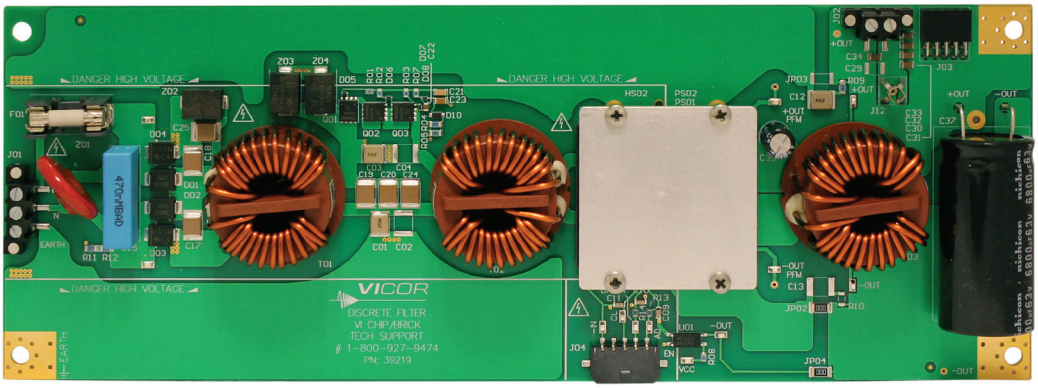
PF175 AC-DC Converter Evaluation Board with External Input Filter

January 2013

Contents Page

Features

- Oscilloscope probe jack for output voltage and ripple measurements
- Simple to use
- Ring lug, screw terminal, and solder connection options
- Replaceable fuse (5A, 216 Littelfuse recommended)



IMPORTANT NOTICE

Please read this document before setting up an evaluation board.

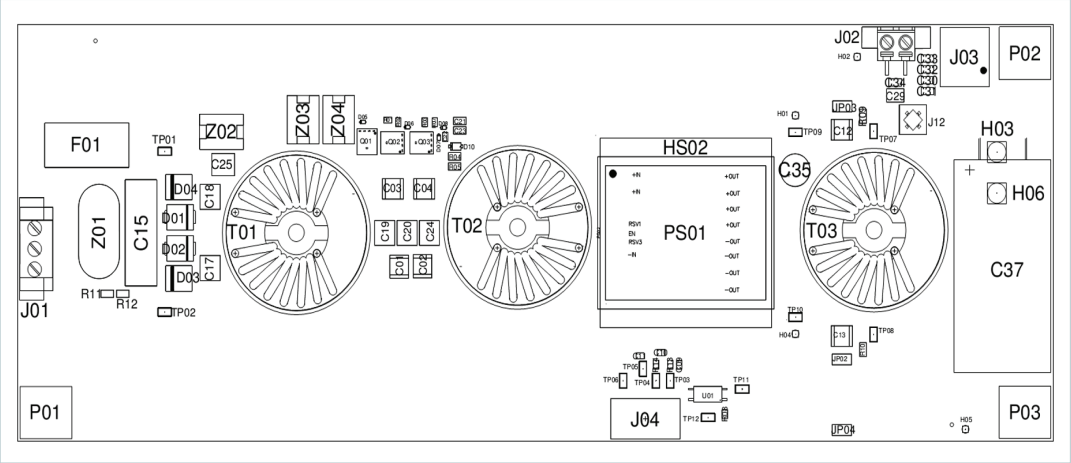
Introduction

This Evaluation Board offers a convenient means to evaluate the performance of Vicor's VI Brick PFM Isolated AC-DC Converter modules with Power Factor Correction, and has been optimized for user convenience. Refer to Table 1 for operating conditions and limits.

This reference design contains an input line filter. It is important to remember the response of the AC line filter is dependent upon the wiring connected to the evaluation board. Care should be exercised to minimize stray source impedances in order to fully exercise the features of the converter.

Figure 1.

VI Brick PFM AC DC Converter Evaluation Board layout and dimensional drawing, component side



Basic Specifications and Operating Limits

Please use the following table for operating limits:

Table 1.

Description	Specification	Notes
Input range	85 – 264 Vac	Universal input
Output voltage	48 Vdc	Regulated
Output power	330 W	Over entire input range
Operating temperature	-40 to 85°C	Limited by C37, T01-T03, U01, Z01-Z04
Output capacitance	6,000 to 12,000 µF	63 V rating, 20% tolerance

NOTE: Module operating temperature will depend on its Product Grade as specified in the data sheet.

Please refer to Figure 1 for locations of the input and output connections as viewed from the component side. Wires may be soldered directly to the pads instead of ring lugs if desired to minimize circuit impedances.

⚠ DANGER! HIGH VOLTAGE! ⚠ DANGER! HOT SURFACE!

The VI Brick AC-DC Converter Evaluation Board contains exposed hazardous voltages. These voltages are within the area marked by the letter H on the PCB.

The VI BRICK DC-DC Converter Evaluation Board may be operated at surface temperatures which may pose a thermal hazard to the operator. Because of the thermal and voltage hazards, be careful not to touch any exposed surface unless the power is disconnected and the evaluation board has been given sufficient time to cool. The evaluation board is not intended for use in end item equipment.

Set Up

The Customer Evaluation Board should be set up as follows:

Note: Care should be taken to avoid reversing polarities if connecting to the opposite (solder) side of the board.

AC Input Connections (J01) ⚠ DANGER! HIGH VOLTAGE!

J01, the screw terminal connector, is for connection of AC input to the AC-DC converter evaluation board. The interconnect leads should be appropriate for the current and voltage supplied to the board.

For single phase power, connect LINE to the pin marked L, NEUTRAL to the pin marked N and earth ground to the pin marked EARTH. Corresponding wires in an IEC cable are brown, blue, and yellow with a green stripe.

The board can be used with three phase power. Connect LINE1 to L and LINE2 to N. Earth ground should still be connected to the EARTH terminal of J1.

+OUT, –OUT

There are several connections available on the VI Brick AC-DC converter. Table 1 lists the available connectors and their current rating. Do not exceed the rating of the connector or the AC-DC converter.

Table 2.
Output Connector Ratings

Connector	Rating	Recommended Connection
J02	10 A	Hold-up capacitor
J03	12 A (3 A/contact)	Mating PRM and BCM eval boards
Ring lugs	100 A	EARTH, +OUT, -OUT
2 mm holes beside C37	12 A	Snap-in type capacitor 10 mm sp

Output bulk (electrolytic) capacitance must be attached across the output of the VI Brick AC-DC converter evaluation Board. Refer to the table above for the appropriate range of output capacitance.

The load should be connected to +OUT and –OUT terminals of the evaluation board with short leads of suitable gauge to carry the output current and minimize losses. A sufficient number of terminal connections should be used to ensure that no terminal sees more than its maximum rated current. The evaluation board can be connected directly to the application for which the AC-DC converter is intended. However the interconnect impedances between the evaluation board and the application can greatly affect the transient response. For applications where transient response is critical, the user should consider mounting the VI Brick AC-DC converter directly to the target application PCB.

Earth Connections

There is one EARTH connection available on the board, in the lower left hand corner, P01 in the schematic diagram. The EARTH connection used for local return for the EMI filter is the same as safety ground.

EARTH may optionally be connected to either of the AC-DC converter outputs in order to provide a positive or negative voltage rail with respect to earth.

The default configuration of the evaluation board is to have the EARTH terminal connected to –OUT through jumper JP02, while JP03 is unpopulated. To leave the outputs floating, remove JP03 so that both JP02 and JP03 are unpopulated. To connect EARTH to +OUT, remove JP02 and populate JP03.

The insulation of the AC/DC converter modules supported by this evaluation board has not been designed to exceed SELV voltages, and should not exceed +/-60Vdc from EARTH potential by stacking.

Input Current Measurement

A current probe can be passed around either input lead connected to the VI BRICK evaluation board. This can be used to measure DC currents and AC currents in front of the EMI filter and transient suppression circuits.

Output Voltage Measurement Jack (J12)

This connector is provided to make accurate measurements of the output ripple voltage of the VI Brick AC-DC converter. Many types of scope probes may be directly connected to this point if the probe is equipped with a removable plastic sheath. To avoid creating ground loops when making measurements of the output or input voltage, these measurements should be made separately. Clamp on ferrite chokes, such as Digikey PN 240-2132-ND placed over the leads of passive oscilloscope probes also help to reduce common mode high frequency switching noise pickup. A capacitor can be added at C29 to reduce high frequency noise at the probe if necessary.

Enable (EN) ⚠ DANGER! HIGH VOLTAGE!

The EN pin can be used to disable the VI Brick AC-DC converter. Connecting EN to the –IN-PFM pin will disable the AC-DC converter. This will also clear any latching output OVP fault if one has occurred. Note that the EN pin is referenced to the primary (hazardous voltage) side of the converter. The EN pin can be accessed from J04, for which a mating connector can be used. The mating connector is Molex P/N 43645-0500 with Molex 43030 series pins.

An optocoupler has been provided to allow connection to output referenced equipment. The input to the optocoupler is connected to –OUT by default. Jumper JP04 can be removed, allowing the customer to provide their own reference for the enable input. This input can be floated up to +/-1000V from EARTH.

Efficiency Measurement

As the VI Brick AC-DC Converter can deliver and consume large currents, the effect of the PCB must be considered when making an efficiency measurement. When testing your design based on this reference design, be sure to probe different points in the input filter and rectifier section to verify that voltage drops are not excessive in your layout.

If efficiency tests are to be automated, then Kelvin type connections are recommended to reduce common current errors during voltage measurements.

Recommended Hardware

The hardware kit provided with the evaluation board includes the following:

- 6 #10 lock washers
- 3 #10-32 screws
- 3 #10-32 hex nuts

Ring lugs are also recommended for making output connections.

Theory of Operation

The schematic diagram is presented in functional blocks with text descriptions.

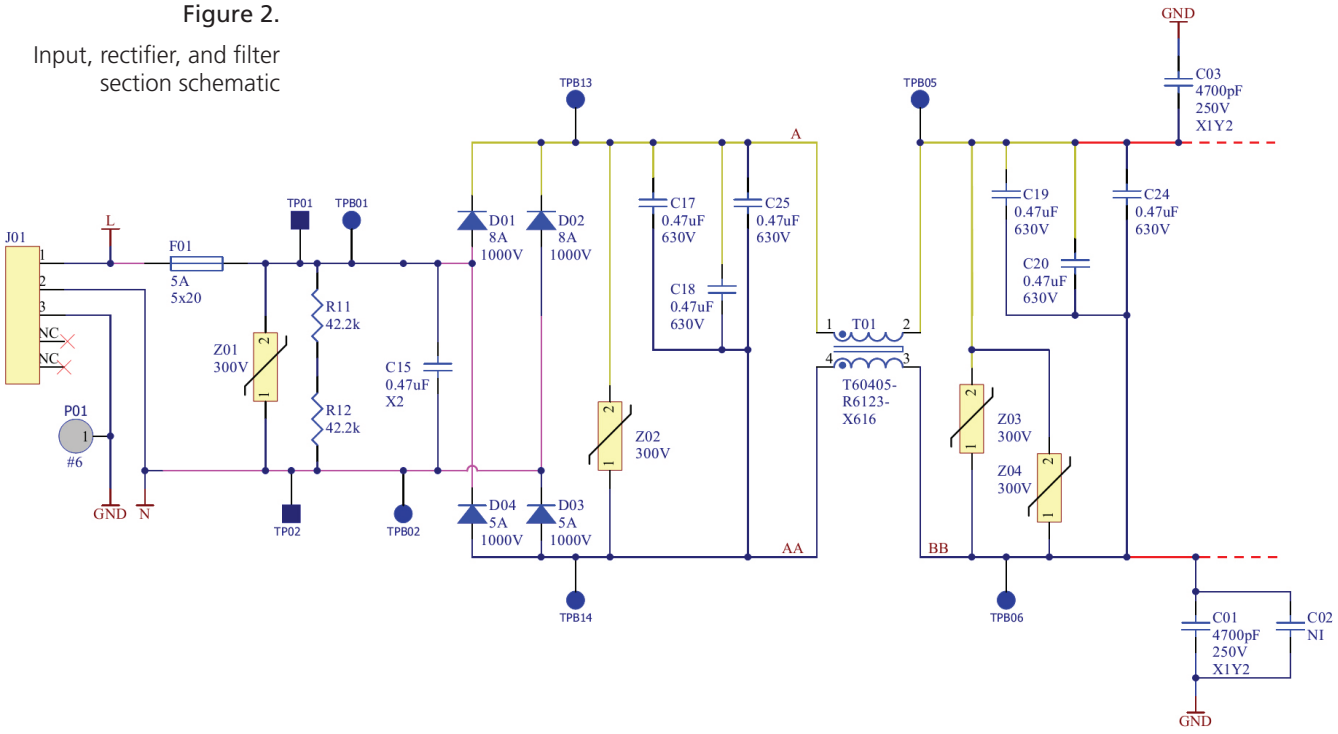
Component values are given in Bill of Materials, layout in PCB Layout (Figure 7). Soft copies are available with download.

Input, Rectifier, and Filter Section

Input power is connected to screw terminal block J01. A 5A fuse in F01 protects against overcurrent. 330W at 93% efficiency draws 355W. At 85V input, 4.17A is drawn. Z01 is a 20mm disk MOV that can withstand higher surges than Z02-Z04. R11 and R12 discharge the input capacitors when the line cord is pulled. Capacitors C15, C17-C20, C24, and C25 return high frequency differential current before it exits the line cord. D01 through D04 form the input bridge rectifier. T01 is a high frequency common mode inductor chosen for its high impedance up to 5MHz. C01 and C03 are Y caps that return common mode high frequency currents to GND (EARTH) rather than through LINE or NEUTRAL.

Figure 2.

Input, rectifier, and filter section schematic

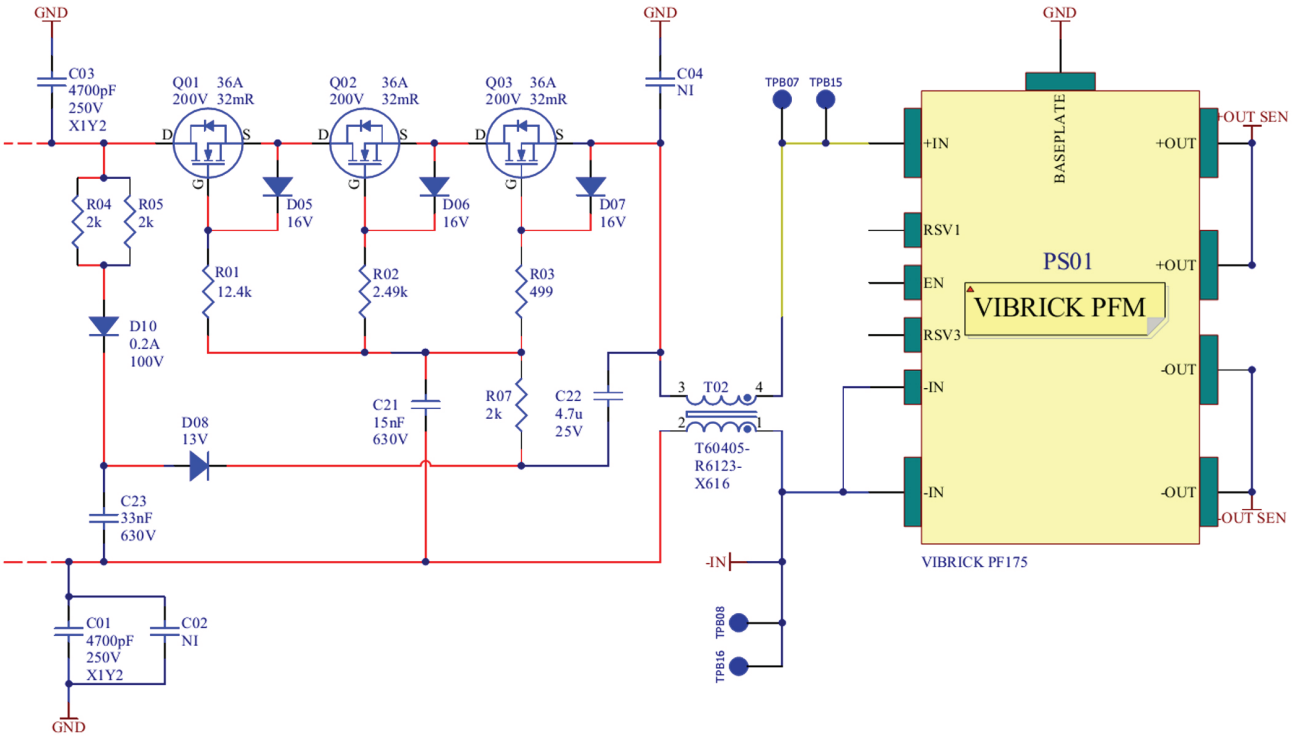


Active Transient Suppression Section

Input power enters from the filter at left. C24 and C01 are repeated in the schematic snippet. Q01 through Q03 transistors turn off during a transient event, and can block up to 200V each. R04/R05 through to C22 form the control mechanism for the transistors. T02 works with the capacitors inside the VI Brick PFM module as part of the conducted emissions filter.

Figure 3.

Active transient suppression section schematic



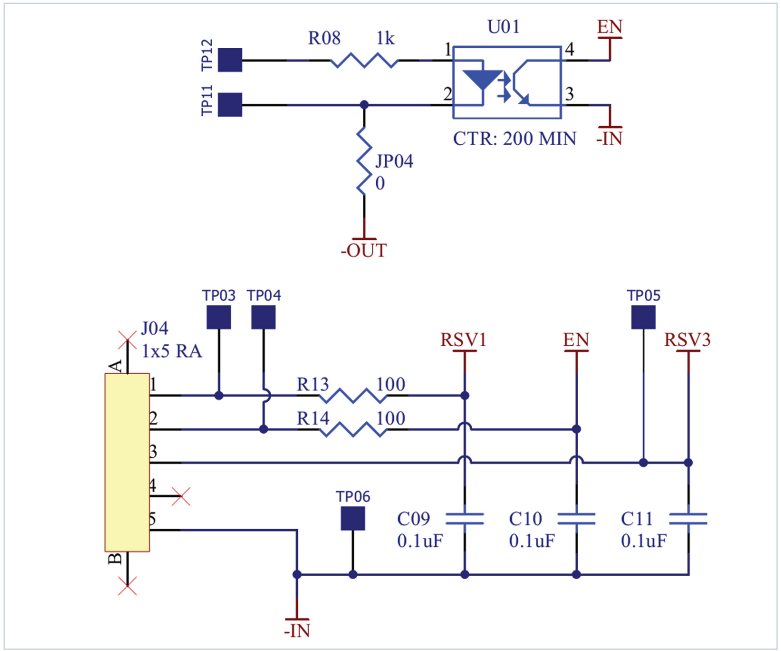
Output Enable Control

The EN pin is pulled low to disable the AC-DC converter. If pulled high to 3.3V or left floating, the VI Brick PFM will operate. A 1x5 0.100″ spaced socket allows easy connection to automated test equipment. This part of the circuit is referenced to primary ground.

Users can connect their own secondary referenced control circuit by connecting through the optocoupler U01, and connecting to TP12 and TP11 as needed. JP04 can be removed to allow a floating reference for the enable input. On this TP12 input, a high signal will result in shutdown of the AC-DC converter.

Figure 4.

Output enable control schematic



Output Filter Section

A common mode inductor should be used at the output to isolate switching noise from this converter so it does not cause beat frequencies with downstream converters. The one used in this reference design is the same used at the input so that a single part number can be stocked. If space is at a premium, a smaller common mode inductor can be substituted. Peak impedance should be between 500kHz and 5MHz.

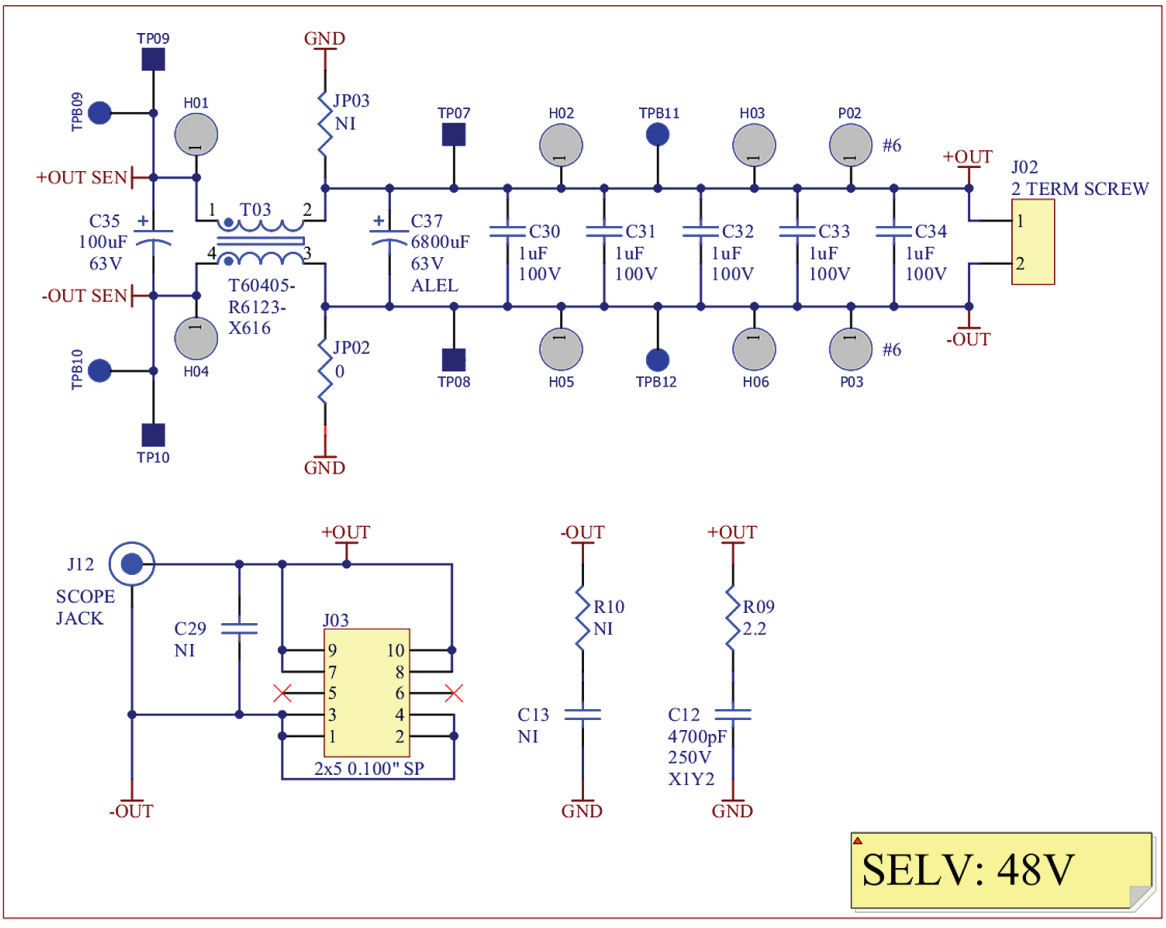
C37 is the bulk capacitor default on this board. Hold time will be increased roughly 50% and power factor increased roughly 0.5% if a 10,000uF capacitor is substituted. This default capacitor is a 25mm x 45mm capacitor that is laid on its side. There are also two 2mm holes, 10mm spacing, which can be used for snap in type electrolytic capacitors. Diameters up to 35mm will clear other components on the PCB. This capacitor filters the rectified line ripple, which is twice the input frequency. RMS ripple current rating should be 80% of output current or higher for longer lifetime. Ripple current ratings vary as a function of ambient temperature.

C30 through C34 are output ceramic filter capacitors. There are used to reduce the switching ripple on the 48V bus near 1MHz. Screw terminal J02 or 0.100" spaced J03 can be used to connect output wires to the load or connect an external capacitor.

J12 is a probe socket with a local capacitor to reduce switching noise. R09 and R10 are used to connect either the positive or negative output terminal to GND (EARTH). Only one should be connected at a time. Both can be removed for a floating output.

Figure 5.

Output filter section schematic



Thermals

For most lab environments a fan blowing across the evaluation board is recommended See VI BRICK Thermal Management Application Note at: www.vicorpower.com/documents/application_notes/AN_Vibrick%20%20thermManage.pdf

or contact Vicor Applications Engineering for assistance (800) 927-9474.

Ordering Information

Two models of the evaluation board are available:

Order Number	Power Module On PCB	AC-DC Format
PFM-DISCRETE-FILTR	PS01 PFM175D480C330A00	VI Chip
PFB-DISCRETE-FILTR	PS02 PF175B480C033FP-00	VI Brick

Bill of Materials

Ref. Des.	Description	Digi-Key Manufacturer	Digi-Key Part Number	Future Manufacturer	Future Part Number
C01	CAPY X7R 4700pF 10% 250V 2220	Murata	490-3482-2-ND	Murata	GA355DR7GF472KW01L
C02	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED
C03	CAPY X7R 4700pF 10% 250V 2220	Murata	490-3482-2-ND	Murata	GA355DR7GF472KW01L
C04	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED
C09	CAP X7R .1uF 10% 25V 0805	Kemet	399-1170-2-ND	AVX	08053C104KAT2A
C10					
C11					
C12	CAPY X7R 4700pF 10% 250V 2220	Murata	490-3482-2-ND	Murata	GA355DR7GF472KW01L
C13	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED
C15	0.47uF/20/275VAC X2 CAP	Kemet	399-5429-ND	Wima	MKS4 0.47/630/10 PCM 27.5
C17	CAP X7T 0.47uF 10% 630V 2220	TDK	445-8876-2-ND	TDK	C5750X7T2J474K
C18					
C19					
C20					
C21	CAP X7R .015uF 10% 630V 1206	TDK	445-4489-2-ND	TDK	C3216X7R2J153M
C22	CAP X7R 4.7uF 10% 25V 0805	TDK	445-5972-2-ND	TDK	CL21A475KAQNNNG
C23	CAP X7T 0.033uF 10% 630V 1206 .060MAXHT	TDK	445-7762-2-ND	Yageo	CC1206KKX7RZB333
C24	CAP X7T 0.47uF 10% 630V 2220	TDK	445-8876-2-ND	TDK	C5750X7T2J474K
C25					
C29	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED
C30	CAP X7R 1.0uF 10% 100V 1206	TDK	445-4467-2-ND	TDK	C3216X7R2A105K
C31					
C32					
C33					
C34					
C35	CAP ALUM 100UF 63V 20% RADIAL	Nichicon	UVY1J101MPD-ND	Nichicon	UVY1J101MPD
C37	CAP ALEL 6800uF 20% 63V 25X50	Kemet	493-1135-ND	Nichicon	UVZ1J682MRD
D01	DPN 1000V 8A DO214AB	Diodes Inc	S8MCDITR-ND	Diodes Inc	S8MC-13
D02					
D03	DPN 1000V 5A SMC	*Stocked by Arrow NAC, Manufacturer: Taiwan Semiconductor, Part#: HS5M R7			
D04					

D05	DZEN 16V 2% 300mW SOD523	NXP Semiconductor	BZX585-B16,115-ND	NXP Semiconductor	BZX585-B16,115
D06					
D07					
D08	DZEN 13V 2% 300mW SOD523	NXP Semiconductor	BZX585-B13,135	NXP Semiconductor	BZX585-B13,135
D10	DPN 100V 200mA SOD-123	Diodes Inc	BAV19W-7-F	Diodes Inc	BAV19W-7-F
F01	FUSE HOLDER, SMD, 5x20	Wickmann	F4546-ND	Schurter	31.8225
FUSE	FUSE 5A 250V FAST 5X20 CARTRIDGE	Littelfuse	F2369-ND	Littelfuse	6005.HXP
FW	OUTPUT WASHER, FLATPAC	Generic	Generic	Generic	Generic
HS01	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED
J01	CON 3CKT TERM BLK SMD	No Stock	No Stock	Weco	140-A-126-SMD/03
J02	CON 2 CKT TERM BLK SMD	No Stock	No Stock	Weco	140-A-126-SMD/02
J03	CONN 10POS 90DEG THRUHOLE FEMALE 0.1SPC	Sullins Electron-ics	S5519-ND	Sullins Electronics	PPTC052LJBN-RC
J04	CONN 5POS SINGLE ROW RIGHT ANGLE	Molex	WM1893-ND	TE Connectivity	1445057-5
J12	JACK VERTICAL MECH THRU HOLE	*Stocked by Tektronix, Part#: 131-5031-00			
JP02	RES 0 OHM 3/4W 5% 2010	Vishay Dale	541-0.0WTR-ND	Vishay Dale	CRCW20100000Z0EF
JP03	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED
JP04	RES 0 OHM 3/4W 5% 2010	Vishay Dale	541-0.0WTR-ND	Vishay Dale	CRCW20100000Z0EF
LARGE_PIN	PIN .081 DIA X .21LG VICBRICK	Generic	Generic	Generic	Generic
LOCK_ WSHR	PLTD #10 INT TOOTH LW PHOS/BR	Generic	Generic	Generic	Generic
OUTPT_ NUT	OUTPUT NUT, FLATPAC	Generic	Generic	Generic	Generic
PAD1	FOOT, FLIP FIXTURE	Generic	Generic	Generic	Generic
PAD2	FOOT, FLIP FIXTURE	Generic	Generic	Generic	Generic
PAD3	FOOT, FLIP FIXTURE	Generic	Generic	Generic	Generic
PAD4	FOOT, FLIP FIXTURE	Generic	Generic	Generic	Generic
PAD5	FOOT, FLIP FIXTURE	Generic	Generic	Generic	Generic
PAD6	FOOT, FLIP FIXTURE	Generic	Generic	Generic	Generic
PP1	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED
PP2	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED
PP3	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED
PP4	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED
PS01	Model Specific	Vicor	Model Specific	Vicor	Model Specific
Q01	QMOS N 200V 32mR 36A 5X6 MLP	Infineon	BSC320N20NS3 GTR-ND	No Stock	No Stock
Q02					
Q03					
R01	RES 12.4K OHM 1/8W 1% 0805	Vishay Dale	541-12.4KCTR-ND	Vishay Dale	CRCW080512K4FKEA
R02	RES 2.49K OHM 1/8W 1% 0805	Vishay Dale	541-2.49KCTR-ND	Vishay Dale	CRCW08052K49FKEA
R03	RES 499 OHM 1/8W 1% 0805	Vishay Dale	541-499CTR-ND	Vishay Dale	CRCW0805499RFKEA
R04	RES 2K OHM 1/4W 1% 1206	Vishay Dale	541-2.00KFTR-ND	Vishay Dale	CRCW12062K00FKEA
R05					
R07	RES 2K OHM 1/8W 1% 0805	Vishay Dale	541-2.00KCTR-ND	Vishay Dale	CRCW08052K00FKEA
R08	RES 1K OHM 1/8W 1% 0805	Vishay Dale	541-1.00KCTR-ND	Rohm	MCR10EZPF1001
R09	RES 2.2 OHM 1/4W 1% 1206	Vishay Dale	541-2.20FFTR-ND	Vishay Dale	CRCW12062R20FKEA
R10	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED	NOT APPLIED
R11	RES 42.2K OHM 1/4W 1% 1206	Vishay Dale	541-42.2KFTR-ND	Vishay Dale	CRCW120642K2FKEA
R12					

R13 R14	RES 100 OHM 1/8W 1% 0805	Vishay Dale	541-100CTR-ND	Vishay Dale	CRCW0805100RFKEA
SCREW	SCREW, 10-32 X 3/8 PHIL PH	Generic	Generic	Generic	Generic
SMALL_PIN	PIN .031 DIA X .21LG VICBRICK	Generic	Generic	Generic	Generic
STNDFF_LGFF	STANDOFF,.287 LG FEMALE-FEMALE	Generic	Generic	Generic	Generic
T01 T02 T03	IND COM MODE 013 mH -30%+30% 016A Ø1.6mm	*Stocked by VACUUMSCHMELZE Gmbh, part#: T60405-R6123-X616			
TP01 TP02 TP03 TP04 TP05 TP06 TP07 TP08 TP09 TP10 TP11 TP12	TEST POINT, SURFACE MOUNT	Keystone	5017-ND	Keystone	5017
U01	IC OPTO 70V 100mA SOP 4L	No Stock	No Stock	Vishay	TCLT-1009
Z01	VAR MOV, 300V 10KA 20mm DIA RADIAL	Littelfuse	TMOV20RP300EL2T7-ND	Littelfuse	TMOV20RP300E
Z02 Z03 Z04	VAR MOV 300V 11.5X8.3 SMD	Littelfuse	F3551TR-ND	Littelfuse	V300SM7

Figure 6.
Schematic diagram

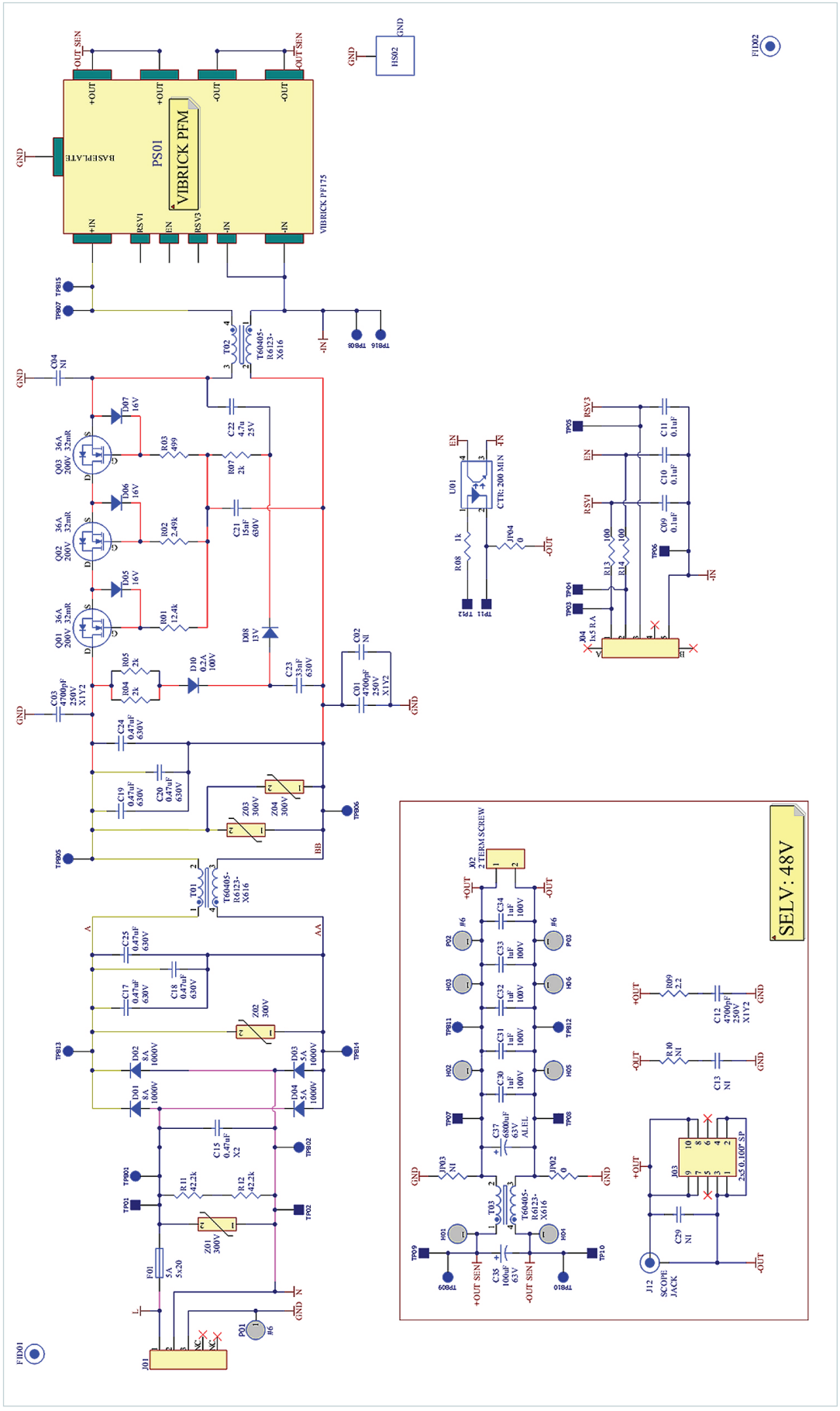


Figure 7.

PCB Layout
Left, top layer,
right, bottom layer.