltage systems, verify wiring of the voltage feedback measurement circuit.
		See fault code troubleshooting table for more details.

7.1.2 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 (P7/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 (P1/QST01) or CT ratio (P68/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 or CTs

7.1.3 Acceleration not operating as desired

Condition	Cause	Solution
Motor accelerates too quickly.	Ramp time (P8/QST08) too short.	Increase ramp time.
	Initial current (P6/QST06) set too high.	Decrease Initial current.
	Maximum current (P7/QST07) set too high.	Decrease Maximum current.
	Kick start current (P13/CFN10) too high.	Decrease or turn off Kick current.
	Kick start time (P14/CFN11) too long.	Decrease Kick time.
	Motor FLA (P1/QST01) or CT ratio (P68/FUN03) parameter set incorrectly.	Verify that Motor FLA and CT ratio parameters are set correctly.
	Starter Type parameter (P64/FUN07) set incorrectly.	Verify that Starter Type parameter is set correctly.
Motor accelerates too slowly	Maximum Motor Current setting (P7/QST07) set too low.	Review acceleration ramp settings.
	Motor loading too high.	Reduce load on motor during starting.
	Motor FLA (P1/QST01) or CT ratio (P68/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

7.1.4 Deceleration not operating as desired

Condition	Cause	Solution
Motor stops too quickly.	Decel Time (P18/CFN17) set too short.	Increase Decel Time.
	Decel Begin and End Levels (P16/CFN15 and P17/CFN16) 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 (P16/CFN15) 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 (P17/CFN16) 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 (P17/CFN16) set too high.	Decrease Decel End Level until water hammer is eliminated.
	Decel Time (P18/CFN17) too short.	If possible, increase Decel Time to decelerate system more gently.
Motor speed drops sharply before decel	Decel begin level to low.	Increase the Decel Begin Level until drop in speed is eliminated.

7.1.5 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 permissives that may be wired into the run command (Start/Stop)
Display Blank, Heartbeat LED on MX card not blinking.	Control voltage absent.	Check for proper control voltage input. Verify wiring and fuses.
	MX control card problem.	Consult factory.

7.1.6 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.
	CT ratio parameter (P68/FUN03) set incorrectly.	Verify that the CT ratio parameter is set correctly.
	Burden switches set incorrectly.	Verify that the burden switches are 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 (P66/FUN05) set incorrectly.	Verify that Rated Voltage parameter is set correctly.
Current Metering not reading correctly.	CT ratio parameter (P68/FUN03) set incorrectly.	Verify that the CT ratio parameter is set correctly.
	Burden switches set incorrectly.	Verify that the burden switches are 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.
Ground Fault Current Metering not reading correctly.	CT ratio parameter (P68/FUN03) set incorrectly.	Verify that the CT ratio parameter is set correctly.
	Burden switches set incorrectly.	Verify that the burden switches are 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.

7.1.7 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 if necessary 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 jumper (JP1) not set correctly.	Set jumper to give correct output.
	Wiring problem	Verify output wiring.
	Analog Output Function parameter (P50/ I/O12) set incorrectly.	Verify that the Analog Output Function parameter is set correctly.
	Analog Output Offset and/or Span parameters (P51/ I/O13 and P52/ I/O14) set incorrectly.	Verify that the Analog Output Span and Offset parameters are set correctly.
	Load on analog output too high.	Verify that load on analog output meets the MX 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 control card.
	Display interface card (when present) not firmly plugged in.	Verify that the display interface card (if present) is firmly attached to MX control card.
	Remote display damaged.	Replace remote display.

7.2 Fault Code Troubleshooting Table

The following is a list of possible faults that can be generated by the MX 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 (P9/QST09) expired.
		Check motor for jammed or overloaded condition.
		Verify that the combined kick time (P14/CFN11) and acceleration ramp time (P8/QST08) is shorter than the UTS timer setting is.
		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 (P9/QST09).
F02 (F OL)	Motor Thermal Overload Trip	The MX motor thermal overload protection has tripped.
		Check motor for mechanical failure, jammed, or overloaded condition.
		Verify the motor thermal overload parameter settings (P3/QST03 and P35-P38/PFN12-PFN16,) and motor service factor setting (P2/QST02).
		Verify that the motor FLA (P1/QST01), CT ratio (P68/FUN03) and burden switch 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 15%.
F10	Phase Rotation Error, not ABC	Input phase rotation is not ABC and Input Phase Sensitivity parameter (P67/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 (P67/FUN04).
F11	Phase Rotation Error, not CBA	Input phase rotation is not CBA and Input Phase Sensitivity parameter (P67/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 (P67/FUN04).
F12	Low Line Frequency	Line frequency below 23 Hz was detected.
		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 72 Hz was detected.
		Verify input line frequency.
		If operating on a generator, check generator speed governor for malfunctions.
		Line power quality problem / excessive line distortion.

Fault Code	Description	Detailed Description of Fault / Possible Solutions
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 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 control card.
		On medium voltage systems, verify wiring of the voltage feedback measurement circuit.
F21	Low Line L1-L2	Low voltage below the Undervoltage Trip Level parameter setting (P31/PFN08) was detected for longer than the Over/Under Voltage Trip delay time (P32/PFN09).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (P66/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 Undervoltage Trip Level parameter setting (P31/PFN08) was detected for longer than the Over/Under Voltage Trip delay time (P32/PFN09).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (P66/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.
F23	Low Line L3-L1	Low voltage below the Undervoltage Trip Level parameter setting (P31/PFN08) was detected for longer than the Over/Under Voltage Trip delay time (P32/PFN09).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (P66/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 (P30/PFN07) was detected for longer than the Over/Under Voltage Trip delay time (P32/PFN09).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (P66/FUN05) is set correctly.
		Line power quality problems/ excessive line distortions.

Fault Code	Description	Detailed Description of Fault / Possible Solutions
F25	High Line L2-L3	High voltage above the Over voltage Trip Level parameter setting (P30/PFN07) was detected for longer than the Over/Under Voltage Trip delay time (P32/PFN09).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (P66/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 (P30/PFN07) was detected for longer than the Over/Under Voltage Trip delay time (P32/PFN09).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (P66/FUN05) is set correctly.
		Line power quality problems/ excessive line distortions.
F27	Phase Loss	The MX 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 card
F28	No Line	No input voltage was detected for longer than the Inline Configuration time delay parameter setting (P53/ I/O15) 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 (P53/ I/O15) allows enough time for the inline contactor to completely close before the No Line fault occurs.
		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 control card.
		On medium voltage systems, verify wiring of the voltage feedback measurement circuit.
F30	I.O.C. (Instantaneous Overcurrent Current)	During operation, the MX 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 (P1/QST01), CT ratio (P68/FUN03), and burden switch settings are correct.
F31	Overcurrent	Motor current exceeded the Over Current Trip Level setting (P24/PFN01) for longer than the Over Current Trip Delay Time setting (P25/PFN02).
		Check motor for a jammed or an overload condition.

F34	Undercurrent	Motor current dropped under the Under Current Trip Level setting (P26/PFN03) for longer than the Under Current Trip Delay time setting (P27/PFN04).
		Check system for cause of under current condition.
F37	Current Imbalance	A current imbalance larger than the Current Imbalance Trip Level parameter setting (P28/PFN05) was present for longer than ten (10) seconds.
		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 (P29/PFN06) has been detected for longer than 3 seconds.
		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 (P1/QST01), CT ratio (P68/FUN03) and burden switch 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 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 control card.
		Verify that the motor FLA (P1/QST01), CT ratio (P68.FUN03) and burden switch 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 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 control card.
		Check all SCRs with ohmmeter for shorts.
		Verify that the Input Phase Sensitivity parameter setting (P67/FUN04) is correct.
		Verify that the Starter Type parameter setting (P64/FUN07) is correct.
		Verify the motor wiring. (Verify dual voltage motors for correct wiring configuration).

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 (P1/QST01), CT ratio (P68/FUN03) and burden switch settings are correct.
F47	Stack Protection Fault (stack thermal overload)	The MX electronic power stack OL protection has detected an overload condition.
		Check motor for jammed or overloaded condition.
		Verify Starter Model Number parameter setting (P70/FUN13) is correct (if available).
		Verify that the CT ratio (P68/FUN03) and burden switch settings are 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 (P54/ I/O16).
		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.
		Verify that the bypass/2M contactor power supply is present.
		Verify that the appropriate Digital Input Configuration parameter has been programmed correctly.
		Verify that the bypass contactor(s) are actually not damaged or faulty.
F50	Control Power Low	Low control power (below 90V) has been detected while running, by the MX.
		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 control card self-diagnostics have detected a problem with one or more of the current sensor inputs.
		Verify that the motor FLA (P1/QST01), CT ratio (P68/FUN03) and burden switch settings 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.
F52	Burden Switch Error	The burden switch settings were changed when starter was running. Only change burden switches when starter is not running.
F60	External Fault on DI#1 Input	DI#1 has been programmed as a fault type digital input and the input indicates a fault condition is present.
		Verify that the appropriate Digital Input Configuration parameter has been programmed correctly.
		Verify wiring and level of input.

F61	External Fault on DI#2 Input	DI#2 has been programmed as a fault type digital input and input indicates a fault condition is present.
		Verify that the appropriate Digital Input Configuration parameter has been programmed correctly.
		Verify wiring and level of input.
F62	External Fault on DI#3 input	DI#3 input has been programmed as a fault type digital input and input indicates a fault condition is present.
		Verify that the appropriate Digital Input Configuration parameter has been programmed correctly.
		Verify wiring and level of input.
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 (P46/ I/O08) for longer than the Analog Input Trip Delay time (P47/ I/O09).
		Measure value of analog input to verify correct reading.
		Verify settings of all Analog Input parameters (P45-P49/ I/O07- I/O 11).
		Verify correct positioning of input jumper JP3 (Voltage or Current) on the MX control card.
		Verify correct grounding of analog input connection to prevent noise or ground loops from affecting input.
F81	SPI 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 control card is powered up. Only connect and disconnect a remote keypad when the control power is off.)
		Verify that the remote keypad cable has not been damaged and that its connectors are firmly seated at both the keypad and the MX control card.
		Verify that the display interface card (when present) is firmly attached to MX 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 (P59/FUN12) defined time.
		Verify communication parameter settings (P59-P61/ FUN 10- FUN12).
		Check wiring between the remote network and the MX control card.
		Examine remote system for cause of communication loss.
F94	CPU Error – SW fault	Typically occurs when attempting to run a version of control software that is incompatible with the MX control card hardware being used. Verify that the software is a correct version for the MX control card being used. Consult factory for more details.
		Fault can also occur if the MX control has detected an internal software problem. Consult factory.

F95	CPU Error – Parameter EEPROM Checksum Fault	The MX found the non-volatile parameter values to be corrupted. Typically occurs when the MX 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 has detected an internal CPU problem. Consult factory.
F97	CPU Error – SW Watchdog Fault	The MX has detected an internal software problem. Consult factory.
F98	CPU Error	The MX 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 control card before normal operation can resume.

8 Theory of Operation

8 – THEORY OF OPERATION

Motor Overload

8.1 Solid State Motor Overload Protection

8.1.1 Overview

The MX contains an advanced I^2t electronic motor overload (OL) protection function. For optimal motor protection, the MX 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 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 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.

8.1.2 Setting up the MX Motor Overload

Motor overload protection is easily configured through seven parameters (please refer to the descriptions of each parameter in section 5 of this manual for additional parameter information):

1. Motor FLA
2. Motor Service Factor
3. Motor Running Overload Class
4. Motor Starting Overload Class
5. Independent Starting/Running Overload
6. Motor Overload Hot/Cold Ratio
7. Motor Overload Cooling Time

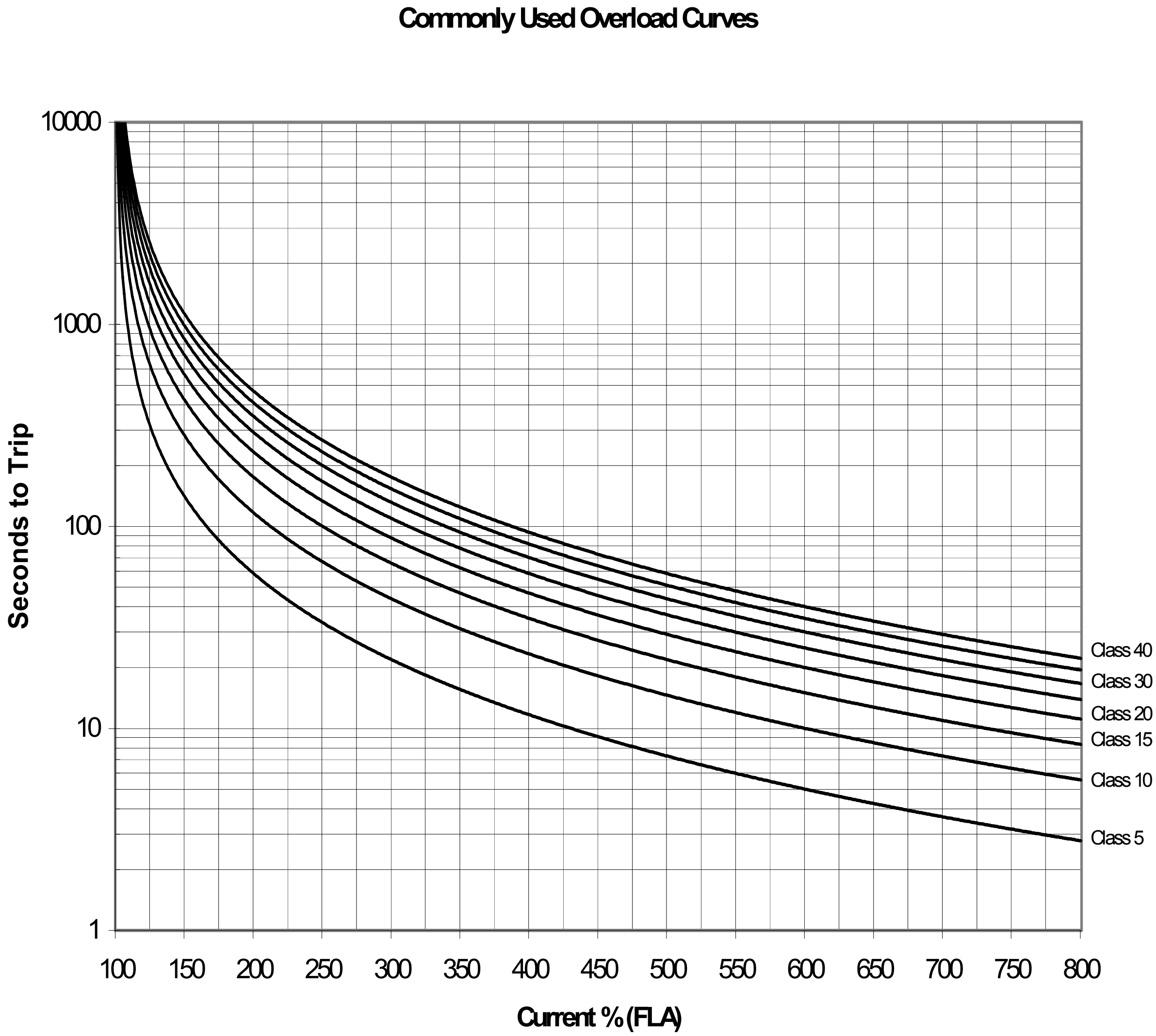
The Motor FLA and Service Factor parameter settings define the motor overload "pickup" point. For example, if the motor service factor is set to 1.00, the motor overload begins accumulating or incrementing when the measured motor current is >100% FLA (100% * 1.00). The overload will NOT trip if the motor 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 standard overload curves after the "pick-up" point has been reached is:

$$\text{Time to Trip (seconds)} = \frac{35\,\text{seconds} \ * \ \text{Class}}{\left(\dfrac{\text{Measured Current} * \dfrac{1}{\text{Current Imbal Derate Factor}}}{\text{Motor FLA}}\right)^2 - 1}$$

Motor Overload



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 RBX power stack is designed for class 10 duty without derating. Refer to the RBX Hardware Manual for the specifics of the RBX 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 http://www.benshaw.com/olcurves.html for an automated overload calculator.

Motor Overload

8.1.3 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

When the accumulated motor overload content reaches 90%, an overload alarm condition is declared. A relay output can be programmed to change state when a motor overload alarm condition is present to warn of an impending motor overload fault.

Overload Trip

When the motor overload content reaches 100%, the MX starter trips, protecting the motor from damage. If the controlled fault stop feature of the MX is enabled, the starter first performs the defined deceleration or DC braking profile before stopping the motor. 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 15%.

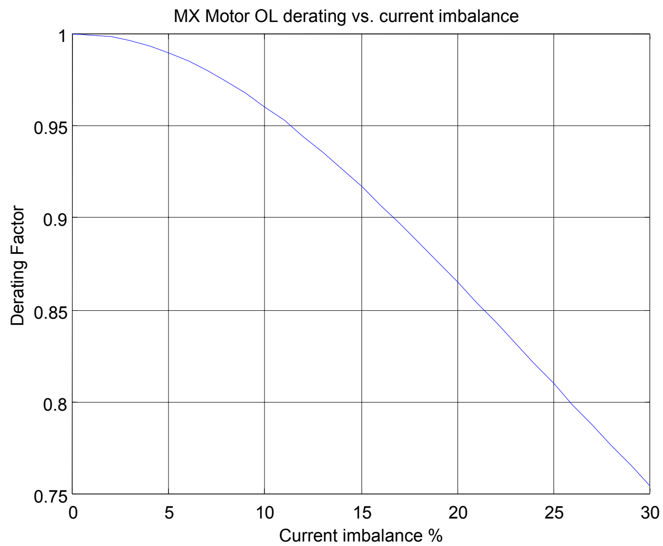
8.1.4 Current Imbalance / Negative Sequence Current Compensation

The MX motor overload calculations automatically compensate for the additional motor heating which results from the presence of unbalanced phase currents. When a current imbalance is present, there can be significant negative sequence currents present in the motor. 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 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 below in section 8.1.6 – Hot / Cold Motor Overload Compensation. The MX's derating factor is based on NEMA MG-1 14.35 specifications and is shown in the following Figure 14 – Overload Derated for Current Imbalance.

Motor Overload

Figure 14 – Overload Derated for Current Imbalance



8.1.5 Harmonic Compensation

The MX 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, uninterruptable power supplies, and other similar loads.

8.1.6 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 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 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 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:

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

The running OL content is also adjusted based on the derating factor due to the presence of any current imbalances and or harmonics.

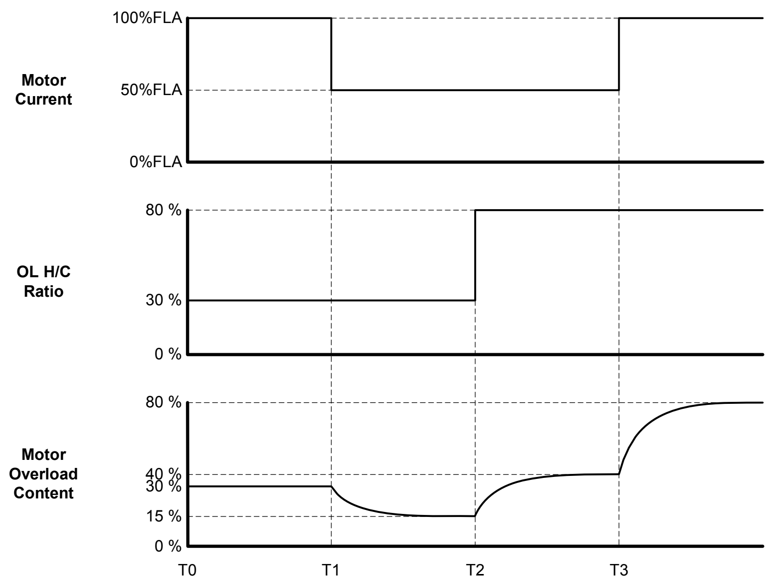
If the existing motor overload content is less than the calculated running OL content, the motor overload exponentially increases the overload content until the appropriate running overload content level is achieved. If the existing motor overload content is greater than the calculated running OL content level, the overload exponentially cools down or decreases to the appropriate running overload

Motor Overload

content level. The rate of the running motor overload heating or cooling is controlled by the Motor Overload Cooling Time parameter.

The following diagram illustrates how the current and the Motor Overload Hot/Cold Ratio parameter determine the steady state overload content. It assumes there is no current imbalance.

Figure 15 – Motor Overload H/C Ratio Example



At time T0, the motor current is 100%FLA and the OL H/C 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/C 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%).

8.1.7 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 parameter needs to be set on to allow independent overload operation. Once set to "ON", the individual Motor Starting Overload Class and Motor Running Overload Class parameters can be set to either off or the desired overload class settings.

The Motor Starting Overload Class 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 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.

Motor Overload

NOTE: When the Independent Starting/Running Overload parameter is set to “OFF”, the running OL is used at all times.

NOTE: When one or the other overload is disabled, the Hot/Cold motor compensation is still active. Therefore the motor overload content may still slowly increase or decrease depending on the measured motor current. However if the motor overload is disabled in one of the operating modes, the motor overload content is limited in that mode 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.

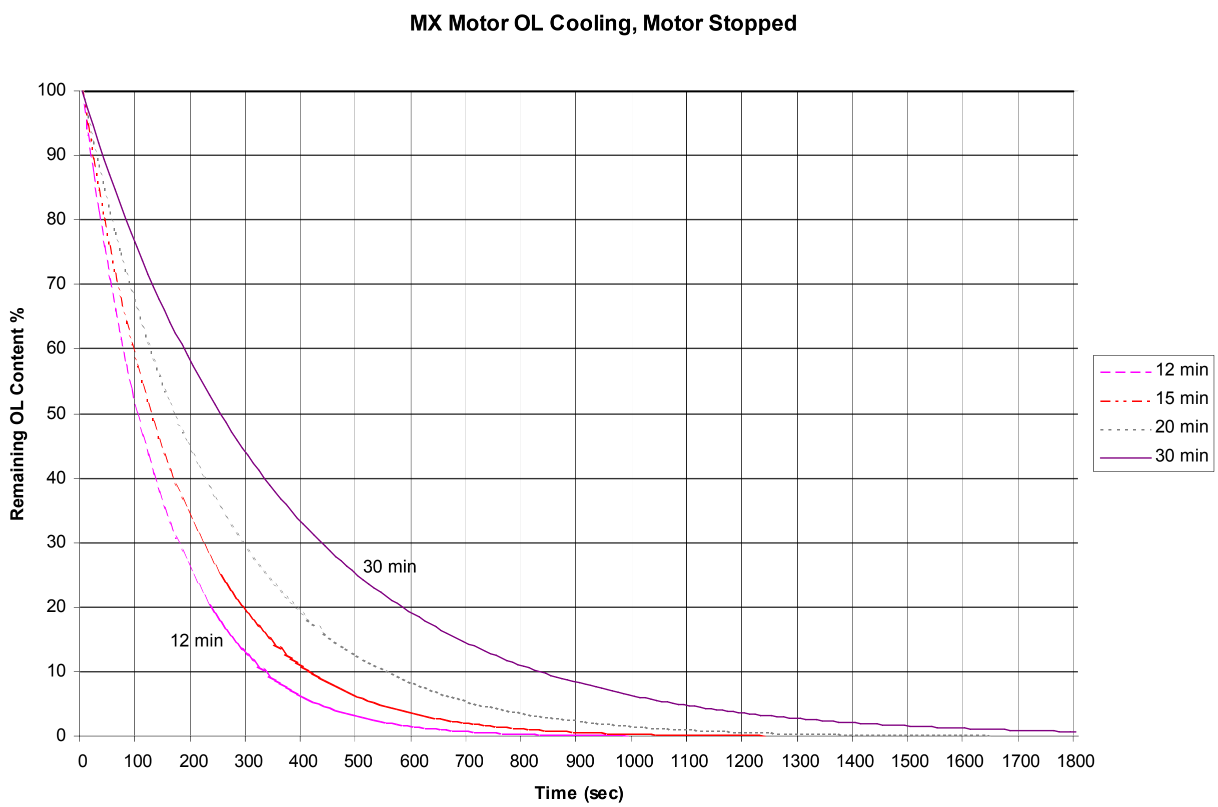
8.1.8 Motor Cooling While Stopped

The Motor Overload Cooling Time 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.

Figure 16 – 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 parameter:

$$\text{Motor Cooling Time (minutes)} \approx \frac{\text{60 minutes}}{\text{Starts per hour}}$$

The Motor Overload Cooling Time 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 (τ or tau) value. In these cases, the Motor Overload Cooling Time parameter should be set to five (5) times the specified time constant value.

8.1.9 Motor Cooling While Running

When the motor is running, the Motor Overload Cooling Time parameter and the Motor Overload Hot/Cold Ratio parameter settings control the motor OL content. If the motor overload content is above the steady state OL running level (See section 8.1.6, 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.

8.1.10 Emergency Motor Overload Reset

The MX 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's motor protection functions may not be able to fully protect the motor from damage during a restart after performing an emergency motor overload reset.

8.2 Motor Service Factor

General

The Motor Service Factor 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

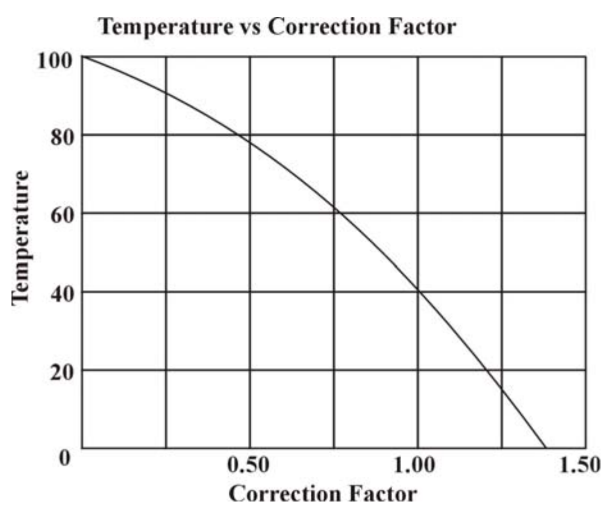
Service factor 1.15 or more	1.25
Motor temp. rise 40°C or less	1.25
All others	1.15

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.

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Acceleration Control

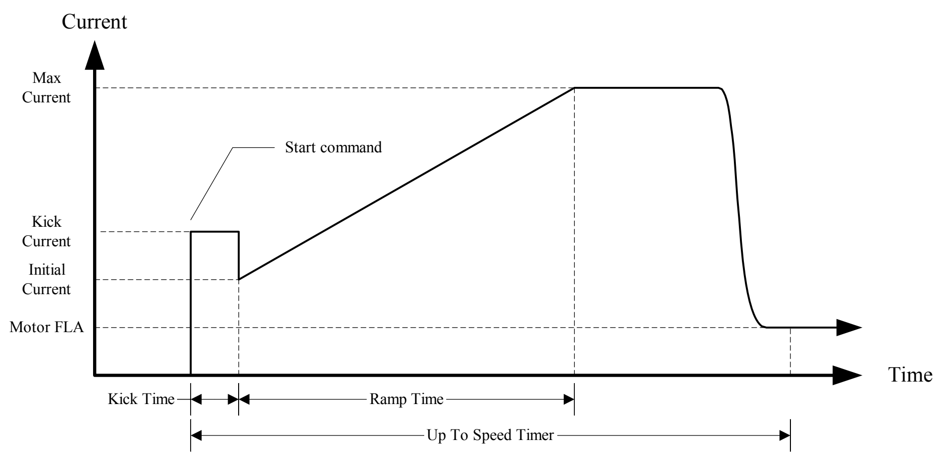
8.3 Acceleration Control

8.3.1 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 17 – 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.

Acceleration Control

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.

8.3.2 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

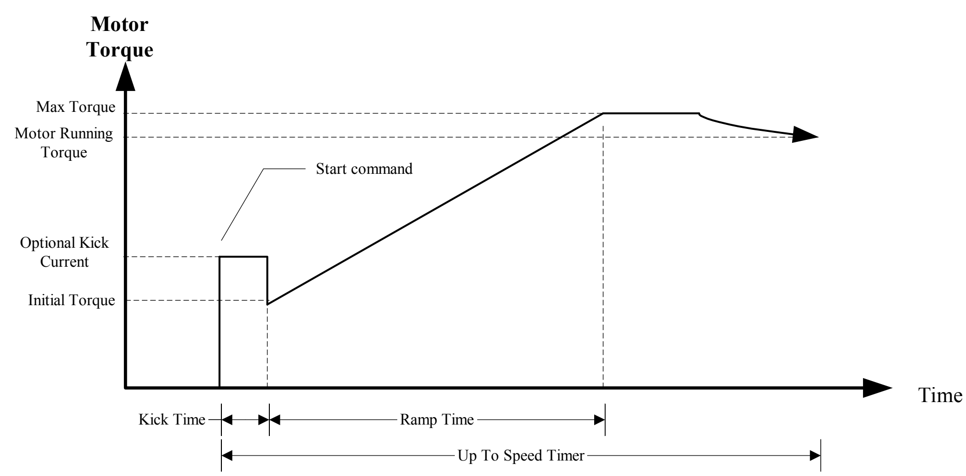
The kick time adjustment should begin at 0.5 seconds and be adjusted by 0.1 or 0.2 second intervals until the motor begins rotating. If the kick time is adjusted above 2.0 seconds without the motor rotating, start over with a higher kick current setting.

8.3.3 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 18 – TruTorque Ramp



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Acceleration Control

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 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.

Maximum Torque

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.

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.

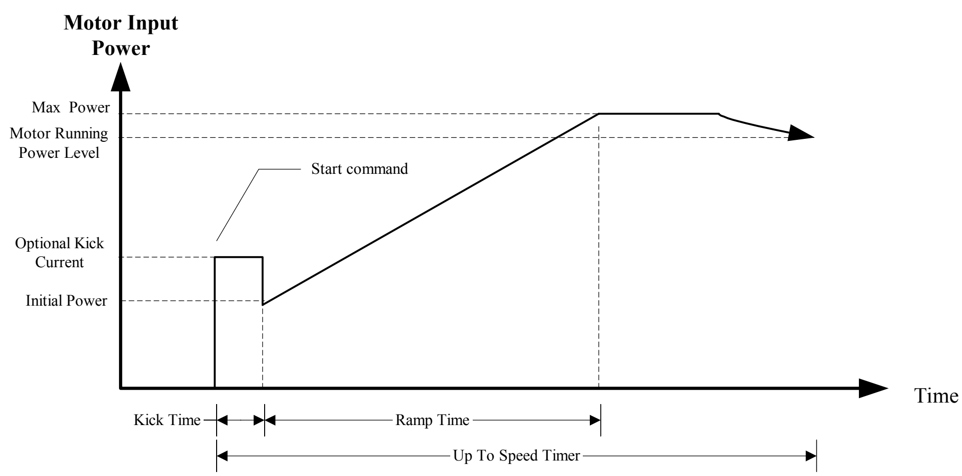
Note: Setting the ramp time to a specific value does not necessarily mean that the motor takes that exact amount of time to accelerate to full speed. The motor and load may achieve full speed before the ramp time expires if the load does not require the set ramp time or set torque level to reach full 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.

8.3.4 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 19 – 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 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 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.

Acceleration Control

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.

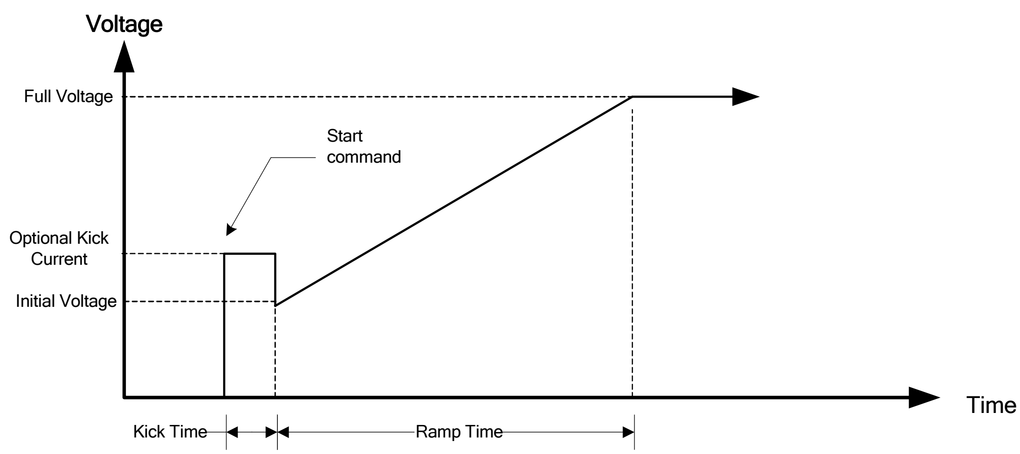
Acceleration Control

8.3.5 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 it 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 20 – 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.

Note: Setting the ramp time to a specific value does not necessarily mean that the motor takes 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/or voltage to reach full speed. Alternatively, the motor and load may take longer than the set ramp time to achieve full speed.

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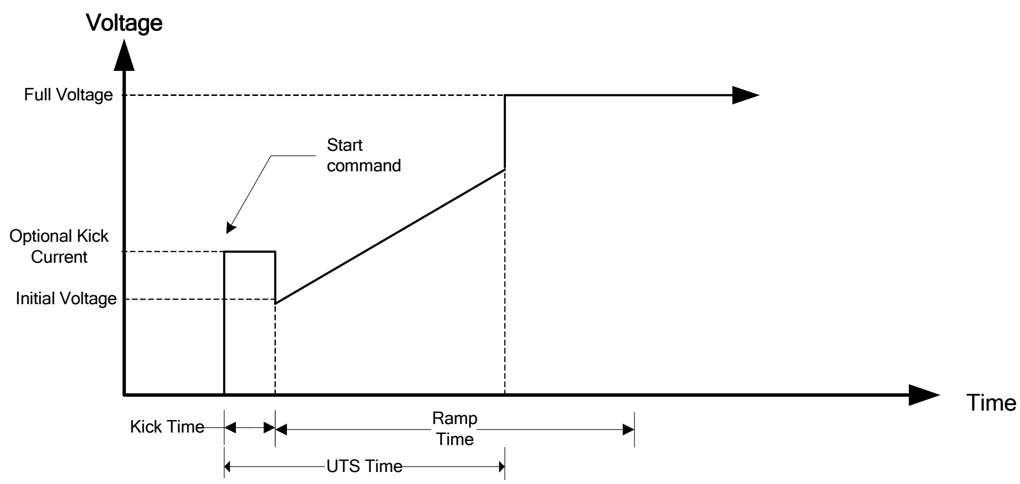
Acceleration Control

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 closed-loop starting profiles be used.

Figure 21 – Effect of UTS Timer on Voltage Ramp



8.3.6 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.

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 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 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

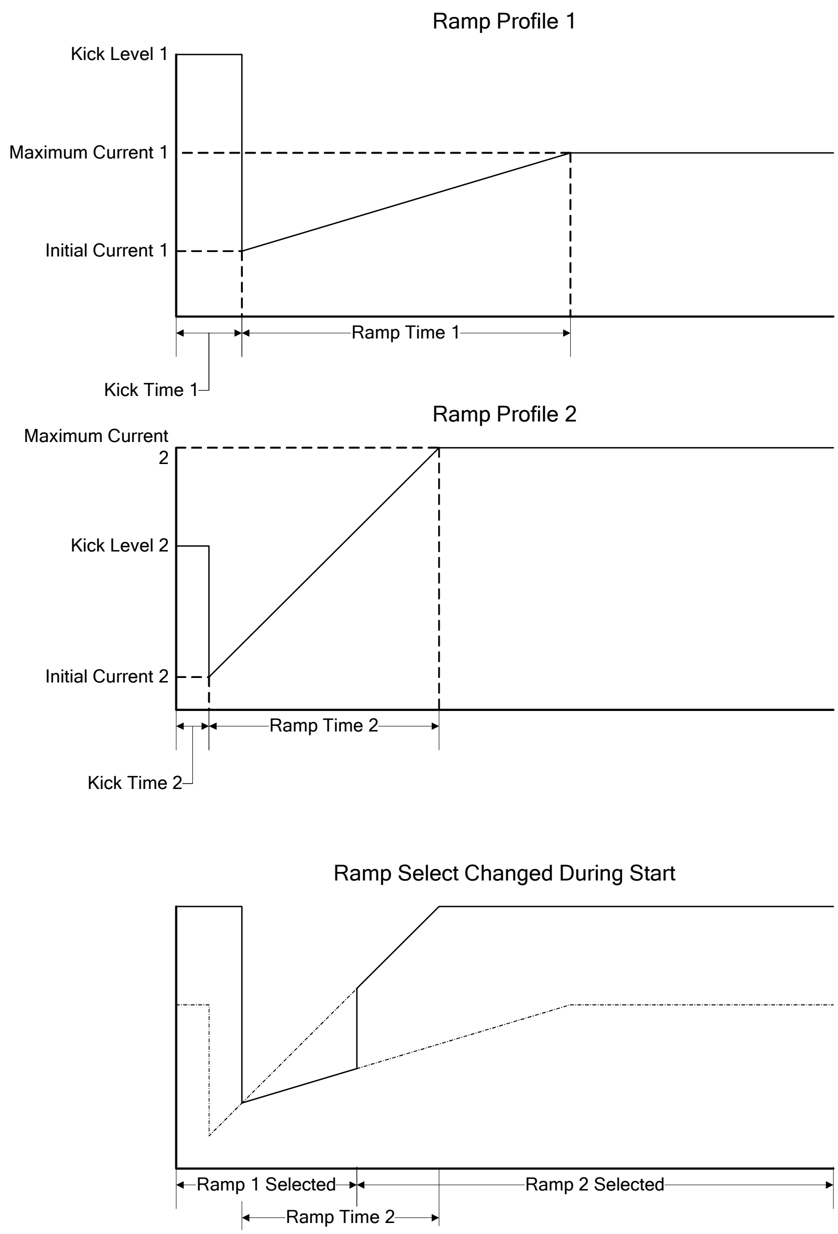
Acceleration Control

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 22 – Ramp Select Change During Start



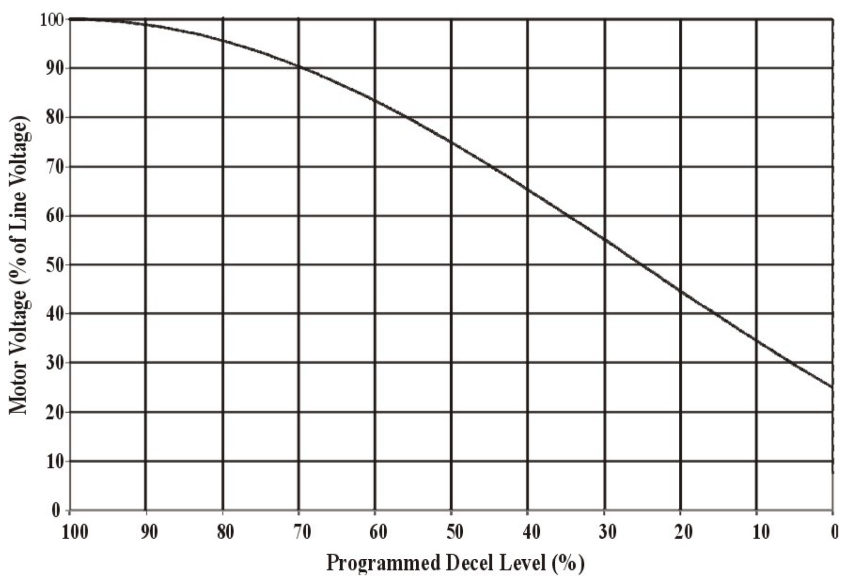
8.4 Deceleration Control

8.4.1 Voltage Control Deceleration

Overview

The deceleration control on the MX uses an open loop voltage ramp. The MX ramps the voltage down to decelerate the motor. The curve shows the motor voltage versus the decel setting.

Figure 23 – 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.

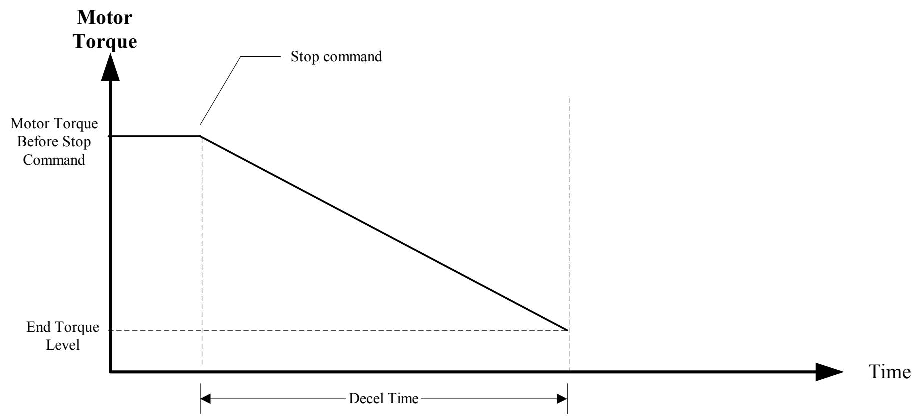
Deceleration Control

8.4.2 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 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 24 – TruTorque Deceleration



Beginning Level

TruTorque deceleration control automatically calculates the motor loading when the stop command was given and uses this value as the beginning level for the TruTorque deceleration ramp. Therefore there is no parameter to set and the calculated beginning torque value provides a very smooth transition from running to 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.

8.5 Wye-Delta Operation

When the Starter Type parameter is set to Wye-Delta, the MX is configured to operate an electromechanical Wye-Delta (Star-Delta) starter. When in Wye-Delta mode, all MX motor and starter protective functions except bad SCR detection and power stack overload, are available to provide full motor and starter protection.

The MX utilizes an intelligent Wye to Delta transition algorithm. If during starting, the measured motor current drops below 85% of FLA and more than 25% of the Up To Speed Time has elapsed, then a Wye to Delta transition occurs. The intelligent transition algorithm prevents unnecessarily prolonged motor starts thereby reducing 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 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 these resistors in a closed transition starter smoothes the transition from Wye to Delta operating mode. A typical closed transition Wye-Delta starter schematic is shown in Figure 12 on page 92.

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 for more information)

Based on the typical closed transition schematic shown in Figure 12, 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 starter remains in the Wye mode until either:

1. The start command is removed.
2. The Up To Speed Time expires

   or

   The measured motor current is less than 85% of FLA and at least 25% of the Up To Speed Time has elapsed.
3. 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 Up To Speed Time expires

   or

   The measured motor current is less than 85% of FLA and at least 25% of the Up To Speed Time has elapsed.
2. The UTS relay is energized which energizes the 2S contactor.

Wye Delta Operation

3. When the 2S contactor pulls in, resistors are inserted in the circuit and the 1S contactor is DE-energized.

4. When the 1S contactor drops out the 2M contactor is energized.

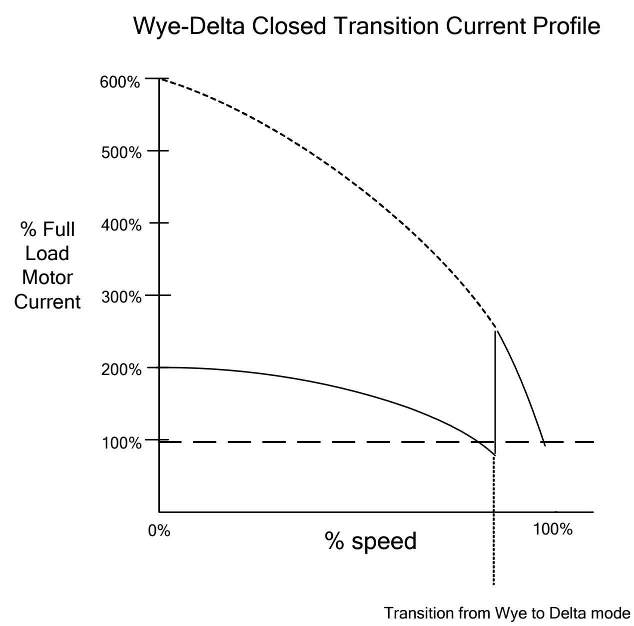
5. When the 2M contactor is pulled in, feedback can be sent to the MX control card to confirm that the transition sequence to Delta is complete.

The starter remains in the Delta or running mode until the start command is removed or a fault occurs.

Usually the MX intelligent Wye to Delta transition algorithm provides an optimal transition point that minimizes the transient current and torque surges that can occur. However sometimes, based on the motor and loading, the Wye to Delta transition occurs only after the Up To Speed Time has expired. In order to reduce the current surge that can take place 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, a large current and torque surge may occur during the transition. 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 25.

Figure 25 – 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.

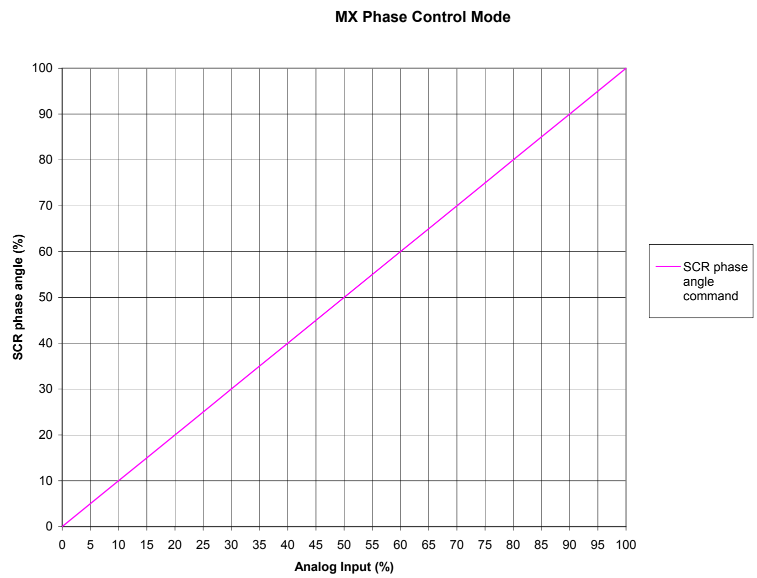
Note: When in Wye-Delta mode, the acceleration ramp, kick, and deceleration settings have no effect on motor operation.

Note: When in Wye-Delta mode, the SCR gate outputs are disabled.

8.6 Phase Control

When the Starter Type parameter is set to Phase Control, the MX 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 26 – 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.

The Phase Control mode has many uses. Two typical applications are use in master/slave starter configurations and as a basic phase controller.

<u>Phase Controller:</u>

When in Phase Control mode, the MX can function as a general phase controller. Phase control can be used to directly control the voltage applied to motors, resistive heaters, etc. When in Voltage Control mode, the phase angle of the SCRs and hence the voltage applied is directly controlled based on the measured analog input signal. The MX's reference command can be generated from any 0-10V, 0-20mA, or similar sources such as a potentiometer, another MX, or an external controller such as a PLC.

<u>Master/Slave Starter (Lead/Follower) Configuration:</u>

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 control card needs to be connected to the analog input(s) of the slave card(s).

2. The master MX's 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's 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 MXs need to be provided with a start command from the master MX. A RUN programmed relay from the master MX 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 analog input(s) need to be configured for the appropriate voltage or current input signal type. Set the analog input jumper (JP3) to the desired input type.

   For additional master / slave application information, consult the factory.

Note: The power stack must be rated for continuous non-bypassed duty in order to operate in Phase Control mode continuously, NO BYPASS.

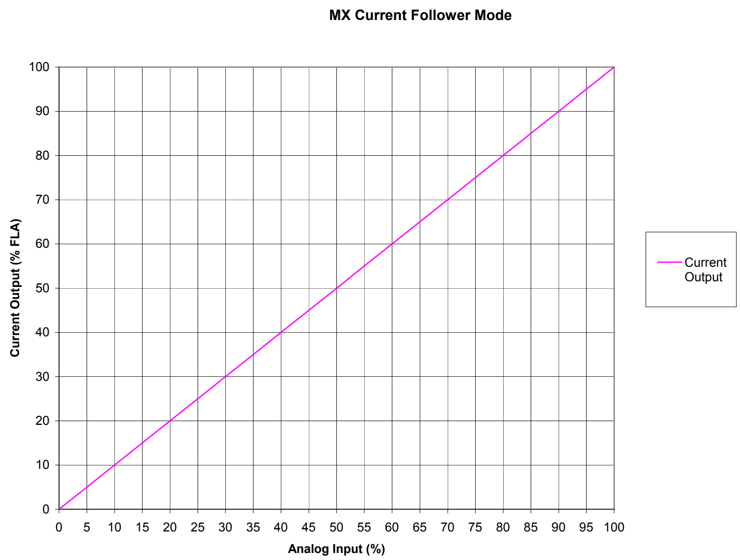
Note: When operating in Phase Control mode, the acceleration ramp, kick, and deceleration settings have no effect on operation.

Note: When in Phase Control mode the following motor / starter protective functions are available:

- Current Imbalance
- Over Current
- 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)

8.7 Current Follower

When the Starter Type parameter is set to Current Follower, the MX 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's reference command can be generated from any 0-10V, 0-20mA, 4-20mA source such as a potentiometer, another MX, or an external controller such as a PLC. When a start command is given, the RUN programmed relay output energizes and the SCRs are gated.



A reference input value of 0% results in no output. A reference input value of 100% results in a current output equal to the 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 continuously.

Note: When operating in Current Follower mode, the acceleration ramp, kick, and deceleration settings have no effect on operation.

Note: When in Current Follower mode the following motor / starter protective functions are available:

- 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)

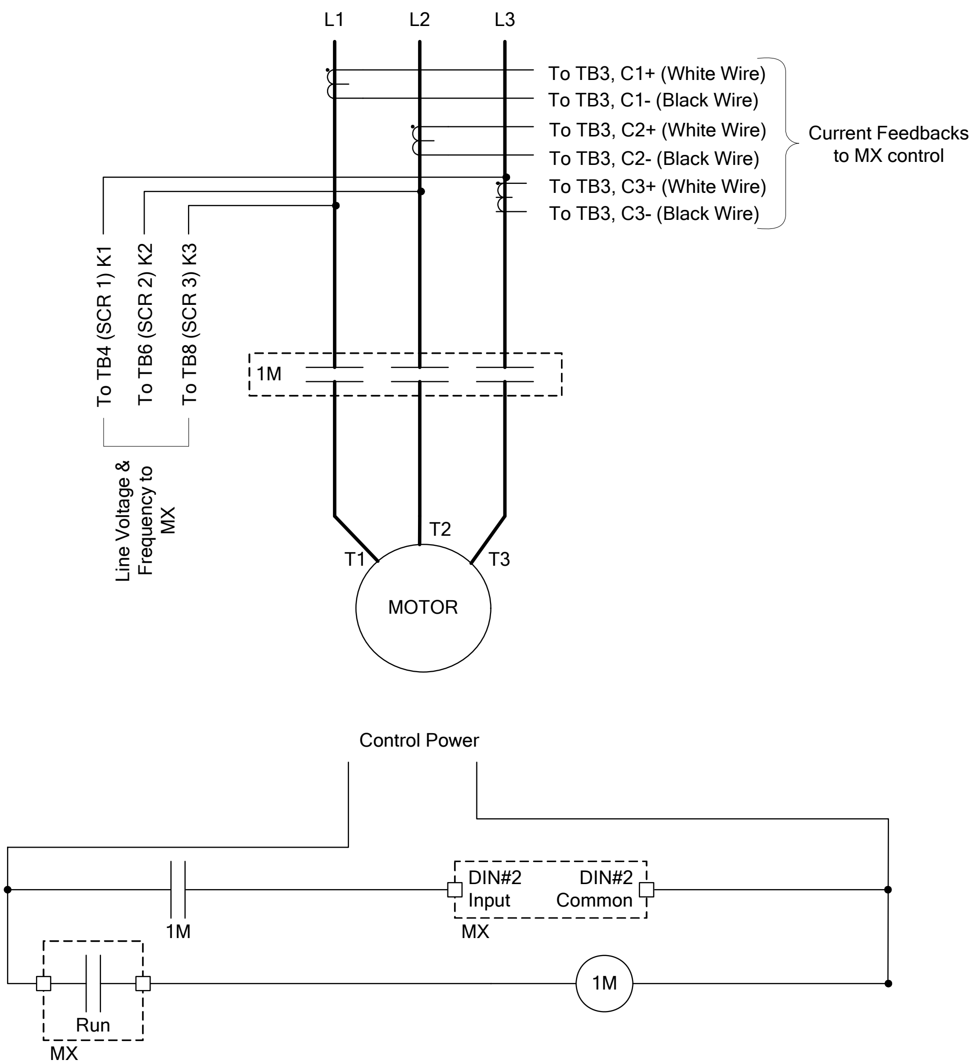
Across The Line / Full Voltage Operation

8.8 Across The Line / Full Voltage Operation

When the Starter Type parameter is set to ATL, the MX is configured to operate an electromechanical full voltage or across-the-line (ATL) starter.

In the ATL configuration, the MX assumes that the motor contactor (1M) is directly controlled by a digital output relay that is programmed for the RUN function. Therefore, when a start command is given, the RUN programmed relay energizes the motor contactor, which applies power to the motor. When the MX has determined that the motor has reached full speed, the up-to-speed (UTS) condition is indicated by energizing the UTS programmed relays. When configured as an ATL starter, all MX motor and starter protective functions except bad SCR detection and power stack overload are available to provide full motor and starter protection.

Figure 27 – ATL Starter Schematic



Note: When in ATL mode, the acceleration ramp, kick, and deceleration settings have no effect on motor operation.

Note: When in ATL mode, the SCR gate outputs are disabled.

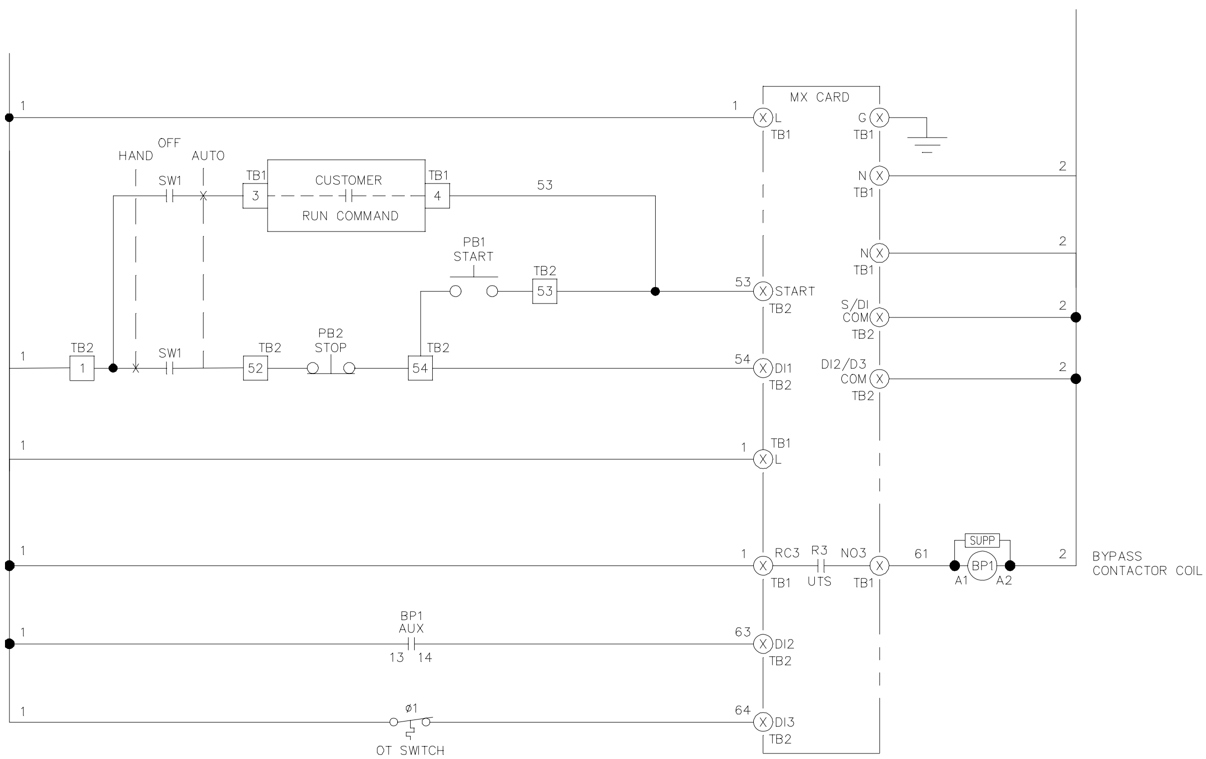
8.9 Start/Stop Control with a Hand/Off/Auto Selector Switch

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 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 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 trick 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 is programmed as a Stop input.

Figure 28 – Example of Start/Stop with a Hand/Off/Auto Selector Switch



When the Hand/Off/Auto selector switch is in the Hand position, current flow to the Stop push button contact and to the Stop input on the MX. 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

8.10 Simplified I/O Schematics

Figure 29 – Digital Input Simplified Schematic

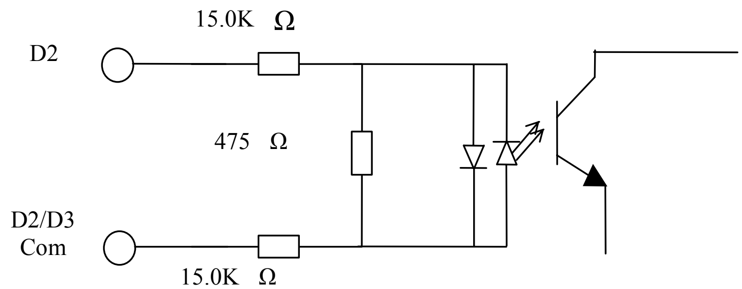


Figure 30 – Analog Input Simplified Schematic

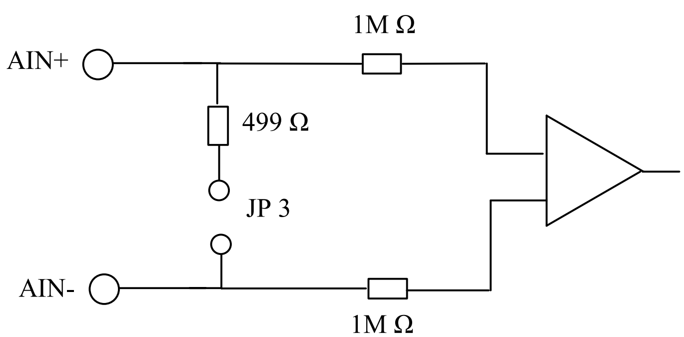
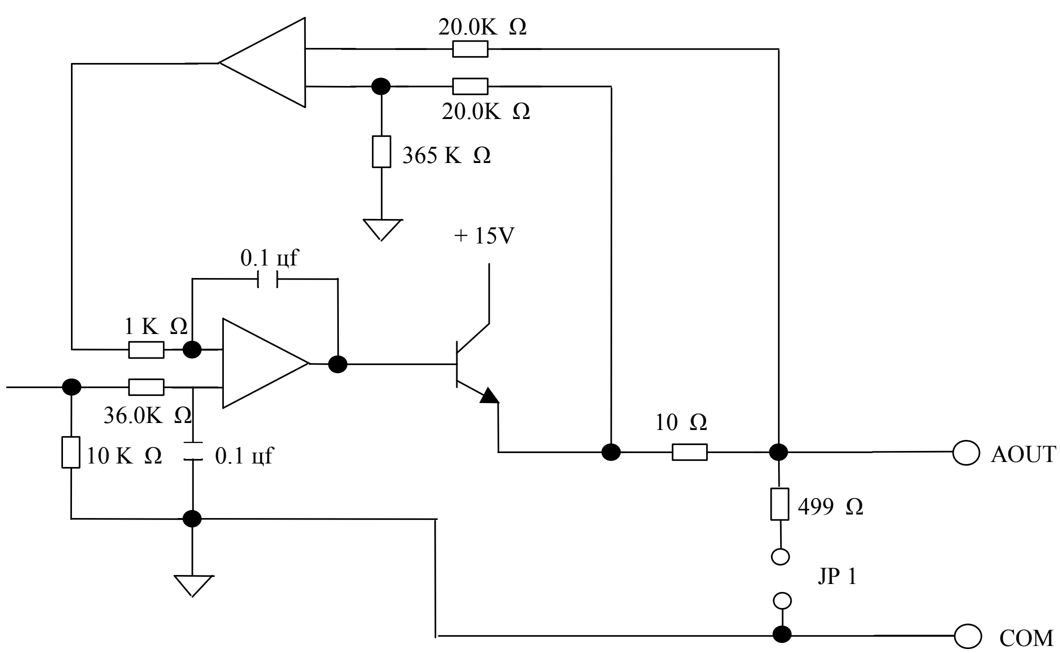


Figure 31 – Analog Output Simplified Schematic



8.11 Using Modbus

Supported Commands

The MX 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.

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, the register maps are identical for both the holding registers and the input registers. For example, the Motor FLA parameter is available both in holding register 40050 and in input register 30050. This is why the register addresses in the Appendix D – Modbus Register Map, are listed with both numbers (e.g. 30050/40050).

Cable Specifications

Good quality twisted, shielded communications cable should be used when connecting to the Modbus port on the MX. 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.

Terminating Resistors

The MX contains a jumper site (JP2) located next to the Modbus connection terminals for installing a 120 Ohm impedance matching terminating resistor. Installing a jumper on JP2 connects a 120 Ohm resistor between the RS-485 A(-) and B(+) lines.

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 baud rate of 19,200 supported by the MX is not high enough to warrant a terminating resistor unless the network is extremely long (3,000 feet or more). A jumper should only be installed on the MX if signal reflection is known to be a problem and only if the MX is at the end of the network. Terminating resistors should never be installed on nodes that are not at the end of the network.

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.

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.

8 – THEORY OF OPERATION

Using Modbus Communication

9 Technical Information

9 – TECHNICAL INFORMATION

Technical Specifications

9.1 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.

This document covers the control electronics and several power sections:

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

9.2 Environmental Conditions

Table 7 – Environmental Ratings

Operating Temperatures	0°C to +40°C (32°F to 104°F)
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	Natural convection

9.3 Altitude Derating

Benshaw's starters are capable of operating at altitudes up to 3,300 feet (1000 meters) without requiring altitude derating. Table 8 provides the derating percentage to be considered when using a starter above 3,300 feet (1000 meters).

Table 8 – 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%

For derating above 10,000 feet consult Benshaw Inc.

9.4 Approvals

MX Control Card UL, cUL Recognized

9.5 Certificate of compliance

CE Mark

9.6 List of Motor Protection Features

- ANSI 51 – Electronic motor overload (Off, class 1 to 40, separate starting and running curves available)
- ANSI 86 – Overload lockout
- ANSI 51 – Overcurrent detection (Off or 50 to 800% and time 0.1 to 90.0 sec. in 0.1 sec. intervals)
- ANSI 50 - Instantaneous electronic overcurrent trip
- ANSI 37 – Undercurrent detection (Off or 5 to 100% and time 0.1 to 90.0 sec. in 0.1 sec. intervals)
- ANSI 46 – Current imbalance detection (Off or 5 to 40%)
- ANSI 51G – Ground fault detection (Off or 5 to 100%)
- ANSI 48 – Adjustable up-to-speed / stall timer (1 to 900 sec. in 1 sec. intervals)
- ANSI 59 / 27 – 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 47 - Phase rotation (selectable ABC, CBA, Insensitive, or Single Phase)
- ANSI 81 – Over / Under Frequency
- ANSI 74 – Alarm relay output available
- Single Phase Protection
- Shorted SCR detection

9 – TECHNICAL INFORMATION

Technical Specifications

9.7 MX Control Card

9.7.1 Terminal Points, Functions and Ratings

Table 9 – Terminals

Function	Terminal Number	Description
TB1		
Control Power Input	N, neutral L, line G, ground	96 – 144V AC input, 50/60 Hz 45VA current requirements
Relay Output R1	NC1: Normally Closed RC1:Common NO1:Normally Open	Relay Output, SPDT form C 3 Amp, 125VAC, resistive 1 Amp, 125VAC, 0.4PF 100VA Inrush
Relay Output R2 & R3	NC2, RC2, NO2 NC3, RC3, NO3	Relay Output, SPDT form C 16 Amp, 250VAC, resistive 8 Amp, 250VAC, 0.4PF 2000VA Inrush
TB2		
Digital Inputs Start & DI1	Start, DI1, S/DI1 Com	120V AC digital input, 2500V optical isolation, 4mA cur. draw Off = 0 to 35 VAC, On = 60 to 120VAC See Figure 29 – Digital Input Simplified Schematic
Digital Inputs DI2 & DI3	DI2, DI3, DI2/DI3 Com	120V AC digital input, 2500V optical isolation, 4mA cur. draw Off = 0 to 35 VAC, On = 60 to 120V AC
Serial Comm. (Slave)	SA-, SB+, SCOM, SHLD	Modbus slave serial communication port. RS485 interface, SHLD is chassis ground Data Rates; 19.2k baud maximum Modbus RTU 2500V Optical Isolation
Serial Comm	MA-, MB+, MCOM, SHLD	Factory Use Only, not isolated
TB12		
Analog Output	AOUT, COM, SHLD	Voltage or Current Output, selectable by JP1 Voltage; 0-10VDC (20mA Maximum), Current; 0-20mA, Software scalable, 500ohm load max. Accuracy ±1.5% Full Scale Update rate: 25msec. See Figure 31 – Analog Output Simplified Schematic
TB13		
Analog Input	AIN+, ANI-, SHLD	Voltage or Current Input, selectable by JP3 Voltage; 0-10VDC, 1 Meg. impedance Current; 0-20mA, 499 ohm impedance, Software scalable, Accuracy ± 3% of full scale See Figure 30 – Analog Input Simplified Schematic
Reference Supply	AIN PWR	10V DC (4 mA Maximum) Reference Source
Jumpers		
JP1	Analog Output	Voltage output when installed, Current loop removed
JP3	Analog Input	Current input when installed, Voltage input removed
JP0, JP2,JD3		Factory Use Only

9.7.2 Terminal Block Rating

9.7.2.1 Wire Gauge

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

9.7.2.2 Torque rating

The terminals on the control card have a torque rating of 3.5-inch lb. or 0.4nm. This MUST be followed or damage will occur to the terminals.

9.7.3 Connectors, Functions and Ratings

Table 10 – Connectors

Connectors		**Description**
Aux Power	TB0	120V AC, 5 amps, Aux. Connector for control voltage
Current Transformers (CT) Connection	TB3	CT connection for CT1, CT2 and CT3 Molex Connector: #39-01-2065 Molex Connector Pins: #39-00-0090 crimp,
SCR Connection	TB4	Cathode and Gate for SCR # 1
SCR Connection	TB5	Cathode and Gate for SCR # 4
SCR Connection	TB6	Cathode and Gate for SCR # 2
SCR Connection	TB7	Cathode and Gate for SCR # 5
SCR Connection	TB8	Cathode and Gate for SCR # 3
SCR Connection	TB9	Cathode and Gate for SCR # 6
		Molex Connector for gates: #39-01-3028 Molex Connector pins: #39-00-0056 crimp,
Remote Display	Conn 3	Remote Display or Option Card Interface
	TB10, Conn 4	Factory Use Only

9.7.4 Measurements, Accuracy and Ratings

Table 11 – Accuracy

Internal Measurements	
CT Inputs	Conversion; True RMS, Sampling @ 1.562kHz
Line Voltage Inputs	Conversion; True RMS, Range; 100VAC to 600VAC ± 10%, 23 to 72 Hz
Metering	
Current	0 – 40,000 Amps ± 3%
Voltage	0 – 660 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)
Run Time	± 3 seconds per 24 hour period
Analog Input	Accuracy ± 3% of full scale
Analog Output	Accuracy ±1.5% of full scale
	Note: Percent accuracy is percent of full scale of the given ranges, Current = Motor FLA Full Range, Voltage = 660V, Watts/Volts-Amps/Watt-Hours = Motor & Voltage range

9 – TECHNICAL INFORMATION

Technical Specifications

10 Appendix

10 – APPENDIX

Lists, Tables and Figures

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Appendix A – CE Mark

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 Numbers:

Model Number	Model Number	Model Number	Model Number
RBX-1-S-027A-11C	RBX-1-S-240A-15C	RCX-1-S-027A-11C	RCX-1-S-240A-15C
RBX-1-S-040A-11C	RBX-1-S-302A-15C	RCX-1-S-040A-11C	RCX-1-S-302A-15C
RBX-1-S-052A-12C	RBX-1-S-361A-16C	RCX-1-S-052A-12C	RCX-1-S-361A-16C
RBX-1-S-065A-12C	RBX-1-S-414A-17C	RCX-1-S-065A-12C	RCX-1-S-414A-17C
RBX-1-S-077A-13C	RBX-1-S-477A-17C	RCX-1-S-077A-13C	RCX-1-S-477A-17C
RBX-1-S-096A-13C	RBX-1-S-515A-17C	RCX-1-S-096A-13C	RCX-1-S-515A-17C
RBX-1-S-125A-14C	RBX-1-S-590A-18C	RCX-1-S-125A-14C	RCX-1-S-590A-18C
RBX-1-S-156A-14C	RBX-1-S-720A-19C	RCX-1-S-156A-14C	RCX-1-S-720A-19C
RBX-1-S-180A-14C	RBX-1-S-838A-20C	RCX-1-S-180A-14C	RCX-1-S-838A-20C
RBX-1-S-180A-15C		RCX-1-S-180A-15C	

Manufacturer's Name: Benshaw, Inc.

Manufacturer's Address: 1659 East Sutter Road
Glenshaw, PA USA
15116

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.

EMC:
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 AC motors.

For application information, consult the following document from Benshaw:

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	Harry Hagerty, PE
Quality Control	VP and General Manager
Manager	Industrial Controls Division

Appendix B – Fault Codes

See the hardware manual for Troubleshooting Solutions

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	Jog Time Limit Expired	N	N	N
F04	Reserved			
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	Reserved			
F30	I.O.C.	N	Y	N
F31	Overcurrent	Y	N	Y
F34	Undercurrent	Y	N	Y
F35	Reserved			
F36	Reserved			
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
F47	Stack Protection Fault (stack thermal overload)	N	N	Y
F48	Bypass Contactor Fault	Y	N	N
F50	Control Power Low	N	N	Y
F51	Current Sensor Offset Error	-	Y	N
F52	Burden Switch Error	N	N	N
F53	Reserved			
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	Reserved			
F64	Reserved			
F71	Analog Input #1 Level Fault Trip (local)	Y	N	Y
F72	Reserved			
F73	Reserved			
F81	SPI Communication Fault	Y	N	N
F82	Modbus Timeout Fault	Y	N	Y
F94	CPU Error – SW fault	N	N	N
F95	CPU Error – Parameter EEPROM Checksum Fault	N		N
F96	CPU Error	N	Y	N
F97	CPU Error - SW Watchdog	N	Y	N
F98	CPU Error	N	N	N
F99	CPU Error – Program EPROM Checksum Fault	N	N	N

Appendix C – Alarm Codes

The following is a list of all MX alarm codes. The alarm codes correspond to associated 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 90%. The MX trips when it reaches 100%. The alarm continues until the overload trip lockout is reset.
A10	Phase Rotation not ABC	This alarm exists while the MX is stopped and 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 is stopped and 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 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 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 is stopped, set to single phase mode, and line voltage is detected. If a start is commanded, a Fault 14 occurs.
A15	Input power not three phase	This alarm exists while the MX 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 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 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 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 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 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 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 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 needs to be synced or is trying to sync to the line and no line is detected.
A31	Overcurrent	This alarm exists while the MX 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 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	Reserved	
A36	Reserved	

Alarm Code	Description	Notes
A37	Current Imbalance	This alarm exists while the MX 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 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	Reserved	
A71	Analog Input #1 Trip	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.

Appendix D – 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).

Modbus Registers				
Absolute Register Address	**Description**	**R/W**	**Range**	**Units**
30020/40020	Starter Control	R/W	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 13: Relay 3 Bit 14: Relay 2 Bit 15: Relay 1	-
30021/40021	Starter Status	R	Bit 0: Ready Bit 1: Running Bit 2: UTS Bit 3: Alarm Bit 4: Fault Bit 5: Lockout	-
30022/40022	Input Status	R	Bit 0: Start Bit 1: DI 1 Bit 2: DI 2 Bit 3: DI 3	-
30023/40023	Alarm Status 1	R	Bit 0: "A OL" – Motor overload Bit 1: "A 10" – Phase rotation not ABC Bit 2: "A 11" – Phase rotation not CBA Bit 3: "A 12" – Low Line Frequency Bit 4: "A 13" – High Line Frequency Bit 5: "A 14" – Phase rotation not SPH Bit 6: "A 15" – Phase rotation not 3 Phase Bit 7: "A 21" – Low line L1-L2 Bit 8: "A 22" – Low line L2-L3 Bit 9: "A 23" – Low line L3-L1 Bit 10: "A 24" – High line L1-L2 Bit 11: "A 25" – High line L2-L3 Bit 12: "A 26" – High line L3-L1 Bit 13: "A 27" – Phase loss Bit 14: "noL" – No line Bit 15: Reserved	-
30024/40024	Alarm Status 2	R	Bit 0: "A 31" – Overcurrent Bit 1: "A 34" – Undercurrent Bit 2: Reserved Bit 3: Reserved Bit 4: "A 37" – Current imbalance Bit 5: "A 38" – Ground fault Bit 6: "A 47" – Stack overload Bit 7: Reserved Bit 8: "A 71" – Analog Input Trip Bit 9: Reserved	-
30025/40025	Lockout Status	R	Bit 0: "L OL" – Motor overload Bit 1: "L Ot" – Stack overload Bit 2: "L CP" – Control power	-
30026/40026	Present Fault Code	R	See Appendix B for list of codes	
30027/40027	Average Current	R		Arms
30028/40028	L1 Current	R		Arms
30029/40029	L2 Current	R		Arms
30030/40030	L3 Current	R		Arms
30031/40031	Current Imbalance	R		0.1 %

Modbus Registers				
Absolute Register Address	**Description**	**R/W**	**Range**	**Units**
30032/40032	Residual Ground Fault Current	R		%FLA
30033/40033	Average Voltage	R		Vrms
30034/40034	L1-L2 Voltage	R		Vrms
30035/40035	L2-L3 Voltage	R		Vrms
30036/40036	L3-L1 Voltage	R		Vrms
30037/40037	Motor Overload	R		%
30038/40038	Power Factor	R	-99 – +100 (in 16-bit two's compliment signed format)	0.01
30039/40039	Watts (lower 16 Bits)	R	(in 32 bit unsigned integer format)	W
30040/40040	Watts (upper16 Bits)	R		
30041/40041	VA (lower 16 Bits)	R	(in 32 bit unsigned integer format)	VA
30042/40042	VA (upper 16 Bits)	R		
30043/40043	VARS (lower 16 Bits)	R	(in 32 bit two's compliment signed interger format)	var
30044/40044	VARS (upper 16 Bits)	R		
30045/40045	kW hour (lower 16 Bits)	R	0 – 999	kWh
30046/40046	KW hours (upper 16 Bits)	R		
30047/40047	Phase Order	R	0: no line 1: ABC 2: CBA 3: SPH	-
30048/40048	Line Frequency	R	230 – 720, or 0 if no line	0.1 Hz
30049/40049	Analog Input	R	-1000 – +1000 (in 16-bit two's compliment signed format)	0.1 %
30050/40050	Analog Output	R	0 – 1000	0.1%
30051/40051	Running Time	R	0 – 65535	Hours
30052/40052	Running Time	R	0 – 59	Minutes
30053/40053	Starts	R	0 – 65535	-
30054/40054	TruTorque %	R		%
30055/40055	Power %	R		%
30101/40101	Motor FLA	R/W	1 – 6400	Arms
30102/40102	Rated Power Factor	R/W	100 – 199	0.01
30103/40103	Independent Starting/Running Overload	R/W	0: Disabled 1: Enabled	-
30104/40104	Motor Running Overload Enable	R/W	0: Disabled 1: Enabled	-
30105/40105	Motor Running Overload Class	R/W	1 – 40	-
30106/40106	Motor Starting Overload Enable	R/W	0: Disabled 1: Enabled	-
30107/40107	Motor Starting Overload Class	R/W	1 – 40	-
30108/40108	Motor Overload Hot/Cold Ratio	R/W	0 – 99	%
30109/40109	Motor Overload Cooling Time	R/W	1 – 9999	0.1 Min
30110/40110	Local Source	R/W	0: Keypad 1: Terminal 2: Serial	-
30111/40111	Remote Source	R/W	0: Keypad 1: Terminal 2: Serial	-
30112/40112	Start Mode	R/W	0: Open Loop Voltage Ramp 1: Closed Loop Current Ramp 2: TruTorque Ramp 3: Power Ramp	-
30113/40113	Initial Current 1	R/W	50 – 600	% FLA

Modbus Registers				
Absolute Register Address	**Description**	**R/W**	**Range**	**Units**
30114/40114	Maximum Current 1	R/W	100 – 800	% FLA
30115/40115	Ramp Time 1	R/W	0 – 300	Sec
30116/40116	Initial Current 2	R/W	50 – 600	% FLA
30117/40117	Maximum Current 2	R/W	100 – 800	% FLA
30118/40118	Ramp Time 2	R/W	0 – 300	Sec
30119/40119	Up To Speed Time	R/W	1 – 900	Sec
30120/40120	Initial Voltage/Torque/Power	R/W	1 – 100	%
30121/40121	Maximum Torque/Power	R/W	10 – 325	%
30122/40122	Stop Mode	R/W	0: Coast 1: Voltage Decel 2: TruTorque Decel	-
30123/40123	Decel Begin Level	R/W	100 – 1	%
30124/40124	Decel End Level	R/W	99 – 1	%
30125/40125	Decel Time	R/W	1 – 180	Sec
30126/40126	Kick 1Enable	R/W	0: Disabled 1: Enabled	-
30127/40127	Kick Level 1	R/W	100 – 800	% FLA
30128/40128	Kick Time 1	R/W	1 – 100	100 mSec
30129/40129	Kick 2 Enable	R/W	0: Disabled 1: Enabled	-
30130/40130	Kick Level 2	R/W	100 – 800	% FLA
30131/40131	Kick Time 2	R/W	1 – 100	100 mSec

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Modbus Registers				
Absolute Register Address	**Description**	**R/W**	**Range**	**Units**
30132/40132	Rated Voltage	R/W	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: 1000 22: 1140 23: 2200 24: 2300 25: 2400 26: 3300 27: 4160 28: 4600 29: 4800 30: 6000 31: 6600 32: 6900 33: 10000 34: 11000 35: 11500 36: 12000 37: 12470 38: 13200 39: 13800	Vrms
30133/40133	Phase Order	R/W	0: Ins 1: ABC 2: CBA 3: SPH	-
30134/40134	Rated Power Factor	R/W	1–100	-
30135/40135	Over Current Trip Enable	R/W	0: Disabled 1: Enabled	-
30136/40136	Over Current Level	R/W	50 – 800	% FLA
30137/40137	Over Current Time Enable	R/W	0: Disabled 1: Enabled	-
30138/40138	Over Current Time	R/W	1 – 900	100 mSec
30139/40139	Under Current Trip Enable	R/W	0: Disabled 1: Enabled	-
30140/40140	Under Current Level	R/W	5 – 100	% FLA
30141/40141	Under Current Time Enable	R/W	0: Disabled 1: Enabled	-
30142/40142	Under Current Time	R/W	1 – 900	100 mSec
30143/40143	Current Imbalance Trip Enable	R/W	0: Disabled 1: Enabled	-
30144/40144	Current Imbalance Level	R/W	5 – 40	%

Modbus Registers				
Absolute Register Address	**Description**	**R/W**	**Range**	**Units**
30145/40145	Ground Fault Trip Enable	R/W	0: Disabled 1: Enabled	-
30146/40146	Ground Fault Level	R/W	5 – 100	% FLA
30147/40147	Over Voltage Trip Enable	R/W	0: Disabled 1: Enabled	-
30148/40148	Over Voltage Level	R/W	1 – 40	%
30149/40149	Under Voltage Trip Enable	R/W	0: Disabled 1: Enabled	-
30150/40150	Under Voltage Level	R/W	1 – 40	%
30151/40151	Voltage Trip Time	R/W	1 – 900	100 mSec
30152/40152	Auto Reset Enable	R/W	0: Disabled 1: Enabled	-
30153/40153	Auto Reset Delay Time	R/W	1 – 900	100 mSec
30154/40154	Controlled Fault Stop Enable	R/W	0: Disabled 1: Enabled	-
30155/40155 30156/40156 30157/40157	DI 1 Configuration DI 2 Configuration DI 3 Configuration	R/W	0: Off 1: Stop 2: Fault High 3: Fault Low 4: Fault Reset 5: Bypass / 2M Feedback (F48) 6: Emergency Motor OL Reset 7: Local / Remote Control Source 8: Heat Disable 9: Heat Enable 10: Ramp Select	-
30158/40158 30159/40159 30160/40160	R1 Configuration R2 Configuration R3 Configuration	R/W	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	-
30161/40161	Analog Input Trip Enable	R/W	0: Disabled 1: Enabled	-
30162/40162	Analog Input Trip Type	R/W	0: Low – Fault below preset level 1: High – Fault above preset level	-
30163/40163	Analog Input Trip Level	R/W	0 – 100	%
30164/40164	Analog Input Trip Time	R/W	1 – 900	100 mSec
30165/40165	Analog Input Span	R/W	1 – 100	%
30166/40166	Analog Input Offset	R/W	0 – 99	%

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Modbus Registers				
Absolute Register Address	**Description**	**R/W**	**Range**	**Units**
30167/40167	Analog Output Function	R/W	0: Off (no output) 1: Ave. Current (0 – 200% FLA) 2: Ave. Current (0 – 800% FLA) 3: Ave. Voltage (0 – 150% Rated) 4: Thermal Overload % 5: kW (0 – 10kW) 6: kW (0 – 100kW) 7: kW (0 – 1MW) 8: kW (0 – 10MW) 9: Analog Input 10: Output Voltage to Motor (based on firing angle) 11: Calibrate (full 100% output)	-
30168/40168	Analog Output Span	R/W	1 – 125	%
30169/40169	Analog Output Offset	R/W	0 – 99	%
30170/40170	Inline Enable	R/W	0: Disabled 1: Enabled	-
30171/40171	Inline Delay Time	R/W	10 – 100	100 mSec
30172/40172	Bypass Feedback Time	R/W	1 – 50	100 mSec
30173/40173	Keypad Stop Disable	R/W	0: Disabled 1: Enabled	-
30174/40174	Reserved			
30175/40175	Reserved			
30176/40176	Reserved			
30177/40177	Communication Timeout Enable	R/W	0: Disabled 1: Enabled	-
30178/40178	Communication Timeout	R/W	1 – 120	Sec
30179/40179	CT Ratio	R/W	0: 72:1 1: 96:1 2: 144:1 3: 288:1 4: 864:1 5: 1320:1 6: 2640:1 7: 2880:1 8: 3900:1 9 5760:1 10: 8000:1 11: 14.4K:1 12: 28.8K:1	-
30180/40180	Energy Saver	R/W	0: Disabled 1: Enabled	
30181/40181	Heater Enable	R/W	0: Disabled 1: Enabled	-
30182/40182	Heater Level	R/W	1 – 25	% FLA
30183/40183	Starter Type	R/W	0: Normal (Outside Delta) 1: Inside Delta 2: Wye-Delta 3: Phase Controller 4: Current Follower 5: Across the Line (Full Voltage)	-

Modbus Registers				
Absolute Register Address	**Description**	**R/W**	**Range**	**Units**
30184/40184	LED Display Meter	R/W	0: Status 1: Ave Current 2: L1 Current 3: L2 Current 4: L3 Current 5: Current Imbalance % 6: 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 %	-
30185/40185	LCD Display Meter 1	R/W	Same as above but without 0 Status	-
30186/40186	LCD Display Meter 2	R/W	Same as above but without 0 Status	-
30187/40187	Custom Stack Enable	R/W	1: Disabled 0: Enabled	-
30188/40188	Starter Model Number	R/W	0: None	-
30189/40189	Miscellaneous Commands	R/W	0: None 1: Reset Run Time 2: Reset kWh 3: Enter Reflash Mode 4 Store Parameters 5 Load Parameters 6 Factory Reset	-
30301/40301	Fault Code – Most Recent Fault Log Entry	R	See the fault table in Appendix B	-
30302/40302	Fault Code – 2nd Most Recent Fault Log Entry	R		-
30303/40303	Fault Code – 3rd Most Recent Fault Log Entry	R		-
30304/40304	Fault Code – 4th Most Recent Fault Log Entry	R		-
30305/40305	Fault Code – 5th Most Recent Fault Log Entry	R		-
30306/40306	Fault Code – 6th Most Recent Fault Log Entry	R		-
30307/40307	Fault Code – 7th Most Recent Fault Log Entry	R		-

Modbus Registers				
Absolute Register Address	Description	R/W	Range	Units
30308/40308	Fault Code – 8th Most Recent Fault Log Entry	R		-
30309/40309	Fault Code – 9th Most Recent Fault Log Entry	R		-
30311/40311	System State – Most Recent Fault Log Entry	R	0: Initializing 1: Locked Out 2: Faulted 3: Stopped 4: Heating 5: Kicking 6: Ramping 7: Jogging 8: Not UTS 9: UTS 10: Phase Controlling / Current Following 11: Decelling 12: Braking 13: Wye 14: PORT	-
30312/40312	System State – 2nd Most Recent Fault Log Entry	R		-
30313/40313	System State – 3rd Most Recent Fault Log Entry	R		-
30314/40314	System State – 4th Most Recent Fault Log Entry	R		-
30315/40315	System State – 5th Most Recent Fault Log Entry	R		-
30316/40316	System State – 6th Most Recent Fault Log Entry	R		-
30317/40317	System State – 7th Most Recent Fault Log Entry	R		-
30318/40318	System State – 8th Most Recent Fault Log Entry	R		-
30319/40319	System State – 9th Most Recent Fault Log Entry	R		-
30321/40321	Current – Most Recent Fault Log Entry	R		Arms
30322/40322	Current – 2nd Most Recent Fault Log Entry	R		Arms
30323/40323	Current – 3rd Most Recent Fault Log Entry	R		Arms
30324/40324	Current – 4th Most Recent Fault Log Entry	R		Arms

Modbus Registers				
Absolute Register Address	**Description**	**R/W**	**Range**	**Units**
30325/40325	Current – 5th Most Recent Fault Log Entry	R		Arms
30326/40326	Current – 6th Most Recent Fault Log Entry	R		Arms
30327/40327	Current – 7th Most Recent Fault Log Entry	R		Arms
30328/40328	Current – 8th Most Recent Fault Log Entry	R		Arms
30329/40329	Current – 9th Most Recent Fault Log Entry	R		Arms
30331/40331	Voltage – Most Recent Fault Log Entry	R		Vrms
30332/40332	Voltage – 2nd Most Recent Fault Log Entry	R		Vrms
30333/40333	Voltage – 3rd Most Recent Fault Log Entry	R		Vrms
30334/40334	Voltage – 4th Most Recent Fault Log Entry	R		Vrms
30335/40335	Voltage – 5th Most Recent Fault Log Entry	R		Vrms
30336/40336	Voltage – 6th Most Recent Fault Log Entry	R		Vrms
30337/40337	Voltage – 7th Most Recent Fault Log Entry	R		Vrms
30338/40338	Voltage – 8th Most Recent Fault Log Entry	R		Vrms
30339/40339	Voltage – 9th Most Recent Fault Log Entry	R		Vrms
30341/40341	Line Period – Most Recent Fault Log Entry	R		micro-seconds
30342/40342	Line Period – 2nd Most Recent Fault Log Entry	R		micro-seconds
30343/40343	Line Period – 3rd Most Recent Fault Log Entry	R		micro-seconds
30344/40344	Line Period – 4th Most Recent Fault Log Entry	R		micro-seconds
30345/40345	Line Period – 5th Most Recent Fault Log Entry	R		micro-seconds
30346/40346	Line Period – 6th Most Recent Fault Log Entry	R		micro-seconds

Modbus Registers				
Absolute Register Address	**Description**	**R/W**	**Range**	**Units**
30347/40347	Line Period – 7th Most Recent Fault Log Entry	R		micro-seconds
30348/40348	Line Period – 8th Most Recent Fault Log Entry	R		micro-seconds
30349/40349	Line Period – 9th Most Recent Fault Log Entry	R		micro-seconds

Starter Control Register:

Bit 0 – Run/Stop	0 1	Stop Start
Bit 1 – Fault Reset	0 1	No action Fault Reset
Bit 2 –Emergency Overload Reset	0 1	No action Emergency Overload Reset
Bit 3 –Local/Remote	0 1	Local Remote
Bit 4 –Heat Disabled	0 1	Heater Enabled Heater Disabled
Bit 5 –Ramp Select	0 1	Ramp 1 Ramp 2
Bit 13 – Relay 3	0 1	Energize(d) De-energize(d)
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 Run/Stop bit must be set back to a 0 before another start can occur.

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.

Watts, VA, vars, and kW hour Registers:

These 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.

Starter Status Register:

Bit 0 – Ready	0 – Initializing or Faulted and Decelling 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

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 E – 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	41	
P2	QST 02	Motor Service Factor	1.00 – 1.99		1.15	41	
P3	QST 03	Motor Running Overload Class	Off, 1 – 40		10	42	
P4	QST 04	Local Source	Keypad Terminal Serial		Terminal	43	
P5	QST 05	Remote Source				44	
P6	QST 06	Initial Current 1	50 – 600	%FLA	100	45	
P7	QST 07	Maximum Current 1	100 – 800	%FLA	600	46	
P8	QST 08	Ramp Time 1	0 – 300	Seconds	15	47	
P9	QST 09	Up To Speed Time	1 – 900	Seconds	20	48	

Control Function Group

LED	LCD	Parameter	Setting Range	Units	Default	Page	Setting
P10	CFN 01	Start Mode	Voltage Ramp Current Ramp TT Ramp Power Ramp		Current Ramp	49	
P8	CFN 02	Ramp Time 1	0 – 300	Seconds	15	47	
P6	CFN 03	Initial Current 1	50 – 600	%FLA	100	45	
P7	CFN 04	Maximum Current 1	100 – 800	%FLA	600	46	
P21	CFN 05	Ramp Time 2	0 – 300	Seconds	15	57	
P19	CFN 06	Initial Current 2	50 – 600	%FLA	100	56	
P20	CFN 07	Maximum Current 2	100 – 800	%FLA	600	57	
P11	CFN 08	Initial Voltage/Torque/Power	1 – 100	%	25	50	
P12	CFN 09	Maximum Torque/Power	10 – 325	%	105	51	
P13	CFN 10	Kick Level 1	Off, 100 – 800	%FLA	Off	52	
P14	CFN 11	Kick Time 1	0.1 – 10.0	Seconds	1.0	52	
P22	CFN 12	Kick Level 2	Off, 100 – 800	%FLA	Off	57	
P23	CFN 13	Kick Time 2	0.1 – 10.0	Seconds	1.0	58	
P15	CFN 14	Stop Mode	Coast Volt Decel TT Decel		Coast	53	
P16	CFN 15	Decel Begin Level	100 – 1	%	40	54	
P17	CFN 16	Decel End Level	50 – 1	%	20	55	
P18	CFN 17	Decel Time	1 – 180	Seconds	15	56	

Protection Function Group

LED	LCD	Parameter	Setting Range	Units	Default	Page	Setting
P24	PFN 01	Over Current Level	Off, 50 – 800	% FLA	Off	58	
P25	PFN 02	Over Current Time	Off, 0.1 – 90.0	Seconds	0.1	59	
P26	PFN 03	Under Current Level	Off, 5 – 100	% FLA	Off	60	
P27	PFN 04	Under Current Time	Off, 0.1 – 90.0	Seconds	0.1	60	
P28	PFN 05	Current Imbalance Level	Off, 5 – 40	%	15	61	
P29	PFN 06	Ground Fault Level	Off, 5 – 100	% FLA	Off	62	
P30	PFN 07	Over Voltage Level	Off, 1 – 40	%	Off	63	
P31	PFN 08	Under Voltage Level	Off, 1 – 40	%	Off	63	
P32	PFN 09	Voltage Trip Time	0.1 – 90.0	Seconds	0.1	64	

LED	LCD	Parameter	Setting Range	Units	Default	Page	Setting
P33	PFN 10	Auto Reset	Off, 1 – 900	Seconds	Off	64	
P34	PFN 11	Controlled Fault Stop Enable	Off, On		On	64	
P35	PFN 12	Independent Starting/Running Overload	Off, On		Off	65	
P36	PFN 13	Motor Starting Overload Class	Off, 1 – 40		10	66	
P3	PFN 14	Motor Running Overload Class	Off, 1 – 40		10	42	
P37	PFN 15	Motor Overload Hot/Cold Ratio	0 – 99	%	60	67	
P38	PFN 16	Motor Overload Cooling Time	1.0 – 999.9	Minutes	30.0	68	

I/O Group

LED	LCD	Parameter	Setting Range	Units	Default	Page	Setting
P39	I/O 01	DI 1 Configuration	Off Stop Fault High Fault Low Fault Reset Bypass Cnfrm E OL Reset Local/Remote Heat Disable Heat Enable Ramp Select		Stop	69	
P40	I/O 02	DI 2 Configuration			Bypass Cnfrm		
P41	I/O 03	DI 3 Configuration			Fault Low		
P42	I/O 04	R1 Configuration	Off Fault FS Fault NFS Running UTS Alarm Ready Locked Out Overcurrent Undercurrent OL Alarm Shunt Trip FS Shunt Trip NFS Ground Fault Energy Saver Heating		Fault FS	70	
P43	I/O 05	R2 Configuration			Running		
P44	I/O 06	R3 Configuration			UTS		
P45	I/O 07	Analog Input Trip Type	Off Low Level High Level		Off	71	
P46	I/O 08	Analog Input Trip Level	0 – 100	%	50	72	
P47	I/O 09	Analog Input Trip Time	0.1 – 90.0	Seconds	0.1	72	
P48	I/O 10	Analog Input Span	1 – 100	%	100	73	
P49	I/O 11	Analog Input Offset	0 – 99	%	0	74	
P50	I/O 12	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	74	
P51	I/O 13	Analog Output Span	1 – 125	%	100	75	
P52	I/O 14	Analog Output Offset	0 – 99	%	0	75	
P53	I/O 15	Inline Configuration	Off, 1.0 – 10.0	Seconds	3.0	76	

LED	LCD	Parameter	Setting Range	Units	Default	Page	Setting
P54	I/O 16	Bypass Feedback Time	0.1 – 5.0	Seconds	2.0	76	
P55	I/O 17	Keypad Stop Disable	Enabled, Disabled		Enabled	77	

Function Group

LED	LCD	Parameter	Setting Range	Units	Default	Page	Setting
P69	FUN 01	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 %		Ave Current	84	
NA	FUN 02	Meter 2			Ave Volts		
P68	FUN 03	CT Ratio	72, 96, 144, 288, 864, 1320, 2640, 2880, 3900, 5760, 8000, 14400, 28800		288	83	
P67	FUN 04	Phase Order	Insensitive ABC CBA Single Phase		Insens.	83	
P66	FUN 05	Rated 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	82	
P65	FUN 06	Rated Power Factor	-0.01 (Lag) – 1.00 (Unity)		-0.92	82	
P64	FUN 07	Starter Type	Normal Inside Delta Wye-Delta Phase Ctl Curr Follow ATL		Normal	81	
P63	FUN 08	Heater Level	Off, 1 – 25	%FLA	Off	80	
P62	FUN 09	Energy Saver	Off, On		Off	79	
P61	FUN 10	Communication Drop Number	1 – 247		1	79	

LED	LCD	Parameter	Setting Range	Units	Default	Page	Setting
P60	FUN 11	Communication Baud Rate	1200 2400 4800 9600 19200	bps	9600	79	
P59	FUN 12	Communication Timeout	Off, 1 – 120	Seconds	Off	78	
P70	FUN 13	Starter Model Number	Model Dependent			84	
P71	FUN 14	Software Part Number	Display Only			85	
P58	FUN 15	Miscellaneous Commands	None Reset RT Reset kWh Reflash Mode Store Parameters Load Parameters Factory Reset		None	78	
P72	FUN 16	Passcode			Off	86	

Fault Group

Group	Description	Setting Range	Display
FL1	Last Fault (newest)	Display Only	Fault #
FL2	Previous Fault	Display Only	Fault #
FL3	Previous Fault	Display Only	Fault #
FL4	Previous Fault	Display Only	Fault #
FL5	Previous Fault	Display Only	Fault #
FL6	Previous Fault	Display Only	Fault #
FL7	Previous Fault	Display Only	Fault #
FL8	Previous Fault	Display Only	Fault #
FL9	Previous Fault (oldest)	Display Only	Fault #

10 – APPENDIX

Revision History

Revision	Date	Changes	ECO#
-00	28 June, 2004	Initial Release	
-01	24 November, 2004	Corrections and enhancements	E0896
-02	29 July 2005	Shield grounding corrected	E1041

BENSHAW PRODUCTS

Low Voltage Solid State Reduced Voltage Starters

- RSD/RSM6 – SSRV Non or Separate Bypass
- RDB/RMB6 – SSRV Integral Bypass
- RSM7 – SSRV + DC Injection Braking
- RSM10 – SSRV + Reversing
- RSM11 – SSRV + DC Injection Braking + Reversing
- RSM10/12TS – SSRV Two Speed
- WRSM6 – SSRV Wound Rotor
- SMRSM6 – SSRV Synchronous
- DCB3 – Solid State DC Injection Braking
- RBX/RBM – SSRV with integral or separate Bypassed,
- RCX/RCM – SSRV with no bypass

Medium Voltage Solid State Reduced Voltage Starters

- 5kV – Induction or Synchronous to 10,000HP
- 7.2kV – Induction or Synchronous to 10,000HP
- 15kV – Induction or Synchronous to 60,000HP

Low Voltage – AC Drives

- Standard Drives to 1000HP
- Custom Industrial Packaged Drives
- HVAC Packaged Drives
- 18 Pulse/IEEE 519 Compliant Drives

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- SPO/SPE/SPD Motor Protection Relays
- Enclosed Full Voltage, Wye Delta, Two Speed Part Winding and Reversing Starters

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