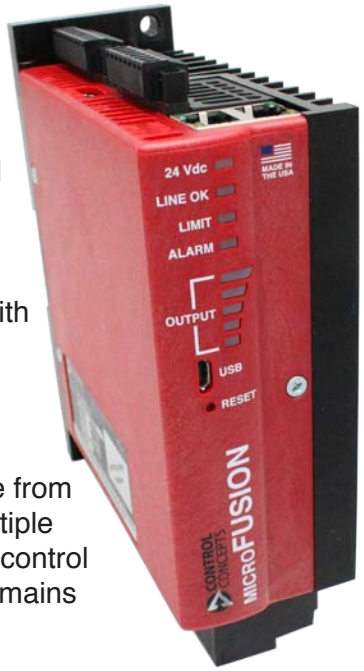
1. OVERVIEW



MicroFUSION is an ultra-compact high-performance microprocessor-based power controller, available in single, three phase, or three phase two leg models to control AC loads.

Resistive or transformer-connected loads can be controlled in either Phase Angle, Zero Cross, or Zero Cross Transformer (ZCT) Mode. Output is controlled linearly with respect to command signal and can be set to the average or RMS value of the voltage and current, as well as true instantaneous power or external feedback.

MicroFUSION Series power controllers are available in current ratings from 16, 32, 50, 80 amps AC. Auto-ranging voltage circuitry enables main supply voltage from 24-600 VAC, (45-65 Hz) eliminating the need for hardware jumpers or stocking multiple controllers for international voltages. A separate 24 Vdc power source supplies the control electronics and maintains critical communications to your control system when the mains are absent.

Status LEDs and an LED bar graph make operation and troubleshooting simple. A plug-n-play USB interface and free MicroFUSION Control Panel software for the PC further simplifies installing and configuring the controller to your application. For example, controller settings can be duplicated simply by loading a configuration file saved from a previous unit.

Setpoints can be controlled through the standard analog or optional digital fieldbus interface. The factory-configured analog setpoint signal ranges are 0 - 5 Vdc and 4 - 20 mA, both of which are field scalable from 0 - 10 Vdc or 0 - 20 mA.

External fieldbus interface options include DeviceNet™, EtherNet/IP, EtherCAT, PROFINET, Modbus RTU (RS-485), or Modbus TCP. These can be used to communicate with a PLC or factory control system. PROFINET, Modbus TCP, and EtherNet/IP are available as internal fieldbus options. Furthermore, a single external network module can control up to ten zones, reducing system installation costs.

The robust design of MicroFUSION allows for continuous full-frame current operation - without derating - at up to 50° C / 6000 ft altitude. Cooling is accomplished through either natural convection, forced air, optional external panel mount, or optional liquid-cooled chill plate.

1.1 Certifications / Markings

c UL us LISTED

CE EN60947-4

100kA SHORT CIRCUIT CURRENT RATING

FC Part 15 Subpart B Class A Device

RoHS COMPLIANT

Pb Pb-Free

ODVA

In addition to certification markings, the controllers will also be marked with:

- Model Number
- Serial Number
- Voltage Range (24 - 600 Vac)
- Current Size
- Control Concepts contact information
- Frequency (45 - 65 Hz)
- Torque information on Line / Load connections

1.2 Points of Interest

A. CCI LINK™
A proprietary deterministic digital bus that enables multiple Control Concepts devices to communicate with each other.

B. DIGITAL COMMUNICATIONS OPTION
PROFINET, Modbus TCP, and EtherNet/IP are available as internal fieldbus options.

C. RETRANSMITS & RELAY CONNECTIONS
(P2) Retransmits and Relay

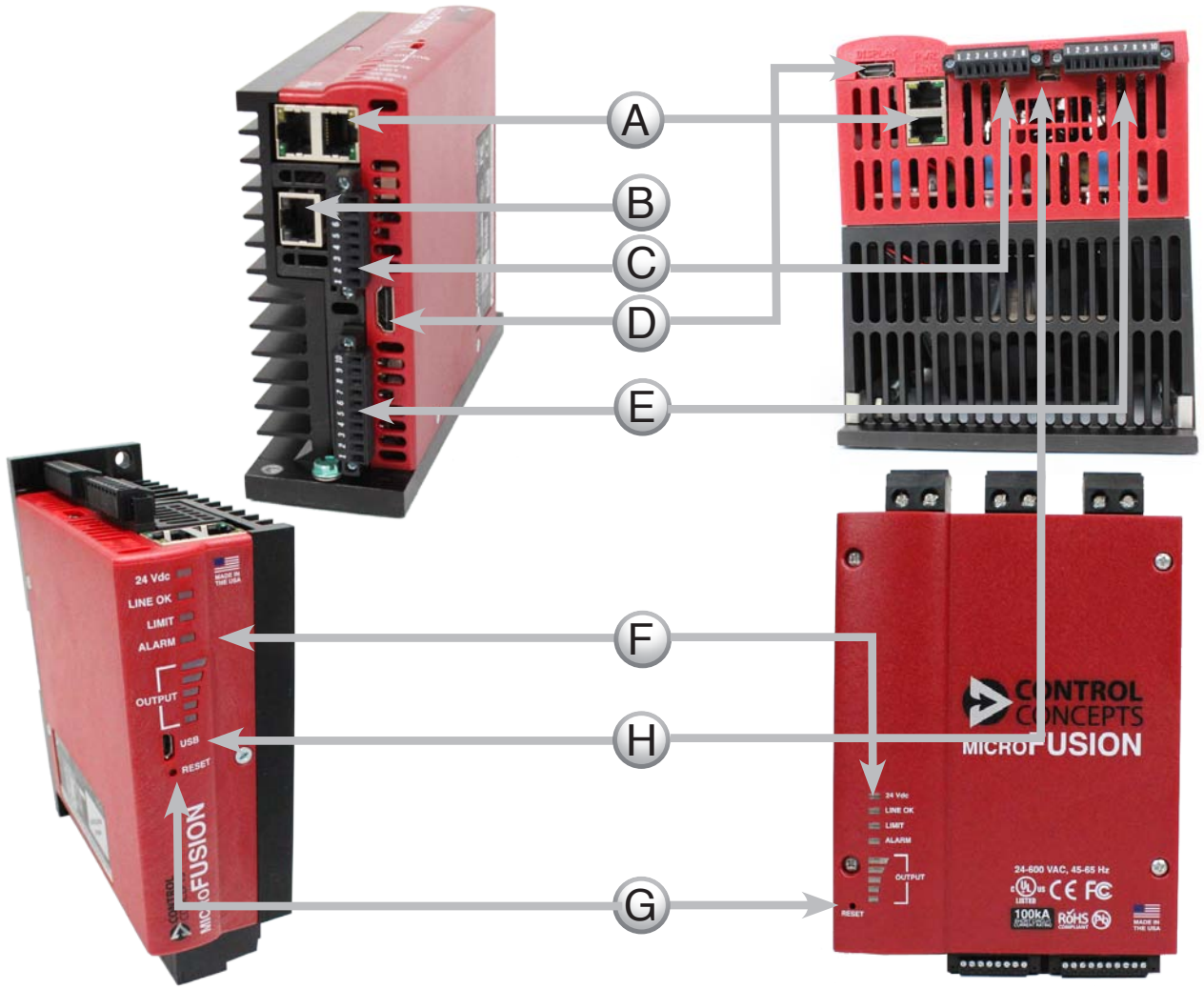
D. OPTIONAL REMOTE DISPLAY
Shows parameter name with information such as setpoints, limit settings, monitor features, alarms, and more. The display can be easily mounted outside an electrical panel for efficiency.

E. COMMAND CONNECTIONS
(P1) Analog inputs, general purpose input, + 24 Vdc supply, run/stop

F. INDICATOR LEDs
Assist with Diagnostics

G. CONTROLLER RESET
MicroFUSION processor can be reset externally

H. USB PORT
Streamlines controller setup with the use of the MicroFUSION control panel.



1.3 Feature Comparison

MicroFUSION is available with one of two circuit boards. SX is a lower-cost alternative, whereas HX is a fully populated board that can be field-upgraded to include retransmits and other features.

● = Included O = Field Upgradable Option
☐ = Option Available at Manufacturing Time - = Not available

FEATURE LIST	SX	HX
24-600 VAC Auto-Ranging Input	●	●
Phase Angle and Zero Cross Firing Modes	●	●
LED Bar Graph	●	●
Touchsafe Design	●	●
UL-Listed, CE, 100kA SCCR, and RoHS certifications	●	●
Micro USB Connection (USB Plug-N-Play)	●	●
Free Control Panel Software	●	●
DIN Rail Mountable	●	●
Panel Mount	●	●
RUN/STOP	●	●
Overcurrent Trip	●	●
Analog Input (0-10V, 0/4-20 mA or potentiometer)	●	●
CCI Link™ Connectivity	●	●
Fixed Current Limit - 105% of Frame	●	-
Adjustable Current Limit	O	●
Alarm Relay	O	●
Current Control	O	●
Load Voltage Control	-	●
Voltage Limit	-	●
Monitor Current	O	O
Analog Channel 2 Input	O	O
General Purpose Input	O	O
Pulse Width Modulation Input	O	O
Accessory Option: Remote Display	O	O
SYNC-GUARD™ Connectivity	O	O
External Fieldbus Options: DeviceNet, Modbus TCP, Modubs RTU, EtherNet/IP, PROFINET, EtherCat	O	O
Internal Fieldbus Options: PROFINET, Modbus TCP, and EtherNet/IP	☐	☐
External Panel Mount Heatsink	☐	☐
Water-Cooled Heatsink	☐	☐
Zero Cross Transformer Firing Mode	-	O
Retransmit (RTX): 2x High Resolution Analog Retransmits 0-10 VDC or 0/4-20 mA	-	O
Power Limit	-	O
True Power Control	-	O
Monitor True RMS Power	-	O
High Resolution Control Loop	-	O

1.4 Model Options & Description

Single Phase AC

The single phase AC power controller is a phase angle or zero cross fired controller. It linearly controls, with respect to the setpoint, the AC voltage, current or true power applied to an electrical load. Control is achieved by means of a pair of inverse parallel SCR's.

Three Phase - Two Leg

The three phase two leg AC power controller is a zero cross fired controller. It linearly controls, with respect to the setpoint, the AC voltage, current, or true power applied to an electrical load. Control is achieved by two pairs of inverse parallel SCR's.

Three Phase - Three Leg

The three phase three leg AC power controller is a phase angle or zero cross fired controller. It linearly controls, with respect to the setpoint, the AC voltage, current or true power applied to an electrical load. Control is achieved by three pairs of inverse parallel SCR's.

1.5 Load Types

Loads / Applications

1. Constant Resistive Loads (Nickel Chromium)
2. Variable Resistive Loads
    a. Silicon Carbide
    b. Molybdenum Disilicide
    c. Graphite
    d. Tungsten Lamps
3. Transformer Coupled Loads
4. Inductive (not intended for motor applications)
5. Gas Discharge
    a. Ultra Violet
6. Electron Beam
7. Crystal Growing and Processing

Transformers

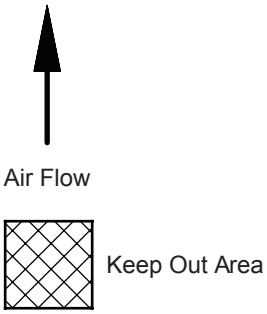
Scott-T & Wye transformers: Excessive voltage transients can occur when operating Scott-T transformers with an open or unloaded secondary. It is recommended that Scott-T transformer be limited to a maximum of 480 Volts.

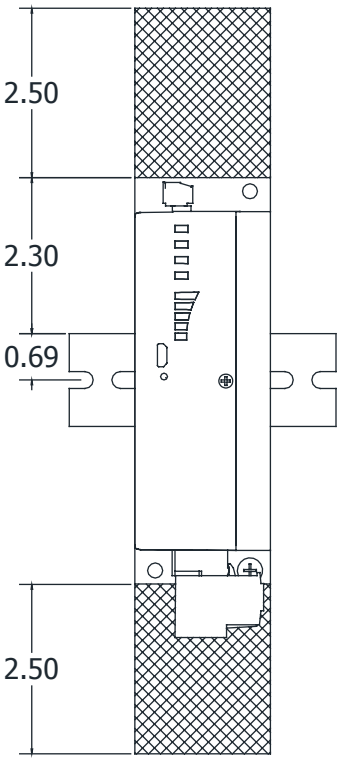
NOTE: It is recommended that a Delta to 4-Wye transformer be used to power a 4-wire Wye load. Delta to 3-wire Wye transformers are acceptable, but Wye to Wye transformers are not suited for use between the controller and load due to possible transient conditions.

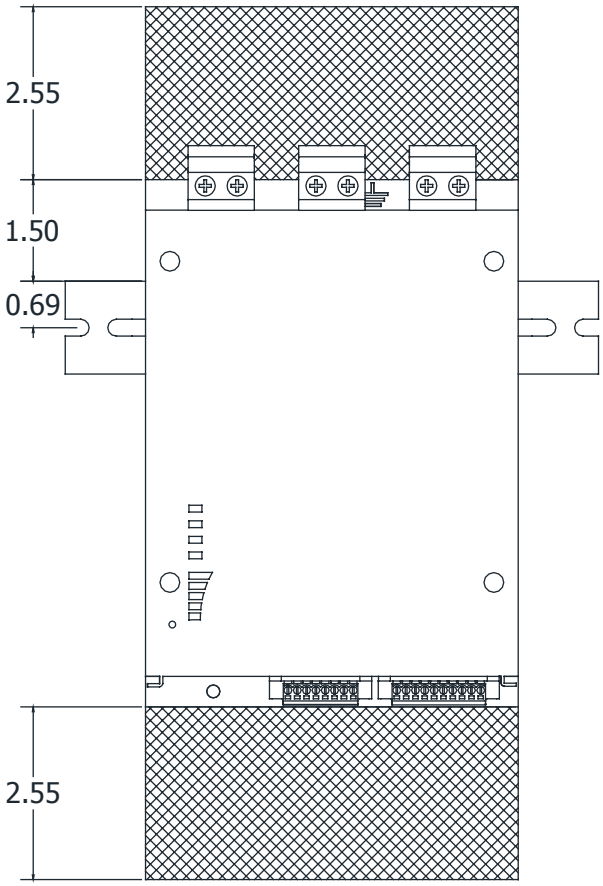
2. INSTALLATION

2.1 Mounting Considerations

Dimensions: Inches







Mount controllers vertically.

The keep out area on the top and bottom is for air circulation. The top and bottom of the controller must have a minimum of 3.00 [76.2] free from obstructions as measured from the edge of the heatsink fins. Dimensions above are measured from the edge of the heatsink base.

Mounting hardware (Not included):
Figures above show dimensions for din rail mounting. For mounting hardware when not using din rail, use the following:

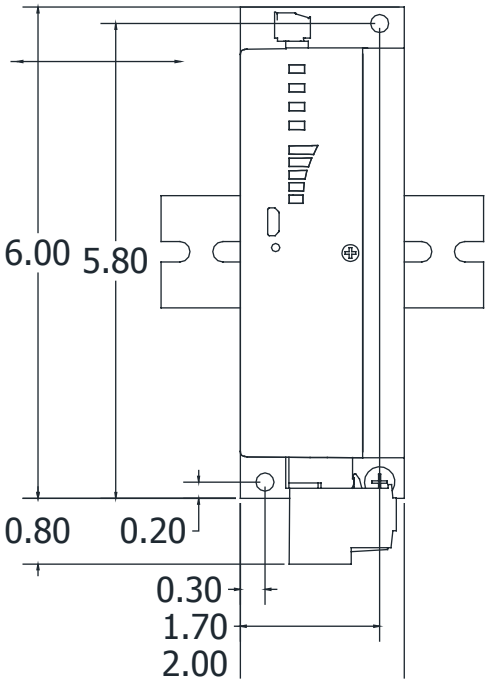
Single Phase	#10 or M5 screws with star washers
Three Phase	#8 or M4 screws with star washers

Din rail and/or screws are not provided.

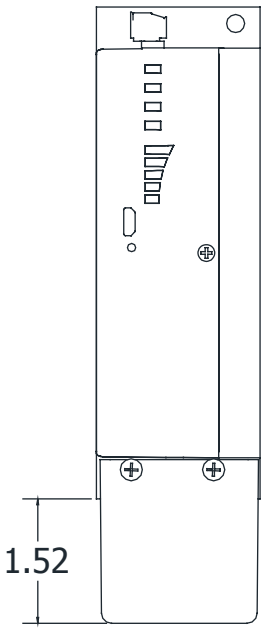
2.1.1 Single Phase (16 - 32 Amps)

Dimensions: Inches [mm]

Height
6.00 [152.4]
Width
2.00 [50.8]
Depth
5.10 [129.54]



Pluggable terminal block

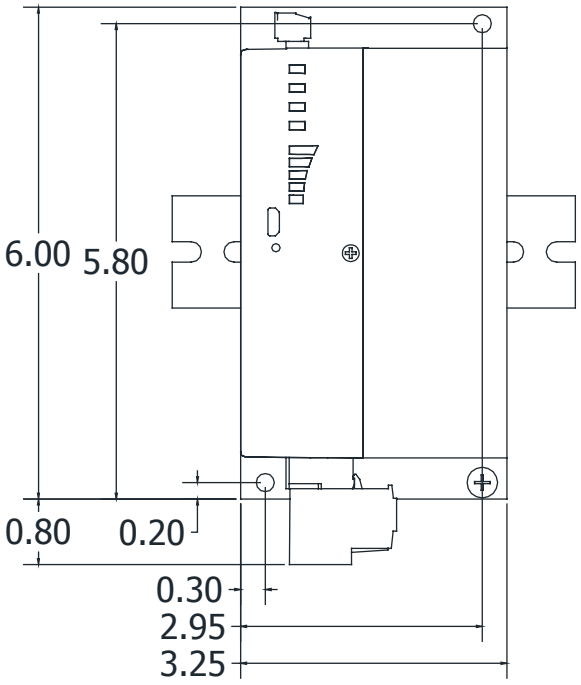


Ring Terminal

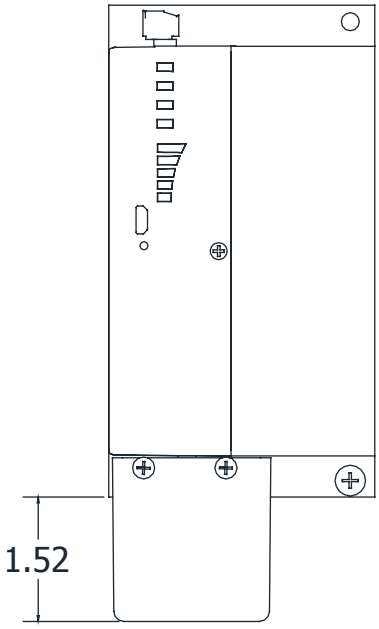
2.1.2 Single Phase (50 - 80 Amps)

Dimensions: Inches [mm]

Height
6.00 [152.4]
Width
3.25 [82.55]
Depth
5.10 [129.54]



Pluggable terminal block

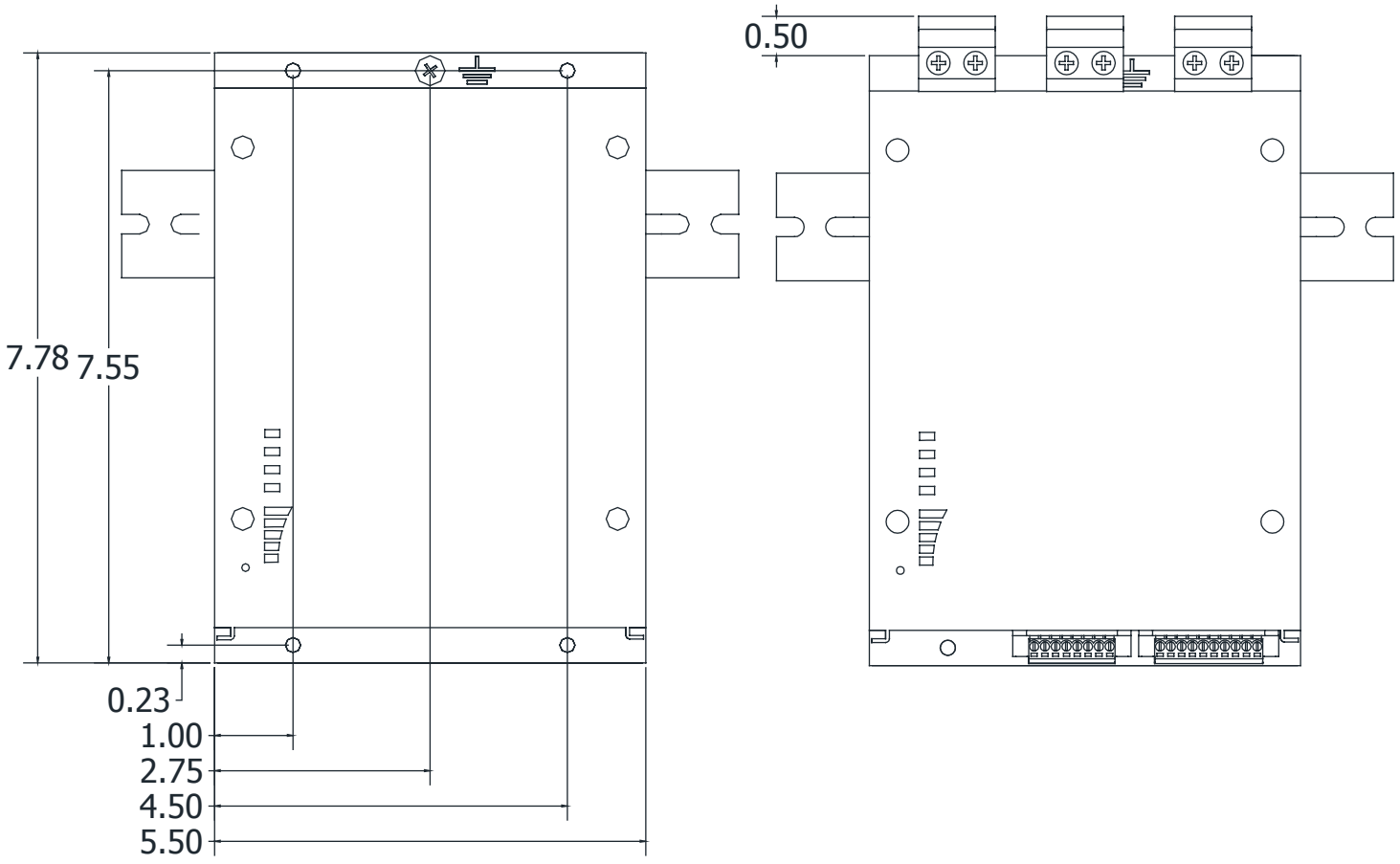


Ring Terminal

2.1.3 Three Phase (16 - 80 Amps)
Three Phase Two Leg (16 - 80 Amps)

Dimensions: Inches [mm]

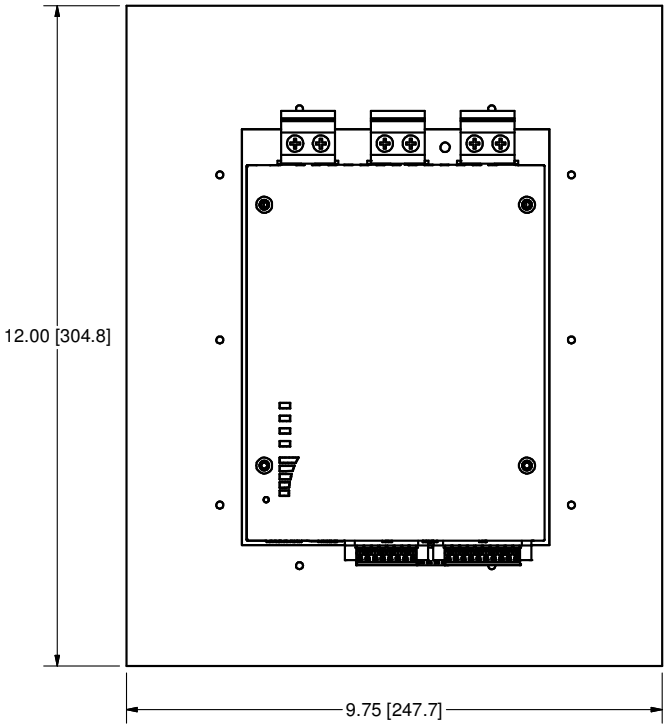
Height
7.78 [197.61]
Width
5.50 [139.7]
Depth
6.40[162.56]

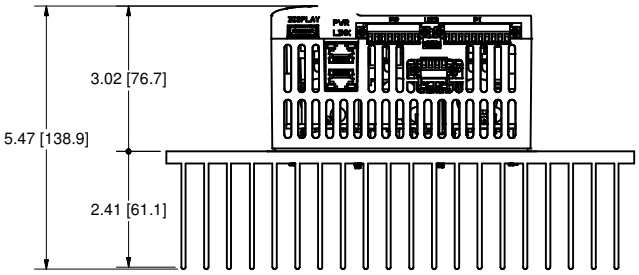


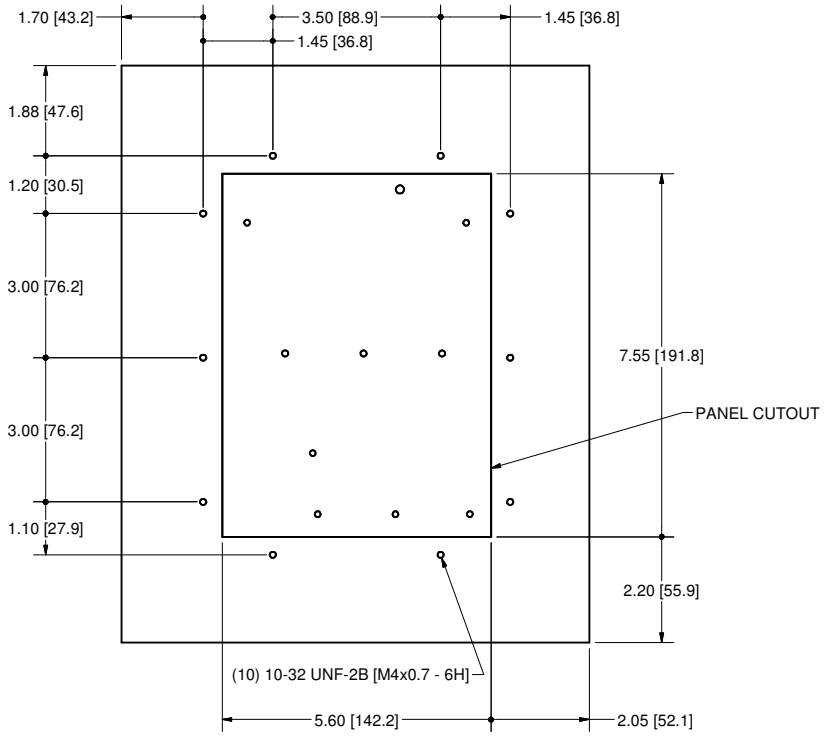
2.1.4 Three Phase External Mount Heatsink (16 - 50 Amps)

Dimensions: Inches [mm]

Height
12.00 [304.8]
Width
9.75 [247.7]
Depth
5.47 [138.9]





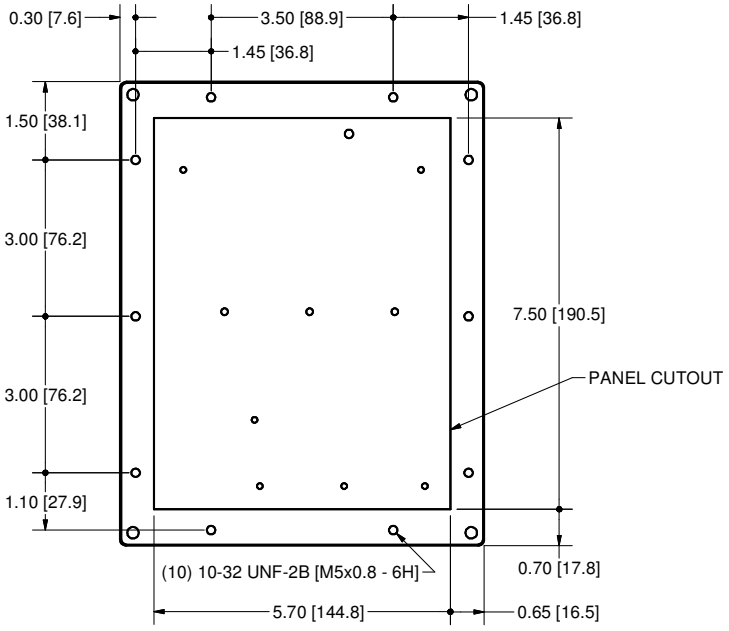


2.1.5 Three Phase Water Cooled Heatsink (16 - 80 Amps)

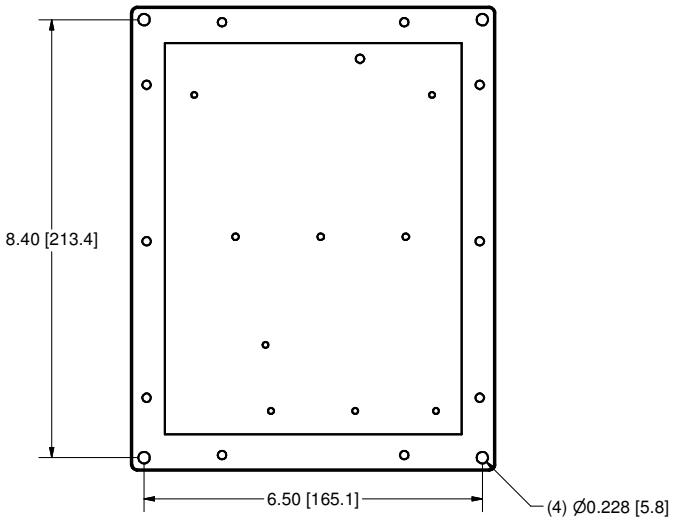
Dimensions: Inches [mm]

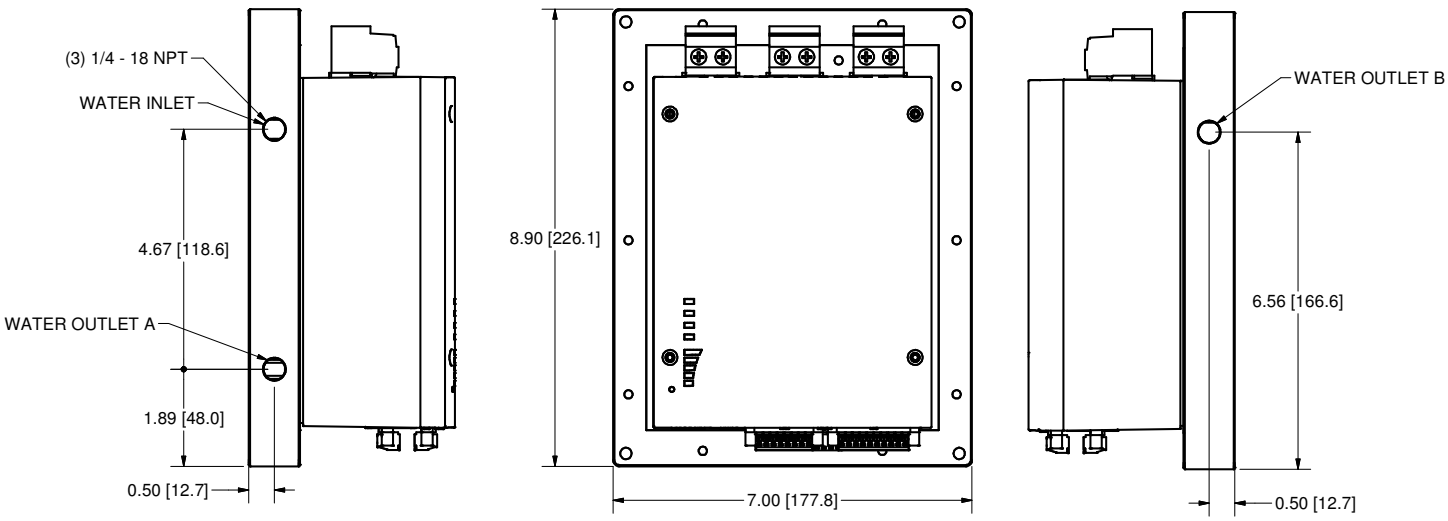
Height
6.00 [152.4]
Width
3.25 [82.55]
Depth
5.10 [129.54]

EXTERNAL MOUNT



PANEL MOUNT





3. WIRING

Control Concepts configures and tests each controller before shipping. Once received, the controller is ready to install. The following sections will describe how to properly wire the unit with the recommended fusing.

For line and load connections use copper conductors rated 75°C minimum. See torque tables for proper tightening.

A ground wire is recommended for proper operation. Use 10 AWG or larger wire.

Note: Wire controllers to conform with the National Electric Code (NEC) and/or other local wiring codes.

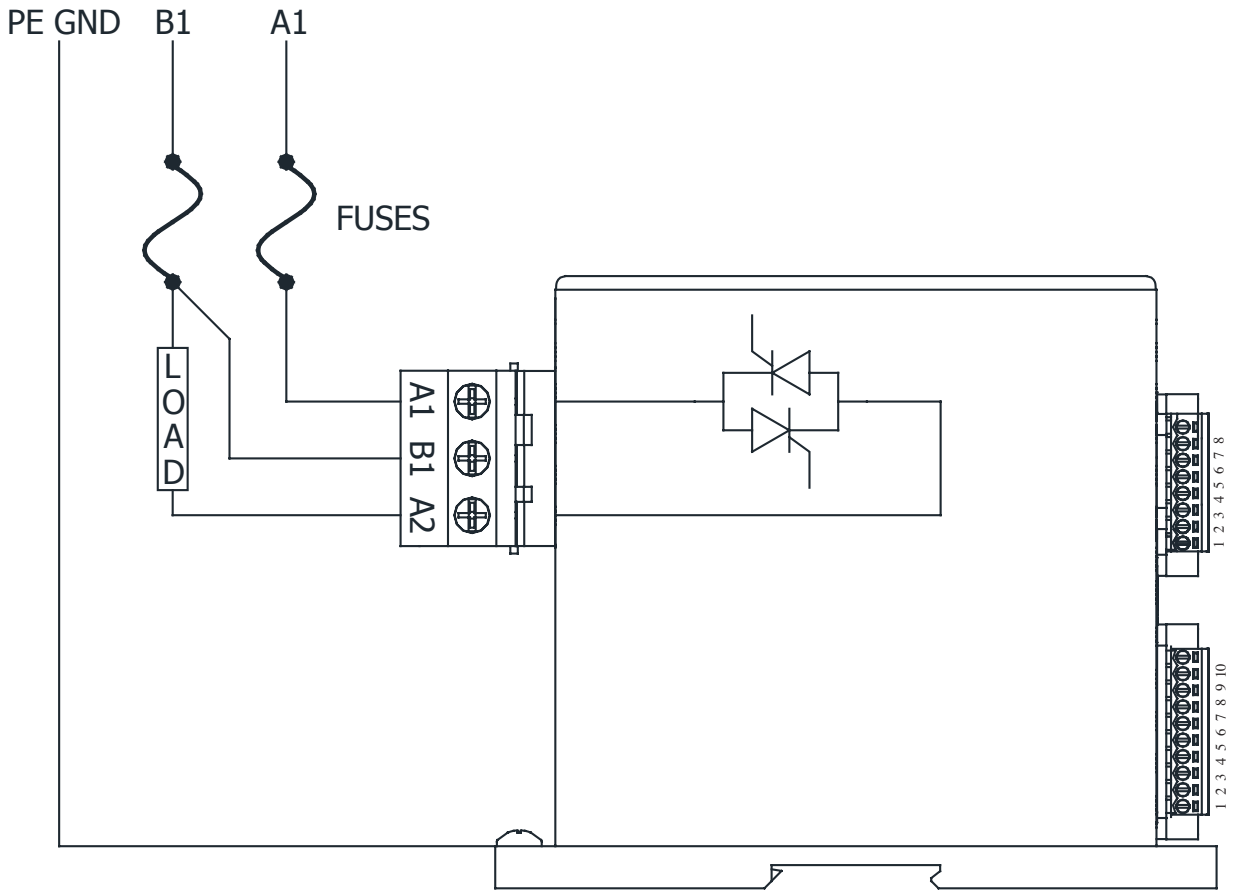
3.1 Torque Specifications

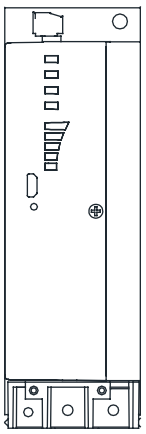
Recommended Tightening Torque For Line/Load Connectors	
Wire Size (AWG)	Torque
3 - 14	24 IN-LBS [2.70 Nm]

Recommended Tightening Torque For P1/P2 Connectors		
Number of wires	Wire Size (AWG)	Torque
1	16 - 26	3.0 IN-LBS [0.34 Nm]
2	20	3.0 IN-LBS [0.34 Nm]

3.2 AC Line / Load Connections

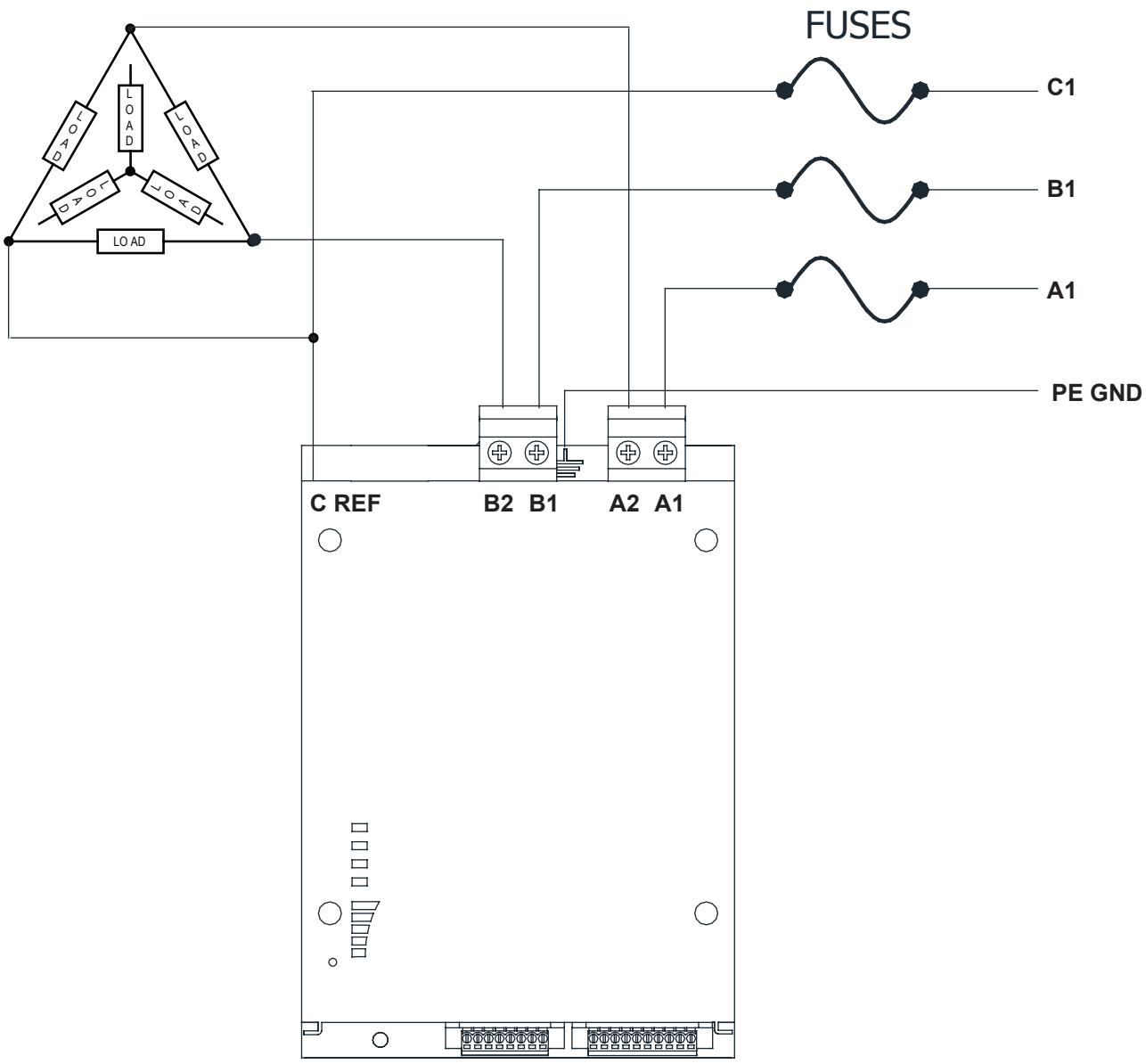
3.2.1 Single Phase



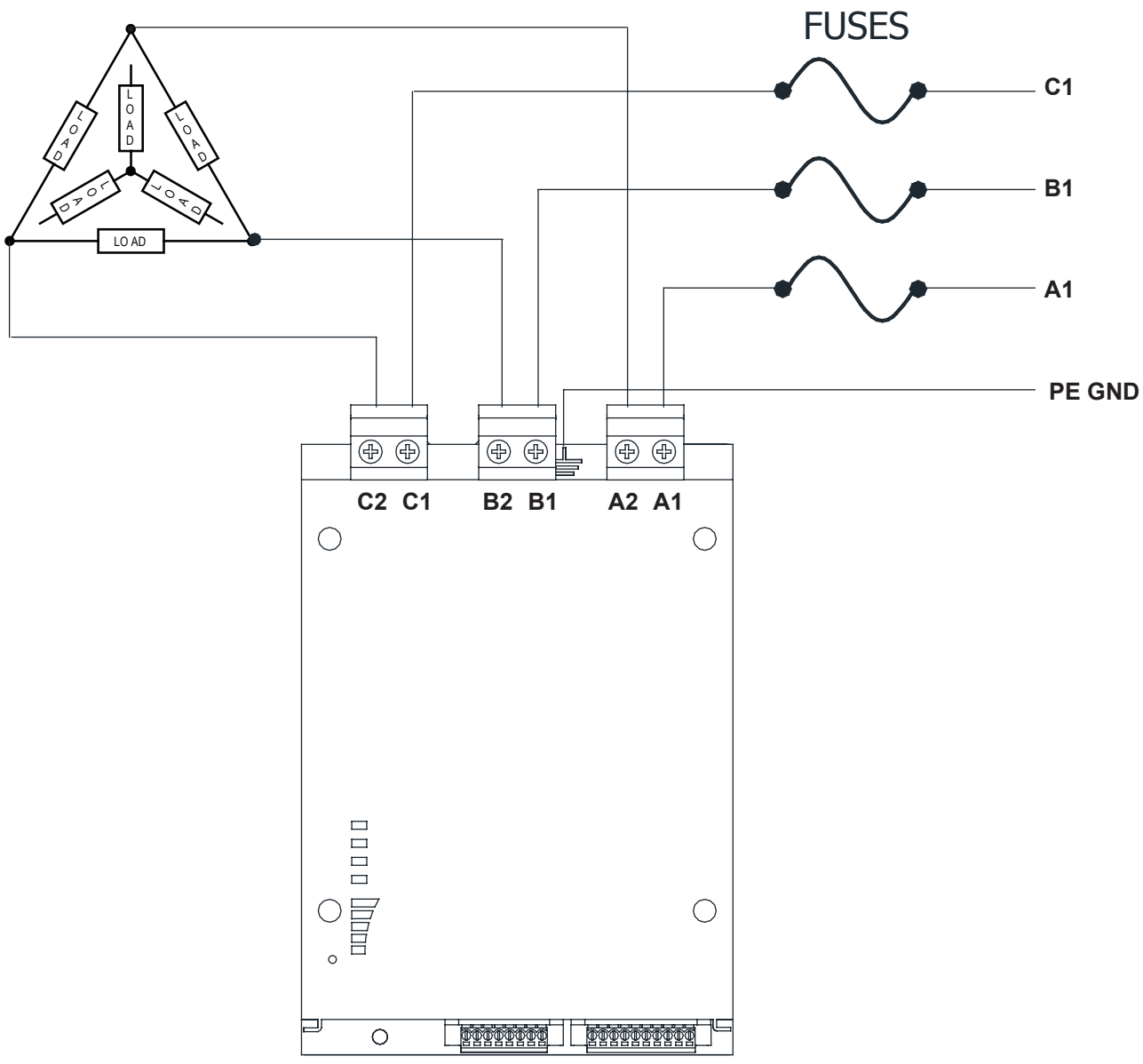


B1 uses #6 or M3.5 ring terminal.
A1 and A2 use #10 or M5 ring terminal.
See drawing above for wiring

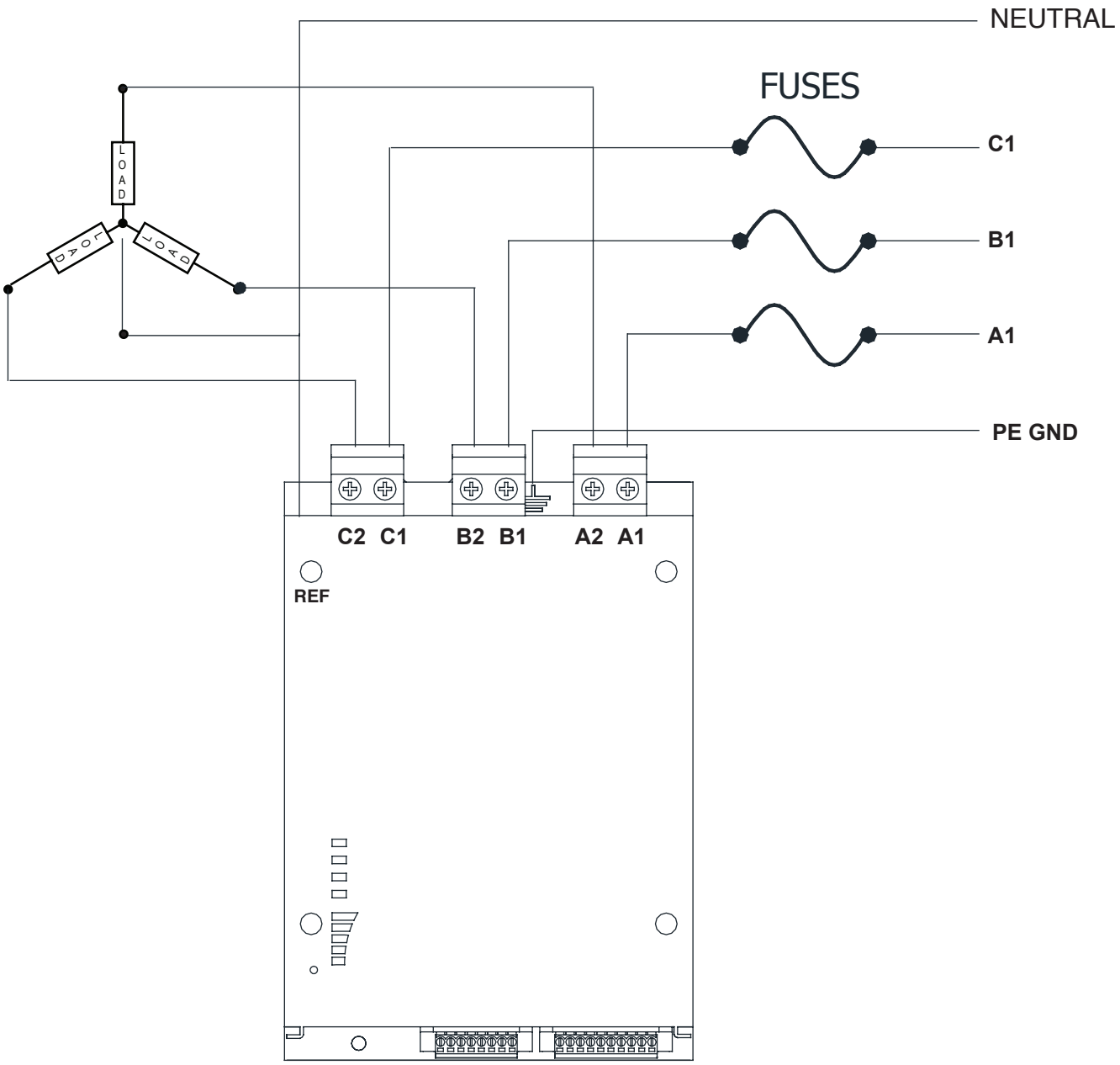
3.2.2 Three Phase, 2 Leg



3.2.3 Three Phase, Delta or Wye



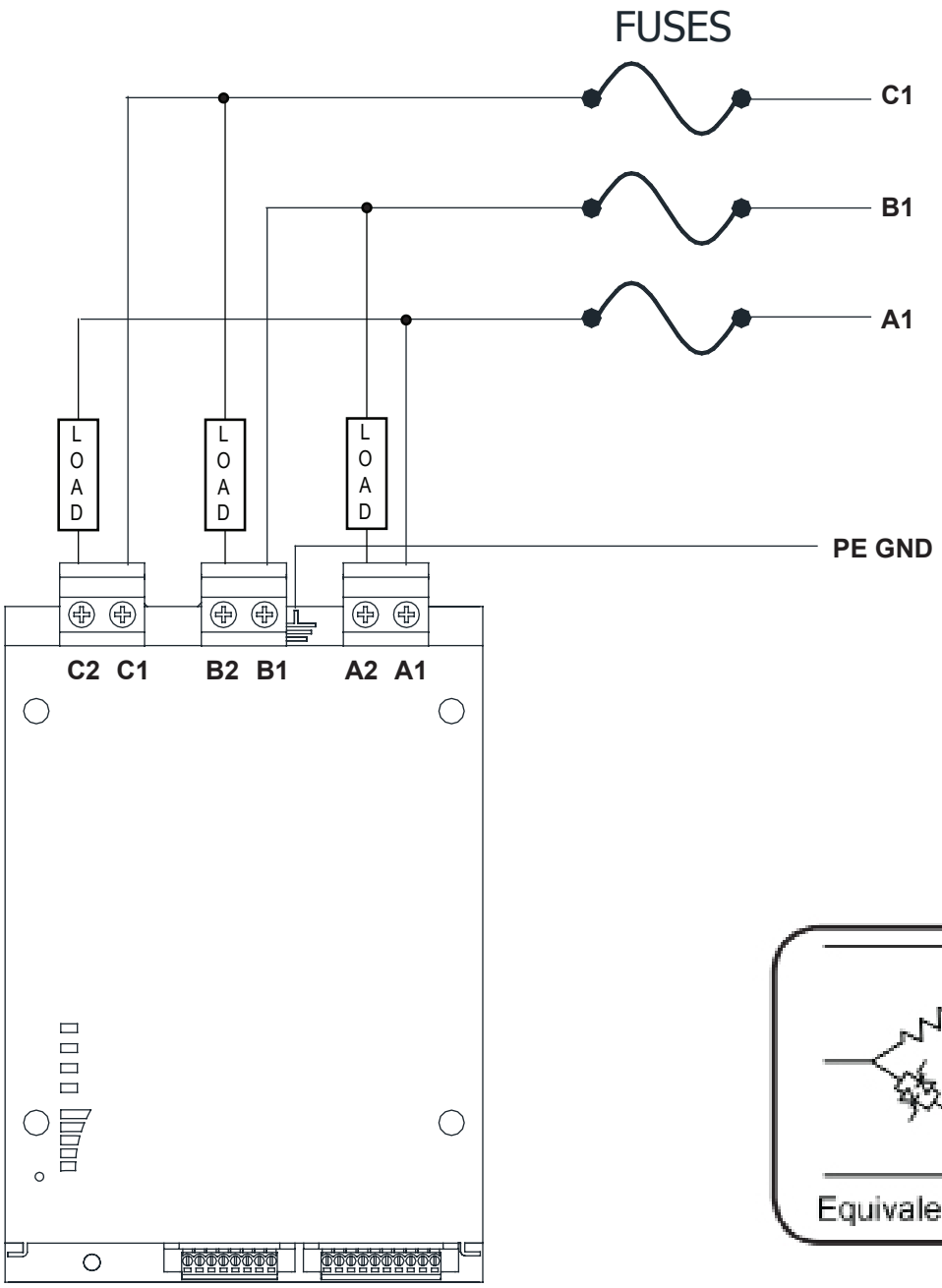
3.2.4 Three Phase, Four Wire Wye

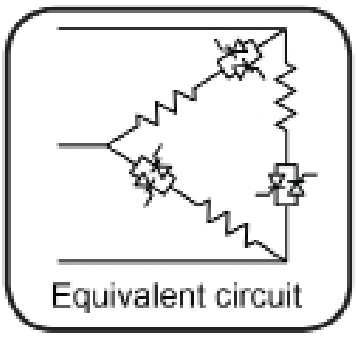


The MicroFUSION controllers normally display line and load voltages from Line to Line. When the controller is in 4 Wire Wye operation the line voltages read Line to Line while the load voltages read Line to Neutral.

3.2.5 Three Phase, Inside Delta

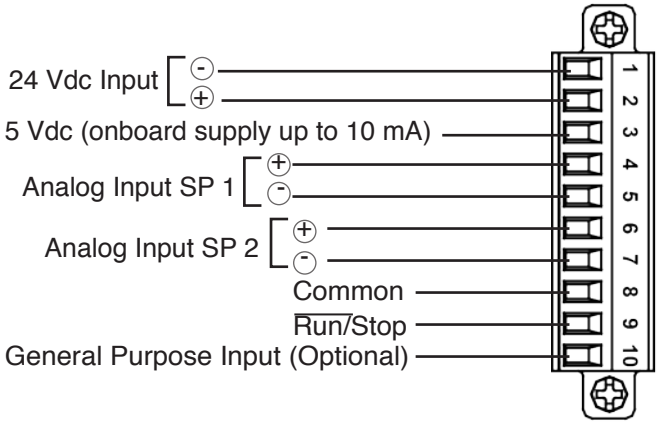
When wiring this controller if must be wired as per the diagram.
Load A must return to Line B.
Load B must return to Line C.
Load C must return to Line A.



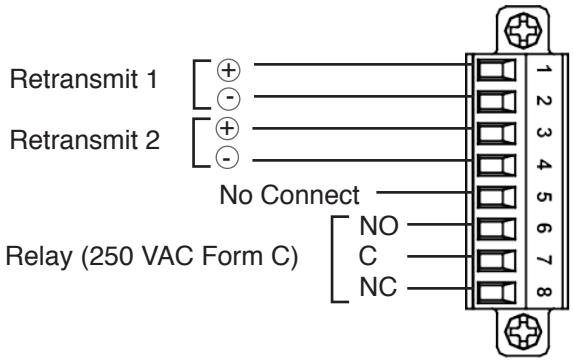


3.3 Connectors

3.3.1 P1-10 Pin Command Connector



3.3.2 P2-8 Pin Command Connector



4. INDICATOR LEDs

See chart below for LED Colors and indicated Operation.

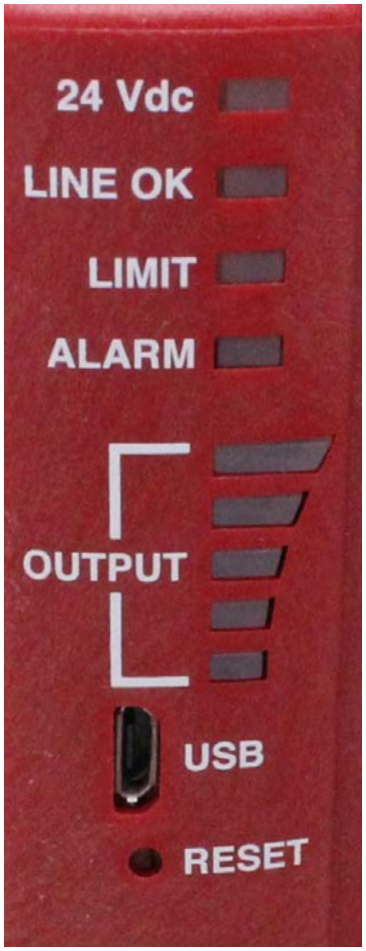
24VDC	
Green	+24 Vdc present
Red	+24 Vdc wired backwards

LINE OK	
Off	No AC Line V
Green	Ok, Locked
Orange	Boot Segment
Red	Phase Lock Loss

LIMIT	
Off	Ok, No Limits
Orange	Voltage Limit
Red	Current Limit
Flash between Red/Green	Power Limit

ALARM	
Off	Ok, No Alarms, Not in RUN
Green	Ok, No Alarms, in RUN
Orange	Warning Alarm
Red	Inhibit Alarm

OUTPUT	
Green	LEDs turn green in pro-portion to output
Top LED Red	Indicates 100% on



5. USB INTERFACE

5.1 USB Interface

A MicroUSB interface is standard on all controllers. Included with each controller is a software package titled 'MicroFUSION Control Panel'. This allows the user to connect to the controller using a computer and MicroUSB cable.

Control Concepts stocks 15 foot USB cables for customers to purchase (P/N: 0058006-0000-15).

6. OPTION BOARD

6.1 Internal Factory Industrial Communications

A fieldbus interface options can be used to communicate with a PLC or factory control system. PROFINET, Modbus TCP, and EtherNet/IP are available as internal fieldbus options.

Note: Only one type of interface is available per unit. For example a controller with Modbus RTU cannot also have Modbus TCP.

Control Concepts highly recommends the use of shielded wiring and offers a variety of lengths to purchase.

6.2 External Factory Industrial Communications

DeviceNet™, EtherNet/IP, EtherCAT, PROFINET, Modbus RTU (RS-485), or Modbus TCP are available through an external module. Furthermore, a single external network module can control up to 10 zones, reducing system installation costs.

Control Concepts highly recommends the use of shielded wiring and offers a variety of lengths to purchase.

See Fieldbus module in the Accessories section of this manual for more details.

7. PERFORMANCE

7.1 Feedback [SP 1]

	SX	HX
FF Voltage	* Included	* Included
RMS Voltage	N/A	optional
AVG Voltage	N/A	optional
RMS Current	N/A	optional
AVG Current	N/A	optional
Real Power	N/A	optional
Apparent Power	N/A	optional

*** = default**
The optional feedback types are only available if the Performance section of the model number contains a “P”.

The Feedback type determines how the control loop feedback works.

FF Voltage – Use RMS Voltage based on line voltage as the control loop feedback.
RMS Voltage – Use RMS Voltage as the control loop feedback.
AVG Voltage – Use average voltage as the control loop feedback.
RMS Current – Use RMS current as the control loop feedback.
AVG Current – Use average current as the control loop feedback.
Power – Use real power as the control loop feedback
Apparent Power – Use apparent power as the control loop feedback.

7.1.1 Feedback Type Calculations

Here are the calculations on how the feedback is measured:

RMS Voltage

$$V_{rms} = \sqrt{\frac{\sum_{i=1}^{n}(V^i)^2}{n}} = 0.707\ V_{pk}$$

RMS Current

$$I_{rms} = \sqrt{\frac{\sum_{i=1}^{n}(I^i)^2}{n}} = 0.707\ I_{pk}$$

Power
The output is adjusted via the real Power.

$$\text{Real Power} = \frac{\sum_{i=1}^{n}(V^i * I^i)}{n}$$

$$\text{Apparent Power} = V_{rms} * I_{rms}$$

$$\text{Power Factor} = \frac{\text{Real Power}}{\text{Apparent Power}}$$

AVG Voltage

$$V_{avg} = 1.11\ \frac{\sum_{i=1}^{n}|V^i|}{n} = 0.707\ V_{pk}$$

AVG Current

$$I_{avg} = 1.11\ \frac{\sum_{i=1}^{n}|I^i|}{n} = 0.707\ I_{pk}$$

V_{pk} = Peak Voltage
V^i = Instantaneous Voltage sample
n = number of samples in 1 AC line cycle
I_{pk} = Peak Current
I^i = Instantaneous Current sample

7.1.2 External Feedback

External feedback uses an external analog signal to represent the output to the load. These types of signals often come from a transducer that measures voltage, current, temperature or power and scales it proportionally to a 0 – 5 Vdc or 4 – 20 mA signal.

Connect the external feedback signal to an analog setpoint. Select the correct Feedback Source (SP19). Scale the external feedback by setting up the analog setpoint via the Analog I/O tab of the Control Panel software.

7.1.3 Feedback Source [SP19]

	SX	HX
Internal	* Included	* Included
Analog SP1	Included	Included
Analog SP2	Optional	Optional

*** = default**
The Analog SP2 source is only available if the I/O section of the model number contains a “2” or “3”.

This selects the type of feedback used. For external feedback select Analog SP1 or SP2.

7.2 Firing Mode [SP 2]

	SX	HX
Zero Cross	Included	* Included
Phase Angle	** Included	** Included
Zero Cross Transformer	N/A	optional

*** = default for three phase 2 leg**
**** = default for all other models**
The Zero Cross Transformer mode is only available if the Zero Cross Transformer Mode section of the model number contains a “Z”.

Knowing the application and the type of load you are trying to control is critical for choosing the right mode of operation. The MicroFUSION Series power controllers are capable of Phase Angle, Zero Cross, and ZCT operations. The following sections will describe each type of operation and will show the expected output.

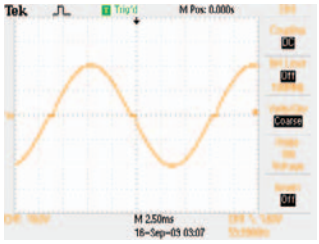
Note: For proper load operation, correct wiring is critical. See the “Wiring” section of the Installation & Maintenance Manual.

7.2.1 Phase Angle

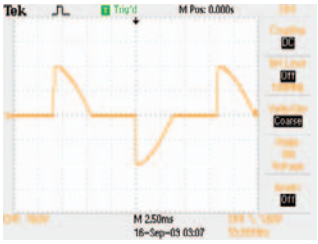
In phase-angle control, each SCR of the back-to-back pair is turned on for a variable portion of the half-cycle that it conducts. Power is regulated by advancing or delaying the point at which the SCR is turned ON within each half cycle. Light dimmers are an example of phase-angle control.

Phase-angle control provides a very fine resolution of power and is used to control fast responding loads such as tungsten-filament lamps or loads in which the resistance changes as a function of temperature.

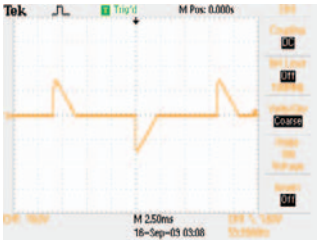
Single Phase Operation



100% Load Power

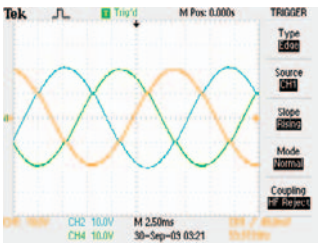


50% Load Power

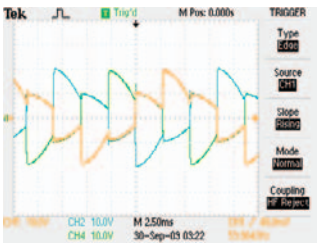


25% Load Power

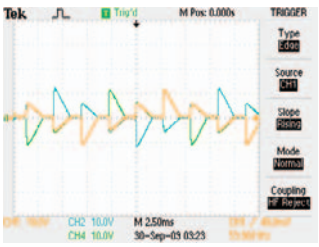
Three Phase Operation



100% Load Power

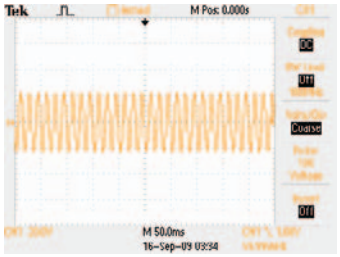


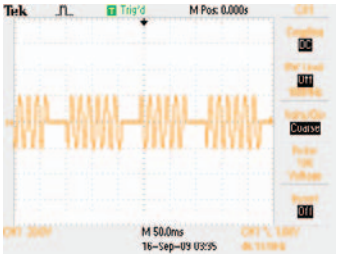
50% Load Power

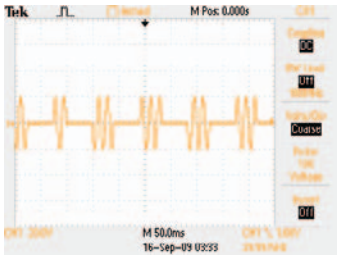


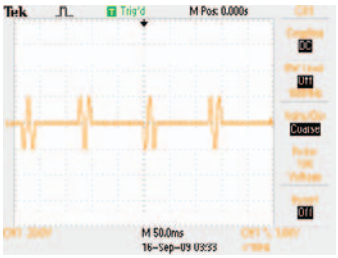
25% Load Power

7.2.2 Zero Cross









In zero-cross control, load power is turned ON and OFF only when instantaneous value of the sinusoidal waveform is zero. Load power is controlled by switching the SCRs "ON" for a number of complete electrical half-cycles, and then "OFF" for a number of complete electrical half-cycles.

The wave form in the top left shows the 1 phase AC waveform into the controller. This would also be the representation of the output with the command at 100%. The rest of the waveforms show the "ON" and "OFF" cycles of the output at various setpoints.

The tabulation on the right shows the sequence of "ON" and "OFF" electrical half-cycles that are applied to the load to achieve the percentage of load power indicated. The percentage of load power is equal to; the ratio of the number of electrical half-cycles that power is applied, to the total number of electrical half-cycles.

From the tabulation, it can be seen that power is applied for 16 out of 32 electrical half-cycles to achieve 50% load power and that power is applied for 136 out of 160 electrical half-cycles to obtain 85% power. When operating with a 60 Hz supply, the sequence of ON and OFF cycles repeats 0.266 seconds on 50% and every 1.33 seconds at 85% power.

LOAD POWER TIMING				
10%	25%	50%	75%	85%
5 ON	5 ON	9 ON	17 ON	23 ON
46 OFF	14 OFF	8 OFF	6 OFF	4 OFF
5 ON	5 ON	7 ON	19 ON	23 ON
44 OFF	16 OFF	8 OFF	6 OFF	4 OFF
				23 ON
				4 OFF
				23 ON
				4 OFF
				23 ON
				4 OFF
				21 ON
				4 OFF

Note: Even though it takes 1.33 seconds to obtain precisely 85% power, the load power during the 23 ON and 4 OFF cycles is 23/27 or 85.185% power and that this cycle is repeated every 0.225 seconds.

7.2.3 Zero Cross Transformer Mode (ZCT)

This is a Control Concepts proprietary algorithm that uses hybrid control to avoid the excessive inrush currents that can occur when firing into inductive or variable resistive loads.

In this firing mode the (on-off) duty cycle is adjusted to obtain the desired amount of power to the load. The "ON" portion of the output begins with a set number of cycles that increase to full conduction, remain at full conduction for a number of cycles, and then turn off. This pattern restarts with each subsequent duty cycle.

When utilizing the "Zero Cross Transformer" (ZCT) firing mode, the Power Factor measured by the controller is typically 0.90 with a setpoint that is greater than or equal to 50%. When the setpoint is less than 50% the controller will maintain a measured Power Factor of approximately 0.70.

Current Limit is enabled during the "phase-up" section of each "ON" portion of the duty cycle. A Power Factor of 0.90 (Setpoint > 50%), or 0.70 (Setpoint < 50%), may not be able to be achieved if the controller was current limiting the output to the load during the phase-up time.

Set-up
After connecting the MicroFUSION controller to the MicroFUSION Control Panel Software, click on the Zone 1 tab. Set the Firing_Mode_Zone_1 to ZeroCross_PhaseAngleStart. Set the Phase_ZC _Switch_Cycles_Zone_1 to the desired number of cycles the controller will use to ramp up to full conduction. This parameter is adjustable from 5 to 20 cycles (default is 6 cycles). If the controller is firing into a transformer, the value entered should be set high enough so that the transformer does not saturate during the start section of the "ON" portion of the duty-cycle.

Transformer Selection
A transformer of at least 1.3 Tesla (13000 Gauss) is preferred for best performance, up to 1.5 Tesla (15000 Gauss) is permissible.

7.3 Control Mode [SP 3]

* = default	SX	HX
Open Loop	Included	Included
Closed Loop	* Included	* Included

Closed Loop adjusts the output so that the feedback equals the setpoint. When using Open Loop the output percentage is directly proportional to the setpoint. The feedback is not used.

7.4 Full Scale Settings

7.4.1 Full Scale Voltage [SP 8]

The Full Scale Voltage is the voltage that will be applied when the load is at full capacity. The closer the Full Scale Voltage is to the actual voltage, the more accurate the controller will be. Setting this slightly higher than the actual voltage is common. This should not be set to more than 2X the actual voltage. The factory default is set to 480 V.

7.4.2 Full Scale Current [SP 9]

The Full Scale Current is the current that the load will draw when the load is at full capacity. The closer the Full Scale Current is to the actual current, the more accurate the controller will be. Setting this slightly higher than the actual current is common. This should not be set to more than 2X the actual current. The factory default is set to the frame rating of the controller.

7.4.3 Full Scale Power [SP 10]

The Full Scale Power is the power consumed by the load when at full capacity. This should not be set to more than 2X of the actual power. The default value is calculated from the following:

1 Phase AC	3 Phase AC	
	Delta, 3 & 4 Wire Wye	Inside Delta
[Full Scale V] x [Full Scale I]	[Full Scale V] x [Full Scale I] x [√3]	[Full Scale V] x [Full Scale I] x [3]

Note: In the MicroFUSION Control Panel Software there is a “Calculate” button for these equations. This will automatically fill in the full scale power once pressed. It will also automatically set up the limit settings.

7.5 Setpoints

	SX	HX
Digital Fieldbus	Included	Included
Digital Keypad	Included	Included
Analog SP1	* Included	* Included
Analog SP2	optional	optional

* = default

The Analog SP2 is only available if the I/O section of the model number contains a “2” or “3”.

There are four possible setpoints: two digital and two analog. To designate which setpoint the controller uses, the Setpoint Source (SP102, SP103) and Control Setpoint Select (SP104) need to be setup within the System Tab of the Control Panel software.

7.5.1 Setpoint Source [SP102] & [SP103]

	SX	HX
Analog SP1	Included	Included
Analog SP2	Optional	Optional
Digital Fieldbus	Included	Included
Digital Keypad	Included	Included
PWM Input	Optional	Optional

The Analog SP2 and the Pulse Width Modulated (PWM) input are only available if the I/O section of the model number contains a “2” or “3”.

There are two setpoints that can be configured. They can both be set to digital, or both to analog or a combination of either analog or digital. The controller will use the Control Setpoint Select (SP104) parameter to determine which setpoint to use. By default SP102 is set to Analog SP1 and SP103 is set to Analog SP2.

For a PWM input the signal must be connected to Analog SP1.

7.5.2 Control Setpoint Select [SP104]

	SX	HX
Setpoint 1 [SP102]	Included	Included
Setpoint 2 [SP103]	Included	Included

The Control Setpoint Select determines which setpoint the controller will use. The setpoint source is configured using Setpoint Source (SP102 & SP103). By default this is set to Setpoint 1.

7.5.3 Digital Setpoints [SP100] & [SP101]

There are two digital setpoints (Fieldbus, Keypad). The setpoints can be sent via USB, a fieldbus interface, or from the remote display keypad.

When using digital setpoints the Digital Enable (SP129) must be used.

7.5.4 Digital Enable [SP129]

When using a digital setpoint the digital enable must be enabled. It is common for this to be set to “enable” whenever a setpoint is assigned. The Digital Enable Always On (SP3401) parameter found on the System Tab may be used to always have the Digital Enable set to “enable.” This remains set even during a processor reset or power cycle.

7.5.5 Setpoint Resolution [SP115]

	SX	HX
10000 counts	* Included	Included
64000 counts	N/A	* Included

* = default

The Setpoint Resolution sets the setpoint entry valve that equates to 100% output
The count value equates to:

0 counts = 0% output
SP115 setting (10000 or 64000) = 100% output

7.5.6 Analog Setpoints

	Default	Range
Analog SP1 (Vdc)	0 – 5 Vdc	0 – 10 Vdc
Analog SP1 (mA)	* 4 – 20 mA	0 – 20 mA
Analog SP2 (Vdc)	* 0 – 5 Vdc	0 – 10 Vdc
Analog SP2 (mA)	4 – 20 mA	0 – 20 mA

* = default
The Analog SP2 is only available if the I/O section of the model number contains a “2” or “3”.

The inputs allow a wide array of input scaling for the user. The hardware capabilities are 0 – 10 Vdc for voltage and 0 – 20 mA for current. To make changes to the analog inputs, open the Control Panel software and check the Analog I/O Tab.

7.6 Run / Stop

This refers to pins 8 & 9 of the P1 connector. Pin 9 is directly connected to the gates and monitored by the processor. When pin 9 is pulled low (connected to pin 8), the output of the controller is enabled (Run state). With no connection between these two pins the controller will remain in a Stop state.

Run state does not mean the controller is outputting. Run state means the controller is able to output as long as a command/setpoint is present (digital or analog) and there are no inhibit alarms.

7.7 Limits and Trip Parameters

	SX	HX
Voltage Limit	N/A	optional
Current Limit	Included	Included
Over Current Trip	Included	Included
Power Limit	N/A	optional

The Limit and Trip parameters are only available if the Performance section of the model number contains an “L” or “P”.

These are safety features designed to help protect from excessive voltage, current and/or power being applied to the Load.

7.7.1 Voltage Limit [SP 11]

	SX	HX
Adjustable	N/A	optional

Limits the voltage applied to the load. The recommended setting is 105% of the full scale voltage. The default value is set to 630 Volts which is 105% of a 600 VAC frame voltage.

7.7.2 Current Limit [SP 12]

	SX	HX
Fixed	Included	N/A
Adjustable	optional	Included

To adjust the Current Limit value for SX models the Performance section of the model number must contain an “L”.

This limits the current applied to the Load. The recommended setting is 105% of the full scale current. The default value is set to 105% of the frame rating. The current can be limited by the RMS or AVG value. Use the Current Limit Type parameter [SP13] to change between RMS or AVG.

7.7.3 Over Current Trip [SP 14]

	SX	HX
Adjustable	Included	Included

If the current exceeds the Over-Current Trip setting the controller will shut down. This responds faster than the Current Limit setting. When experiencing an Over-Current Trip the controller will disable the output and display the condition on the LED indicators and the remote display (if present). This feature is designed to protect the controller from experiencing surge currents that could damage the controller.
Recommended settings:
Phase Angle firing mode: 175% of frame rating.
Zero Cross firing mode: 350% of frame rating.

7.7.4 Power Limit [SP 15]

	SX	HX
Adjustable	N/A	optional

Limits the power applied to the load. The controller will continue to operate but will not exceed the power specified in this field. The recommended setting is 105% of the full scale power. The default value is set to 105% of the full scale power.

8. I/O

8.1 Alarm Relay [SP16, SP85]

	SX	HX
Relay Alarm Mask (SP16)	optional	optional
System Relay Mask (SP85)	optional	optional

The Relay is only available if the I/O section of the model number contains a “1” or “3”.

There is one relay available on the MicroFusion controller. Both the Relay Alarm Mask (SP16) and the System Relay Mask (SP85) map to the same relay. All alarms mapped to the relay are OR’ed together.

The Relay Alarm Mask maps any or all of the following:

- Heatsink Over Temperature
- Over Current Trip
- Heatsink High Temperature Warning
- AC Line Phase Loss
- Shorted SCR
- Power Limit
- Current Limit
- Voltage Limit
- Digital Run Enable (Run State request)
- 3 Phase Load Imbalance
- Low Output

The System Relay Alarm Mask maps any or all of the following:

- Run Enable (Switch terminals closed)
- Controller is in Run State
- Phase Lock Loop – Lock Loss
- Watchdog Timeout
- Memory Error
- Communication Error
- Processor Error Trap

Rating for the Relay are as follows:

Maximum switching Voltage	220 Vdc
	250 Vac
Maximum switching Current	2 A
Maximum switching capacity	60 W, 62.5 VA
UL contact ratings	220 Vdc / 0.24 A - 60 W
	125 Vdc / 0.24 A - 30 W
	250 Vac / 0.25 A - 62.5 VA
	125 Vac / 0.50 A - 62.5 VA
	30 Vdc / 2 A - 60 W

8.2 General Purpose Input

	SX	HX
Pin 10 functionality of P1 connector	optional	optional

The General Purpose Input is only available if the I/O section of the model number contains a “2” or “3”.

The General Purpose Input uses pins 8 and 10 of the P1 connector. When using this feature the General Purpose Input Function (SP133) must be defined. When pin 10 is pulled low (connected to pin 8) the controller will toggle the function defined in the General Purpose Input Function parameter.

8.3 General Purpose Input Function [SP133]

Opening and closing the connection between pin 8 & pin 10 of the P1 connector toggles:

[SP133] Function	Possible Settings	See this parameter for reference
Control Setpoint Select	Setpoint 1 Setpoint 2	Control Setpoint Select (SP104)
Open/Closed Loop	Open Loop Closed Loop	Control Mode (SP3)

Other selections may be available. Contact factory for special requests.

8.4 Pulse Width Modulation Input

A pulse width modulation signal may be used as a setpoint. The signal must be connected to Analog SP1 to function. The setpoint source [SP102] or [SP103] must also be set to PWM input.

Input Range:
20 Hz ≤ Frequency ≤ 2 kHz
0 - 5 Vdc maximum

8.5 Retransmits

	SX	HX
Retransmit 1	N/A	optional
Retransmit 2	N/A	optional

The Retransmits are only available if the Retransmits section of the model number contains an “R”.

The Retransmits are configured similarly to the analog inputs. The two Retransmits can be configured independently as either a current source (0 – 20 mA) or as a voltage source (0 – 10 Vdc). The Retransmits may be mapped to Load Voltage, Current or Power. It can also be set to a direct out signal.

9. CCI LINK™

This is a proprietary deterministic digital bus that enables multiple Control Concepts devices to communicate with each other.

9.1 Network LED Indicators

The CCI Link™ connector has 4 LEDs, 2 yellow and 2 green. There is one LED in each corner of the connector. The Network LED indicators use the yellow and green LED located closest to the heatsink of the controller. The yellow LED opposite of the heatsink is not used. The green LED is used in the Auto Terminating Resistor Circuit.

Network State	Green	Yellow	Description
Non-existent	OFF	OFF	Initializing
On-Line Unallocated	Flashing	OFF	No connections
On-Line Allocated	ON	OFF	Connection established, OK
Wait-4-who's there	OFF	Blink (5 sec intrvl)	Not on the network, waiting
Identify	X	OFF-Flash-OFF	Response to Identify request
Timeout	ON	ON	Connection timed out
Comm Fault	OFF	ON	Bus-OFF, DUP MAC failure

X = don't care, or same state as before is maintained

When the controller does not detect any other devices on the CCI Link™ network the green LED will be OFF and the yellow LED will flash every 5 seconds.

The yellow network LED is also used to identify a specific controller on the CCI Link™ network. When a controller is commanded to identify itself, the yellow network LED will flash 5 times.

9.2 Auto Terminating Resistor Circuit

When connecting multiple devices on the CCI Link™ network, a terminating resistor must be pulled in at each end of the network tree. With the Auto Terminating Resistor Circuit the device automatically determines if the resistor needs to be pulled in based on if it is connected to one or two devices. When the resistor is pulled in the green LED on the CCI Link™ connector furthest away from the heatsink will be illuminated.

9.3 SYNC-GUARD™

The SYNC-GUARD™ feature reduces the possibility of synchronous operation of two or more zero cross controllers. This feature does not alter the power applied to the load, but adjusts the time when power is applied in such a manner as to reduce the possibility of two or more controllers being ON and OFF in unison.

SYNC-GUARD™ is useful whenever there are two or more power controllers connected to the same power source with a zero-cross firing mode selected. The SYNC-GUARD™ feature can significantly reduce the peak current required from a source that is connected to multiple power controllers while all are zero cross firing.

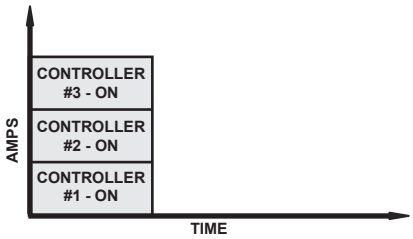
Zero cross firing is an ON-OFF type of control where the desired voltage, current, or power is delivered to the load by varying the controller's ON-OFF duty cycle. With zero cross firing, when the controller's output is ON, full supply voltage and current are provided to the load.

Without SYNC-GUARD™, multiple zero cross firing controllers could potentially be ON and OFF all at the same time. This would require heavy current to be drawn from the source while the controllers are all ON and no current when they are all OFF. The SYNC-GUARD™ feature works to reduce the peak current draw required from the source over time by causing each controller to attempt to find a time to turn ON when fewer, or no other, controllers are firing.

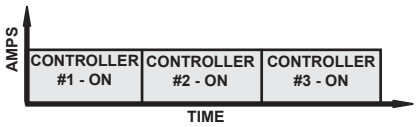
Limitations

As stated before: the SYNC-GUARD™ feature works to reduce the peak current draw required from the source for multiple controllers over time. However, each controller cannot predict when another controller is going to fire. Therefore the probability of multiple controllers firing at the same time exists even when using the SYNC-GUARD™ feature. The probability of this happening is highest when many controllers transition into the RUN state, and therefore turn ON at the same time. It is recommended that no more than 10 controllers be linked together with SYNC-GUARD™ over CCI Link™.

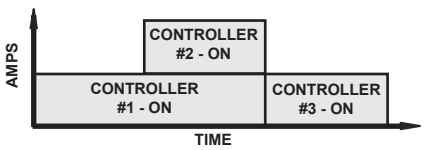
The figures below show the total current as a function of time for three controllers, with, and without SYNC-GUARD™ and various load powers. When using the SYNC-GUARD™ feature, the current command signals must be isolated from each other. To set up the SYNC-GUARD™ feature, see the Installation manual.



Three controllers providing 33.3% power each, operating synchronously without SYNC-GUARD™



Three controllers providing 33.3% power each, with SYNC-GUARD™



Three controllers with SYNC-GUARD™, two providing 33.3% power & one providing 66.6% power.

9.4 External Fieldbus Module

The external fieldbus module connects to other Control Concepts devices over the CCI Link™ bus.

See Fieldbus Module in the Accessories Section of this manual for more details.

10. ACCESSORIES

10.1 CCI Link™ Cables

Available cable lengths:

- 6 inch cable – 0058003-0050-005
- 1 foot cable – 0058003-0050-01
- 5 foot cable – 0058003-0050-05
- 10 foot cable – 0058003-0050-10
- 15 foot cable – 0058003-0050-15

10.2 Fieldbus Module

The Fieldbus Module has any one of the following fieldbus interfaces: EtherCAT, EtherNet/IP, DeviceNet, Modbus RTU (RS-485), Modbus TCP, or PROFINET. Powered from the CCI Link™ bus, it can interface with up to 10 Control Concept devices. Each device must be given a unique MAC ID. All controllers can send or receive data over the CCI Link™ bus via one IP address.

From the fieldbus interface, configurations may be saved and loaded. Performance and data logging are available with the use of a Real Time Clock and Calander (RTCC). The Fieldbus Module also takes advantage of the Auto Termination Resistor Circuit.

Electrical Characteristics:

- 24 Vdc input power (via CCI Link™ bus)
- 100 mA maximum draw
- 3000 Vdc isolation

10.3 Remote Display

Easily view and customize limits, setpoints, and alarm conditions
2-Line, 16-character text display (Figure 1)
UL-type 1 & 12 ratings, IP65

See Appendix C for Remote Display setup and operation instructions

Figure 1

10.4 Din Rail Power Supplies

Ratings: 85-264 Vac input, +24 Vdc output

- 24 Watt – 0091011-0024-1
- 60 Watt – 0091011-0060-1
- 96 Watt – 0091011-0096-1

10.5 USB Cable

- 15 foot, A to Micro B – 0058006-0000-15

APPENDIX A: SPECIFICATIONS

PERFORMANCE		
	Standard	**High Performance Option**
Setpoint Resolution	10,000 counts	Selectable 10,000 or 64,000 counts
Internal Control Loop Resolution	16,000 counts	64,000 counts
Output Resolution	12,000 counts @ 50Hz, 10,000 counts @ 60Hz	50,000 counts @ 50Hz, 42k,000 counts @ 60Hz
Accuracy (Full Conduction)		
Voltage	3% of span	0.5% of span
Current	3% of span	0.5% of span
Power	3% of span	1% of span
Output Linearity	4% from 5 to 100% output range	1% from 5 to 100% output range
Accuracy	A +10% to -15% line voltage change will result in a max output change of 0.5% from 5 to 100% output range	A +10% to -15% line voltage change will result in a max output change of 0.05% from 5 to 100% output range
Temperature Drift	Output shall not change greater than 0.5% per degree C max over the operating temperature range from 5 to 100% output range	Output shall not change greater than 0.2% per degree C max over the operating temperature range from 5 to 100% output range

POWER	
Line Voltage (Auto Ranging)	24 - 600 Vac (Nominal) +10% / -15% (Contact factory for other options)
Line Frequency (Auto Ranging)	45 - 65 Hz
Frame Current Ratings (Amps)	I Continuous RMS (AC) 16 I 32 I 50 I 80
Current Rating- Peak Surge	20X frame rating
Minimum Hold/Latch Current	500 mA
SCR Rating (PIV)	1600 V peak forward & reverse
Fusing	Optional external Class T, branch-rated, touch-safe fusing
Thermal	Integrated heat sink thermal sensor
Current Limit	20% – 105% of continuous rating of Frame Amp Rating
Current Trip	50% - 450% of continuous rating
Power Dissipation	1.3 Watt per amp of load current per phase
Control Power / Operates Internal Control Electronics	24 Vdc +10 / -15%

ENVIRONMENTAL	
Surrounding Air Operating Temperature	32°F [0°C] - 122°F [50°C] with no derating 32°F [0°C] - 140°F [60°C] with current derating 140°F [60°C] 16A Frame = 16A Max Output 140°F [60°C] 32A Frame = 25A Max Output 140°F [60°C] 50A Frame = 40A Max Output 140°F [60°C] 80A Frame = 60A Max Output
Humidity	20% to 90% RH Non-Condensing
Rated Operating Altitude	Up to 6000 ft [1750m] at full rated current
Contaminates	ROHS Compliant, CE Pollution Degree 2
Storage Temperature	- 4 to 176°F [- 20 to 80°C]

DC POWER CONSUMPTION	
16 - 50 Amp Single Phase	9 Watts
80 Amp Single Phase	11 Watts
16 - 80 Amp Three Phase	24 Watts

ENCLOSURE PROTECTIVE RATING	
International	IP 20
Remote Display	IP 65, UL Type 1 & 12

RELIABILITY	
Mean Time Between Failure (MTBF)	Designed for 50,000 Hours

SCCR		
Frame 1 Ø or 3 Ø	**Recommended Fusing**	**SCCR Rating**
16	20 Fast Acting J or T	100 kA
32	40 Fast Acting J or T	100 kA
50	60 Fast Acting J or T	100 kA
80	100 Fast Acting J or T	100 kA

COOLING	
1Ø - 16 -50 Amp	Natural Convection
1Ø - 80 Amp	Forced Air with 1 fan PN 1608VL-05W-B60
3Ø - Din Rail	Forced Air with 1 fan PN 3100KL-05W-B60
3Ø - Liquid Cooled	Flow rate: 1 GPM [3.79 LPM] Maximum inlet temperature: 122° F [30° C] Maximum pressure: 60 PSI [4.137 Bar]
3Ø - External Panel Mount	Natural convection

ISOLATION	
Signal to Line/Load	3750 Vac minimum
Line/Load to Ground	2500 Vac minimum
Signal to Ground	1500 Vac minimum
Line to Load	1400 Vac minimum
Network	1500 Vac minimum
USB	2500 Vac minimum
Signal to Processor	1500 Vac minimum
Remote Display	2500 Vac minimum

All controllers have 100kA when using less than or equal to 100 Amp class J or T fuses. Installed in enclosure with two latches, 150% of controller size.

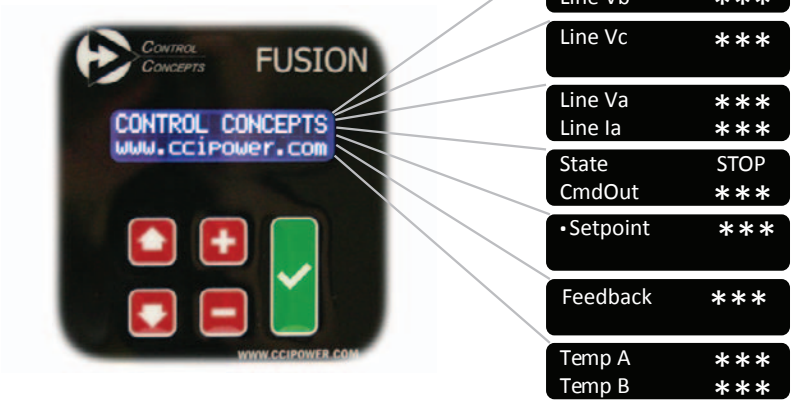
Control Concepts recommends sizing fuses approximately 125% frame rating.

APPENDIX B: DIGITAL FIELDBUS

TO BE
DETERMINED

APPENDIX C: REMOTE DISPLAY

After applying universal input power, the user can now edit parameters via the display or the MicroFUSION Control Panel Software.

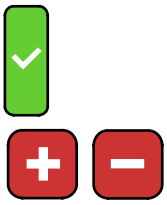


Auto Scroll
The 5 button display has an auto scroll and manual scroll display list.

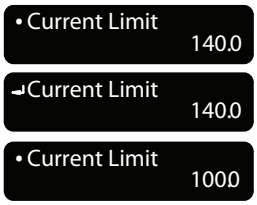
Pictured right are examples of how screens will appear.

Manual Scroll
The controller will automatically start in auto scroll mode. The screen will change every few seconds. Press the arrow keys to access the manual scroll display list.

The up and down buttons will also scroll through different screens . To return to auto scroll, press and hold either button for a minimum of two seconds. If the display idles for ten minutes in manual scroll, it will automatically return to auto scroll.



Changing Value
On setable parameters there will be a dot in front of the parameter name. To adjust the value, press the green button. The dot will change to an arrow. See examples, right. Press the Plus and Minus buttons to adjust the value up or down. After the desired value is reached, press the green button to accept the changes. The screen should appear as before with the adjusted value.



Note: If the parameter entry is left unchanged, or the accept button is not pressed, within 20 seconds the parameter will abort and return to the original value.

Screen Lists

Each controller is shipped with a customizable screen list that pertains to the hardware configuration of the controller. The default lists will show things such as line/load voltages, load currents and heatsink temperatures. If the controller is equipped with a communications card the default list will also show specific parameters pertaining to the communications settings.

The screen list can be customized by connecting to the MicroFUSION Control Panel software. Within the software any combination of screens can be programmed onto the screen (limit 50 screens).

Parameter Lock

A parameter lock can be setup to prevent anyone from changing parameter values using the display keypad. See direction on how to set this up in the Display Control section of the MicroFUSION Control Panel software manual.

APPENDIX D: FUSING OPTIONS

All touchsafe kits have 600 VAC, Branch-Rated, Class T Fusing

Single phase controllers require 2 Pole Fuseblocks, while Three Phase controllers require 3 Pole Fuseblocks.

Touchsafe Kits: Single Phase

MODEL NUMBER	CCI PART NUMBER	AMP SIZE	DESCRIPTION
F010	SFKTS62T10	10	2 Pole Assy - 2 x Fuse, 1 x Block, 2 x Cover
F015	SFKTS62T15	15	2 Pole Assy - 2 x Fuse, 1 x Block, 2 x Cover
F020	SFKTS62T20	20	2 Pole Assy - 2 x Fuse, 1 x Block, 2 x Cover
F025	SFKTS62T25	25	2 Pole Assy - 2 x Fuse, 1 x Block, 2 x Cover
F030	SFKTS62T30	30	2 Pole Assy - 2 x Fuse, 1 x Block, 2 x Cover
F035	SFKTS62T35	35	2 Pole Assy - 2 x Fuse, 1 x Block, 2 x Cover
F040	SFKTS62T40	40	2 Pole Assy - 2 x Fuse, 1 x Block, 2 x Cover
F045	SFKTS62T45	45	2 Pole Assy - 2 x Fuse, 1 x Block, 2 x Cover
F050	SFKTS62T50	50	2 Pole Assy - 2 x Fuse, 1 x Block, 2 x Cover
F060	SFKTS62T60	60	2 Pole Assy - 2 x Fuse, 1 x Block, 2 x Cover
F070	SFKTS61T70	70	1 Pole Assy - 1 x Fuse, 1 x Block, 1 x Cover (2 required)
F080	SFKTS61T80	80	1 Pole Assy - 1 x Fuse, 1 x Block, 1 x Cover (2 required)
F090	SFKTS61T90	90	1 Pole Assy - 1 x Fuse, 1 x Block, 1 x Cover (2 required)
F100	SFKTS61T100	100	1 Pole Assy - 1 x Fuse, 1 x Block, 1 x Cover (2 required)

Touchsafe Kits: Three Phase

MODEL NUMBER	CCI PART NUMBER	AMP SIZE	DESCRIPTION
F010	SFKTS63T10	10	3 Pole Assy - 3 x Fuse, 1 x Block, 3 x Cover
F015	SFKTS63T15	15	3 Pole Assy - 3 x Fuse, 1 x Block, 3 x Cover
F020	SFKTS63T20	20	3 Pole Assy - 3 x Fuse, 1 x Block, 3 x Cover
F025	SFKTS63T25	25	3 Pole Assy - 3 x Fuse, 1 x Block, 3 x Cover
F030	SFKTS63T30	30	3 Pole Assy - 3 x Fuse, 1 x Block, 3 x Cover
F035	SFKTS63T35	35	3 Pole Assy - 3 x Fuse, 1 x Block, 3 x Cover
F040	SFKTS63T40	40	3 Pole Assy - 3 x Fuse, 1 x Block, 3 x Cover
F045	SFKTS63T45	45	3 Pole Assy - 3 x Fuse, 1 x Block, 3 x Cover
F050	SFKTS63T50	50	3 Pole Assy - 3 x Fuse, 1 x Block, 3 x Cover
F060	SFKTS63T60	60	3 Pole Assy - 3 x Fuse, 1 x Block, 3 x Cover
F070	SFKTS63T70	70	3 Pole Assy - 3 x Fuse, 1 x Block, 3 x Cover
F080	SFKTS63T80	80	3 Pole Assy - 3 x Fuse, 1 x Block, 3 x Cover
F090	SFKTS63T90	90	3 Pole Assy - 3 x Fuse, 1 x Block, 3 x Cover
F100	SFKTS63T100	100	3 Pole Assy - 3 x Fuse, 1 x Block, 3 x Cover

APPENDIX E: 1Ø PART NUMBERS

uF1 □□□□□-□□-□□□□□-□□□□

Board Type
- SX = Standard
- HX = High performance

Terminal
- T = Pluggable terminal block
- R = Ring terminal[1]

Frame Style
- A = 16 - 32A (Panel Mount / DIN Rail)
- B = 50 - 80A (Panel Mount / DIN Rail)

Option Board
- 0 = None
- I = EtherNet/IP
- E = Modbus TCP
- N = PROFINET

Amp Size
- 16 = 16 Amps
- 32 = 32 Amps
- 50 = 50 Amps
- 80 = 80 Amps

Performance

Available with SX:
- S = Standard
- L = Adjustable Current Limit and current feedback

Available with HX:
- L = Adjustable Current Limit, current feedback, load voltage feedback, & voltage limit
- P = High Performace (Includes Load Voltage Feedback, True RMS Power Control, Current Limit, Power Limit, High Resolution Control Loop)

I/O
- 0 = None (Only applicable for SX; HX board is equipped with an alarm relay by default)
- 1 = Alarm Relay (1x Form C)
- 2 = General Purpose Input / Analog Input Channel 2 / Pulse Width Modulation Input
- 3 = Both

Retransmits
- 0 = None
- R = Retransmits[2] (Two 16-bit analog retransmits for voltage, current, or power)

Sync
- 0 = None
- S = Digital SYNC-GUARD™

Zero Cross Transformer Mode
- 0 = None
- Z = Zero Cross Transformer Mode[2]

Branch Rated Class T Fuse Options
- Blank = None
- F010 = 10A
- F015 = 15A
- F020 = 20A
- F025 = 25A
- F030 = 30A
- F035 = 35A
- F040 = 40A
- F045 = 45A
- F050 = 50A
- F060 = 60A
- F070 = 70A
- F080 = 80A
- F090 = 90A
- F100 =100A

See “Fusing Options,” page 7, for more information.

[1] Contact factory for availability

[2] Only available with HX type board

APPENDIX E: 3Ø PART NUMBERS

uF3□□□□□□□-□□-□□□□□-□□□□

Board Type
- SX = Standard
- HX = Upgradable High Performance

Load Configuration
- 4DY = Three Phase 4 SCR (2 Leg)
- 6DY = Three Phase Delta/Wye, 6 SCR
- 64Y = Three Phase 4 Wire Wye, 6 SCR
- 6ID = Three Phase Inside Delta, 6 SCR

Frame
- A = 16 - 32A (Panel Mount / Din Rail)
- B = 50 - 80A (Panel Mount / Din Rail)
- C = 16 - 32A (External Mount) [1]
- D = 50A (External Mount) [1]
- E = 16 - 32A (Liquid Cooled) [1]
- F = 50 - 80A (Liquid Cooled) [1]

Option Board
- 0 = None
- E = Modbus TCP
- I = EtherNet/IP
- N = PROFINET

Amp Size
- 16 = 16 Amps
- 50 = 50 Amps
- 32 = 32 Amps
- 80 = 80 Amps [2]

Performance

Available with SX:
- S = Standard
- L = Adjustable Current Limit and current feedback

Available with HX:
- L = Adjustable Current Limit, current feedback, load voltage feedback, & voltage limit
- P = High Performace (Includes Load Voltage Feedback, True RMS Power Control, Current Limit, Power Limit, High Resolution Control Loop)

I/O
- 0 = None (Only applicable for SX; HX board is equipped with an alarm relay by default)
- 1 = Alarm Relay (1x Form C)
- 2 = General Purpose Input / Analog Input Channel 2 / Pulse Width Modulation Input
- 3 = Both

Retransmits
- 0 = None
- R = Retransmits [3] (Two 16-bit analog retransmits for voltage, current, or power)

Sync
- 0 = None
- S = Digital SYNC-GUARD™

Zero Cross Transformer Mode
- Z = Zero Cross Transformer Mode [3]

Branch Rated Class T Fuse Options
- Blank = None
- F010 = 10A
- F015 = 15A
- F020 = 20A
- F025 = 25A
- F030 = 30A
- F035 = 35A
- F040 = 40A
- F045 = 45A
- F050 = 50A
- F060 = 60A
- F070 = 70A
- F080 = 80A
- F090 = 90A
- F100 =100A

See “Fusing Options,” page 7, for more information.

[1] UL pending

[2] 80 Amps not available for external panel mount

[3] Only available with HX type board