Military 440V 3-Phase Non-Isolated PFC EVAL-KIT-1000040-01

Evaluation KIT for Non-Isolated 440V 3-Phase PFC Converters

Summary

SynQor has developed the EVAL-KIT-1000040-01, an evaluation kit to facilitate testing of our 440V 3-Phase Non-Isolated 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 kit. The applicable converter modules are the MACF-440-3PH-UNV-MP 3-Phase AC Line Filter and the MPFC-440-3PH-400-LE 3-Phase Non-Isolated PFC.

Contents

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

Section 1 – Converter Description

The Military 3-Phase Non-Isolated PFC converter has two stages. The input stage has a nominal 3-Phase input of AC (254 Vrms L-N / 440 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). The +MIDBUS output voltage is around 400 Vdc, with a controlled output resistance to facilitate parallel operation. During line dropout events, the +MIDBUS voltage can droop as low as 215 Vdc. A second boost stage maintains 400 Vdc regulation of the main output during these brownout or dropout conditions. The 3-Phase Non-Isolated PFC will startup and operate under any valid load condition.

Thermal Considerations: When testing EMI filters and converters on an evaluation board, be sure to provide adequate cooling. Apply cooling air with a fan blowing across the EMI filter and the converter or across the heatsinks attached to the EMI filter and converter. Monitor the EMI filter and converter temperatures to ensure they don't exceed the maximum rated temperatures shown in the module datasheets.

Shock Warning: There are areas of this evaluation board that have exposed access to hazardous voltage levels. The plastic covers are in place to reduce the chance of contact with high voltages. Do not remove the covers. Exercise caution to avoid contact with any high voltage areas. Also note that the evaluation board may temporarily retain high voltage after the input power has been removed. Exercise caution when handling all board components and connectors.

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 400 Vdc output and 400 Vdc +MIDBUS 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.

In most applications, the output of the 3-Phase Non-Isolated PFC is followed by an isolated DC-DC converter. The USB port, enable switch, and control signals are isolated from the AC line.

Section 2 – Evaluation Board Block Diagram

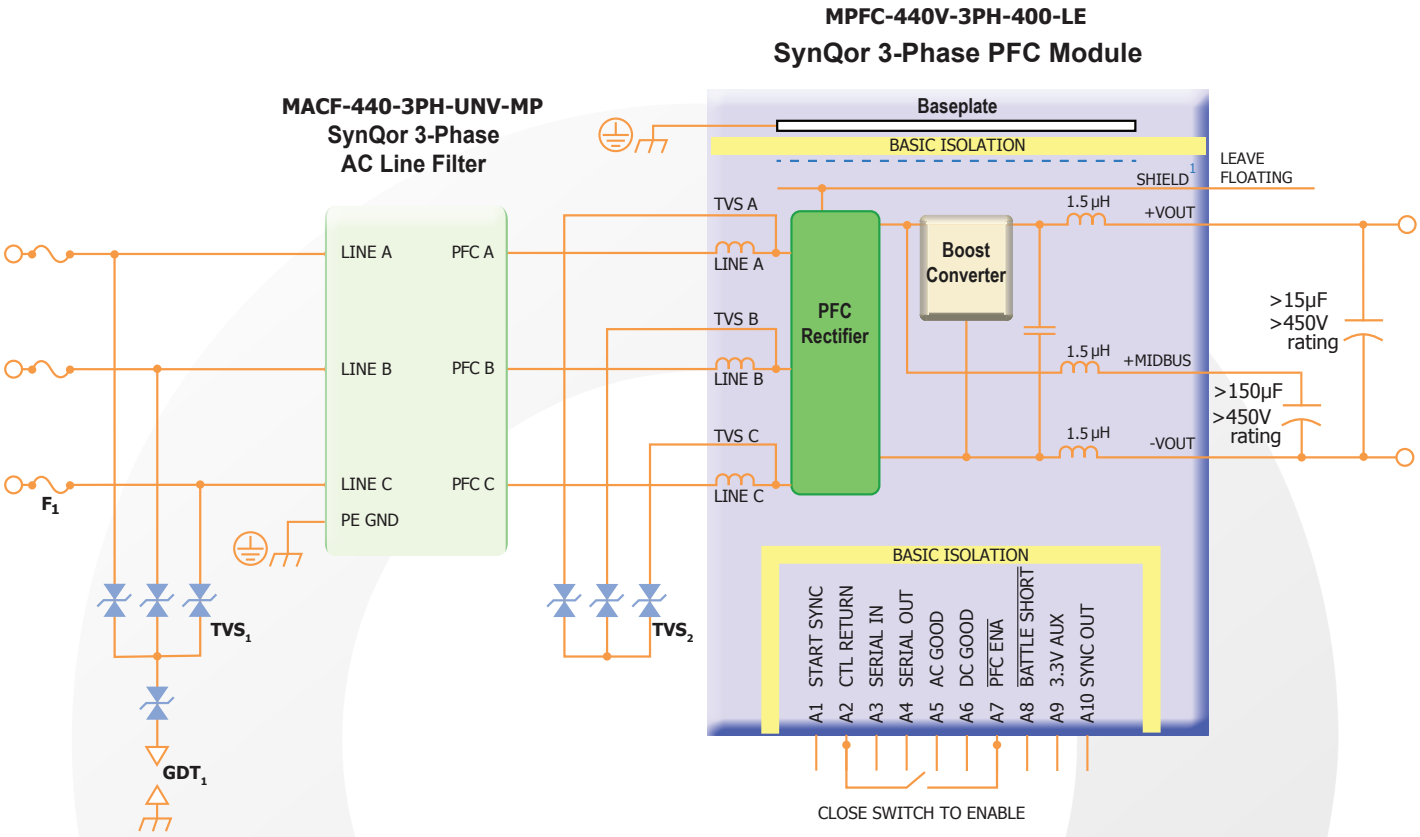


Figure 1. Typical connection diagram for the MPFC-440V-3PH-400-LE AC-DC converter.

Suggested Parts:

TVS_1: 430 Vrms, 10 kA; Littelfuse AK10-430 or Bourns PTVS10-430C-TH

TVS_2: 430 Vrms, 3kA; Littelfuse AK3-430 or Bourns PTVS3-430C-TH

GDT_1: 1.5kV, 3kA; Littelfuse GTCA28-152M-R03

F_1: 500VAC, 30kA; Littelfuse 0505020.MXEP .

Section 3 – Schematic

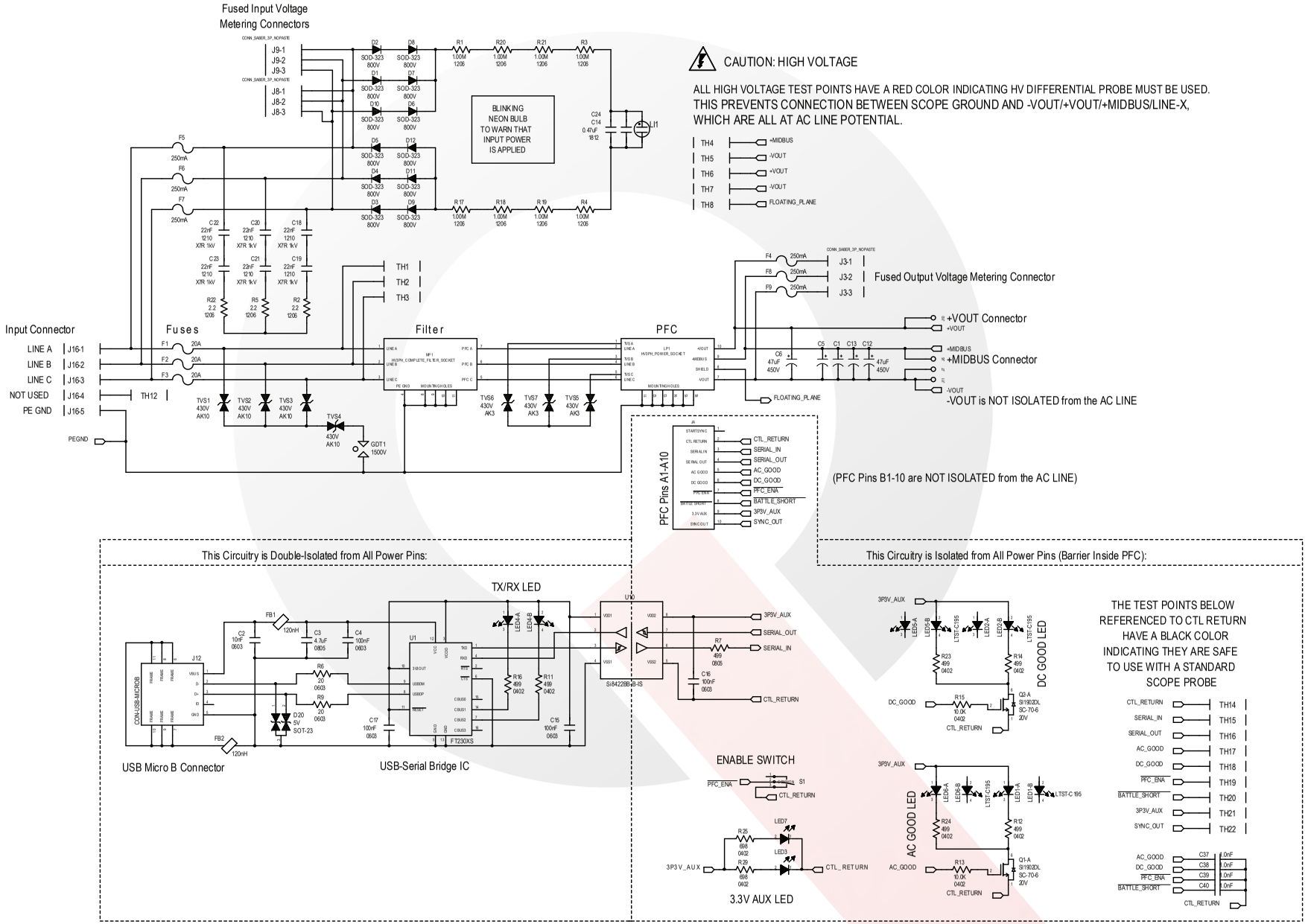
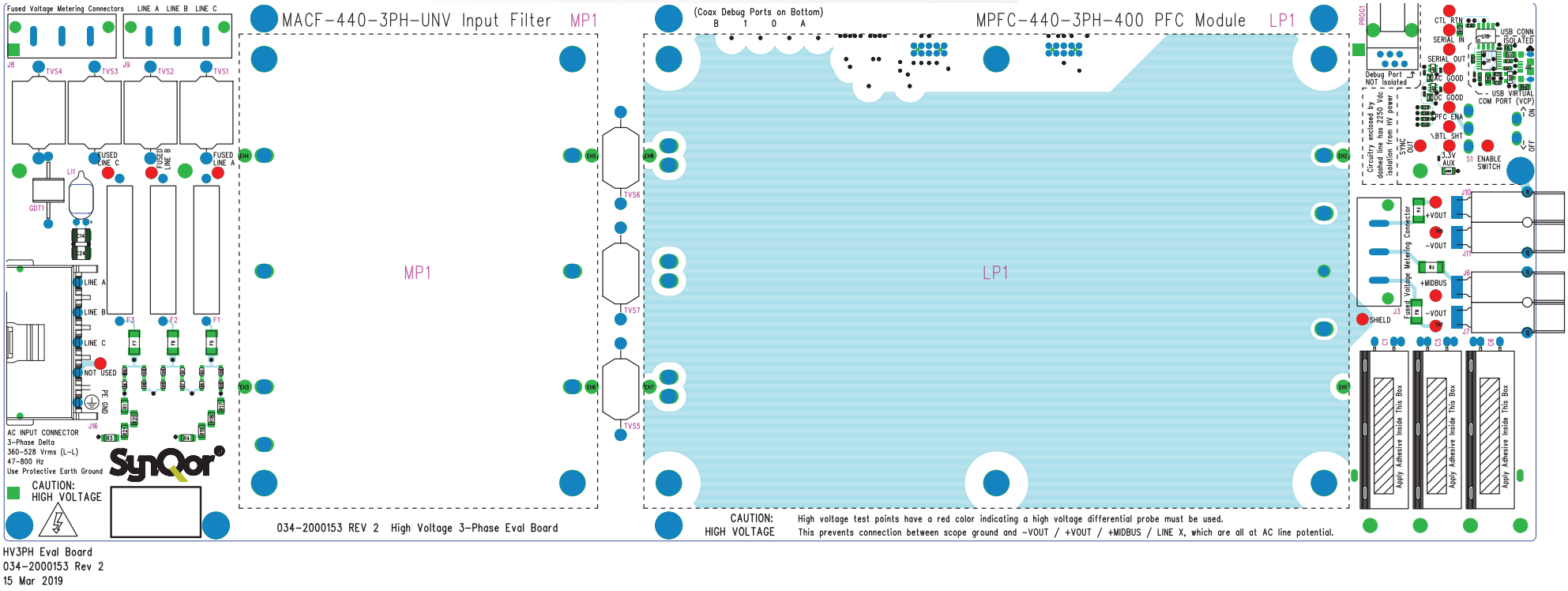


Figure 2. Schematic Diagram for the Military 440V 3-Phase Non-Isolated PFC Evaluation Kit.

Section 4 – Component Placement



HV3PH Eval Board
034-2000153 Rev 2
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Figure 3. Military 440V 3-Phase Non-Isolated PFC evaluation board component placement

Section 5 - Input and Output Connections

Input power is applied through connector J16, see Table 1. The mating connector for J16 is DF22-5P-7.92DS(05) from Hirose Electric Company in Japan and is provided.

Output power is delivered 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	Part Number
J16-1	AC Line A Input	Hirose Electric Company, DF22-5P-7.92DS(05)
J16-2	AC Line B Input	Hirose Electric Company, DF22-5P-7.92DS(05)
J16-3	AC Line C Input	Hirose Electric Company, DF22-5P-7.92DS(05)
J16-4	Not Used	Hirose Electric Company, DF22-5P-7.92DS(05)
J16-5	PE Ground	Hirose Electric Company, DF22-5P-7.92DS(05)

Table 2: Output Power Connector

Connector Terminal #	Signal Name	Part Number
J10	+VOUT	Anderson, 1336G1
J6	+MIDBUS	Anderson, 1336G1
J7/J11	-VOUT	Anderson, 1336G1

Table 3: Metering Power Connectors J8/J9

Connector Terminal #	Signal Name	Part Number
J8/J9-1	AC Line A Input	Molex, 172042-0301
J8/J9-2	AC Line B Input	Molex, 172042-0301
J8/J9-3	AC Line C Input	Molex, 172042-0301

Table 4: Output Power Connectors J3

Connector Terminal #	Signal Name	Part Number
J3-1	+VOUT	Molex, 172042-0301
J3-2	+MIDBUS	Molex, 172042-0301
J3-3	-VOUT	Molex, 172042-0301

Metering connectors have been included in the Eval to facilitate connection to some of the high voltage lines in the board. Use high voltage differential probes to measure these line voltages. This prevents a connection between the scope ground and -VOUT/+VOUT/+MIDBUS/LINE_X which are all at AC line potential. The metering J3, J8 and J9 connectors are 3 position Molex Super Sabre 7.5m connectors.

The boards have a set of isolated test points (black) which are referenced to CTL_RETURN and are safe to use a standard scope probe. Table 5 references each signal to the appropriate test point.

Table 5. Eval board high voltage test points

Black Test Points	Signal Names	Test Point Color
TH14	CTL RETURN	Red
TH15	SERIAL IN	Red
TH16	SERIAL OUT	Red
TH17	AC GOOD	Red
TH18	DC GOOD	Red
TH19	PFC ENABLE	Red
TH20	BATTLE SHORT	Red
TH21	3.3V AUX	Red
TH22	SYNC OUT	Red

Note: *Test points are red in figure 3 but black on physical unit.*

Section 6 – Switches, Lights, LEDs and External Transient Protections

Description of Switches

Enable On/Off Switch

Toggling S1 switch to the ON position enables the 3-Phase Non-Isolated PFC converter. Toggling S1 switch to the OFF position disables the 3-Phase Non-Isolated PFC converter.

Description of Lights

Neon Lamp Indicator

LI1: Blinking neon light warns that input power is present.

LED Indicators

LED1: AC GOOD

LED2: DC GOOD

LED3: Bias On

Description of Transient Protection Devices

The evaluation board includes protective Transient Voltage Suppressors (TVS) devices on all three input lines. The three TVS are connected to PE ground through an additional TVS in series with a gas discharge tube (GDT). These protections are in place to absorb energy from potential transients that may be present on the AC line.

An additional set of Transient voltage suppressors (TVS) are included after the filter to clamp the peak line-line voltage seen by the PFC rectifier switches behind the line input inductors, when stimulated by an input transient

TVS1-4 Devices

Line A to TVS_4: TVS_1

Line B to TVS_4: TVS_2

Line C to TVS_4: TVS_3

TVS_{1-3} to GND: TVS_4

TVS_{5-7} Devices

PFC Line C Virtual Neutral: TVS_5

PFC Line A Virtual Neutral: TVS_6

PFC Line B Virtual Neutral: TVS_7

Section 7 – Basic Operation Instructions

Apply the 3-Phase input, 440 Vrms (L-L) at J16 in middle 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. Lamp LI1 indicates the presence of hazardous voltages at the input.

Connect the loads at:

MIDBUS for loosely regulated 400 V

and/or+

+VOUT for regulated 400 V

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

Be aware that the 400 Vdc output and 400 Vdc +MIDBUS 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 high voltage differential probes or clamp on style current probes to avoid these issues. This prevents a connection between the scope ground and -VOUT/+VOUT/+MIDBUS/LINE X which are all at AC line potential. Use the metering connectors to access the line input voltages, the +MIDBUS voltage or the output voltage in the board. Do not attempt to probe any of these voltages directly on the board. DC output Measurements may be taken at the MIDBUS and OUTPUT connectors or a converter can be added to test the PFC.

All test points referenced to the isolated CTL RETURN are colored black, indicating it is safe to use a standard scope probe.

Capacitor Bank on the Evaluation Board

The test board includes a small amount of output capacitance on the MAIN OUTPUT (47µF, 450 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 board includes four 47µF capacitors across the MIDBUS and VOUT- terminals. 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.

On-Board Capacitance:

188 µF @ +MIDBUS (four capacitors in parallel)

47 µF @ +VOUT (one capacitor)

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

Additional Information

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

Serial Communications Interface

The evaluation kit is equipped with a USB serial interface. In order to communicate to the MPFC, the serial terminal emulator interface has to be configured to: 9600 baud, 8 data bits, no parity, and one stop bit. Set the terminal emulator to send both a line-feed and carriage return. The MPFC does not echo any characters sent to the unit. In order to see the characters being sent to the module in your terminal emulator window, enable the echo feature on your terminal emulator. The USB port in the Evaluation board is a USB 2.0 Micro B female port. To communicate with the adaptor board via USB interface, a USB 2.0 Micro B male cable is needed (Table 7).

Table 6. Suggested USB interface cable

Manufacturer	Part Number	Description
Qualtek	3021079-06	USB 2.0 A male to Micro B

Please refer to application note *SynQor MPFC-440-3PH-400-LE PFC Terminal Commands* for information regarding the communications standards and parameters available for monitoring.

Host computer USB Serial Communications Interface Setup

To communicate with the evaluation board kit, the appropriate USB driver must be installed. The FT230XS driver can be found at FTDI chip web site[1].

"Once the USB drivers are properly installed, a new serial port object should become available for application use. Under Windows, the serial port should become visible from the Windows Device Manager, in the "Ports (COM & LPT)" category, and should be assigned a new COMx name (where x is a number, ex: "COM2"). The exact COMx number assigned to the hardware will depend in part on how many COMx based hardware devices have previously been connected to the machine, as each new hardware instance must be assigned a new and unique number to avoid potential conflicts.

If a machine currently has more than one COMx based hardware device attached to the machine, multiple COMx entries (but different numbers, e.g., COM1 and COM2) may exist in the Windows Device Manager "Ports (COM & LPT)" category, and it may not be clear which COMx port number is specifically associated with the FT230X device. If this occurs, the COMx number can be manually identified by temporarily detaching the USB connection to the FT230X while watching the Windows Device Manager to identify which device entry disappears (and subsequently re-appears in the list upon re-attaching the FT230X).

Once the COMx port number assigned to the FT230X is known, any conventional serial port terminal program can be used to open/close/read/write to the COMx port. To communicate with the adaptor board kit, a USB Micro-B Male cable can be used for a direct connection to the USB port."

[1] Please refer to the FTDI website: *https://www.ftdichip.com*

Appendix A – Bill of Materials (BOM)

Table 7: Evaluation board bill of materials.

Ref Des	Value	Package	Description
C163 C166	0.10uF	0402	X7R 16V
C37 C38 C39 C40	10nF	0603	X7R 50V
C23	10nF	0603	X7R 50V
C15 C16 C17 C4	100nF	0603	X7R 25V
C165	0.022uF	0603	X7R 50V
C7	0.22uF	0603	X7R 25V
C164	1.0uF	0603	X7R 16V
C3	4.7uF	0805	X7R 16V
C10 C11 C8 C9	10uF	1206	X7R 16V
C18 C19 C20 C21 C22 C23	22nF	1210	X7R 1kV
C14 C24	0.47uF	1812	Capacitor, ceramic, 0.47uF, 450V, 10%, X7T, 1812
D1 D10 D11 D12 D2 D3 D4 D5 D6 D7 D8 D9	800V	SOD-323	High Voltage Signal Diode, 800V, SOD-323
D20	5V	SOT-23	TVS Double BIDI ESD Protection Diodes, 5V, SOT-23
F4 F5 F6 F7 F8 F9	250mA	2410	Fuse
FB1 FB2	120nH	0805	120nH, 25%, 0805 Ferrite Bead

Ref Des	Value	Package	Description
J1 J2 J4 J5			Miniature SMT Coax Connector
J12		USB MICRO B	USB Micro-B Female SMT Receptacle
JA JB	OPEN		
LED1 LED2 LED4 LED5 LED6		LTST-C195	BI-COLOR GREEN/YELLOW LED
LED3 LED7		1206	Orange LED Top-View
Q1 Q2	20V	SC-70-6	Dual 20V Low Threshold N-Fet
R190 R191	49.9	0603	Resistor
R11 R12 R14 R16 R23 R24	499	402	Resistor
R25 R29	698	402	Resistor
R13 R15	10.0K	0402	Resistor
R10 R8	1.0uH	0402	Chip Inductor
R6 R9	20	0603	Resistor
R53 R55	49.9	0603	Resistor
R192	100	0603	Resistor
R7	499	0805	Resistor
R2 R22	2.2	1206	Resistor
R1 R17 R18 R19 R20 R21 R3 R4	1.0M	1206	Resistor, High Voltage
R5	2.2	1206	Resistor
U1		SSOP-16	USB-UART Bridge by FTDI
U10		SO-8	Dual-Channel Digital Isolator, SO-8, Bi-Directional, 150Mbps, Safety Rated
U23		SO-8	Voltage Regulator, Charge pump
U46		SO-8	12-Bit DAC
U47	2.048V	SOT-23-5	V-Reference
U48		QSOP-16	Low Power, 5-Fwd-Channel Digital Isolator, 150 Mbps