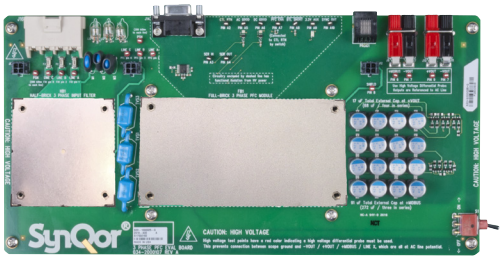
SynQor®

Advancing The Power Curve ®

EVAL-KIT-1000025-01
Evaluation KIT for 3-Phase PFC Converters



Summary

SynQor has developed EVAL-1000025, an evaluation board to facilitate testing of our 3-phase PFC converter and its associated 3-phase AC line filter.

Introduction

This application note is a guide to the features, schematic, component placement, and BOM for this evaluation board. The applicable converter modules are the MACF-115-3PH-UNV-HT 3-phase AC Line Filter and the MPFC-115-3PH-270-FP 3-phase PFC.

For assistance with testing the performance of our DC-DC power converters, please refer to our application note “Guidelines for Testing SynQor DC-DC Converters”.

Contents

This evaluation board and schematic are intended for demonstration purposes only and no guarantees are made for standards compliance.

Shock Warning: There are areas of this evaluation board that have exposed access to hazardous high voltage levels. Exercise caution to avoid contact with those voltages. Also note that the evaluation board may retain high voltage temporarily after input power has been removed. Exercise caution when handling.

Thermal Considerations: When testing converters on an evaluation board, ensure adequate cooling. Apply cooling air with a fan blowing across the converter or across a heatsink attached to the converter. Monitor the converter temperature to ensure it doesn’t exceed the maximum rated per the datasheet specification.

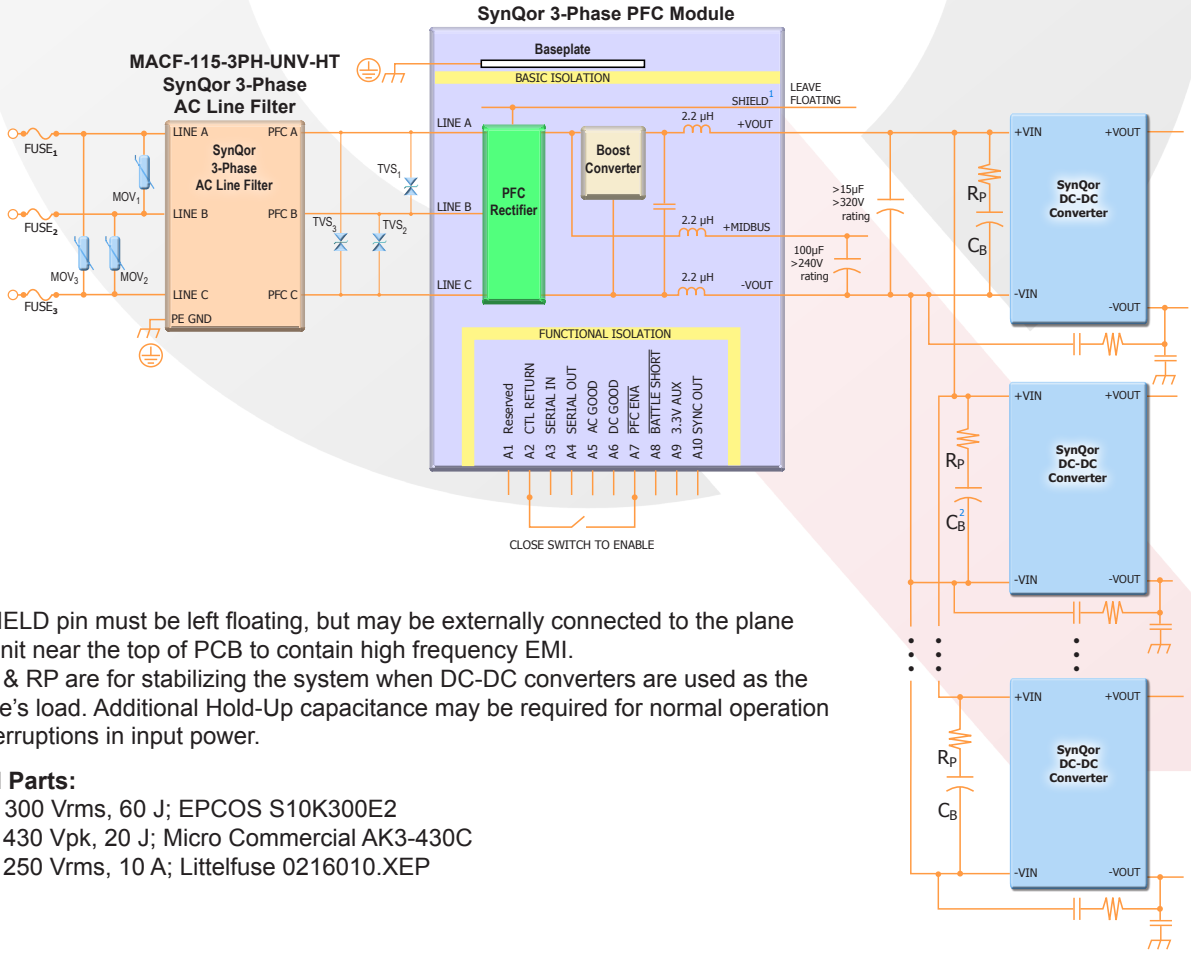
Section 1 – Converter Description

The 3-phase PFC converter has two stages. The input stage takes 3-phase AC (115 Vrms L-N / 200 Vrms L-L) and shapes and balances the three AC input currents. Phase relation (A, B, C phases) are not connection specific. The PFC will work in any orientation. The output of the first stage is called +MIDBUS and it has an external capacitor on the evaluation board (see *Capacitor Bank on the Evaluation Board* section of the application note for more details). +MIDBUS voltage ranges from 160 Vdc to 220 Vdc over specified operating conditions. The +MIDBUS is then fed into a second stage that has a typical output voltage of 270 Vdc. The 3-phase PFC will startup and operate under any valid load condition.

Isolation Warning

Circuitry on this evaluation board is non-isolated with respect to the AC line inputs. This requires great care in making connections and taking measurements. Be aware that the output 270 Vdc and +MIDBUS 200 Vdc are non-isolated with respect to input AC lines. As such, take great care before taking any measurement with equipment that may make a connection to ground. The return line for either DC voltage is **NOT ground**. Connecting a scope probe to any power DC voltage on this board may result in damage to the board and/or the scope or scope probe. Use isolated differential probes or clamp on style current probes to avoid these issues. Note that the shield pin connects to a shield that lies between the converter and the baseplate and is meant to provide noise reduction in cases where the baseplate is connected to a heatsink that can become a noise radiator. For safety, **DO NOT CONNECT THE SHIELD TO THE BASEPLATE** as the shield is line referenced. In most applications, the output of the 3-phase PFC is followed by an isolated DC-DC converter. The serial port and enable switch are isolated.

Section 2 – Evaluation Block Diagram / Typical Application



Notes:

Note 1: SHIELD pin must be left floating, but may be externally connected to the plane under the unit near the top of PCB to contain high frequency EMI.

Note 2: CB & RP are for stabilizing the system when DC-DC converters are used as the PFC module's load. Additional Hold-Up capacitance may be required for normal operation through interruptions in input power.

Suggested Parts:

MOV 1-3 : 300 Vrms, 60 J; EPCOS S10K300E2
TVS 1-3 : 430 Vpk, 20 J; Micro Commercial AK3-430C
Fuse 1-3 : 250 Vrms, 10 A; Littelfuse 0216010.XEP

Section 3 – Input and Output Connections

Input power is applied through connector J16, see Table 1. The mating connector for J16 is DF22-4S-7.92C (28) from Hirose Electric Company in Japan and is provided.

Output power is applied through connectors J10 and J11 or J6 and J7. See Table 2. The mating connectors are provided.

+MIDBUS is connected to J6, see Table 2.

Table 1: Input Power Connector J16

Connector Terminal #	Signal Name
J16-1	AC Line A Input
J16-2	AC Line B Input
J16-3	AC Line C Input
J16-4	Earth Ground

Table 2: Output Power Connectors

Connector Terminal #	Signal Name
J10	+VOUT
J6	+MIDBUS
J7/J11	-VOUT

Table 3: Test Points

All high voltage test points have a red color indicating a High Voltage Differential Probe must be used. This prevents a connection between the scope ground and -VOUT/+VOUT/+MIDBUS/LINE_X which are all at AC line potential. All black colored test points are referenced to CTL_RETURN and are safe to use a standard scope probe.

Red Test Points	Signal Name
TH1	LINE A
TH2	LINE B
TH3	LINE C
TH4	PFC A
TH5	PFC B
TH6	PFC C
TH7	+MIDBUS
TH8	-VOUT
TH9	+VOUT
TH10	-VOUT
TH11	FLOATING_PLANE
TH12	PSEUDO-NEUTRAL AT LINE INPUT
TH13	PSEUDO-NEUTRAL AT PFC INPUT

Black Test Points	Signal Name
TH14	CTL RETURN
TH15	SERIAL IN
TH16	SERIAL OUT
TH17	AC GOOD
TH18	DC GOOD
TH19	$\overline{\text{PFC ENABLE}}$
TH20	$\overline{\text{BATTLE SHORT}}$
TH21	3.3V AUX
TH22	SYNC OUT

Note: *Please refer to the appropriate SynQor converter datasheet for descriptions of these features.*

Section 4 – Switches, Lights, LEDs, External Transient Protection and BNC Connectors

Description of Switches

Enable On/Off Switch

Toggling S1 switch to the ON position enables the 3-phase PFC converter. Toggling S1 switch to the OFF position disables the 3-phase PFC converter.

Description of Lights

Neon Lamp Indicators

LI1: AC Line A power present
LI2: AC Line B power present
LI3: AC Line C power present

LED Indicators

LED1: AC GOOD
LED2: DC GOOD
LED3: Bias On

Description of Transient Protection Devices

The evaluation board includes protective MOV devices on all three input lines. These are in place to absorb energy from potential transients that may be present on your line. Transient voltage suppressors (TVS) are included after the filter to clamp the peak line-line voltage seen by the PFC module, when stimulated by an input transient.

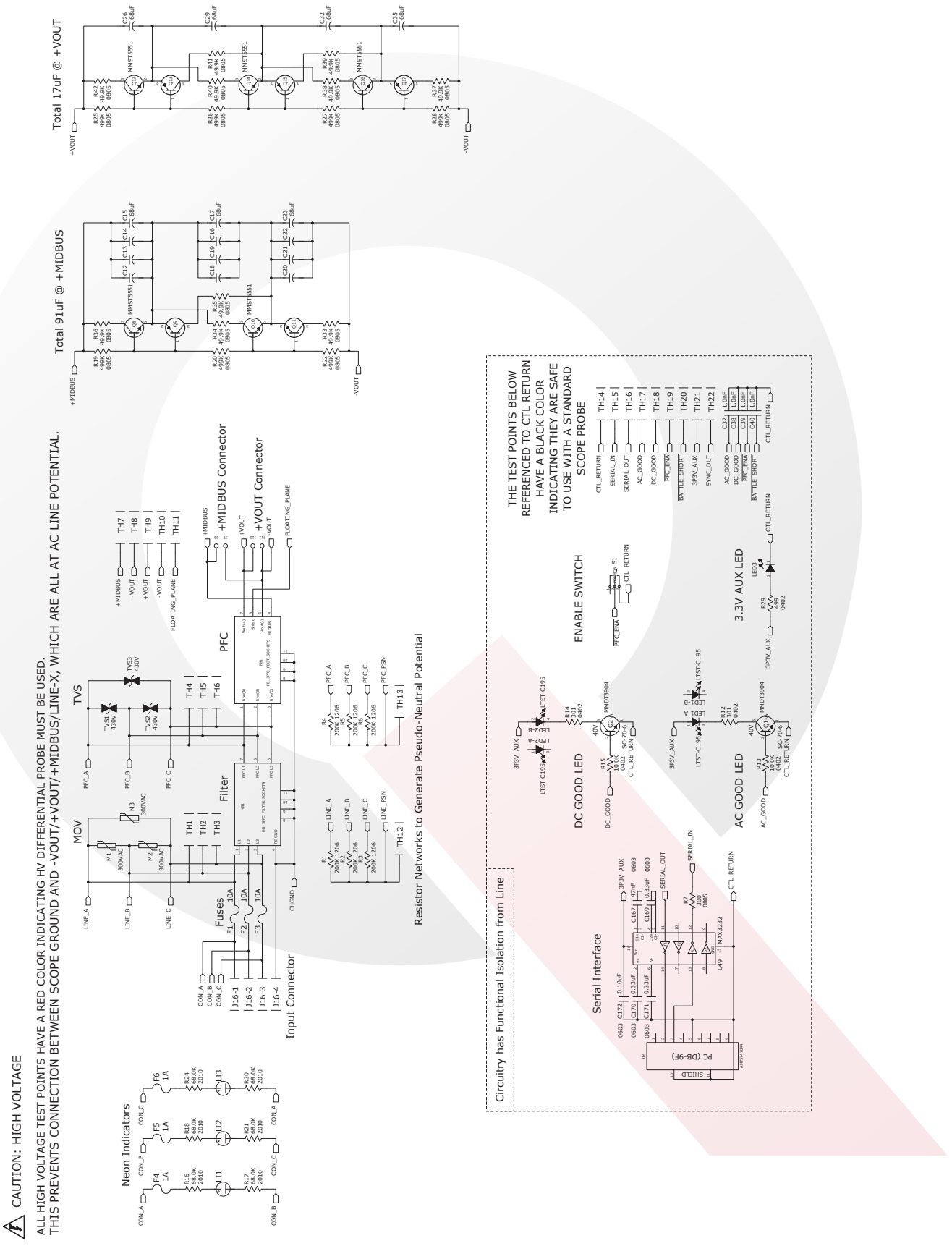
MOV Devices

PAin to PBin: M1
PAin to PCin: M2
PBin to PCin: M3

TVS Devices

PAMID to PBMID: M5 and M6
PBMID to PCMID: M4 and M5
PAMID to PCMID: M4 and M6

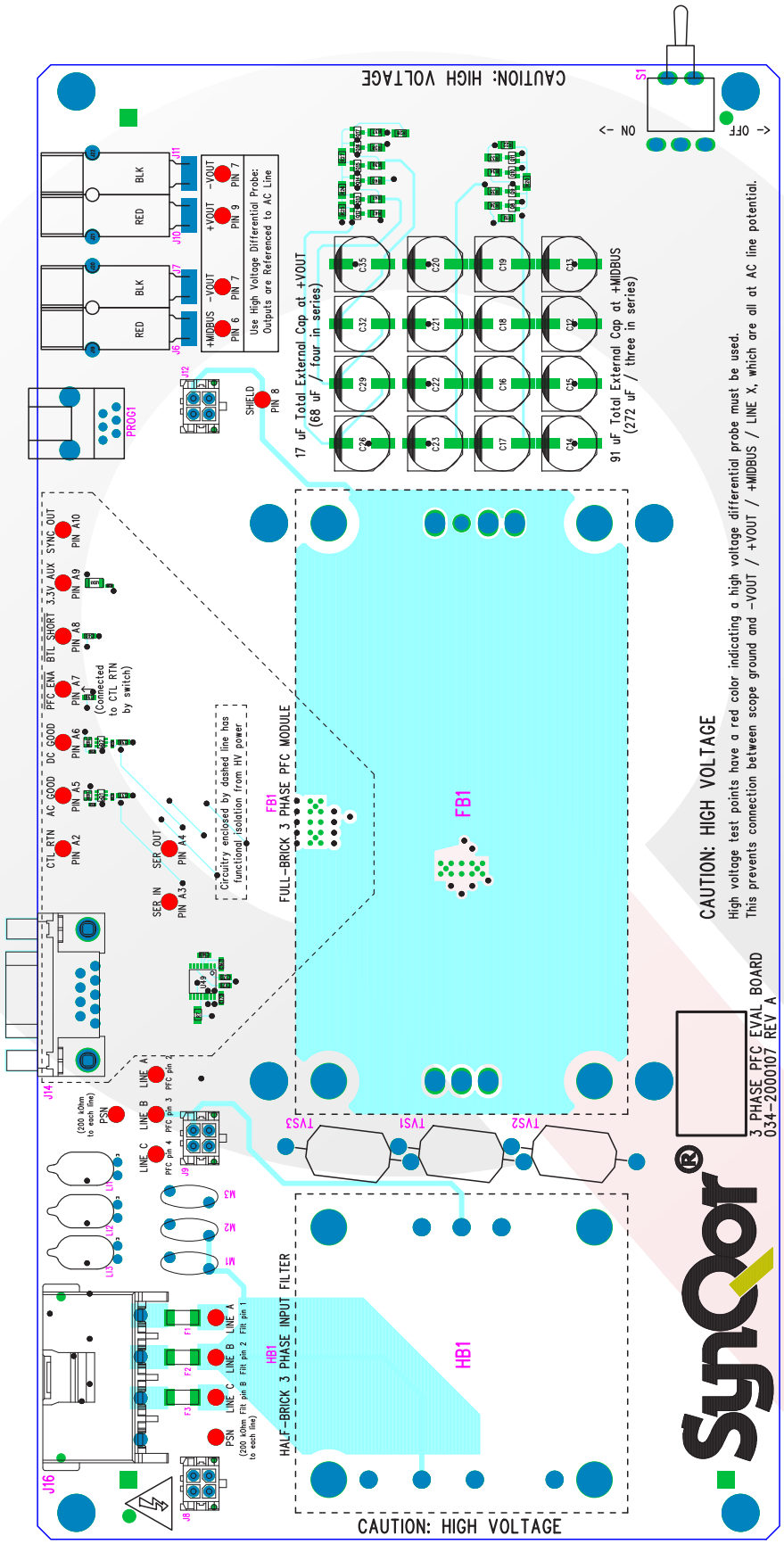
Section 5 – Schematic



Section 6 – Component Placement

All high voltage test points have a red color indicating a High Voltage Differential Probe must be used.
This prevents a connection between the scope ground and -VOUT/+VOUT/+MIDBUS/LINE_X which are all at AC line potential.

All black colored test points are referenced to CTL_RETURN and are safe to use a standard scope probe.



Section 7 – Basic Operating Instructions

Apply the 3-phase input, 115 Vrms (L-N) at J16 in upper left, using the provided cable assembly. Earth ground, and Phases A, B, and C are labeled. There is no neutral connection, and phase rotation (A, B, C) does not matter to the device. Lamps LI1, LI2, LI3 indicate the presence of hazardous voltages at the input.

Connect the loads at:

+MIDBUS for loosely regulated 200 V

and/or

+VOUT for regulated 270 V

Use Switch S1 in lower right for enable / disable control.

Be aware that the output 270 Vdc and +MIDBUS 200 Vdc are non-isolated with respect to input AC lines. As such, take great care before taking any measurement with equipment that may make a connection to ground. The return line for either DC voltage is **NOT ground**. Connecting a scope probe to any power DC voltage on this board may result in damage to the board and/or the scope or scope probe. Use isolated differential probes or clamp on style current probes to avoid these issues.

All high voltage test points have a red color indicating a High Voltage Differential Probe must be used. This prevents a connection between the scope ground and -VOUT/+VOUT/+MIDBUS/LINE X which are all at AC line potential. All black colored test points are referenced to CTL RETURN and are safe to use a standard scope probe.

Measurements may be taken or a downstream converter added to test the PFC in an evaluation system.

Capacitor Bank on the Evaluation Board

The test board includes a small amount of output capacitance on the MAIN OUTPUT (270 Vdc). Although no large bulk hold-up capacitance is required for operation, the device will require a nominal amount of capacitance at the +MIDBUS node for normal operation. The capacitors selected are rated from -55 °C to 125 °C, and arranged in groups in series due to their voltage rating. A single larger value electrolytic capacitor would also be acceptable. Capacitors on the output nodes serve to stabilize the input system both for this converter and downstream power converters.

Capacitors are solid polymer electrolytic for good ESR at low temperature and lifetime at high temperature. The highest voltage rating for Nichicon PCR is 80V continuous so capacitors are wired in series with active balancing.

On-Board Capacitance:

91 µF @ +MIDBUS
17 µF @ +VOUT

+MIDBUS has 4 sets of 3 series capacitors in parallel for a total of 12 capacitors
+VOUT has 1 set of 4 series capacitors in parallel for a total of 4 capacitors

Please refer to the applications section of the datasheet for more detailed information on additional capacitance.

http://www.synqor.com/Datasheets/MPFC-115-3P-270-FP_Datasheet.pdf

Additional Information

Two LEDs next to BNC1 indicate the status of the AC GOOD and DC GOOD signals.

The PCB and PFC module have means in place for shield layers on both the PCB itself, under the module and between the baseplate and module, as part of the 3-phase PFC full brick. The baseplate retains electrical isolation. These layers are in place to reduce EMI radiation. The evaluation board and PFC module properly connect these shields.

Serial Interface Communications

To communicate with adaptor board kit, a DB9 Male to DB9 Female and USB RS232 adaptor are required.

Manufacturer	Part Number	Description
Future Technology Devices Intl.	UC232R-10	Cable USB RS232 Embedded 10CM
Assmann WSW Components	AK131-2	Cable DB9M-DB9F 2M

Please refer to application note "*MPFC-115-3PH-270-FP Serial Interface*" for information regarding the communications standards and parameters available for monitoring.

Appendix A – Bill of Materials (BOM)

Table 4: EVAL-1000025

Ref Des	Value	Package	Description
A1		ANDERSON_HOUSING	Black PP15-45 Anderson Housing; Anderson Power 1327G6FP
A2		ANDERSON_HOUSING	Red PP15-45 Anderson Housing; Anderson Power 1327FP
A3		ANDERSON_HOUSING	Black PP15-45 Anderson Housing; Anderson Power 1327G6FP
A4		ANDERSON_HOUSING	Red PP15-45 Anderson Housing; Anderson Power 1327FP
C12	68uF	Radial	Solid Polymer Electrolytic SMT, 80V; Nichicon PCR1K680MCL1GS
C13	68uF	Radial	Solid Polymer Electrolytic SMT, 80V; Nichicon PCR1K680MCL1GS
C14	68uF	Radial	Solid Polymer Electrolytic SMT, 80V; Nichicon PCR1K680MCL1GS
C15	68uF	Radial	Solid Polymer Electrolytic SMT, 80V; Nichicon PCR1K680MCL1GS
C16	68uF	Radial	Solid Polymer Electrolytic SMT, 80V; Nichicon PCR1K680MCL1GS
C17	68uF	Radial	Solid Polymer Electrolytic SMT, 80V; Nichicon PCR1K680MCL1GS
C18	68uF	Radial	Solid Polymer Electrolytic SMT, 80V; Nichicon PCR1K680MCL1GS
C19	68uF	Radial	Solid Polymer Electrolytic SMT, 80V; Nichicon PCR1K680MCL1GS
C20	68uF	Radial	Solid Polymer Electrolytic SMT, 80V; Nichicon PCR1K680MCL1GS
C21	68uF	Radial	Solid Polymer Electrolytic SMT, 80V; Nichicon PCR1K680MCL1GS
C22	68uF	Radial	Solid Polymer Electrolytic SMT, 80V; Nichicon PCR1K680MCL1GS
C23	68uF	Radial	Solid Polymer Electrolytic SMT, 80V; Nichicon PCR1K680MCL1GS
C26	68uF	Radial	Solid Polymer Electrolytic SMT, 80V; Nichicon PCR1K680MCL1GS
C29	68uF	Radial	Solid Polymer Electrolytic SMT, 80V; Nichicon PCR1K680MCL1GS
C32	68uF	Radial	Solid Polymer Electrolytic SMT, 80V; Nichicon PCR1K680MCL1GS
C35	68uF	Radial	Solid Polymer Electrolytic SMT, 80V; Nichicon PCR1K680MCL1GS
C37	1.0nF	0603	X7R 50V
C38	1.0nF	0603	X7R 50V
C39	1.0nF	0603	X7R 50V
C40	1.0nF	0603	X7R 50V
C167	47nF	0603	X7R 16V
C169	0.33uF	0603	X7R, 16V
C170	0.33uF	0603	X7R, 16V
C171	0.33uF	0603	X7R, 16V
C172	0.10uF	0603	X7R 16V
F1	10A	2410	10A Fuse; Littelfuse R45 1010
F2	10A	2410	10A Fuse; Littelfuse R45 1010
F3	10A	2410	10A Fuse; Littelfuse R45 1010
F4	250mA	2410	250mA Fuse; Littelfuse 0451.250MRL
F5	250mA	2410	250mA Fuse; Littelfuse 0451.250MRL
F6	250mA	2410	250mA Fuse; Littelfuse 0451.250MRL
J6		Anderson40RA	Right Angle 40A CRIMP Pin for Anderson Connectors; 1336G1
J7		Anderson40RA	Right Angle 40A CRIMP Pin for Anderson Connectors; 1336G1
J8			3mm Header, Surface Mount Compatible, Dual Row, Vertical, with PCB Polarizing Peg, 4 Circuits, Tin (Sn) Plating, with Kinked PC Tails; Molex 43045-0412, Wurth 662 004 211 22
J9			3mm Header, Surface Mount Compatible, Dual Row, Vertical, with PCB Polarizing Peg, 4 Circuits, Tin (Sn) Plating, with Kinked PC Tails; Molex 43045-0412, Wurth 662 004 211 22

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Ref Des	Value	Package	Description
J10		Anderson40RA	Right Angle 40A CRIMP Pin for Anderson Connectors; 1336G1
J11		Anderson40RA	Right Angle 40A CRIMP Pin for Anderson Connectors; 1336G1
J12			3mm Header, Surface Mount Compatible, Dual Row, Vertical, with PCB Polarizing Peg, 4 Circuits, Tin (Sn) Plating, with Kinked PC Tails; Molex 43045-0412, Wurth 662 004 211 22
J14			RIGHT-ANGLE FEMALE DB9 CONNECTOR, TH HOLE; Tyco 574844-6
J16	4 PIN	4PINRASRTH	4-Pin RA Header; Hirose EI DF22-4P-7.92DS(05)
J19		STAPLE	Anderson Connector PCB Mount Staple Spanning 2 Modules; Anderson Power Products 114555P2
J20	OPEN		Pin hole for Anderson Connector Mounting
J21		STAPLE	Anderson Connector PCB Mount Staple Spanning 2 Modules; Anderson Power Products 114555P2
J22	OPEN		Pin hole for Anderson Connector Mounting
LED1		LTST-C195	BI-COLOR GREEN/YELLOW LED
LED2		LTST-C195	BI-COLOR GREEN/YELLOW LED
LED3		1206	Orange LED Top-View
LI1		Radial	Neon Lamp; Visual Communications A1C
LI2		Radial	Neon Lamp; Visual Communications A1C
LI3		Radial	Neon Lamp; Visual Communications A1C
M1	300VAC	Radial	Metal Oxide Varistor, 300V AC, 10mm disc; E pcos S10K300E2, Epcos B72210S2301K101
M2	300VAC	Radial	Metal Oxide Varistor, 300V AC, 10mm disc; E pcos S10K300E2, Epcos B72210S2301K101
M3	300VAC	Radial	Metal Oxide Varistor, 300V AC, 10mm disc; E pcos S10K300E2, Epcos B72210S2301K101
PROG1		RJ25	Jack, CAT3, 6p6c (RJ11, RJ12, RJ14, RJ25); AMP, 5555165-1
Q1	40V	SC-70-6	Dual NPN Transistor; Diodes, Inc. 118-0DT3904
Q2	40V	SC-70-6	Dual NPN Transistor; Diodes, Inc. 118-0DT3904
Q8		SC-70-3	NPN Transistor; Diodes, Inc. MMST5551-7, Philips PMST5551 TR
Q9	-150V	SC-70-3	PNP Transistor; Diodes, Inc. MMST5401-7-F
Q10		SC-70-3	NPN Transistor; Diodes, Inc. MMST5551-7, Philips PMST5551 TR
Q11	-150V	SC-70-3	PNP Transistor; Diodes, Inc. MMST5401-7-F
Q12		SC-70-3	NPN Transistor; Diodes, Inc. MMST5551-7, Philips PMST5551 TR
Q13	-150V	SC-70-3	PNP Transistor; Diodes, Inc. MMST5401-7-F
Q14		SC-70-3	NPN Transistor; Diodes, Inc. MMST5551-7, Philips PMST5551 TR
Q15	-150V	SC-70-3	PNP Transistor; Diodes, Inc. MMST5401-7-F
Q16		SC-70-3	NPN Transistor; Diodes, Inc. MMST5551-7, Philips PMST5551 TR
Q17	-150V	SC-70-3	PNP Transistor; Diodes, Inc. MMST5401-7-F
R1	200K	1206	Resistor, High Voltage; Stackpole Electronics RVC1206FT200K, Yageo RV1206FR-07200KL
R2	200K	1206	Resistor, High Voltage; Stackpole Electronics RVC1206FT200K, Yageo RV1206FR-07200KL
R3	200K	1206	Resistor, High Voltage; Stackpole Electronics RVC1206FT200K, Yageo RV1206FR-07200KL
R4	200K	1206	Resistor, High Voltage; Stackpole Electronics RVC1206FT200K, Yageo RV1206FR-07200KL

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Ref Des	Value	Package	Description
R5	200K	1206	Resistor, High Voltage; Stackpole Electronics RVC1206FT200K, Yageo RV1206FR-07200KL
R6	200K	1206	Resistor, High Voltage; Stackpole Electronics RVC1206FT200K, Yageo RV1206FR-07200KL
R7	300	0805	Resistor; Vish/Dale, WSE0805300R0FEEA, IRC, PWC-PW-C0805LF-300R-J, Panasonic, ERJ-P06J301V
R12	301	0402	Resistor
R13	10.0K	0402	Resistor
R14	301	0402	Resistor
R15	10.0K	0402	Resistor
R16	68.1K	2010	Resistor
R17	68.1K	2010	Resistor
R18	68.1K	2010	Resistor
R19	499K	0805	Resistor - Special High Voltage, 499K, 0.5%, 0805
R20	499K	0805	Resistor - Special High Voltage, 499K, 0.5%, 0805
R21	68.1K	2010	Resistor
R22	499K	0805	Resistor - Special High Voltage, 499K, 0.5%, 0805
R24	68.1K	2010	Resistor
R25	499K	0805	Resistor - Special High Voltage, 499K, 0.5%, 0805
R26	499K	0805	Resistor - Special High Voltage, 499K, 0.5%, 0805
R27	499K	0805	Resistor - Special High Voltage, 499K, 0.5%, 0805
R28	499K	0805	Resistor - Special High Voltage, 499K, 0.5%, 0805
R29	499	0402	Resistor
R30	68.1K	2010	Resistor
R33	49.9K	0805	Resistor
R34	49.9K	0805	Resistor
R35	49.9K	0805	Resistor
R36	49.9K	0805	Resistor
R37	49.9K	0805	Resistor
R38	49.9K	0805	Resistor
R39	49.9K	0805	Resistor
R40	49.9K	0805	Resistor
R41	49.9K	0805	Resistor
R42	49.9K	0805	Resistor
S1			SPDT-T series Subminiature toggle switch
TH1			PC Test Point Compact Red
TH3			PC Test Point Compact Red
TH4			PC Test Point Compact Red
TH5			PC Test Point Compact Red
TH6			PC Test Point Compact Red
TH7			PC Test Point Compact Red
TH8			PC Test Point Compact Red
TH9			PC Test Point Compact Red

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Ref Des	Value	Package	Description
TH10			PC Test Point Compact Red
TH11			PC Test Point Compact Red
TH12			PC Test Point Compact Red
TH13			PC Test Point Compact Red
TH14			PC Test Point Compact Black
TH15			PC Test Point Compact Black
TH22			PC Test Point Compact Black
TVS1	430V	Axial	High Energy Bidirectional TVS; Micro Commercial AK3-430C-BP, Littelfuse AK3-430C
TVS2	430V	Axial	High Energy Bidirectional TVS; Micro Commercial AK3-430C-BP, Littelfuse AK3-430C
TVS3	430V	Axial	High Energy Bidirectional TVS; Micro Commercial AK3-430C-BP, Littelfuse AK3-430C
U49	3.3/5.0V	TSSOP-16	RS-232, 3.3/5.0V TRANSCEIVER; Texas Instruments MAX3232