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BENSHAW
ADVANCED CONTROLS & DRIVES

RediStart Solid State Starter Condensed User Manual

MX² Control

(RB2, RC2, RX2E Models)

For full user manual including

Installation, ModBus Tables and more, visit

www.Benshaw.com

The Leader In

Solid State Motor Control

Technology

April 2007
Software Version: 810023-01-02
Hardware Version: 300055-01-04

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Do not attempt to install, operate, maintain or inspect the starter until you have thoroughly read this manual and related documents carefully and can use the equipment correctly.
Do not use the starter until you have a full knowledge of the equipment, safety procedures and instructions.
Always follow NFPA 70E guidelines.

Electrical Hazard that could result in injury or death.

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

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

1 Introduction

Benshaw Services

General Information

Benshaw offers its customers the following:

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

⌘ **NOTE:** Information about products and services is available by contacting Benshaw, refer to page 3.

Start-Up Services

Benshaw technical field support personnel are available to customers with the initial start-up of the RediStart MX^2. Information about start-up services and fees are available by contacting Benshaw.

On-Site Training Services

Benshaw technical field support personnel are available to conduct on-site training on RediStart MX^2 operations and troubleshooting.

Technical Support

Benshaw technical support personnel are available (at no charge) to answer customer questions and provide technical support over the telephone. For more information about contacting technical support personnel, refer to page 3.

Documentation

Benshaw provides all customers with:

- Quick Start manual.
- Wiring diagram.

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

On-Line Documentation

All RediStart MX^2 documentation including Operations Manual is available on-line at **http://www.benshaw.com**.

Replacement Parts

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

Software Number

This manual pertains to the software version numbers 810023-01-02.

Hardware Number

This manual pertains to the hardware version numbers 300055-01-04.

Warranty

Benshaw provides a 3 year standard warranty with its starters. All recommended maintenance procedures must be followed throughout the warranty period to ensure validity. This information is also available by going online to register at www.benshaw.com.

Contacting Benshaw

Contacting Benshaw

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

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

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

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

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

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

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

Technical support for the RediStart MX^2 Series is available at no charge by contacting Benshaw's customer service department at one of the above telephone numbers. A service technician is available Monday through Friday from 8:00 a.m. to 5:00 p.m. EST.

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

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

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

NOTES:

2 Technical Specifications

Technical Specifications

2.0.1 CT Ratios

Table 1: CT Ratios

CT Ratio	Minimum FLA (A rms)	Maximum FLA (A rms)
72:1 (4 wraps 288:1)	4	16
96:1 (3 wraps 288:1)	5	21
144:1 (2 wraps 288:1)	8	32
288:1	15	64
864:1	45	190
2640:1	135	590
3900:1	200	870
5760:1	295	1285
8000:1	410	1800
14400:1 (CT-CT combination)	740	3200
28800:1 (CT-CT combination)	1475	6400

Starter Power Ratings

2.0.2 Standard Duty (350% for 30 sec) Ratings

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

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

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

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

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

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

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

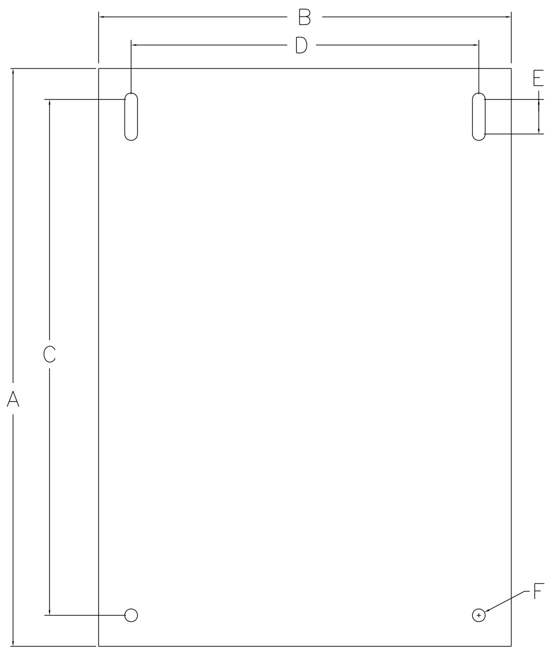
2.0.6 RB2 Power Stack Ratings and Protection Requirements

Mechanical Drawings

2.1 Dimensions

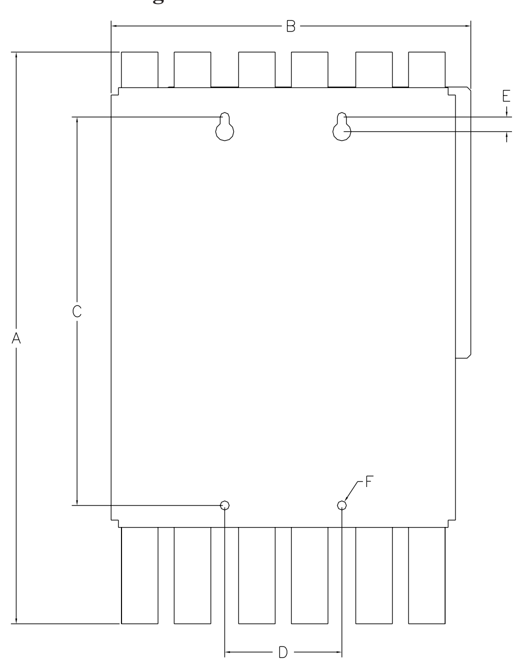
2.1.1 RB2 Chassis with Integral Bypass

Figure 1: RB2 - 96A, 830A



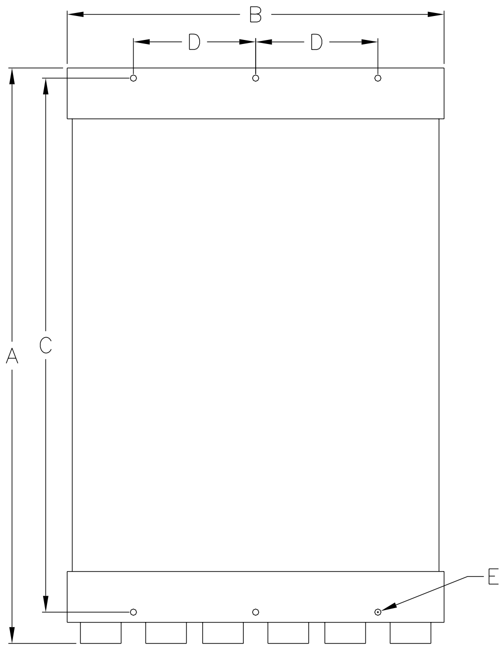
Model	A	B	C	D	E	F
RB2 27-65A	14	10	12.5	8.43	0.84	0.31
RB2 77-96A	15	10	13.5	8.43	0.84	0.31

Figure 2: RB2 125 - 361A



Model	A	B	C	D	E	F
RB2 125A	19.5	12.27	13.25	4	0.5	0.31
RB2 156-180A	21.25	12.00	15.25	4	0.5	0.31
RB2 180-302A	22.75	12.16	16.75	4	0.5	0.31
RB2 361A	23.91	13.16	18.63	4.31	0.5	0.31

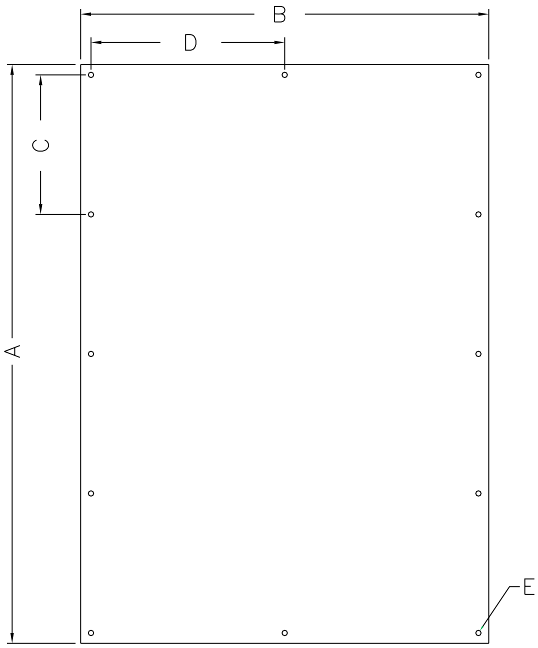
Figure 3: RB2 414 - 838A



Model	A	B	C	D	E	F
RB2 414-590A	27.66	18.5	26.25	6	N/A	0.31
RB2 720A	29.38	18.5	28	6	N/A	0.31
RB2 838A	27.75	26.6	23.5	8.7	N/A	0.31

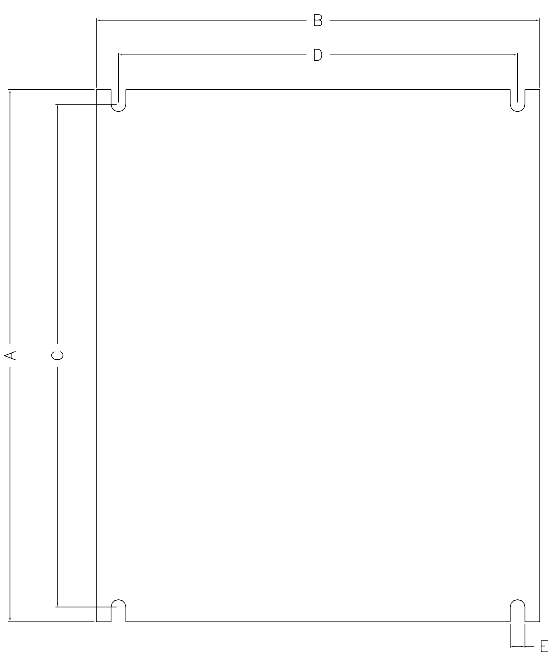
2.1.2 RC2 Chassis with no Bypass

Figure 4: RC2 0 - 124A



Model	A	B	C	D	E
RC2 27-52A	14	9.875	3.375	4.69	8-32 TAP
RC2 65-77A	18	10	4.375	4.75	¼-20 TAP
RC2 96-124A	27	10	5.313	4.75	¼-20 TAP

Figure 5: RC2 156 - 590A



Model	A	B	C	D	E
RC2 156-180A	18	15	17	13.5	0.3
RC2 240A	24	15	23	13.5	0.5
RC2 302-361A	28	17.25	27	15.75	0.5
RC2 477A	28	20	27	18.5	0.5
RC2 590A	35	20	34	18.5	0.5

NOTES:

3 Installation

Power and Control Drawings for Bypassed and Non Bypassed Power Stacks

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

Figure 6: Power Schematic for RB2 Low HP

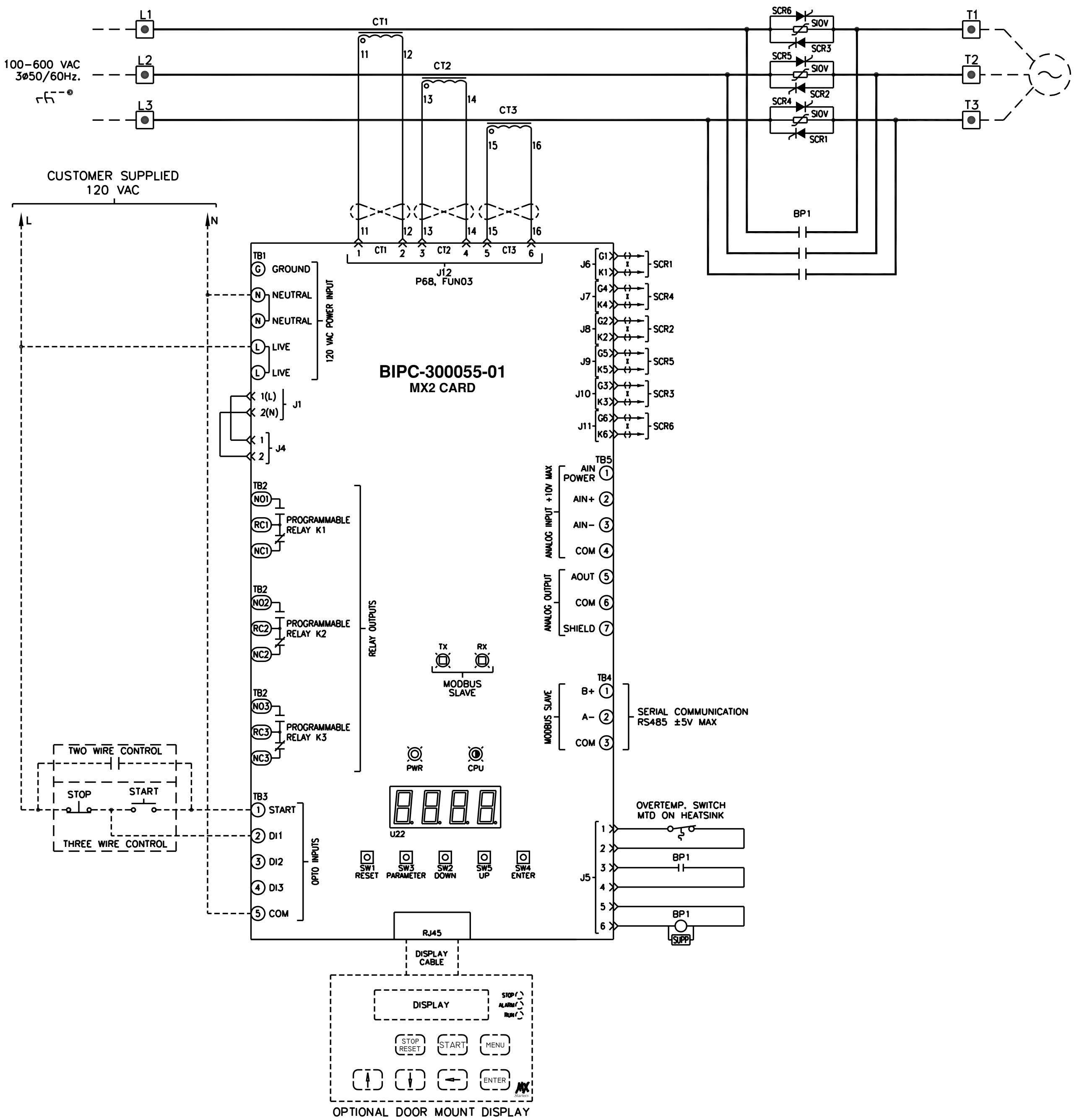


Figure 7: Power Schematic for RB2 High HP

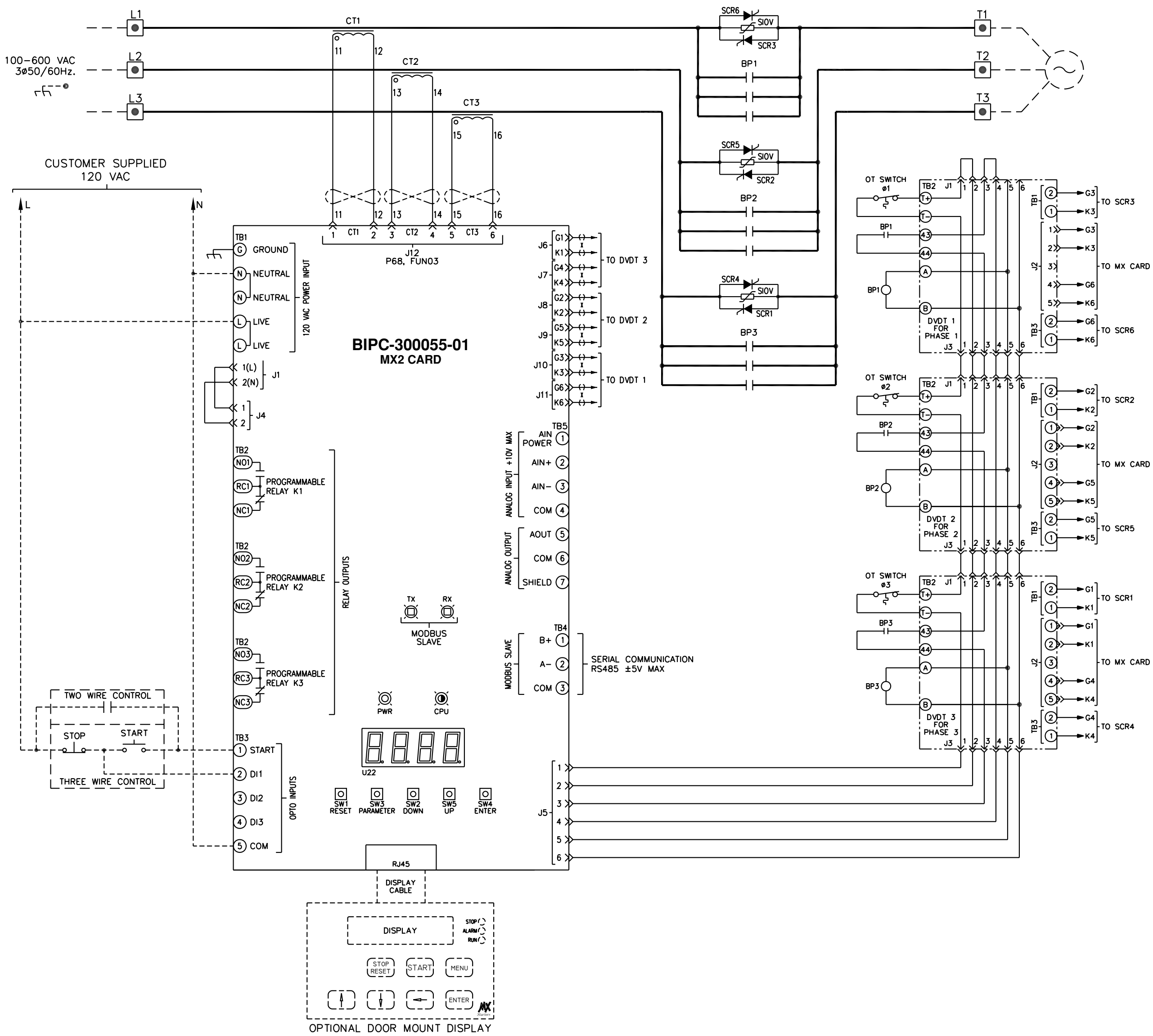
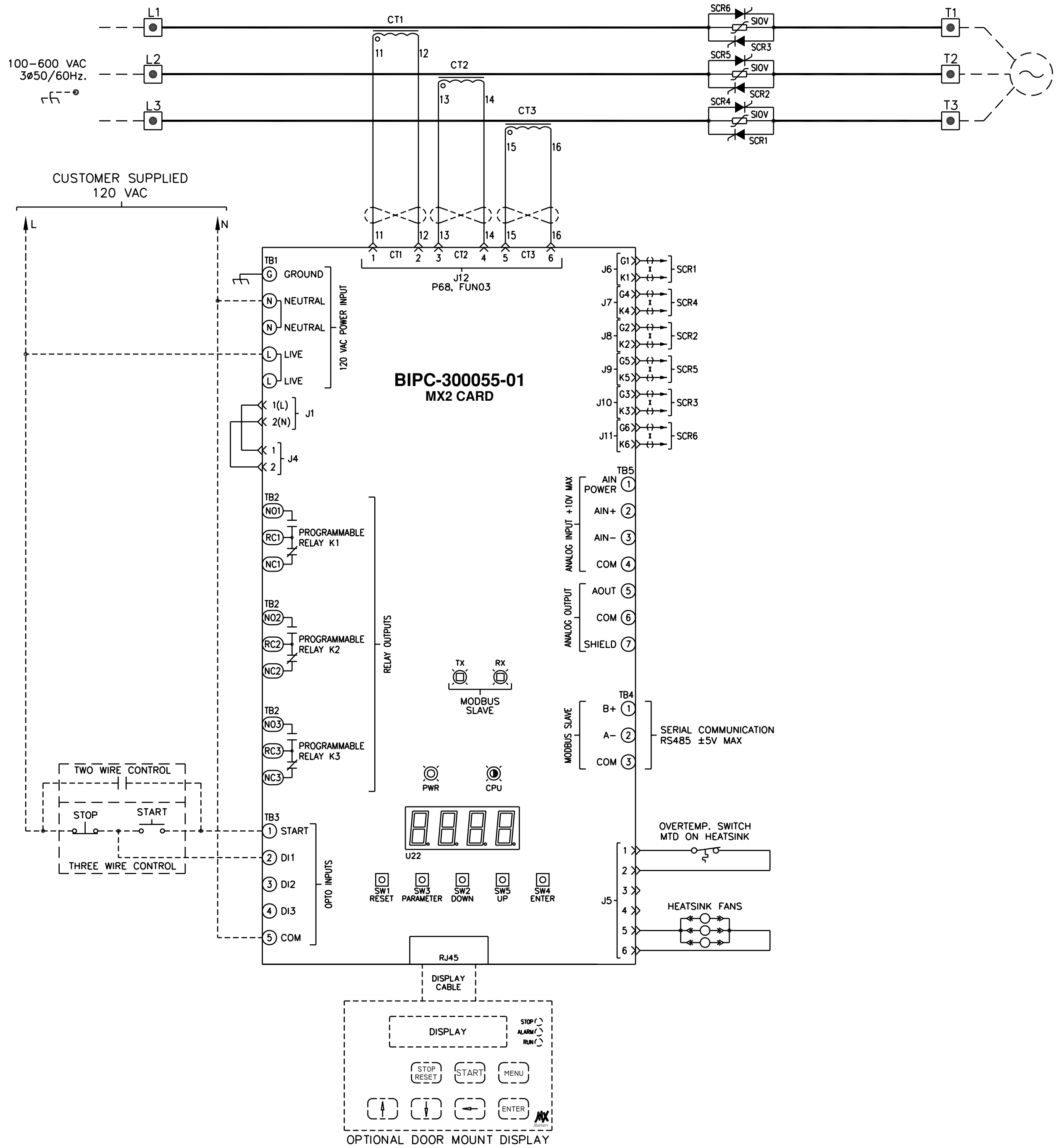


Figure 8: Power Schematic for RC2



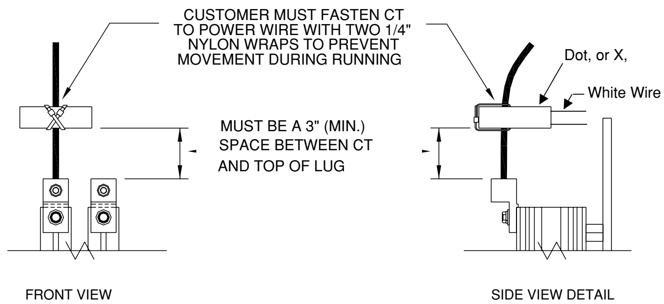
Current Transformers

3.2 Current Transformers

3.2.1 CT Mounting

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

Figure 9: Typical CT Mounting, Input of Starter



3.2.2 CT Polarity

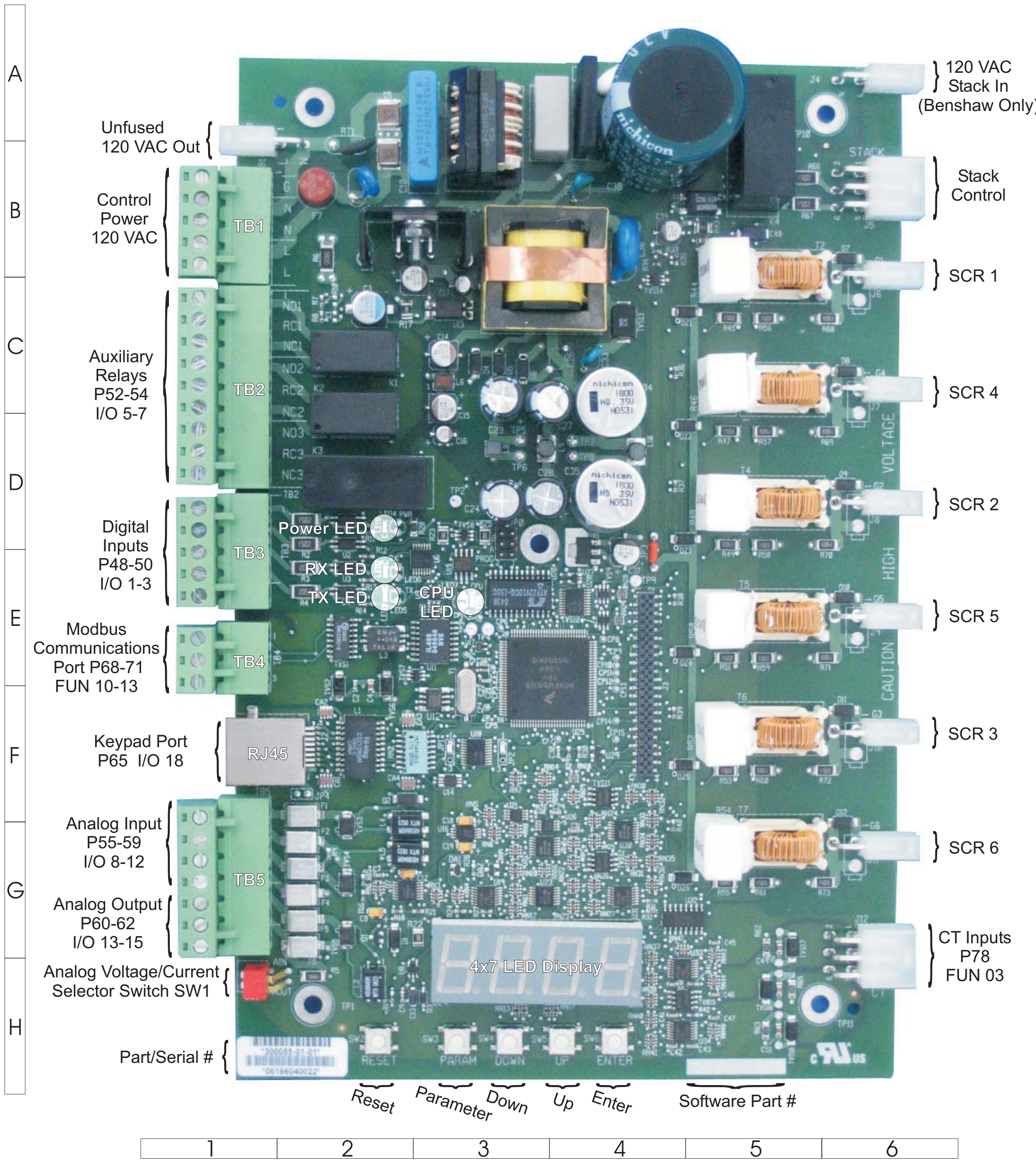
The CT has a polarity that must be correct for the starter to correctly measure Watts, kW Hours, Power Factor, and for the Power and TruTorque motor control functions to operate properly.

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

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

3.3 Control Card Layout

Figure 10: Control Card Layout



4 Parameter Groups

Introduction

4.1 Introduction

The MX^2 incorporates a 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. The parameters are subdivided into six groups. The groups are **QST** (Quick Start), **CFN** (Control Functions), **PFN** (Protection Functions), **I/O** (Input/Output Functions), **FUN** (Function) and **FL1** (Faults) .

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

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. Section 4.2 is a cross-reference between the two.

LED & LCD Display Parameters Cross Reference

4.2 LED and LCD Display Parameters Cross Reference

Parameter Number	Group	Parameter Name	Page #	Parameter Number	Group	Parameter Name	Page #
P1	QST 01	Motor FLA	34	P42	PFN 11	Auto Reset Limit	55
P2	QST 02	Motor Service Factor	34	P43	PFN 12	Controlled Fault Stop Enable	55
P3	QST 03	Motor Running Overload Class	34	P44	PFN 13	Independent Starting/Running Overload	56
P4	QST 04	Local Source	35	P45	PFN 14	Motor Starting Overload Class	56
P5	QST 05	Remote Source	36	P46	PFN 16	Motor Overload Hot/Cold Ratio	57
P6	QST 06	Initial Current 1	37	P47	PFN 17	Motor Overload Cooling Time	58
P7	QST 07	Maximum Current 1	37	P48	I/O 01	DI 1 Configuration	59
P8	QST 08	Ramp Time 1	38	P49	I/O 02	DI 2 Configuration	59
P9	QST 09	Up To Speed Time	38	P50	I/O 03	DI 3 Configuration	59
P10	CFN 01	Start Mode	39	P51	I/O 04	Digital Fault Input Trip Time	60
P11	CFN 08	Initial Voltage/Torque/Power	40	P52	I/O 05	R1 Configuration	60
P12	CFN 09	Maximum Torque/Power	40	P53	I/O 06	R2 Configuration	60
P13	CFN 10	Kick Level 1	41	P54	I/O 07	R3 Configuration	60
P14	CFN 11	Kick Time 1	41	P55	I/O 08	Analog Input Trip Type	61
P15	CFN 14	Stop Mode	42	P56	I/O 09	Analog Input Trip Level	61
P16	CFN 15	Decel Begin Level	43	P57	I/O 10	Analog Input Trip Time	62
P17	CFN 16	Decel End Level	43	P58	I/O 11	Analog Input Span	62
P18	CFN 17	Decel Time	44	P59	I/O 12	Analog Input Offset	63
P19	CFN 18	DC Brake Level	44	P60	I/O 13	Analog Output Function	64
P20	CFN 19	DC Brake Time	45	P61	I/O 14	Analog Output Span	65
P21	CFN20	DC Brake Delay	45	P62	I/O 15	Analog Output Offset	65
P22	CFN 06	Initial Current 2	46	P63	I/O 16	Inline Configuration	66
P23	CFN 07	Maximum Current 2	46	P64	I/O 17	Bypass Feedback Time	66
P24	CFN 05	Ramp Time 2	46	P65	I/O 18	Keypad Stop Disable	67
P25	CFN 12	Kick Level 2	47	P66	I/O 19	Power On Start Selection	67
P26	CFN 13	Kick Time 2	47	P67	FUN 15	Miscellaneous Commands	68
P27	CFN 21	Slow Speed	47	P68	FUN 12	Communication Timeout	69
P28	CFN 22	Slow Speed Current Level	48	P69	FUN 11	Communication Baud Rate	69
P29	CFN 23	Slow Speed Time Limit	48	P70	FUN 10	Communication Address	69
P30	CFN 24	Slow Speed Kick Level	49	P71	FUN 13	Communication Byte Framing	70
P31	CFN 25	Slow Speed Kick Time	49	P72	FUN 09	Energy Saver	70
P32	PFN 01	Over Current Level	50	P73	FUN 08	Heater Level	71
P33	PFN 02	Over Current Time	50	P74	FUN 07	Starter Type	72
P34	PFN 03	Under Current Level	51	P75	FUN 06	Rated Power Factor	72
P35	PFN 04	Under Current Time	51	P76	FUN 05	Rated Voltage	73
P36	PFN 05	Current Imbalance Level	52	P77	FUN 04	Phase Order	73
P37	PFN 06	Residual Ground Fault Level	53	P78	FUN 03	CT Ratio	73
P38	PFN 07	Over Voltage Level	53	P79	FUN 01	Meter 1	74
P39	PFN 08	Under Voltage Level	54	n/a	FUN 02	Meter 2	74
P40	PFN 09	Voltage Trip Time	54	P80	FUN 14	Software Version 1	75
P41	PFN 10	Auto Fault Reset Time	55	P81	FUN 16	Passcode	75
				P82	FL1	Fault Log	76

LED Display Parameters

4.3 LED Display Parameters

Number	Modbus Register Address	Parameter	Setting Range	Units	Default	Page
P1	30101/40101	Motor FLA	1 – 6400	RMS Amps	10	34
P2	30102/40102	Motor Service Factor	1.00 – 1.99		1.15	34
P3	30105/40105	Motor Running Overload Class	Off, 1 – 40		10	34
P4	30110/40110	Local Source	PAd: Keypad tEr: Terminal SEr: Serial		tEr	35
P5	30111/40111	Remote Source				36
P6	30113/40113	Initial Motor Current 1	50 – 600	%FLA	100	37
P7	30114/40114	Maximum Motor Current 1	100 – 800	%FLA	600	37
P8	30115/40115	Ramp Time 1	0 – 300	Seconds	15	38
P9	30119/40119	Up To Speed Time	1 – 900	Seconds	20	38
P10	30112/40112	Start Mode	oLrP: Voltage Ramp curr: Current Ramp tt: TT Ramp Pr: Power Ramp		curr	39
P11	30120/40120	Initial Voltage/Torque/Power	1 – 100	%	25	40
P12	30121/40121	Maximum Torque/Power	10 – 325	%	105	40
P13	30130/40130	Kick Level 1	Off, 100 to 800	%FLA	Off	41
P14	30131/40131	Kick Time 1	0.1 – 10.0	Seconds	1.0	41
P15	30122/40122	Stop Mode	CoS: Coast SdcL: Volt Decel tdcL: TT Decel dcb: DC Braking		CoS	42
P16	30123/40123	Decel Begin Level	100 – 1	%	40	43
P17	30124/40124	Decel End Level	99 – 1	%	20	43
P18	30125/40125	Decel Time	1 – 180	Seconds	15	44
P19	30126/40126	DC Brake Level	10 – 100	%	25	44
P20	30127/40127	DC Brake Time	1 – 180	Seconds	5	45
P21	30128/40128	DC Brake Delay	0.1 – 3.0	Seconds	0.2	45
P22	30116/40116	Initial Motor Current 2	50 – 600	%FLA	100	46
P23	30117/40117	Maximum Motor Current 2	100 – 800	%FLA	600	46
P24	30118/40118	Ramp Time 2	0 – 300	Seconds	15	46
P25	30133/40133	Kick Level 2	Off, 100 – 800	%FLA	Off	47
P26	30134/40134	Kick Time 2	0.1 – 10.0	Seconds	1.0	47
P27	30136/40136	Slow Speed	Off, 7.1 14.3	%	Off	47
P28	30137/40137	Slow Speed Current Level	10 – 400	%FLA	100	48
P29	30139/40139	Slow Speed Time Limit	Off, 1 – 900	Seconds	10	48
P30	30141/40141	Slow Speed Kick Level	Off, 100 – 800	%FLA	Off	49
P31	30142/40142	Slow Speed Kick Time	0.1 – 10.0	Seconds	1.0	49
P32	30147/40147	Over Current Trip Level	Off, 50 – 800	%FLA	Off	50
P33	30149/40139	Over Current Trip Delay Time	Off, 0.1 – 90.0	Seconds	0.1	50
P34	30151/40151	Under Current Trip Level	Off, 5 – 100	%FLA	Off	51
P35	30153/40153	Under Current Trip Delay Time	Off, 0.1 – 90.0	Seconds	0.1	51
P36	30155/40155	Current Imbalance Trip Level	Off, 5 – 40	%	15	52
P37	30157/40157	Residual Ground Fault Trip Level	Off, 5 – 100	%FLA	Off	53
P38	30159/40159	Over Voltage Trip Level	1 – 40	%	Off	53
P39	30161/40161	Under Voltage Trip Level	1 – 40	%	Off	54

Number	Modbus Register Address	Parameter	Setting Range	Units	Default	Page
P40	30162/40162	Over/Under Voltage Trip Delay Time	0.1 – 90.0	Seconds	0.1	54
P41	30165/40165	Auto Fault Reset Time	Off, 1 – 900	Seconds	Off	55
P42	30167/40167	Auto Reset Limit	Off, 1 – 10		Off	55
P43	30168/40168	Controlled Fault Stop Enable	Off, On		On	55
P44	30103/40103	Independent Starting/Running Overload	Off, On		Off	56
P45	30107/40107	Motor Starting Overload Class	Off, 1 – 40		10	56
P46	30108/40108	Motor Overload Hot/Cold Ratio	0 – 99	%	60	57
P47	30109/40109	Motor Overload Cooling Time	1.0 – 999.9	Minutes	30.0	58
P48	30169/40169	DI 1 Configuration	OFF: Off StOP: Stop FH: Fault High FL: Fault Low Fr: Fault Reset diSc: Disconnect InLn: Inline Cnfrm byP: Bypass Cnfrm EoLr: E OL Reset L-r: Local/Remote hdIS: Heat Disable hEn: Heat Enable rSEL: Ramp Select SS F: Slow Speed Forward SS R: Slow Speed Reverse BdIS: DC Brake Disable BEn: DC Brake Enable		Stop	59
P49	30170/40170	DI 2 Configuration			Off	
P50	30171/40171	DI 3 Configuration			Off	
P51	30163/40163	Digital Fault Input Trip Time	0.1 – 90.0	Seconds	0.1	60
P52	30172/40172	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 SSpd: Slow Speed SS F: Slow Speed Forward SS r: Slow Speed Reverse dcb: DC Braking FAn: Cooling Fan		FLFS	60
P53	30173/40173	R2 Configuration			Off	
P54	30174/40174	R3 Configuration			Off	
P55	30176/40176	Analog Input Trip Type	Off: Disabled Lo: Low Level Hi: High Level		Off	61
P56	30177/40177	Analog Input Trip Level	0 – 100	%	50	61
P57	30178/40178	Analog Input Trip Delay Time	0.1 – 90.0	Seconds	0.1	62
P58	30179/40179	Analog Input Span	1 – 100	%	100	62

Number	Modbus Register Address	Parameter	Setting Range	Units	Default	Page
P59	30180/40180	Analog Input Offset	0 – 99	%	0	63
P60	30181/40181	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: Off (no output)	64
P61	30182/40182	Analog Output Span	1 – 125	%	100	65
P62	30183/40183	Analog Output Offset	0 – 99	%	0	65
P63	30185/40185	Inline Configuration	Off, 1.0– 10.0	Seconds	3.0	66
P64	30186/40186	Bypass Feedback Time	0.1 – 5.0	Seconds	2.0	66
P65	30187/40187	Keypad Stop Disable	Enabled, Disabled		Enabled	67
P66	30191/40191	Power On Start Selection	0: Disabled 1: Start after power applied only 2: Start after fault reset only 3: Start after power applied and after fault reset		0	67
P67	30199/40199	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 7: Std. BIST 8: Powered BIST		0	68
P68	30189/40189	Communication Timeout	Off, 1 – 120	Seconds	Off	69
P69		Communication Baud Rate	1200, 2400, 4800, 9600, 19200	bps	19200	69
P70		Communication Address	1 – 247		1	69
P71		Communication Byte Framing	0: Even Parity, 1 Stop Bit 1: Odd Parity, 1 Stop Bit 2: No Parity, 1 Stop Bit 3: No Parity, 2 Stop Bits		0	70
P72	30192/40192	Energy Saver	Off, On		Off	70
P73	30194/40194	Heater Level	Off, 1 – 40	%FLA	Off	71
P74	30195/40195	Starter Type	nor: Normal Id: Inside Delta y-d: Wye-Delta / Other Electro mechanical PctL: Phase Control cFol: Current Follow AtL: Full Voltage ATL		nor	72
P75		Rated Power Factor	-0.01 (Lag) to 1.00 (Unity)		-0.92	72
P76	30143/40143	Rated Voltage	100, 110, 120, 200, 208, 220, 230, 240, 350, 380, 400, 415, 440, 460, 480, 500, 525, 575, 600, 660, 690, 800, 1000, 1140	RMS Voltage	480	73
P77	30144/40144	Phase Order	InS: Insensitive AbC: ABC CbA: CBA SPH: Single Phase		InS	73

Number	Modbus Register Address	Parameter	Setting Range	Units	Default	Page
P78	30190/40190	CT Ratio	72:1, 96:1, 144:1, 288:1, 864:1, 2640:1, 3900:1, 5760:1, 8000:1, 14400:1, 28800:1		288:1	73
P79	30196/40196	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 % 27: Peak Starting Current 28: Last Starting Duration		1: Ave Current	74
P80		Software Version 1	Display Only			75
P81		Passcode			Off	75
P82	30601/40601 to 30609/40609	Fault Log	1FXX - 9FXX			76

LCD Display Parameters

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

The MX^2 incorporates a number of parameters that allow you to configure the starter to meet the special requirements of your particular application.

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

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

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

Number	Display	Parameter	Setting Range	Units	Default	Page
QST 00	Jump Code	Jump to Parameter	1 to 9		1	34
QST 01	Motor FLA	Motor FLA	1 to 6400	RMS Amps	10	34
QST 02	Motor SF	Motor Service Factor	1.00 to 1.99		1.15	34
QST 03	Running OL	Motor Overload Class Running	Off, 1 to 40		10	34
QST 04	Local Src	Local Source	Keypad Terminal Serial		Terminal	35
QST 05	Remote Src	Remote Source	Keypad Terminal Serial		Terminal	36
QST 06	Init Cur 1	Initial Motor Current 1	50 to 600	%FLA	100	37
QST 07	Max Cur 1	Maximum Motor Current 1	100 to 800	%FLA	600	37
QST 08	Ramp Time 1	Ramp Time 1	0 to 300	Seconds	15	38
QST 09	UTS Time	Up To Speed Time	1 to 900	Seconds	20	38

4.4.2 Control Function Group

Number	Display	Parameter	Setting Range	Units	Default	Page
CFN 00	Jump Code	Jump to Parameter	1 to 25		1	39
CFN 01	Start Mode	Start Mode	Voltage Ramp Current Ramp TT Ramp Power Ramp		Current Ramp	39
CFN 02	Ramp Time 1	Ramp Time 1	0 to 300	Seconds	15	38
CFN 03	Init Cur 1	Initial Motor Current 1	50 to 600	%FLA	100	37
CFN 04	Max Cur 1	Maximum Motor Current 1	100 to 800	%FLA	600	37
CFN 05	Ramp Time 2	Ramp Time 2	0 to 300	Seconds	15	46
CFN 06	Init Cur 2	Initial Motor Current 2	50 to 600	%FLA	100	46
CFN 07	Max Cur 2	Maximum Motor Current 2	100 to 800	%FLA	600	46
CFN 08	Init V/T/P	Initial Voltage/Torque/Power	1 to 100	%	25	40
CFN 09	Max T/P	Maximum Torque/Power	10 to 325	%	105	40
CFN 10	Kick Lvl 1	Kick Level 1	Off, 100 to 800	%FLA	Off	41
CFN 11	Kick Time 1	Kick Time 1	0.1 to 10.0	Seconds	1.0	41
CFN 12	Kick Lvl 2	Kick Level 2	Off, 100 to 800	%FLA	Off	47
CFN 13	Kick Time 2	Kick Time 2	0.1 to 10.0	Seconds	1.0	47
CFN 14	Stop Mode	Stop Mode	Coast Volt Decel TT Decel DC Brake		Coast	42
CFN 15	Decel Begin	Decel Begin Level	100 to 1	%	40	43
CFN 16	Decel End	Decel End Level	99 to 1	%	20	43
CFN 17	Decel Time	Decel Time	1 to 180	Seconds	15	44
CFN 18	Brake Level	DC Brake Level	10 to 100	%	25	44
CFN 19	Brake Time	DC Brake Time	1 to 180	Seconds	5	45
CFN 20	Brake Delay	DC Brake Delay	0.1 to 3.0	Seconds	0.2	45
CFN 21	SSpd Speed	Slow Speed	Off, 7.1, 14.3	%	Off	47
CFN 22	SSpd Curr	Slow Speed Current Level	10 to 400	% FLA	100	48
CFN 23	SSpd Timer	Slow Speed Time Limit	Off, 1 to 900	Seconds	10	48
CFN 24	SSpd Kick Curr	Slow Speed Kick Level	Off, 100 to 800	% FLA	Off	49
CFN 25	SSpd Kick T	Slow Speed Kick Time	0.1 to 10.0	Seconds	1.0	49

4.4.3 Protection Group

Number	Display	Parameter	Setting Range	Units	Default	Page
PFN 00	Jump Code	Jump to Parameter	1 to 17		1	49
PFN 01	Over Cur Lvl	Over Current Trip Level	Off, 50 to 800	%FLA	Off	50
PFN 02	Over Cur Tim	Over Current Trip Delay Time	Off, 0.1 to 90.0	Seconds	0.1	50
PFN 03	Undr Cur Lvl	Under Current Trip Level	Off, 5 to 100	%FLA	Off	51
PFN 04	Undr Cur Tim	Under Current Trip Delay Time	Off, 0.1 to 90.0	Seconds	0.1	51
PFN 05	Cur Imbl Lvl	Current Imbalance Trip Level	Off, 5 to 40	%	15	52
PFN 06	Gnd Flt Lvl	Residual Ground Fault Trip Level	Off, 5 to 100	%FLA	Off	53
PFN 07	Over Vlt Lvl	Over Voltage Trip Level	Off, 1 to 40	%	Off	53
PFN 08	Undr Vlt Lvl	Under Voltage Trip Level	Off, 1 to 40	%	Off	54
PFN 09	Vlt Trip Tim	Over/Under Voltage Trip Delay Time	0.1 to 90.0	Seconds	0.1	54
PFN 10	Auto Reset	Auto Fault Reset Time	Off, 1 to 900	Seconds	Off	55
PFN 11	Auto Rst Lim	Auto Reset Limit	Off, 1 to 10		Off	55
PFN 12	Ctrl Flt En	Controlled Fault Stop Enable	Off, On		On	55
PFN 13	Indep S® OL	Independent Starting/Running Overload	Off, On		Off	56
PFN 14	Starting OL	Motor Overload Class Starting	Off, 1 to 40		10	56
PFN 15	Running OL	Motor Overload Class Running	Off, 1 to 40		10	34
PFN 16	OL H© Ratio	Motor Overload Hot/Cold Ratio	0 to 99	%	60	57
PFN 17	OL Cool Tim	Motor Overload Cooling Time	1.0 to 999.9	Minutes	30.0	58

4.4.4 I/O Group

<table>
<tr><th>Number</th><th>Display</th><th>Parameter</th><th>Setting Range</th><th>Units</th><th>Default</th><th>Page</th></tr>
<tr><td>I/O 00</td><td>Jump Code</td><td>Jump to parameter</td><td>1 to 19</td><td></td><td>1</td><td>58</td></tr>
<tr><td>I/O 01</td><td>DI 1 Config</td><td>DI 1 Configuration</td><td rowspan="3">Off
Stop
Fault High
Fault Low
Fault Reset
Disconnect
Inline Cnfrm
Bypass Cnfrm
E OL Reset
Local/Remote
Heat Disable
Heat Enable
Ramp Select
Slow Spd Fwd
Slow Spd Rev
Brake Disabl
Brake Enable</td><td></td><td>Stop</td><td rowspan="3">59</td></tr>
<tr><td>I/O 02</td><td>DI 2 Config</td><td>DI 2 Configuration</td><td></td><td>Off</td></tr>
<tr><td>I/O 03</td><td>DI 3 Config</td><td>DI 3 Configuration</td><td></td><td>Off</td></tr>
<tr><td>I/O 04</td><td>Dig Trp Time</td><td>Digital Fault Input Trip Time</td><td>0.1 to 90.0</td><td>Seconds</td><td>0.1</td><td>60</td></tr>
</table>

<table>
<tr><th>Number</th><th>Display</th><th>Parameter</th><th>Setting Range</th><th>Units</th><th>Default</th><th>Page</th></tr>
<tr><td>I/O 05</td><td>R1 Config</td><td>R1 Configuration (Relay #1)</td><td rowspan="3">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
Slow Spd
Slow Spd Fwd
Slow SPd Rev
Braking
Cool Fan Ctl</td><td></td><td>Fault FS</td><td rowspan="3">60</td></tr>
<tr><td>I/O 06</td><td>R2 Config</td><td>R2 Configuration (Relay #2)</td><td></td><td>Off</td></tr>
<tr><td>I/O 07</td><td>R3 Config</td><td>R3 Configuration (Relay #3)</td><td></td><td>Off</td></tr>
<tr><td>I/O 08</td><td>Ain Trp Type</td><td>Analog Input Trip Type</td><td>Off
Low Level
High Level</td><td></td><td>Off</td><td>61</td></tr>
<tr><td>I/O 09</td><td>Ain Trp Lvl</td><td>Analog Input Trip Level</td><td>0 to 100</td><td>%</td><td>50</td><td>61</td></tr>
<tr><td>I/O 10</td><td>Ain Trp Tim</td><td>Analog Input Trip Delay Time</td><td>0.1 to 90.0</td><td>Seconds</td><td>0.1</td><td>62</td></tr>
<tr><td>I/O 11</td><td>Ain Span</td><td>Analog Input Span</td><td>1 to 100</td><td>%</td><td>100</td><td>62</td></tr>
<tr><td>I/O 12</td><td>Ain Offset</td><td>Analog Input Offset</td><td>0 to 99</td><td>%</td><td>0</td><td>63</td></tr>
<tr><td>I/O 13</td><td>Aout Fctn</td><td>Analog Output Function</td><td>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</td><td></td><td>Off</td><td>64</td></tr>
<tr><td>I/O 14</td><td>Aout Span</td><td>Analog Output Span</td><td>1 to 125</td><td>%</td><td>100</td><td>65</td></tr>
<tr><td>I/O 15</td><td>Aout Offset</td><td>Analog Output Offset</td><td>1 to 99</td><td>%</td><td>0</td><td>65</td></tr>
<tr><td>I/O 16</td><td>Inline Confg</td><td>In Line Configuration</td><td>Off, 1.0 to 10.0</td><td>Seconds</td><td>3.0</td><td>66</td></tr>
<tr><td>I/O 17</td><td>Bypas Fbk Tim</td><td>Bypass / 2M Confirm</td><td>0.1 to 5.0</td><td>Seconds</td><td>2.0</td><td>66</td></tr>
<tr><td>I/O 18</td><td>Kpd Stop Dis</td><td>Keypad Stop Disable</td><td>Enabled, Disabled</td><td></td><td>Enabled</td><td>67</td></tr>
<tr><td>I/O 19</td><td>Auto Start</td><td>Power On Start Selection</td><td>Disabled
Power
Fault
Power and Fault</td><td></td><td>Disabled</td><td>67</td></tr>
</table>

4.4.5 Function Group

Number	Display	Parameter	Setting Range	Units	Default	Page
FUN 00	Jump Code	Jump to parameter	1 to 16		1	67
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 % Pk Accel Cur Last Start T		Ave Current	74
FUN 02	Meter 2	Meter 2			Ave Volts	
FUN 03	CT Ratio	CT Ratio	72:1, 96:1, 144:1, 288:1, 864:1, 2640:1, 3900:1, 5760:1, 8000:1, 14400:1, 28800:1		288:1	73
FUN 04	Phase Order	Input Phase Sensitivity	Insensitive ABC CBA Single Phase		Insens.	73
FUN 05	Rated Volts	Rated RMS Voltage	100, 110, 120, 200, 208, 220, 230, 240, 350, 380, 400, 415, 440, 460, 480, 500, 525, 575, 600, 660, 690, 800, 1000, 1140	RMS Voltage	480	73
FUN 06	Motor PF	Motor Rated Power Factor	-0.01 (Lag) to 1.00 (Unity)		-0.92	72
FUN 07	Starter Type	Starter Type	Normal Inside Delta Wye-Delta Phase Ctl Curr Follow ATL	%	Normal	72
FUN 08	Heater Level	Heater Level	Off, 1 to 40	%FLA	Off	71
FUN 09	Energy Saver	Energy Saver	Off, On	Seconds	0.1	70
FUN 10	Com Drop #	Communication Address	1 to 247		1	69
FUN 11	Com Baud rate	Communication Baud Rate	1200 2400 4800 9600 19200	bps	19200	69
FUN 12	Com Timeout	Communication Timeout	Off, 1 to 120	Seconds	Off	69

Number	Display	Parameter	Setting Range	Units	Default	Page
FUN 13	Com Parity	Communications Byte Framing	Even, 1 Stop Bit Odd, 1 Stop Bit None, 1 Stop Bit None, 2 Stop Bit		Even, 1 Stop	70
FUN 14	Software 1	Software 1 Part Number	Display Only			75
FUN 15	Misc Command	Miscellaneous Commands	None Reset RT Reset kWh Reflash Mode Store Params Load Params Factory Rst Std BIST Powered BIST		None	68
FUN 16	Passcode	Passcode			Off	75

4.4.6 LCD Fault Group

Group	Fault Number	Fault Description	Starter State	I1	I2	I3	V1	V2	V3	kW	Hz	Run Time
FL1												
FL2												
FL3												
FL4												
FL5												
FL6												
FL7												
FL8												
FL9												

4.4.7 LED Fault Group

Group	Fault Number	Fault Description	Fault Number	Fault Description
F1			F6	
F2			F7	
F3			F8	
F4			F9	
F5				

NOTES:

5 Parameter Description

Parameter Descriptions

5.1 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 5 beginning on page 62 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.

5.1.1 Theory of Operation

For Theory of Starter Operation, refer to our website http://www.benshaw.com/literature/manuals/890034-10-xx.pdf

1) Motor Overload
2) Motor Service Factor
3) Acceleration Control
4) Deceleration Control
5) Braking Control
6) Slow Speed Cyclo Converter
7) Inside Delta Connected Starter
8) Wye Delta Starter
9) Across the Line Starter
10) Single Phase Soft Starter
11) Phase Control
12) Current Follower
13) Stop/Start Control with a Hand/Off/Auto Selector Switch
14) Simplified I/O Schematics
15) Remote Modbus Communications

5.1.2 Modbus Register Map

For details refer to http://www.benshaw.com/literature/manuals/890034-11-xx.pdf

P__	Parameter Name	MMM__

LED Display

8.8.8.8.

LCD Display

MMM:Parameter
MI Value

Range Parameter Value (Default: Constant)

OR

LED	**LCD**
EEE	Keypad

Description The description of the function.

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 remote mounted keypad. The LED display shows an example of what actually appears on the built in 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 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.

Jump to Parameter — QST 00

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

P1 — Motor FLA — QST 01

LED Display

10

LCD Display:

QST: Motor FLA
01 10Amp

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

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

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

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

P2 — Motor Service Factor — QST 02

LED Display

1.15

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 Operations: http://www.benshaw.com/literature/manuals/890034-10-xx.pdf

P3 — Motor Overload Class Running — QST 03, PFN 15

LED Display

10

LCD Display

QST: Running OL
03 10

PFN: Running OL
15 10

Range Off, 1– 40 **(Default 10)**

Description

The Motor Running Overload Class parameter sets the class of the electronic overload for starting and running. If separate starting versus running overload classes are desired, set the independent S® O/L (P44 / PFN13) parameter to "On".

The starter stores the thermal overload value as a percentage value between 0 and 100%, with 0% representing a “cold” overload and 100% representing a tripped overload. See section 6.1, for the overload trip time versus current curves.

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

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

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

See Also

Independent Starting/Running Overload (P44 / PFN 13) on page 56.
Motor Starting Overload Class (P45 / PFN 14) on page 56.
Motor Overload Hot/Cold Ratio (P46 / PFN 16) on page 57.
Motor Overload Cooling Time (P47 / PFN 17) on page 58.
Relay Output Configuration (P52-54 / I/O 05 - 07) on page 60.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-10-xx.pdf

P4 — Local Source — QST 04

LED Display

tEr

LCD Display

QST: Local Src
04 Terminal

Range

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

Description

The MX^2 can have three sources of start and stop control; Terminal, Keypad and Serial. Two parameters, (P4 / QST 04) - Local Source and (P5 / QST 05) - 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).

See Also

Remote Source (P5 / QST 05) parameter on page 36.
Digital Input Configuration (P45-P50 / I/O 01- I/O 03) parameters on page 59.
Keypad Stop Disable (P65 / I/O 18) parameter on page 67.
Communication Timeout (P68 / FUN 12) parameter on page 69.
Communication Baud Rate (P69 / FUN 11) parameter on page 69.
Communication Address (P70 / FUN 10) parameter on page 69.

⌘ **NOTE:** By default, the Stop key is always enabled, regardless of selected control source. It may be disabled though using the P65 / I/O18 - Keypad Stop Disable parameter on page 67.

P5	Remote Source	QST 05

LED Display

LCD Display

QST: Remote SRC
05 Terminal

Range

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

Description

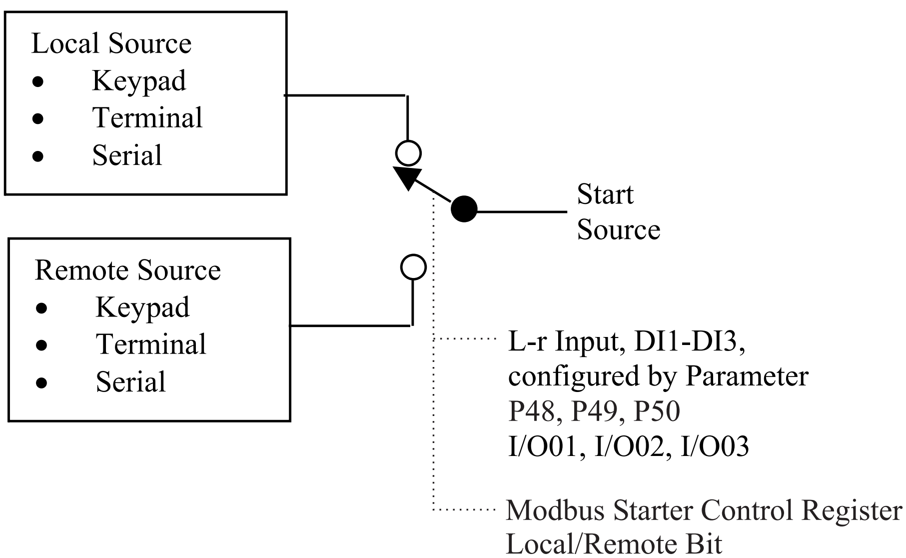
The MX^2 can have three sources of start and stop control; Terminal, Keypad and Serial. Two parameters, (P4 / QST 04) - Local Source and (P5 / QST 05) - Remote Source, select the sources of the start and stop control.

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 Modbus starter control register selects the control source. The default value of the bit is Local (0).

See Also

Local Source (P4 / QST 04) parameter on page 35.
Digital Input Configuration (P45-P50 / I/O 01- I/O 03) parameters on page 59.
Keypad Stop Disable (P65 / I/O 18) parameter on page 67.
Communication Timeout (P68 / FUN 12) parameter on page 69.
Communication Baud Rate (P69 / FUN 11) parameter on page 69.
Communication Address (P70 / FUN 10) parameter on page 69.
For Modbus Register Map, http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

Figure 11: Local Remote Source



P6	Initial Motor Current 1	QST 06, CFN 03

LED Display

```
100
```

LCD Display

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

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

Range 50 – 600 % of FLA **(Default 100%)**

Description The Initial Motor Current 1 parameter is set as a percentage of the Motor FLA (P1 / QST 01) parameter setting. The Initial Current 1 parameter sets the current that is initially supplied to the motor when a start is commanded. The initial current should be set to the level that allows the motor to begin rotating within a couple of seconds of receiving a start command.

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

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

The Initial Current 1 parameter must be set to a value that is lower than the Maximum Current 1 (P7 / QST 07) parameter setting.

See Also

Maximum Current 1 (P7 / QST 07) parameter on page 37.
Ramp Time 1 (P8 / QST 08) parameter on page 38.
Start Mode (P10 / CFN 01) parameter on page 39.
Kick Level 1 (P13 / CFN 10) parameter on page 41.
Kick Time 1 (P14 / CFN 11) parameter on page 41.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P7	Maximum Motor Current 1	QST 07, CFN 04

LED Display

```
600
```

LCD Display

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

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

Range 100 – 800 % of FLA **(Default 600%)**

Description The Maximum Motor Current 1 parameter is set as a percentage of the Motor FLA (P1 / QST 01) parameter setting. This 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 either the UTS timer expires; the motor reaches full speed, or the overload trips.

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

See Also

Initial Current 1 (P6 / QST 06) parameter on page 37.
Ramp Time 1 (P8 / QST 08) parameter on page 38.
Up To Speed Time (P9 / QST 09) parameter on page 38.

Start Mode (P10 / CFN 01) parameter on page 39.
Kick Level 1 (P13 / CFN 10) parameter on page 41.
Kick Time 1 (P14 / CFN 11) parameter on page 41.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P8 — Ramp Time 1 — QST 08, CFN 02

LED Display

15

LCD Display

```
QST:  RampTime1
08     15sec
```

```
CFN:  RampTime1
02    15sec
```

Range

0 – 300 seconds **(Default 15)**

Description

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

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

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

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

See Also

Initial Current 1 (P6 / QST 06) parameter on page 37.
Maximum Current 1 (P7 / QST 07) parameter on page 37.
Up To Speed Time (P9 / QST 09) parameter on page 38.
Start Mode (P10 / CFN 01) parameter on page 39.
Kick Level 1 (P13 / CFN 10) parameter on page 41.
Kick Time 1 (P14 / CFN 11) parameter on page 41.

P9 — Up To Speed Time — QST 09

LED Display

20

LCD Display

```
QST:   UTSTime
09       20sec
```

Range

1– 900 Seconds **(Default 20)**

Description

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

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

⌘ **NOTE:** When the Start Mode (P10 / CFN 01) parameter is set to "Voltage Ramp", the UTS timer acts as an acceleration kick. When the UTS timer expires, full voltage is applied to the motor. This feature can be used to reduce motor oscillations if they occur near the end of an open loop voltage ramp start.

⌘ **NOTE:** When the Starter Type (P74 / FUN 07) 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 if it has not already occurred.

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

See Also

Ramp Time 1 (P8 / QST 08) parameter on page 38.
Start Mode (P10 / CFN 01) parameter on page 39.
Kick Time 1 (P14 / CFN 11) parameter on page 41.
Ramp Time 2 (P24 / CFN 05) parameter on page 46.
Kick Time 2 (P26 / CFN 13) parameter on page 47.
Starter Type (P74 / FUN 07) parameter on page 72.

Jump to Parameter CFN 00

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

P10 Start Mode CFN 01

LED Display

curr

LCD Display

CFN: Start Mode
01 Current Ramp

Range

LED	LCD	Description
oLrP	Voltage Ramp	Open Loop Voltage acceleration ramp.
curr	Current Ramp	Current control acceleration ramp. **(Default)**
tt	TT Ramp	TruTorque control acceleration ramp.
Pr	Power Ramp	Power (kW) control acceleration ramp.

Description

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

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

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

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

See Also

Initial Current 1 (P6 / QST 06) parameter on page 37.
Maximum Current 1 (P7 / QST 07) parameter on page 37.
Ramp Time 1 (P8 / QST 08) parameter on page 38.
Initial Voltage/Torque/Power (P11 / CFN 08) parameter on page 40.
Kick Level 1 (P13 / CFN 10) parameter on page 41.
Kick Time 1 (P14 / CFN 11) parameter on page 41
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P11 Initial Voltage/Torque/Power CFN08

LED Display

```
25
```

LCD Display

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

Range

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

Description

Start Mode (P10/CFN01) set to Open Loop Voltage Acceleration:
This parameter sets the starting point for the voltage acceleration ramp profile. A typical value is 25%. If the motor starts too quickly or the initial current is too high, reduce this parameter. If the motor does not start rotating within a few seconds after a start is commanded, increase this parameter.

Start Mode (P10/CFN01) set to Current Control Acceleration:
Not used when the Start Mode parameter is set to Current control acceleration. Refer to the P6 - Initial Current 1 (CFN03) parameter to set the initial current level.

Start Mode (P10/CFN01) set to TruTorque Control Acceleration:
This parameter sets the initial torque level that the motor produces at the beginning of the starting ramp profile. A typical value is 10% to 20%. If the motor starts too quickly or the initial torque level is too high, reduce this parameter. If the motor does not start rotating within a few seconds after a start is commanded, increase this parameter. If the value is set too low a “No Current at Run” fault may occur during acceleration.

⌘ **NOTE**: It is important that the (P75 / FUN06) - Rated Power Factor parameter is set properly so that the actual initial torque level is the value desired.

Start Mode (P10/CFN01) set to (kW) Power Control Acceleration:
This parameter sets the initial motor power (KW) level that will be achieved at the beginning of the starting ramp profile. A typical value is 10% to 30%. If the motor starts too quickly or the initial power level is too high, reduce this parameter. If the motor does not start rotating within a few seconds after a start is commanded, increase this parameter. If the value is set too low a “No Current at Run” fault may occur during acceleration.

⌘ **NOTE:** It is important that the (P75 / FUN06) - Rated Power Factor parameter is set properly so that the actual initial power level is the value desired.

See Also

Initial Current 1 (P6 / QST 06) parameter on page 37.
Ramp Time 1 (P8 / QST 08) parameter on page 38.
Start Mode (P10 / CFN 01) parameter on page 39.
Maximum Torque/Power (P12 / CFN 09) parameter on page 40.
Rated Power Factor (P75 / FUN 06) parameter on page 72.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P12 Maximum Torque/Power CFN 09

LED Display

```
105
```

LCD Display

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

Range

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

Description

Start Mode (P10/CFN01) set to Open Loop Voltage Acceleration:
Not used when the Start Mode parameter is set to open-loop voltage acceleration. When in open loop voltage acceleration mode, the final voltage ramp value is always 100% or full voltage.

Start Mode (P10/CFN01) set to Current Control Acceleration:
Not used when the Start Mode parameter is set to Current control acceleration mode. Refer to the Initial Current 1 (P6 / CFN03) parameter to set the maximum current level.

Start Mode (P10/CFN01) set to TruTorque Control Acceleration:
This parameter sets the final or maximum torque level that the motor produces at the end of the acceleration ramp time. For a loaded motor, the maximum torque value initially should be set to 100% or greater. If the maximum torque value is set too low, the motor may not produce enough torque to reach full speed and may stall. On lightly loaded motors, this parameter may be reduced below 100% to produce smoother starts.

⌘ **NOTE:** It is important that the (P75 / FUN06) - Rated Power Factor parameter is set properly so that the desired maximum torque level is achieved.

Start Mode (P10/CFN01) set to Power Control Acceleration:
This parameter sets the final or maximum power (KW) consumption level that will be achieved at the end of the ramp time. For a loaded motor, the maximum power value initially should be set to 100% or greater. If the maximum power level is set too low, the motor may not produce enough torque to reach full speed and may stall. On lightly loaded motors, this parameter may be reduced below 100% to provide for smoother starts.

⌘ **NOTE**: It is important that the (P75 / FUN06) - Rated Power Factor parameter is set properly so that the actual maximum power level is achieved.

See Also

Initial Current 1 (P6 / CFN03) on page 37.
Maximum Current 1 (P7 / QST 07) parameter on page 37.
Ramp Time 1 (P8 / QST 08) parameter on page 38.
Start Mode (P10 / CFN 01) parameter on page 39.
Initial Voltage/Torque/Power (P11 / CFN 08) parameter on page 40.
Rated Power Factor (P75 / FUN 06) parameter on page 72.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P13 Kick Level 1 CFN 10

LED Display

OFF

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

Start Mode (P10 / CFN 01) parameter on page 39.
Kick Time 1 (P14 / CFN 11) parameter on page 41.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P14 Kick Time 1 CFN 11

LED Display

1.0

LCD Display

CFN: Kick Time 1
11 1.0sec

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

Description

The Kick Time 1 parameter sets the length of time that the kick current level (P13 / CFN 10) 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

Start Mode (P10 / CFN 01) parameter on page 39.
Up To Speed (P9 / QST 09) parameter on page 38.
Kick Level 1 (P13 / CFN 10) parameter on page 41.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P15 Stop Mode CFN 14

LED Display

CoS

LCD Display

CFN: Stop Mode
14 Coast

Range

LED	LCD	Description
CoS	Coast	Coast to stop. **(Default)**
SdcL	Volt Decel	Open loop voltage deceleration.
tdcL	TT Decel	TruTorque deceleration.
dcb	DC Brake	DC Braking.

Description

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

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

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

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

⌘ **NOTE:** The MX^2 stops the motor when any fault occurs. Depending on the application, it may be desirable for the motor to be stopped in a controlled manner (Voltage Decel, TT Decel or D.C. Braking) instead of being allowed to coast to a stop when this occurs. This may be achieved by setting the Controlled Fault Stop Enable (P43 / PFN12) parameter to "On". Be aware however that not all fault conditions allow for a controlled fault stop.

See Also

Decel Begin Level (P16 / CFN 15) parameter on page 43.
Decel End Level (P17 / CFN 16) parameter on page 43.
Decel Time (P18 / CFN 17) parameter on page 44.
DC Brake Level (P19 / CFN 18) parameter on page 44.
DC Brake Time (P20 / CFN 19) parameter on page 45.
DC Brake Delay (P21 / CFN 20) parameter on page 45.
Controlled Fault Stop Enable (P43 / PFN 12) parameter on page 55.
Digital Input Configuration (P48-P50 / I/O 01-03) parameters on page 59.
Relay Output Configuration (P52-P54 / I/O 05-07) parameters on page 60.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P16	Decel Begin Level	CFN 15

LED Display

40

LCD Display

CFN: Decel Begin
15 40%

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

Description

Stop Mode (P15/CFN14) set to Voltage Deceleration:
The voltage deceleration profile utilizes an open loop S-curve voltage ramp profile. The Decel Begin Level parameter sets the initial or starting voltage level when transferring from running to deceleration. The deceleration beginning level is not a precise percentage of actual line voltage, but defines a point on the S-curve deceleration profile.

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

Stop Mode (P15/CFN14) set to TruTorque Deceleration:
Not used when the Stop Mode parameter is set to TruTorque Decel. The TruTorque beginning deceleration level is automatically calculated based on the motor load at the time the stop command is given.

⌘ **NOTE:** It is important that the (P75 / FUN06) - Rated Power Factor parameter is set properly so that the actual deceleration torque levels are the levels desired.

See Also

Stop Mode (P10 / CFN 14) parameter on page 42.
Decel End Level (P17 / CFN 16) parameter on page 43.
Decel Time (P18 / CFN 17) parameter on page 44.
Controlled Fault Stop Enable (P43 / PFN 12) parameter on page 55.
Rated Power Factor (P75 / FUN 06) parameter on page 72.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P17	Decel End Level	CFN 16

LED Display

20

LCD Display

CFN: Decel End
16 20%

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

Description

Stop Mode (P15/CFN14) set to Voltage Deceleration:
The voltage deceleration profile utilizes an open loop S-curve voltage ramp profile. The Decel End Level parameter sets the ending voltage level for the voltage deceleration ramp profile. The deceleration ending level is not a precise percentage of actual line voltage, but defines an ending point on the S-curve deceleration profile.

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

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

Stop Mode (P15/CFN14) set to TruTorque Deceleration:
The decel end level parameter sets the ending torque level for the TruTorque deceleration ramp profile.

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

See Also

Stop Mode (P15 / CFN 14) parameter on page 42.
Decel Begin Level (P16 / CFN 15) parameter on page 43.
Decel Time (P18 / CFN 17) parameter on page 44.
Controlled Fault Stop Enable (P43 / PFN 12) parameter on page 55.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P18 Decel Time CFN 17

LED Display

15

LCD Display

CFN: Decel Time
17 15sec

Range

1 – 180 seconds **(Default 15)**

Description

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

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

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

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

A typical decel time is 20 to 40 seconds.

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

See Also

Stop Mode (P15 / CFN 14) parameter on page 42.
Decel Begin Level (P16 / CFN 15) parameter on page 43.
Decel End Level (P17 / CFN 16) parameter on page 43.
Controlled Fault Stop Enable (P43 / PFN 12) parameter on page 55.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P19 DC Brake Level CFN 18

LED Display

25

LCD Display

CFN:Brake Level
18 25%

Range

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

Description

When the Stop Mode (P15 / CFN 14) is set to DC brake, the DC Brake Level parameter sets the level of DC current applied to the motor during braking. The desired brake level is determined by the combination of the system inertia, system friction, and the desired braking time. If the motor is braking too fast the level should be reduced. If the motor is not braking fast enough the level should be increased. Refer to Nema MG1, Parts 12 and 20 for maximum load inertia. A Thermistor, Thermostat or RTD MUST be installed to protect the motor.

DC Brake Function Programming Steps:

1. The DC Brake function may be enabled by setting the stop mode (P15 / CFN 14) to DC Brake.

2. Once this function is enabled, a relay output configuration (P52,53,54 / I/O 05,06,07) must be used to control the DC brake contactor or 7th SCR gate drive card during braking. It is recommended to use Relay K3 - (P54 / I/O 07).

⌘ **NOTE:** Standard braking
- For load inertia less than 6 x motor inertia

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

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

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

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

See Also

Stop Mode (P15 / CFN 14) parameter on page 42.
DC Brake Time (P20 / CFN 19) parameter on page 45.
DC Brake Delay (P21 / CFN 20) parameter on page 45.
Controlled Fault Stop Enable (P43 / PFN 12) parameter on page 55.
Digital Input (P48-50 / I/O 01-03) parameters on page 59.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P20 DC Brake Time CFN 19

LED Display

LCD Display

Range

1 – 180 Seconds **(Default 5)**

Description

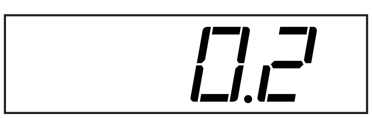
When the Stop Mode (P15 / CFN 14) is set to "DC brake", the DC Brake Time parameter sets the time that DC current is applied to the motor. The required brake time is determined by the combination of the system inertia, system friction, and the desired braking level. If the motor is still rotating faster than desired at the end of the brake time increase the brake time if possible. If the motor stops before the desired brake time has expired decrease the brake time to minimize unnecessary motor heating.

See Also

Motor Running Overload Class (P3 / QST 03) parameter on page 34.
Stop Mode (P15 / CFN 14) parameter on page 42.
DC Brake Level (P19 / CFN 18) parameter on page 44.
DC Brake Delay (P21 / CFN 20) parameter on page 45.
Controlled Fault Stop Enable (P43 / PFN 12) parameter on page 55.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P21 DC Brake Delay CFN 20

LED Display



LCD Display

Range

0.1 – 3.0 Seconds **(Default 0.2)**

Description

When the Stop Mode (P15 / CFN 14) is set to "DC brake", the DC Brake Delay time is the time delay between when a stop is commanded and the DC braking current is applied to the motor. This delay allows the residual magnetic field and motor counter EMF to decay before applying the DC braking current. If a large surge of current is detected when DC braking is first engaged increase the delay time. If the delay before the braking action begins is too long then decrease the delay time. In general, low horsepower motors can utilize shorter delays while large horsepower motor may require longer delays.

See Also

Stop Mode (P15 / CFN 14) parameter on page 42.
DC Brake Level (P19 / CFN 18) parameter on page 44.
DC Brake Time (P20 / CFN 19) parameter on page 45.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P22 Initial Motor Current 2 CFN 06

LED Display

100

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 (P1 / QST 01) parameter setting when the second ramp is active. Refer to the Initial Current 1 (P6 / CFN 03) parameter on page 37 for description of operation.

See Also

Initial Current 1 (P6 / QST 06) parameter on page 37.
Digital Input Configuration (P48-50 / I/O 01-03) parameters on page 59 .
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P23 Maximum Motor Current 2 CFN 07

LED Display

600

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 (P1 / QST 01) parameter setting, when the second ramp is active. Refer to the Maximum Current 1 (P7 / CFN 04) parameter on page 37 for description of operation.

See Also

Maximum Current 1 (P7 / QST 07) parameter on page 37.
Digital Input Configuration (P48 / I/O 01-03) parameters on page 59.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P24 Ramp Time 2 CFN 05

LED Display

15

LCD Display

CFN: Ramp Time 2
05 15sec

Range

0 – 300 seconds **(Default 15)**

Description

The Ramp Time 2 parameter sets the time it takes for the starter to allow the current to go from the initial current to the maximum current when the second ramp is active. Refer to the Ramp Time 1 (P8 / CFN 02) parameter on page 83 for description of operation.

See Also Ramp Time 1 (P8 / QST 08) parameter on page 83.
Digital Input Configuration (P48-P50 / I/O 01-03) parameters on page 59.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P25 — Kick Level 2 — CFN 12

LED Display

OFF

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 (P13 / CFN 10) parameter on page 88 for description of operation.

See Also Kick Level 1 (P13 / CFN 10) parameter on page 88.
Digital Input Configuration (P48-50 / I/O 01-03) parameters on page 5993.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P26 — Kick Time 2 — CFN 13

LED Display

1.0

LCD Display

CFN:Kick Time 2
13 1.0sec

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

Description The Kick Time 2 parameter sets the length of time that the kick current level is applied to the motor when the second ramp is active. Refer to the Kick Time 1 (P14 / CFN 11) parameter on page 88 for description of operation.

See Also: Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P27 — Preset Slow Speed — CFN 21

LED Display

OFF

LCD Display

CFN: SSpd Speed
21 Off

Range Off, 7.1%, 14.3 % **(Default Off)**

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

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

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

See Also

Slow Speed Current Level (P27 / CFN 22) parameter on page 48.
Slow Speed Time Limit (P29 / CFN 23) parameter on page 48.
Digital Input Configuration (P48-P50 / I/O 01-03) parameters on page 59.
Relay Output Configuration (P52-54 / I/O 05-07) parameters on page 60.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P28 Preset Slow Speed Current Level CFN 22

LED Display

```
100
```

LCD Display

```
CFN: SSpd Curr
22     100%
```

Range

10 – 400 % FLA **(Default 100%)**

Description

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

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

See Also

Motor Running Overload Class (P3 / QST 03) parameter on page34.
Slow Speed Time Limit (P29 / CFN 23) parameter on page 48.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P29 Slow Speed Time Limit CFN 23

LED Display

```
10
```

LCD Display

```
CFN: SSpd Timer
23      10sec
```

Range

Off, 1 – 900 Seconds **(Default 10)**

Description

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

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

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

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

See Also

Motor Running Overload Class (P3 / QST 03) parameter on page 34.
Slow Speed Current Level (P28 / CFN 22) parameter on page 48.
Theory of Operations:http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P30 Slow Speed Kick Level CFN 24

LED Display

OFF

LCD Display

CFN:SSpd Kick Cu
24   Off

Range

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

Description

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

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

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

See Also

Kick Level 1 (P13 / CFN 10) parameter on page 41.
Slow Speed Kick Time (P31 / CFN 25) parameter on page 49.
http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P31 Slow Speed Kick Time CFN 25

LED Display

1.0

LCD Display

CFN:SSpd Kick T
25   1.0sec

Range

0.1 – 10.0 seconds **(Default 1.0)**

Description

The Slow Speed Kick Time parameter sets the length of time that the Slow Speed Kick current level (P30, CFN 24) is applied to the motor at the beginning of slow speed operation. After the Slow Speed Kick Level is set, the Slow Speed Kick Time should be adjusted so that the motor starts rotating when a slow speed command is given.

If the motor initially accelerates too fast then reduce the Slow Speed Kick Level (P30 / CFN 24) and/or reduce the Slow Speed Kick Time.

See Also

Slow Speed Kick Level (P30 / CFN 24) parameter on page 49.
http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

Jump to Parameter PFN 00

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

P32	Over Current Trip Level	PFN 01

LED Display

OFF

LCD Display

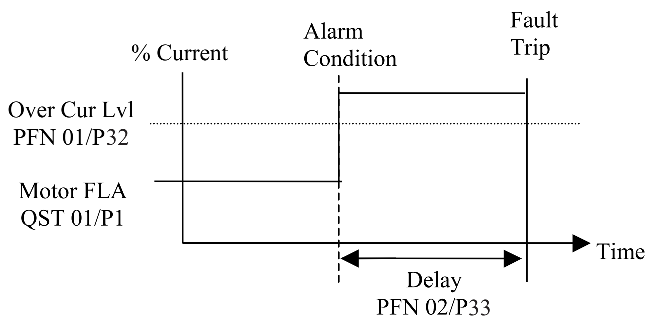
PFN:Over Cur Lvl
01   Off

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

Description If the MX^2 detects a one cycle, average current that is greater than the level defined, an over current alarm condition exists and any relays programmed as alarm will energize. The over current timer starts a delay time. If the over current still exists when the delay timer expires, the starter Over Current Trips (F31) and any relay programmed as fault relay changes state.

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

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



See Also Over Current Time (P33 / PFN 02) parameter on page 50.
Auto Reset Limit (P42 / PFN 11) parameter on page 55.
Controlled Fault Stop Enable (P43 / PFN 12) parameter on page 55.
Relay Output Configuration (P52-P54 / I/O 05-07) parameters on page 60.
http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P33	Over Current Trip Delay Time	PFN 02

LED Display

0.1

LCD Display

PFN:Over Cur Tim
02   0.2sec

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

Description The Over Current Trip Delay Time parameter sets the period of time that the motor current must be greater than the Over Current Level (P32 / PFN 01) parameter before an over current fault and trip occurs.

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

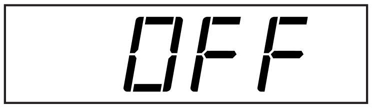
A shear pin function can be implemented by setting the delay to its minimum value.

See Also

Over Current Level (P32 / PFN 01) parameter on page 50.
Auto Reset Limit (P42 / PFN 11) parameter on page 55.
Controlled Fault Stop Enable (P43 / PFN 12) parameter on page 55.
Relay Output Configuration (P52-54 / I/O 05-07) parameters on page 60.
http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P34	Under Current Trip Level	PFN 03

LED Display



LCD Display

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

Range

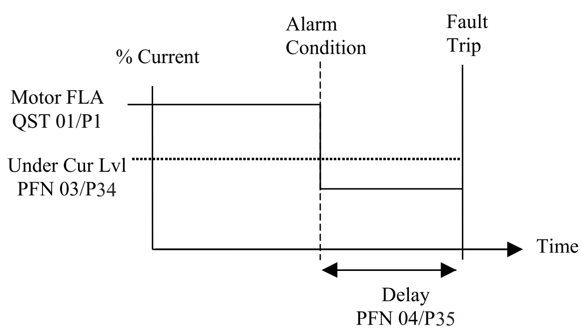
Off, 5 – 100 % of FLA **(Default Off)**

Description

If the MX^2 detects a one cycle, average current that is less than the level defined, an under current alarm condition exists and any relays programmed as alarm will energize. The under current timer starts a delay time. If the under current still exists when the delay time expires, the starter Under Current Trips (F34) and any relay programmed as fault relay changes state.

The Under Current Trip Level 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.

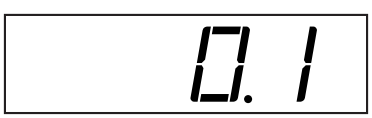


See Also

Under Current Time (P35 / PFN 04) parameter on page 51.
Auto Reset Limit (P42 / PFN 11) parameter on page 55.
Controlled Fault Stop Enable (P43 / PFN 12) parameter on page 55.
Relay Output Configuration (P52-54 / I/O 05-07) parameters on page 60.
http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P35	Under Current Trip Delay Time	PFN 04

LED Display



LCD Display

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

Range

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

Description

The Under Current Trip Delay Time parameter sets the period of time that the motor current must be less than the Under Current Trip Level (P34 / PFN 03) 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 Trip Level (P34 / PFN 03) parameter on page 51.
Auto Reset Limit (P42 / PFN 11) parameter on page 55.
Controlled Fault Stop Enable (P43 / PFN 12) parameter on page 55.
Relay Output Configuration (P52-54 / I/O 05-07) parameters on page 60.
http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P36 Current Imbalance Trip Level PFN 05

LED Display

```
15
```

LCD Display

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

Range

Off, 5 – 40 % **(Default 15%)**

Description

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

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

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

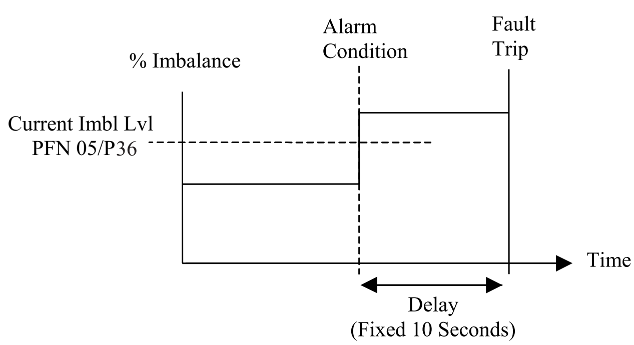
$$\%imbalance = \frac{(Iave - Imax)}{FLA} \times 100\%$$

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

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

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

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



See Also

Auto Reset Limit (P42 / PFN 11) parameter on page 55.
Controlled Fault Stop Enable (P43 / PFN 12) parameter on page 55.

P37	Residual Ground Fault Trip Level	PFN 06

LED Display

OFF

LCD Display

PFN:Resid GF Lvl
06   Off

Range

Off, 5 – 100 % FLA **(Default Off)**

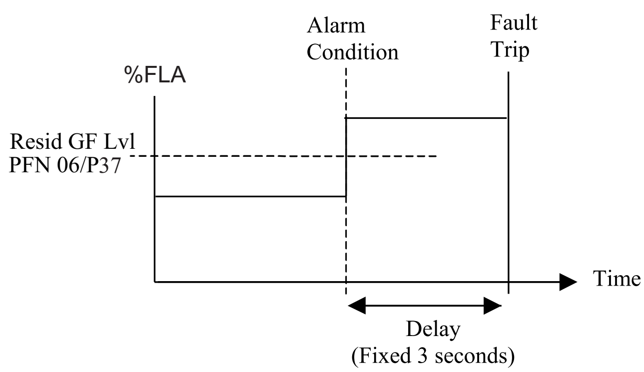
Description

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

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^2 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^2 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^2 during normal operation.

See Also

Auto Reset Limit (P42 / PFN 11) parameter on page 55.
Controlled Fault Stop Enable (P43 / PFN 12) parameter on page 55.
Relay Output Configuration (P52-54 / I/O 05-07) parameters on page 60.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P38	Over Voltage Trip Level	PFN 07

LED Display

OFF

LCD Display

PFN:Over Vlt Lvl
07   Off

Range

Off, 1 – 40 % **(Default Off)**

Description

If the MX[2] detects a one cycle input phase voltage that is above the Over Voltage Trip 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 is displayed.

⌘ **NOTE**: For the over voltage protection to operate correctly, the rated voltage parameter (P76 / FUN05) must be set correctly.

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

See Also

Under Voltage Level (P39 / PFN 08) parameter on page 54.
Voltage Trip Time (P40 / PFN 09) parameter on page 54.
Auto Reset Limit (P42 / PFN 11) parameter on page 55.
Controlled Fault Stop Enable (P43 / PFN 12) parameter on page 55.
Rated Voltage (P76 / FUN 05) parameter on page 73.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P39 Under Voltage Trip Level PFN 08

LED Display

OFF

LCD Display

PFN:Undr Vlt Lvl
08 Off

Range

Off, 1 – 40 % **(Default Off)**

Description

If the MX[2] detects a one cycle input phase voltage that is below the Under Voltage Trip 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 is displayed.

⌘ **NOTE:** For the under voltage protection to operate correctly, the Rated Voltage parameter (P76 / FUN05) must be set correctly.

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

See Also

Over Voltage Level (P38 / PFN 07) parameter on page 53.
Voltage Trip Time (P40 / PFN 09) parameter on page 54.
Auto Reset Limit (P42 / PFN 11) parameter on page 55.
Controlled Fault Stop Enable (P43 / PFN 12) parameter on page 55.
Rated Voltage (P76 / FUN 05) parameter on page 73.

P40 Over/Under Voltage Trip Delay Time PFN 09

LED Display

0.1

LCD Display

PFN:Vlt Trip Tim
09 0.1sec

Range

0.1 – 90.0 seconds **(Default 0.1)**

Description

The Voltage Trip Delay Time parameter sets the period of time that either an over voltage (P38 / PFN 07) or under voltage (P39 / PFN 08) condition must exist before a fault occurs.

See Also

Over Voltage Level (P38 / PFN 07) parameter on page 53.
Under Voltage Level (P39 / PFN 08) parameter on page 54.
Auto Reset Limit (P42 / PFN 11) parameter on page 55.
Controlled Fault Stop Enable (P43 / PFN 12) parameter on page 55.

P41 — Auto Fault Reset Time — PFN 10

LED Display	LCD Display
OFF	PFN: Auto Reset 10 Off

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

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

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

See Also Auto Reset Limit (P42 / PFN 11) parameter on page 55.

P42 — Auto Fault Reset Count Limit — PFN 11

LED Display	LCD Display
OFF	PFN:Auto Rst Lim 11 Off

Range Off, 1 – 10 **(Default Off)**

Description The Auto Fault Reset Count Limit parameter sets the number of times that an auto reset may occur. Once the Auto Reset Limit is reached, faults will no longer be automatically reset.

See Also Auto Fault Reset Time (P41 / PFN 10) parameter on page 55.

P43 — Controlled Fault Stop Enable — PFN 12

LED Display	LCD Display
On	PFN:Ctrl Flt En 12 On

Range Off – On **(Default On)**

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

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

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

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

See Also Stop Mode (P15 / CFN 14) parameter on page 42.

.

P44	Independent Starting/Running Overload	PFN 13

LED Display

```
OFF
```

LCD Display

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

Range Off – On **(Default Off)**

Description

If "Off"
When this parameter is "Off" the overload defined by the Motor Running Overload Class (P3 / QST 03/PFN 15) 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 (P45 / PFN 14) 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 hot/cold motor compensation is still active. The OL% is capped at 99% during starting.

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

See Also

Motor Running Overload Class (P3 / QST 03) parameter on page 34.
Motor Starting Overload Class (P45 / PFN 14) parameter on page 56.
Motor Overload Hot/Cold Ratio (P46 / PFN 16) parameter on page 57.
Motor Overload Cooling Time (P47 / PFN 17) parameter on page 58.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P45	Motor Overload Class Starting	PFN 14

LED Display

```
10
```

LCD Display

```
PFN: Starting OL
14       10
```

Range Off, 1 – 40 **(Default 10)**

Description

The Motor Overload Class Starting 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 (P44 / PFN 13) parameter is set to "On".

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

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

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

See Also

Motor Running Overload Class (P3 / QST 03) parameter on page 34.
Independent Starting/Running Overload (P44 / PFN 13) parameter on page 56.
Motor Overload Hot/Cold Ratio (P46 / PFN 16) parameter on page 57.
Motor Overload Cooling Time (P47 / PFN 17) parameter on page 58.
Relay Output Configuration (P52-P54 / I/O 05-07) parameters on page 60.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

Motor Overload Class Running PFN 15

See Quickstart group QST 03 - Motor Overload Class Running on page 34 for details.

P46 Motor Overload Hot/Cold Ratio PFN 16

LED Display

LCD Display

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

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

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 Running Overload Class (P3 / QST 03) parameter on page 34.
Independent Starting/Running Overload (P44 / PFN 13) parameter on page 56.
Motor Starting Overload Class (P45 / PFN 14) parameter on page 56.
Motor Overload Cooling Time (P47 / PFN 17) parameter on page 58.
Relay Output Configuration (P52-54 / I/O 05-07) parameters on page 60.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P47	Motor Overload Cooling Time	PFN 17

LED Display

30.0

LCD Display

```
PFN:OL Cool Tim
17     30.0min
```

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

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

Refer to the following equation:

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

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

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

See Also

Motor Running Overload Class (P3 / QST 03) parameter on page 34.
Independent Starting/Running Overload (P44 / PFN 13) parameter on page 56.
Motor Starting Overload Class (P45 / PFN 14) parameter on page 56.
Motor Overload Hot/Cold Ratio (P46 / PFN 16) parameter on page 57.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

	Jump to Parameter	I/O 00

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

P48,49,50	Digital Input Configuration	I/O 01,02,03

LED Display	LCD Display
StOP	I/O:DI 1 Config 01 Stop
OFF	I/O:DI 2 Config 02 Off
OFF	I/O:DI 3 Config 03 Off

Range

LED	LCD	Description
OFF	Off	Off, Not Assigned, Input has no function. **(Default DI 2 & DI 3)**
StOP	Stop	Stop Command 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.
Fr	Fault Reset	Reset when input asserted, 120V applied.
dISc	Disconnect	Disconnect switch monitor.
InLn	Inline Cnfrm	Inline contactor feedback.
bYP	Bypass Cnfrm	Bypass/2M, bypass contactor feedback, 2M contactor feedback in full voltage or Wye-delta.
EOLr	E OL 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.
hd IS	Heat Disable	Heater disabled when input asserted, 120V applied.
hEn	Heat Enable	Heater enabled when input asserted, 120V applied.
rSEL	Ramp Select	Ramp 2 is enabled when input asserted, 120V applied.
SS F	Slow Spd Fwd	Operate starter in slow speed forward mode.
SS r	Slow Spd Rev	Operate starter in slow speed reverse mode.
bd IS	Brake Disabl	Disable DC injection braking.
bEn	Brake Enabl	Enable DC injection braking.

Description

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

See Also

Local Source (P4 / QST 04) parameter on page 35 .
Remote Source (P5 / QST 05) parameter on page 36.
Bypass Feedback Time (P64 / I/O 17) parameter on page 66.
Heater Level (P73 / FUN 08) parameter on page 71.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P51 Digital Fault Input Trip Time I/O 04

LED Display

0.1

LCD Display

I/O:Din Trp Time
04 0.1sec

Range

0.1-90.0 Seconds **(Default 0.1 Sec)**

Description:

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

See Also

Digital Input Configuration (P48-50 / I/O 01-03) parameters on page 59.

P52, 53, 54 Relay Output Configuration I/O 05, 06, 07

LED Display

FLFS

OFF

OFF

LCD Display

I/O: R1 Config
05 Fault FS

I/O: R2 Config
06 Off

I/O: R3 Config
07 Off

Range

LED	LCD	Description
OFF	Off	Off, Not Assigned. May be controlled over Modbus **(Default R2 & R3)**
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. Energized when faulted.
run	Running	Running, starter running, voltage applied to motor.
utS	UTS	Up to Speed, motor up to speed 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	Overcurrent	Overcurrent Alarm, overcurrent condition detected.
UC	Undercurrent	Undercurrent Alarm, undercurrent 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.
SSPd	Slow Spd	Starter operating in slow speed mode.
SS F	Slow Spd Fwd	Starter operating in slow speed forward mode.
SS r	Slow Spd Rev	Starter operating in slow speed reverse mode.
dcb	Braking	Starter is applying DC brake current to motor.
FAn	Cool Fan Ctl	Heatsink fan control.

Description

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

See Also

Up To Speed Time (P9 / QST 09) parameter on page 38.
Over Current Level (P32 / PFN 01) parameter on page 50.
Under Current Level (P34 / PFN 03) parameter on page 51.
Residual Ground Fault Level (P37 / PFN 06) parameter on page 53.
Inline Configuration (P63 / I/O 16) parameter on page 66.
Heater Level (P73 / FUN 08) parameter on page 71.
Energy Saver (P72 / FUN 09) parameter on page 70.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P55 Analog Input Trip Type I/O 08

LED Display

OFF

LCD Display

I/O:Ain Trp Type
08 Off

Range

LED	LCD	Description
OFF	Off	Off, Disabled. **(Default)**
Lo	Low Level	Low, Fault if input signal below preset trip level.
H I	High Level	High, Fault if input signal above preset trip level.

Description

The analog input is the reference input for a starter configured as a Phase Controller or Current Follower. In addition, the Analog Input Trip 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 (P56 / I/O 09) parameter to a value less than (<) 20%.

See Also

Analog Input Trip Level (P56 / I/O 09) parameter on page 61.
Analog Input Trip Time (P57 / I/O 10)parameter on page 62.
Analog Input Span (P58 / I/O 11) parameter on page 62.
Analog Input Offset (P59 / I/O 12) parameter on page 63.
Starter Type (P74 / FUN 07) parameter on page 72.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P56 Analog Input Trip Level I/O 09

LED Display

50

LCD Display

I/O:Ain Trp Lvl
09 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 parameter to "Low" and setting the 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 (P55 / I/O 08) parameter is set to "Low", a fault occurs when the analog input signal level is less than (<) 1V or 2mA regardless of what the Analog Input and Analog Input Span parameters values are set to.

See Also

Analog Input Trip Type (P55 / I/O 08) parameter on page 61.
Analog Input Trip Level (P56 / I/O 09) parameter on page 61.
Analog Input Span (P58 / I/O 11) parameter on page 62.
Analog Input Offset (P59 / I/O 12) parameter on page 63.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P57 | Analog Input Trip Delay Time | I/O 10

LED Display

LCD Display

I/O:Ain Trp Tim
10 0.1 sec

Range

0.1 – 90.0 seconds **(Default 0.1)**

Description

The Analog Input Trip Delay Time parameter sets the length of time the analog input trip level (P56 / I/O 09) must be exceeded before a trip occurs.

See Also

Analog Input Trip Type (P55 / I/O 08) parameter on page 61.
Analog Input Trip Level (P56 / I/O 09) parameter on page 61.
Analog Input Span (P58 / I/O 11) parameter on page 62.
Analog Input Offset (P59 / I/O 12) parameter on page 63.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P58 | Analog Input Span | I/O 11

LED Display

LCD Display

I/O: Ain Span
11 100 %

Range

1 – 100% **(Default 100%)**

Description

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

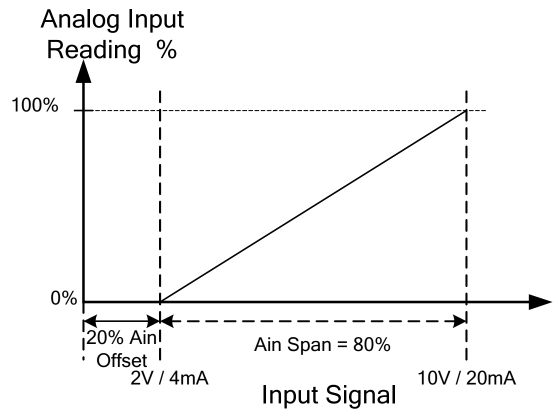
Examples:
For a 0-10V input or 0-20mA input, a 100% Analog Input Span setting results in a 0% input reading with a 0V input and a 100% input reading with a 10V input.

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

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

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

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



See Also

Analog Input Trip Level (P56 / I/O 09) parameter on page 61.
Analog Input Trip Time (P57 / I/O 10) parameter on page 62.
Analog Input Offset (P59 / I/O 12) parameter on page 63.
Starter Type (P74 / FUN 07) parameter on page 72.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P59 Analog Input Offset I/O 12

LED Display

0

LCD Display

I/O: Ain Offset
12 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 (P56 / I/O 09) parameter on page 61.
Analog Input Trip Time (P57 / I/O 10) parameter on page 62.
Analog Input Span (P58 / I/O 11) parameter on page 62.
Starter Type (P74 / FUN 07) parameter on page 72.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P60 Analog Output Function I/O 13

LED Display

```
0
```

LCD Display

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

Range

LED	LCD	Description
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

Description

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

See Also

Analog Output Span (P61 / I/O 14) parameter on page 65.
Analog Output Offset (P62 / I/O 15) parameter on page 65.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P61	Analog Output Span	I/O 14

LED Display

100

LCD Display

I/O: Aout Span
14 100 %

Range 1 – 125% **(Default 100%)**

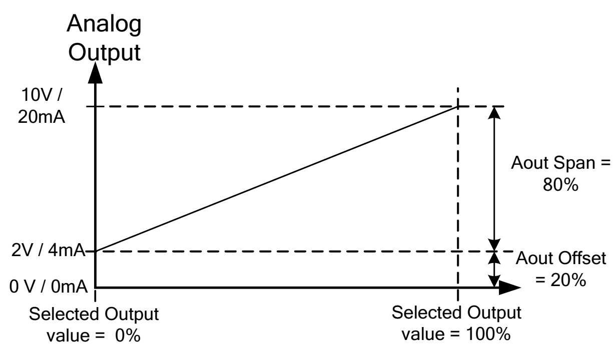
Description

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

⌘ **NOTE:** For a 4-20mA output, set the Analog Output Span to 80% and the Analog Output Offset (P62 / I/O 15) parameter to 20%.

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

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



See Also

Analog Output Offset (P62 / I/O 15) parameter on page 65.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P62	Analog Output Offset	I/O 15

LED Display

0

LCD Display

I/O:Aout Offset
15 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 (P61 / I/O 14) to 80% and the Analog Output Offset to 20%.

See Also

Analog Output Span (P61 / I/O 14) parameter on page 65.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P63 Inline Configuration I/O 16

LED Display

3.0

LCD Display

I/O:Inline Confg
16 3.0 sec

Range

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

Description

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

If the Inline Configuration parameter is set to "Off", then the MX^2 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^2 assumes that there is an Inline contactor and that line voltage need not be present while stopped. If no line is detected, then the No Line alarm condition does not exist and the ready condition does exist. If a start is commanded and there is no detected line voltage for the time period defined by this parameter, then a "noL" (No Line) fault is declared.

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

⌘ **NOTE:** This fault is different than over/under voltage trip delay time (P40 / PFN 09) since it detects the presence of NO line.

See Also

Relay Output Configuration (P52-54 / I/O 05-07) parameters on page 60.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P64 Bypass / 2M Feedback Time I/O 17

LED Display

2.0

LCD Display

I/O:Bpas Fbk Tim
17 2.0 sec

Range

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

Description

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

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

See Also

Digital Input Configuration (P48-P50 / I/O 01-03) parameters on page 59.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P65 Keypad Stop Disable I/O 18

LED Display

On

LCD Display

I/O:Keypad Stop
18 Enabled

Range

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

Description

If "Disabled"
When this parameter is set to "Disabled", the keypad [STOP] button is de-activated. This should be done with caution, as the [STOP] will not stop the starter.

If the keypad is selected as local or remote control sources, the [STOP] key cannot be disabled.

If "Enabled"
When this parameter is set to "Enabled", the keypad [STOP] button is enabled and stops the starter regardless of the selected control source (P4 / QST 04 or P5 / QST 05) selected as (keypad, terminal or serial).

See Also

Local Source (P4 / QST 04) parameter on page 35.
Remote Source (P5 / QST 05) parameter on page 36.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P66 Auto Start Selection I/O 19

LED Display

0

LCD Display

I/O: Auto Start
19 Disabled

Range

LED	LCD	Description
0	Disabled	When Disabled, the Start input must always transition from low to high for a start to occur. **(Default)**
1	Power	When set to Power, a start will occur if the Start input is high while control power is applied.
2	Fault	When set to Fault, a start will occur if the Start input is high when a fault is reset.
3	Power, Fault	When set to Power and Fault, a start will occur if the Start input is high while control power is applied, and a start will occur if the Start input is high when a fault is reset.

Description

The Auto Start parameter determines whether or not a transition from low to high is required on the Start input for a start to occur after either a power up or a fault reset.

Jump to Parameter FUN 00

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

P67	Miscellaneous Commands	FUN 15

LED Display

0

LCD Display

FUN:Misc Command
15 None

Range

LED	LCD	Description
0	None	No commands **(Default)**
1	Reset RT	Reset Run Time Meter
2	Reset kWh	Reset kWh/MWh Meters
3	Reflash Mode	Activate Reflash Mode
4	Store Params	The current parameter values are stored in non-volatile memory
5	Load Params	All parameter are retrieved from non-volatile memory
6	Factory Rst	All parameters are restored to the factory defaults
7	Std BIST	Built In Self Test with no line voltage applied to the starter
8	Powered BIST	Built In Self Test with line voltage applied to the starter

Description

The Miscellaneous Commands parameter is used to issue various commands to the MX^2 starter.

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

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

The Reflash Mode command puts the MX^2 into a reflash program memory mode. The reflash mode can only be entered if the MX^2 starter is idle. When the reflash mode is entered, the MX^2 waits to be programmed. The onboard LED display shows "FLSH". The remote display is disabled after entering reflash mode. The MX^2 does not operate normally until reflash mode is exited. Reflash mode may be exited by cycling control power.

The Store Parameters command allows the user to copy the parameters into non-volatile memory as a backup. If changes are being made, store the old set of parameters before any changes are made. If the new settings do not work, the old parameter values can be loaded back into memory.

The Load Parameters command loads the stored parameters into active memory.

The Factory Reset command restores all parameters to the factory defaults. These can be found in chapter 5.

The standard BIST command will put the starter into the unpowered BIST test. See section 7.6.1 on page 133.

The powered BIST command will put the starter into a powered BIST test. See section 7.6.2 on page 134.

See Also:

Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P68 Communication Timeout FUN 12

LED Display

```
OFF
```

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 Local Source (P4 / QST 04) parameter on page 35.
Remote Source (P5 / QST 05) parameter on page 36.
Stop Mode (P15 / CFN 14) parameter on page 42.
Controlled Fault Stop Enable (P43 / PFN 12) parameter on page 55.
Communication Address (P70 / FUN 10) parameter on page 69.
Communication Baud Rate (P69 / FUN 11) parameter on page 69.
Modbus Register Map: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf

P69 Communication Baud Rate FUN 11

LED Display

```
19.2
```

LCD Display

```
FUN:Com Baudrate
11    19200
```

Range 1200, 2400, 4800, 9600, 19200 bps **(Default 19200)**

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

See Also Local Source (P4 / QST 04) parameter on page 35 .
Remote Source (P5 / QST 05) parameter on page 36.
Communication Address (P70 / FUN 10) parameter on page 69.
Communication Timeout (P68 / FUN 12) parameter on page 69.
Communication Byte Framing (P71 / FUN 13) parameter on page 70.
Modbus Register Map: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf

P70 Communication Address FUN 10

LED Display

```
1
```

LCD Display

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

Range 1 – 247 **(Default 1)**

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

See Also Local Source (P4 / QST 04) parameter on page 35.
Remote Source (P5 / QST 05) parameter on page 36.
Communication Baud Rate (P69 / FUN 11) parameter on page 69.
Communication Timeout (P68 / FUN 12) parameter on page 69.
Communication Byte Framing (P71 / FUN 13) parameter on page 70.
Modbus Register Map: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf

P71 Communication Byte Framing FUN 13

LED Display

```
0
```

LCD Display

```
FUN: Com Parity
13  Even, 1 Stop
```

Range

LED	LCD
0	Even, 1 Stop **(Default)**
1	Odd, 1 Stop
2	None, 1 Stop
3	None, 2 Stop

Description

The Communication Byte Framing parameter sets both the parity and number of stop bits.

See Also

Communication Timeout (P68 / FUN 12) parameter on page 69.
Communication Baud Rate (P69 / FUN 11) parameter on page 69.
Communication Address (P70 / FUN 10) parameter on page 69.
Modbus Register Map: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf

P72 Energy Saver FUN 09

LED Display

```
OFF
```

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.

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

P73	Heater Level	FUN 08

LED Display

OFF

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 D.C. current applied to the motor during this operation needs to be monitored to ensure that the motor is not overheated. The current level should be set as low as possible and then slowly increased over a long period of time. While this is being done, the temperature of the motor should be monitored to ensure it is not overheating.

The Motor should be labeled as being live even when not rotating.

The heater feature should not be used to dry out a wet motor.

⌘ **NOTE:** When in single phase mode, the heater function is disabled.

⌘ **NOTE:** When this function is "on", all of the other parameters cannot be programmed until this parameter is turned "off".

See Also

Digital Input Configuration (P48-50 / I/O 01-03) parameters on page 59.

P74 — Starter Type — FUN 07

LED Display

nor

LCD Display

FUN:Starter Type
07 Normal

Range

LED	LCD	Description
nor	Normal	Normal Reduced Voltage Soft Starter RVSS. **(Default)**
I d	Inside Delta	Inside Delta, RVSS.
Y-d	Wye-Delta	Wye Delta.
PctL	Phase Ctl	Open Loop Phase control using external analog input reference.
cFoL	Curr Follow	Closed Loop Current follower using external analog input reference.
AtL	ATL	Across the line. (Full Voltage)

Description

The MX^2 has been designed to be the controller for many control applications; Solid State Starter, both Normal (outside Delta) and Inside Delta, and Electro mechanical starters, Wye Delta, Across the line full voltage starter, Phase Control/Voltage Follower, Current Follower. In each case, the MX^2 is providing the motor protection and the necessary control for these applications.

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

See Also

Phase Order (P77 / FUN 04) parameter on page 73.
Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P75 — Motor Rated Power Factor — FUN 06

LED Display

-0.92

LCD Display

FUN: Motor PF
06 -0.92

Range

-0.01 – 1.00 **(Default –0.92)**

Description

The Rated Power Factor parameter sets the motor power factor value that is used by the MX^2 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 (P79 / FUN 01) parameters on page 74.

P76	Rated RMS Voltage	FUN 05

LED Display

480

LCD Display

FUN:Rated Volts
05   480 Vlt

Range 100, 110, 120, 200, 208, 220, 230, 240, 350, 380, 400, 415, 440, 460, 480, 500, 525, 575, 600, 660, 690, 800, 1000, 1140 **(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.

See Also

Meter (P79 / FUN 01) parameter on page 74.
Under Voltage Level (P39 / PFN 08) parameter on page 54.
Voltage Trip Time (P40 / PFN 09) parameter on page 54.

⌘**NOTE:** Settings above 1140 volts are for medium voltage applications.

⌘**NOTE:** The rated RMS voltage must be set properly in order for the starter to operate properly.

P77	Input Phase Sensitivity	FUN 04

LED Display

InS

LCD Display

FUN:Phase Order
04 Insensitive

Range

LED	LCD	Description
InS	Insensitive	Runs with any three phase sequence. **(Default)**
AbC	ABC	Only runs with ABC phase sequence.
CbA	CBA	Only runs with CBA phase sequence.
SPH	Single phase	Single Phase.

Description The Input Phase Sensitivity 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.

See Also: Theory of Operations: http://www.benshaw.com/literature/manuals/890034-11-xx.pdf.

P78	CT Ratio	FUN 03

LED Display

288

LCD Display

FUN: CT Ratio
03 288:1

Range 72:1, 96:1, 144:1, 288:1, 864:1, 2640:1, 3900:1, 5760:1, 8000:1, 14400:1, 28800:1 **(Default 288:1)**

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^2 starter. The CT ratio is then normalized to a 1A secondary value. The supplied CT ratio can be confirmed by reading the part number on the CT label. The part number is of the form BICTxxx1M, where xxx is the CT primary and the 1 indicates the normalized 1 amp.

⌘ **NOTE:** It is very important that the CT ratio is set correctly. Otherwise, many starter functions will not operate correctly.

Refer to Table 1 - CT Ratios on page 6.

P79 Meter1 ,Meter 2 FUN 01, 02

LED Display

0

LCD Display

FUN: Meter 1
01 Ave Current

FUN: Meter 2
02 Ave Volts

Range

LED	LCD	Description
0	Status	Running State. **(LED meter only, Default LED meter)**
1	Ave Current	Average current. **(Default LCD Meter 1)**
2	L1 Current	Current in phase 1.
3	L2 Current	Current in phase 2.
4	L3 Current	Current in phase 3.
5	Curr Imbal	Current Imbalance %.
6	Ground Fault	Residual Ground Fault % FLA.
7	Ave Volts	Average Voltage L-L RMS. **(Default LCD 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 In	Analog Input %.
21	Analog Out	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 %.
27	Pk accel Curr	Peak starting current.
28	Last Start T	Last starting duration.

Description

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

P80	Software 1	FUN 14

LED Display

0

LCD Display

FUN:Software PN
14 810023-01-03

Description

The Software Part Number parameter displays the MX^2 software version, for hardware BIPC-300055-01-04. When calling Benshaw for service, this number should be recorded so it can be provided to the service technician.

In addition to viewing 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.

⌘ **NOTE: The seven segment LED in position one will flash the current software version currently in use when first powered on. The full software part number will flash consecutively (one digit per second)**,
For Example: 8...1...0...0...2...3...-...0...1...-...0...3

P81	Passcode	FUN 16

LED Display

OFF

LCD Display

FUN: Passcode
16 Off

Description

The MX^2 supports a 4-digit passcode. When the passcode is set, parameters may not be changed.

The MX^2 provides a means of locking parameter values so that they may not be changed. Once locked, the parameters values may be viewed on the display, but any attempt to change their values by pressing the [UP] or [DOWN] keys is ignored.

Viewing the Passcode parameter indicates whether or not the parameters are locked. If they are locked, the Passcode parameter displays “On”. If they are not locked, the Passcode parameter displays “Off”.

To lock the parameters, press the [ENTER] key while viewing the Passcode parameter. This allows entry of a 4-digit number. Press the [UP] or [DOWN] keys and [ENTER] for each of the four digits. After entering the fourth digit, the number is stored as the passcode and the parameters are locked.

Once parameters are locked, the same 4-digit number must be re-entered into the Passcode parameter in order to unlock them. Any other 4-digit number entered will be ignored.

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^2 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 (P81 / FUN 16).
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 (P81 / 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.

P82 Fault Log FL1

LED Display

```
1F28
```

LCD Display

```
FL1: Last Fault #
FaultName
```

Range

FL1 – FL9

Description

When a fault occurs, the fault number is logged in non-volatile memory. The most recent fault is in FL1 and the oldest fault is in FL9.

If the starter is equipped with an LCD display, pressing [ENTER] toggles through the Starter data recorded at the time of the fault. See section 2 on page 29 for more information.

See Also

Fault Codes on page 126.

6 Theory of Operation

Motor Overload

6.1 Solid State Motor Overload Protection

6.1.1 Overview

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

6.1.2 Setting Up The MX^2 Motor Overload

Motor overload protection is easily configured through seven parameters (please refer to the descriptions of each parameter in section 6 of this manual for additional parameter information):

1. Motor FLA (QST 01)
2. Motor Service Factor (QST 02)
3. Motor Running Overload Class (PFN 15)
4. Motor Starting Overload Class (PFN 14)
5. Independent Starting/Running Overload (PFN 13)
6. Motor Overload Hot/Cold Ratio (PFN 16)
7. Motor Overload Cooling Time (PFN 17)

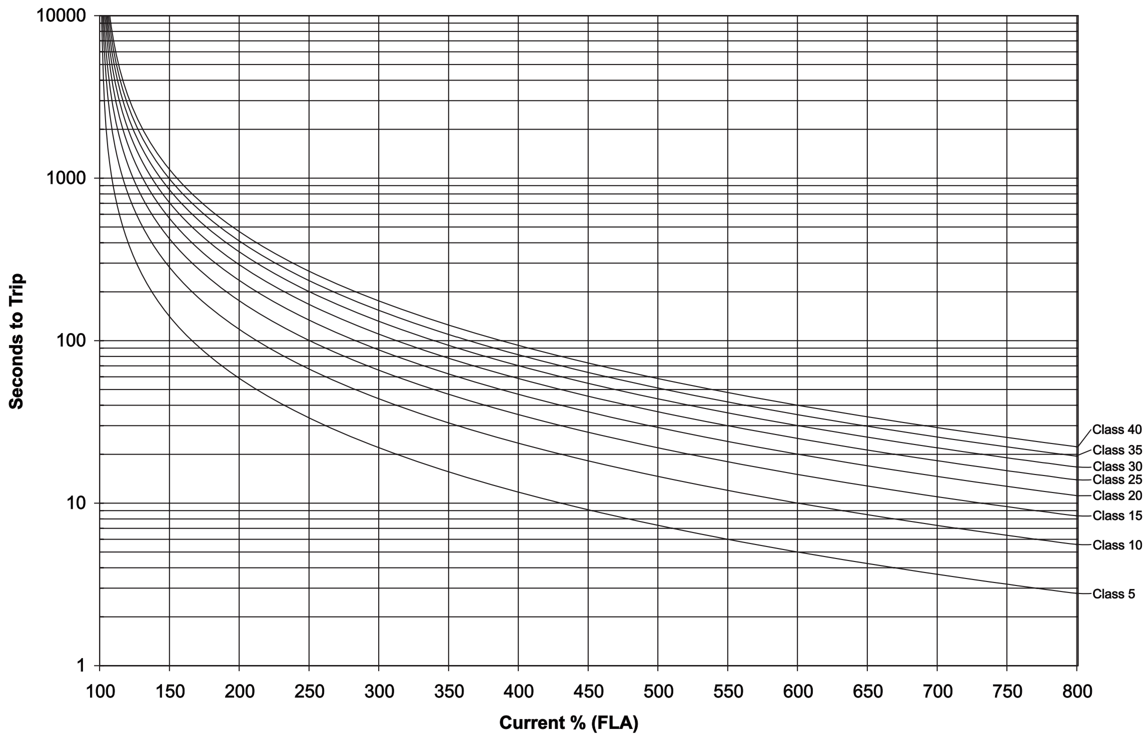
The Motor FLA and Service Factor parameter settings define the motor overload "pickup" point. For example, if the motor service factor is set to 1.00, the motor overload begins accumulating or incrementing when the measured motor current is >100% FLA (100% * 1.00). The overload will NOT trip if the motor 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^2 standard overload curves after the "pick-up" point has been reached is:

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

Figure 12: Commonly Used Overload Curves



⌘ **NOTE:** In some cases the power stack rating may determine what motor overload settings are available. Each power stack is designed to support specific motor overload classes. The RB2 power stack is designed for class 10 duty without derating. Refer to the RB2 for the specific RB2 overload capabilities. Also, in certain heavy duty DC braking applications, the overload settings may be limited to protect the motor from potential damage during braking.

Visit the web at www.benshaw.com for an automated overload calculator.

6.1.3 Motor Overload Operation

Overload Heating
When the motor is operating in the overloaded condition (motor current greater than FLAxSF), the motor overload content accumulates based on the starter's operating mode at a rate established by the overload protection class chosen. The accumulated overload content can be viewed on the display or over the communications network.

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

Overload Trip
The MX^2 starter trips when the motor overload content reaches 100%, protecting the motor from damage. The starter first performs the defined deceleration or DC braking profile before stopping the motor if the controlled fault stop feature of the MX^2 is enabled. The motor overload trip time accuracy is ± 0.2 seconds or ± 3% of total trip time.

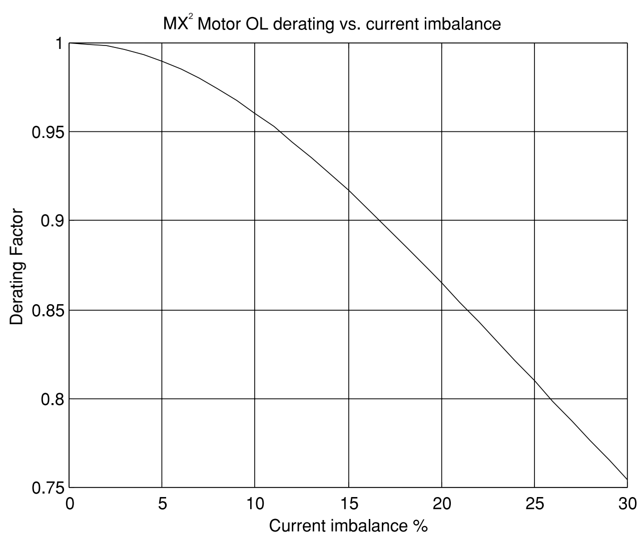
Overload Start Lockout
After tripping on an overload, restarting is prevented and the starter is "locked out" until the accumulated motor overload content has cooled below 15%.

6.1.4 Current Imbalance / Negative Sequence Current Compensation

The MX^2 motor overload calculations automatically compensate for the additional motor heating which results from the presence of unbalanced phase currents. There can be significant negative sequence currents present in the motor when a current imbalance is present. These negative sequence currents have a rotation opposite the motor rotation and are typically at two times the line frequency. Due to the negative sequence currents opposite rotation and higher frequency, these currents can cause a significant increase in rotor heating.

The overload curves provided by a motor manufacturer are based on balanced motor operation. Therefore, if a current imbalance is present, the MX^2 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 6.1.6 . The MX^2 derating factor is based on NEMA MG-1 14.35 specifications and is shown in Figure 13.

Figure 13: Overload Derating for Current Imbalance



6.1.5 Harmonic Compensation

The MX^2 motor overload calculation automatically compensates for the additional motor heating that can result from the presence of harmonics. Harmonics can be generated by other loads connected to the supply such as DC drives, AC variable frequency drives, arc lighting, uninterruptible power supplies, and other similar loads.

6.1.6 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^2 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^2 Hot/Cold Ratio parameter value can be calculated as follows:

If no motor information is available, a Hot/Cold ratio value of 60% is usually a good starting point.

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

The MX^2 adjusts the actual motor overload content based on the programmed Hot/Cold Ratio set point and the present running current of the motor so that the accumulated motor overload content accurately tracks the thermal condition of the motor. If the motor current is constant, the overload content eventually reaches a steady state value. This value is derived as follows:

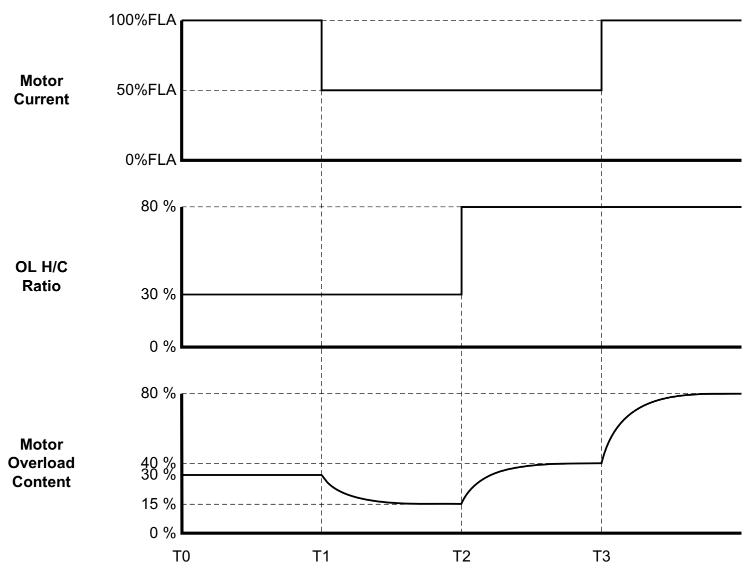
$$\text{OL}_{\text{ss}} = \text{OL H/C Ratio} \times \frac{\text{Current}}{\text{FLA}} \times \frac{1}{\text{Current Imbalance Derate Factor}}$$

The running OL content is also adjusted based on the derating factor due to the presence of any current imbalances 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 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 determines the steady state overload content. It assumes there is no current imbalance.

Figure 14: Motor Overload H© Ratio Example



At time T0, the motor current is 100%FLA and the OL H© Ratio is set at 30%. It is assumed that the motor has been running for some time and the motor overload content has reached a steady state value of 30% (30% H© 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© Ratio x 50% FLA = 15%).

At time T2, the OL H© Ratio is set to 80%. The motor overload content exponentially rises to a new steady state value of 40% (80% H© 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© Ratio x 100% FLA= 80%).

6.1.7 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 to "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.

⌘ **NOTE**: When the Independent Starting/Running Overload (P44 / PFN 13) parameter is set to "OFF", the running OL is used at all times.

⌘ **NOTE:** The Hot/Cold motor compensation is still active when either the starting or running overload is disabled. Therefore the motor overload content may still slowly increase or decrease depending on the measured motor current. However if the motor overload is disabled, the motor overload content is limited to a maximum of 99%. Therefore, a motor overload trip can not occur.

CAUTION: When both overloads are disabled, the accumulated overload content is set to zero (0%) and the starter does not provide any motor overload protection. External motor overload protection must be provided to prevent motor damage and/or the risk of fire in the case of a motor overload.

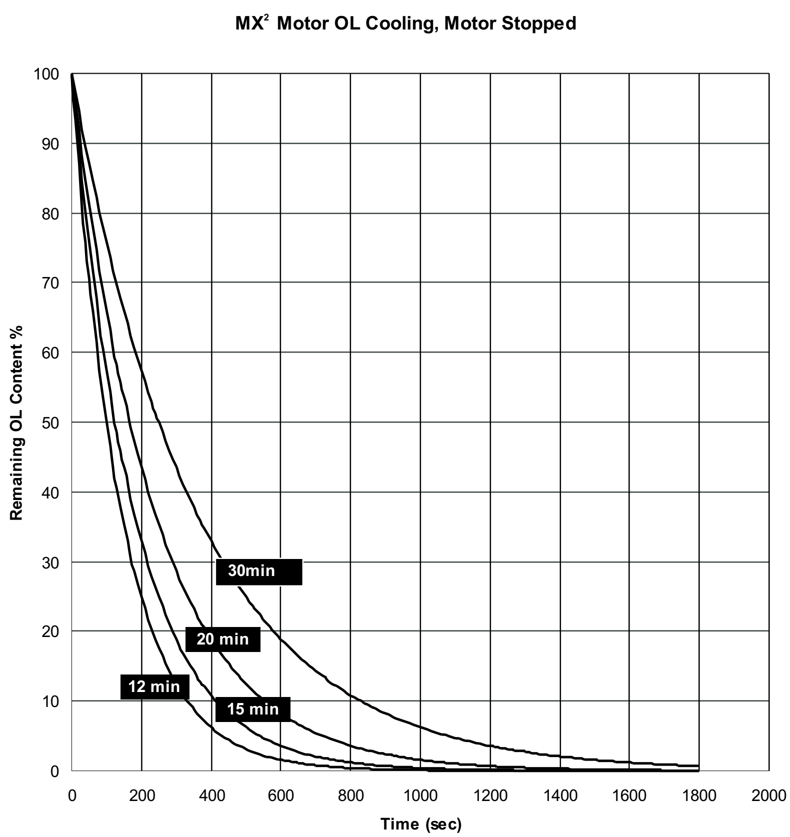
6.1.8 Motor Cooling While Stopped

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 15.

Figure 15: 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:

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

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

6.1.9 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 6.1.6, 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.

6.1.10 Emergency Motor Overload Reset

The MX^2 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^2'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.

Motor Service Factor

6.2 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

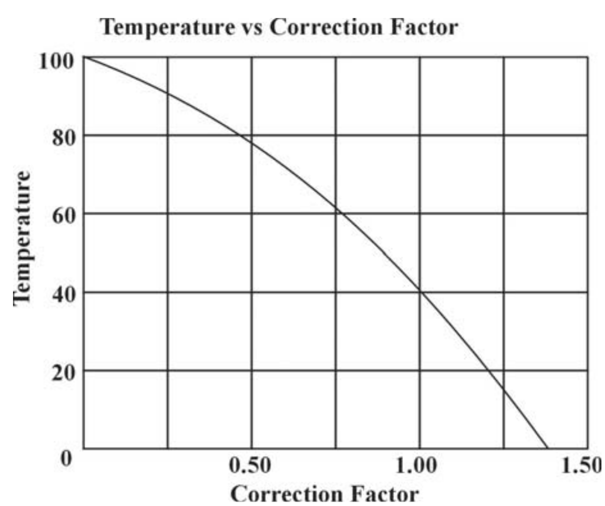
Service factor 1.15 or more	1.25
Motor temp. rise 40°C or less	1.25
All others	1.15

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.

Acceleration Control

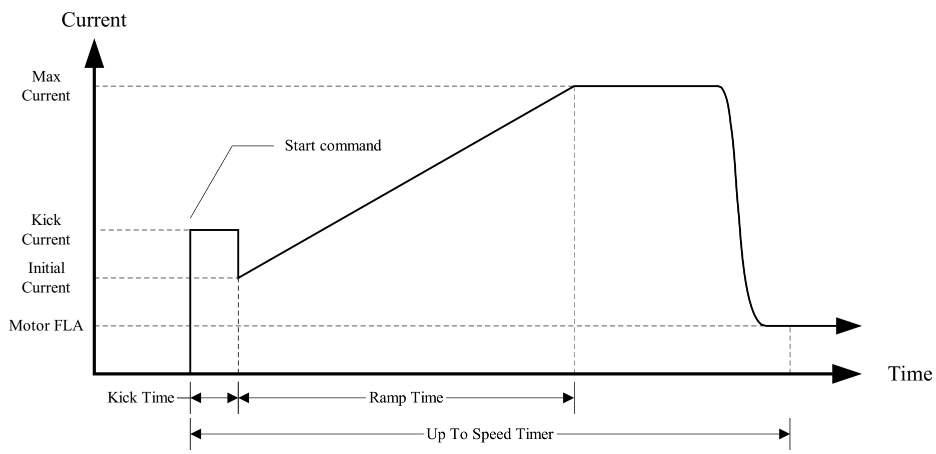
6.3 Acceleration Control

6.3.1 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 16: Current Ramp



Initial Current

The initial current should be set to the level that allows the motor to begin rotating within a couple of seconds of receiving a start command.

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

Maximum Current

For most applications, the maximum current can be left at 600%. This ensures that enough current is applied to the motor to accelerate it to full speed.

The maximum current can also be set to a lower current limit. This is usually done to limit the voltage drop on the power system or to limit the torque the motor produces to help prevent damage to the driven load.

⌘ **NOTE:** The motor may achieve full speed at any time during the current ramp. This means that the maximum current setting may not be reached. Therefore, the maximum current setting is the most current that could ever reach the motor, and not necessarily the maximum current that reaches the motor.

⌘ **NOTE:** When setting a current limit, the motor must be monitored to ensure that the current is high enough to allow the motor to reach full speed under worst case load conditions.

Ramp Time

The ramp time is the time it takes for the current to go from the initial current to the maximum current. To make the motor accelerate faster, decrease the ramp time. To make the motor accelerate slower, increase the ramp time.

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

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

6.3.2 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

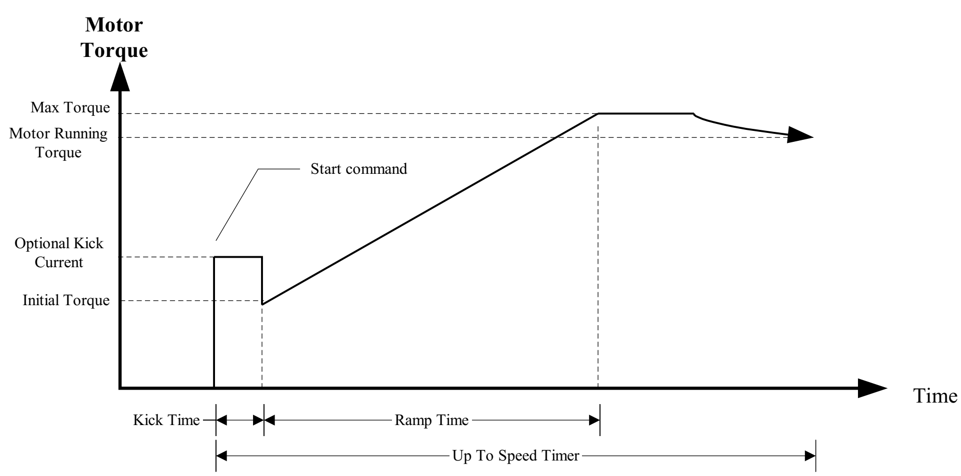
The kick time adjustment should begin at 0.5 seconds and be adjusted by 0.1 or 0.2 second intervals until the motor begins rotating. If the kick time is adjusted above 2.0 seconds without the motor rotating, start over with a higher kick current setting.

6.3.3 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 17: TruTorque Ramp



TruTorque acceleration control can be very useful for a variety of applications. However it is best used to start centrifugal pumps, fans, and other variable torque applications. TruTorque generally should not be used in applications where the starting load varies greatly during the start such as with a reciprocating compressor, where the starting load is very low, or where the starting load varies greatly from one start to another. TruTorque control is not recommended for the starting of AC synchronous motors.

Initial Torque

This parameter sets the initial torque level that the motor produces at the beginning of the starting ramp profile. A typical value is 10% to 20%. If the motor starts too quickly or the initial motor torque is too high, reduce this parameter. If the motor does not start rotating within a few seconds after a start is commanded, increase this parameter. If the value is set too low a "No Current at Run" fault may occur.

Maximum Torque

This parameter 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.

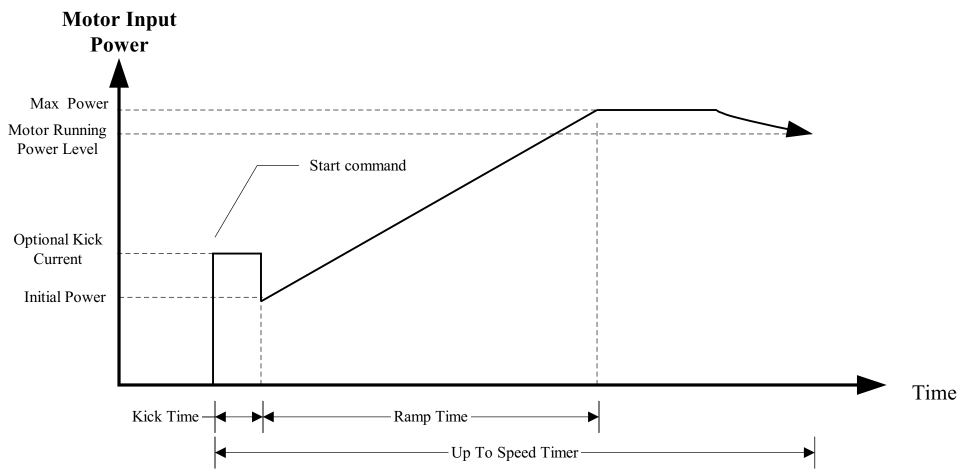
⌘ **NOTE:** Setting the ramp time to a specific value does not necessarily mean that the motor takes that exact amount of time to accelerate to full speed. The motor and load may achieve full speed before the ramp time expires if the load does not require the set ramp time or set torque level to reach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

6.3.4 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 18: 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.

⌘ **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.

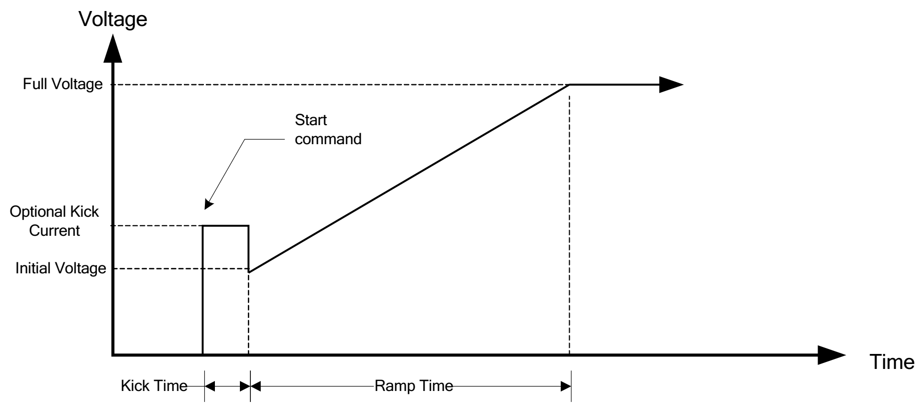
⌘ **NOTE:** Setting the ramp time to a specific value does not necessarily mean that the motor takes that exact amount of time to accelerate to full speed. The motor and load may achieve full speed before the ramp time expires if the load does not require the set ramp time or set power level to reach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

6.3.5 Open Loop Voltage Ramps and Times

General

The open loop voltage ramp provides soft starting of a motor by increasing the voltage applied to motor from the Initial Voltage setting to full (100%) line voltage. The ramp time sets the speed at which the voltage is increased. Because this is an open loop control profile, the motor current during starting tends to be reduced; however, the current is not limited to any particular level. This starting mode (old), is not commonly used except in special circumstances. In most applications, the use of one of the other closed loop starting profiles is recommended.

Figure 19: Voltage Ramp



Initial Voltage

This parameter sets the initial voltage level that is applied to the motor. To adjust the starting voltage level, give the starter a run command and observe the motor operation. If the motor starts too quickly reduce the initial voltage level. If the motor does not start rotating immediately or starts too slowly then increase the initial voltage level until the motor just starts to rotate when a start command is given. If the initial voltage level is set too low, a Fault 39 - No Current at Run may occur. In this case increase the initial voltage level to permit more current to initially flow to the motor.

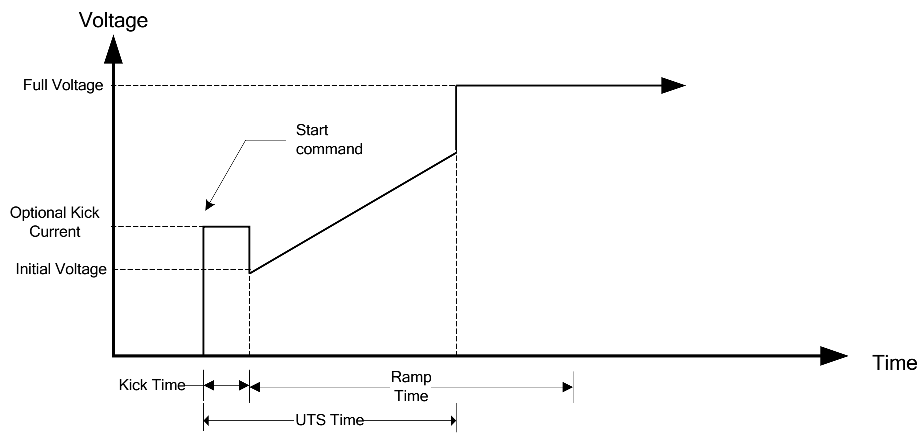
Ramp Time

The ramp time setting is the time that it takes for the applied voltage to go from the initial voltage level to the full voltage (100%) level. To make the motor accelerate faster, decrease the ramp time. To make the motor accelerate slower, increase the ramp time.

UTS Timer

When the start mode is set to open-loop voltage ramp acceleration, the UTS Timer acts as an acceleration kick. When the UTS timer expires, full voltage is applied to the motor. This feature can be used to reduce motor surging that may occur near the end of an open loop voltage ramp start. If a surge occurs near the end of the ramp, set the UTS timer to expire at this time and restart the motor. If the surge still occurs, set the UTS time to a lower time until the surging subsides. If motor surging continues to be a problem, it is recommended that one of the other standard MX^2 closed-loop starting profiles be used.

Figure 20: Effect of UTS Timer on Voltage Ramp



6.3.6 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 Modes

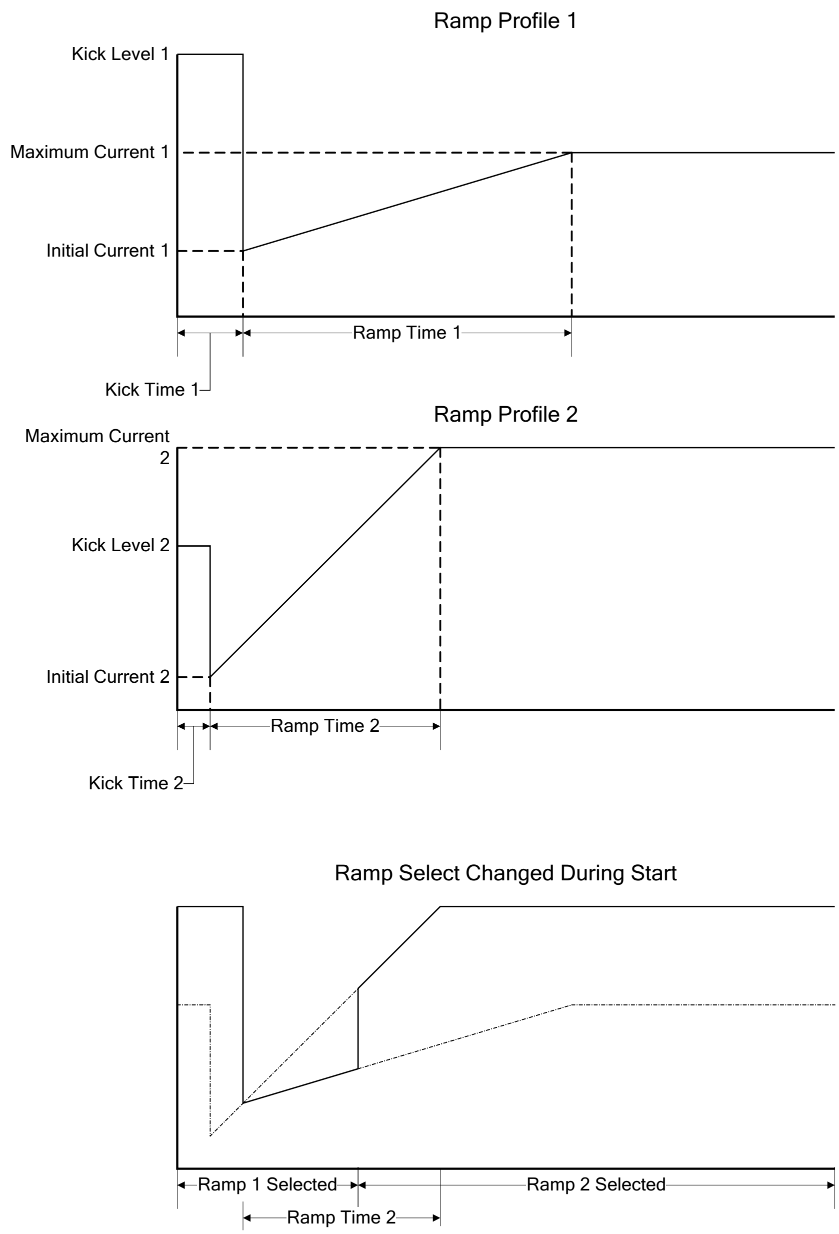
<table>
<tr><th></th><th>Ramp Select De-energized</th><th>Ramp Select Energized</th></tr>
<tr><td rowspan="5">Current Ramp</td><td>Initial Current 1</td><td>Initial Current 2</td></tr>
<tr><td>Maximum Current 1</td><td>Maximum Current 2</td></tr>
<tr><td>Ramp Time 1</td><td>Ramp Time 2</td></tr>
<tr><td>Kick Level 1</td><td>Kick Level 2</td></tr>
<tr><td>Kick Time 1</td><td>Kick Time 2</td></tr>
<tr><td rowspan="5">TruTorque Ramp</td><td colspan="2">Initial Voltage/Torque/Power</td></tr>
<tr><td colspan="2">Maximum Torque/Power</td></tr>
<tr><td colspan="2">Ramp Time 1</td></tr>
<tr><td>Kick Level 1</td><td>Kick Level 2</td></tr>
<tr><td>Kick Time 1</td><td>Kick Time 2</td></tr>
<tr><td rowspan="5">Power (KW) Ramp</td><td colspan="2">Initial Voltage/Torque/Power</td></tr>
<tr><td colspan="2">Maximum Torque/Power</td></tr>
<tr><td colspan="2">Ramp Time 1</td></tr>
<tr><td>Kick Level 1</td><td>Kick Level 2</td></tr>
<tr><td>Kick Time 1</td><td>Kick Time 2</td></tr>
<tr><td rowspan="4">Voltage Ramp</td><td colspan="2">Initial Voltage/Torque/Power</td></tr>
<tr><td colspan="2">Ramp Time 1</td></tr>
<tr><td>Kick Level 1</td><td>Kick Level 2</td></tr>
<tr><td>Kick Time 1</td><td>Kick Time 2</td></tr>
</table>

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 21: Changing Ramps During Acceleration Example



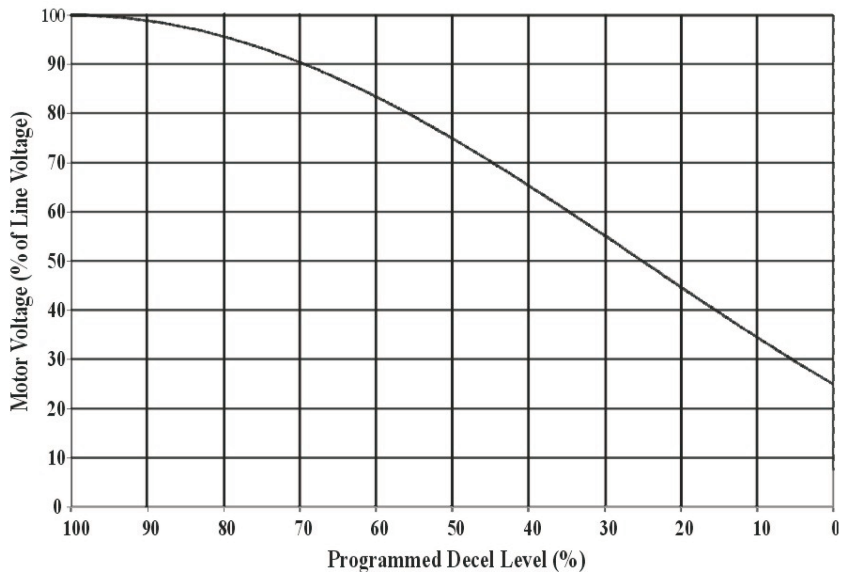
6.4 Deceleration Control

6.4.1 Voltage Control Deceleration

Overview

The deceleration control on the MX^2 uses an open loop voltage ramp. The MX^2 ramps the voltage down to decelerate the motor. The curve shows the motor voltage versus the decel setting.

Figure 22: 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.

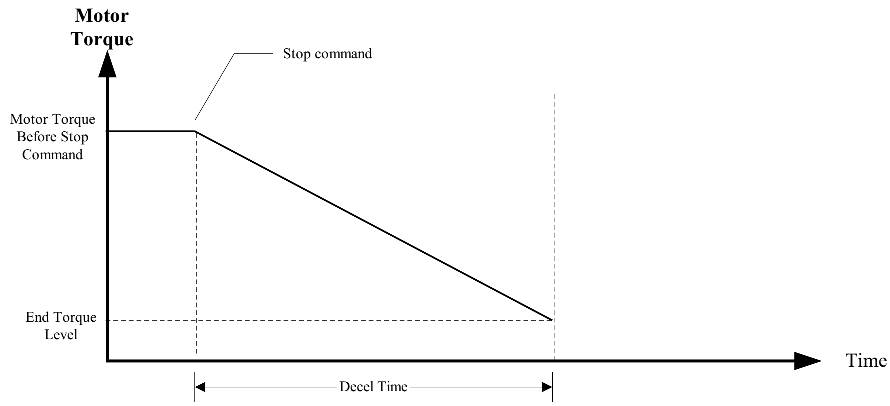
⌘ **NOTE:** Deceleration control provides a smoother stop. However, the motor will take longer to stop than if it was just allowed to coast to stop.

6.4.2 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^2 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 23: TruTorque Deceleration



Ending Level

The Decel End Level parameter sets the ending torque level for the TruTorque deceleration ramp profile.

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

Decel Time

The decel time sets the ramp time between the motor torque level when stop was commanded and the decel end torque level.

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

Braking Controls

6.5 Braking Controls

Overview

When the Stop Mode parameter is set to DC Brake, the MX^2 starter provides DC injection braking for fast and frictionless braking of a three-phase motor. The MX^2 starter applies a controlled DC current to the motor in order to induce a stationary magnetic field that then exerts a braking torque on the motor's rotating rotor. The braking current level and braking time required depends on the motor characteristics, the load inertia, and the friction in the system.

The MX^2 starter supports two different levels of DC injection braking:
1.Standard Duty Brake - For less than 6 x motor inertia.
2.Heavy Duty Brake - For NEMA specified inertia and two motor current feedback methods:
  a) Standard Current Transformers (CTs)
  b) Optional Hall Effect Current Sensor (LEM)

The optional Hall Effect Current sensor can be used when a more precise measurement of braking current is necessary. This can occur if the DC injection braking is applied when the source supply has a very high short circuit capability (very stiff) or in special instances when more precise braking current control is required. The appropriate brake type and feedback method is preset from the factory. Please consult Benshaw for more information if changes need to be made.

Maximum Load Inertia

The following table shows maximum load inertia, NEMA MG1 parts 12 and 20. A thermostat, thermistor or RTD MUST be installed to protect the motor from overheating.

	Speed - RPM						
	3600	1800	1200	900	720	600	514
HP	Inertia (lb-ft2)						
2	2.4	11	30	60	102	158	228
3	3.5	17	44	87	149	231	335
5	5.7	27	71	142	242	375	544
71/2	8.3	39	104	208	356	551	798
10	11	51	137	273	467	723	1048
15	16	75	200	400	685	1061	1538
20	21	99	262	525	898	1393	2018
25	26	122	324	647	1108	1719	2491
30	31	144	384	769	1316	2042	2959
40	40	189	503	1007	1725	2677	3881
50	49	232	620	1241	2127	3302	4788
60	58	275	735	1473	2524	3819	5680
75	71	338	904	1814	3111	4831	7010
100	92	441	1181	2372	4070	6320	9180
125	113	542	1452	2919	5010	7790	11310
150	133	640	1719	3456	5940	9230	-
200	172	831	2238	4508	7750	12060	-
250	210	1017	2744	5540	9530	14830	-
300	246	1197	3239	6540	11270	-	-
350	281	1373	3723	7530	-	-	-
400	315	1546	4199	8500	-	-	-
450	349	1714	4666	9460	-	-	-
500	381	1880	5130	-	-	-	-
600	443	2202	6030	-	-	-	-
700	503	2514	-	-	-	-	-
800	560	2815	-	-	-	-	-

6.5.1 DC Injection Braking, Standard Duty

The MX^2 Standard Duty Braking allows up to approximately 250% FLA current to be applied to the motor. The MX^2 Standard Duty package consists of an extra braking contactor that shorts Motor Terminals 2 & 3 together while braking, as DC current is applied by the MX^2 starter to provide moderate braking torque.

CAUTION: Contactor MUST NOT short phase T1 and phase T3.

⌘ **NOTE:** Contactor sizing requires AC1 contactor rating (Motor FLA / 1.6). The three contacts must be paralleled.

6.5.2 DC Injection Braking, Heavy Duty

The MX^2 Heavy Duty Braking allows up to 400% FLA current to be applied to the motor for maximum braking performance. The MX^2 Heavy Duty braking package includes a freewheel current path between phases 1 and 3 that consists of a fuse and a 7^{th} SCR with gating card. In combination with the applied DC current from the MX^2 starter, the freewheeling current path greatly enhances available braking torque. When Braking, the stop must be counted as another motor start when looking at the motor starts per hour limit.

⌘ **NOTE:** Semi-Conductor Fuse and 7th SCR supplied by Benshaw.

6.5.3 Braking Output Relay

To utilize DC injection braking, one of the user output Relays needs to be programmed as a Braking relay. (Refer to the Relay Output Configuration parameters on page 60 for more information). The output of a Braking relay is needed to control the contactor and/or 7^{th} SCR gating control card used during braking.

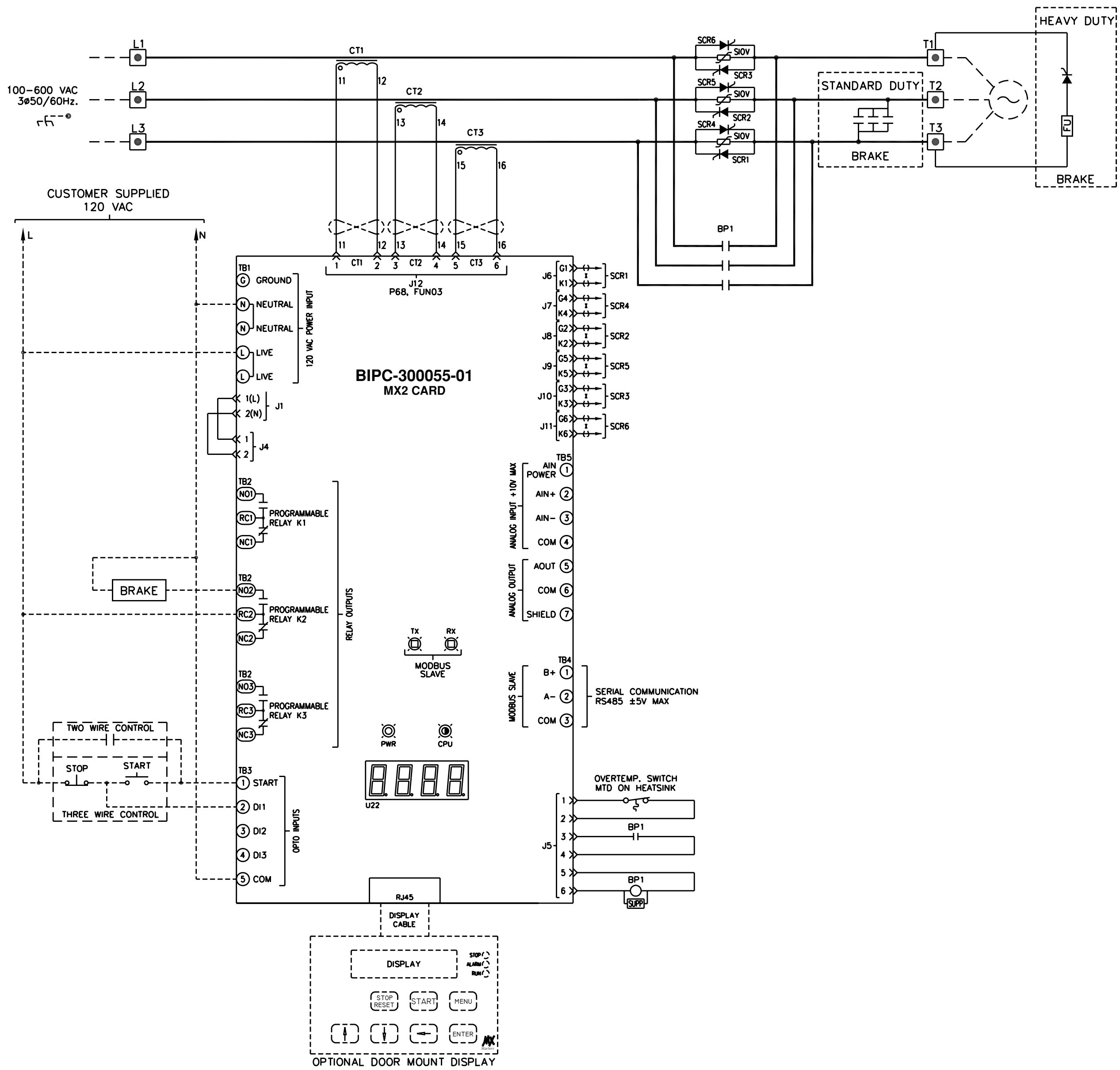
⌘ **NOTE:** Verify that the correct output relay is programmed to Braking and that the wiring of this relay is correct. Damage to the starter can result if the braking relay is not programmed and/or wired properly.

6.5.4 Stand Alone Overload Relay for emergency ATL (Across The Line) operation

Due to the currents being drawn on Line 1 and Line 3 for braking, this stand alone overload relay will cause nuisance current imbalance trips. For a solution consult factory.

6.5.5 DC Injection Brake Wiring Example

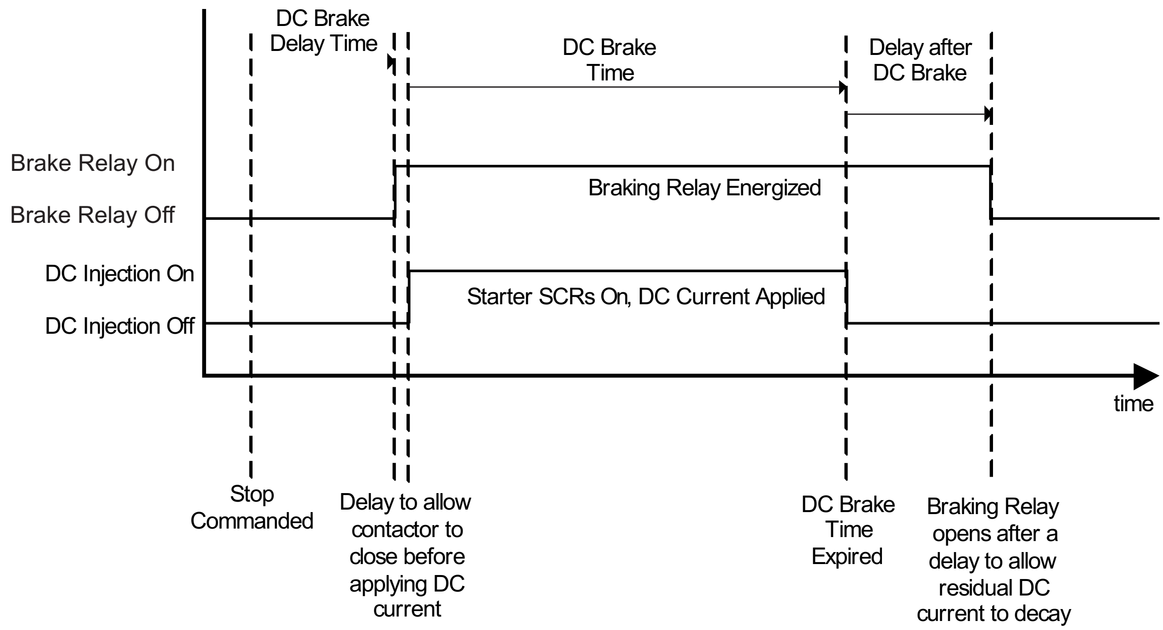
Figure 24: DC Injection Brake Wiring Example



6.5.6 DC Brake Timing

The MX² DC injection brake timing is shown below:

Figure 25: DC Injection Brake Timing



After the DC Brake Time has expired, the Braking Relay is held energized to allow the DC current to decay before opening the freewheel path. This delay prevents a contactor (if used) from having to open significant DC current which greatly prolongs the life of the contactor. This delay time is based on motor FLA, the larger the motor the longer the delay time. The delay after DC brake time is approximately:

Motor FLA	Delay after DC Brake Time
10 A	0.4 seconds
100 A	0.8 seconds
500 A	2.3 seconds
1000 A	4.3 seconds

Motor Overload Calculations During DC Injection Braking

During DC braking the MX² Solid State Motor Overload Protection is fully active. During braking the Running Motor Overload setting is used. The MX² adjusts the overload calculations based on whether Standard Duty or Heavy Duty braking is used. The overload calculations are also adjusted based on whether the standard Current Transformers (CTs) are used for current feedback or if the optional Hall Effect Current sensor is used for current feedback.

⌘ **NOTE:** Discretion must be used when DC injection braking. Motor heating during DC injection braking is similar to motor heating during starting. Although the Motor OL is active (if it has not been intentionally disabled), excessive rotor heating could still result if the load inertia is very large, braking level is high, or the brake time is set too long. Caution must be used to assure that the motor has the thermal capacity to brake the desired load in the desired period of time without excessive heating.

6.5.7 DC Injection Brake Enable and Disable Digital Inputs

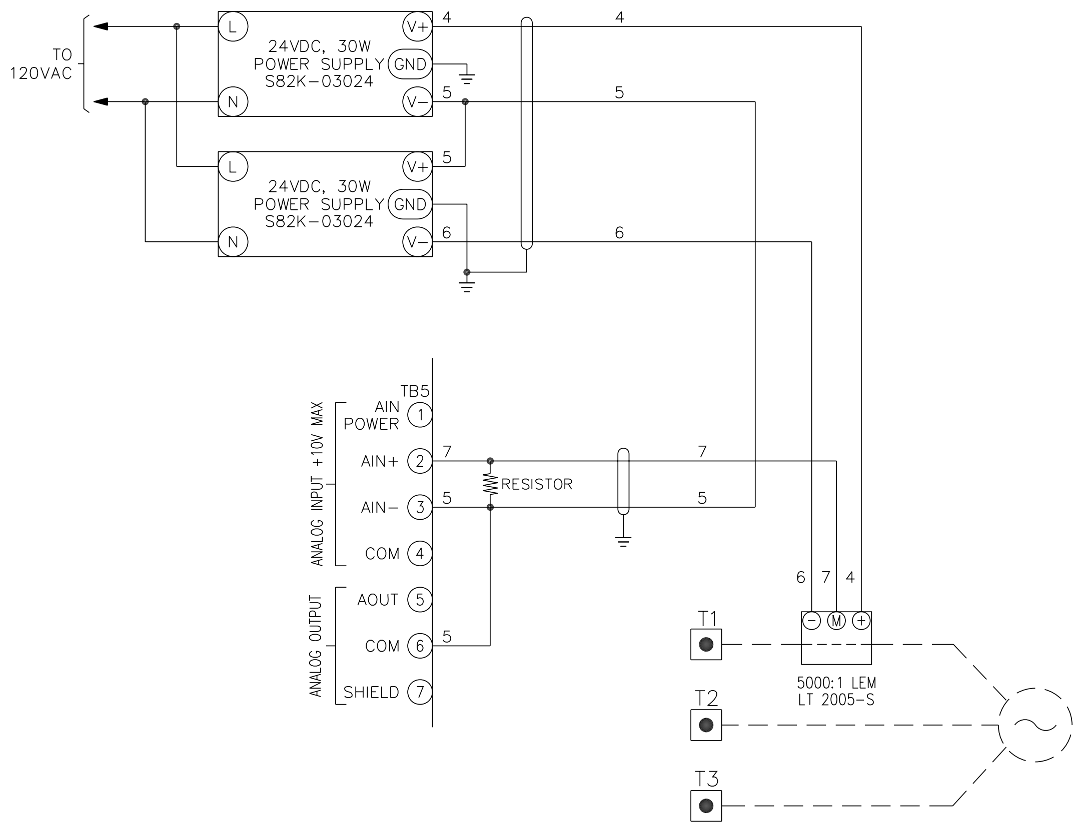
Digital inputs can be programmed to either a Brake Enable or a Brake Disable. In the Brake Enable case the digital input must be energized for DC braking to occur. The braking will immediately stop if the brake enable is de-energized.

In the Brake Disable case, DC braking will occur unless the Brake Disable digital input is energized. DC braking will cease if the brake disable is energized.

Once DC Braking is stopped due to a digital input state change, no further DC braking will take place and the starter will return to the idle state.

6.5.8 Use of Optional Hall Effect Current Sensor

The Hall Effect Current Sensor should be located on Phase 1 of the motor output wiring. The sensor should be located so that the sensor measures both the applied DC current from the starter as well as the freewheel current. The sensor is connected to the analog input of the MX^2 card along with a burden resistor. The analog input must be set to be a 0-10V voltage input for correct operation. The sensor scaling and burden resistance are factory selected. Please consult factory if changes to either the sensor scaling or burden resistance is required.



⌘ **NOTE:** Hall effect current sensor must be used when load inertia exceeds motor manufactures recommended specifications.

6.5.9 DC Injection Braking Parameters

Brake Level: The DC Brake Level parameter sets the level of DC current applied to the motor during braking. The desired brake level is determined by the combination of the system inertia, system friction, and the desired braking time. If the motor is braking too fast the level should be reduced. If the motor is not braking fast enough the level should be increased.

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

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

Slow Speed Cyclo Converter

6.6 Slow Speed Cyclo Converter

The MX^2 Soft Starter implements a patented Slow Speed algorithm that can be used to rotate a three-phase AC motor, with control of the stator current, at speeds less than the rated synchronous speed of the motor. The algorithm is used with a standard three-phase six-switch SCR based soft starter. The advantages of the MX^2 starter algorithm over other "jogging" techniques are that: the low speed motor rotation is done without any additional hardware such as additional mechanical contactors and/or extra SCRs, the peak phase currents are reduced compared with other jogging techniques, motor heating is minimized, and higher shaft torque can be generated.

6.6.1 Operation

Slow speed forward and reverse operation is achieved by energizing a digital input that has been programmed to either Slow Speed Forward or Slow Speed Reverse (refer to the Digital Input Configuration parameters on page 59 for more information). The active Control Source (local or remote source) must be set to terminal. Slow Speed Start/Stop control is not available from the optional LCD keypad. The starter must be in the idle state in order to enter slow speed operation.

Relay outputs can be programmed to energize during slow speed operation (refer to the Relay Output Configuration parameters on page 60 for more information). This feature can be used to disable mechanical brakes or energize clutches during slow speed operation.

Motor Overload Calculations During Slow Speed Operation
During Slow Speed Operation the MX^2 Solid State Motor Overload Protection is fully active. During slow speed operation the Running Motor overload setting is used.

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

6.6.2 Slow Speed Cyclo Converter Parameters

Slow Speed: The Slow Speed parameter selects the speed of motor operation when slow speed is selected. When set to Off, slow speed operation is disabled.

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

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

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

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

Slow Speed Kick Level: The Slow Speed Kick Level sets the short-term current level that is applied to the motor to accelerate the motor for slow speed operation. The Slow Speed Kick feature is disabled if it is set to off. Slow Speed Kick can be used to "break loose" difficult to start loads while keeping the operating slow speed current level lower.

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

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

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

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

Inside Delta Connected Starter

6.7 Inside Delta Connected Starter

There are differences between a line connected soft starter as shown in Figure 26 and the inside delta connected soft starter as shown in Figure 27 that need to be considered.

By observation of Figure 27, 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 26, access to only three leads of the stator windings of the motor is required.

One failed SCR on any phase of the inside delta soft starter results in a single-phase condition. A shunt trip circuit breaker is recommended to protect the motor in this case. A programmable relay can be configured as a shunt trip relay and can be used to trip the breaker. When certain faults occur, the shunt trip relay energizes.

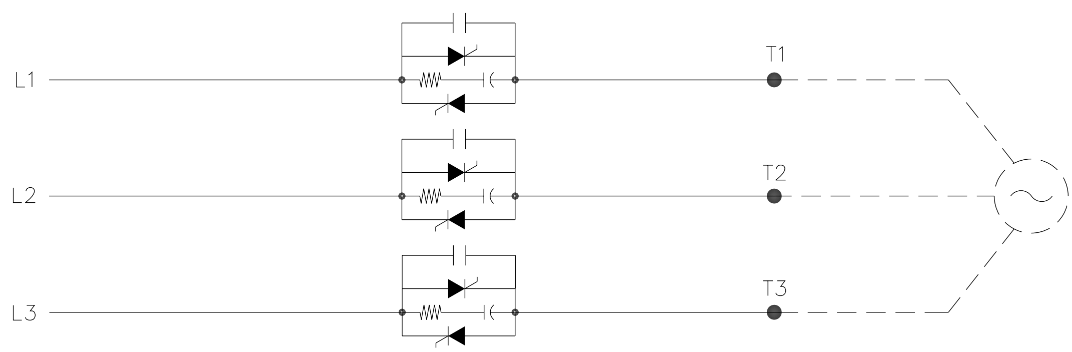
The SCR control for an inside delta application is different than the SCR control for a standard soft starter. The Starter Type parameter needs to be properly set so that the SCRs are gated correctly.

If a circuit breaker is the only means to disconnect the soft starter and motor from the line, then one leg of the motor leads in the inside delta soft starter is always electrically live when the circuit breaker is closed. This requires caution to ensure these leads of the motor are not exposed to personnel.

6.7.1 Line Connected Soft Starter

In Figure 26, the power poles of the soft starter are connected in series with the line. The starter current equals the line current.

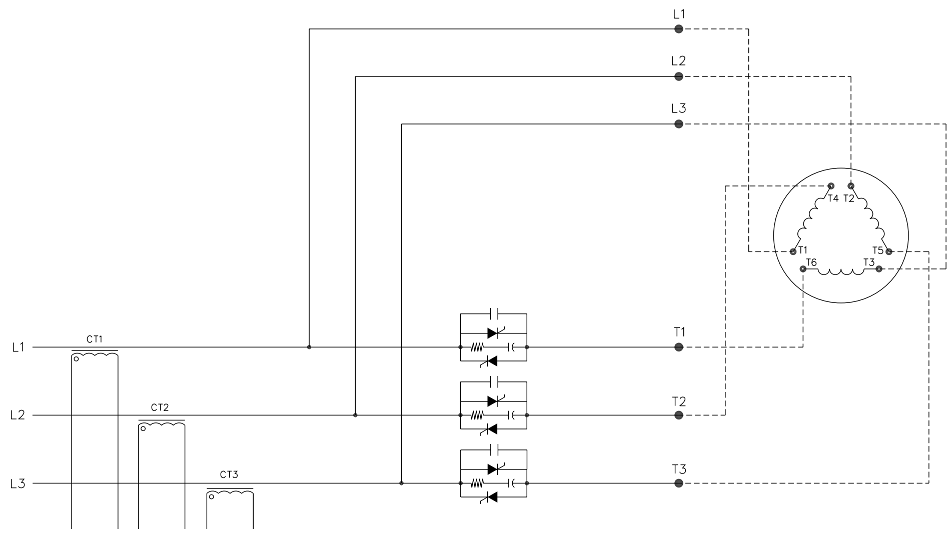
Figure 26: Typical Motor Connection



6.7.2 Inside Delta Connected Starter

An inside delta connected soft starter is shown in Figure 27, where the power poles are connected in series with the stator windings of a delta connected motor.

Figure 27: Typical Inside Delta Motor Connection



For an inside delta connected motor, the starter current is less than the line current by a factor of 1.55 (FLA/1.55). By comparison of Figure 26 and Figure 27, the most obvious advantage of the inside delta starter is the reduction of current seen by the soft starter. The soft starter can be downsized by a factor of 1.55, providing significant savings in cost and size of the starter.

An inside delta soft starter can also be considered for motors with more than 6 leads, including 12 lead dual voltage motors.

NEMA and IEC use different nomenclature for motor terminal markings, for 3 and 6 leaded motors.

NEMA labels motors leads, 1,2,3,4,5,6,
IEC labels motor leads, U1, V1, W1, U2, V2, W2

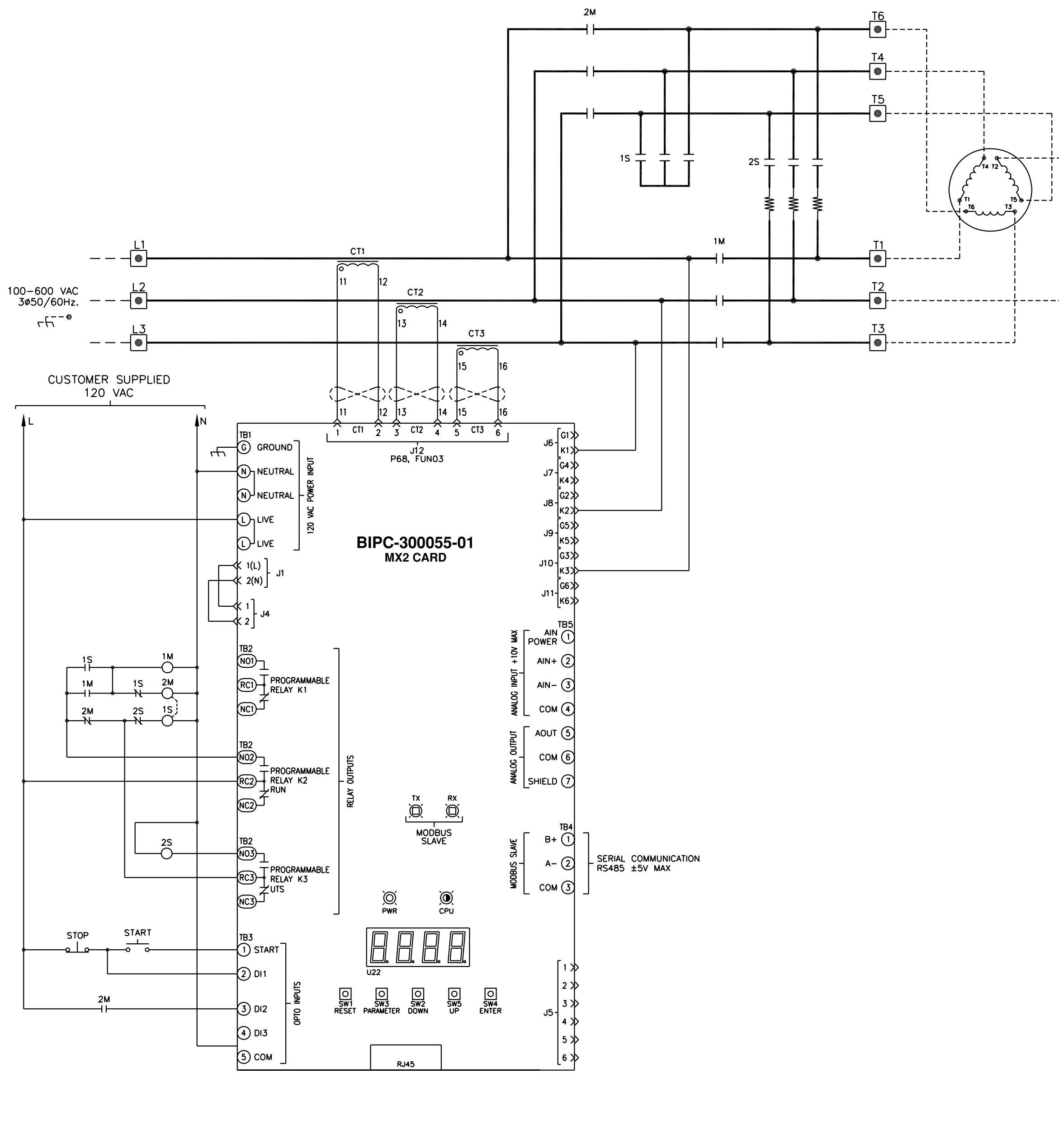
Wye Delta Starter

6.8 Wye Delta Starter

When the Starter Type parameter is set to Wye-Delta, the MX^2 is configured to operate an Electro mechanical Wye-Delta (Star-Delta) starter. When in Wye-Delta mode, all MX^2 motor and starter protective functions except bad SCR detection and power stack overload, are available to provide full motor and starter protection.

A typical closed transition Wye-Delta starter schematic is shown in the following figure.

Figure 28: Wye Delta Motor Connection to the MX^2



The MX^2 utilizes an intelligent Wye to Delta transition algorithm. During starting, if the measured motor current drops below 85% of FLA and more than 25% of the Up To Speed timer setting has elapsed, then a Wye to Delta transition occurs. The intelligent transition algorithm prevents unnecessarily long motor starts which reduces motor heating. If a Wye to Delta transition has not already occurred, a transition always occurs when the complete Up To Speed Time expires.

The MX^2 can operate two configurations of Wye-Delta starters, open transition and closed transition. An open transition starter momentarily disconnects the motor from the input line during the transition from Wye to Delta operating mode. A closed transition starter uses resistors that are inserted during the transition so that the motor is never completely disconnected from the input line. The presence of the resistors in a closed transition starter smooths the transition. A typical closed transition Wye-Delta starter schematic is shown in Figure 28 on page 106.

The closed transition resistors generally are sized to be in the circuit for a short period of time. To protect the resistors from over heating, one input should be programmed as a Bypass/2M contact feedback input and the Bypass/2M confirm parameter must be set.

For the Wye-Delta starter mode to operate properly one output relay needs to be programmed to the RUN output function and another output relay needs to be programmed to the UTS output function. (Refer to the Relay Output Configuration parameters on page 60 for more information).

Based on the typical closed transition schematic shown in Figure 28, 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^2 starter remains in the Wye mode until either:

1. The start command is removed.
2. The Up To Speed Time expires.
3. The measured motor current is less than 85% of FLA and more than 25% of the Up To Speed Timer setting has elapsed.
4. A fault occurs.

When the Up To Speed Time expires, the starter changes from Wye starting mode to the Delta or normal running mode by energizing the relay programmed as UTS. In Delta mode, the RUN and UTS relays are both energized and the motor is connected in the normal running Delta configuration.

The transition to Delta (Run) mode occurs as follows:

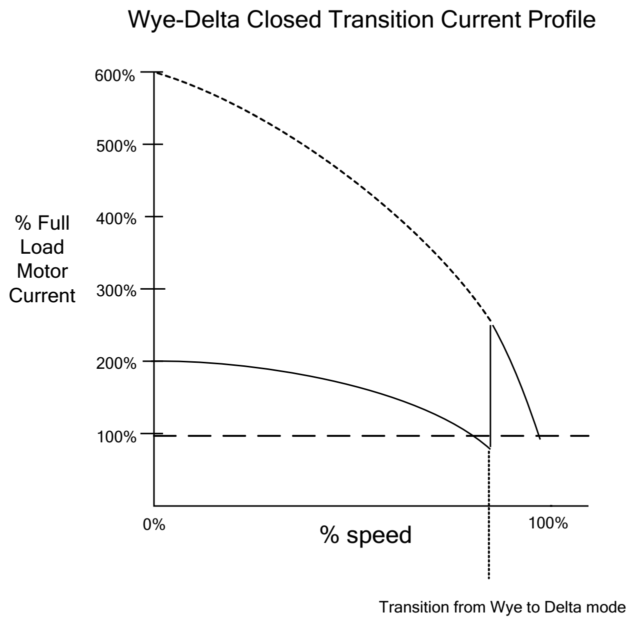
1. The UTS relay is energized which energizes the 2S contactor.
2. When the 2S contactor pulls in, resistors are inserted in the circuit and the 1S contactor is de-energized.
3. When the 1S contactor drops out the 2M contactor is energized.
4. When the 2M contactor is pulled in, feedback can be sent to the MX^2 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^2 intelligent Wye to Delta transition algorithm provides an optimal transition point that minimizes the transient current and torque surges that can occur. However, the Wye to Delta transition will occur when the Up To Speed Time parameter has expired. In order to reduce the current surge during the transition from Wye to Delta mode, the Up To Speed Time parameter should be adjusted so that the transition occurs as close to full speed as possible within the constraints of the load. If the Up To Speed Time is set too short, the starter will transition too soon and a large current and torque surge will occur. If the Up To Speed Time is set too long, the motor may not have sufficient torque to continue accelerating when in Wye mode and may stop accelerating at a low speed until the transition to Delta mode occurs. If this occurs, the start is unnecessarily prolonged and motor heating is increased.

A typical closed transition Wye-Delta starting current profile is shown in Figure 29.

Figure 29: 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.

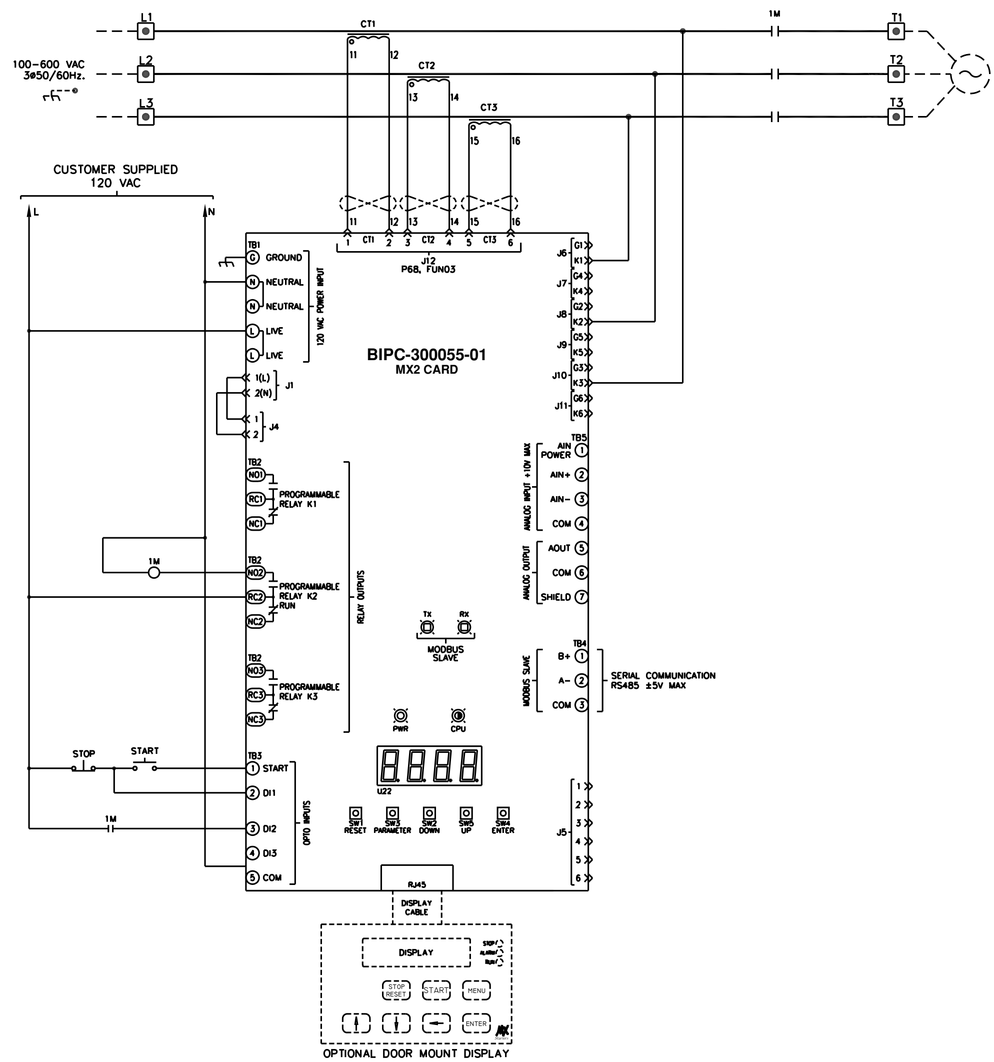
Across The Line Starter

6.9 Across The Line (Full Voltage Starter)

When the Starter Type parameter is set to ATL, the MX^2 is configured to operate an Electro mechanical full voltage or across-the-line (ATL) starter.

In the ATL configuration, the MX^2 assumes that the motor contactor (1M) is directly controlled by an output relay that is programmed to RUN. Therefore, when a start command is given, the RUN programmed relay energizes the motor contactor, which applies power to the motor. When the MX^2 determines that the motor is at full speed, the up-to-speed (UTS) condition is indicated by energizing the UTS programmed relays. When configured as an ATL starter, all MX^2 motor and starter protective functions, except bad SCR detection and power stack overload, are available to provide full motor and starter protection.

Figure 30: A Typical ATL Starter Schematic with the MX^2



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

⌘ **NOTE:** When in ATL mode, the SCR gate outputs are disabled.

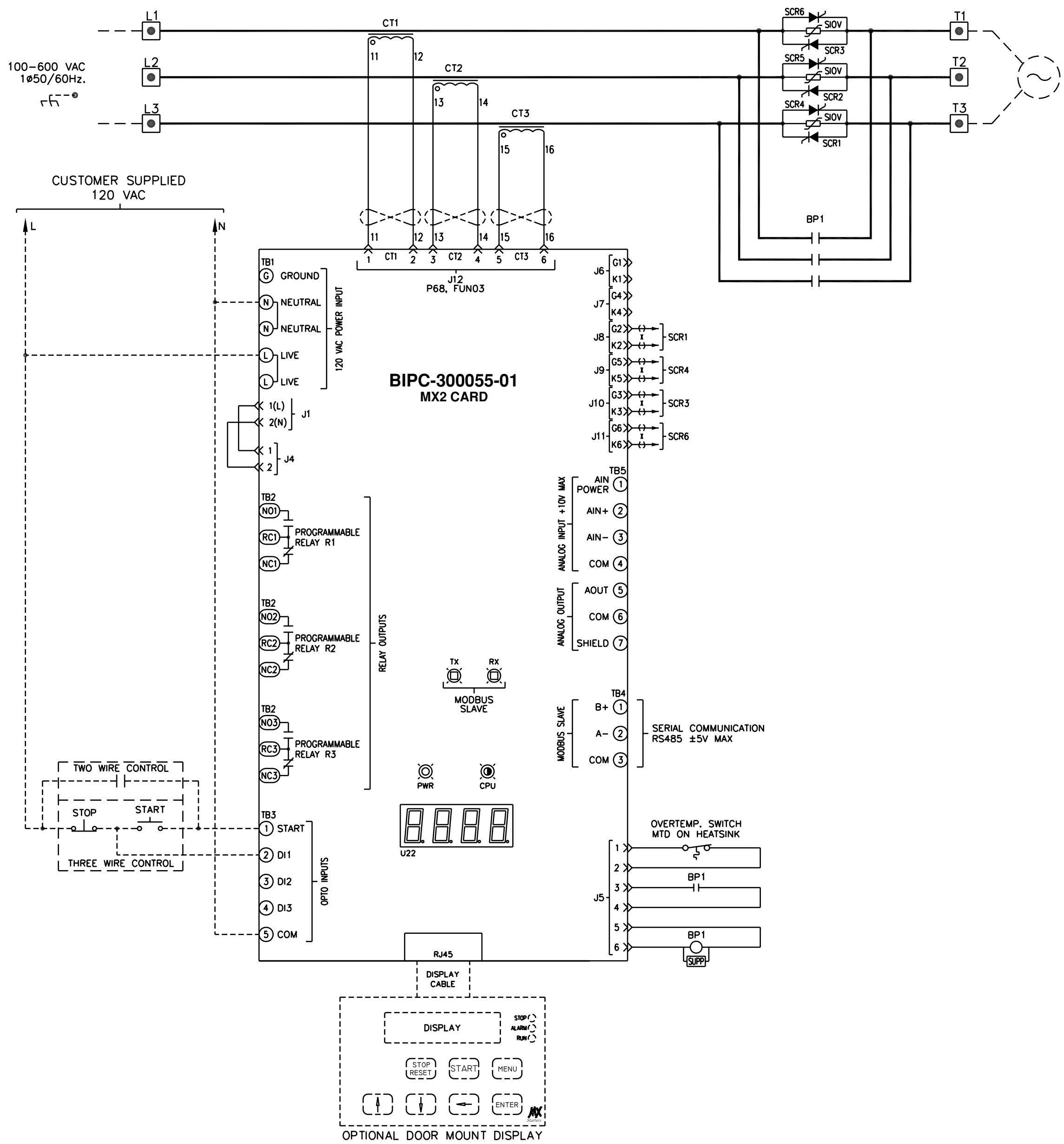
Single Phase Soft Starter

6.10 Single Phase Soft Starter

There are times a single phase motor may need to be started using a soft starter. This can be accomplished with any 3 phase starter with the following modifications to the starter.

- Connect Line power to terminals L1 and L3.
- Remove gate leads from J8 and J9 and tie off so the leads will not touch anything
- Remove gate leads from J6 and reinstall to J8, from J7 and reinstall to J9
- Change Input Phase Sensitivity, (P77/FUN 04) to "SPH" Single Phase.
- Connect motor to terminals T1 and T3.

Figure 31: Power Schematic for RB2 Integral Bypass Power Stack for Single Phase Operation

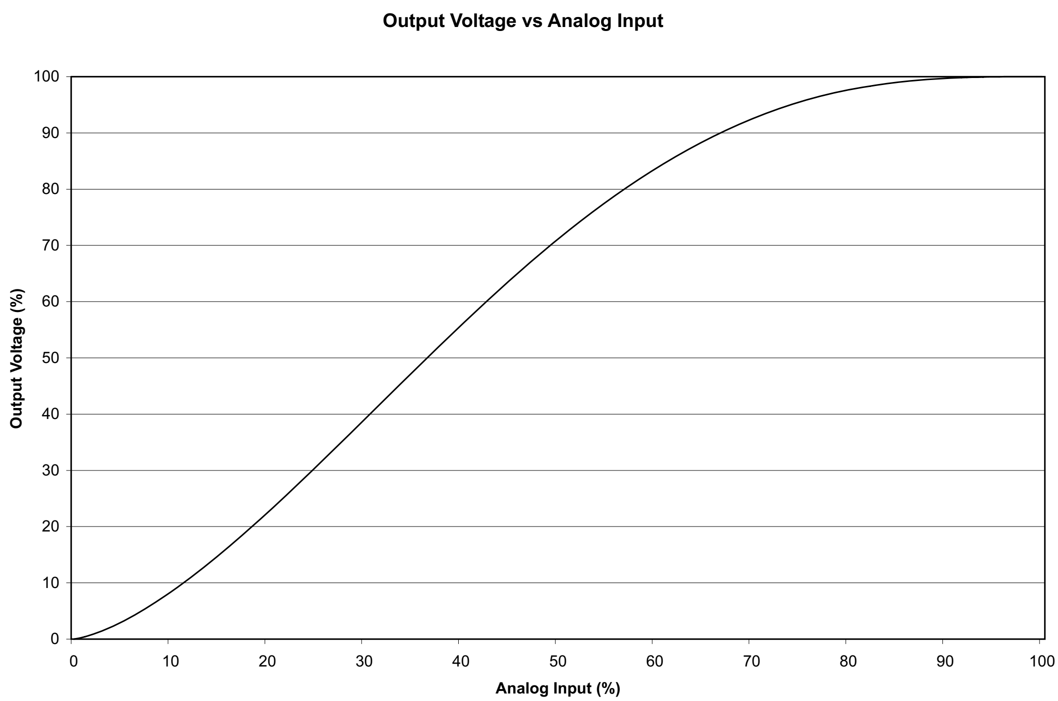


Phase Control

6.11 Phase Control

When the Starter Type parameter is set to Phase Control, the MX^2 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 32: Phase Control Mode



A reference input value of 0% results in no output. A reference input value of 100% results in full (100%) output voltage. The actual input voltage / current that results in a given output can be adjusted through the use of the Analog Input Offset and the Analog Input Span parameters.

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

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

⌘ **NOTE:** When in Phase Control mode the following motor / starter protective functions are available:

- Current Imbalance
- Over Current
- Current while Stopped
- Under Current
- Over Voltage
- Under Voltage
- Motor OL
- Residual Ground Fault
- Instantaneous Over Current (IOC)
- Phase Rotation
- Phase Loss
- Under Frequency
- Over Frequency

6.11.1 Phase Controller:

Phase control can be used to directly control the voltage applied to motors, resistive heaters, etc. When in Phase Control mode, the phase angle of the SCRs, and hence the voltage applied, is directly controlled based on the analog input signal. The MX^2 reference command can be generated from any 0-10V, 0-20mA or similar source, such as a potentiometer, another MX^2 or an external controller such as a PLC.

6.11.2 Master/Slave Starter Configuration:

In the master / slave configuration, one "master" starter can directly control the output of one or more "slave" starters. To utilize the master / slave configuration, one starter needs to be defined as the "master" starter. The Starter Type parameter of the "master" starter should be configured appropriately as a Soft Starter (normal or ID), Phase Controller or Current Follower. If configured as a soft starter, the acceleration and deceleration profiles need to be configured for proper operation.

To configure a master / slave application:

1. The analog output of the master MX^2 control card needs to be connected to the analog input(s) of the slave card(s).

2. The master MX^2'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^2'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 MX^2 needs to be provided with a start command from the master MX^2. A RUN programmed relay from the master MX^2 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^2 analog input(s) needs to be configured for the appropriate voltage or current input signal type. Set the analog input jumper (SWI-1) to the desired input type.

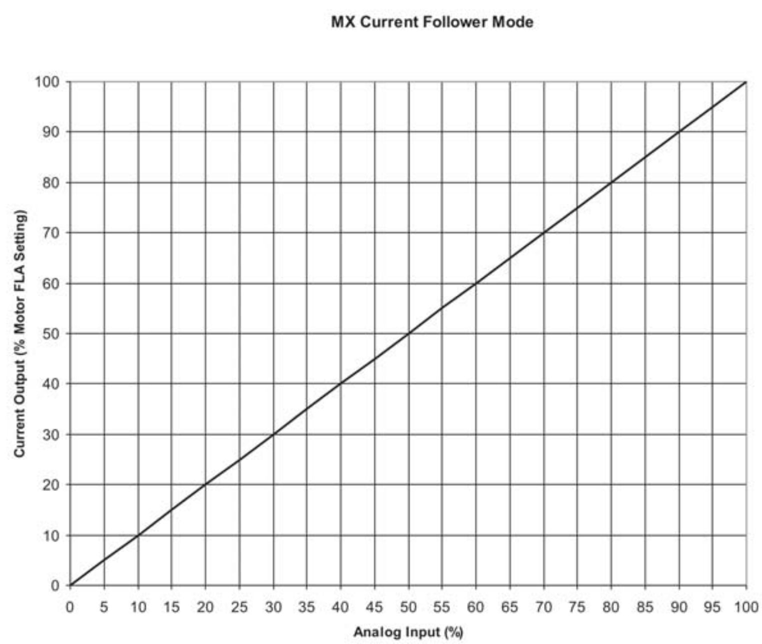
For additional master/slave application information, consult the factory.

Current Follower

6.12 Current Follower

When the Starter Type parameter is set to Current Follower, the MX^2 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 or 4-20mA source such as a potentiometer, another MX^2 or an external controller such as a PLC.

Figure 33: Current Follower Mode



A reference input value of 0% results in no output. A reference input value of 100% results in a current output equal to the Motor FLA setting. The actual voltage or current input that results in a given output can be adjusted through the use of the Analog Input Offset and Analog Input Span parameters.

⌘ **NOTE:** The power stack must be rated for continuous non-bypassed duty in order to operate in Current Follower mode.

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

⌘ **NOTE:** The following motor / starter protective functions are available when in Current Follower mode:

- Current Imbalance
- Over Current
- Under Current
- Over Voltage
- Under Voltage
- Over Frequency
- Under Frequency
- Phase Loss
- Phase Rotation
- Current while Stopped
- Motor OL
- Residual Ground Fault
- Instantaneous Over Current (IOC)

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

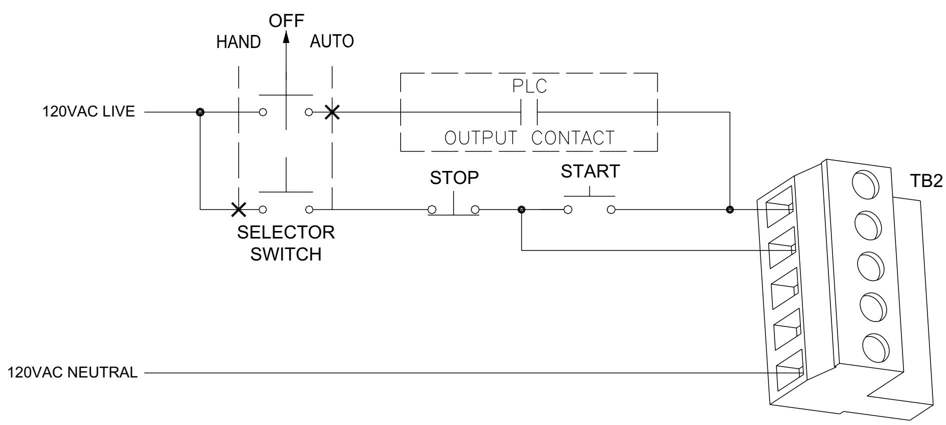
6.13 Start/Stop Control with a Hand/Off/Auto Selector Switch

Often times, a switch is desired to select between local or "Hand" mode and remote or "Auto" mode. In most cases, local control is performed as 3-wire logic with a normally open, momentary contact Start pushbutton and a normally closed, momentary contact Stop pushbutton, while remote control is performed as 2-wire logic with a "Run Command" contact provided by a PLC.

The MX^2 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^2 automatically determines whether to use 2-wire logic or 3-wire logic by the presence of a high level on a Stop input. If there is an input programmed as a Stop input, and that input is high when the Start input goes high, then 3-wire start/stop logic is used. Otherwise, 2-wire start/stop logic is used. This feature eliminates the need for external logic relays often used to "seal in" the momentary Start and Stop pushbuttons, creating a 2-wire logic signal. The key is to have the Stop input be high when the Hand/Off/Auto switch is in the Hand position, but be low when the switch is in the Auto position. The following wiring diagram illustrates a possible implementation. In this example, DI 1 on the MX^2 is programmed as a Stop input.

Figure 34: Example of Start/Stop with a Hand/Off/Auto Selector Switch



When the Hand/Off/Auto selector switch is in the Hand position, current flows to the Stop push button contact and to the Stop input on the MX^2. 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

6.14 Simplified I/O Schematics

Figure 35: Digital Input Simplified Schematic

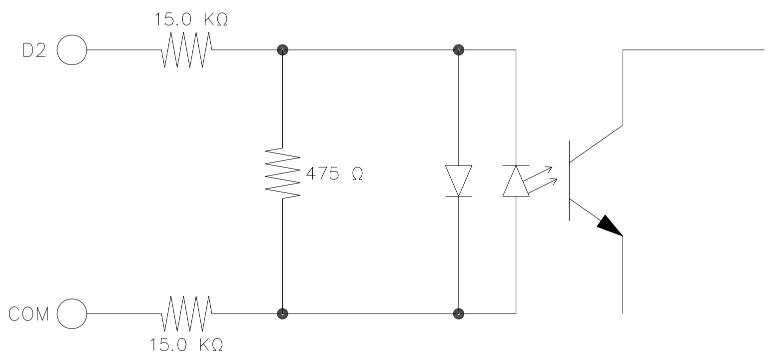


Figure 36: Analog Input Simplified Schematic

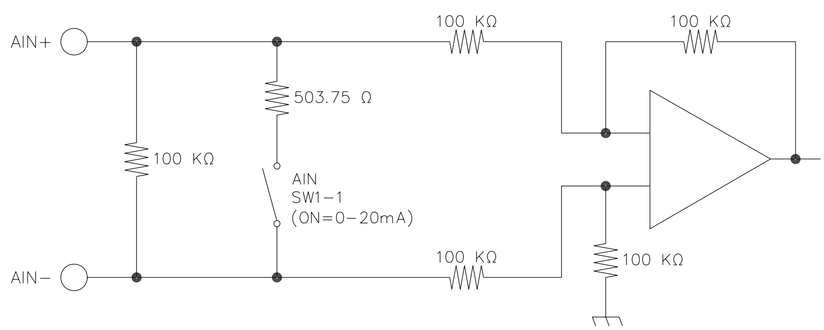
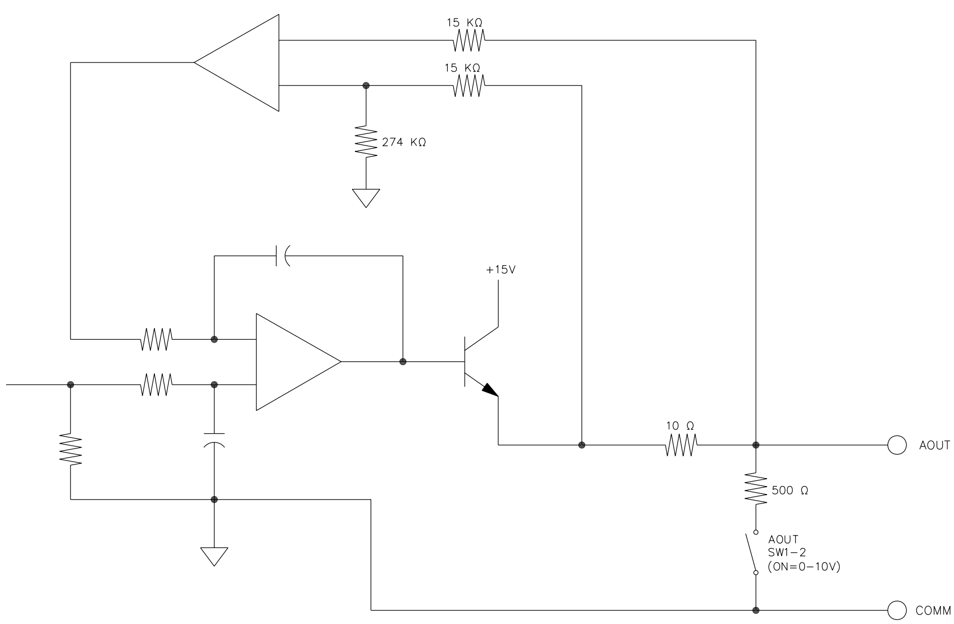


Figure 37: Analog Output Simplified Schematic



Remote Modbus Communications

6.15 Remote Modbus Communications

The MX^2 starter provides a Modbus RTU to support remote communication.

The communication interface is RS-485, and allows up to 247 slaves to be connected to one master (with repeaters when the number of drops exceeds 31). Please refer to Figures 38 and 39 for connection diagrams.

6.15.1 Supported Commands

The MX^2 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.

6.15.2 Modbus Register Addresses

The Modbus specification defines holding registers to begin at 40001 and input registers to begin at 30001. Holding registers may be read and written. Input registers may only be read.

In the MX^2, 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 40101 and in input register 30101. This is why the register addresses in the Modbus Register Map are listed with both numbers (e.g. 30101/40101).
For more information please see the Modbus manual or the full version of the User Manual at www.Benshaw.com

6.15.3 Cable Specifications

Good quality twisted, shielded communications cable should be used when connecting to the Modbus port on the MX^2. 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.

6.15.4 Terminating Resistors

The MX^2 does not have a terminating resistor for the end of the trunk line. If a terminating resistor is required, the resistor must be wired to the terminal block.

The purpose of terminating resistors is to eliminate signal reflections that can occur at the end of a network trunk line. In general, terminating resistors are not needed unless the bit rate is very high, or the network is very long. In fact, terminating resistors place a large load on the network and may reduce the number of drops that may be placed on the network.

The maximum baudrate of 19,200 supported by the MX^2 is not high enough to warrant a terminating resistor unless the network is extremely long (3,000 feet or more). A terminating resistor should only be installed on the MX^2 if signal reflection is known to be a problem and only if the MX^2 is at the end of the network. Terminating resistors should never be installed on nodes that are not at the end of the network.

6.15.5 Grounding

RS-485 buses with isolated nodes are most immune to noise when the bus is not connected to earth ground at any point. If electrical codes require that the bus be connected to earth ground, then the Common signal should be connected to earth ground at one point and one point only. If the Common signal is connected to earth ground at more than one point, then significant currents can flow through the Common signal when earth ground potentials are different at those points. This can cause damage to devices attached to the bus.

6.15.6 Shielding

The shield should be continuous from one end of the trunk to the other. The shield must be tied to the RS-485 Common signal at one point and one point only. If the shield is not tied to Common at any point or is tied to Common at more than one point, then its effectiveness at eliminating noise is greatly reduced.

6.15.7 Wiring

Figure 38 shows the wiring of TB4 to a Modbus-485 Network. If the starter is the end device in the network, a 120Ω, 1/4W terminating resistor may be required. Please refer to Figure 39 for wire and termination practices.

Figure 38: TB4 Connector

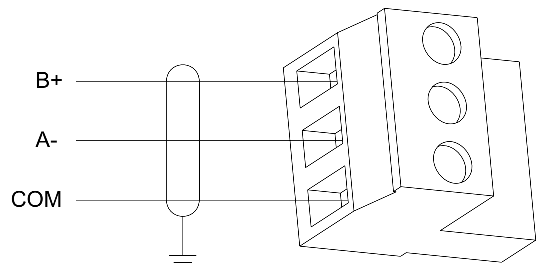
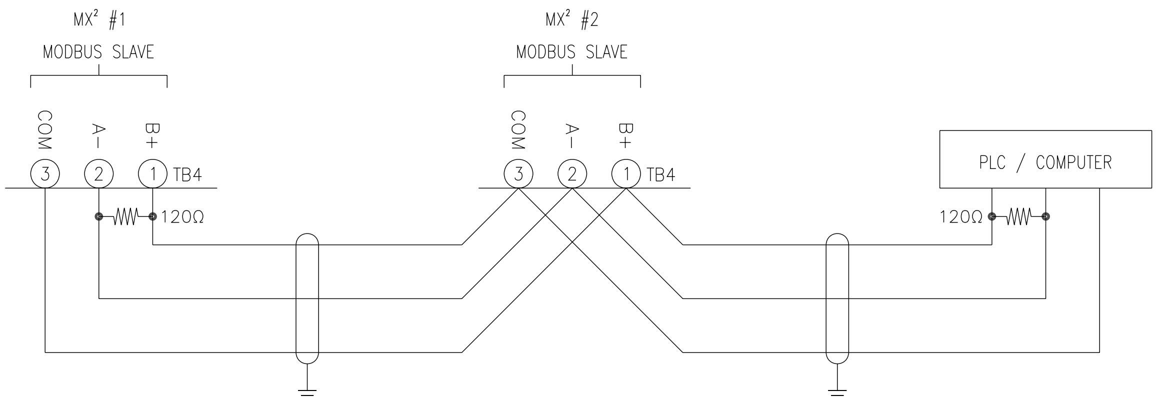
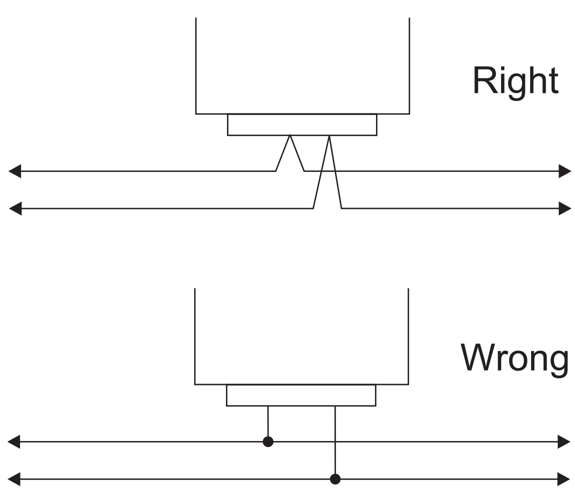


Figure 39: Modbus Network Wiring Example



IMPORTANT

DO NOT CREATE STUBS - CABLE MUST GO TO EACH STARTER.



7 Troubleshooting & Maintenance

Safety Precautions

7.1 Safety Precautions

For safety of maintenance personal as well as others who might be exposed to electrical hazards associated with maintenance activities, the safety related work practices of NFPA 70E, Part II, should always be followed when working on electrical equipment. Maintenance personnel must be trained in the safety practices, procedures, and requirements that pertain to their respective job assignments.

WARNING: To avoid shock hazard, disconnect main power before working on controller/starter, motor or control devices such as start/stop pushbuttons. Procedures which require parts of the equipment to be energized during troubleshooting, testing, etc. must be performed by properly qualified personnel, using appropriate work practices and precautionary measures as specified in NFPA70, Part II.

CAUTION: Disconnect the controller/starter from the motor before measuring insulation resistance (IR) of the motor windings. Voltages used for insulation resistance testing can cause failure of SCR's. Do not make any measurements on the controller with an IR tester (megger).

Preventative Maintenance

7.2 Preventative Maintenance

7.2.1 General Information

Preventative maintenance performed on a regular basis will help ensure that the starter continues to operate reliably and safely. The frequency of preventative maintenance depends upon the type of maintenance and the installation site's environment.

⌘ **NOTE:** A trained technician should always perform preventative maintenance.

7.2.2 Preventative Maintenance

During Commissioning:

- Torque all power connections during commissioning. This includes factory wired equipment.
- Check all of the control wiring in the package for loose connections.
- If fans are installed, ensure proper operation

One month after the starter has been put in operation:

- Re-torque all power connections. This includes factory wired equipment.
- Inspect the cooling fans to ensure proper operation.

After the first month of operation:

- Re-torque all power connections every year.
- Clean any accumulated dust from the starter using a clean source of compressed air.
- Inspect the cooling fans every three months to ensure proper operation.
- Clean or replace any air vent filters on the starter every three months.

⌘ **NOTE:** If mechanical vibrations are present at the installation site, inspect the electrical connections more frequently.

General Troubleshooting Charts

7.3 General Troubleshooting Charts

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

7.3.1 Motor does not start, no output to motor

Condition	Cause	Solution
Display Blank, CPU Heartbeat LED on MX^2 board not blinking.	Control voltage absent.	Check for proper control voltage input. Verify fuses and wiring.
	MX^2 control board problem.	Consult factory.
Fault Displayed.	Fault Occurred.	See fault code troubleshooting table for more details.
Start command given but nothing happens.	Start/Stop control input problems.	Verify that the start/stop wiring and start input voltage levels are correct.
	Control Source parameters (QST 04-05, P4-5) not set correctly.	Verify that the parameters are set correctly.
NOL or No Line is displayed and a start command is given, it will fault in F28.	No line voltage has been detected by the MX^2 when a start command is given.	Check input supply for inline contactor, open disconnects, open fuses, open circuit breakers, or disconnected wiring.
		Verify that the SCR gate wires are properly connected to the MX^2 control board.
		On medium voltage systems, verify wiring of the voltage feedback measurement circuit.
		See fault code troubleshooting table for more details.

7.3.2 During starting, motor rotates but does not reach full speed

Condition	Cause	Solution
Fault Displayed.	Fault Occurred.	See fault code troubleshooting table for more details.
Display shows Accel or Run.	Maximum Motor Current setting (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 (P78/FUN03) parameter set incorrectly.	Verify that Motor FLA and CT ratio parameters are set correctly.
	Abnormally low line voltage.	Fix cause of low line voltage.
	A mechanical or supplemental brake is still engaged.	Verify that any external brakes are disengaged.
Motor Hums before turning.	Initial current to low.	Increase initial current.
	FLA or CT incorrect..	Verify FLA and CT settings.

7.3.3 Starter not accelerating 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 (P78/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 (P78/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.

7.3.4 Starter not decelerating 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.

7.3.5 Motor stops unexpectedly while running

Condition	Cause	Solution
Fault Displayed.	Fault Occurred.	See fault code troubleshooting table for more details.
Ready Displayed.	Start command lost.	Verify start command input signal is present or serial communications start command is present.
		Check any permissive that may be wired into the run command. (Start/Stop)
Display Blank, Heartbeat LED on MX^2 card not blinking.	Control voltage absent.	Check for proper control voltage input. Verify wiring and fuses.
	MX^2 control card problem.	Consult factory.

7.3.6 Metering incorrect

Condition	Cause	Solution
Power Metering not reading correctly.	CTs installed or wired incorrectly.	Verify correct CT wiring and verify that the CTs are installed with all the White dots towards the input line side. CT1=L1 CT2=L2 CT3=L3
	CT ratio parameter (P78/FUN03) set incorrectly.	Verify that the CT ratio parameter is set correctly.
PF Meter not reading correctly.	CTs installed or wired incorrectly.	Verify correct CT wiring and verify that the CTs are installed with all the White dots towards the input line side.
Motor Current or Voltage meters fluctuating with steady load.	Energy Saver active.	Turn off Energy Saver if not desired.
	Loose connections.	Shut off all power and check all connections.
	SCR fault.	Verify that the SCRs gate leads are connected properly and the SCRs are ok.
	Load actually is not steady.	Verify that the load is actually steady and that there are not mechanical issues.
	Other equipment on same power feed causing power fluctuations and/or distortion.	Fix cause of power fluctuations and/or distortion.
Voltage Metering not reading correctly.	In medium voltage systems, Rated Voltage parameter (P76/FUN05) set incorrectly.	Verify that Rated Voltage parameter is set correctly.
Current Metering not reading correctly.	CT ratio parameter (P78/FUN03) set incorrectly.	Verify that the CT ratio parameter is set correctly.
	CTs installed or wired incorrectly.	Verify correct CT wiring and verify that the CTs are installed with all the White dots towards the input line side.CT1=L1 CT2=L2 CT3=L3
Ground Fault Current Metering not reading correctly.	CT ratio parameter (P78/FUN03) set incorrectly.	Verify that the CT ratio parameter is set correctly.
	CTs installed or wired incorrectly.	Verify correct CT wiring and verify that the CTs are installed with all the White dots towards the input line side.CT1=L1 CT2=L2 CT3=L3

7.3.7 Other Situations

Condition	Cause	Solution
Motor Rotates in Wrong Direction.	Phasing incorrect.	If input phasing correct, exchange any two output wires.
		If input phasing incorrect, exchange any two input wires.
Erratic Operation.	Loose connections.	Shut off all power and check all connections.
Motor Overheats.	Motor overloaded.	Reduce motor load.
	Too many starts per hour.	Allow for adequate motor cooling between starts. Set Hot/Cold ratio higher or lengthen cooling time.
	High ambient temperature.	Reduce ambient temperature or provide for better cooling. Set OL class lower to compensate for ambient temperature.
	Acceleration time too long.	Reduce starting load and/or review acceleration ramp settings.
	Incorrect motor OL settings.	Review and correct motor OL settings.
	Motor cooling obstructed/damaged.	Remove cooling air obstructions. Check motor cooling fan.
Starter cooling fans do not operate. (When Present)	Fan power supply lost.	Verify fan power supply, check fuses.
	Fan wiring problem.	Check fan wiring.
	Fan failure.	Replace fan.
Analog Output not functioning properly.	Voltage/Current output switch(SWI-2) not set correctly.	Set switch SW1 to give correct output.
	Wiring problem.	Verify output wiring.
	Analog Output Function parameter (P60/ I/O12) set incorrectly.	Verify that the Analog Output Function parameter is set correctly.
	Analog Output Offset and/or Span parameters (P61/ I/O13 and P62/ 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^2 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^2 control card.
	Remote display damaged.	Replace remote display.
Cannot change parameters.	Passcode is set.	Clear passcode.
	Starter is running.	Stop starter.
	Modbus is overriding.	Stop communications.
	Heater Level (P73 / FUN08) parameter is "On"	Turn Heater Level (P73 / FUN08) parameter "Off"

Fault Code Table

7.4 Fault Code Table

The following is a list of possible faults that can be generated by the MX^2 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.
		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	Motor Thermal Overload Trip	Check motor for mechanical failure, jammed, or overloaded condition.
		Verify the motor thermal overload parameter settings (P3/QST03 and P44-P47/PFN12-PFN16,) and motor service factor setting (P2/QST02).
		Verify that the motor FLA (P1/QST01) and CT ratio (P78/FUN03) 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.
F03	Slow Speed Timer Limit Expired	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 (P77/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 (P77/FUN04).
F11	Phase Rotation Error, not CBA	Input phase rotation is not CBA and Input Phase Sensitivity parameter (P77/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 (P77/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..

Fault Code	Description	Detailed Description of Fault / Possible Solutions
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.
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^2 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^2 control card.
		On medium voltage systems, verify wiring of the voltage feedback measurement circuit.
F21	Low Line L1-L2	Low voltage below the Under voltage Trip Level parameter setting (P39/PFN08) was detected for longer than the Over/Under Voltage Trip delay time (P40/PFN09).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (P76/FUN05) is set correctly.
		Check input supply for open fuses or open connections.
		On medium voltage systems, verify wiring of the voltage measurement circuit.
F22	Low Line L2-L3	Low voltage below the Under voltage Trip Level parameter setting (P39/PFN08) was detected for longer than the Over/Under Voltage Trip delay time (P40/PFN09).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (P76/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 Under voltage Trip Level parameter setting (P39/PFN08) was detected for longer than the Over/Under Voltage Trip delay time (P40/PFN09).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (P76/FUN05) is set correctly.
		Check input supply for open fuses or open connections.
		On medium voltage systems, verify wiring of the voltage feedback measurement circuit.

Fault Code	Description	Detailed Description of Fault / Possible Solutions
F24	High Line L1-L2	High voltage above the Over voltage Trip Level parameter setting (P35/PFN07) was detected for longer than the Over/Under Voltage Trip delay time (P40/PFN09).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (P76/FUN05) is set correctly.
		Line power quality problems/ excessive line distortions.
F25	High Line L2-L3	High voltage above the Over voltage Trip Level parameter setting (P38/PFN07) was detected for longer than the Over/Under Voltage Trip delay time (P40/PFN09).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (P76/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 (P38/PFN07) was detected for longer than the Over/Under Voltage Trip delay time (P40/PFN09).
		Verify that the actual input voltage level is correct.
		Verify that the Rated Voltage parameter (P76/FUN05) is set correctly.
		Line power quality problems/ excessive line distortions.
F27	Phase Loss	The MX^2 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^2 card.
F28	No Line	No input voltage was detected for longer than the Inline Configuration time delay parameter setting (P63/ I/O16) 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/O16) allows enough time for the inline contactor to completely close.
		Check input supply for open disconnects, open fuses, open circuit breakers or disconnected wiring.
		Verify that the SCR gate wires are properly connected to the MX^2 control card.
		On medium voltage systems, verify wiring of the voltage feedback measurement circuit.

Fault Code	Description	Detailed Description of Fault / Possible Solutions
F30	I.O.C. (Instantaneous Over current)	During operation, the MX^2 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) and CT ratio (P78/FUN03) settings are correct.
F31	Overcurrent	Motor current exceeded the Over Current Trip Level setting (P32/PFN01) for longer than the Over Current Trip Delay Time setting (P33/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 (P36/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 (P37/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) and CT ratio (P78/FUN03) settings are correct.
		Verify that the CTs are installed with all the White dots towards the input line.
		In Single phase applications, verify that only two CTs are being used; that they are installed with all the White dots or Xs in the correct direction; and that the CTs are connected to the L1 and L3 CT inputs on the MX^2 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^2control card.
		Verify that the motor FLA (P1/QST01) and CT ratio (P78.FUN03) settings are correct.
		Check if load is still connected to starter.
		Check if motor may have been driven by the load (a regeneration condition).
		Check Gate and Cathode connections to MX^2 for loose connections.
		Check for inline contactor or disconnect.

Fault Code	Description	Detailed Description of Fault / Possible Solutions
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^2 control card.
		Check all SCRs with ohmmeter for shorts.
		Verify that the Input Phase Sensitivity parameter setting (P77/FUN04) is correct.
		Verify that the Starter Type parameter setting (P74/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) and CT ratio (P78/FUN03) settings are correct.
F46	Disconnect Fault	A signal on the disconnect digital input was not present when a start was commanded.
		Verify that disconnect feedback wiring is correct.
		Verify that the disconnect is not faulty.
F47	Stack Protection Fault (stack thermal overload)	The MX^2 electronic power stack OL protection has detected an overload condition.
		Check motor for jammed or overloaded condition.
		Verify that the CT ratio (P78/FUN03) and burden switch settings are correct.
		Motor load exceeds power stack rating. Consult factory
F48	Bypass /2M Contactor Fault	An incorrect bypass feedback has been detected for longer than the Bypass Confirm time parameter setting (P64/ I/O17).
		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 not damaged or faulty.
F49	Inline Contactor Fault	Verify that the appropriate Digital Input Configuration parameter has been programmed correctly.
		Verify that the inline contactor(s) are actually not damaged or faulty.
F50	Control Power Low	Low control power (below 90V) has been detected while running.
		Verify that the control power input level is correct, especially during starting when there may be significant line voltage drop.
		Check control power transformer tap setting (if available).
		Check control power transformer fuses (if present).
		Check wiring between control power source and starter.

Fault Code	Description	Detailed Description of Fault / Possible Solutions
F51	Current Sensor Offset Error	Indicates that the MX^2 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 (P78/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.
F54	BIST Fault	The starter has detected a voltage or a current. Remove line power from input of starter. Disconnect must be open.
F55	BIST CT Fault	Verify CT location, CT1 on L1, CT2 on L2, CT3 on L3. or CTs are connected backwards (the polarity dot must be facing the supply line).
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 (P56/ I/O 09) for longer than the Analog Input Trip Delay time (P57/ I/O 010).
		Measure value of analog input to verify correct reading.
		Verify settings of all Analog Input parameters (P55-P59/ I/O 08- I/O 12).
		Verify correct positioning of input switch (SW1) (Voltage or Current) on the MX^2 control card.
		Verify correct grounding of analog input connection to prevent noise or ground loops from affecting input.
F81	SPI / Keypad Communication Fault	Indicates that communication has been lost with the remote keypad. (This fault normally occurs if the remote keypad is disconnected while the MX^2 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^2 control card.
		Verify that the display interface card (when present) is firmly attached to MX^2 control card.
		Route keypad cables away from high power and/or high noise areas to reduce possible electrical noise pickup.

SCR Testing

7.5 SCR Testing

7.5.1 Resistance

The SCRs in the starter can be checked with a standard ohmmeter to determine their condition.

Remove power from the starter before performing these checks.

- Check from L to T on each phase. The resistance should be over 50k ohms.
- Check between the gate leads for each SCR (red and white twisted pair).
  The resistance should be from 8 to 50 ohms.

⌘ **NOTE:** The resistance measurements may not be within these values and the SCR may still be good. The checks are to determine if an SCR is shorted "L" to "T" of if the gate in an SCR is shorted or open. An SCR could also still be damaged even though the measurements are within the above specifications.

7.5.2 Voltage

When the starter is running, the operation of the SCRs can be confirmed with a voltmeter.

Extreme caution must be observed while performing these checks since the starter has lethal voltages applied while operating.

While the starter is running and up to speed, use an AC voltmeter, check the voltage from "L" to "T" of each phase. The voltage should be less than 1.5 Volts. If the starter has a bypass contactor, the voltage drop should be less than 0.3 volts.

Using a DC voltmeter, check between the gate leads for each SCR (red and white twisted pair). The voltage should between 0.5 and 2.0 volts.

7.5.3 Integral Bypass

A voltage check from "L" to "T" of each phase of the RediStart starter should be preformed every 6 months to confirm the bypass contactors are operating correctly.

Extreme caution must be observed while performing these checks since the starter has lethal voltages applied while operating.

While the starter is running and Up to Speed, use an AC voltmeter; check the voltage from "L" to "T" of each phase. The voltage drop across the contactor contacts should be less than 300mV. If greater that 300mV the integral bypass should be disassembled. It may be necessary to clean the contact tips or replace the contactor.

Built-In Self Test Functions

7.6 Built In Self Test Functions

The MX^2 has two built in self test (BIST) modes. The first test is the standard self test and is used to test many of the basic functions of the starter without line voltage being applied. The second test is a line powered test that is used to verify the current transformer's locations and connections and to test for shorted SCRs/power poles, open or non-firing SCRs/power poles, and ground fault conditions.

7.6.1 Standard BIST Tests:

(P67 / #7) / FUN 15 - Std BIST

The standard BIST tests are designed to be run with no line voltage applied to the starter. In selected low voltage systems where a disconnect switch is used, the Disconnect Switch must be opened before starting the standard tests. Standard BIST mode can be initiated by entering the appropriate value into P67 or FUN 15 - Misc Command user parameter.

CAUTION: In order to prevent back feeding of voltage through the control power transformer (if used), control power must be carefully applied to the MX^2 control card and contactors so that self testing can occur safely. In low voltage applications, the user must verify that the applied test control power cannot be fed backwards through the system. "Run/Test" isolation switches, test power plugs, and wiring diagrams are available from Benshaw.

CAUTION: In low voltage systems with an inline/isolation contactor. Before the inline test is performed verify that no line voltage is applied to the line side of the inline contactor. Otherwise when the inline test is performed the inline contactor will be energized, applying line voltage to the starter, and a BIST test fault will occur.

The standard BIST tests comprise of:

Programming / Test Instructions:

Step 1

LED Display	**LCD Display**
Go to P67 and press [ENTER].	Go to FUN 15- misc commands and press [ENTER].
Press [UP] button to #7 and press [ENTER].	Increment up to "Std BIST" and press [ENTER].
Powered BIST test will commence**.**	Std BIST test will commence.

```
FUN:Misc Command
15  Std BIST
```

⌘ **NOTE:** Designed to run with no line voltage applied to starter.

Step 2– RUN relay test and Inline Feedback Test:

In this test, the RUN assigned relays are cycled on and off once and the feedback from an inline contactor is verified. In order to have a valid inline contactor feedback, a digital input needs to be set to Inline Confirm and the input needs to be wired to an auxiliary contact of the inline contactor. The feedback is checked in both the open and closed state. If the feedback does not match the state of the RUN relay within the amount of time set by the Inline Config parameter an "Inline" fault will occur.

⌘ **NOTE:** If no digital input is assigned as an Inline Confirm input this test will always pass.

⌘ **NOTE:** If the Inline Config (I/O 16) parameter on page 66 is set to "Off" this test will be skipped.

LED Display	**LCD Display** (BIST Mode)
b ic (inline closed)	Inline Closed
b io (inline open)	Inline Open

```
BIST Mode
Inline Closed
```

```
BIST Mode
Inline Open
```

Step 3– UTS relay test and Bypass Feedback Test:

In this test, the dedicated bypass relay (if assigned) and the UTS assigned relays are cycled on and off once, and the feedback from a bypass contactor is verified. In order to have a valid bypass contactor feedback, the individual bypass input and any other inputs set to Bypass Confirm input needs to be wired to an auxiliary contact of the bypass contactor. The feedback is checked in both the open and closed state. If the feedback does not match the state of the UTS relay within the amount of time set by the Bypass Feedback parameter a "Bypass/2M Fault" will occur.

⌘ **NOTE**: If one dedicated bypass is set to "fan" and if no digital input are assigned as a Bypass Confirm input, this test will always pass.

LED Display	**LCD Display** (BIST Mode)
b bc (bypass closed)	Bypass Closed
b bo (bypass open)	Bypass Open

```
BIST Mode
Bypass Closed
```

```
BIST Mode
Bypass Open
```

Step 4– Sequential SCR gate firing (L1+, L1-, L2+, L2-, L3+, L3-):

In this test the SCR gate outputs are sequentially fired starting with the L1+ device(s) and ending with the L3- device(s). This test can be used to verify that the SCR gate leads are connected properly. In LV systems, the gate voltage can be verified using a DC voltage meter or oscilloscope. The voltage on each red and white wire pair should be between 0.5VDC and 2.0VDC.

LED Display	**LCD Display** (BIST Mode)
b 96 (gate 6 on)	Gate 6 On
b 93 (gate 3 on)	Gate 3 On
b 95 (gate 5 on)	Gate 5 On
b 92 (gate 2 on)	Gate 2 On
b 94 (gate 4 on)	Gate 4 On
b 91 (gate 1 on)	Gate 1 On

```
BIST Mode
Gate G? On
```

Step 5– Simultaneous SCR gate firing:

In this test the SCR gate outputs are simultaneously fired (all gates on). This test can be used to verify that the SCR gate leads are connected properly. The gate voltage can be verified using a DC voltage meter or oscilloscope. The voltage on each red and white wire pair should be between 0.5VDC and 2.0VDC.

Pressing [ENTER] on the keypad at any time will abort the current test in progress and proceed to the next BIST test.

During the standard BIST tests if line voltage or phase current is detected, the MX^2 will immediately exit BIST mode and declare a "BIST Abnormal Exit" fault.

LED Display	**LCD Display**
b 9A (all gates on)	All Gates On

```
BIST Mode
All gates on
```

Step 6

LED Display	**LCD Display**
b-- (tests completed)	Tests completed

```
BIST Mode
Tests completed
```

7.6.2 Powered BIST Tests:

(P67 / #8) / FUN 15 - Powered BIST

The powered BIST tests are designed to be run with normal line voltage applied to the starter and a motor connected. Powered BIST verifies that the power poles are good, no ground faults exist, CTs are connected and positioned correctly and that the motor is connected. Powered BIST mode can be entered by entering the appropriate value into the FUN 15- Miscellaneous Command user parameter.

⌘ **NOTE:** The powered BIST test is only for use with SCR based reduced voltage soft starters. Powered BIST can not be used with wye-delta or ATL types of starters.

⌘ **NOTE:** The motor wiring MUST be fully connected before starting the powered BIST tests. Also the motor must be at rest (stopped). Otherwise the powered BIST tests will not function correctly.

⌘ **NOTE:** Before using the powered BIST test function, the following MX^2 user parameters MUST be set for correct operation of the powered BIST test: Motor FLA (P1 / QST 01), CT Ratio (P78 / FUN 03), Phase Order (P77 / FUN 04), Rated Voltage (P76 / FUN 05), and Starter Type (P74 / FUN 07).

The powered BIST tests comprise of:

Programming / Test Instructions:

Step 1

LED Display	**LCD Display**
Go to P67 and press [ENTER].	Go to FUN 15 and press [ENTER].
Press [UP] button to #8 and press [ENTER].	Increment up to "Powered BIST" and press [ENTER].
Powered BIST test will commence**.**	Powered BIST test will commence.

```
FUN:Misc Command
15  Powered BIST
```

Step 2– **Shorted SCR and Ground Fault Test:**

In this test each power pole is energized individually. If current flow is detected, the MX^2 controller attempts to differentiate whether it is a shorted SCR/shorted power pole condition or a ground fault condition and either a "Bad SCR Fault" or "Ground Fault" will occur.

LED Display	**LCD Display** (BIST Mode)
b 59 -(Gating individual SCRs)	Shorted SCR / GF

```
BIST Mode
Shorted SCR/GF
```

Step 3– **Open SCR and Current Transformer (CT) Test:**

In this test, a low-level closed-loop controlled current is selectively applied to various motor phases to verify that the motor is connected, all SCRs are turning on properly, and that the CTs are wired and positioned properly. If current is detected on the wrong phase then a "BIST CT Fault" fault will be declared. If an open motor lead, open SCR, or non-firing SCR is detected then a "Bad SCR Fault" will occur.

⌘ **NOTE:** When this test is in progress 6 audible humming or buzzing sounds will be heard from the motor.

LED Display	**LCD Display** (BIST Mode)
b oc	Open SCR / CTs

```
BIST Mode
Open SCR/CTs
```

Step 4

LED Display	**LCD Display**
b-- (tests completed)	Tests completed.

```
BIST Mode
Tests completed
```

Pressing [ENTER] on the keypad at any time will abort the current test in progress and proceed to the next BIST test.

⌘ **NOTE**: If line voltage is lost during the powered tests a "BIST Abnormal Exit" fault will occur.

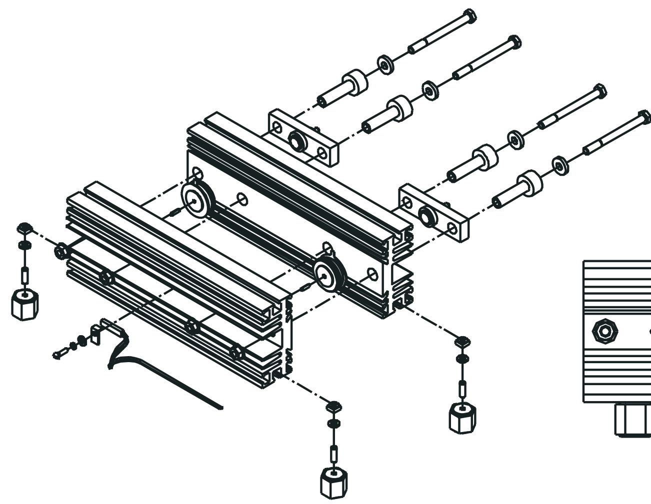
⌘ **NOTE:** The powered BIST tests will verify that the input phase order is correct. If the measured phase order is not the same as the "Phase Order" (FUN 04) parameter a phase order fault will occur.

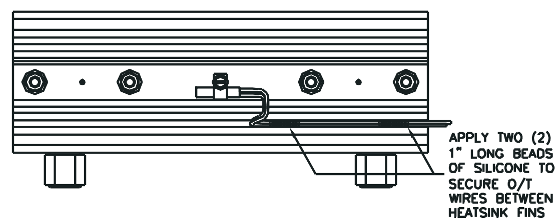
SCR Replacement

7.7 SCR Replacement

This section is to help with SCR replacements on stack assemblies. Please read prior to installation.

7.7.1 Typical Stack Assembly





7.7.2 SCR Removal

To remove the SCR from the heatsink, loosen the two bolts (3) on the loader bar side of the clamp. Do not turn on the nuts (5). The nuts have a locking ridge that sink into the aluminum heatsink. Do ¼ turns until the SCR comes loose. Remove the SCRs from the heatsink.

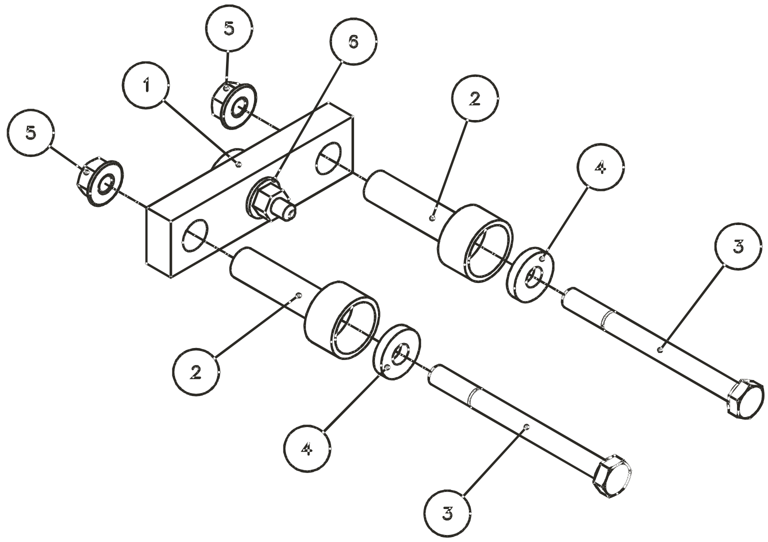
⌘ **NOTE:** Do not loosen nut on indicator washer (6). This will change the clamping pressure of the clamp and the clamp will be defective.

7.7.3 SCR Installation

- Coat the faces of the SCRs to be installed with a thin layer of EJC (Electrical Joint Compound).
- Place the SCRs onto the dowel pins. The top SCR will have the cathode to the left and the bottom SCR will have the cathode to the right. The SCR symbol has a triangle that points to the cathode.
- Finger tighten nuts on the bolts.

7.7.4 SCR Clamp

Below is an exploded view of a typical SCR clamp. Refer to the Clamp Parts List below for names of the parts being used.



SCR CLAMP PARTS

Item #	Quantity	Description
1	1	Loader Bar
2	2	Insulator cup
3	2	Bolt
4	2	Washer
5	2	Serrated nut (larger style clamp has 1 support bar)
6	1 or 2	Indicator Washer – Quantity dependant on style of clamp

7.7.5 Tightening Clamp

Finger tighten the clamp. Ensure both bolts are tightened an equal amount so that the loader bar (item 1) is square in the heatsink. Tighten the bolts equally in 1/8 turn increments until the indicator washer(s) (item 6), which are under the nut(s) in the center of the loader bar, becomes loose indicating the clamp is tight. On the loader bars with two indicator washers, it may be necessary to tighten or loosen one side of the clamp to get both indicator washers free.

7.7.6 Testing SCR

After the SCRs have been replaced, conduct the resistance test as defined in section 7.5.

NOTES:

Publication History;

Revision	Date	ECO#
00		Initial Release
01	22-Mar-07	E1721

BENSHAW PRODUCTS

Low Voltage Solid State Reduced Voltage Starters

- RB2/RC2 - SSRV Non or Separate Bypass
- RB2/ RC2 + DC Injection Braking + Reversing
- WRB - SSRV Wound Rotor
- SMRSM6 - SSRV Synchronous
- DCB3 - Solid State DC Injection Braking

Medium Voltage Solid State Reduced Voltage Starters

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

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