M2L 3000

Medium Voltage Variable Frequency Drive

User Guide

BENSHAW®
ADVANCED CONTROLS & DRIVES

890048-01-00
Software Version (810041-05-12)


BENSHAW®
ADVANCED CONTROLS & DRIVES

Important Reader Notice

Congratulations on the purchase of your new Benshaw M2L 3000 Medium Voltage Variable Frequency Drive, hereafter referred in this document as the “M2L 3000” or the “drive”.

This User Guide may not cover all of the applications for the M2L 3000, nor can it provide information on every possible contingency concerning installation, programming, operation, or maintenance specific to M2L 3000 VFD systems.

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

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

Incorrect handling of the drive may result in an unexpected fault or equipment damage. For best results when operating the M2L 3000 drive, carefully read this manual and all warning labels attached to the system before installation and operation. Keep this manual on hand for reference.

Do not attempt to install, operate, maintain or inspect the drive until you have thoroughly read this manual and related documents carefully, and can use the equipment correctly.

Do not use the drive until you have a full knowledge of the equipment, safety procedures and instructions.

Symbols

This User Guide classifies safety, protection, and general information levels as *Warning*, *Caution*, and *Note.*

WARNING: Warns of a physical safety condition or Electrical Hazard which can cause personal injury or death

CAUTION: Warns of situations in which equipment damage may occur

NOTE: Indicates a specific piece of information applicable to the use or operation of the drive.

WARNINGS

HAZARDS OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH.

Failure to follow the instructions below may result in serious injury or death.

DANGER. This equipment does not provide isolation. Separate isolating means required. Isolation devices can take several forms with the most simple being an appropriately sized disconnect switch and contactor pair utilizing the Inverter 'Shunt Trip' controls, or an appropriately sized and protected vacuum circuit breaker also capable of remote operation from the inverter 'Shunt Trip' controls. See page 32 for more information.

WARNING: At any time the system is energized with Medium Voltage power, apply appropriate personal protective equipment (PPE) and follow safe electrical work practices when operating or working near the system. See NFPA 70E.

Cabinet Fault Limit:	<10kA @ 10 Cycles
Min Arc Boundary:	40 Inches
Recommended Min. PPE:	#1 at > 40 inches

WARNING: Branch circuit protection is required for the equipment. See page 32 for more information.

WARNING: Only qualified personnel familiar with the use and hazards of medium voltage equipment are to perform work described in this set of instructions.

WARNING: Before performing visual inspections, tests, or maintenance on the equipment, disconnect all sources of electric power. Assume that circuits are live until completely de-energized, tested, and tagged.

Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of backfeeding.

Use a properly rated voltage sensing device to confirm that the power is fully removed.

WARNING: Always perform applicable lock-out/tag-out procedures (either general or site-specific) before performing any maintenance or troubleshooting on the system.

WARNING: To avoid potentially lethal levels of both AC and DC voltages, do not remove the cover to access the MV Input/Output section of the Inverter while the Inverter is energized.

WARNING: Equipment may be supplied from multiple power sources. Refer to drawings for more information.

WARNING: Potentially hazardous voltages will remain in the cells until the capacitors are able to de-energize. Wait at least 30 minutes after main power is removed for the stored voltages to dissipate if removing the Inverter Cell or Input/Output section covers. Do not rely solely on the voltage values displayed on the HMI Meter Values screen to determine if it is safe to remove the covers on the Inverter Cell and Input/Output sections.

WARNING: The Control section contains 240V control power when active. The Control section does not contain medium voltage levels supplied from the mains, and can be carefully accessed by qualified personnel while medium voltage from the AC mains is applied to the system.

WARNING: Replace all devices, doors, and covers before applying power to this equipment.

WARNING: Do not attempt to lift and position either the Converter or Inverter with a crane without the proper equipment or experience performing this type of operation. Benshaw can arrange the services of professional firms who routinely rig and lift heavy equipment.

CAUTIONS

CAUTION: Special care must be taken with covers that have a ground wire attached to the inside that ties them to ground potential. It is important that the connection integrity of this wire be maintained to avoid compromising the immunity of the Inverter to Electromagnetic Interference (EMI) and safety.

CAUTION: Always be aware of electrostatic discharge (ESD) when working near or touching components inside the drive. Handling of components sensitive to ESD should be done by qualified personnel only, familiar with ESD mitigation techniques.

CAUTION: Parameter settings and adjustments should be performed by those familiar with VFD and motor operation characteristics. It is not recommended for users unfamiliar with these concepts.


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Table of Contents


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1 - Introduction

Benshaw personnel are available to answer all inquiries including information regarding start-up services and on-site training. Refer to the following pages for contact information.

Documentation

Benshaw can provide all customers with:

- User Guides
- Drawings / Wiring Diagrams

Drawings are available on CD / DVD or via e-mail by contacting Benshaw Customer Service.

On-Line Documentation

All MVVFD documentation is available on-line at *www.benshaw.com.*

Replacement Parts

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

Publication History

Refer to the inside back cover.

Warranty

Benshaw provides a standard 5 Year factory warranty on the M2L 3000 MVVFD System.

Contacting Benshaw

Information about all Benshaw products and services is available on the internet at *www.benshaw.com*, or by contacting Benshaw at one of the following offices:

Benshaw Corporate Headquarters	Benshaw Canada
615 Alpha Drive Pittsburgh, PA 15238	550 Bright Street East Listowel, Ontario N4W 3W3
Phone: 412-968-0100 **Tech Support**: 1-800-203-2416 **Fax**: 412-968-5415	**Phone**: 519-291-5112 **Tech Support**: 1-877-291-5112 **Fax**: (519) 291-2595

Technical support is available by contacting Benshaw Customer Service at any 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. Call Benshaw and follow 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
- A brief description of the application

System Design Features

Compact Modular Design

- Simplistic component arrangement with minimal total part count compared to competitive offerings
- Unique modular power inverter
  - *Voltage requirements met by configuring standard IGBT cells*
  - *Self-healing film capacitors that do not need reforming, superior to common electrolytics*
  - *Field maintenance and repair using pre-assembled, pre-tested power cells*
  - *Internal communication through high-speed fiber optics using Ethernet protocol for high noise immunity and high bandwidth*

Installation Flexibility

- Patented topology that enables extended separation of converter and inverter sections
- Uses a standard input transformer in the converter that can accommodate a wide range of input voltages (480 - 13.8 kV)
- Interconnection using standard high-voltage cable
- Reduced heat load and space requirements in environmentally-conditioned equipment rooms with a remotely located converter
- Customer sourcing of the transformer (per Benshaw's specification)
- Operation directly from customer DC bus (per Benshaw's specification)
- Remote or direct mounted HMI and optional controls

Robust Control Architecture

- Modern Control Platform
- Distributed control with intelligent power cells
- Ultra-fast dual core processor for high-speed processing and expansion capability
- Industry-standard card cage
  - *Front access for easy removal and replacement*
  - *Low Voltage Differential Signaling backplane - EMI resistant*
- Industry standard field buses and communication protocols
- Profibus DP, Modbus TCP/IP, http, Ethernet IP, DeviceNet, via built in components or industrial gateways
- Benshaw Connect for monitoring, parameter setting, and review of event logs at the drive or over the internet via optional modem

Arc Flash Resistant Design

- Arc flash footprint inherently lower
  - *Utilizes distributed energy storage*
  - *No centralized bulk storage capacitors*
  - *Optical arc flash detection in each power cell*
  - *Offending cell is immediately reported to the control system*
- Fault currents greatly reduced compared to other VFDs
  - *Converter will not feed energy into faults*
- Increased user safety work envelope
  - Remote control via HMI, industrial gateway, digital and analog I/o, or Benshaw Connect PC tool

User Interface

- Intuitive, user-friendly touch screen
- No need to remember multi-use key assignments used on other low-end user interfaces
- Benshaw Connect Tool Suite
  - *Application allows for seamless connectivity between a PC and the drive*
  - *Easy to use configuration and diagnostic tool*
  - *Windows-based tool for use on Windows XP, Windows 7 and Windows 10*

Energy Efficiency

- Unique modular inverter design has improved efficiency over Cascaded H-Bridge and Neutral Point Clamped (NPC) inverter designs.
- Uses the latest in efficient IGBT designs for minimum losses and maximum performance.
- Inverter efficiency >99% over a wide speed range and wide load range
- Modular inverter design allowing the input converter to operate more efficiently than other inverter designs reducing losses
- No efficiency reducing output transformers or output filters are required
- Input power supply power factor of $\geqslant$0.95 minimizes losses in the power supply and input wiring

Energy Savings

- Shaft power of motor driven equipment (fans, pumps, blower) is proportional to the cube of the rotational speed
- By design, VFDs improve efficiency at low speeds
- Considerable energy savings can be achieved by outfitting motors with VFDs, as the speed can be adjusted to match the required load

Part Number Definitions

Converter

Example: XCS | 3 | A | C | 6 | D | J |

Base:
XCS M2L Converter

Series: *Choose one ONLY*
3 Standard
U UL Listed

Transformer configuration *Choose one ONLY*
A Benshaw supplied, inside of converter
B Benshaw supplied, outside of converter
C Customer supplied (external)

Input Voltage: *Choose one ONLY*
A 2300
B 3300
C 4160
D 4800
E 6600
F 6900
G 7200
H 8320
I 10000
J 11000
K 12000
L 12470
M 13200
N 13800
O Other (specify)

Input Frequency: *Choose one ONLY*
5 50 Hz
6 60 Hz

Motor voltage: *Choose one ONLY*
A 2300
B 3300
C 4160
D 4800
E 6600
F 6900
G 7200
H 8320
I 10000
J 11000
K 12000
L 12470
M 13200
N 13800

Motor Horsepower: *Choose one ONLY*
A 100
B 200
C 300
D 400
E 500
F 600
G 700
H 800
I 900
J 1000
K 1250
L 1500
M 1750
N 2000
O 2250
P 2500
Q 2750
R 3000
S 3250
T 3500
U 3750
V 4000
W 4250
X 4500
Y 4750
Z 5000
1 5500
2 6000
3 6500
4 7000
5 7500
6 8000
7 8500
8 9000
9 9500
0 10000

Options (See Sheet 2) *Multiple choices OK*

Inverter

Example: M2L | 3 | 6 | F | A |

Base:
M2L M2L Inverter

Series: *Choose one ONLY*
3 Standard
U UL Listed

Input Frequency: *Choose one ONLY*
5 50 Hz
6 60 Hz

Motor Voltage: *Choose one ONLY*
A 2300
B 3300
C 4160
D 4800
E 6600
F 6900
G 7200
H 8320
I 10000
J 11000
K 12000
L 12470
M 13200
N 13800

Power Cell Size (amps): *Choose one ONLY*
A 35
B 70
C 100
D 130
E 190
F 260
G 300
H 440
I 550
J 660
K 770

Options (See Sheet 2) *Multiple choices OK*

HMI

Example: HMI | 3 | 12 |

Base:
HMI Human-Machine Interface

Series: *Choose one ONLY*
3 Standard
U UL Listed

Touch Screen Size (inches): *Choose one ONLY*
12
7

Options (See Sheet 2) *Multiple choices OK*

UL Applicable Base Part Numbers:

Converter

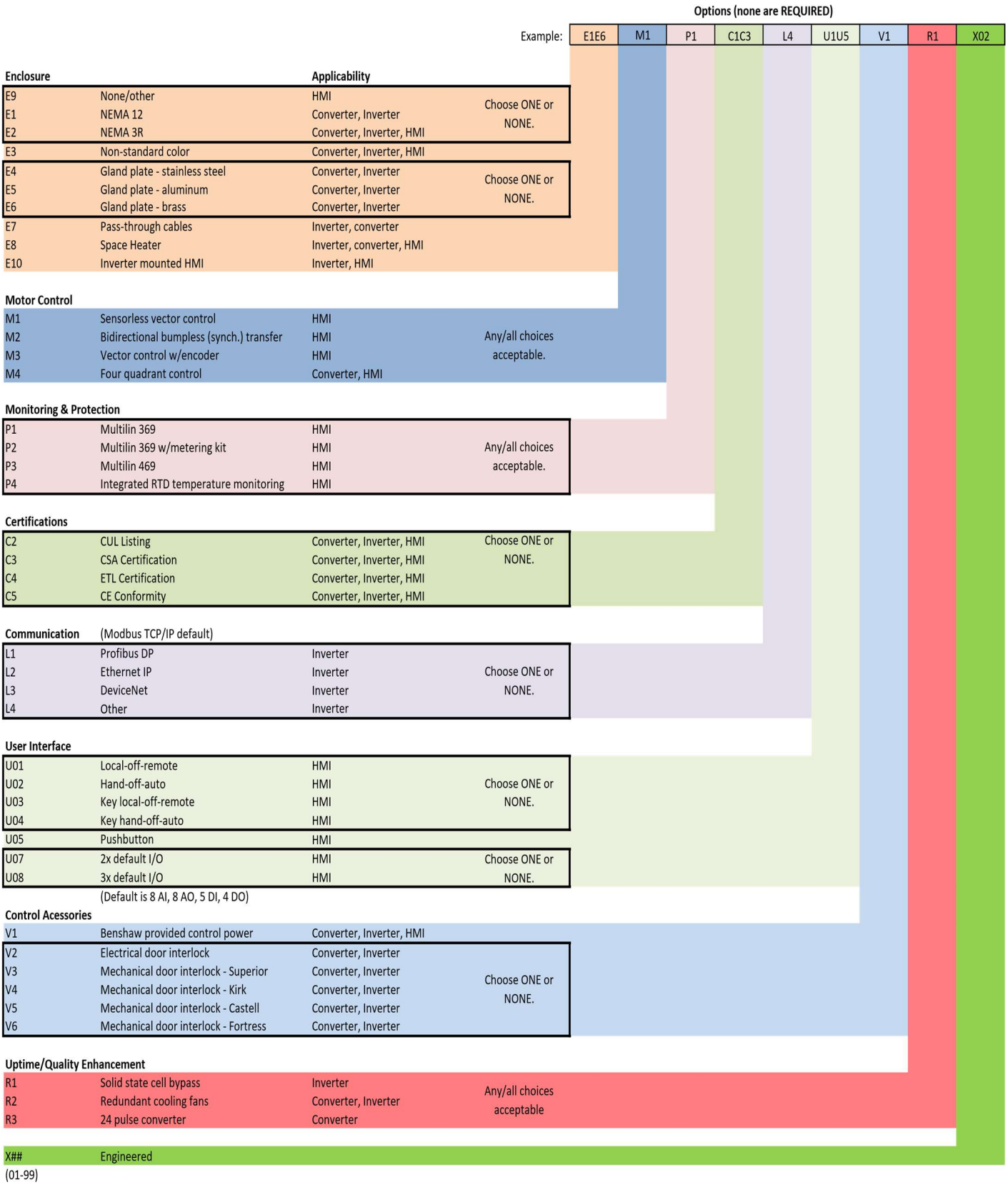
XCS	U	A	C		6	C	K
							L
							M
							N
							O

Inverter

M2L	U	6	C		F
					G

HMI

HMI	U	7



				Options (none are REQUIRED)								
			Example:	E1E6	M1	P1	C1C3	L4	U1U5	V1	R1	X02
Enclosure		**Applicability**										
E9	None/other	HMI	Choose ONE or NONE.									
E1	NEMA 12	Converter, Inverter										
E2	NEMA 3R	Converter, Inverter, HMI										
E3	Non-standard color	Converter, Inverter, HMI										
E4	Gland plate - stainless steel	Converter, Inverter	Choose ONE or NONE.									
E5	Gland plate - aluminum	Converter, Inverter										
E6	Gland plate - brass	Converter, Inverter										
E7	Pass-through cables	Inverter, converter										
E8	Space Heater	Inverter, converter, HMI										
E10	Inverter mounted HMI	Inverter, HMI										
Motor Control												
M1	Sensorless vector control	HMI	Any/all choices acceptable.									
M2	Bidirectional bumpless (synch.) transfer	HMI										
M3	Vector control w/encoder	HMI										
M4	Four quadrant control	Converter, HMI										
Monitoring & Protection												
P1	Multilin 369	HMI	Any/all choices acceptable.									
P2	Multilin 369 w/metering kit	HMI										
P3	Multilin 469	HMI										
P4	Integrated RTD temperature monitoring	HMI										
Certifications												
C2	CUL Listing	Converter, Inverter, HMI	Choose ONE or NONE.									
C3	CSA Certification	Converter, Inverter, HMI										
C4	ETL Certification	Converter, Inverter, HMI										
C5	CE Conformity	Converter, Inverter, HMI										
Communication	(Modbus TCP/IP default)											
L1	Profibus DP	Inverter	Choose ONE or NONE.									
L2	Ethernet IP	Inverter										
L3	DeviceNet	Inverter										
L4	Other	Inverter										
User Interface												
U01	Local-off-remote	HMI	Choose ONE or NONE.									
U02	Hand-off-auto	HMI										
U03	Key local-off-remote	HMI										
U04	Key hand-off-auto	HMI										
U05	Pushbutton	HMI										
U07	2x default I/O	HMI	Choose ONE or NONE.									
U08	3x default I/O	HMI										
	(Default is 8 AI, 8 AO, 5 DI, 4 DO)											
Control Acessories												
V1	Benshaw provided control power	Converter, Inverter, HMI										
V2	Electrical door interlock	Converter, Inverter	Choose ONE or NONE.									
V3	Mechanical door interlock - Superior	Converter, Inverter										
V4	Mechanical door interlock - Kirk	Converter, Inverter										
V5	Mechanical door interlock - Castell	Converter, Inverter										
V6	Mechanical door interlock - Fortress	Converter, Inverter										
Uptime/Quality Enhancement												
R1	Solid state cell bypass	Inverter	Any/all choices acceptable									
R2	Redundant cooling fans	Converter, Inverter										
R3	24 pulse converter	Converter										
X##	Engineered											
(01-99)												

- **NOTE:** Only the 260A and 300A models are presently available as UL listed models.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2 - Specifications

General Specifications

Inverter Output – Variable Torque:	Rated Output Power	Up to 9 MW
	Output Voltage	0 – 7200 Volts
	Output Frequency (Min/Max)	0.1 – 300 Hz
	Rated Output Currents Available	130A, 260A, 300A, 440A, 550A, 660A, 770A
	Required Auxiliary Supply	230 VAC (-0%/+10%), 60 Hz
Converter Input:	Rated Supply Voltage	480 – 13.8 kV
	Rated System Frequency	50 – 66 Hz
	Input Distortion	Meets IEEE 519 when using 18-pulse or greater rectifier system
	Voltage Variations	Steady State: +/- 10% Transient State: +10%, -30% for 30 Line Cycles
	Frequency Variations	Steady State: 95 - 105% Transient State: +/-5% / sec
Environmental Conditions	Ambient Temperature	Min. 0° C (no frost), Max. 40° C
	Humidity	95%, no condensation
	Air Quality	No corrosive gasses or semi-conductive dust
	Pollution	IEC 61010-1 and UL 840 Degree 2 IEC 60664-3 (Optional)
	Seismic	IBC-2006 (3G on stiff soil)
	Altitude	1,000 meters 4,000 meters derated operation

Cooling System	Cooling Method	
	• Inverter/Converter • Fans Designed for N-1 Redundancy	Forced Air
	Fans Designed for N-1 Redundancy	
	Heat Loss at Full Load (max)	
	• Inverter • Converter	<1% Full Load kW <2% Full Load kW
Construction	Power Connection Entry	Bottom or Top
	Power Connection Type	
	• Inverter • Converter	Cables Cables
	Auxiliary Cable Entry	Bottom or Top
Lifting Provisions	Integral channel slots in bottom cabinet frames	
Minimum Clearance	(Front x Back x Sides x Above)	36 x 0 x 0 x 36 inches

Electrical Ratings – 300A Unit

Terminal Points and Functions

Table 1: Converter Power Wiring Terminals

Function	Terminal	Description
AC Line Power Input	H1 (L1/R)	3 Phase AC Line Power to Converter (Transformer Terminals) 4160VAC 260A 50/60Hz.
	H2 (L2/S)	
	H3 (L3/T)	
Chassis Ground	CG	Ground Input
DC Power Output	DC (+)	DC Power to Inverter 6300VDC 292A
	DC (-)	
AC Control Power Input	FU10 (L)	Single Phase AC Control Power from Inverter (for Fans) 230VAC 20A 50/60Hz.
	FU11 (N)	

Table 2: Converter Control Wiring Terminals

Function	Terminal	Description
Control Wiring to / from Converter	TB1-6 (relay common)	115VAC from Inverter
	TB1-6TW (relay NC contact)	3A 125VAC
	TB1-6TF (relay NC contact)	
	TB1-6CW (relay NC contact)	
	TB1-6CF (relay NC contact)	

Table 3: Inverter Power Wiring Terminals

Function	Terminal	Description
DC Bus Power Input	DC (+)	DC Bus Power from Converter 6300VDC 292A
	DC (-)	
Ground	CG	Chassis Ground
AC Motor Power Output	T1	3 Phase AC Power to Motor 0 to 4160VAC 300A 0 to 60Hz. PWM
	T2	
	T3	
AC Control Power Input	TB1-4 (L)	Single Phase AC Control Power to Inverter 230VAC 40A 50/60Hz.
	TB1-5 (N)	
	TB1-GND	
AC Control Power Output	TB2-4D TB2-5D	Single Phase AC Control Power to Converter (for Fans) 230VAC 20A 50/60Hz.

Electrical Ratings – 260A unit

Terminal Points and Functions

Table 4: Converter Power Wiring Terminals

Function	Terminal	Description
AC Line Power Input	H1 (L1/R)	3 Phase AC Line Power to Converter (Transformer Terminals) 4160VAC 230A 50/60Hz.
	H2 (L2/S)	
	H3 (L3/T)	
Chassis Ground	CG	Ground Input
DC Power Output	DC (+)	DC Power to Inverter 6300VDC 259A
	DC (-)	
AC Control Power Input	FU10 (L)	Single Phase AC Control Power from Inverter (for Fans) 230VAC 20A 50/60Hz.
	FU11 (N)	

Table 5: Converter Control Wiring Terminals

Function	Terminal	Description
Control Wiring to / from Converter	TB1-6 (relay common)	115VAC from Inverter
	TB1-6TW (relay NC contact)	3A 125VAC
	TB1-6TF (relay NC contact)	
	TB1-6CW (relay NC contact)	
	TB1-6CF (relay NC contact)	

Table 6: Inverter Power Wiring Terminals

Function	Terminal	Description
DC Bus Power Input	DC (+)	DC Bus Power from Converter 6300VDC 259A
	DC (-)	
Ground	CG	Chassis Ground
AC Motor Power Output	T1	3 Phase AC Power to Motor 0 to 4160VAC 260A 0 to 60Hz. PWM
	T2	
	T3	
AC Control Power Input	TB1-4 (L)	Single Phase AC Control Power to Inverter 230VAC 40A 50/60Hz.
	TB1-5 (N)	
	TB1-GND	
AC Control Power Output	TB2-4D TB2-5D	Single Phase AC Control Power to Converter (for Fans) 230VAC 20A 50/60Hz.

Common Electrical Ratings – 260A and 300A Units

Table 7: Inverter Control Wiring Terminals

Function	Terminal	Description
Control Wiring to / from Inverter	TB5-6	115VAC to Converter
	TB6-6TW	120VAC Digital Inputs
	TB6-6TF	2500V optical isolation
	TB6-6CW	2.3mA current draw
	TB6-6CF	Off: 0-40VAC, On: 79-120VAC
Control Wiring to Shunt Trip Circuit Breaker from Inverter	TB6-100 (relay NC contact)	Resistive: 10A
	TB6-101 (relay common)	Inductive: 7A
	TB6-102 (relay NO contact)	20mA / 5VDC minimum

Table 8: Inverter Signal Wiring Terminals (To Customer)

Function	Terminal	Description
Signal Wiring from Inverter	TB7-60 (AO1)	4 – 20mA Analog Outputs
	TB7-61 (AO1 COM)	500V optical isolation
	TB7-62 (AO3)	600 ohm load maximum
	TB7-63 (AO3 COM)	
	TB7-64 (AO2)	
	TB7-65 (AO2 COM)	
	TB7-66 (AO4)	
	TB7-67 (AO4 COM)	

Table 9: Inverter Control Wiring Terminals (From Customer)

Function	Terminal	Description
Control Wiring to Inverter	TB7-68 (DI4)	120VAC Digital Inputs
	TB7-69 (DI5)	2500V optical isolation
	TB7-70 (DI7)	2.3mA draw
	TB7-71 (DI6)	Off: 0-40VAC, On: 79-120VAC
	TB7-80 (DI11)	
	TB7-81 (DI10)	
	TB7-82 (DI12)	

Table 10: Inverter Signal Wiring Terminals (From Customer)

Function	Terminal	Description
Signal Wiring to Inverter	TB7-72 (AI1)	4 – 20mA Analog Inputs
	TB7-73 (AI1 COM)	500V optical isolation
	TB7-74 (AI3)	<100 ohm input resistance
	TB7-75 (AI3 COM)	
	TB7-76 (AI2)	
	TB7-77 (AI2 COM)	
	TB7-78 (AI4)	
	TB7-79 (AI4 COM)	

Table 11: Inverter Control Wiring Terminals (To Customer)

Function	Terminal	Description
Control Wiring from Inverter	TB7-83 (DO2)	230VAC Relay Outputs
	TB7-84 (L2)	2500V optical isolation
	TB7-85 (DO3)	2A maximum
	TB7-86 (L1)	10mA / 5VDC minimum
	TB7-87 (DO4)	
	TB7-88 (L2)	
	TB7-89 (DO5)	
	TB7-90 (L1)	
	TB7-91 (DO6)	
	TB7-92 (L2)	

Table 12: UL Ratings Label / Nameplate 300A

MEDIUM VOLTAGE CONVERSION EQUIPMENT XXXX PA

UL MODEL NO: XCSUAC6CO + M2LU6CGE10

DESCRIPTION: CONVERTER + INVERTER

HP: 2250

NOM. INPUT: 4160 VAC, 260 A, 3Ø, 60 Hz

MAX. INPUT: 4576 VAC, 285 A.

OUTPUT: 0 – 4160 VAC, 300 A, 3Ø, 0 – 60 Hz

SHORT CIRCUIT WITHSTAND RATING: 50 KA @ 4160 V

RESISTENCIA A CORTOCIRCUITOS: 50 KA @ 4160 V

INDICE DE RESISTANCE AUX COURTS-CIRCUITS: 50 KA @ 4160 V

BIL RATING: 45 KV ALTITUDE CLASS 2000m

DILECTRIC RATING: 16975 VDC

BENSHAW ITEM NO.: XCSUAC6CO (Enclosure 1 of 2)

SERIAL NO.:

INPUT: 4160 VAC, 260A, 3Ø, 60 Hz

TRANSITION OUTPUT: 6200 VDC, 300 ADC

CONTROL VOLTAGE: 230 VAC, 20 A, 1Ø, 60 Hz (FROM Enclosure 2 of 2)

FUSE #	MFR	MODEL	AMPS	VOLTS
FU1,FU2.FU3	MERSEN	A150X	300	1500
FU4,FU5,FU6	MERSEN	A150X	300	1500
FU7,FU8,FU9	MERSEN	A150X	300	1500
*FU10,FU11	MERSEN	ATDR	20	600
FU12A,FU12B	MERSEN	CC1500CP	20	1500
FU13A,FU13B	MERSEN	CC1500CP	20	1500
FU14A,FU14B	MERSEN	CC1500CP	20	1500

***WARNING:** FUSES MAY BE ENERGIZED / LAB-100435-01

BENSHAW ITEM NO.: M2LU6CGE10 (Enclosure 2 of 2)

SERIAL NO.:

TRANSITION INPUT: 6200 VDC, 300 ADC

OUTPUT: 0 – 4160 VAC, 300 A, 30, 0 – 60 Hz

INPUT CONTROL VOLTAGE: 230 VAC, 40 A, 10, 60 Hz

FUSE #	MFR	MODEL	AMPS	VOLTS
*FU1,FU2	MERSEN	AJT	40	600
*FU3,FU4	MERSEN	ATQR	10	600
*FU5,FU6	MERSEN	ATQR	3	600
*FU7,FU8	MERSEN	ATQR	10	600
*FU9,FU10	MERSEN	ATQR	20	600
*FU11,FU12	MERSEN	ATQR	15	600

***WARNING:** FUSES MAY BE ENERGIZED / LAB-100436-01

Table 13: UL Ratings Label / Nameplate 260A

MEDIUM VOLTAGE CONVERSION EQUIPMENT XXXX PA

UL MODEL NO: XCSUAC6CN + M2LU6CFE10

DESCRIPTION: CONVERTER + INVERTER

HP: 2000

NOM. INPUT: 4160 VAC, 230 A, 3Ø, 60 Hz

MAX. INPUT: 4576 VAC, 253 A.

OUTPUT: 0 – 4160 VAC, 300 A, 3Ø, 0 – 60 Hz

SHORT CIRCUIT WITHSTAND RATING: 50 KA @ 4160 V

RESISTENCIA A CORTOCIRCUITOS: 50 KA @ 4160 V

INDICE DE RESISTANCE AUX COURTS-CIRCUITS: 50 KA @ 4160 V

BIL RATING: 45 KV ALTITUDE CLASS 2000m

DILECTRIC RATING: 16975 VDC

BENSHAW ITEM NO.: XCSUAC6CN (Enclosure 1 of 2)

SERIAL NO.:

INPUT: 4160 VAC, 230A, 3Ø, 60 Hz

TRANSITION OUTPUT: 6200 VDC, 300 ADC

CONTROL VOLTAGE: 230 VAC, 20 A, 1Ø, 60 Hz (FROM Enclosure 2 of 2)

FUSE #	MFR	MODEL	AMPS	VOLTS
FU1,FU2.FU3	MERSEN	A150X	300	1500
FU4,FU5,FU6	MERSEN	A150X	300	1500
FU7,FU8,FU9	MERSEN	A150X	300	1500
*FU10,FU11	MERSEN	ATDR	20	600
FU12A,FU12B	MERSEN	CC1500CP	20	1500
FU13A,FU13B	MERSEN	CC1500CP	20	1500
FU14A,FU14B	MERSEN	CC1500CP	20	1500

***WARNING:** FUSES MAY BE ENERGIZED / LAB-100442-01

BENSHAW ITEM NO.: M2LU6CFE10 (Enclosure 2 of 2)

SERIAL NO.:

TRANSITION INPUT: 6200 VDC, 259 ADC

OUTPUT: 0 – 4160 VAC, 260 A, 3Ø, 0 – 60 Hz

INPUT CONTROL VOLTAGE: 230 VAC, 40 A, 1Ø, 60 Hz

FUSE #	MFR	MODEL	AMPS	VOLTS
*FU1,FU2	MERSEN	AJT	40	600
*FU3,FU4	MERSEN	ATQR	10	600
*FU5,FU6	MERSEN	ATQR	3	600
*FU7,FU8	MERSEN	ATQR	10	600
*FU9,FU10	MERSEN	ATQR	20	600
*FU11,FU12	MERSEN	ATQR	15	600

***WARNING:** FUSES MAY BE ENERGIZED / LAB-100443-01

3 – Installation

EMC Installation Guidelines

General

In order to help our customers comply with European electromagnetic compatibility standards, Benshaw Inc. has developed the following guidelines.

Attention

This product has been designed for Class A equipment. Use of the product in domestic environments may cause radio interference, in which case the installer may need to use additional mitigation methods.

Enclosure

Install the product in a grounded metal enclosure.

Grounding

Connect a grounding conductor to the screw or terminal provided as standard on each controller. Refer to lay out/power wiring schematic for grounding provision location.

Wiring

Refer to Wiring Practices on page 26.

Wiring Considerations

Wiring Practices

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

- Never connect input AC power to the motor output terminals T1/U, T2/V, or T3/W.
- Power wiring from the power source and to the motor must have the maximum possible physical separation-from all other wiring. Do not run control wiring or signal wiring in the same conduit; this separation reduces the possibility of coupling electrical noise between circuits. Minimum spacing between metallic conduits containing different wire groups should be three inches (8cm).
- Minimum spacing between different wiring groups in the same wire tray should be six inches (15 cm)
- Wire runs outside an enclosure should be run in metallic conduit or have shielding/armor with equivalent attenuation.
- Whenever power and control or signal wiring cross, it should be at a 90 degree angle.
- Different wire groups should be run in separate conduits.

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

Considerations for Control and Power Wiring

Control wiring refers to wires connected to control terminal strips that normally carry 24V to 115V. AC Power wiring refers to wires connected to the line and load terminals that normally carries 4160VAC. Power wiring for cabinet fans carries 240VAC. DC Power wiring refers to wires connected to terminals that normally carry 6400VDC. Select power wiring as follows:

- Use only UL or CSA recognized wire.
- Grounding must be in accordance with NEC, CEC, or local codes. If multiple Drives are installed, then each Drive must be individually connected to ground. Take care not to form a ground loop. The grounds should be connected in a STAR configuration.

Considerations for Signal Wiring

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

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

Meggering a Motor

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

High Pot (High Potential) Testing

If the Drive needs to be high pot tested, perform a DC high pot test. The maximum high pot voltage must not exceed 8520VDC. Failure to comply WILL damage the control circuitry, which WILL NOT be replaced under warranty.

- Note: For Inverter High Pot Test, both control cables connected to the sides of the Pre-Charge Board need to be temporarily disconnected.

Wiring Schematics

Figure 1: MV Drive System Layout

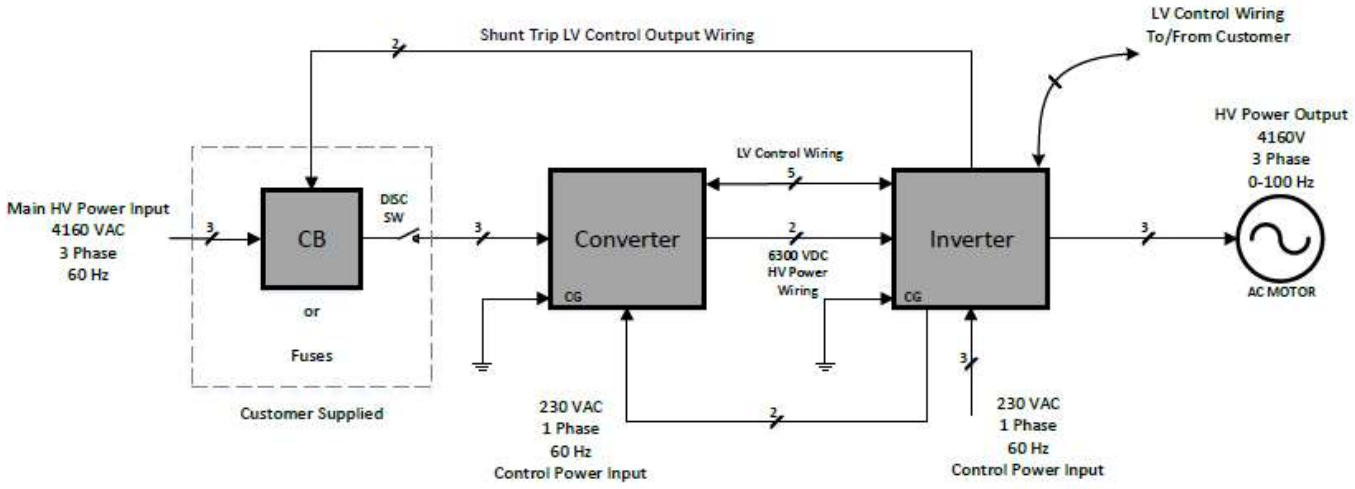


Figure 2: Converter Power and Control Circuit Portions

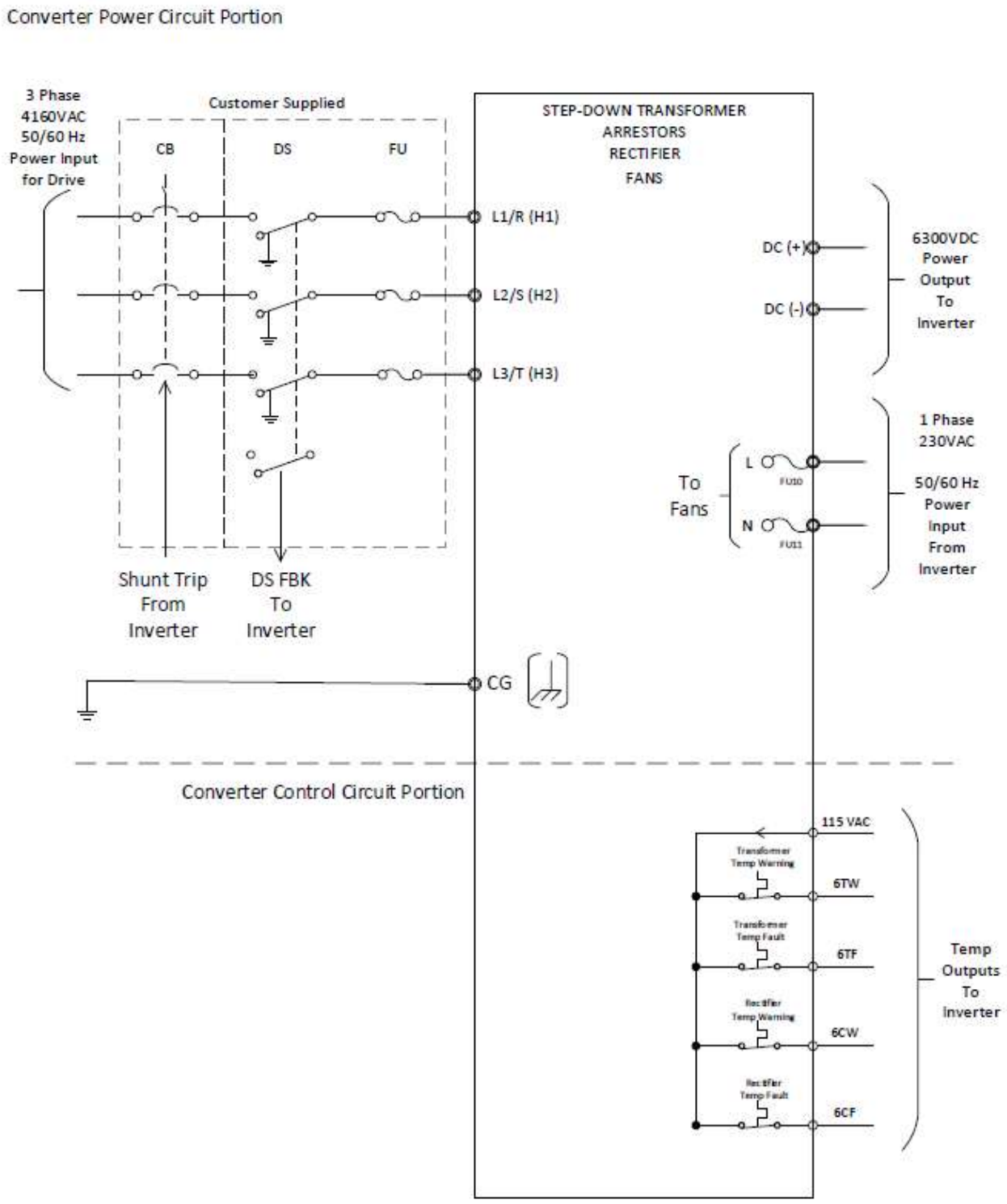
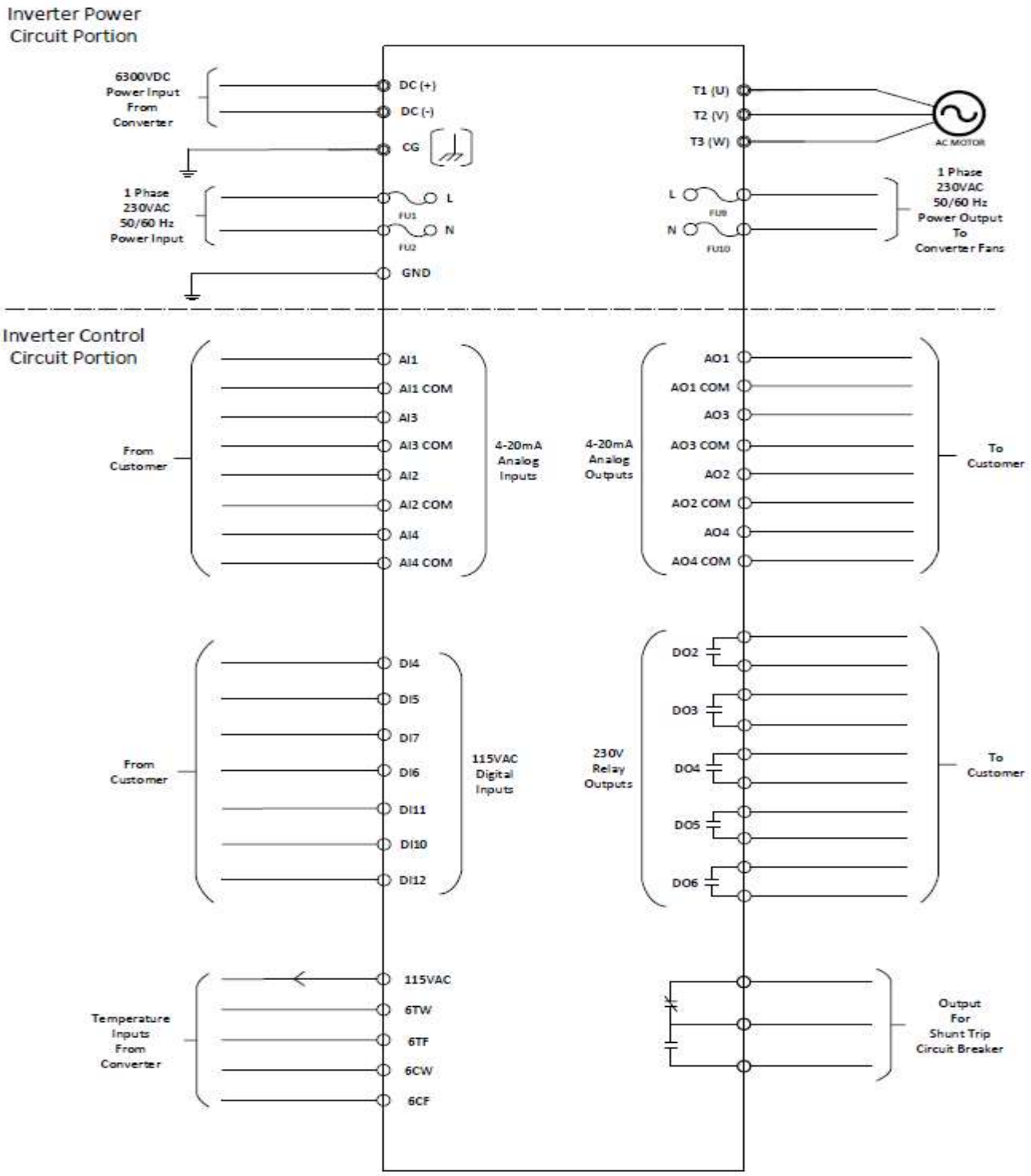


Figure 3: Inverter Power and Control Circuit Portions



Power Wiring

Input Line Requirements

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

Recommended Wire Gauges

The wire gauge selection is based on the FLA of the motor. Refer to NEC table 310, 60 or CEC Part 1, Table 2 or local code requirements for selecting the correct wire sizing. Ensure appropriate wire derating for temperature is applied. In some areas local codes may take precedence over the NEC or CEC. Refer to your local requirements.

Power Wire Connections

Attach the motor cables:
• Use the T1, T2 and T3 terminals. Use lugs/crimps or terminals (lugs and crimps are to be provided by the customer).
Attach the power source cables:
• Use the L1, L2 and L3 terminals. Use lugs/crimps or terminals (lugs and crimps are to be provided by the customer).

Compression Lugs

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

Table 14: Single Hole Compression Lugs

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

Table 15: Two Hole Compression Lugs

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

Motor Lead Length

The standard drive can operate a motor with a maximum of 600 feet of properly sized cable between the “T” leads of the drive and those of the motor. For wire runs greater than 600 feet contact Benshaw Inc. for application assis tance.

Input Line Requirements

The standard drive can operate with a maximum of 300 feet of properly sized cable between the converter and the inverter.

- For wire runs greater than 300 feet, contact Benshaw for application assistance.

DC Lead Length Between Converter and Inverter

The converter and inverter can be located separate from each other. However, the maximum separation distance is limited by the voltage drop of the wiring. The wire gauge must be chosen to minimize voltage drop. The wiring should comply with all local electrical codes, as stated on previous page. Consult Benshaw for more information.

Torque Requirements for Power Wiring Terminations

Table 16: Slotted Screws and Hex Bolts

Wire size installed in conductor		Tightening torque, pound-inches (N-m)							
		Slotted head NO.10 and larger				Hexagonal head-external drive socket wrench			
AWG or kcmil	(mm²)	Slot width 0.047 inch (1.2mm) or less and slot length ¼ inch (6.4mm) or less		Slot width over 0.047 inch (1.2mm) or slot length ¼ inch (6.4mm) or greater		Split-bolt connectors		Other connectors	
18 - 10	(0.82 - 5.3)	20	(2.3)	35	(4.0)	80	(9.0)	75	(8.5)
8	(8.4)	25	(2.8)	40	(4.5)	80	(9.0)	75	(8.5)
6 - 4	(13.3 - 21.2)	35	(4.0)	45	(5.1)	165	(18.6)	110	(12.4)
3	(26.7)	35	(4.0)	50	(5.6)	275	(31.1)	150	(16.9)
2	(33.6)	40	(4.5)	50	(5.6)	275	(31.1)	150	(16.9)
1	(42.4)	--	--	50	(5.6)	275	(31.1)	150	(16.9)
1/0 - 2/0	(53.5 -64.4)	--	--	50	(5.6)	385	(43.5)	180	(20.3)
3/0 - 4/0	(85.0 - 107.2)	--	--	50	(5.6)	500	(56.5)	250	(28.2)
250 - 350	(127-177)	--	--	50	(5.6)	650	(73.4)	325	(36.7)
400	(203)	--	--	50	(5.6)	825	(93.2)	375	(42.4)
500	(253)	--	--	50	(5.6)	825	(93.2)	375	(42.4)
600 - 750	(304-380)	--	--	50	(5.6)	1000	(113.0)	375	(42.4)
800 - 1000	(406-508)	--	--	50	(5.6)	1100	(124.3)	500	(56.5)
1250 - 2000	(635-1010)	--	--	--	--	1100	(124.3)	600	(67.8)

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

Table 17: Tightening Torque for Hex Screws

Socket size across flats		Tightening torque	
Inches	**(mm)**	**Pound-inches**	**(N-m)**
1/8	(3.2)	45	(5.1)
5/32	(4)	100	(11.3)
3/16	(4.8)	120	(13.6)
7/32	(5.6)	150	(16.9)
1/4	(6.4)	200	(22.6)
5/16	(7.9)	275	(31.1)
3/8	(9.5)	275	(42.4)
1/2	(12.7)	500	(56.5)
9/16	(14.3)	600	(67.8

NOTE: For screws with multiple tightening means, the largest torque value associated with the conductor size shall be marked. Slot length shall be measured at the bottom of the slot..

DANGER. This equipment does not provide isolation. Separate isolating means required. Isolation devices can take several forms with the most simple being an appropriately sized disconnect switch and contactor pair utilizing the Inverter 'Shunt Trip' controls, or an appropriately sized and protected vacuum circuit breaker also capable of remote operation from the inverter 'Shunt Trip' controls.

WARNING: Primary power source overcurrent protection is required. For disconnect switch and contactor pairs, the components must be sized to accommodate the following fuse size ratings per chart below: (this also includes the table requirement of the list)

4160 Volt 260 Amp VFD; 300E 5500V fuse Mersen A055F2DORO-300E or equiv.

4160 Volt 300 Amp VFD; 350E 5500V fuse Mersen A055F2DORO-350E or equiv.

This unit provides electronic motor overload protection, refer to pages 77-79 for setup and operational details.

Grounding of the Inverter System: Install ground connections for the inverter system (transformer rectifier converter and inverter) and the motor by following the correct specifications to ensure safe and accurate operation. Using the inverter and the motor without the specified grounding connections may result in electric shock and damage to the equipment. This shall include all input, output, and DC shielded power cable connection grounds as applicable per installation.

4 - Theory of Operation

The Benshaw M2L 3000 family of medium voltage variable frequency motor drives features a unique power circuit, and a state-of-the-art control platform, to provide the utmost in performance and application flexibility.

The M2L 3000 product family is forced-air cooled, and spans a power range from 300 hp to 6,200 hp, operating at industry standard medium voltages up to 7200 VAC output. The drives can be used to control induction and wound field synchronous motors.

This section provides an overview of the drive architecture, along with descriptions of major system components.

M2L 3000 Overview

The M2L 3000 variable frequency drive consists of two major system elements, shown in Figure 4; A Converter (Input Power Stage) and an Inverter (Output Power Stage). The purpose of the Converter is to convert incoming voltage from the AC mains into DC. The DC is passed to the Inverter using standard high-voltage shielded cable, where it is converted into variable voltage, variable frequency 3-phase AC, then applied to the motor.

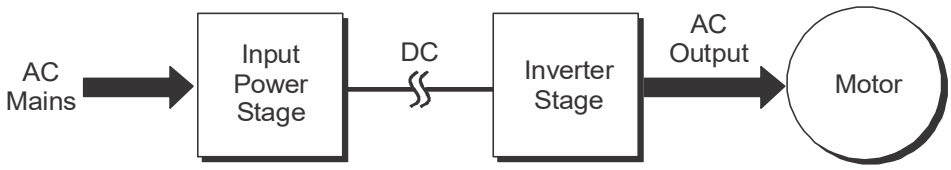


Figure 4: Benshaw M2L 3000 Block Digrams

Most modern MV VFDs employ dual energy conversions (i.e. AC-to-DC and AC-to-DC), but are constrained to have these constituent elements located in close physical proximity to each other, to avoid electrical complications that would compromise the operation of the drive, and adversely affect reliability. The M2L 3000 is *not* constrained in this manner. The Inverter can be located adjacent to, or remotely from, the Converter without causing any adverse affects on the operation of the drive. This feature imparts great application flexibility to users who may have space constraints, or choose to locate the heat producing Converter away from environmentally conditioned equipment rooms or spaces.

Converter

The Converter, or Input Stage, consists of a medium voltage transformer and full-bridge rectifiers that convert the incoming AC mains voltage to a fixed source of DC. Individual 3-phase bridge rectifiers are connected in series, as shown in Figure 5, to produce the required DC voltage for the inverter.

The Converter does not contain any capacitors for energy storage. Energy storage in the drive is distributed among identical power modules in the drive's Inverter. The distributed capacitive energy storage greatly reduces arc flash potential and substantially improves reliability.

The transformer is a standard rectifier grade transformer consisting of a single 3-phase primary winding, with three (3) secondary windings, appropriately phase shifted to yield an 18-pulse current waveform in the primary for low harmonic distortion. The total harmonic distortion (THD) of the primary current is typically ~2.3% for a 1000 hp, 4160 VAC drive operating at full power, which easily complies with IEEE 519 distortion requirements.

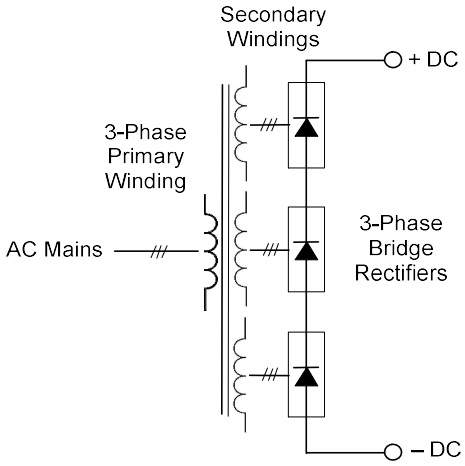


Figure 5: M2L 3000 Converter

Typically, the primary voltage of the transformer is identical to the AC operating voltage of the motor; however, the M2L 3000 can accommodate voltages that differ from the motor voltage. For example, a customer application may require that a 4160 VAC induction motor be operated from a 2300 VAC or 13.8k VAC source. In this case, the primary winding would be specified to be 2300 VAC or 13.8 kVAC. The secondary winding voltages have been selected to generate the DC voltage needed to synthesize AC waveforms for 4160 VAC at its output terminals.

Two typical size Converter enclosures (small and large frame) are shown in Figure 6, with all electrical components contained within the enclosures. The enclosure design allows for top or bottom entry of all cable connections between the AC mains and the Inverter.

The Converter is forced-air cooled. Cooling air is drawn through filters on the front of the enclosure by multiple blowers mounted on the top. The Converter is designed to function with "N-1 Redundancy" (for example only 2 of 3, or 4 of 5 blowers operating), providing redundant protection and high operating availability. Filter elements are provided in series on the front of the enclosure, to block the ingress of dirt and dust particulates. The filter assembly mounts over a protective screen, welded to the enclosure, that prevents inadvertent contact with the resident high voltages when the filter media is removed for cleaning or replacement.

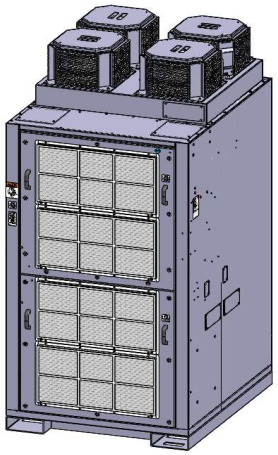


Figure 6: 300 Amp Converter

The enclosure also contains internal baffles that route air flow through critical areas of the transformer, and across the rectifier assemblies. Thermal sensors are located in the input air stream to the blowers, to detect over temperature conditions. The standard Converter enclosure is rated for NEMA 1 applications. Enclosures with other environmental ratings are available.

Converter Details

The standard transformer consists of a single 3-phase primary winding, with three 3-phase secondary windings that are phase displaced to produce an 18-pulse current waveform in the primary winding. The primary winding includes taps to adjust for slight variations in the incoming line voltage, to accommodate nominal, low, or high line conditions. Variations of ±5% can be accommodated by jumpering the incoming AC cables to the to +5% tap for high line conditions and the -5% tap for low line conditions.

Three secondary windings are physically shifted on the transformer core to yield voltages that are phase displaced by ±20 electrical degrees with respect to the primary winding. Figure 4 shows the schematic diagram of a typical transformer.

Each secondary winding is connected to a dedicated 6-pulse, full-wave bridge rectifier that converts AC to DC, as shown schematically in Figure 7.

The DC terminals of all three (3) rectifier bridges are connected in series, such that the appropriate output voltage is generated at the output of the VFD.

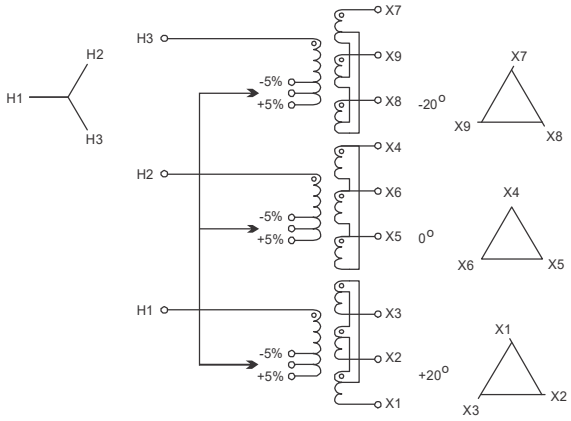


Figure 7: Main Transformer

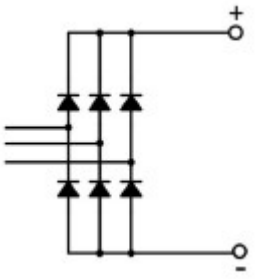


Figure 8: 6-Pulse Bridge Rectifier

12, 24 and 36 pulse converters are optionally avalilable

Inverter

The role of the Inverter is to convert DC voltage produced by the Converter to variable voltage, variable frequency AC, to be applied to the motor terminals. The Inverter utilizes a topology known as Modular Multi-Level Converter (M^2LC), which offers many benefits.

M^2LC topology allows the Converter to be located remotely from the Inverter, for the ultimate in application flexibility. The Inverter is a modular design enabling rapid drive repair by simple removal and replacement of a faulty module or “cell”. Replacing a cell can be done in a matter of minutes, minimizing downtime and process interruption.

IGBT Cell

The standard building block in the M2L 3000 Converter is the “cell”. A variety of cell sizes are available, having different current ratings to configure drives at different power levels.

A cell consists of Insulated Gate Bipolar Transistors (IGBTs), capacitors, associated control, communication and gating circuitry, heatsinks, and sensors; all housed in a metal enclosure. A depiction of the cell is shown below in Figure 9.

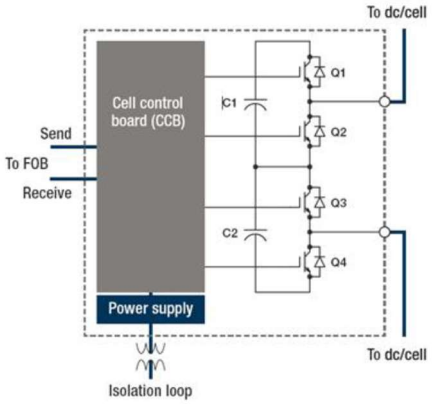


Figure 9: IGBT Cell

Each cell contains IGBT switching devices and film capacitors. These film capacitors offer significant improvements over conventional electrolytic capacitor technologies. This technology is more stable, and safer, than conventional capacitors that can explode from the buildup of high pressures within the capacitor if a failure should occur.

Embedded cell circuitry provides intelligence for control and communication. Communication with the central control system of the drive occurs over optical fiber, using an Ethernet protocol that greatly improves speed and noise immunity. Each cell is designed to sense voltage and current, eliminating the need to place external voltage and current sensors on the motor leads.

The elimination of external sensors removes single points of failure, improving drive reliability.

A typical 4160VAC inverter contains eighteen (18) cells, arranged 6 cells per phase as shown in Figure 7. The cells are connected in series within each phase, and the phases are connected in parallel across the internal DC bus. DC voltage is divided evenly among the cells in each phase.

The cells in each phase work together to create the AC output waveform. Pulse width modulation (PWM) control is used to convert DC voltage into a low distortion AC waveform, which is applied to the motor terminals labeled A, B and C in Figure 10. Each output phase provides an equivalent waveform for optimal harmonic characteristics. As such, output filters are not required. Additionally, the Inverter has been designed to work with standard, non-inverter grade motors commonly found in use today.

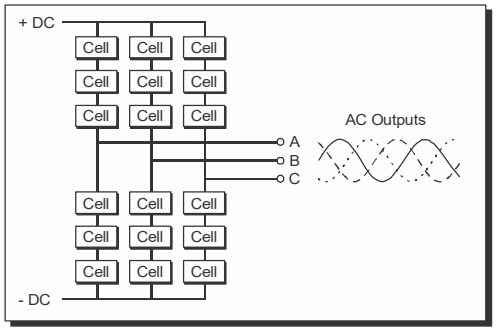


Figure 10: 18 Cell Inverter

Inverter Packaging

The front view of a typical small frame 1500 hp Inverter is shown below in Figure 11. Other specialized configurations of the Inverter can be utilized for higher horsepower and/or voltage applications. The typical enclosure is partitioned into 3 sections: Cell, Input/Output and Control. The enclosure contains internal structural members that provide strength, rigidity and voltage isolation, with bolt-on metal covers for each section attached to the structural members.

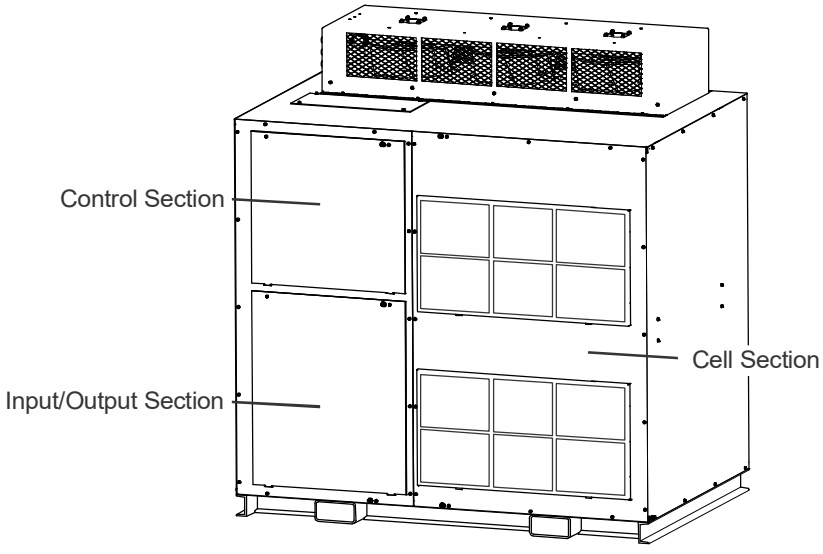


Figure 11: Typical 1500 hp Inverter Front View

WARNING: Do not remove the Cell or Input/Output Section covers to access the Inverter while the Inverter is energized. Potentially lethal levels of both AC and DC voltages will be exposed which may result in serious injury or death.

WARNING: Potentially hazardous voltages will remain in the cells until the internal capacitors are able to de-energize. Wait at least 30 minutes after main power is removed for the stored voltages to dissipate if removing the Inverter Cell or Input/Output section covers. Do not rely solely on the voltage values displayed on the HMI to determine if it is safe to remove the covers on the Inverter Cell and Input/Output sections.

WARNING: The Control section contains 240V control power when active. The Control section does not contain medium voltage levels supplied from the mains, and can be carefully accessed by qualified personnel while medium voltage from the AC mains is applied to the system.

CAUTION: Special care must be taken with the cover over the Control section and all access panels. A ground wire is attached to the inside of that cover that ties it to ground potential. It is important that the connection integrity of this wire be maintained to avoid compromising the immunity of the Inverter to Electromagnetic Interference (EMI.).

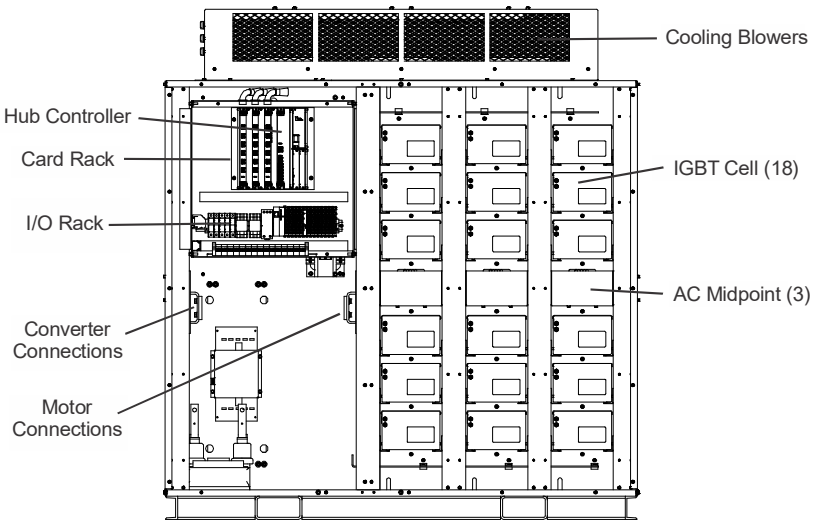


Figure 12: Typical 1500 hp Inverter – Front View with Covers Removed

Figure 12 represents a typical small frame, 1500 hp, 18 Cell Inverter with the front covers removed. IGBT cells can be seen as 3 vertical columns in the right side of the enclosure. The leftmost vertical column, located closest to the center of the enclosure, is Phase A followed by Phases B and C. The AC midpoint of each phase is located behind the grey panels covering the AC terminals and inductive filters.

Internal cabling routes the AC outputs from the phases to the Input/Output section of the Inverter, in the area located in the lower left of the enclosure. Also shown in this section are components associated with the pre-charge function and current loop power for the IGBT cells.

The Input/Output section of the enclosure is the area where power connections are made to the Inverter. AC output cables from the motor are attached to landing pads on the right side of the Input/Output section, while high voltage cables that interconnect the Converter and Inverter are attached to landing pads on the left side. The enclosure allows for top or bottom entry of both AC and DC cables.

The Inverter is forced-air cooled. Air is drawn through filters on the front of the enclosure by blowers mounted on the top. The Inverter is designed to function with only 3 of the 4 blowers operating at any given time, providing redundancy and high operating availability. Two filter elements are provided in series on the front of the enclosure to block the ingress of dirt and dust particles. The filter assembly mounts over a protective screen, welded to the enclosure, that prevents inadvertent contact with the resident high voltages when the filter media is removed for cleaning or replacement.

The compartmental nature of the Inverter's internal design provides baffling to route air flow through critical areas of the enclosure. The standard Inverter enclosure is rated for NEMA 1 applications.

For testing and checkout purposes, the Inverter is designed with a power supply system that enables control power to be applied without medium voltage main power being applied.

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BENSHAW®
ADVANCED CONTROLS & DRIVES

5 - Operation

This section provides basic operation instructions for the M2L 3000 HMI (Human-Machine Interface) controller.

WARNING: Only qualified personnel familiar with the use and hazards of medium voltage equipment are to perform work described in this set of instructions.

Introduction

The HMI is an interactive controller and display which provides the ability to both monitor and control operation of the drive.

Custom parameters are accessible to modify the characteristics of drive performance. Refer to *Section 5 - Parameter List*, for the complete list of user accessible parameters in tabular format, and to *Section 6 - Parameter Descriptions*, for explanations of how each parameter is used. Initial setup of basic parameters may be required for your site application, and should be configured during drive commissioning. Many parameters can also be adjusted while the drive is running, as noted in the parameter tables in Section 5 of this manual.

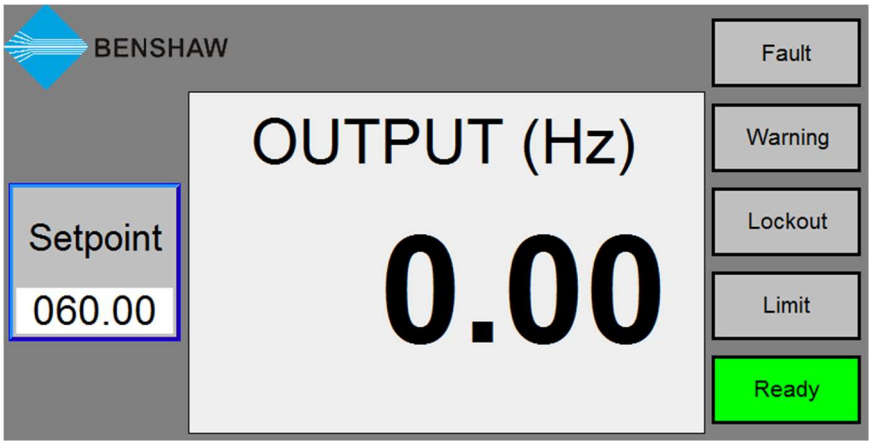
CAUTION: Parameter settings and adjustments should be performed by those familiar with VFD and motor operation characteristics. It is not recommended for users unfamiliar with these concepts.

HMI Overview

The HMI display can be divided into three primary areas:

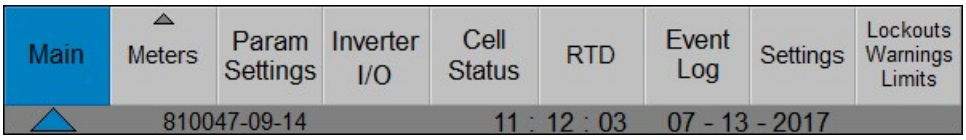
Selectable View

Most of the HMI screen is dedicated to the active view, selectable at run time. The default view shows Speed Setpoint, Output Frequency, and general status indicators, intended to be visible at a distance.



Navigation Menu

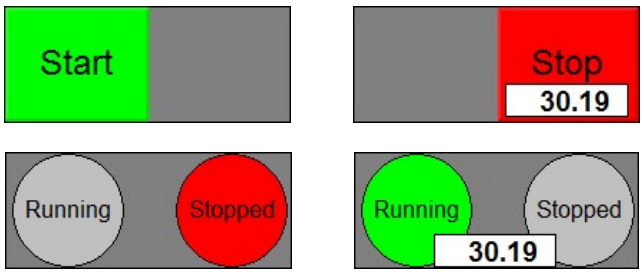
This menu is visible at all times, at a fixed position at the bottom of the screen. The navigation buttons can be used to switch between different views.



Drive Controls

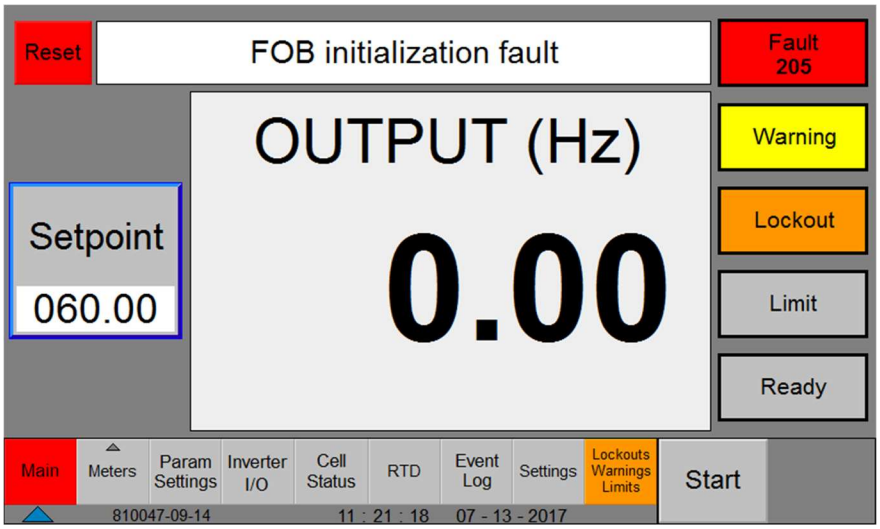
Located to the right of the Navigation Menu, the Drive controls also remain visible regardless of the active View.

This area will contain *Start/Stop* buttons when the drive is configured for HMI control, and *Running/Stopped* status indicators for other control modes. If the default view is not selected, this area will also display the output frequency while the Drive is running.



Status Indicators

The general status indicators shown on the *Main* HMI view give an overview of the Drive status. Blinking indicators on this screen are designed to draw attention so that error conditions can be quickly resolved.



Ready

This indicator will turn green when the Drive is ready to run. If the Drive is configured for HMI control, the *Start* button will also turn green.

Fault

The M2L 3000 is designed to detect and report various fault conditions. When a fault occurs, the status indicator on the right and the *Main* button on the Navigation Menu will blink red. The name of the latched fault will appear across the top of the screen. Refer to Section 7 - Fault Conditions, for a complete list of Faults, descriptions and solutions.

Once the underlying cause of a fault is resolved, the fault can be cleared by pressing the *Reset* button to the left of the fault name. A fault reset can also be performed by a configured digital input, or by a plant PLC writing to the control register.

Lockout

Lockout conditions will prevent the Drive from running. When any lockout occurs, the status indicator on the right and the *Lockouts Warnings Limits* button will blink orange. Unlike faults, lockouts do not latch; the lockout will clear as soon as the underlying condition is resolved, without a manual reset.

Any lockout condition that occurs while the Drive is running will trigger a fault with the same name. This fault is latched, so that the lockout cannot be cleared before it is seen by the operator.

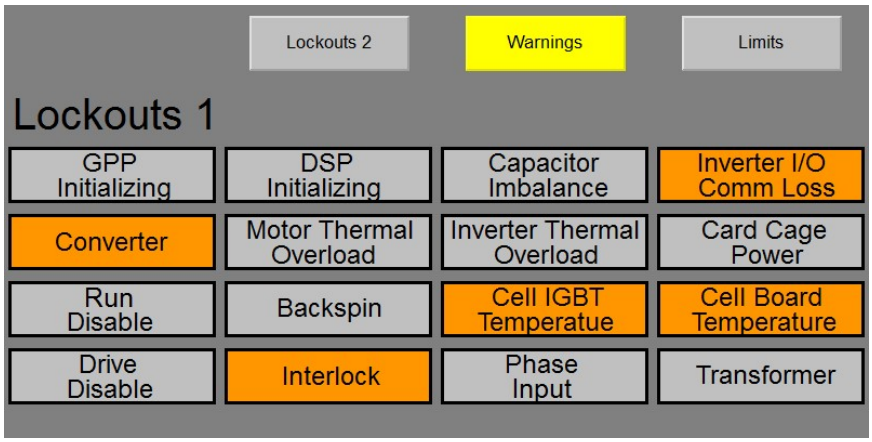
Warning

Warning conditions are less serious than faults or lockouts, and will not prevent the drive from running. Some warnings, such as *Cell Board Temperature,* indicate that a meter is approaching the trip point, and a fault or lockout is likely to occur. When a warning occurs, the indicator on the right will display solid yellow. If no lockout is active, the *Lockouts Warnings Limits* menu button will also turn yellow.

Limit

Limits are triggered when following normal operation would cause the Drive to fault. The Drive will temporarily ignore some parameter settings, such as *Acceleration Ramp Time,* in order to run without faulting. When a limit occurs, the indicator on the right will display solid yellow. If no lockout is active, the *Lockouts Warnings Limits* menu button will also turn yellow.

Select *Lockouts Warnings Limits* from the navigation menu to view the specific lockout, warning, and limit conditions. For each status indicator on the *Main* view, multiple conditions could be present.

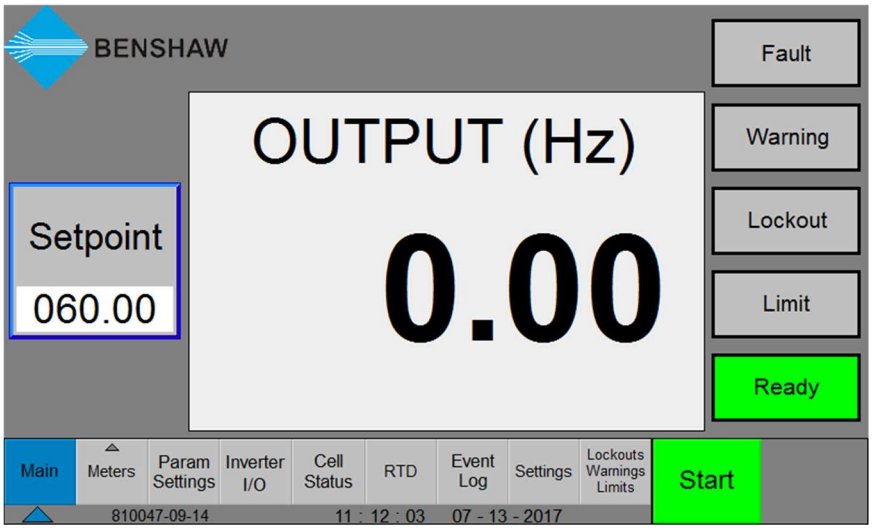


NOTE: Lockout, Warning, and Limit conditions are not latched indefinitely, and can all be cleared without user interaction. Check the *Event Log* for other conditions that may have already cleared.

NOTE: The HMI will automatically navigate to display the first active lockout, warning, or limit. If other conditions are active, the additional navigation buttons at the top of the screen will change color.

Getting the Drive Ready

The ready state indicates that the Drive is ready to run. Until the Drive is ready, all run commands are ignored.



Apply control power to the drive. Control power provides power to run the Drive inverter and the HMI. The HMI will turn on, and the fans on the inverter cabinet will start.

CAUTION: The drive is not equipped with a power switch of any type. Control and Main power must be supplied separately by means of appropriate line application equipment or switchgear. Contact Benshaw for assistance in the selection of applicable devices.

NOTE: If main power (e.g. 4160V nominal) is not applied, a “No DC Bus Fault” will occur. After main power is applied, press the *Reset* button next to the fault name on the HMI

NOTE: If a series of question marks are displayed on the HMI over each display field, there is a failure in connectivity between the Drive inverter and the HMI. Check to ensure proper seating of the interconnection cables.

The automatic pre-charge sequence of the cell capacitors will initiate on start-up. When the pre-charge is complete, and any fault or lockout conditions are cleared, the *Main* view will indicate a ready state.

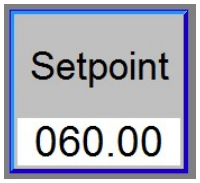
Operating the Drive

With default parameter settings, the Drive can be fully operated from buttons on the HMI. If a plant PLC or some other control source is active, the *Start* and *Stop* buttons will not be available, and the speed setpoint will be shown as a meter.

> **NOTE**: Basic parameter settings for your application were set during drive commissioning. If changes from those settings are required, select *Parameter Settings* from the navigation menu to select and change any parameters required.

1. Navigate to the *Main* view.

2. Select *Setpoint* to set the desired speed of the motor in Hz.

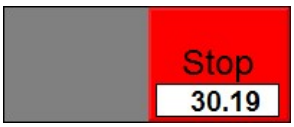


> **NOTE:** The allowable range of 0-300Hz presented by the HMI will not always match parameter settings. If a value is entered outside of the range defined by the *Minimum Frequency* and *Maximum Frequency* Drive parameters, the setpoint will change to the nearest acceptable value.
>
> **NOTE:** A negative setpoint is not used to run the Drive in reverse. The *Run Reverse* button takes the inverse of the speed setpoint to run at a negative frequency.

3. To start the motor, select *Start*. The Drive will accelerate according to the *Start Mode* and other parameter settings.

> **NOTE**: If reverse capabilities are enabled, select either *Run Forward* or *Run Reverse* to start the motor.

4. To stop the motor, select Stop. The Drive will stop the motor according to parameter settings.



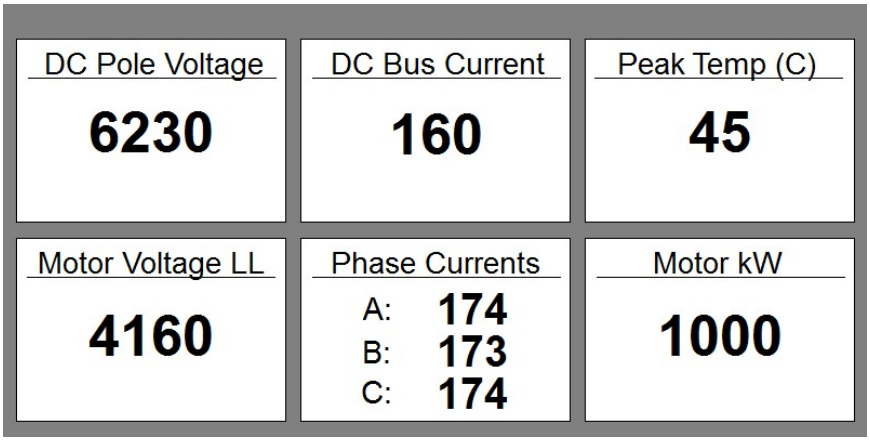
> **NOTE:** The speed setpoint can be adjusted at any time while the drive is running.

Selectable View Options

At any time, the navigation menu can be used to select different view options. Each view presents different information for monitoring the Drive meters or adjusting settings.

Meter Values

The *Meter Values* view displays real time feedback for the following values:



DC Pole Voltage
This value reflects voltage stored in the system capacitors.

WARNING: Potentially hazardous voltages will remain in the cells until the capacitors are able to de-energize. Wait at least 30 minutes after main power is removed for the stored voltages to dissipate if removing the Inverter Cell or Input/Output section covers. Do not rely solely on the voltage values displayed on the HMI Meter Values screen to determine if it is safe to remove the covers on the Inverter Cell and Input/Output sections.

DC Bus Current
This value reflects the DC Bus current.

Peak Temperature (C)
This value reflects the highest measured temperature from all cell temperature monitors.

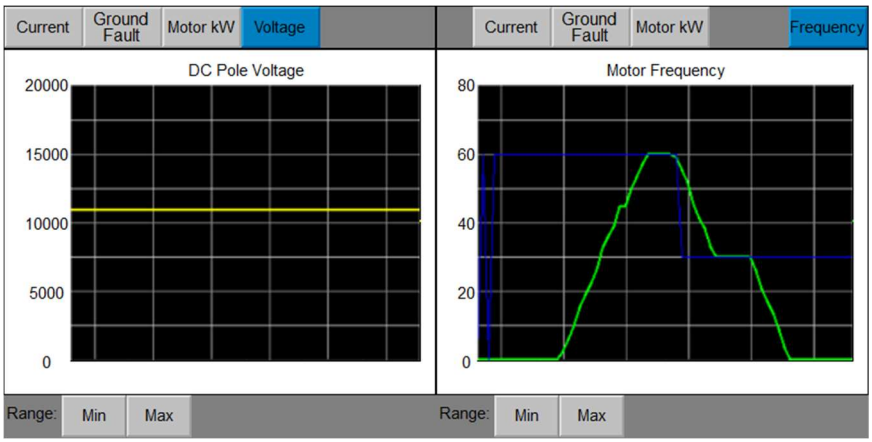
Motor Voltage LL (Line-to-Line)
This value reflects the voltage that the drive is sending to the motor.

Phase Currents
This value reflects the individual RMS motor phase currents.

Motor kW
This value reflects the real power on the motor, or “motor load in kW”.

Meter Trending

Real-time feedback is provided in the form of trending graphs. Two of five graphs can be displayed at any given time that reflect the following data:



Current
The three values on this graph reflect the actual three-phase current being applied to the motor.

Ground Fault
This value reflects the ground fault analog input. The Drive is typically configured to trip when the ground fault input exceeds 5V in either the positive or negative direction.

Motor kW
This value reflects the real power on the motor, or motor load, in kW.

Voltage
This value represents the DC Bus voltage.

Frequency
This graph shows the output frequency of the motor in green, and the frequency command in blue.

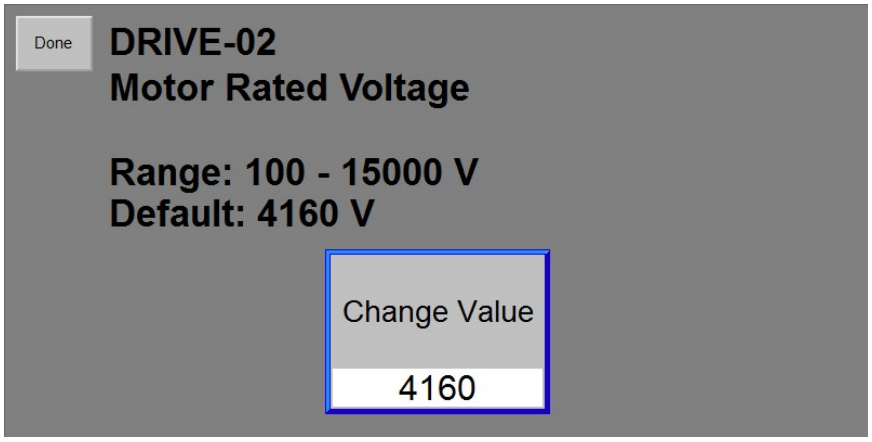
NOTE: The scale of each meter can be changed using the Min and Max buttons below the graph. An option in the HMI settings can be used to reset all trend ranges to their default values.

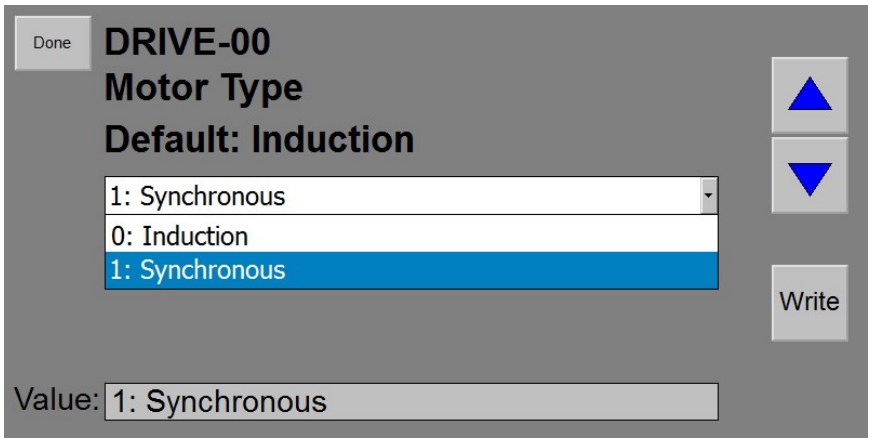
NOTE: These values are displayed in real time only, and not stored within the system.

Parameter Settings

System parameters can be viewed and adjusted from the HMI, to customize the behavior of the Drive. Parameter values are stored by the Drive, and retained when control power is lost. Refer to *Section 5 - Parameter List* for a listing of all user accessible parameters, and *Section 6 - Parameter Descriptions* for information regarding the usage of each parameter.

Depending on the parameter, the HMI will display either a numeric value, or a drop-down selection.



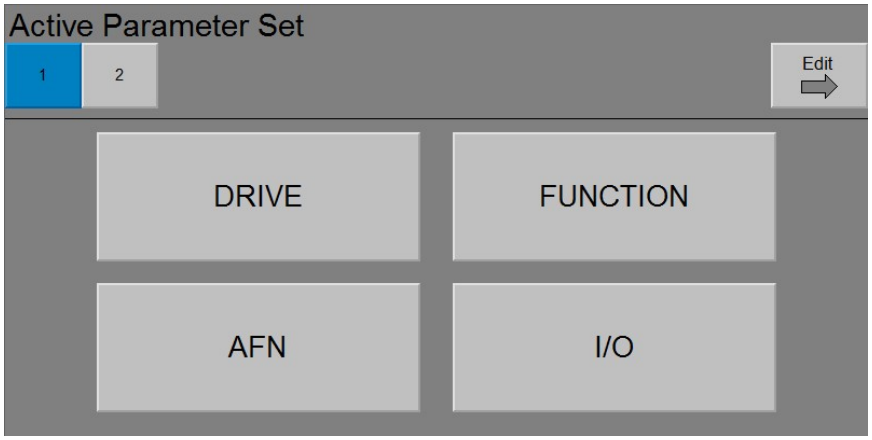


NOTE: Some parameters cannot be changed while the drive is running. The HMI will display an error message, and the requested value will not be saved to the Drive.

NOTE: A security pin can be used to lock all parameters. Each parameter can still be selected to view the current value, but the HMI will not allow that value to be changed. This lock can be adjusted in *Settings.*

Parameter sets can be used to quickly change multiple parameter values. This optional configuration allows the Drive to switch between different operation or load conditions without pausing to change numerous settings.

Once parameter sets are configured, any changes made to specific parameter settings are only saved to the active parameter set, highlighted in blue. The *Edit* button can be used to create and delete parameter sets, copy all values from the active parameter set, or restore factory default settings.



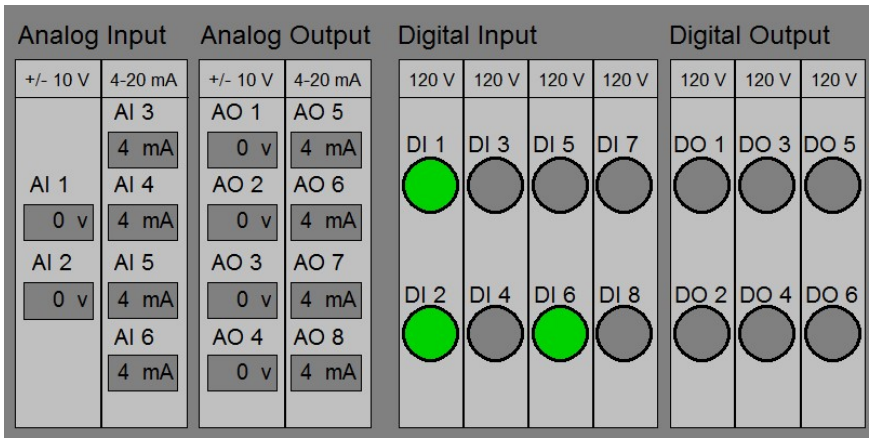
NOTE: If no parameter sets have been created, the parameter set selection buttons will not be displayed. Use the *Edit* button to generate new parameter sets.

NOTE: If the parameters are locked with a security pin, the *Edit* button will be disabled. Go to *Settings* to unlock parameters.

NOTE: For synchronous transfer drives operating multiple motors, a parameter set must be generated for each motor. If the motors are identical, the values from parameter set 1 can be copied to all other required sets. Any additional changes to parameter settings should then be copied across each parameter set.

Inverter I/O

This view shows the status of all inputs and outputs to the block of I/O located inside the Inverter cabinet.



This information can be used to check control signals from the plant, and monitor any feedback. If the analog input and output values do not match those expected by the connected device, parameters for each I/O point can be adjusted. *Section 7 - Parameter Descriptions* explains how to adjust analog I/O settings.

NOTE: The status of this screen only reflects the meter values read by the HMI, and is not a guarantee that voltage is absent from the I/O wiring. Control power should be removed before servicing any I/O wiring.

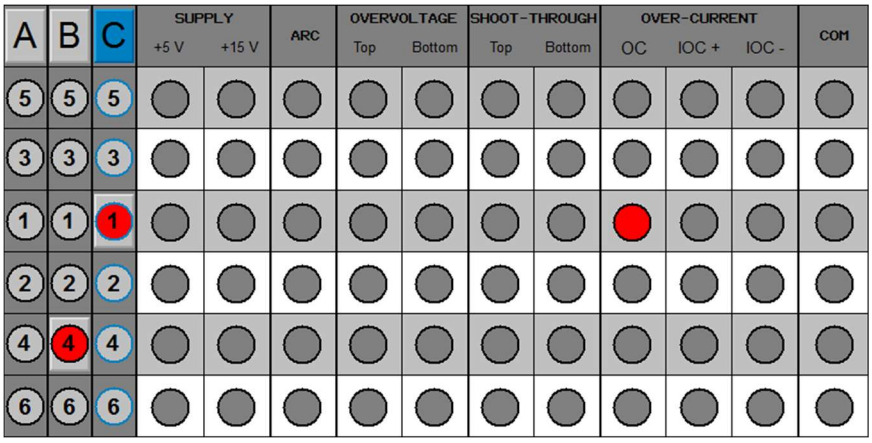
Cell Status

This view displays meter values for each individual cell in the inverter. The top menu can be used to switch between phases (A, B, C). The cell numbers listed on the left of the screen correspond to the physical cell layout, and can be used as a reference when testing and replacing problematic cells.

A	B	C	CAP VOLTAGE Top	CAP VOLTAGE Bottom	SUPPLY VOLTAGE +5	SUPPLY VOLTAGE +15	IGBT TEMP Top	IGBT TEMP Bottom	PWB Temp
5	5	5	1007	1008	4.90	14.7	55	41	39
3	3	3	1003	1007	4.90	14.7	55	42	39
1	1	1	1010	1008	4.91	14.8	55	41	39
2	2	2	1004	1007	4.91	14.8	55	41	36
4	4	4	1008	1008	4.91	14.7	55	41	35
6	6	6	1007	1008	4.91	14.7	55	41	36

NOTE: Yellow or red meter values indicate abnormal conditions in the cell, tied to warnings and faults. Black text in the *Capacitor Voltage* columns is normal while the drive precharges, and should change to green before precharge completes.

When any cell is faulted, the numbered indicator on the left will turn red. Specific faults can then be viewed by pressing the button around the indicator. Multiple cells can fault at the same time, and multiple fault conditions can be present in each cell. See *Section 8 – Fault Conditions* for information on each type of cell fault.

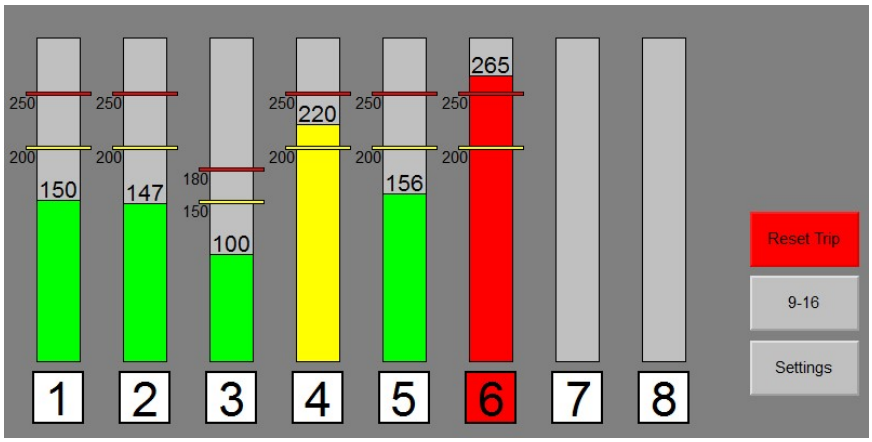


NOTE: For Drives with 12 or more cells per phase, meters are only displayed for 1 cell at a time, with a cell selection menu taking up most of the screen.

WARNING: Potentially hazardous voltages will remain in the cells until the capacitors are able to de-energize. Wait at least 30 minutes after main power is removed for the stored voltages to dissipate if removing the Inverter Cell or Input/Output section covers. Do not rely solely on the voltage values displayed on the HMI Meter Values screen to determine if it is safe to remove the covers on the Inverter Cell and Input/Output sections.

RTD

The system has the capability of displaying real-time feedback from an optional RTD (Resistance Temperature Detector) module. Up to 16 RTD channels can be monitored. The warning and trip level (in degrees Celsius) can be set individually for each RTD channel. Setting the trip level to zero for any channel indicates that no RTD is connected, and the value will not be displayed.



Digital Output 0 from the RTD Module must be wired to one of the digital inputs of the drive as an enable signal in order for the Drive to respond to RTD trips.

- Configured as a Run Enable will stop the motor according to the programmed Stop Mode whenever an RTD Trip occurs.
- Configured as a Drive Enable will cause the Drive to coast to a stop whenever an RTD Trip occurs, regardless of Stop Mode setting.

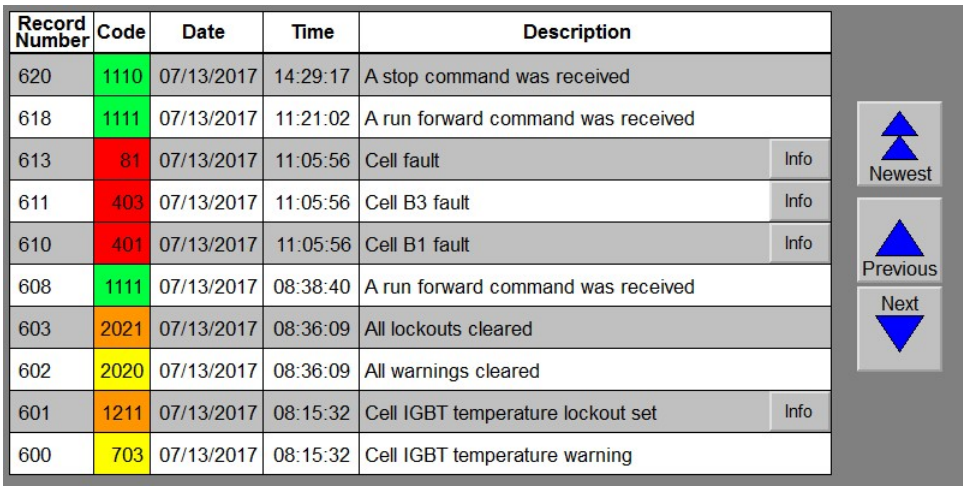
Digital Output 1 of the RTD module indicates when any RTD temperature is above the WARNING level, and may be interfaced to customer control logic.

Digital Output 2 of the RTD module indicates when any RTD temperature is above the TRIP level, and may be interfaced to customer control logic.

NOTE: If no RTD module is connected, the warning and trip levels can still be adjusted. This can cause the HMI to display an RTD trip, but it will have no effect on the operation of the Drive.

Event Log

Recent events from the Drive event log can be viewed on the HMI. These events are stored in the Drive, and are saved after a power cycle. When the *Event Log* button is pressed on the navigation menu, the newest events automatically load.



Ten events at a time are displayed on the HMI, with the most recent event at the top of the list. Use the *Next* and *Previous* buttons to navigate between older events, and the *Newest* button to return to the most recent events.

Some events store additional diagnostic information, viewable as text. Use the *Info* button next to any event to display the info text.

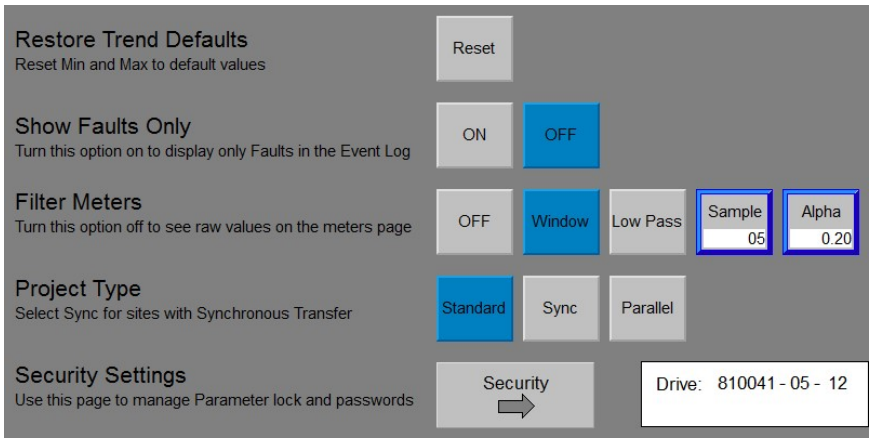
NOTE: If the *Next* button has been used to view older events, navigating back to the Event Log will no longer automatically load the newest events. Use the *Newest* button to return to the most recent events and re-enable this feature.

NOTE: The HMI displays a selection of the most important events. Benshaw's *Event Viewer* program for Windows can be used to load all events, and to more easily navigate to older events. Available from Benshaw.com.

NOTE: The Event Log can also be configured as a traditional fault log; turn this option on in *Settings* to show ten faults at a time, and hide all other events.

Settings

The HMI settings configure how the HMI displays information from the Drive. Unlike *Parameter Settings,* these have no effect on the operation of the Drive.



Restore Trend Defaults

This button reverts all trend displays to the factory default setting. Use this option to ensure full visibility on trended meters.

Show Faults Only

Turn this option *ON* to remove all non-fault events from the *Event Log.* This will also change the text on the navigation menu to *Fault Log.*

Filter Meters

By default, all meters in the *Meter Values* view are displayed with a simple Window filter. This makes the values easier to read, and less sensitive to noise. This filter is not applied to the Output Frequency, which will always display the raw value from the Drive.

OFF

Meter values are updated as fast as the HMI can read them from the Drive, about five times per second.

Window Sample Range: 1 - 10

Meters are displayed as an average of the last set of values read from the Drive. The *Sample* setting determines the size of the window, and how often the displayed value will update.

Low Pass Sample Range: 1 - 10

Alpha Range: 0.01 - 0.99

Meters are displayed using an internal low pass filter algorithm. A higher *Alpha* value increases the response of the filter. The *Sample* setting determines how often the display is updated with the new calculated value.

Project Type

There are three configurations of the Drive that require different view options on the HMI. Simple variations between Drive installations, such as voltage levels and plant interface, do not require special HMI views. This selection should be set during commissioning, and will not need to change.

Standard

A single Inverter, controlling a single motor. This is the default option for Drives.

Sync

Synchronous Transfer. Additional Benshaw equipment allows a single inverter to control multiple motors. Motors, one at a time, can be connected to the Drive, run to match line frequency, and transferred across the line. All motors in a system can be connected to the line, or one motor can be run at a variable frequency.

This option adds two new selectable views to the navigation menu, for status information of the Synchronous Transfer PLC.

Parallel

For the highest horsepower loads, multiple Inverters are connected in parallel to run a single motor. The HMI then shows data for all inverters, along with combined diagnostic information.

This option adds an additional menu to the HMI, described in a separate manual for Parallel Drives.

Security

Use this button to open security settings. These settings determine if the *Parameter Settings* can be changed from the HMI, and for how long. A *User* pin can unlock parameters for thirty minutes, and the *Master* pin can be used to disable parameter protection.

> **NOTE:** Security settings are only applied to parameters. If the HMI is configured as the active control source, any user can still access the *Start* and *Stop* buttons in the control area.

6 - Parameter List

DRIVE Group Parameter List

Table 18: DRIVE Group Parameter List

Parameter	Description	Units / Range	Default	Adjust During Run?	Modbus Register
DRIVE-00	Motor Type	0: Induction 1: Synchronous	Induction	Yes	40173
DRIVE-01	Motor Rated Current	1.0 – 6000.0 A	126.0	No	40048
DRIVE-02	Motor Rated Voltage	100 – 15000 V	4160	No	40050
DRIVE-03	Motor Base Frequency	20.00 – 300.00 Hz	60.00	No	40051
DRIVE-04	Motor Rated kW	0 – 50000 kW	746	Yes	40174
DRIVE-05	Motor Poles	2 – 36	4	No	40053
DRIVE-06	Motor Rated Slip	0.00 – 10.00 Hz	1.00	No	40052
DRIVE-07	Reverse Enable	0: Disabled 1: Enabled	Disabled	No	44484
DRIVE-08	Starting Frequency	0.00 – 10.00 Hz	0.10	Yes	40047
DRIVE-09	Minimum Frequency	0.00 – 300.00 Hz	0.00	Yes	44489
DRIVE-10	Maximum Frequency	1.00 – 300.00 Hz	60.00	Yes	40046
DRIVE-11	Acceleration Ramp Time	0.0 – 1200.0 Sec	120.0	Yes	40040
DRIVE-12	Acceleration Profile	0: Linear 1: U Curve 2: S Curve	Linear	No	40041
DRIVE-13	Acceleration S Curve Factor	1 – 99%	50	No	40042
DRIVE-14	Deceleration Ramp Time	0.0 – 1200.0 Sec	120.0	Yes	40043
DRIVE-15	Deceleration Profile	0: Linear 1: U Curve 2: S Curve	Linear	No	40044
DRIVE-16	Deceleration S Curve Factor	1 – 99%	50	No	40045

FUNCTION Group Parameter List

Table 19: FUNCTION Group Parameter List

Parameter	Description	Units / Range	Default	Adjust During Run?	Modbus Register
FUNCTION-00	Start Mode	0: Accel 1: Flying Start 2: DC Brake then Start	Accel	No	40161
FUNCTION-01	Stop Mode	0: Coast to Stop 1: Decel 2: Coast then DC Brake 3: Decel then DC Brake	Decel	No	40068
FUNCTION-02	Brake Output Frequency	0.10 – 5.00 Hz	0.10	Yes	40160
FUNCTION-03	Starting Brake Time	0.1 – 300.0 sec	0.1	Yes	40162
FUNCTION-04	Starting Brake Level	1 – 100%	1	Yes	40163
FUNCTION-05	Stop Delay Time	0.1 – 60.0 Sec	10.0	Yes	40133
FUNCTION-06	Coast to Brake Time	0.1 – 10.0 sec	0.1	Yes	40156
FUNCTION-07	Stopping Brake Time	0.1 – 300.0 sec	0.1	Yes	40157
FUNCTION-08	Stopping Brake Level	1 – 100%	1	Yes	40158
FUNCTION-09	Decel to Brake Frequency	0.10 – 300.0 Hz	20.00	Yes	40159
FUNCTION-10	Motor Thermal Overload Enable	0: Disabled 1: Enabled	Enabled	Yes	40071
FUNCTION-11	Motor Thermal Overload Level	100 – 300%	110	Yes	40073
FUNCTION-12	Motor Thermal Overload Time	0 – 300 sec	60	Yes	40074
FUNCTION-13	Motor Thermal Overload Release Level	1 – 99%	60	Yes	40137
FUNCTION-14	Motor Service Factor	1.00 – 1.25	1.00	Yes	40129
FUNCTION-15	Motor Thermal Overload Hot/Cold Ratio	0 – 99%	0	Yes	40130
FUNCTION-16	Motor Cooling Type	0: Self Cooled 1: Blower Cooled	Self Cooled	Yes	40072
FUNCTION-17	Motor Cooling Time	0 – 60000 sec	1200	Yes	40075
FUNCTION-18	Motor Self Cool Derate Level at Zero Frequency	0 – 100%	65	Yes	40149
FUNCTION-19	Motor Self Cool Derate Level at Frequency Point	0 – 100%	95	Yes	40151
FUNCTION-20	Motor Self Cool Derate Frequency Point	0.0 – 300.0 Hz	20.0	Yes	40150
FUNCTION-21	Overcurrent Enable	0: Disabled 1: Enabled	Disabled	Yes	40076

Table 19: FUNCTION Group Parameter List

Parameter	Description	Units / Range	Default	Adjust During Run?	Modbus Register
FUNCTION-22	Overcurrent Level	1 – 300%	120	Yes	40077
FUNCTION-23	Overcurrent Trip Time	0.0 – 600.0 sec	0.1	Yes	40078
FUNCTION-24	Undercurrent Enable	0: Disabled 1: Enabled	Disabled	Yes	40134
FUNCTION-25	Undercurrent Level	1 – 99%	1	Yes	40135
FUNCTION-26	Undercurrent Trip Time	0.0 – 600.0 sec	0.1	Yes	40136
FUNCTION-27	Output Phase Loss Enable	0: Disabled 1: Enabled	Disabled	Yes	40079
FUNCTION-28	Output Phase Loss Level	50 – 150%	90	Yes	40080
FUNCTION-29	Output Phase Loss Trip Time	0.1 – 600.0 sec	0.1	Yes	40081
FUNCTION-30	Backspin Lockout Enable	0: Disabled 1: Enabled	Disabled	Yes	44490
FUNCTION-31	Backspin Lockout Time	10 – 3600 sec	10	Yes	44491
FUNCTION-32	Local Control Source	0: Digital Input 1: HMI 2: Modbus TCP 3: DeviceNet	HMI	No	44448
FUNCTION-33	Remote Control Source		Digital Input	No	44449
FUNCTION-34	Local Speed Reference Source	0: HMI 1: Inverter Analog Inpt 1 2: Inverter Analog Inpt 2 3: Inverter Analog Inpt 3 4: Inverter Analog Inpt 4 5: Inverter Analog Inpt 5 6: Inverter Analog Inpt 6 7: Inverter Analog Inpt 7 8: Inverter Analog Inpt 8 9: CCI Analog Input 1 10: CCI Analog Input 2 11: CCI Analog Input 3 12: CCI Analog Input 4 13: CCI Analog Input 5 14: CCI Analog Input 6 15: CCI Analog Input 7 16: CCI Analog Input 8 17: Modbus TCP 18: DeviceNet	HMI	No	44452
FUNCTION-35	Remote Speed Reference Source		Analog Input 3	No	44453
FUNCTION-36	Controller IP Address 1	0 – 255	172	No	44454
FUNCTION-37	Controller IP Address 2	0 – 255	29	No	44455
FUNCTION-38	Controller IP Address 3	0 – 255	87	No	44456
FUNCTION-39	Controller IP Address 4	0 – 255	15	No	44457

Table 19: FUNCTION Group Parameter List

Parameter	Description	Units / Range	Default	Adjust During Run?	Modbus Register
FUNCTION-40	Modbus Master Timeout	0.0 – 600.0 sec	0	Yes	44662
FUNCTION-41	Modbus Master IP Address 1	0 – 255	0	Yes	44663
FUNCTION-42	Modbus Master IP Address 2	0 – 255	0	Yes	44664
FUNCTION-43	Modbus Master IP Address 3	0 – 255	0	Yes	44665
FUNCTION-44	Modbus Master IP Address 4	0 – 255	0	Yes	44666
FUNCTION-45	Year	2000 – 2136	-	Yes	44691
FUNCTION-46	Month	1 – 12	-	Yes	44692
FUNCTION-47	Day	1 – 31	-	Yes	44693
FUNCTION-48	Hour	0 – 23	-	Yes	44694
FUNCTION-49	Minute	0 – 59	-	Yes	44695
FUNCTION-50	Second	0 – 59	-	Yes	44696

AFN (Advanced Function) Group Parameter List

Table 20: AFN (Advanced Function) Group Parameter List

Parameter	Description	Units / Range	Default	Adjust During Run?	Modbus Register
AFN-00	Skip Frequency Enable	0: Disabled 1: Enabled	Disabled	Yes	40139
AFN-01	Skip Frequency Low 1	0.00 – 300.00 Hz	20.00	Yes	40140
AFN-02	Skip Frequency High 1	0.00 – 300.00 Hz	21.00	Yes	40141
AFN-03	Skip Frequency Low 2	0.00 – 300.00 Hz	30.00	Yes	40142
AFN-04	Skip Frequency High 2	0.00 – 300.00 Hz	31.00	Yes	40143
AFN-05	Skip Frequency Low 3	0.00 – 300.00 Hz	40.00	Yes	40144
AFN-06	Skip Frequency High 3	0.00 – 300.00 Hz	41.00	Yes	40145
AFN-07	Dwell Enable	0: Disabled 1: Enabled	Disabled	Yes	40146
AFN-08	Dwell Frequency	0.00 – 300.00 Hz	0.00	Yes	40147
AFN-09	Dwell Time	0.01 – 600.00 sec	0.01	Yes	40148
AFN-10	Flying Start Current Level	1 – 99%	25	Yes	40164
AFN-11	Flying Start Current Application Time	0.01 – 10.00 sec	5.00	Yes	40165
AFN-12	Flying Start Initial Frequency	0.00 – 60.00 Hz	60 Hz	Yes	40197
AFN-13	Flying Start Frequency Ramp Time	0.01 – 30.00 sec	30.00	Yes	40166
AFN-14	Flying Start Current Threshold	1 – 50%	15	Yes	40167
AFN-15	Control Fault Stop Enable	0: Disabled 1: Enabled	Enabled	Yes	40069
AFN-16	Auto Start	0: Disabled 1: Power 2: Fault 3: Power & Fault	Disabled	No	44450
AFN-17	Motor No Load Current	1.0 – 6000.0 A	33.0	No	40049
AFN-18	Motor Rotor Time Constant	0.01 – 10.00 sec	1.00	Yes	40127
AFN-19	Motor Magnetizing Inductance	0.000 – 20.000 pu	3.500	Yes	40125
AFN-20	Motor Leakage Inductance	0.000 – 0.500 pu	0.200	Yes	40126
AFN-21	Motor Stator Resistance	0.000 – 30.000 pu	0.020	Yes	40122

I/O (Input/Output) Group Parameter List

Table 21: I/O (Input/Output) Group Parameter List

Parameter	Description	Units / Range	Default	Adjust During Run?	Modbus Register
I/O-00	Inverter Digital In #1 Function	For Internal Use Only	Converter Warning	No	44313
I/O-01	Inverter Digital In #2 Function	For Internal Use Only	Converter Fault	No	44314
I/O-02	Inverter Digital In #3 Function	For Internal Use Only	Main Cont FBK	No	44315
I/O-03	Inverter Digital In #4 Function	0: None 1: Run FWD 2: Run REV 3: Stop 4: Fault Reset 5: Run Enable 6: Run Disable 7: Local/Remote 8: DC Brake Enable 9: DC Brake Disable 10: External Fault High 11: External Fault Low 12: Drive Enable 13: Drive Disable 14: Input Phase Fault High 15: Transformer Fault Low 16: Transformer Warning Low 17: Converter Warning Low 18: Converter Fault Low 19: Main Contactor Feedback 20: Output Contactor Feedback 21: Input Disconnect Feedback 22: Output Disconnect Feedback 23: DC Link Reactor Warning 24: DC Link Reactor Fault 25: Output Reactor Warning 26: Output Reactor Fault	None	No	44316
I/O-04	Inverter Digital In #5 Function		Run FWD	No	44317
I/O-05	Inverter Digital In #6 Function		Run REV	No	44318
I/O-06	Inverter Digital In #7 Function		Stop	No	44319
I/O-07	Inverter Digital In #8 Function		None	No	44320
I/O-08	Inverter Digital In #9 Function		None	No	44321
I/O-09	Inverter Digital In #10 Function		None	No	44322
I/O-10	Inverter Digital In #11 Function		None	No	44323
I/O-11	Inverter Digital In #12 Function		None	No	44324
I/O-12	Inverter Digital In #13 Function		None	No	44325
I/O-13	Inverter Digital In #14 Function		None	No	44326
I/O-14	Inverter Digital In #15 Function		None	No	44327
I/O-15	Inverter Digital In #16 Function		None	No	44328
I/O-16	Inverter Digital Out #1 Function	For Internal Use Only	Precharge Contactor	No	44330

Table 21: I/O (Input/Output) Group Parameter List

Parameter	Description	Units / Range	Default	Adjust During Run?	Modbus Register
I/O-17	Inverter Digital Out #2 Function	0: None 1: Run 2: Fault - Non Fail Safe 3: Fault - Fail Safe 4: Ready 5: At Speed 6: Forward 7: Reverse 8: DC Brake Active 9: Local Control Source Active 10: Remote Control Source Active 11: Stopped 12: Warning 13: Overcurrent Warning 14: Undercurrent Warning 15: Motor Overload Warning 16: Drive Overload Warning 17: Motor Overload Trip 18: Drive Overload Trip 19: Bus Overvoltage Trip 20: Bus Undervoltage Trip 21: Cell Fault 22: Ground Fault Trip 23: Precharged 24: Precharge Contactor 25: Lockout Active 26: Main Contactor 27: Output Contactor Control 28: Shunt Trip NFS 29: Shunt Trip FS	None	No	44331
I/O-18	Inverter Digital Out #3 Function		None	No	44332
I/O-19	Inverter Digital Out #4 Function		None	No	44333
I/O-20	Inverter Digital Out #5 Function		None	No	44334
I/O-21	Inverter Digital Out #6 Function		None	No	44335
I/O-22	Inverter Digital Out #7 Function		None	No	44336
I/O-23	Inverter Digital Out #8 Function		None	No	44337
I/O-24	Inverter Digital Out #9 Function		None	No	44338
I/O-25	Inverter Digital Out #10 Function		None	No	44339
I/O-26	Inverter Digital Out #11 Function		None	No	44340
I/O-27	Inverter Digital Out #12 Function		None	No	44341
I/O-28	Inverter Digital Out #13 Function		None	No	44342
I/O-29	Inverter Digital Out #14 Function		None	No	44343
I/O-30	Inverter Digital Out #15 Function		None	No	44344
I/O-31	Inverter Digital Out #16 Function		None	No	44345
I/O-32	Inverter Analog In #1 Function	For Internal Use Only	Ground Fault	No	44347
I/O-33	Inverter Analog In #2 Function	0: None 1: Speed Reference	None	No	44348
I/O-34	Inverter Analog In #3 Function		Speed Reference	No	44349
I/O-35	Inverter Analog In#4 Function		None	No	44350
I/O-36	Inverter Analog In #5 Function		None	No	44351
I/O-37	Inverter Analog In #6 Function		None	No	44352
I/O-38	Inverter Analog In #7 Function		None	No	44353
I/O-39	Inverter Analog In #8 Function		None	No	44354
I/O-40	Inverter AI #1 Process - Low	-100.0 – 100.0%	0.0	Yes	44356

Table 21: I/O (Input/Output) Group Parameter List

Parameter	Description	Units / Range	Default	Adjust During Run?	Modbus Register
I/O-41	Inverter AI #1 In - Low	-10.0 – 20.0	0.0	Yes	44357
I/O-42	Inverter AI #1 Process - High	-100.0 – 100.0%	100.0	Yes	44358
I/O-43	Inverter AI #1 In - High	-10.0 – 20.0	10.0	Yes	44359
I/O-44	Inverter AI #2 Process - Low	-100.0 – 100.0%	0.0	Yes	44361
I/O-45	Inverter AI #2 In - Low	-10.0 – 20.0	0.0	Yes	44362
I/O-46	Inverter AI #2 Process - High	-100.0 – 100.0%	100.0	Yes	44363
I/O-47	Inverter AI #2 In - High	-10.0 – 20.0	10.0	Yes	44364
I/O-48	Inverter AI #3 Process - Low	-100.0 – 100.0%	0.0	Yes	44366
I/O-49	Inverter AI #3 In - Low	-10.0 – 20.0	4.0	Yes	44367
I/O-50	Inverter AI #3 Process - High	-100.0 – 100.0%	100.0	Yes	44368
I/O-51	Inverter AI #3 In - High	-10.0 – 20.0	20.0	Yes	44369
I/O-52	Inverter AI #4 Process - Low	-100.0 – 100.0%	0.0	Yes	44371
I/O-53	Inverter AI #4 In - Low	-10.0 – 20.0	4.0	Yes	44372
I/O-54	Inverter AI #4 Process - High	-100.0 – 100.0%	100.0	Yes	44373
I/O-55	Inverter AI #4 In - High	-10.0 – 20.0	20.0	Yes	44374
I/O-56	Inverter AI #5 Process - Low	-100.0 – 100.0%	0.0	Yes	44376
I/O-57	Inverter AI #5 In - Low	-10.0 – 20.0	4.0	Yes	44377
I/O-58	Inverter AI #5 Process - High	-100.0 – 100.0%	100.0	Yes	44378
I/O-59	Inverter AI #5 Inp - High	-10.0 – 20.0	20.0	Yes	44379
I/O-60	Inverter AI #6 Process - Low	-100.0 – 100.0%	0.0	Yes	44381
I/O-61	Inverter AI #6 In - Low	-10.0 – 20.0	4.0	Yes	44382
I/O-62	Inverter AI #6 Process - High	-100.0 – 100.0%	100.0	Yes	44383
I/O-63	Inverter AI #6 In- High	-10.0 – 20.0	20.0	Yes	44384
I/O-64	Inverter AI #7 Process - Low	-100.0 – 100.0%	0.0	Yes	44386

Table 21: I/O (Input/Output) Group Parameter List

Parameter	Description	Units / Range	Default	Adjust During Run?	Modbus Register
I/O-65	Inverter AI #7 In - Low	-10.0 – 20.0	0.0	Yes	44387
I/O-66	Inverter AI #7 Process - High	-100.0 – 100.0%	100.0	Yes	44388
I/O-67	Inverter AI #7 In - High	-10.0 – 20.0	10.0	Yes	44389
I/O-68	Inverter AI #8 Process - Low	-100.0 – 100.0%	0.0	Yes	44391
I/O-69	Inverter AI #8 In - Low	-10.0 – 20.0	0.0	Yes	44392
I/O-70	Inverter AI #8 Process - High	-100.0 – 100.0%	100.0	Yes	44393
I/O-71	Inverter AI #8 Input - High	-10.0 – 20.0	10.0	Yes	44394
I/O-72	Inverter Analog Out #1 Function	0: None 1: Output Frequency 2: Output Freq Magnitude 3: Freq Command 4: Freq Cmd Magnitude 5: Output Voltage 6: Inverter Output Current 7: Inverter Output kW 8: DC Bus V 9: Drive Output Current 10: Drive Output kW 11: Inverter AI 1 12: Inverter AI 2 13: Inverter AI 3 14: Inverter AI 4 15: Inverter AI 5 16: Inverter AI 6 17: Inverter AI 7 18: Inverter AI 8 19: CCI AI 1 20: CCI AI 2 21: CCI AI 3 22: CCI AI 3 23: CCI AI 5 24: CCI AI 6 25: CCI AI 7 26: CCI AI 8 27: Cal + 100% 28: Cal - 100%	None	No	44396
I/O-73	Inverter Analog Out #2 Function		None	No	44397
I/O-74	Inverter Analog Out #3 Function		None	No	44398
I/O-75	Inverter Analog Out #4 Function		None	No	44399
I/O-76	Inverter Analog Out #5 Function		None	No	44400
I/O-77	Inverter Analog Out #6 Function		None	No	44401
I/O-78	Inverter Analog Out #7 Function		None	No	44402
I/O-79	Inverter Analog Out #8 Function		None	No	44403
I/O-80	Inverter AO #1 Process - Low	-100.0 – 100.0%	0.0	Yes	44405
I/O-81	Inverter AO #1 Output - Low	-10.0 – 20.0	0.0	Yes	44406
I/O-82	Inverter AO #1 Process - High	-100.0 – 100.0%	100.0	Yes	44407
I/O-83	Inverter AO #1 Out- High	-10.0 – 20.0	10.0	Yes	44408
I/O-84	Inverter AO #2 Process - Low	-100.0 – 100.0%	0.0	Yes	44410
I/O-85	Inverter AO #2 Out - Low	-10.0 – 20.0	0.0	Yes	44411
I/O-86	Inverter AO #2 Process - High	-100.0 – 100.0%	100.0	Yes	44412
I/O-87	Inverter AO #2 Out - High	-10.0 – 20.0	10.0	Yes	44413

Table 21: I/O (Input/Output) Group Parameter List

Parameter	Description	Units / Range	Default	Adjust During Run?	Modbus Register
I/O-88	Inverter AO #3 Process - Low	-100.0 – 100.0%	0.0	Yes	44415
I/O-89	Inverter AO #3 Out - Low	-10.0 – 20.0	0.0	Yes	44416
I/O-90	Inverter AO #3 Process - High	-100.0 – 100.0%	100.0	Yes	44417
I/O-91	Inverter AO #3 Out - High	-10.0 – 20.0	10.0	Yes	44418
I/O-92	Inverter AO #4 Process - Low	-100.0 – 100.0%	0.0	Yes	44420
I/O-93	Inverter AO #4 Out - Low	-10.0 – 20.0	0.0	Yes	44421
I/O-94	Inverter AO #4 Process - High	-100.0 – 100.0%	100.0	Yes	44422
I/O-95	Inverter AO #4 Out - High	-10.0 – 20.0	10.0	Yes	44423
I/O-96	Inverter AO #5 Process - Low	-100.0 – 100.0%	0.0	Yes	44425
I/O-97	Inverter AO #5 Out - Low	-10.0 – 20.0	4.0	Yes	44426
I/O-98	Inverter AO #5 Process - High	-100.0 – 100.0%	100.0	Yes	44427
I/O-99	Inverter AO #5 Out - High	-10.0 – 20.0	20.0	Yes	44428
I/O-100	Inverter AO #6 Process - Low	-100.0 – 100.0%	0.0	Yes	44430
I/O-101	Inverter AO #6 Out- Low	-10.0 – 20.0	4.0	Yes	44431
I/O-102	Inverter AO #6 Process - High	-100.0 – 100.0%	100.0	Yes	44432
I/O-103	Inverter AO #6 Out - High	-10.0 – 20.0	20.0	Yes	44433
I/O-104	Inverter AO #7 Process - Low	-100.0 – 100.0%	0.0	Yes	44435
I/O-105	Inverter AO #7 Out - Low	-10.0 – 20.0	4.0	Yes	44436
I/O-106	Inverter AO #7 Process - High	-100.0 – 100.0%	100.0	Yes	44437
I/O-107	Inverter AO #7 Out - High	-10.0 – 20.0	20.0	Yes	44438
I/O-108	Inverter AO #8 Process - Low	-100.0 – 100.0%	0.0	Yes	44440
I/O-109	Inverter AO #8 Out - Low	-10.0 – 20.0	4.0	Yes	44441
I/O-110	Inverter AO #8 Process - High	-100.0 – 100.0%	100.0	Yes	44442
I/O-111	Inverter AO #8 Out - High	-10.0 – 20.0	20.0	Yes	44443

Table 21: I/O (Input/Output) Group Parameter List

Parameter	Description	Units / Range	Default	Adjust During Run?	Modbus Register
I/O-112	CCI Digital In #1 Function	0: None 1: Run FWD 2: Run REV 3: Stop 4: Fault Reset 5: Run Enable 6: Run Disable 7: Local/Remote 8: DC Brake Enable 9: DC Brake Disable 10: External Fault High 11: External Fault Low 12: Drive Enable 13: Drive Disable 14: Input Phase Fault High 15: Transformer Fault Low 16: Transformer Warning Low 17: Converter Warning Low 18: Converter Fault Low 19: Main Contactor Feedback	None	No	44401
I/O-113	CCI Digital In #2 Function		None	No	44502
I/O-114	CCI Digital In #3 Function		None	No	44503
I/O-115	CCI Digital In #4 Function		None	No	44504
I/O-116	CCI Digital In #5 Function		None	No	44505
I/O-117	CCI Digital In #6 Function		None	No	44506
I/O-118	CCI Digital In #7 Function		None	No	44507
I/O-119	CCI Digital In #8 Function		None	No	44508
I/O-120	CCI Digital In #9 Function		None	No	44509
I/O-121	CCI Digital In #10 Function		None	No	44510
I/O-122	CCI Digital In #11 Function		None	No	44511
I/O-123	CCI Digital In #12 Function		None	No	44512
I/O-124	CCI Digital In #13 Function		None	No	44513
I/O-125	CCI Digital In #14 Function		None	No	44514
I/O-126	CCI Digital In #15 Function		None	No	44515
I/O-127	CCI Digital In #16 Function		None	No	44516

Table 21: I/O (Input/Output) Group Parameter List

Parameter	Description	Units / Range	Default	Adjust During Run?	Modbus Register
I/O-128	CCI Digital Out #1 Function	0: None 1: Run 2: Fault - Non Fail Safe 3: Fault - Fail Safe 4: Ready 5: At Speed 6: Forward 7: Reverse 8: DC Brake Active 9: Local Control Source Active 10: Remote Control Source Active 11: Stopped 12: Warning 13: Overcurrent Warning 14: Undercurrent Warning 15: Motor Overload Warning 16: Drive Overload Warning 17: Motor Overload Trip 18: Drive Overload Trip 19: Bus Overvoltage Trip 20: Bus Undervoltage Trip 21: Cell Fault 22: Ground Fault Trip 23: Precharged 24: Precharge Contactor 25: Lockout Active 26: Main Contactor	None	No	44517
I/O-129	CCI Digital Out #2 Function		None	No	44518
I/O-130	CCI Digital Out #3 Function		None	No	44519
I/O-131	CCI Digital Out #4 Function		None	No	44520
I/O-132	CCI Digital Out #5 Function		None	No	44521
I/O-133	CCI Digital Out #6 Function		None	No	44522
I/O-134	CCI Digital Out #7 Function		None	No	44523
I/O-135	CCI Digital Out #8 Function		None	No	44524
I/O-136	CCI Digital Out #9 Function		None	No	44525
I/O-137	CCI Digital Out #10 Function		None	No	44526
I/O-138	CCI Digital Out #11 Function		None	No	44527
I/O-139	CCI Digital Out #12 Function		None	No	44528
I/O-140	CCI Digital Out #13 Function		None	No	44529
I/O-141	CCI Digital Out #14 Function		None	No	44530
I/O-142	CCI Digital Out #15 Function		None	No	44531
I/O-143	CCI Digital Out #16 Function		None	No	44532
I/O-144	CCI Analog In #1 Function	For Internal Use Only	None	No	44533
I/O-145	CCI Analog In #2 Function	0: None 1: Speed Reference	None	No	44534
I/O-146	CCI Analog In #3 Function		None	No	44535
I/O-147	CCI Analog In #4 Function		None	No	44536
I/O-148	CCI Analog In #5 Function		None	No	44537
I/O-149	CCI Analog In #6 Function		None	No	44538
I/O-150	CCI Analog In #7 Function		None	No	44539
I/O-151	CCI Analog In #8 Function		None	No	44540
I/O-152	CCI Analog In #1 Process Low	-100.0 – 100.0%	0.0	Yes	44542
I/O-153	CCI Analog In #1 Input Low	-10.0 – 20.0	4.0V or mA	Yes	44543
I/O-154	CCI Analog In #1 Process HIgh	-100.0 – 100.0%	100.0%	Yes	44544
I/O-155	CCI Analog In #1 Input HIgh	-10.0 – 20.0	20.0V or mA	Yes	44545

Table 21: I/O (Input/Output) Group Parameter List

Parameter	Description	Units / Range	Default	Adjust During Run?	Modbus Register
I/O-156	CCI Analog In #2 Process Low	-100.0 – 100.0%	0.0%	Yes	44547
I/O-157	CCI Analog In #2 Process Low	-10.0 – 20.0	4.0V or mA	Yes	44548
I/O-158	CCI Analog In #2 Process High	-100.0 – 100.0%	100.0%	Yes	44549
I/O-159	CCI Analog In #2 Input High	-10.0 – 20.0	20.0V or mA	Yes	44550
I/O-160	CCI Analog In #3 Process Low	-100.0 – 100.0%	0.0%	Yes	44552
I/O-161	CCI Analog In #3 Input Low	-10.0 – 20.0	4.0V or mA	Yes	44553
I/O-162	CCI Analog In #3 Process High	-100.0 – 100.0%	100.0%	Yes	44554
I/O-163	CCI Analog In #3 Input High	-10.0 – 20.0	20.0V or mA	Yes	44555
I/O-164	CCI Analog In #4 Process Low	-100.0 – 100.0%	0.0%	Yes	44557
I/O-165	CCI Analog In #4 Input Low	-10.0 – 20.0	4.0V or mA	Yes	44558
I/O-166	CCI Analog In #4 Process High	-100.0 – 100.0%	100.0%	Yes	44559
I/O-167	CCI Analog In #4 Input High	-10.0 – 20.0	20.0V or mA	Yes	44560
I/O-168	CCI Analog In #5 Process Low	-100.0 – 100.0%	0.0%	Yes	44562
I/O-169	CCI Analog In #5 Input Low	-10.0 – 20.0	4.0V or mA	Yes	44563
I/O-170	CCI Analog In #5 Process High	-100.0 – 100.0%	100.0%	Yes	44564
I/O-171	CCI Analog In #5 Input High	-10.0 – 20.0	20.0V or mA	Yes	44565
I/O-172	CCI Analog In #6 Process Low	-100.0 – 100.0%	0.0%	Yes	44567
I/O-173	CCI Analog In #6 Input Low	-10.0 – 20.0	4.0V or mA	Yes	44568
I/O-174	CCI Analog In #6 Process High	-100.0 – 100.0%	100.0%	Yes	44569
I/O-175	CCI Analog In #6 Input High	-10.0 – 20.0	20.0V or mA	Yes	44570
I/O-176	CCI Analog In #7 Process Low	-100.0 – 100.0%	0.0%	Yes	44572
I/O-177	CCI Analog In #7 Input Low	-10.0 – 20.0	4.0V or mA	Yes	44573
I/O-178	CCI Analog In #7 Process High	-100.0 – 100.0%	100.0%	Yes	44574
I/O-179	CCI Analog In #7 Input High	-10.0 – 20.0	20.0V or mA	Yes	44575
I/O-180	CCI Analog In #8 Process Low	-100.0 – 100.0%	0.0%	Yes	44577
I/O-181	CCI Analog In #8 Input Low	-10.0 – 20.0	4.0V or mA	Yes	44578

Table 21: I/O (Input/Output) Group Parameter List

Parameter	Description	Units / Range	Default	Adjust During Run?	Modbus Register
I/O-182	CCI Analog In #8 Process High	-100.0 – 100.0%	100.0%	Yes	44579
I/O-183	CCI Analog In #8 Input High	-10.0 – 20.0	20.0V or mA	Yes	44580
I/O-184	CCI Analog Out #1 Funtion	0: None 1: Output Frequency 2: Output Freq Magnitude 3: Freq Command 4: Freq Cmd Magnitude 5: Output Voltage 6: Inverter Output Current 7: Inverter Output kW 8: DC Bus V 9: Drive Output Current 10: Drive Output kW 11: Inverter AI 1 12: Inverter AI 2 13: Inverter AI 3 14: Inverter AI 4 15: Inverter AI 5 16: Inverter AI 6 17: Inverter AI 7 18: Inverter AI 8 19: CCI AI 1 20: CCI AI 2 21: CCI AI 3 22: CCI AI 3 23: CCI AI 5 24: CCI AI 6 25: CCI AI 7 26: CCI AI 8 27: Cal + 100% 28: Cal - 100%	None	No	44581
I/O-185	CCI Analog Out #2 Funtion		None	No	44582
I/O-186	CCI Analog Out #3 Funtion		None	No	44583
I/O-187	CCI Analog Out #4 Funtion		None	No	44584
I/O-188	CCI Analog Out #5 Funtion		None	No	44585
I/O-189	CCI Analog Out #6 Funtion		None	No	44586
I/O-190	CCI Analog Out #7 Funtion		None	No	44587
I/O-191	CCI Analog Out #8 Funtion		None	No	44588
I/O-192	CCI Analog Out #1 Process Low	-100.0 – 100.0%	0.0%	Yes	44590
I/O-193	CCI Analog Out #1 Output Low	-10.0 – 20.0	4.0V or mA	Yes	44591
I/O-194	CCI Analog Out #1 Process High	-100.0 – 100.0%	100.0%	Yes	44592
I/O-195	CCI Analog Out #1 Output High	-10.0 – 20.0	20.0V or mA	Yes	44593
I/O-196	CCI Analog Out #2 Process Low	-100.0 – 100.0%	100.0%	Yes	44595
I/O-197	CCI Analog Out #2 Output Low	-10.0 – 20.0	20.0V or mA	Yes	44596
I/O-198	CCI Analog Out #2 Process High	-100.0 – 100.0%	0.0%	Yes	44597
I/O-199	CCI Analog Out #2 Output High	-10.0 – 20.0	4.0V or mA	Yes	44598
I/O-200	CCI Analog Out #3 Process Low	-100.0 – 100.0%	100.0%	Yes	44600
I/O-201	CCI Analog Out #3 Output Low	-10.0 – 20.0	20.0V or mA	Yes	44601

Table 21: I/O (Input/Output) Group Parameter List

Parameter	Description	Units / Range	Default	Adjust During Run?	Modbus Register
I/O-202	CCI Analog Out #3 Process High	-100.0 – 100.0%	0.0%	Yes	44602
I/O-203	CCI Analog Out #3 Output High	-10.0 – 20.0	4.0V or mA	Yes	44603
I/O-204	CCI Analog Out #4 Process Low	-100.0 – 100.0%	100.0%	Yes	44605
I/O-205	CCI Analog Out #4 Output Low	-10.0 – 20.0	20.0V or mA	Yes	44606
I/O-206	CCI Analog Out #4 Process High	-100.0 – 100.0%	0.0%	Yes	44607
I/O-207	CCI Analog Out #4 Output High	-10.0 – 20.0	4.0V or mA	Yes	44608
I/O-208	CCI Analog Out #5 Process Low	-100.0 – 100.0%	100.0%	Yes	44610
I/O-209	CCI Analog Out #5 Output Low	-10.0 – 20.0	20.0V or mA	Yes	44611
I/O-210	CCI Analog Out #5 Process High	-100.0 – 100.0%	100.0%	Yes	44612
I/O-211	CCI Analog Out #5 Output High	-10.0 – 20.0	20.0V or mA	Yes	44613
I/O-212	CCI Analog Out #6 Process Low	-100.0 – 100.0%	0.0%	Yes	44615
I/O-213	CCI Analog Out #6 Output Low	-10.0 – 20.0	4.0V or mA	Yes	44616
I/O-214	CCI Analog Out #6 Process High	-100.0 – 100.0%	100.0%	Yes	44617
I/O-215	CCI Analog Out #6 Output High	20.0V or mA	20.0V or mA	Yes	44618
I/O-216	CCI Analog Out #7 Process Low	-100.0 – 100.0%	0.0%	Yes	44620
I/O-217	CCI Analog Out #7 Output Low	-10.0 – 20.0	4.0V or mA	Yes	44621
I/O-218	CCI Analog Out #7 Process High	-100.0 – 100.0%	100.0%	Yes	44622
I/O-219	CCI Analog Out #7 Output High	-10.0 – 20.0	20.0V or mA	Yes	44623
I/O-220	CCI Analog Out #8 Process Low	-100.0 – 100.0%	0.0%	Yes	44625
I/O-221	CCI Analog Out #8 Output Low	-10.0 – 20.0	4.0V or mA	Yes	44626
I/O-222	CCI Analog Out #8 Process High	-100.0 – 100.0%	100.0%	Yes	44627
I/O-223	CCI Analog In #8 Output High	-10.0 – 20.0	20.0V or mA	Yes	44628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7 - Parameter Descriptions

This section provides descriptions of each user accessible parameter in the M2L 3000 drive. There are four basic groups of parameters which include the Drive Group, the Function Group, the Advanced Function Group, and the I/O (Input/Output) Group.

Drive Group Parameters

DRIVE-00 (40173) Motor Type Value: 0: Induction 1: Synchronous Default: 0

Motor Type configures the drive to match the type of motor connected to the drive.

DRIVE-01 (40048) Motor Rated Current Value: 1.0 – 6000 Amps Default: 126.0

Motor Rated Current defines the motor rated Full Load current, which can be found on the motor name plate.

DRIVE-02 (40050) Motor Rated Voltage Value: 100 – 15000 Volts Default: 4160

Motor Rated Voltage defines the rated voltage of the motor, which can be found on the motor nameplate

DRIVE-03 (40051) Motor Base Frequency Value: 20.00 – 300.00 Hz Default: 60.00

Motor Base Frequency defines the rated frequency of the motor, which can be found on the motor nameplate.

DRIVE-04 (40174) Motor Rated kW Value: 0 – 50000 kW Default: 746

If not directly listed, *Motor Rated kW* can be derived from the rated horsepower found on the motor nameplate. 1 HP is equal to 0.746 kW. Divide the listed HP value by 1.34 to derive the Motor Rated kW.

DRIVE-05 (40053) Motor Poles Value: 2-36 Default: 4

Motor Poles configures the drive to match the number of poles of the connected motor.

	Nameplate RPM	Synchronous RPM	Poles
60 Hz	3000-3600	3600	2
	1500-1800	1800	4
	1000-1200	1200	6
	750-900	900	8
	600-720	720	10
	500-600	600	12
	375-450	450	16

	Nameplate RPM	Synchronous RPM	Poles
50 Hz	2400-3000	3000	2
	1200-1500	1500	4
	800-1000	1000	6
	600-750	750	8
	480-600	600	10
	400-500	500	12
	300-375	375	16

DRIVE-06 Motor Rated Slip Value: 0.00-10.00 Hz Default: 1.0

Motor Rated Slip frequency, in Hertz, can be calculated using the following formula, where “P” is equal to the number of poles.

$$\text{Slip (Hz)} = \frac{(\text{RPM}_{\text{sync}} - \text{RPM}_{\text{nameplate}})}{120} \times \text{Poles}$$

NOTE: If the drive is connected to a synchronous motor (as selected in DRIVE-00), the Motor Rated Slip value will be 0 Hz**.**

DRIVE-07 (40047) Reverse Enable Value: 0: Disabled Default: Disabled
1: Enabled

When disabled, *Reverse Enable* prevents running of the motor in the reverse direction.

DRIVE-08 (40047) Starting Frequency Value: 0.00 – 10.00 Hz Default: 0.10

Starting Frequency determines the minimum frequency at the end of the deceleration, where the motor is released.

Starting Frequency is also used to determine the minimum frequency at which the drive will hold output until the ramp time expires in any programmed deceleration profile.

DRIVE-09 (44489) Minimum Frequency Value: 0.00 – 300.00 Hz Default: 0.00

Minimum Frequency defines the minimum speed setpoint that can be entered on the HMI or by any plant controller.

DRIVE-10 (40046) Maximum Frequency Value: 1.00 – 300.00 Hz Default: 60.00

Maximum Frequency defines the highest frequency that the drive will generate. The Maximum Frequency value is also used (along with Ramp Time values) in the calculation of acceleration and deceleration rates in both acceleration and deceleration profiles.

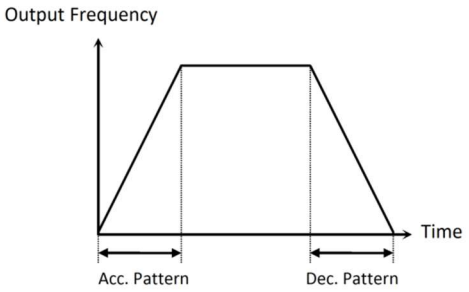
DRIVE-11 (40040) Acceleration Ramp Time Value: 0 – 1200 Seconds Default: 120.0

Acceleration Ramp Time is the amount of time that it takes for the drive to reach the maximum frequency when a Start command is received. Acceleration Ramp Time and Maximum Frequency (DRIVE-10) are used in the calculation of the acceleration rate in the acceleration profile.

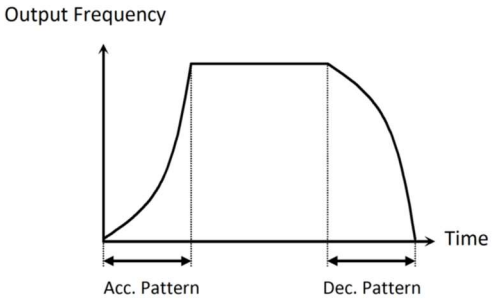
DRIVE-12 (40041) Acceleration Profile Value: 0: Linear Default: 0
1: U Curve
2: S Curve

Acceleration Profile allows the selection of alternate types or shapes of the acceleration ramp.

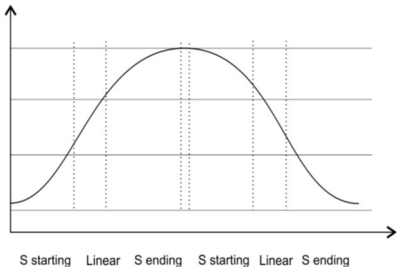
Linear: The default shape of the ramp is a straight line. (Graphic shows both acceleration and deceleration profiles.)



U-Curve: This pattern provides efficient control of acceleration and deceleration in typical applications. *(Graphic shows both acceleration and deceleration profiles.)*



S-Curve: The shape of the ramp is curved at both the beginning and end (remaining linear in the middle) to prevent shock during acceleration or deceleration.*(Graphic shows both acceleration and deceleration profiles.)*



DRIVE-13 (40042) Acceleration S Curve Factor Value: 1 – 99% Default: 50

Acceleration S Curve Factor determines the percentage of the profile that is curved, as opposed to linear, in the S Curve acceleration profile. Refer to the S-Curve graphic in DRIVE-12.

DRIVE-14 (40043) Deceleration Ramp Time Value: 0 – 1200.0 Seconds Default: 120.0

Deceleration Ramp Time is the amount of time that it takes for the drive to stop when running at maximum frequency and a Stop command is received. Deceleration Ramp Time and Maximum Frequency (DRIVE-10) are used in the calculation of the deceleration rate in the deceleration profile.

DRIVE-15 (40044) Deceleration Profile Value: 0: Linear Default: 0
1: U Curve
2: S Curve

Deceleration Profile allows the selection of the type or shape of the deceleration ramp. This profile can be the same as, or different from, the Acceleration Profile selected in DRIVE-12. Refer to DRIVE-12 for basic profile models and descriptions.

DRIVE-16 (40045) Deceleration S Curve Factor Value: 1 – 99% Default: 50

Deceleration S Curve Factor determines the percentage of the profile that is curved, as opposed to linear, in the S Curve deceleration profile. Refer to the S-Curve graphic in DRIVE-12.

Function Group Parameters

FUNCTION-00 (40161) Start Mode Value: 0: Accel Default: 0
1: Flying Start
2: DC Brake then Start

Start Mode determines what happens when a Start Command is received.

0: Accel, follows the *Acceleration Profile* (DRIVE-12) from zero speed.

1: Flying Start, determines the speed of a freewheeling motor, and resumes the Acceleration Profile from that point. Used in fan type applications (starting in a spinning load).

2: DC Brake then Start, the drive applies a DC current to brake the motor before starting a normal acceleration profile from zero speed. Used in fan type applications where the fan may be freewheeling backward, and needs to be stopped before restarting the drive.

FUNCTION-01 (40068) Stop Mode Value: 0: Coast to Stop Default: 1
1: Decel
2: Coast then DC Brake
3: Decel then DC Brake

0: Coast to Stop, disables the output of the drive, allowing the motor to coast to a stop.

1: Decel, follows the *Deceleration Profile* (DRIVE-14) to zero speed.

2: Coast then DC Brake, the drive allows the motor to coast before applying a DC current to brake the motor. The amount of time coasting is defined by the *Coast to Brake Time* (FUNCTION-06).

3: Decel then DC Brake, follows the *Deceleration Profile* (DRIVE-14) until applying a DC current to brake the motor. The transition from deceleration to braking occurs when the drive output reaches the value defined by the *Decel to Brake Frequency* (FUNCTION-09).

FUNCTION-02 (40160) Brake Output Frequency Value: 0.10 – 5.00 Hz Default: 0.1

Brake Output Frequency creates a low frequency AC output to simulate DC output for producing braking torque.

FUNCTION-03 (40162) Starting Brake Time Value: 0.1 – 300.0 Seconds Default: 0.1

When the *Start Mode* (FUNCTION-00) is set to “DC Brake then Start”, the *Starting Brake Time* determines how long the system will apply the DC Brake (a DC current), used to stop a freewheeling motor before starting. The amount of braking is determined by the *Starting Brake Level* (FUNCTION-04).

FUNCTION-04 (40163) Starting Brake Level Value: 1 – 100% Default: 1

When the *Start Mode* (FUNCTION-00) is set to “DC Brake then Start”, the *Starting Brake Level* determines how much current the DC Brake will use to stop a freewheeling motor before starting. This value represents a percentage of the *Motor Rated Current* (DRIVE-01), the duration of which is determined by the *Starting Brake Time* (FUNCTION-03).

FUNCTION-05 (40133) Stop Delay Time Value: 0.1 – 60.0 Seconds Default: 10.0

When the *Stop Mode* (FUNCTION-01) is set to any mode other than Decel, Stop Delay Time is used to prevent the drive from being quickly restarted if the motor is still decelerating from a Stop command. *Stop Delay Time* imposes a delay after the drive determines that the motor has stopped, by monitoring it’s voltage and current, before it can be started again.

FUNCTION-06 (40156) Coast to Brake Time Value: 0.1 – 10.0 Seconds Default: 0.1

When *the Stop Mode* (FUNCTION-01) is set to “Coast then DC Brake”, *Coast to Brake Time* allows for a programmed delay, in which the motor coasts, between pressing “STOP” and the DC Brake being applied. This allows the magnetic field in the motor to decay before applying the brake.

FUNCTION-07 (40157) Stopping Brake Time Value: 0.1 – 300.0 Seonds Default: 0.1

When the *Stop Mode* (FUNCTION-01) is set to “Coast then DC Brake” or “Decel then DC Brake”, the Stopping Brake Time determines how long the system will apply the DC Brake. The amount of braking is determined by the *Stopping Brake Level* (FUNCTION-08).

FUNCTION-08 (40158) Stopping Brake Level Value: 1 – 100% Default: 1

When *Stop Mode* (FUNCTION-01) is set to “Coast then DC Brake” or “Decel then DC Brake”, the Stopping Brake Level determines how much current the DC Brake will apply. This value represents a percentage of the *Motor Rated Current* (DRIVE-01), the duration of which is determined by the *Stopping Brake Time* (FUNCTION-07).

FUNCTION-09 (40159) Decel to Brake Frequency Value: 0.10 – 300.00 Hertz Default: 20.0

When the *Stop Mode* (FUNCTION-01) is set to “Decel then DC Brake”, the Decel to Brake Frequency determines the frequency at which, after following the *Deceleration Profile* (DRIVE-15), DC current is applied to brake the motor.

FUNCTION-10 (40071) Motor Thermal Overload Enable Value: 0 Disabled 1: Enabled Default: Enabled

The motor overload function enables protection of the motor from thermal breakdown of the insulation and windings. When enabled, the drive will trip when the output current persists over the value programmed in *Motor OL Level* (FUNCTION-11), for a duration longer than that programmed in *Motor OL Time* (FUNCTION-12).

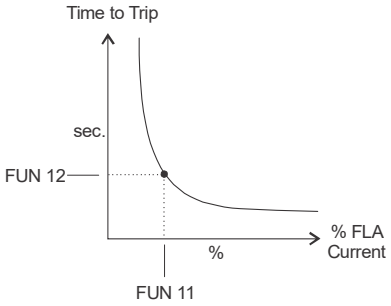
$$\textit{if} \quad \left(\begin{array}{c}\text{Actual}\\ \text{Motor Current}\end{array} \geq \begin{array}{c}\text{Service Factor}\\ \text{[FUNCTION-14]}\end{array} \times \begin{array}{c}\text{Rated Current}\\ \text{[DRIVE-01]}\end{array} \right)$$

$$\textit{then} \quad \begin{array}{c}\text{Overload}\\ \text{Trip Time}\\ \text{at Given}\\ \text{Current}\\ \text{(in sec.)}\end{array} = \frac{\begin{array}{c}\text{Motor Thermal}\\ \text{Overload Time}\\ \text{[FUNCTION-12]}\end{array} \times \left(\left(\frac{\begin{array}{c}\text{Motor Thermal}\\ \text{Overload Level}\\ \text{[FUNCTION-11]}\end{array}}{100\%} \right)^2 - 1 \right)}{\left(\frac{\begin{array}{c}\text{Actual}\\ \text{Motor Current}\end{array}}{\begin{array}{c}\text{Rated Current}\\ \text{[DRIVE-01]}\end{array}} \right)^2 - 1}$$

NOTE: Do not rely on the drive for motor overload protection when the drive is used in a synchronous transfer application. The drive cannot monitor motor current when the motor is transferred across the line.

FUNCTION-11 (40073) Motor Thermal Overload L1 Value: 100 – 300% Default: 110

Used in conjunction with *Motor Thermal Overload Enable* (FUNCTION-10) and *Motor Thermal Overload Time* (FUNCTION-12), this value determines the overload threshold at which the drive will trip to protect the motor windings from overload.



FUNCTION-12 (40074) Motor Thermal Overload T1 Value: 0 – 300 Seconds Default: 60

Used in conjunction with *Motor Thermal Overload Enable* (FUNCTION-10) and *Motor Thermal Overload Level* (FUNCTION-11), this value determines the overload duration of running at the current level set by FUNCTION-11; after which the drive will trip to protect the motor windings from overload.

FUNCTION-13 (40137 Motor Thermal Overload Release Level Value: 1 – 99 % Default: 60

After tripping on an overload, restarting is prevented, and the drive is “locked out” until the accumulated motor overload content has cooled below this programmed value.

FUNCTION-14 (40129) Motor Service Factor Value: 1.00 – 1.25 Default: 1.00

Motor Service Factor, used in overload calculations, defines the Service Factor of the motor, and can be found on the motor name plate. The motor can run at a value of less than the Service Factor multiplied by the rated current, continuously.

NOTE: If the Service Factor of a particular motor is not known, this value should be set to 1.0.

FUNCTION-15 (40130) Motor Thermal Overload Hot/Cold Ratio Value: 0 – 99 % Default: 0

The *Motor Thermal Overload Hot/Cold Ratio* determines the amount of available thermal capacity for a motor that has been running at full load current. The default value of 60% is typical and appropriate for most motors. If required, custom values can be derived from the hot and cold locked rotor times available from most motor manufacturers. A motor that is already hot from previous running will trip the motor overload sooner than a cold motor.

FUNCTION-16 (40072) Motor Cooling Type Value: 0: Self Cooled 1:-Blower Cooled Default: 0

Motor Cooling Type defines the type of cooling provided for the motor. Self Cooled indicates that the motor is equipped with shaft-driven cooling, which requires current derating at lower speeds due to less cooling air flow. Blower Cooled indicates that the motor is equipped with a separately powered cooling device that does not require low speed derating.

FUNCTION-17 (40075) Motor Cooling Time Value: 0 – 60000 Seconds Default: 12

When a thermal overload condition occurs, *Motor Cooling Time* determines the time for the water to cool from 100% to the Motor Thermal Overload Release Level.

NOTE: Consult motor manufacturer data to determine the correct moto cooling time for your application.

FUNCTION-18 (40149) Motor Self Cool Derate L1 Value: 0 – 100% Default: 65

Motor Self Cool Derate defines the motor cooling derate level to be applied at an output frequency of zero Hz.

FUNCTION-19 (40151) Motor Self Cool Derate L2 Value: 0 – 100% Default: 95

Motor Self Cool Derate defines the motor derate cooling level to be applied at the frequency point set in *Motor Self Cool Derate* (FUNCTION-20).

FUNCTION-20 (40150) Motor Self Cool Derate F2 Value: 0.0 – 300.0 Hz Default: 20.0

Motor Self Cool Derate defines a midrange frequency below which motor current capability is derated.

FUNCTION-21 (40076) Overcurrent Enable Value: 0: Disabled Default: 0

1: Enabled

To protect the motor from abnormal load conditions, when this function is enabled the drive will trip if an overcurrent condition is detected that exceeds the level programmed in *Overcurrent Level* (FUNCTION-31).

FUNCTION-22 (40077) Overcurrent Level Value: 1 – 300 % Default: 120

A percentage of *Motor Rated Current* (DRIVE-01), *Overcurrent Level* determines the level at which the drive will trip when Overcurrent Trip Protection is enabled in *Overcurrent Enable* (FUNCTION-21).

FUNCTION-23 (40078) Overcurrent Trip Time Value: 0.0 – 600.0 Seconds Default: 0.1

When *Overcurrent Trip Protection* is enabled in *Overcurrent Enable* (FUNCTION-21), this value determines the duration of time before the drive will trip when the threshold set in *Overcurrent Level* (FUNCTION-22) is exceeded.

FUNCTION-24 (40134) Undercurrent Enable Value: 0: Disabled Default: 0

1: Enabled

To protect the motor from abnormal load conditions, when this function is enabled the drive will trip if an undercurrent condition is detected that falls below the level programmed in *Undercurrent Level* (FUNCTION-25).

FUNCTION-25 (40135) Undercurrent Level Value: 1 – 99 % Default: 1

A percentage of *Motor Rated Current* (DRIVE-01), *Undercurrent Level* determines the level at which the drive will trip when Undercurrent Trip Protection is enabled in *Undercurrent Enabl* (FUNCTION-24).

FUNCTION-26 (40136) Undercurrent Trip Time Value: 0.0 – 600.0 Seconds Default: 0.1

When *Undercurrent Trip Protection* is enabled in *Undercurrent Enable* (FUNCTION-24), this value determines the duration of time before the drive will trip when the current falls below the threshold set in *Undercurrent Level* (FUNCTION-25).

FUNCTION-27 (40079) Output Phase Loss Enable Value: 0: Disabled Default: 0
1: Enabled

To protect the motor from an output phase loss condition, when this function is enabled the drive will trip if a phase loss condition is detected that exceeds the level programmed in *Output Phase Loss Level* (FUNCTION-28).

FUNCTION-28 (40080) Output Phase Loss Level Value: 50 – 150 % Default: 90

A percentage of current imbalance, *Output Phase Loss Level* determines the level at which the drive will trip when Output Phase Loss Protection is enabled in *Output Phase Loss Enable* (FUNCTION-27).

FUNCTION-29 (40081) Output Phase Loss Trip Time Value: 0.1 – 600.0 Default: 0.1
Seconds

When Output Phase Loss Protection is enabled in *Output Phase Loss Enable* (FUNCTION-27), this value determines the duration of time before the drive will trip when the threshold set in *Output Phase Loss Level* (FUNCTION-28) is exceeded.

FUNCTION-30 (44490) Backspin Lockout Enable Value: 0: Disabled Default: 0
1: Enabled

When a load causes the motor to backspin after stopping, a Backspin Lockout can be enabled to prevent the motor from starting until the backspin cycle is complete. A typical application is a pump that backspins until the load has back-flowed through the system.

FUNCTION-31 (44491) Backspin Lockout Time Value: 10 – 3600 Seconds Default: 10

When a Backspin Lockout is enabled, this value determines the time that a restart will be prevented after the drive stops.

FUNCTION-32 (44448) Local Control Source Value: 0: Digital Input HMI
1: HMI
2: Modbus TCP
3: DeviceNet

FUNCTION-33 (44449) Remote Control Source Digital Input

A digital input function can be selected as Local/Remote in order to switch between local and remote sources for start and stop functions, otherwise the local source (HMI) will be the default.

FUNCTION-34 (44452) Local Speed Reference Source Value:0-18 HMI
0: HMI
1-8: Inverter Analog Inputs
9-16: CCI Analog Inputs
17: Modbus TCP
18: DeviveNet

FUNCTION-35 (44453) Remote Speed Referenc Source Inverter Analog Input 3

A digital input function can be selected as Local/Remote in order to switch between local and remote sources for the speed reference, otherwise the local source (HMI) will be the default.

FUNCTION-36 (44454)	Controller IP Address 1	0 – 255	172
FUNCTION-37 (44455)	Controller IP Address 2	0 – 255	29
FUNCTION-38 (44456)	Controller IP Address 3	0 – 255	87
FUNCTION-39 44457)	Controller IP Address 4	0 – 255	15

These parameters specify the IP Address for the controller that provides either start and stop or speed reference, when either the local or remote source parameters are set to Modbus TCP. Control com mands from any other IP address will be ignored.

FUNCTION-40 (44662)	Modbus Master Timeout	Value: 0-600 seconds	Default: 0
FUNCTION-41 (44663)	Modbus Master IP Address 1	Value: 0-255	Default: 0
FUNCTION-42 (44664)	Modbus Master IP Address 2	Value: 0-255	Default: 0
FUNCTION-43 (44665)	Modbus Master IP Address 3	Value: 0-255	Default: 0
FUNCTION-44 (44666)	Modbus Mstr IP Address 4	Value: 0-255	Default: 0

When enabled, the Computer Card monitors communications from a modbus master at a specified IP address. If the drive is running and the Computer Card does not receive a poll from the master within the specified time-out period, a fault will occur and the drive will stop. Set the time-out value and IP address to non-zero values to enable this feature.

This feature may be used for failsafe operation when some external protective or con trol device that normally polls the drive malfunctions or losses communication. Rather than interlocking a status output from that device with the drive's run command, this method enables the drive to declare a specific fault to indicate the reason that the drive stopped

FUNCTION-45 (44691)	Year	Value: 2000 - 2136
FUNCTION-46 (44692)	Month	Value: 1 – 12
FUNCTION-47 (44693)	Day	Value: 1 – 31
FUNCTION-48 (44694)	Hour	Value: 0 – 23
FUNCTION-49 (44695)	Minute	Value: 0 – 59
FUNCTION-50 (44696)	Second	Value: 0 – 59

Functions 32 through 37 allow setting of the time parameters used to time-stamp events in the drive logs.

AFN (Advanced Function) Group Parameters

AFN-00 (40139)	Skip Frequency Enable	Value: 0: Disabled 1: Enabled	Default: 0
AFN-01 (40140)	Skip Frequency Low 1	Value: 0.00 – 300.00 Hz	Default: 20.00
AFN-02 (40141)	Skip Frequency High 1	Value: 0.00 – 300.00 Hz	Default: 21.00
AFN-03 (40142)	Skip Frequency Low 2	Value: 0.00 – 300.00 Hz	Default: 30.00
AFN-04 (40143)	Skip Frequency High 2	Value: 0.00 – 300.00 Hz	Default: 31.00
AFN-05 (40144)	Skip Frequency Low 3	Value: 0.00 – 300.00 Hz	Default: 40.00
AFN-06 (40145)	Skip Frequency High 3	Value: 0.00 – 300.00 Hz	Default: 41.00

The Skip Frequency function locks out certain frequencies that can cause resonance in the driven equipment. The drive will accelerate and decelerate through these frequencies but will not remain at the locked out frequencies. Three different Skip Frequency ranges can be programmed (AFN-01 through AFN-06).

AFN-07 (40146) Dwell Enable — Value: 0: Disabled, 1: Enabled — Default: 0

The Dwell Function enables the drive to ramp to the programmed *Dwell Frequency* (AFN-08), and remain there for the programmed *Dwell Time* (AFN-09) before continuing the programmed acceleration or deceleration ramp.

AFN-08 (40147) Dwell Frequency — Value: 0.00 – 300.00 Hz — Default: 0.00

When the Dwell function is enabled in AFN-07, this value determines the frequency at which the drive will remain for the duration programmed in *Dwell Time* (AFN-09).

AFN-09 (40148) Dwell Time — Value: 0.01 – 600.00 Seconds — Default: 0.01

When the Dwell function is enabled in AFN-07, this value determines the duration of time that the drive will remain at the frequency programmed in *Dwell Frequency* (AFN-08).

AFN-10 (40164) Flying Start Current Level — Value: 1 – 99 % — Default: 25

When the Start Mode (FUNCTION-00) is set to “Flying Start”, a sequence is enabled to “catch the motor on the fly”. This sequence can be defined in the following steps:

- 1 - **Current Application**: The drive applies a low level current to the motor
- 2 - **Frequency Ramp**: Beginning at the selected starting (AFN-14) frequency, the drive ramps output frequency down until the speed of the motor is matched
- 3 - **Voltage Adjust**: The drive sets the voltage to the appropriate level based on the frequency determined in Step 2.

Once this sequence is complete, the drive then accelerates along the programmed acceleration profile.

Flying Start Current Level defines the low level current output used to begin the Flying Start sequence Step 1. While in Flying Start sequence Step 2, the output voltage is reduced as necessary to maintain current below the Flying Start Current Level.

AFN-11 (40165) Flying Start Current Application Time — Value: 0.01 – 10.00 Seconds — Default: 5.00

Flying Start Current Application Time defines the length of time for Step 1 of the Flying Start sequence. The drive applies the Flying Start Current Level (AFN-10) before continuing with the flying start sequence.

AFN-12 (40197) Flying Start Initial Frequency Value: 1 – 300 Hz Default: 60

Flying Start Initial Frequency defines the inverter output frequency that the drive begins its speed search. The drive starts at this frequency and searches down towards zero speed.

AFN-13 (40166) Flying Start Frequency Ramp Time Value: 0.01 – 60.00 Seconds Default: 30.00

Flying Start Frequency Ramp Time defines the length of time for the ramp in Step 2 of the Flying Start sequence.

AFN-14 (40167) Flying Start Current Threshold Value: 1 – 50 % Default: 15

Flying Start Current Threshold defines the level which the current must drop below for the drive to recognize that it has matched the motor speed. Once the current drops below this level, the drive continues to Step 3 of the Flying Start sequence.

AFN-15 (40069) Controlled Fault Stop Enable Value: 0: Disable 1: Enabled Default: 1

Most fault conditions typically result in the motor coasting to a stop. When *Control Fault Stop Enable* is set to "Enabled", the following specific faults will override this default, and stop the motor using the programmed deceleration profile.

- Motor Overload
- Drive Overtemp
- Overcurrent/Undercurrent
- Converter Overtemp
- Remote I/O Timeout
- HMI Communication Loss
- Fieldbus Communication Loss
- External Fault from a digital input

AFN-16 (44450) Auto Start Configuration Value: 0-3 Default: Disabled

0: The *Auto Start* parameter determines if the drive can automatically initiate a start sequence under the given conditions:

- Control *Source* (Local or Remote, I/O-136 or I/O-137) must be set to "Digital Input"
- One active *Digital Input* must be set to "Run Forward" or "Run Reverse"

1: *Control Power:* The drive will automatically initiate a start sequence when control power is applied.

2: *Fault Reset:* The drive will automatically initiate a start sequence when a fault condition is cleared.

3: *Control Power or Fault Reset:* The drive will automatically initiate a start sequence both when control power is applied and when a fault condition is cleared.

AFN-17 (40049)	Motor No Load Current	Value: 1 – 6000 Amps	Default: 33.0
AFN-18 (40127)	Motor Rotor Time Constant	Value: 0.01 – 10.00 Seconds	Default: 0.01
AFN-19 (40125)	Motor Magnetizing Inductance	Value: 0.000 – 20.000 Per Unit	Default: 3.500
AFN-20 (40126)	Motor Leakage Inductance	Value: 0.000 – 0.500 Per Unit	Default: 0.200
AFN-21 (40122)	Motor Resistance	Value: 0.000 – 30.000 Per Unit	Default: 0.020

Advanced Functions AFN-17 through AFN-21 are motor model parameters used by the Sensorless Vector Control method. These functions are set automatically by the Auto Tune function of the drive during commissioning. If desired, and complete motor specifications are available from the manufacturer, these values can be entered manually for even greater accuracy in sensorless control of the motor.

I/O (Input/Output) Group Parameters

Inverter Digital In Functions (I/O-00 through I/O-15)

I/O-00 (44313)	Inverter	Digital In #1 Function	Values: 0-22	Locked: Converter Warning
I/O-01 (44314)	Inverter	Digital In #2 Function		Locked: Converter Fault
I/O-02 (44315)	Inverter	Digital In #3 Function		Locked: Main Cont Fdbk
I/O-03 (44316)	Inverter	Digital In #4 Function		Default: NONE
I/O-04 (44317)	Inverter	Digital In #5 Function		Default: Run FWD
I/O-05 (44318)	Inverter	Digital In #6 Function		Default: Run REV
I/O-06 (44319)	Inverter	Digital In #7 Function		Default: Stop
I/O-07 (44320)	Inverter	Digital In #8 Function		Default: NONE
I/O-08 (44321)	Inverter	Digital In #9 Function		Default: NONE
I/O-09 (44322)	Inverter	Digital In #10 Function		Default: NONE
I/O-10 (44323)	Inverter	Digital In #11 Function		Default: NONE
I/O-11 (44324)	Inverter	Digital In #12 Function		Default: NONE
I/O-12 (44325)	Inverter	Digital In #13 Function		Default: NONE
I/O-13 (44326)	Inverter	Digital In #14 Function		Default: NONE
I/O-14 (44327)	Inverter	Digital In #15 Function		Default: NONE
I/O-15 (44328)	Inverter	Digital In #16 Function		Default: NONE

Digital Input Options

For use with external control logic, the following options are available as input selections for I/O-00 through I/O-15:

0: *Run Forward / Run Reverse* - Allows start and stop capabilities from any external control logic (such as start and stop pushbuttons, or PLC control). To enable, the Control Source (Local or Remote, I/O-136 or I/O-137) must be set to “Digital Input”.

1: *Stop* - Enables use of 3-wire start logic (for use with external Start and Stop buttons).

2: *Fault Reset* - Enables reset of fault conditions from external control logic (pushbutton or PLC).

3: *Run Enable / Run Disable* - For use with external control logic, all Run Enable inputs must be on, and all Run Disable inputs must be off, for the drive to run. If the motor is running and a Run Enable is removed, the motor will stop according to the setting of the Stop Mode (FUNCTION-01).

4: *Local/Remote* - Selects whether the Local Control Source and Speed Reference Source or the Remote Control Source and Speed Reference Source are the control and speed reference sources.

5: When the signal is low, start/stop and speed reference functions are controlled by the Local Control Source and the Local Speed Reference Source

6: When the signal is high, start/stop and speed reference functions are controlled by the Remote Control Source and the Remote Speed Reference Source.

7: *DC Brake Enable / DC Brake Disable* - For use with external control logic, all DC Brake Enable inputs must be on, and all DC Brake Disable inputs must be off, for the DC Brake feature to function when stopping. If not enabled, the drive will allow the motor to coast instead of employing the DC Brake.

8: *External Fault High / External Fault Low* - Allows external sources to trigger an external fault to the assigned digital input by either applying or removing voltage (high or low). The drive will produce a unique code indicating the digital input source of the fault.

9:*Drive Enable / Drive Disable* - For use with external control logic, all Drive Enable inputs must be on, and all Drive Disable inputs off, for the drive to run. If a Drive Enable input is removed while the motor is running, the motor will coast to a stop.

10: *Input Phase Fault* - For use with an external incoming line voltage protection relay, if this input goes high, the drive will fault.

11:*Transformer Fault* - For use with protection switches on a remotely located front end transformer, such as applications monitoring pressure or level switches of an oil-filled transformer. If this input goes low, the drive will fault.

12:*Transformer Warning* -Also for use with protection switches on a remotely located front end transformer. If this input goes low, the drive will indicate a warning.

13: *Converter Warning* - For use with protection switches in the Convertor or rectifier section. If this input goes low, the drive will indicate a warning.

14: *Converter Fault* - Also for use with protection switches in the Converter or rectifier section. If this input goes low, the drive will fault.

15: *Main Contactor Feedback* - For internal control logic only. The drive uses this input to monitor the main contactor in the Inverter section.

16: *Output Contactor Feedback* - When there is an output contactor controlled by the drive with a digital output programmed as “Output Contactor Control”, a digital input should be programmed to monitor feedback from its normally open auxiliary contact.

17: *Input Disconnect Feeback* – When there is an input disconnect switch, a digital input should be programmed to monitor feedback from its normally open auxiliary contact.

18: *Output Disconnect Feedback* – When there is an output disconnect switch, a digital input should be programmed to monitor feedback from its normally open auxiliary contact.

19: *DC Link Rector Warning* – When there is a DC link reactor, a digital input should be programmed to monitor its normally closed temperature warning switch.

20: *DC Link Ractor Fault* – When there is a DC link reactor, a digital input should be programmed to monitor its normally close temperature trip switch.

21: *Output Reactor Warning* – When there is an output reactor, a digital input should be programmed to monitor its normally closed temperature warning switch.

22: *Output Reactor Fault* – When there is an output reactor, a digital input should be programmed to monitor its normally closed temperature trip switch.

Inverter Digital Output Functions (I/O-16 through I/O-31)

I/O-16 (44330)	Inverter	Digital Out #1 Function	Values: 0-27	Locked: Precharge Contactor
I/O-17 (44331)	Inverter	Digital Out #2 Function		Default: NONE
I/O-18 (44332)	Inverter	Digital Out #3 Function		Default: NONE
I/O-19 (44333)	Inverter	Digital Out #4 Function		Default: NONE
I/O-20 (44334)	Inverter	Digital Out #5 Function		Default: NONE
I/O-21 (44335)	Inverter	Digital Out #6 Function		Default: NONE
I/O-22 (44336)	Inverter	Digital Out #7 Function		Default: NONE
I/O-23 (44337)	Inverter	Digital Out #8 Function		Default: NONE
I/O-24 (44338)	Inverter	Digital Out #9 Function		Default: NONE
I/O-25 (44339)	Inverter	Digital Out #10 Function		Default: NONE
I/O-26 (44340)	Inverter	Digital Out #11 Function		Default: NONE
I/O-27 (44341)	Inverter	Digital Out #12 Function		Default: NONE
I/O-28 (44342)	Inverter	Digital Out #13 Function		Default: NONE
I/O-29 (44343)	Inverter	Digital Out #14 Function		Default: NONE
I/O-30 (44344)	Inverter	Digital Out #15 Function		Default: NONE
I/O-31 (44345)	Inverter	Digital Out #16 Function		Default: NONE

Digital Output Options

For use with external control logic, the following options are available as output selections for I/O-16 through I/O-31 to report drive status:

0: *Run* – The drive is running the motor.

1: *Fault - Non Fail Safe* – Faulted, Non Fail Safe Operation, energized when faulted.

2: *Fault - Fail Safe* – Faulted, Fail Safe Operation, energized when no fault is present, de-energized when faulted.

3: *Ready* – The Drive is ready to run.

4: *At Speed* – Drive is running at the reference speed.

5: *Forward* – The drive is running the motor in the forward direction.

6: *Reverse* – The drive is running the motor in the reverse direction.

7: *DC Brake Active* – The DC injection brake feature is active.

8: *Local Control Source Active* – The drive is being controlled by the source selected.

9: *Remote Control Source Active* – The drive is being controlled by the source selected.

10:*Stopped* – The drive is not running.

11: *Warning* – Any Warning condition is active.

12: Overcurrent Warning – Reserved 1.

13: Undercurrent Warning – Reserved 2.

14: Motor Overload Warning – Reserved 3.

15: Drive Overload Warning – Reserved 4.

16: *Motor Overload Trip* – The drive has faulted due to motor overload.

17: *Drive Overload Trip* – The drive has faulted due to drive overload.

18: *Bus Overvoltage Trip* – The drive has faulted due to a bus overvoltage condition.

19: *Bus Under voltage Trip* – The drive has faulted due to a bus under voltage condition.

20: *Cell Fault* – The drive has faulted due to a cell fault.

21: *Ground Fault Trip* – The drive has faulted due to excessive ground fault current.

22: *Pre-charged* – The drive capacitors are charged.

23: *Pre-charge Contactor* – The drive capacitors are charging.

24: *Lockout Active* – The drive is in a lockout condition and cannot be started.

24: *Main Contactor* - The drive's main contactor is energized, bypassing the pre-charge resistors.

25: *Output Contactor Control* – When there is an output contactor for each inverter in a parallel inverter drive, each inverter should have a digital output programmed to control its output contactor.

26: *Shunt Trip Non Fail Safe* – Relay 2 on the Computer Card must always be incorporated in the logic to trip the shunt on the feeding circuit breaker. Additional digital outputs may be programmed as shunt trip non fail safe outputs and incorporated in the logic. For a Parallel Inverter Drive, one of the CCI digital outputs shoud be programmed as a shunt trip output. Non Fail Safe outputs are normally de-energized.

27: *Shunt Trip Fail Safe* – Relay 2 on the Computer Card must always be incorporated in the logic to trip the shunt on the feeding circuit breaker. Additional digital outputs may be programmed as shunt trip non fail safe outputs and incorporated in the logic. For a Parallel Inverter Drive, one of the CCI digital outputs shoud be programmed as a shunt trip output. Fail Safe outputs are normally energized.

Analog Input Functions (I/O-32 through I/O-39)

I/O-32 (44347)	Inverter	Analog In #1 Function	Values: 0-1	Locked: Ground Fault
I/O-33 (44348)	Inverter	Analog In #2 Function		Default: NONE
I/O-34 (44349)	Inverter	Analog In #3 Function		Default: NONE
I/O-35 (44350)	Inverter	Analog In #4 Function		Default: NONE
I/O-36 (44351)	Inverter	Analog In #5 Function		Default: NONE
I/O-37 (44352)	Inverter	Analog In #6 Function		Default: NONE
I/O-38 (44353)	Inverter	Analog In #7 Function		Default: NONE
I/O-39 (44354)	Inverter	Analog Int #8 Function		Default: NONE

Analog Input Options

0: Analog inputs can be received from various external control sources including, PLCs, potentiometers and sensors.

1: Speed Reference – An external control source can provide a speed reference to the drive.

Analog Input Parameters (I/O-40 through I/O-71)

Low/High Parameters Process and Input Value

The *Process and Input Value Low/High* parameters define the scaling for each of the Analog Inputs.

The “Input” parameters describe the electrical signal going into the analog input. If it is a 4-20mA type analog input, the units are in milliamps. If it is a 0-10V or -10 to 10V type analog input, the units are in volts.

The “Process” parameters describe what that electrical signal is translated to. These parameters are entered as a percentage of the full scale process variable. The process variable is determined by the Analog Input Function selection.

For example, if Speed Reference is selected for the Analog Input Function, then the process variable is percentage of the Maximum Frequency parameter (DRIVE-10).

For scaling to the fullest, set Process Low to 0% and Process High to 100%, then set Input Low to the minimum electrical signal, and Input High to the maximum electrical signal.

For scaling to a different gain, or to incorporate an offset, adjust these four parameters as necessary.

I/O-40 (44356)	Inverter	AI #1 Process - Low	Value: -100.0 – +100.0%	Default: 0.0
I/O-41 (44357)	Inverter	AI #1 Input - Low	Value: -10.0 – +20.0	Default: 0.0
I/O-42 (44358)	Inverter	AI #1 Process - High	Value: -100 – +100.0%	Default: 100.0
I/O-43 (44359)	Inverter	AI #1 Input - High	Value: 10.0 – 20.0	Default: 10.0

Refer to I/O-40 through I/O 44 (AI #1) for I/O-44 through I/O-71 (AI #2 through AI#8) range and parameters.

Inverter Analog Output Functions (I/O-72 through I/O-79)

I/O-72 (44396)	*Analog Out #1 Function*	Values: 0-27	Default: NONE
I/O-73 (44397)	*Analog Out #2 Function*		Default: NONE
I/O-74 (44308)	*Analog Out #3 Function*		Default: NONE
I/O-75 (44399)	*Analog Out #4 Function*		Default: NONE
I/O-76 (44400)	*Analog Out #5 Function*		Default: NONE
I/O-77 (44401)	*Analog Out #6 Function*		Default: NONE
I/O-78 (44402)	*Analog Out #7 Function*		Default: NONE
I/O-79 (44403)	*Analog Out #8 Function*		Default: NONE

Analog Output Options

The following analog output options are available for I/O-72 through I/O-79:

0: *Output Frequency* – Outputs frequency as a percentage of the Maximum Frequency (DRIVE-10). When running in reverse, a negative percentage is represented.

1: *Output Frequency Magnitude* – Outputs the absolute value of the current frequency as a percentage of the Maximum Frequency (DRIVE-10).

2: *Frequency Command* – Outputs the speed command as a percentage of the Maximum Frequency (DRIVE-10). When running in reverse, a negative percentage is represented.

3: *Frequency Command Magnitude* – Outputs the absolute value of the speed command as a percentage of the Maximum Frequency (DRIVE-10).

4: *Output Voltage* – Outputs voltage as a percentage of the Motor Rated Voltage (DRIVE-02).

5: *Inverter Output Current* – For a single inverter drive, outputs drive current as a percentage of the Motor Rated Current (DRIVE-01). For a parallel inverter drive, outputs the individual inverter's current as a percentage of the Motor Rated Current (DRIVE-01) divided by the number of inverters.

6: *Inverter Output kW* – For a single inverter drive, outputs drive kilowatts as a percentage of the Motor Rated Kilowatts (DRIVE-04). For a parallel inverter drive,outputs the individual inverter's kilowatts as a percentage of the Motor Rated Kilowatts (Drive-04) divided by the number of inverters.

7: *DC Bus Voltage* – Output of the bus voltage Inverter as a percentage of 25 Kv.

8: *Inverter Analog Input 1* – Outputs the scaled input on Inverter Analog Input 1.

9: *Inverter Analog Input 2* – Outputs the scaled input on Inverter Analog Input 2.

10: *Inverter Analog Input 3* – Outputs the scaled input on Inverter Analog Input 3.

11: *Inverter Analog Input 4* – Outputs the scaled input on Inverter Analog Input 4.

12: *Inverter Analog Input 5* – Outputs the scaled input on Inverter Analog Input 5.

13: *Inverter Analog Input 6* – Outputs the scaled input on Inverter Analog Input 6.

14: *Inverter Analog Input 7* – Outputs the scaled input on Inverter Analog Input 7.

15: *Inverter Analog Input 8* -–Outputs the scaled input on Inverter Analog Input 8.

16: *CCI Analog Input 1* – Outputs the scaled input on CCI Analog Input 1.

17: *CCI Analog Input 2* – Outputs the scaled input on CCI Analog Input 2.

18: *CCI Analog Input 3* – Outputs the scaled input on CCI Analog Input 3.

19: *CCI Analog Input 4*– Outputs the scaled input on CCI Analog Input 4.

20: *CCI Analog Input 5* – Outputs the scaled input on CCI Analog Input 5.

21: *CCI Analog Input 6* – Outputs the scaled input on CCI Analog Input 6.

22: *CCI Analog Input 7*– Outputs the scaled input on CCI Analog Input 7.

23: *CCI Analog Input 8* – Outputs the scaled input on CCI Analog Input 8.

24: *Calibrate +100%* – Outputs a +100% value for calibration purposes. Set the Analog Output to “None” for reference, then set the Analog Output to “Calibrate +100%”. Adjust the external device to be calibrated accordingly.

25: *Calibrate -100%* – Outputs a -100% value for calibration purposes. Set the Analog Output to “None” for reference, then set the Analog Output to “Calibrate +100%”. Adjust the external device to be calibrated accordingly.

26: *Drive Output Current* – In a parallel inverter drive, outputs the total current of all inverters in the drive as a percentage of the Motor Rated Current (Drive-01). Only applicable for CCI Analog Outputs in a parallel inverter drive.

27: *Drive Output kW* –In a parallel inverter drive, outputs the total kilowatts of all inverters in the drive as a percentage of the Motor Rated Kilowatts (Drive-04). Only applicable for CCI Analog Outputs in a parallel inverter drive.

Analog Output Parameters (I/O-80 through I/O-223)

Analog Output Type

The *Analog Output Type* parameters define the electrical characteristics of each analog signal sent to the external control logic.

Process and Output Value Low/High

The *Process and Input Value Low/High* parameters define the scaling for each of the Analog Outputs.

The “Output” parameters describe the electrical signal generated by the analog output. If it is a 4-20mA type analog output, the units are in milliamps. If it is a 0-10V or -10 to 10V type analog output, the units are in Volts.

The “Process” parameters describe which specific values are translated into an electrical signal.

For example, if Output Frequency is selected for the Analog Output Function, then the process variable is the output frequency as a percentage of the Max Speed parameter (DRIVE-10).

For scaling to the fullest, set Process Low to 0% and Process High to 100%, then set Output Low to the minimum electrical signal, and Output High to the maximum electrical signal.

For scaling to a different gain, or to incorporate an offset, adjust these four parameters as necessary.

I/O-80 (44405)	Inverter	AO #1 Process Value - Low	Value: -100.0 – +100.0%	Default: 0.0
I/O-81 (44406)	Inverter	AO #1 Output Value - Low	Value: -10.0 – +20.0	Default: 0.0
I/O-82 (44407)	Inverter	AO #1 Process Value - High	Value: -100 – +100.0%	Default: 100.0
I/O-83 (44408)	Inverter	AO #1 Output Value - High	Value: 10.0 – 20.0	Default: 10.0

CCI I/O Parameters

Refer to I/O-0 through I/O-111 for I/O-112 through I/O-223 range and prameters.

8 – Fault Conditions

This section contains a Fault Condition Table which provide descriptions, along with a suggested course of action, for each Fault condition possible in the M2L 3000 drive.

Table Key

Fault Codes — Each Fault has a unique code.

Fault Displayed — Fault Displayed represents what will be displayed to the user on the HMI, at the top portion of the Main Screen.

Reaction Type — Different faults result in the drive reacting in different ways. In some fault conditions, the drive immediately stops outputting voltage and opens the main contactor, resulting in the motor coasting to a stop. For others, it can follow the deceleration ramp profile to a stop. For those that stop immediately, some assert a shunt trip. Some faults require that the control power be cycled in order to reset them. The *Reaction Type* column codes are defined as:

- C The drive stops voltage output immediately, and the motor/load coasts to a stop
- D The motor/load decelerates to a stop following the deceleration ramp profile
- S The drive asserts a shunt trip fail safe relay
- F Requires a control power cycle to reset

Description — The *Description* column provides basic information regarding what has occurred within the system when a specific fault occurs.

Course of Action — This column contains the recommended actions that can be taken in the field by on-site technicians to remedy the fault condition. If the condition persists, contact Benshaw for further assistance, or to arrange on-site repair.

WARNING: At any time the system is energized with Medium Voltage power, apply appropriate personal protective equipment (PPE) and follow safe electrical work practices when operating or working near the system. See NFPA 70E.

Cabinet Fault Limit:	<10kA @ 10 Cycles
Min Arc Boundary:	40 Inches
Recommended Min. PPE:	#1 at > 40 inches

WARNING: Only qualified personnel familiar with the use and hazards of medium voltage equipment are to perform work described in this set of instructions

WARNING: Before performing visual inspections, tests, or maintenance on the equipment, disconnect all sources of electric power. Assume that circuits are live until completely de-energized, tested, and tagged.

Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of backfeeding.

Use a properly rated voltage sensing device to confirm that the power is fully removed.

WARNING: Always perform applicable lock-out/tag-out procedures (either general or site-specific) before performing any maintenance or trouble-shooting on the system.

WARNING: To avoid potentially lethal levels of both AC and DC voltages, do not remove the cover to access the Input/Output section of the Inverter while the Inverter is energized.

WARNING: Potentially hazardous voltages will remain in the cells until the capacitors are able to de-energize. Wait at least 30 minutes after main power is removed for the stored voltages to dissipate if removing the Inverter Cell or Input/Output section covers. Do not rely solely on the voltage values displayed on the HMI Meter Values screen to determine if it is safe to remove the covers on the Inverter Cell and Input/Output sections.

WARNING: The Control section contains 240V control power when active. The Control section does not contain medium voltage levels supplied from the mains, and can be carefully accessed by qualified personnel while medium voltage from the AC mains is applied to the system.

WARNING: Replace all devices, doors, and covers before applying power to this equipment.

CAUTION: The contacts on the supplied shunt trip relay must be connected to the feed breaker. The shunt trip is used to protect the drive and motor from damage in the event of certain fault conditions.

CAUTION: Special care must be taken with the cover over the Control section and all panels. A ground wire is attached to the inside of that cover that ties it to ground potential. It is important that the connection integrity of this wire be maintained to avoid compromising the immunity of the Inverter to Electromagnetic Interference (EMI.)

CAUTION: Always be aware of electrostatic discharge (ESD) when working near or touching components inside the drive. Handling of components sensitive to ESD should be done by qualified personnel only, familiar with ESD mitigation techniques.

CAUTION: Parameter settings and adjustments should be performed by those familiar with VFD and motor operation characteristics. It is not recommended for users unfamiliar with these concepts.

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
2	Motor overload fault	D	Occurs when the motor thermal overload I^2T calculation exceeds 100%. Parameters that can affect the motor thermal overload I^2T calculation exceeding 100% include: • Motor Rated Current (DRIVE-01) • Motor Thermal Overload Level (FUNCTION-11) • Motor Thermal Overload Time (FUNCTION-12) • Motor Service Factor (FUNC-TION-14) • Motor Cooling Type (FUNC-TION-16).	Verify that the parameters are set appropriately for the motor, and that the motor is not operating beyond its capability. The overload protection can be relaxed by setting either the *Motor Thermal Overload Level* (FUNCTION-11) higher, or setting the *Motor Thermal Overload Time* (FUNCTION-12) longer. It may even be defeated by turning off the *Motor Thermal Overload Enable* (FUNCTION-10). Doing either of these risks damaging the motor.
3	Inverter overload fault	D	Occurs when the inverter thermal overload I^2T calculation exceeds 100%.	Contact Benshaw
20	Bus undervoltage fault	C	Occurs when the drive is running and the DC bus voltage drops 15% below the expected nominal level.	If this is caused by a seasonal drop in the utility voltage, the taps on the primary side of the front end transformer can be moved down 5% to boost its output voltage by 5%. Front end transformers supplied by Benshaw have taps for -5%, 0% and +5%. This condition could also be caused by the loss of one or more fuses or diodes in the front end rectifier.
21	Bus overvoltage fault	C	Occurs when the drive is running and the DC bus voltage rises 20% above the expected nominal level.	This condition could be caused by: • A seasonal rise in the utility voltage. The taps on the primary side of the front end transformer can be moved up 5% to reduce its output voltage by 5%. Front end transformers supplied by Benshaw have taps for -5%, 0% and +5%. • The motor regenerating due to de-celerating too quickly. Lengthen the Deceleration Ramp Time (DRIVE-14). • Oscillations in current (which can be viewed in the Meter Trending func-tion, or often heard in the motor). Contact Benshaw for assistance.
22	Bus undervoltage fault 2	C	Occurs when the drive is running and DC bus voltage drops 50% below the expected nominal level for 50 milliseconds. This is typically due to a brown out or loss of medium voltage.	If line power quality monitoring equipment is installed on the feed to the drive, verify that all three phases of medium voltage are present and energized. If all three phases of medium voltage are present and energized, and the drive lineup contains a fused disconnect switch, de-energize the supply to the fused disconnect cabinet and check its fuses. Contact Benshaw in the case of a cleared fuse.

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
27	Output phase loss fault	C	Occurs when the drive is running and the calculated phase current imbalance exceeds the level set in the *Output Phase Loss Level* parameter (FUNCTION-28), for the time specified by the *Output Phase Loss Trip Time* parameter (FUNCTION-29).	This condition could be caused by: • current imbalances that occur at the beginning of a ramp • a loose or open power wiring connection • a damaged motor Set the *Output Phase Loss Enable* (FUNCTION-27) parameter to Disabled, and observed the three phase currents on the Meter Trending screen while the motor is starting. If the currents are only imbalanced at the beginning of the ramp, extend the *Output Phase Loss Trip Time* (FUNCTION-29) parameter, and set the *Output Phase Loss Enable* (FUNCTION-27) parameter back to Enabled. Check power wiring connections between the inverter and the motor. Megger test the motor.
28	Input phase loss fault	C	Occurs when the drive is running and detects the loss of an input phase, or a blown fuse or damaged rectifier diode in the rectifier section.	This condition could be caused by: • loss of one input phase from the power source (blown supply fuse, loss of phase from the utility source • a loose or open power wiring connection to the primary windings of the input • a blown fuse in the rectifier section • a damaged rectifier diode • an oscillating load on the motor resulting in a 120Hz DC bus voltage ripple.
31	Overcurrent fault	D	Occurs when the motor current exceeds the *Overcurrent Level* (FUNCTION-22), for a time exceeding the *Overcurrent Trip Time* (FUNCTION-23).	Verify that the motor and load are not inhibited in any way from rotating. Possible conditions include worn bearings or moving parts.
32	Undercurrent fault	D	Occurs when the motor current drops below the *Undercurrent Level* (FUNCTION-25) for a time exceeding the *Undercurrent Trip Time* (FUNCTION-26).	Verify that the attached machinery has not become decoupled or unexpectedly unloaded. It is also possible that the motor current could have dropped out if the drive was not supplying enough voltage. In this case, the motor would either stop spinning, or spin slowly before the fault occurs. Verify that the *Motor Rated Voltage* (DRIVE-02) parameter matches the motor nameplate.
50	Speed control fault	C	Occurs when the drive is running and the drive output frequency deviates above the set reference speed by greater than a predetermined amount. Also occurs when the drive attempts to decelerate, but a regeneration condition prevents the drive from completing its deceleration profile.	Verify that the attached load has not become decoupled or become unexpectedly unloaded. If the fault occurs during deceleration, verify that there is not a continuous regeneration condition present that is back-driving the motor.

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
71	Follower inverter fault	*	Occurs on the leader inverter when a follower inverter faults. *The Reaction Type is dictated by the fault declared on the follower inverter.	Examine the fault that occurred on the follower.
79	Leader shunt tripped	C,S	Occurs on all follower inverters when the leader inverter declares a fault with a shunt trip reaction type.	Examine the fault that occurred on the leader.
80	FOB fault	C,S	A general FOB (Fiber Optic Board) fault will always be accompanied by one of the more specific FOB faults below (351-354, 451-454, 551-554).	Refer to the specific fault codes below.
81	Cell fault	C,S	A general Cell fault will always be accompanied by one of the more specific Cell faults below (301-316, 401-416, 501-516).	Refer to the specific fault codes below.
82	Follower inverter PWMs not synced	C,S	Occurs on the leader inverter when a follower loses PWM Synchronization to it.	Contact Benshaw

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
84	Precharge timeout fault		The fault is triggered if the cell capacitors do not charge to 90% of nominal within 30 seconds of first applying control power, or after resetting of a fault.	Verify that all upstream switchgear for the medium voltage supply to the drive is closed. Reset the fault, then monitor capacitor voltages on the Cell Status screen as the drive attempts to precharge. If there is only one cell with capacitors that are not charging like the others, replace that cell. If medium voltage is available to the drive, and none of the cell capacitors charge, then the Precharge Board is not closing its precharge relays. The Precharge Board receives the command to close its relays from Digital Output 1 on the Remote IO block by a 120VAC signal on wire 50. • Verify that Digital Output 1 is receiving 120VAC on wire 6B • Verify that Digital Output 1 closes during precharge, and supplies 120VAC on wire 50 • If the LED on Digital Output 1 indicates that it is closed, but does not supply 120VAC on wire 50, the digital output may have failed. Replace the digital output module. If Digital Output 1 is functioning normally, the Precharge Board may have failed, or there may be a loose connection to the Precharge Board. Be sure to remove Medium Voltage and allow time for the cell capacitors to discharge before accessing the Precharge Board. • Verify that wires 50 and 7 are securely connected to the Precharge Board • Verify that the thick white wires are securely connected to the main contactor tabs and studs on the Precharge Board. • If all wires are securely connected, the Precharge Board may have failed. Replace the Precharge Board. If medium voltage is available to the drive, the drive has multiple Precharge Boards in parallel, and all of the cells charge to a value that is only a fraction of the expected voltage before the Precharge timeout fault occurs, one of the multiple precharge circuits may have a loose connection, or failed component. Follow the same troubleshooting steps outlined above.

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
85	Cell calibration fault	S	A general Cell calibration fault will always be accompanied by one of the more specific Cell calibration faults below (317-332, 417-432, 517-532).	Refer to the specific cell faults.
86	Cell parameter configuration fault	S	A general Cell parameter configuration fault will always be accompanied by one of the more specific Cell configuration faults below (333-348, 433-448, 533-548).	Refer to the specific cell faults.
87	No DC bus fault		Similar to the Precharge timeout fault, this occurs when the cell capacitors do not charge either after resetting a fault, or after first applying control power. In this case, the drive faults if the capacitors do not charge to 25% of nominal bus voltage within 3 seconds. This fault is primarily intended to protect the precharge resistors in a scenario where the DC bus is connected with the wrong polarity.	Verify that the DC bus wiring is connected with the proper polarity. Follow the steps outlined for the Precharge timeout fault.
89	DSP initialization of backplane fault	S,F	Occurs after first applying control power and the digital signal processor on the Computer Card can not establish communications with the FOBs (Fiber Optic Boards) over the backplane.	Contact Benshaw
90	DSP to backplane communication fault	C,S	Occurs when too many CRC errors or timeouts occur in the communication between the digital signal processor on the Computer Card and the FOBs (Fiber Optic Boards) over the backplane.	Contact Benshaw
93	GPP / DSP interface fault	C,S,F	Occurs when there is an issue with communications between the digital signal processor and general purpose processor on the Computer Card.	Contact Benshaw
97	DSP self watchdog fault	C,S	Occurs when the digital signal processor on the Computer Card detects that one of its tasks has stopped executing.	Contact Benshaw
98	DSP monitoring GPP watchdog fault	C,S	Occurs when there is an issue with communications between the digital signal processor and general purpose processor on the Computer Card.	Contact Benshaw
100	Unknown DSP fault	C,S	Occurs when software releases for the digital signal processor, and the general purpose processor on the Computer Card, are not coordinated.	Contact Benshaw
200	TCP/IP initialization fault	F	Occurs if the Computer Card is unable to initialize its TCP/IP protocol stack after control power is first applied	Contact Benshaw

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
201	GPP initialization of DSP fault	F	Occurs if the general purpose processor on the Computer Card is unable to initialize the digital signal processor on the Computer Card after control power is first applied.	Contact Benshaw
202	GPP initialization fault monitor	F	Occurs if the general purpose processor is unable to initialize some of its processes after control power is first applied.	Contact Benshaw
203	GPP initialization of backplane fault	F	Occurs if the general purpose processor on the Computer Card cannot initialize the FPGA (which communicates to the Fiber Optic Boards) over the backplane after control power is first applied.	Contact Benshaw
204	PCI FPGA initialization fault	F	Occurs if the general purpose processor on the Computer Card cannot initialize the FPGA (which communicates over the PCI bus) over the backplane after control power is first applied.	Contact Benshaw
205	FOB initialization fault	F	Occurs if the Computer Card is unable to initialize the Fiber Optic Boards after control power is first applied.	Contact Benshaw
206	Cell initialization fault	F	Occurs if the Computer Card is unable to initialize the cells after control power is first applied.	Refer to the specific cell faults.
207	HTTP server initialization fault	F	Occurs if the Computer Card is unable to create a task for the HTTP server after control power is first applied.	Contact Benshaw
208	FTP Server initialization fault	F	Occurs if the Computer Card is unable to create a task for the FTP server after control power is first applied.	Contact Benshaw
209	Missing drive parameters fault		Occurs if the Computer Card is unable to retrieve parameters from the SD card because it could not find the file used to store parameters.	Remove the Computer Card to verify that the SD card is present, and securely inserted in the SD card slot in the Computer Card. If the SD card has failed, obtain a replacement from Benshaw, part number SD-100000-00. Do not use an off-the-shelf commercial SD card, as they are typically not rated for harsh environments.
210	Invalid drive parameters fault		Occurs if the Computer Card is unable to retrieve parameters from the SD card because the contents of the file used to store parameters are unexpected or corrupted.	After detecting invalid drive parameters on the SD card, the Computer Card will set all parameters to their default values and overwrite the file on the SD card. Use the HMI or Benshaw Connect to set parameter values to the required values. Contact Benshaw to determine if further action is necessary.
211	Real Time Clock initialization fault		Occurs if the Computer Card is unable to initialize some of its processes or is unable to establish communications with its real time clock chip.	Contact Benshaw

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
212	Invalid lockout timers fault		Occurs if the Computer Card is unable to retrieve lockout timers from the SD card because the contents of the file used to store lockout timers are unexpected or corrupted.	After detecting invalid lockout timers on the SD card, the Computer Card will overwrite the file with a valid file. No further action is required.
213	Missing lockout timers fault		Occurs if the Computer Card is unable to retrieve lockout times from the SD card because it could not find the file used to store lockout timers.	After detecting missing lockout timers on the SD card, the Computer Card will generate the file required on the SD card. No further action is required.
214	FOBs hardware mismatch fault		Occurs if the Computer Card detects that the Fiber Optic Boards are not all reporting the same hardware version after first applying control power.	Contact Benshaw
215	FOB firmware mismatch fault		Occurs if the Computer Card detects that the Fiber Optic Boards are not all reporting the same firmware version after control power is first applied.	Contact Benshaw
216	Cell hardware mismatch fault		Occurs if the Computer Card detects that the cells are not all reporting the same hardware version after control power is first applied.	Contact Benshaw
217	Cell firmware mismatch fault		Occurs if the Computer Card detects that the cells are not all reporting the same firmware version after control power is first applied.	Contact Benshaw
218	ComX initialization fault		Occurs if, after first applying control power, the Computer Card detects that a comX fieldbus module is installed, but was unable to initialize it.	Contact Benshaw
219	Drive module nitiation fault		Occurs if the Computer Card is unable to create a task for monitoring other inverters in a parallel inverter drive after control power is first applied	Contact Benshaw
220	Missing overload backup fault		Occurs if the Computer Card is unable to retrieve the motor overload content from the SD card because the Computer Card could not find the file used to store the overload content.	The Computer Card will generate the file on the SD card. No further action is required.
221	Invalid overload backup fault		Occurs if the Computer Card is unable to retrieve the motor overload content from the SD card because the contents of the file used to store the motor overload content are unexpected or corrupted.	The Computer Card will generate a new file on the SD card. No further action is required.
222	File system initialization fault		Occurs if the Computer Card is unable to connect to the file system on its SDcard.	Contact Benshaw
230	Operating system fault	C,S	Occurs when an interprocess communication fault occurs on the Computer Card.	Contact Benshaw
231	GPP exception fault	C,S	Reported if the Computer Card reset itself due to a general purpose processor exception fault.	Contact Benshaw

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
232	MPU exception fault	C,S	Reported if the Computer Card reset itself due to a memory protection unit exception fault.	Contact Benshaw
233	Realtime clock reset fault		Occurs after first applying control power if the Computer Card detects that the real time clock chip lost battery power.	Replace the CR2032 battery on the Computer Card, then set the time on the HMI (FUNCTION-45 through FUNCTION-50). This is a common battery that can be found at many retail stores. The only purpose of the battery on the Computer Card is to maintain the real time clock while the computer card is not powered. Parameter values will not be lost when the battery dies.
234	Application buffer overflow fault	C,S	Occurs when an index into an application buffer exceeds its bounds.	Contact Benshaw
250	Inverter IO communication loss fault	C,S	Occurs when communication between the Computer Card and its Remote IO in the low voltage control wiring section of the inverter stops for more than two seconds.	Contact Benshaw
251	Card Cage power loss fault	C	Occurs when the Computer Card detects that the power supply in the card cage is reporting a fault. This could be caused by a malfunction with the power supply in the card cage, or by a malfunction of the Computer Card.	If the red Fault LED on the power supply is illuminated, replace the power supply. If the problem persists after replacing the card cage power supply, replace the Computer Card.
252	HMI communication loss fault	D	Occurs if communication between the Computer Card and the HMI stops for more than five seconds while the drive is running, and the HMI is selected to be the start and stop control source.	Contact Benshaw
253	Fieldbus communication loss fault	D	Occurs if communication between the Computer Card and the controller stops for more than five seconds while the drive is running, and the drive is configured to receive its start and stop commands over Modbus TCP.	Verify that the controller supplying the drive with start and stop commands polls the drive at least once every five seconds.
254	Modbus master communication loss fault	C	Occurs if the modbus master located at the IP address specified by the *Modbus Master IP Address* parameters (Function-41, Function-42, Function-43, and Function-44) does not poll the Computer Card for the time specified by the *Modbus Master Timeout* parameter (Function-40).	Verify that the equipment acting as a modbus master located at the IP address specified by the *Modbus Master IP Address* parameters is connected to the network and operating normally. Increase the *Modbus Master Timeout* (Function-40) parameter.

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
301	Cell A1 fault	C	Monitoring various conditions, each cell continuously verifies its own status. When required, the cell will attempt to protect itself by declaring a fault and shutting down its power devices. Anomalous events can cause multiple cells to fault, and each cell can report multiple conditions causing it to declare a fault.	Before resetting the fault, view the Cell Overview screen on the HMI to determine which cells are faulted. This screen indicates which cells are faulted by turning its indicator into a red button. Determine if one or multiple cells are faulted, then determine if the same cells continue to fault, or if the faulted cells are random. For each faulted cell, push its button on the HMI to view its detailed fault indications. Cells may declare faults due to: • +5 V Supply • +15 V Supply • Arc Flash Detected • Top Capacitor Overvoltage • Bottom Capacitor Overvoltage • Top IGBT Shoot-Through • Bottom IGBT Shoot-Through • Overcurrent • Communications If the drive continues to trip due to the same cell, then the cell may be malfunctioning. Replace the cell. If replacing the cell does not solve the problem, or if the drive continues to trip due to random cells, the problem may be more systemic. Contact Benshaw.
302	Cell A2 fault			
303	Cell A3 fault			
304	Cell A4 fault			
305	Cell A5 fault			
306	Cell A6 fault			
307	Cell A7 fault			
308	Cell A8 fault			
309	Cell A9 fault			
310	Cell A10 fault			
311	Cell A11 fault			
312	Cell A12 fault			
313	Cell A13 fault			
314	Cell A14 fault			
315	Cell A15 fault			
316	Cell A16 fault			

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
317	Cell A1 calibration fault	C	Occurs when any cell reports that it is not calibrated.	If this always occurs with the same cell, the cell could be malfunctioning. Replace the cell. If this occurs while the drive is running, it may be an indication that a cell reset during operation. Contact Benshaw.
318	Cell A2 calibration fault			
319	Cell A3 calibration fault			
320	Cell A4 calibration fault			
321	Cell A5 calibration fault			
322	Cell A6 calibration fault			
323	Cell A7 calibration fault			
324	Cell A8 calibration fault			
325	Cell A9 calibration fault			
326	Cell A10 calibration fault			
327	Cell A11 calibration fault			
328	Cell A12 calibration fault			
329	Cell A13 calibration fault			
330	Cell A14 calibration fault			
331	Cell A15 calibration fault			
332	Cell A16 calibration fault			

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
333	Cell A1 configuration fault	C	Occurs when any cell reports that it has not received its configuration parameter settings from the Computer Card.	If this always occurs with the same cell, the cell could be malfunctioning. Replace the cell. If this occurs while the drive is running, it may be an indication that a cell reset during operation. Contact Benshaw.
334	Cell A2 configuration fault			
335	Cell A3 configuration fault			
336	Cell A4 configuration fault			
337	Cell A5 configuration fault			
338	Cell A6 configuration fault			
339	Cell A7 configuration fault			
340	Cell A8 configuration fault			
341	Cell A9 configuration fault			
342	Cell A10 configuration fault			
343	Cell A11 configuration fault			
344	Cell A12 configuration fault			
345	Cell A13 configuration fault			
346	Cell A14 configuration fault			
347	Cell A15 configuration fault			
348	Cell A16 configuration fault			

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
351	FOB A backplane communication fault	C	Occurs when the Power Fiber Optic Board on phase A receives a bad message from the Computer Card over the backplane in the card cage.	Replace the Power Fiber Optic Board. If the problem persists, contact Benshaw.
352	FOB A fiber communication fault	C	Occurs when the Power Fiber Optic Board on phase A receives a bad message from a cell over a plastic optical fiber optic (POF) connection.	Replace the PowerFiber Optic Board. If the problem persists, contact Benshaw.

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
401	Cell B1 fault	C	Monitoring various conditions, each cell continuously verifies its own status. When required, the cell will attempt to protect itself by declaring a fault, shutting down its power devices. Anomalous events can cause multiple cells to fault, and each cell can report multiple conditions causing it to declare a fault.	Before resetting the fault, view the Cell Overview screen on the HMI to determine which cells are faulted. This screen indicates which cells are faulted by turning its indicator into a red button. Determine if one or multiple cells are faulted, then determine if the same cells continue to fault, or if the faulted cells are random. For each faulted cell, push its button on the HMI to view its detailed fault indications. Cells may declare faults due to: • +5 V Supply • +15 V Supply • Arc Flash Detected • Top Capacitor Overvoltage • Bottom Capacitor Overvoltage • Top IGBT Shoot-Through • Bottom IGBT Shoot-Through • Overcurrent • Communications If the drive continues to trip due to the same cell, then the cell may be malfunctioning. Replace the cell. If replacing the cell does not solve the problem, or if the drive continues to trip due to random cells, the problem may be more systemic. Contact Benshaw.
402	Cell B2 fault			
403	Cell B3 fault			
404	Cell B4 fault			
405	Cell B5 fault			
406	Cell B6 fault			
407	Cell B7 fault			
408	Cell B8 fault			
409	Cell B9 fault			
410	Cell B10 fault			
411	Cell B11 fault			
412	Cell B12 Fault			
413	Cell B13 fault			
414	Cell B14 fault			
415	Cell B15 fault			
416	Cell B16 fault			

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
417	Cell B1 calibration fault	C	Occurs when any cell reports that it is not calibrated.	If this always occurs with the same cell, the cell could be malfunctioning. Replace the cell. If this occurs while the drive is running, it may be an indication that a cell reset during operation. Contact Benshaw.
418	Cell B2 calibration fault			
419	Cell B3 calibration fault			
420	Cell B4 calibration Fault			
421	Cell B5 calibration fault			
422	Cell B6 calibration fault			
423	Cell B7 calibration fault			
424	Cell B8 calibration fault			
425	Cell B9 calibration fault			
426	Cell B10 calibration fault			
427	Cell B11 calibration fault			
428	Cell B12 calibration fault			
429	Cell B13 calibration fault			
430	Cell B14 calibration fault			
431	Cell B15 calibration fault			
432	Cell B16 calibration fault			

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
433	Cell B1 configuration fault	C	Occurs when any cell reports that it has not received its configuration parameter settings from the Computer Card.	If this always occurs with the same cell, the cell could be malfunctioning. Replace the cell. If this occurs while the drive is running, it may be an indication that a cell reset during operation. Contact Benshaw.
434	Cell B2 configuration fault			
435	Cell B3 configuration fault			
436	Cell B4 configuration fault			
437	Cell B5 configuration fault			
438	Cell B6 configuration fault			
439	Cell B7 configuration fault			
440	Cell B8 configuration fault			
441	Cell B9 configuration fault			
442	Cell B10 configuration fault			
443	Cell B11 configuration fault			
444	Cell B12 configuration fault			
445	Cell B13 configuration fault			
446	Cell B14 configuration fault			
447	Cell B15 configuration fault			
448	Cell B16 configuration fault			

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
451	FOB B backplane communication fault	C	Occurs when the Power Fiber Optic Board on phase B receives a bad message from the Computer Card over the backplane in the card cage.	Replace the Fiber Optic Board. If the problem persists, contact Benshaw.
452	FOB B fiber communication fault	C	Occurs when the Power Fiber Optic Board on phase B receives a bad message from a cell over a plastic optical fiber optic (POF) connection.	Replace the Fiber Optic Board. If the problem persists, contact Benshaw.

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
501	Cell C1 fault	C	Monitoring various conditions, each cell continuously verifies its own status. When required, the cell will attempt to protect itself by declaring a fault, shutting down its power devices. Anomalous events can cause multiple cells to fault, and each cell can report multiple conditions causing it to declare a fault.	Before resetting the fault, view the Cell Overview screen on the HMI to determine which cells are faulted. This screen indicates which cells are faulted by turning its indicator into a red button. Determine if one or multiple cells are faulted, then determine if the same cells continue to fault, or if the faulted cells are random. For each faulted cell, push its button on the HMI to view its detailed fault indications. Cells may declare faults due to: • +5 V Supply • +15 V Supply • Arc Flash Detected • Top Capacitor Overvoltage • Bottom Capacitor Overvoltage • Top IGBT Shoot-Through • Bottom IGBT Shoot-Through • Overcurrent • Communications If the drive continues to trip due to the same cell, then the cell may be malfunctioning. Replace the cell. If replacing the cell does not solve the problem, or if the drive continues to trip due to random cells, the problem may be more systemic. Contact Benshaw.
502	Cell C2 fault			
503	Cell C3 fault			
504	Cell C4 fault			
505	Cell C5 fault			
506	Cell C6 fault			
507	Cell C7 fault			
508	Cell C8 fault			
509	Cell C9 fault			
510	Cell C10 fault			
511	Cell C11 fault			
512	Cell C12 fault			
513	Cell C13 fault			
514	Cell C14 fault			
515	Cell C15 fault			
516	Cell C16 fault			

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
517	Cell C1 Calibration fault	C	Occurs when any cell reports that it is not calibrated.	If this always occurs with the same cell, the cell could be malfunctioning. Replace the cell. If this occurs while the drive is running, it may be an indication that a cell reset during operation. Contact Benshaw.
518	Cell C2 Calibration fault			
519	Cell C3 Calibration fault			
520	Cell C4 Calibration fault			
521	Cell C5 Calibration fault			
522	Cell C6 Calibration fault			
523	Cell C7 Calibration fault			
524	Cell C8 Calibration fault			
525	Cell C9 Calibration fault			
526	Cell C10 Calibration fault			
527	Cell C11 Calibration fault			
528	Cell C12 Calibration fault			
529	Cell C13 Calibration fault			
530	Cell C14 Calibration fault			
531	Cell C15 Calibration fault			
532	Cell C16 Calibration fault			

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
533	Cell C1 Configuration fault	C	Occurs when any cell reports that it has not received its configuration parameter settings from the Computer Card.	If this always occurs with the same cell, the cell could be malfunctioning. Replace the cell. If this occurs while the drive is running, it may be an indication that a cell reset during operation. Contact Benshaw.
534	Cell C2 Configuration fault			
535	Cell C3 Configuration fault			
536	Cell C4 Configuration fault			
537	Cell C5 Configuration fault			
538	Cell C6 Configuration fault			
539	Cell C7 Configuration fault			
540	Cell C8 Configuration fault			
541	Cell C9 Configuration fault			
542	Cell C10 Configuration fault			
543	Cell C11 Configuration fault			
544	Cell C12 Configuration fault			
545	Cell C13 Configuration fault			
546	Cell C14 Configuration fault			
547	Cell C15 Configuration fault			
548	Cell C16 Configuration fault			
551	FOB C Backplane Communication fault	C	Occurs when the Power Fiber Optic Board on phase C receives a bad message from the Computer Card over the backplane in the card cage.	Replace the Fiber Optic Board. If the problem persists, contact Benshaw.
552	FOB C Fiber Communication fault	C	Occurs when the Power Fiber Optic Board on phase C receives a bad message from a cell over a plastic optical fiber optic (POF) connection.	Replace the Fiber Optic Board. If the problem persists, contact Benshaw.

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
600	Interlock fault	C,S	Occurs when digital input 1 on the Computer Card stops receiving 24 VDC.	Verify that the 24 VDC power supply is functioning. If not, check the fuse supplying its input power. Verify that 24VDC is present across terminals I/O4 and I/O3 on the breakout board for the Computer Card IO. If no devices are installed in the E-stop loop, verify the yellow jumper wire is installed between terminals 29 and 31, and that 24 VDC is present on terminal 31. If there are devices in the E-stop loop, verify that they are all closed.
604	Inverter Digital Input 4 fault	D	Occurs when *Inverter Digital Input #4 Function* (IO-03) is set to "External Fault High", and 120 VAC is applied to Digital Input 4 on the Remote IO. Occurs when *Inverter Digital Input #4 Function* (IO-03) is set to "External Fault Low", and 120 VAC is removed from Digital Input 4 on the Remote IO.	Verify the control wiring supplied to Inverter Digital Input 4 on the Remote IO, broken out to terminal 87 on the terminal block. View the Inverter I/O Status screen on the HMI. Verify that the indicator for Inverter DI 4 on the screen toggles as the 120 VAC going into Inverter Digital Input 4 toggles. If not, replace the digital input module in the Remote IO block.
605	Inverter Digital Input 5 fault	D	Occurs when *Inverter Digital Input #5 Function* (IO-04) is set to "External Fault High" and 120 VAC is applied to Digital Input 5 on the Remote IO. Occurs when *Inverter Digital Input #5 Function* (IO-04) is set to "External Fault Low" and 120 VAC is removed from Digital Input 5 on the Remote IO.	Verify the control wiring supplied to Inverter Digital Input 5 on the Remote IO, broken out to terminal 88 on the terminal block. View the Inverter I/O Status screen on the HMI. Verify that the indicator for Inverter DI 5 on the screen toggles as the 120 VAC going into Inverter Digital Input 5 toggles. If not, replace the digital input module in the Remote IO block.
606	Inverter Digital Input 6 fault	D	Occurs when *Inverter Digital Input #6 Function* (IO-05) is set to "External Fault High" and 120 VAC is applied to Digital Input 6 on the Remote IO. Occurs when *Inverter Digital Input #6 Function* (IO-05) is set to "External Fault Low" and 120 VAC is removed from Digital Input 6 on the Remote IO.	Verify the control wiring supplied to Inverter Digital Input 6 on the Remote IO, broken out to terminal 89 on the terminal block. View the Inverter I/O Status screen on the HMI. Verify that the indicator for Inverter DI 6 on the screen toggles as the 120 VAC going into Inverter Digital Input 6 toggles. If not, replace the digital input module in the Remote IO block.
607	Inverter Digital Input 7 fault	D	Occurs when *Inverter Digital Input #7 Function* (IO-06) is set to "External Fault High" and 120 VAC is applied to Digital Input 7 on the Remote IO. Occurs when *Inverter Digital Input #7 Function* (IO-06) is set to "External Fault Low" and 120 VAC is removed from Digital Input 7 on the Remote IO.	Verify the control wiring supplied to Inverter Digital Input 7 on the Remote IO, broken out to terminal 90 on the terminal block. View the Inverter I/O Status screen on the HMI. Verify that the indicator for Inverter DI 7 on the screen toggles as the 120 VAC going into Inverter Digital Input 7 toggles. If not, replace the digital input module in the Remote IO block.

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
608	Inverter Digital Input 8 fault	D	Occurs when *Inverter Digital Input #8 Function* (IO-07) is set to "External Fault High" and 120 VAC is applied to Digital Input 8 on the Remote IO. Occurs when *Inverter Digital Input #8 Function* (IO-07) is set to "External Fault Low" and 120 VAC is removed from Digital Input 8 on the Remote IO.	Verify the control wiring supplied to Inverter Digital Input 8 on the Remote IO, broken out to terminal 91 on the terminal block. View the Inverter I/O Status screen on the HMI. Verify that the indicator for Inverter DI 8 on the screen toggles as the 120 VAC going into Inverter Digital Input 8 toggles. If not, replace the digital input module in the Remote IO block.
609	Inverter Digital Input 9 fault	D	Reserved for Future Use	Reserved for Future Use
610	Inverter Digital Input 10 fault	D		
611	Inverter Digital Input 11 fault	D		
612	Inverter Digital Input 12 fault	D		
613	Inverter Digital Input 13 fault	D		
614	Inverter Digital Input 14 fault	D		
615	Inverter Digital Input 15 fault	D		
616	Inverter Digital Input 16 fault	D		
617	Input Phase Digital Input fault	D	Occurs when one of the digital inputs *Digital Input #4 Function* (IO-03) through *Digital Input #8 Function* (IO-07) is programmed as "Input Phase Fault High", and 120 VAC is applied to that digital input on the Remote IO.	It is intended for a digital input to be programmed as an "Input Phase Fault High" input, and connected to a phase rotation protection relay when the drive is used in a synchronous transfer system. If this is the case, determine if the phase rotation protection relay is asserting this signal and if it is due to improper phase rotation. Verify that no other digital inputs are programmed as "Input Phase Fault High" and have 120 VAC applied.

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
618	Transformer Digital Input fault	C,S	Occurs when one of the digital inputs is programmed as “Transformer Fault High”, and 120 VAC is applied to that digital input on the Remote IO. Occurs when one of the digital inputs is programmed as “Transformer Fault Low”, and 120 VAC is removed from that digital input on the Remote IO.	It is intended for a digital input to be programmed as a “Transformer Fault” input, and connected protective devices such as temperature or oil pressure switches when a front end transformer is supplied separately from the drive. If this is the case, determine if those protective devices have tripped. If the protective devices are failsafe (normally closed type switches) and the input is programmed as “Transformer Fault Low”, verify that 120 VAC is being supplied to those switches. If not, check the input fuse and output fuse of the 120 VAC control power transformer (T3). Verify that no other digital inputs are programmed as “Transformer Fault High” or “Transformer Fault Low”. Verify that all fans for the transformer cabinet are working. Check and replace fuses as necessary. Verify that the filters for the transformer cabinet are not clogged. Clean as necessary.
619	Main Contactor Feedback fault	C,S	Occurs when feedback from the main DC bus contactor in the inverter section of the drive does not follow the command to the coil of that contactor. Either the main contactor is supposed to be open, and the feedback indicates that it is closed, or, the main contactor is supposed to be closed, and the feedback indicates that it is open.	This could be caused by the main contactor pickup ice-cube relay (M1) not being seated well in its socket. Verify that it’s seated and that its lamp indicator lights momentarily when the drive completes its precharge. This could be caused by a lack of 24 VDC. Check that the “DC ON” led on the 24 VDC power supply is on. If not, check and replace the fuse supplying its input power if necessary. This could be caused by digital inputs on the Remote IO other than Digital Input 3 being programmed as a “Main Contactor Feedback” input. Check settings for *Digital Input #4 Function* (IO-03) through *Digital Input #8 Function* (IO-07) and verify that none are set to “Main Contactor Feedback”.

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
701	Converter fault	C,S	Occurs when 120 VAC is removed from *Digital Input 2* on the Remote IO.	Digital Input 2 on the Remote IO is intended to monitor failsafe (normally closed) temperature switches in the converter section of the drive. It is intended for Digital Input 2 on the Remote IO to monitor failsafe (normally closed) protective devices such as temperature or airflow switches in the converter section of the drive, or the combined transformer and converter section of the drive. Determine if those switches have tripped or have malfunctioned. Verify that 120 VAC is being supplied to those switches. If not, check the input fuse and output fuse of the 120 VAC control power transformer (T3). This could be caused by digital inputs on the Remote IO other than Digital Input 2 being programmed as a “Converter Fault Low” input. Check settings for *Digital Input #4 Function* (IO-03) through *Digital Input #8 Function* (IO-07) and verify that none are set to “Converter Fault”. Verify that all fans for the converter cabinet are working. Check and replace fuses as necessary. Verify that the filters for the converter cabinet are not clogged. Clean as necessary.
702	Ground Current fault	C,S	Occurs when excessive ground currents are detected.	The ground fault current is detected by a circuit on the Precharge Board in the power wire connection section of the inverter. The circuit produces a bi-polar signal that is connected to Analog Input 1 on the Remote IO. A ground fault is declared when the absolute value of the level on that input exceeds 5V. Open the inverter and visually inspect to ensure that no wires are touching any of the cells. Visually inspect power wiring including the DC bus and motor leads. Pay particular attention to any splices that may be in the motor leads. Disconnect the motor leads from the drive and Megger the motor through the motor leads. Use a megaohm meter / insulation tester capable of producing the motor’s rated voltage.

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
706	Cell IGBT Temperature fault	D	Occurs when any cell's IGBT temperature reaches 70 °C or 0 °C.	Verify that all fans for the inverter cabinet are working. Check and replace fuses as necessary. If one of the fan fuses is blown or the fan is otherwise inooerable, that fan will rotate backwards due to the air flow being forced across the blades. Verify that the filters for the inverter cabinet are not clogged. Clean as necessary. If cooling fans are 3 phase, verify that all 3 fans are rotating counter-clockwise.
707	Cell Board Temperature fault	D	Occurs when any cell's control board temperature reaches 70 °C or 0 °C.	Verify that all fans for the inverter cabinet are working. Check and replace fuses as necessary. If one of the fan fuses is blown or the fan is otherwise inoperable, that fan will rotate backwards due to the air flow being forced across the blades. Verify that the filters for the inverter cabinet are not clogged. Clean as necessary. If cooling fans are 3 phase, verify that all 3 fans are rotating in same direction.
714	Input Disconnect Open	C,S	Occurs when one of the digital inputs *Digital Input #4 Function through Inverter Digital In #8* or *CCI Digital In #8* is programmed as "Input Disconnect Feedback" and 120VAC is removed from that digital input on the reader I/O.	It is intended for a normally open auxialiary contact on an input disconnect switch to be monitored by a digital input programmed as an "Input Disconnect Feedback" input. Determine if that auxiliary contact has opened or malfunctioned. Verify that 120VAC is being supplied to that auxiliary contact. Verify that no other inputs are programmed as "Input Disconnect Feedback".
715	Output Disconnect Open	C,S	Occurs when one of the digital inputs *Digital Input #4 Function through Inverter Digital In #8* or *CCI Digital In #8* is programmed as "Output Disconnect Feedback" and 120VAC is removed from that digital input on the reader I/O.	It is intended for a normally open auxialiary contact on an output disconnect switch to be monitored by a digital input programmed as an "Output Disconnect Feedback" input. Determine if that auxiliary contact has opened or malfunctioned. Verify that 120VAC is being supplied to that auxiliary contact. Verify that no other inputs are programmed as "Output Disconnect Feedback".

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
716	Output Contactor Feedback	C,S	Occurs when feedback from an output contactor does not follow the command to the coil of that conactor. Either the output contactor is supposed to be open and the feedback dictates that it is cosed, or the output contactor is supposed to be closed, and the feedback indicates that it is open..	When there is an output contactor, it is intended to be controlled by a digital output programmed as “Output Contactor Control” and to have its normally open auxiliary contact monitored by a digital input programmed as “Output Contactor Feedback”. Determine if the auxiliary contact has malfunctioned. Verify that 120VAC is being supplied to the auxiliary contactor. Verify that no other inputs are programmed as “Output Contactor Feedback”.
717	DC Link Reactor	C,S	Occurs when one of the digital inputs…is programmed as “DC Link Reactor Fault”, and 120VAC is removed from that digital input on the remote I/O.	When there is a DC Link reactor, it is intended to monitor its failsafe (normally closed) protective devices (temperature or air flow switches) with a digital input programmed as “DC Link Reactor Fault”. Verify that 120VAC is being supplied to the switches. Verify that no other inputs are programmed as “DC Link Reactor Fault”.
718	Output Reactor	D	Occurs when one of the digital inputs…is programmed as “Output Reactor Fault”, and 120VAC is removed from that digital input on the remote I/O.	When there is a Output reactor, it is intended to monitor its failsafe (normally closed) protective devices (temperature or air flow switches) with a digital input programmed as “Output Reactor Fault”. Verify that 120VAC is being supplied to the switches. Verify that no other inputs are programmed as “Output Reactor Fault”.
719	CCI IO Coomunication Loss	C,S	Occurs when communication between the Computer Card and the Remote IO in the Customer Control Interface enclosure stops for more than two seconds.	Verify that all network cables inside the Customer Control Interface enclosure inside the low voltage section of the inverter and between the two sections, are installed properly and that all network routers are powered.

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
720	Multiple Leader Inverters		Occurs when multiple inverters in a parallel inverter drive are configured as leaders.	Contact Benshaw.
721	Inverter Address Conflict		Occurs when multiple inverters in a parallel inverter drive are configured with the same logical addtress.	Contact Benshaw.
722	Mesh FOB Backplane Communication fault	C	In a parallel inverter drive, occurs when the Mesh Fiber Optic Board receives a bad message from the Computer Card over the backplane in the card cage.	Replace the Mesh Fiber Optic Board. If the problem persists, contact Benshaw.
723	Mesh FOB Fiber Communication fault	C	In a parallel inverter drive, occurs when the Mesh Fiber Optic Board receives a bad message from another inverter over a plastic optical fiber (POF) connection.	Replace the Mesh Fiber Optic Board. If the problem persists, contact Benshaw.
730	CCI Digital Input 1 fault	D	Occurs when *CCI Digital Input #1* Function (I0-112) is set to “External Fault High” and 120VAC is applied to CSI Difital Input 1. Occurs when *CCI Digital Input #1* Function is set to “External Fault Low” and 120VAC is removed from CCI Digital Input 1.	Verify the control wiring supplied to CCI Digital Input 1, broken out to terminal 30 on TB2. View the CCI I/O Monitor screen on the HMI. Verify that the indicator for CCI DI1 on the screen toggles as the 120VAC going into CCI Digital Input 1 toggles. If not, replace the digital input module.

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
731	CCI Digital Input 2 fault	D	Occurs when *CCI Digital Input #2* Function (I0-112) is set to "External Fault High" and 120VAC is applied to CCI Digital Input 2. Occurs when *CCI Digital Input #2* Function is set to "External Fault Low" and 120VAC is removed from CCI Digital Input 2.	Verify the control wiring supplied to CCI Digital Input 2, broken out to terminal 31 on TB2. View the CCI I/O Monitor screen on the HMI. Verify that the indicator for CCI DI1 on the screen toggles as the 120VAC going into CCI Digital Input 2 toggles. If not, replace the digital input module.
732	CCI Digital Input 3 fault	D	Occurs when *CCI Digital Input #3* Function (I0-112) is set to "External Fault High" and 120VAC is applied to CCI Digital Input 3. Occurs when *CCI Digital Input #3* Function is set to "External Fault Low" and 120VAC is removed from CCI Digital Input 3.	Verify the control wiring supplied to CCI Digital Input 3, broken out to terminal 32 on TB2. View the CCI I/O Monitor screen on the HMI. Verify that the indicator for CCI DI1 on the screen toggles as the 120VAC going into CCI Digital Input 3 toggles. If not, replace the digital input module.
733	CCI Digital Input 4 fault	D	Occurs when *CCI Digital Input #4* Function (I0-112) is set to "External Fault High" and 120VAC is applied to CCI Digital Input 4. Occurs when *CCI Digital Input #4* Function is set to "External Fault Low" and 120VAC is removed from CCI Digital Input 4.	Verify the control wiring supplied to CCI Digital Input 4, broken out to terminal 33 on TB2. View the CCI I/O Monitor screen on the HMI. Verify that the indicator for CCI DI1 on the screen toggles as the 120VAC going into CCI Digital Input 4 toggles. If not, replace the digital input module.
734	CCI Digital Input 5 fault	D	Occurs when *CCI Digital Input #5* Function (I0-112) is set to "External Fault High" and 120VAC is applied to CCI Digital Input 5. Occurs when *CCI Digital Input #5* Function is set to "External Fault Low" and 120VAC is removed from CCI Digital Input 5.	Verify the control wiring supplied to CCI Digital Input 5, not broken out to TB. View the CCI I/O Monitor screen on the HMI. Verify that the indicator for CCI DI1 on the screen toggles as the 120VAC going into CCI Digital Input 5 toggles. If not, replace the digital input module.
735	CCI Digital Input 6 fault	D	Occurs when *CCI Digital Input #6* Function (I0-112) is set to "External Fault High" and 120VAC is applied to CCI Digital Input 6. Occurs when *CCI Digital Input #6* Function is set to "External Fault Low" and 120VAC is removed from CCI Digital Input 6.	Verify the control wiring supplied to CCI Digital Input 6, broken out to terminal 34 on TB2. View the CCI I/O Monitor screen on the HMI. Verify that the indicator for CCI DI1 on the screen toggles as the 120VAC going into CCI Digital Input 6 toggles. If not, replace the digital input module.

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
736	CCI Digital Input 7 fault	D	Occurs when *CCI Digital Input #7* Function (I0-112) is set to "External Fault High" and 120VAC is applied to CCI Digital Input 7. Occurs when *CCI Digital Input #7* Function is set to "External Fault Low" and 120VAC is removed from CCI Digital Input 7.	Verify the control wiring supplied to CCI Digital Input 7, broken out to terminal 35 on TB2. View the CCI I/O Monitor screen on the HMI. Verify that the indicator for CCI DI1 on the screen toggles as the 120VAC going into CCI Digital Input 7 toggles. If not, replace the digital input module.
737	CCI Digital Input 8 fault	D	Occurs when *CCI Digital Input #8* Function (I0-112) is set to "External Fault High" and 120VAC is applied to CCI Digital Input 8. Occurs when *CCI Digital Input #8* Function is set to "External Fault Low" and 120VAC is removed from CCI Digital Input 8.	Verify the control wiring supplied to CCI Digital Input 8, broken out to terminal 36 on TB2. View the CCI I/O Monitor screen on the HMI. Verify that the indicator for CCI DI1 on the screen toggles as the 120VAC going into CCI Digital Input 8 toggles. If not, replace the digital input module.
738	CCI Digital Input 9	D	Reserved for Future Use.	Reserved for Future Use.
739	CCI Digital Input 10	D	Reserved for Future Use.	Reserved for Future Use.
740	CCI Digital Input 11	D	Reserved for Future Use.	Reserved for Future Use.

Table 22: Fault Conditions

Fault Code	Fault Displayed	Reaction Type	Description	Course of Action
741	CCI Digital Input 12	D	Reserved for Future Use.	Reserved for Future Use.
742	CCI Digital Input 13	D	Reserved for Future Use.	Reserved for Future Use.
743	CCI Digital Input 14	D	Reserved for Future Use.	Reserved for Future Use.
744	CCI Digital Input 15	D	Reserved for Future Use.	Reserved for Future Use.
745	CCI Digital Input 16	D	Reserved for Future Use.	Reserved for Future Use.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9 – Spare Parts

Spare Parts List

Quantity	Part Name
3	Power Cell
1	Computer Card
1	Power FOB
1 of each	Control power supplies
1 of each	Control power fuses
1	Rectifier Assembly with fuses
1	Snubber Assembly with fuses
1 set	Air filters
1 of each unique size	Modular Fan Assembly
1 set of each unique size	Fan fuses
1 of each unique size	Fiber Optic Cable Assembly


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References

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Appendix A: Profibus-DP Modbus

Profibus-DP Connection

The M2L 3000 Profibus setup can be reached through the built in web configuration tool (192.168.1.5).

Profibus-DP Input Data

NOTE: All Modbus registers are read-only.

Table 24: Profibus-DP Output Data

Slot	Register Address	Description	Data Type	Range	Multiplier
1 [0,1]	40400	Output Frequency	INT	-300.00 – 300.00 Hz	100
1 [2,3]	40404	Motor kW	INT	-32767 – 32767 kW	1
1 [4,5]	40406	Motor Torque	INT	-6.000 – 6.000 per unit	1000
1 [6,7]	40408	Bus kW	INT	-32767 – 32767 kW	1
1 [8,9]	40409	Motor Power Factor	INT	-1.000 – 1.000 per unit	1000
1 [10,11]	40426	Peak Drive Temperature	INT	-128 – 127 C	1
1 [12,13]	40427	Average Drive Temperature	INT	-128 – 127 C	1
1 [14,15]	Xxxxx	POINT NOT MAPPED	X	POINT NOT MAPPED	-
2 [0,1]	40401	Motor Current	UINT	0 – 6000 A	1
2 [2,3]	40402	Motor Voltage (Line to Neutral)	UINT	0 – 15000 V	1
2 [4,5]	40403	Bus Voltage	UINT	0 – 32000 V	1
2 [6,7]	40405	Motor kVA	UINT	0 – 65535 kVA	1
2 [8,9]	40407	Bus Current	UINT	0 – 6000 A	1
2 [10,11]	40410	Motor Overload Level	UINT	0.00 – 200.00%	100
2 [12,13]	40411	Drive Overload Level	UINT	0.00 – 200.00%	100
2 [14,15]	40422	Motor Overload Time	UINT	0 – 65535 seconds	1
2 [16,17]	40423	L1 Motor Current	UINT	0 – 6000 Arms	1

Slot	Register Address	Description	Data Type	Range	Multiplier
2 [18,19]	40424	L2 Motor Current	UINT	0 – 6000 Arms	1
2 [20,21]	40425	L3 Motor Current	UINT	0 – 6000 Arms	1
2 [22,23]	40433	DC Pole Voltage	UINT	0 – 32000 V	1
2 [24,25]	44827	VFD Fault Code	UINT	-	-
2 [26,27]	44828	VFD Lockouts 1 Status	UINT	Bit 0: GPP Initializing Bit 1: DSP Initializing Bit 2: Capacitor Imbalance Bit 3: Remote IO Communication Loss Bit 4: Converter Overtemperature Bit 5: Motor Thermal Overload Bit 6: Inverter Thermal Overload Bit 7: Card Cage Power Bit 8: Run Disable Bit 9: Backspin Bit 10: Cell IGBT Temperature Bit 11: Cell Board Temperature Bit 12: Drive Disable Bit 13: Interlock Bit14: Input Phase Bit 15: Transformer	-
2 [28,29]	44829	Lockout Time Remaining	UINT	0 - 65535 seconds	-
2 [30,31]	44830	VFD Warnings	UINT	Bit 0: Converter Temperature Bit 1: Cell IGBT Temperature Bit 2: Cell Board Temperature Bit 3: Transformer	-
3 [0,1]	44831	Control Source	UINT	0 – Digital Inputs 1 - HMI 2 - Modbus TCP 3 - DeviceNet	-
3 [2,3]	44832	Speed Reference Source	UINT	0 - HMI 1 - Analog Input #1 2 - Analog Input #2 3 - Analog Input #3 4 - Analog Input #4 5 - Analog Input #5 6 - Analog Input #6 7 - Analog Input #7 8 - Analog Input #8 9 - Modbus TCP 10 - DeviceNet	-
3 [4,5]	45002	Drive Status	UINT	Bit 0: Faulted Bit 1: Warning Bit 2: Running Forward Bit 3: Running Reverse Bit 4: Locked Out Bit 5: Ready Bit 6: Control Limited	-
3 [6,7]	44833	VFD Lockouts 2 Status	UINT	Bit 0: HMI Comm Loss Bit 1: Fieldbus Comm Loss	-

Profibus-DP Output Data

Slot	Register Address	Description	Data Type	Range	Multiplier
11 [0,1]	45001	Speed Reference	INT	0.00 – 300.00 Hz	100
12 [0,1]	45000	Drive Control	UINT	Bit 0: Run Forward Bit 1: Run Reverse Bit 2: Fault Reset	-


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Glossary

Components

18-Pulse Transformer

An 18-Pulse Transformer is a three-phase transformer with three sets of outputs that are phase shifted 20° from each other. Along with the Rectifier Modules, it is a major component of the Converter. The outputs of the transformer feed the Rectifier Modules in the Converter.

2-Position DC Landing Pad

A 2-Position DC Landing Pad consists of two metal bus bars mounted on insulators. One side of the bus bar is wired to equipment within the enclosure. The other side of the bus bar has holes for mounting cable lugs.

The Converter has a 2-Position DC Landing Pad in the bottom of its Transformer Section.

The Inverter has a 2-Position DC Landing Pad in its Input Section.

The landing pads provide the termination point for the Medium Voltage DC cables connecting the enclosures. They prevent mechanical stress by those cables from being imparted onto equipment within the enclosure.

3-Position AC Landing Pad

A 3-Position AC Landing Pad consists of three metal bus bars mounted on insulators. One side of the bus bar is wired to equipment within the enclosure. The other side of the bus bar has holes for mounting cable lugs.

The Inverter has a 3-Position AC Landing Pad in its Input Section.

The landing pads provide the termination point for the three-phase Medium Voltage cables run between enclosures and the motor. They prevent mechanical stress by those cables from being imparted onto equipment within the enclosure.

Card Cage

The Card Cage is in the Low Voltage Section of the Inverter. It houses the Computer Card and FOBs. It protects them mechanically, and shields them from electrical noise. It includes a power supply and backplane that provide the cards with power and a data bus.

Computer Card

The Computer Card is a card in the Card Cage. It executes the algorithms for controlling the motor by monitoring voltage and current feedback from the Power Cells, and commanding the voltage to be output by the Power Cells. It also implements the intelligence for the external interfaces to the drive including serial interfaces, and discrete IO points.

Control Power Transformer

A Control Power Transformer is a single-phase transformer, often with configurable taps on its primary side to accommodate different input voltages. The Inverter has a Control Power Transformer mounted on the Top Back Panel in its Input Section. It provides 120 VAC control power to accessory equipment within the Inverter, and isolates it from the external control power supplied to the Inverter.

Converter

The Converter is one of the major components of the drive. It is an enclosure that houses the 18-Pulse Transformer and the Rectifier Modules. It converts the three-

	phase Medium Voltage supply to Medium Voltage DC, which is then fed to the Inverter.
DC Bus Bar	The two DC Bus Bars are in the Cell Section of the Inverter. They supply the DC bus to the Power Cells.
Disconnect Switch	A Disconnect Switch is a mechanical switch. There may be Disconnect Switches on the input and on the output of the drive. They may be opened to isolate the drive or motor from sources of power for maintenance.
Dual Diode Module	A Dual Diode Module is a package that contains two high-current, high-voltage diodes in series, three terminals, and a metal heat transfer plate. Each Rectifier Module contains three Dual Diode Modules mounted on a heatsink. They are connected in a bridge circuit to implement a full-wave, three-phase rectifier.
Ethernet Switch	An Ethernet Switch is a network device with multiple ports. It is used to connected multiple host devices to the same network. It learns the IP address of each host connected to a port. It reduces messages received by each host by only sending traffic to a port if the message's target IP address is attached to that port.
FOB	Fiber Optic Board. See Power FOB.
HMI	The Human Machine Interface is a touch-sensitive, graphical display. It is mounted in the door of the Low Voltage Section of the Inverter. It provides real-time status of the drive. It may be used to configure drive parameters, and view the event log.
IGBT	Insulated Gate Bipolar Transistors are the power semiconductor switching devices in the Power Cells.
Inner Air Filter	An Inner Air Filter is the second stage of a two-stage air filter. It is located inside the enclosure.
Inverter	The Inverter is one of the major components of the drive. It is an enclosure that houses the Power Cells, the Card Cage, and the HMI. It performs multi-level, pulse width modulation to convert Medium Voltage DC to three-phase Medium Voltage, which is then fed to the motor.
Inverter IO	The Inverter IO is a set of analog and digital inputs and outputs located in the Low Voltage Section of the Inverter. Some of the IO points are reserved for use by components internal to the Inverter. Other IO points are configurable and may be used to interface to the plant.

Isolating CT	An Isolating CT is a toroid-shaped current transformer mounted on an insulating cylinder. The insulating cylinder has a hole in its center that retains the primary current-carrying conductor. The Inverter has Isolating CTs on the back of its Power Cell Back Panels for each Power Cell. The Converter has two Isolating CTs mounted above its Low Voltage Box. The Isolating CTs provide a means of transferring power from the primary, current-carrying conductor to a load attached to its secondary side, while maintaining Medium Voltage isolation between the primary and secondary sides of the transformer.
Loop Power Supply Reactor	The Loop Power Supply Reactor is a Single-Pole Line Reactor. The Inverter has a Loop Power Supply Reactor on the Top Back Panel of its Input Section. The Loop Power Supply Reactor limits the current through the loop of wire when all the Power Cells are removed.
Loop Power Supply Transformer	A Loop Power Supply Transformer is a single-phase step-down transformer. The Inverter has a Loop Power Supply Transformer on the Top Back Panel of its Input Section. It drives a high current through a loop of wire.
Main Contactor	The Main Contactor is a medium voltage, vacuum bottle contactor. It is in the Input Section of the Inverter. Once the Power Cells have been charged through the Precharge Resistors, the Main Contactor closes to connect the Medium Voltage DC input from the 2-Position DC Landing Pad directly to the two DC Bus Bars in the inverter.
Main Contactor Relay	The Main Contactor Relay is a plug-in, single pole, double throw relay with a status indicator light. It is in the Low Voltage Section of the Inverter. It interposes a 24VDC relay on the Computer Card to the 120VAC coil of the Main Contactor.
Modular Fan Assembly	A Modular Fan Assembly is a ventilated housing that contains a single fan. The fans remove heat from the (enclosures?) by blowing air out of (it/them?).
Outer Air Filter	An Outer Air Filter is the first stage of a two-stage air filter. It is located outside the enclosure.
Pole Filter	A Pole Filter is a metal tray that contains multiple reactors electrically arranged to create two ends and one midpoint. There are three Pole Filters in the Cell Section of an **Error! Reference source not found.**. Each end connects to one Arm of Power Cells in a phase. The midpoint is connected to the 3-Position AC Landing Pad for the **Error! Reference source not found.**'s output. The pole filters reduce current flow between the positive and negative Arm of Power Cells in the phase.
Power Cell	The Power Cells in the Inverter are metal boxes that contain IGBTs, capacitors, circuit boards, and voltage and current sensors. By switching the IGBTs to different states, each Power Cell is capable of outputting three different voltage levels. Multiple Power Cells are connected in series to create a multi-level phase, and three phases are combined to produce the **Error! Reference source not found.**'s output.

	Voltage and current sensed by each of the cells is combined to produce the motor voltage and current used by the motor control algorithm.
Power Cell Back Panel	A Power Cell Back Panel is a fiberglass panel in the Inverter. There is one behind each column of Power Cells. It provides the electrical connections for the Power Cells and provides the path for the air flow from the Power Cells to the air plenum. The Isolating CTs are mounted on the back side of the Power Cell Back Panel.
Power FOB	Power Fiber Optic Boards are boards in the Card Cage that have multiple fiber optic interfaces. They communicate with the Power Cells.
Precharge Board	The Precharge Board contains Medium Voltage relays, Ground Fault sensing circuitry, and Look Ahead sensing circuitry. It is in the Inverter. The Medium Voltage relays close to connect the Precharge Resistors to the two DC Bus Bars. The Ground Fault sensing circuitry detects ground fault currents. The Look Ahead sensing circuitry detects the voltage applied to the 2-Position DC Landing Pad.
Precharge Board Cover	The Precharge Board Cover is a sheet metal cover for the Precharge Board. It protects the components on the board from physical damage and acts as a shield for electrical noise.
Precharge Resistor	The Precharge Resistors are high-wattage resistors. They are in the Inverter. They the limit the inrush current into the Power Cell's capacitors when Medium Voltage DC is first applied to the 2-Position DC Landing Pad. Once the cell's capacitors are charged, the Precharge Resistors are bypassed by the Main Contactor.
Rectifier Module	A Rectifier Module is a metal (box?, tray?) in the Converter that contains Dual Diode Modules, heatsink, and fuses. It converts a three-phase, Medium Voltage AC input to a Medium Voltage DC output.
SD Card	An SD Card is a removable, flash memory, electronic storage device. An industrial-grade SD Card is installed in an SD Card socket on the Computer Card. The SD Card stores the drive's configuration parameters and event log.
Shunt Trip Relay	The Shunt Trip Relay is a plug-in, single pole, double throw relay with a status indicator light. It is in the Low Voltage Section of the Inverter. It interposes a 24 VDC relay on the Computer Card in series with a customer-supplied switch to the shunt trip input on the customer's circuit breaker that feeds the drive.
Snubber Assembly	The Snubber Assembly is a circuit board that contains high-wattage resistors, high-voltage and current diodes, and high-energy capacitors to create an RCD (resistor, capacitor, diode) snubber circuit. The Snubber Assemblies are in the Rectifier Modules in the Converter. The snubber circuits protect the diodes in the Rectifier Modules from voltage transients.
Surge Arrestor	Surge Arrestors are mounted directly to the inputs on the primary side of the 18-Pulse Transformer in the Converter. They protect the drive from lightning-induced

voltage transients on the incoming Medium Voltage power by shunting those transients to ground.

Thermal Switch Isolation Receiver Board

A Thermal Switch Isolation Receiver Board is a circuit board with four fiber optic receivers and four relay outputs. The Converter has a Thermal Switch Isolation Receiver Board in its Low Voltage Box. The Thermal Switch Isolation Receiver Board is connected by fiber optic cables to Thermal Switch Isolation Transmitter Boards. The fiber optic cables between the boards isolate the thermal switches on the Medium Voltage components from the controls used to monitor them.

Thermal Switch Isolation Transmitter Board

A Thermal Switch Isolation Transmitter Board is a circuit board that monitors two thermal switches, and transmits their state over two fiber optic cables to a Thermal Switch Isolation Receiver Board. The Converter has a Thermal Switch Isolation Transmitter Board in its Rectifier Section and another in its Transformer Section. The fiber optic cables between the boards isolate the thermal switches on the Medium Voltage components from the controls used to monitor them.

Concepts

Arm

In an **Error! Reference source not found.**, Multiple Power Cells are connected in series with a Pole Filter in the middle to create a phase. One end is connected to the positive side of the DC bus, the other end is connected to the negative side of the DC bus, and the middle connection point of the Pole Filter is connected to the **Error! Reference source not found.**'s output. The cells between the positive side of the DC bus and the Pole Filter are the Positive Arm of the phase. The cells between the negative side of the DC bus and the Pole Filter are the Negative Arm of the phase.

ATL

Across-The-Line is when a motor is connected directly to the line. It is not being controlled by the drive.

Control Power

Control Power is used within the drive to power its controls and auxiliary equipment. It does not provide power to the motor controlled by the drive.

Front End

The Front End portion of a drive converts the incoming AC Line voltage into a DC voltage, which is then converted back into an AC voltage by the Inverter.

A conventional Front End uses diode bridges to convert AC to DC. It may use a transformer with multiple phase-shifted outputs, and multiple diode bridges to reduce the ripple on the generated DC voltage and to reduce the harmonics on the input.

An Active Front End uses power semiconductor switches instead of diode bridges, doesn't require a transformer, and can transfer power from the inverter back onto the line.

Ground Fault

A Ground Fault is an unintended contact between energized conductors is ground. It results in current flow through the grounding system, equipment, or personnel that provides a path to ground.

Look Ahead	The Inverter uses the Look Ahead circuit on the Precharge Board to determine whether or not Medium Voltage DC is being supplied by the Front End before it attempts to Precharge.
Loop Power Supply	A Loop Power Supply is a means of providing isolated Control Power to components which may be exposed to Medium Voltage. A step-down transformer is used to drive a high current through a loop of wire. The loop of wire passes through a current transformer, which then supplies power to the component exposed to Medium Voltage. The distance between the loop of wire and the current transformer provides the required amount of isolation.
Low Voltage	Per NEMA, Low Voltage refers to any voltage less than 1 kV.
Medium Voltage	Per NEMA, Medium Voltage refers to any voltage between 1 kV and 100 kV.
Precharge	The Power Cells in the Inverter contain capacitors that must be charged before it's able to run a motor. When the Inverter is energized, it prevents a large inrush of current into the capacitors by executing a Precharge sequence. It first uses the Precharge Board to connect the incoming Medium Voltage DC to the DC Bus Bars through the Precharge Resistors. The resistors limit the current as the capacitors charge. Once the capacitors are charged, the Inverter then closes its Main Contactor and disconnects the Precharge Resistors.
VFD	A Variable Frequency Drive controls the speed of an AC motor by varying the frequency of the voltage it supplies to that motor.

Revision History

Revision	Date	ECO	Description
00	December 15, 2017	E5306	Initial Release

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