Documentation

EVA4201/4301 – User Guide

Evaluation Board for
150W – 400W (800)
Power Factor Corrected (PFC) Supply

Rev 1.1

Featured Products: PE4201/PE4301

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1. Revision History

Version	Date	Changes	Page
Initial Version V1.0	12/2008		
V1.1	03/2011	Added paragraph 7	19, 20

2. Safety Instuctions

Please take care - the board operates at 405V DC and is directly plugged to the powernetwork. Operating the Board requires an isolated transformer!

More details under paragraph 5. Operating.

The EVA4201/4301 was designed to help understand and evaluate the features of two Power Factor Correction IC`s. Used external devices are standard components chosen for safe operation and do not represent a completely fine-tuned OEM application. The BOM (bill of material) for a final application may look slightly different.

3. Introduction

3.1 Features

The board is designed to support applications of our two PFC-IC’s PE4201 and PE4301

PE4201
- Low Total Harmonic Distortion (THD)
- Low StartUp Current (<5µA)
- Low Operating Current (<450µA)
- Disable Function (<170µA)
- Under-Voltage Lockout with >8V Hysteresis
- Over voltage and Over current protection with separate Reference
- Reduse operating Frequency if Output Power low
- High Efficiency at high and low Output Power
- Internal Clamping Resistor at G
- fast Driver Switch ‘off’
- very fast Driver ‘off’ at over current sense
- Driver load up to 5nF

PE4301
- Wide Range Input
- Low Total Harmonic Distortion (THD)
- Low Operating Current (<550µA)
- Disable Function (<100µA)
- Under-Voltage Lockout with >8V Hysteresis
- Over voltage protection, Peak current protection and Open loop protection with separate Reference
- low Peak current protection threshold
- Operating Frequency between 40 kHz and 250 kHz dependent upon load
- High Efficiency at high and low Output Power
- Internal Clamping Resistor at Driver
- Soft start
- fast Driver Switch ‘off’

- **Applications PE4201/PE4301**
- Active power factor correction
- Switch mode power supplies

3.2 IC`s General Description

The **PE4201** is a wide input range controller IC for active power factor correction converters.
The IC operates in the CRM with voltage mode PWM control, and in DCM under light load condition. The maximum switching frequency is clamp with internal delay circuit. Compensations for voltage loop are external.
PE4201 provides many protection functions, such over voltage protection, open loop protection, supply under voltage lockout, output under voltage protection and peak current limit protection. These protection functions are working with separate reference. If an error in regulation reference the protection function operates. If the disable function was activated the current consumption fall below 170µA.

The **PE4301** is a wide input range controller IC for active power factor correction converters. The IC operates in the CCM with average current control. The switching frequency depends upon load. At high output load the frequency is low and with low load the frequency is high. The Compensation for voltage loop and soft start is external.
PE4301 provides many protection functions, such over voltage protection for output voltage and for supply voltage, open loop protection, supply under voltage lockout, output under voltage protection and peak current limit protection. These protection functions work with separate reference. If an error in the regulation reference the protection function operates. The soft start function is reducing the start up current and the stress on the boost diode.
If the disable function is activated, the current consumption falls below 150µA.

4 How to design an application

4.1 Given board specification

PE4201/PE4301

The board setup in the original state has the following specification parameters. The following chapters show, what has to be changed to design an active PFC supply towards different parameters. Please take caution when calculating. Wrong device parameter calculation can damage the Evaluation board or other devices.

AC Line Input voltage	85 VAC ... 265 VAC
AC Line Frequency	47 ... 63Hz
Switching Frequency	40 ... 250 kHz
Output voltage	405V DC
Output Load	200W at 85V, 400W at 265V
Over Voltage Threshold	416V DC

4.2 Calculating the Current

PE4201

The input power:

$$P_{in} = \frac{P_{out}}{\eta} = \frac{200W}{92\%} = 217W \qquad (1)$$

$$P_{in} = \frac{P_{out}}{\eta} = \frac{300W}{92\%} = 326W \qquad (2)$$

The input current:

$$I_{ACin\_LL} = \frac{P_{in}}{V_{AC}} = \frac{217W}{85V} = 2{,}55A \qquad (3)$$

$$I_{ACin\_HL} = \frac{P_{in}}{V_{AC}} = \frac{326W}{265V} = 1{,}23A \qquad (4)$$

The peak current: $$I_{pk\_LL} = 2 * \sqrt{2} * I_{ACin\_LL} = 2 * \sqrt{2} * 2{,}55A = 7{,}21A \quad (5)$$

$$I_{pk\_HL} = 2 * \sqrt{2} * I_{ACin\_HL} = 2 * \sqrt{2} * 1{,}23A = 3{,}48A \quad (6)$$

This peak current affects the component selection on the current sense resistor, Power-MOSFET, diode and inductor.

PE4301

The input power: $$P_{in} = \frac{P_{out}}{\eta} = \frac{400W}{92\%} = 435W \quad (7)$$

$$P_{in} = \frac{P_{out}}{\eta} = \frac{800W}{92\%} = 870W \quad (8)$$

The input current: $$I_{ACin\_LL} = \frac{P_{in}}{V_{AC}} = \frac{435W}{85V} = 5{,}12A \quad (9)$$

$$I_{ACin\_HL} = \frac{P_{in}}{V_{AC}} = \frac{870W}{265V} = 3{,}28A \quad (10)$$

The ripple current ΔI is set to 20%

$$\Delta I_{LL} = 0{,}2 * \sqrt{2} * I_{ACin\_LL} = 0{,}2 * \sqrt{2} * 5{,}12A = 1{,}45A \quad (11)$$

$$\Delta I_{HL} = 0{,}2 * \sqrt{2} * I_{ACin\_HL} = 0{,}2 * \sqrt{2} * 3{,}28A = 0{,}93A \quad (12)$$

The peak current:

$$I_{pk\_LL} = \sqrt{2} * I_{ACin\_LL} + \frac{\Delta I_{LL}}{2} = \sqrt{2} * 5{,}12A + \frac{1{,}45}{2} = 7{,}97A \quad (13)$$

$$I_{pk\_HL} = \sqrt{2} * I_{ACin\_HL} + \frac{\Delta I_{HL}}{2} = \sqrt{2} * 3{,}28A + \frac{0{,}93}{2} = 5{,}10A \quad (14)$$

This peak current affects the component selection on the current sense resistor, MOSFET, diode and inductor.

4.3 Inductor

PE4201

For CRM operation, the maximum 'on' time and the maximum 'off' time control the lowest frequency. The minimum CRM inductance $L_{(CRM)}$ at low and high line input voltage can be calculated as follows:

$$L_{(CRM)} = \frac{V_{out} - V_{in}}{V_{out}} * \frac{V_{in}}{I_{pk}} * \frac{1}{f} \quad (15)$$

$$L_{(CRM)} = \frac{405V - \sqrt{2} * 85V}{405V} * \frac{\sqrt{2} * 85V}{5{,}27A} * \frac{1}{40kHz} = 400{,}6\mu H \qquad (16)$$

$$L_{(CRM)} = \frac{405V - \sqrt{2} * 265V}{405V} * \frac{\sqrt{2} * 265V}{3{,}48A} * \frac{1}{40kHz} = 199{,}5\mu H \qquad (17)$$

For high line voltage and high output power the inductor has to have a nominal inductance of 400µH. The switching frequency at low line voltage can be calculated according to equation (18):

$$f = \frac{V_{out} - V_{in}}{V_{out}} * \frac{V_{in}}{I_{pk}} * \frac{1}{L_{(CRM)}} \qquad (18)$$

$$f = \frac{405V - \sqrt{2} * 85V}{405V} * \frac{\sqrt{2} * 85V}{5{,}27A} * \frac{1}{400\mu H} = 40{,}1kHz \qquad (19)$$

PE4301

For CCM operation, the maximum 'on' time and the maximum 'off' time control are the lowest frequencies. The minimum CCM inductance $L_{(CCM)}$ at low and high line input voltage can be calculated as follows:

Duty Cycle

$$D = \frac{V_{out} - V_{in}}{V_{out}} \qquad (20)$$

$$D_{LL} = \frac{405V - \sqrt{2} * 85V}{405} V = 0{,}70 \qquad (21)$$

$$D_{HL} = \frac{405V - \sqrt{2} * 265V}{405} V = 0{,}074 \qquad (22)$$

CCM Inductor

$$L_{CCM} = \frac{\sqrt{2} * V_{in} * D}{f * \Delta I} \qquad (23)$$

$$L_{CCM\_LL} = \frac{\sqrt{2} * 85V * 0{,}70}{40kHz * 1{,}45A} = 1448\mu H \qquad (24)$$

$$L_{CCM\_HL} = \frac{\sqrt{2} * 265V * 0{,}074}{40kHz * 0{,}93A} = 746\mu H \qquad (25)$$

For high line voltage and high output power the inductor set to 750µH.
The switching frequency at low line voltage obtaint as:

$$f = \frac{\sqrt{2} * V_{in} * D}{L_{CCM} * \Delta I} \tag{26}$$

$$f = \frac{\sqrt{2} * 85V * 0{,}70}{750\mu H * 1{,}45A} = 77{,}2kHz \tag{27}$$

4.4 Current Sense Resistor

PE4201

The current sense resistor provides the threshold voltage for the over-current protection function. The maximum inductor peak current is set to 7,3A.

$$R_S = \frac{V_{SHPCP}}{I_{OCP}} = \frac{0{,}22V}{7{,}3A} = 0{,}03\Omega \tag{28}$$

R1*=0,03 Ω

PE4301

$$R_S = \frac{V_{CSPCP}}{I_{OCP}} = \frac{0{,}95V}{7{,}3A} = 0{,}13\Omega \tag{29}$$

R1**=0,12 Ω

For higher/lower output power the resistor RS has to be reduced/increased and the inductor has to be re-calculated.

2.5 Output Bypass Capacitor

PE4201/PE4301

The bypass capacitor on the output of the circuit has to be able to suppress the ripple of the switching frequency and the residues of the full-wave rectified input frequency (2 * f_{in}).

$$C_{out} = \frac{P_{out}}{V_{out}} * \frac{1}{\Delta V_{out}} * \frac{1}{f} \tag{30}$$

It is recommended to use 4 * f_{in} to suppress the sine wave residues of the input voltage for calculation. The ripple shall be assumed to be at 5% of the output voltage.

$$\text{at } 200W: C_{out} = \frac{\sqrt{2} * 200W}{405V} * \frac{1}{0.05 * 405V} * \frac{1}{4 * 50Hz} = 172\mu F \tag{31}$$

$$\text{at } 600W: C_{out} = \frac{\sqrt{2} * 300W}{405V} * \frac{1}{0.05 * 405V} * \frac{1}{4 * 50Hz} = 258\mu F \tag{32}$$

A 220µF capacitor with at least 220µF (C11) should be used. It has to withstand the maximum output voltage (on the board we used 100µF with a little bit higher ripple).
The equivalent series resistance (ESR) of the capacitor shall not build up a voltage higher than half the ripple amplitude (2,5% of $V_{out\text{-}max}$) at peak-current.

$$R_C = \frac{\Delta V_{out}}{I_{peak}} = \frac{0{,}025 * 405V}{7{,}3A} = 1{,}37\Omega \tag{33}$$

To reduce the ESR it is recommend to place a capacitor with small ESR in parallel to the high capacitance device. For 2% ripple at minimum switching frequencys the parallel capacitance can be calculated according to equation (25):

$$C_{out2} = \frac{300W}{405V} * \frac{1}{0.02 * 405V} * \frac{1}{40kHz} = 2{,}3\mu F \tag{34}$$

The capacitor on the board is C12=100n/630V.

4.5 Input Filter

PE4201/PE4301

A high-frequency has to be applied in the primary AC input to reduce reflections from and to the power grid.

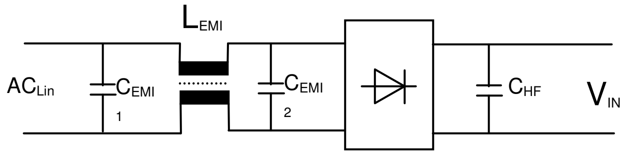


Figure 1: Input Filter

The capacitor C_{HF} following the bridge rectifier provides the peak current and reduces the voltage ripple. This is typical for a 330nF or for a 470nF capacitor. A high capacitance here will decrease the power factor (C1).
The L-C filter before the bridge rectifier has to suppress the switching frequency by about 20dB. The cut-off frequency shall be below 10 kHz.

4.6 Error Amplifier Compensations

PE4201/PE4301

The output of the integrated error amplifier has to be filtered by means of an RC filter for frequency compensation.

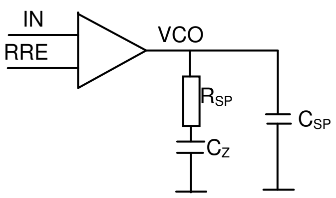


Figure 2: Error Amplifier Compensation

At the same time the capacitor C_{SP} ensures a soft start function. Capacitance can be calculated according to equation (35). The soft start time is set up at 30ms.

$$C_Z = \frac{t_{ss} * i_{VCOmax}}{V_{RREF}} = \frac{30ms * 20\mu A}{2,53V} = 237nF \qquad (35)$$

C8 = 220nF shall be chosen here.

The frequency response should have a second pole slightly above twice the power grid frequency. This is set up by R_{SP} and C_Z.

$$R_{SP} = \frac{1}{2\pi * f_Z * C_Z} = \frac{1}{2\pi * 100Hz * 220nF} = 6{,}028k \quad (36)$$

R4 = 5,6kOhm shall be chosen here.

The frequency of the second pole shall be at about 1/7 of the switching frequency. This defines the capacitance of C_{SP}.

$$C_{SP} = \frac{1}{2\pi * f_Z * R_{SP}} = \frac{1}{2\pi * 5{,}7kHz * 6k} = 4{,}6nF \quad (37)$$

C9 = 4,7nF shall be chosen here.

4.7 Self Biasing

PE4201/PE4301

Power supply of the PE4201/PE4301 during start up is provided through a high resistance resistor from the power grid input voltage. The maximum resistance has to be calculated resulting from the minimum input voltage and the required supply voltage of the PE4301 as well as the minimum required start up current.

$$R_{STUP} = \frac{\sqrt{2} * V_{in} - V_{ST}}{I_{ST}} = \frac{\sqrt{2} * 85V - 20V}{5\mu A} = 20Meg\Omega \quad (38)$$

To reduce start up time and account for leakage currents in the external diode the resistor is chosen to be 4MOhm. This is an experimental trade-off. Make sure the chosen resistor type has the proper power dissipation. Also, relatively high voltage over the resistor is to be accounted for (245V). It is recommended to use two 2MOhm resistors is series.

The capacitor on VDD has to provide power until the switching of the power-MOSFET has started and power will be provided from the help winding on the transformer. That can only happen after start-up and when the input voltage is at maximum level. At 50Hz this time t_{VDD} is about 10ms.
Current consumption calculates from the IC supply current and the loss in the power-MOSFET when switching.

Power consumption of the IC is <450µA. Power-MOSFET switching consumption consists of an ohmic part (resistor on ‘G’) and the dynamical part in the MOSFET. This is a charge changing process at the gate capacitance in the device.
Switching frequency will not be constant over an input frequency period. It can be assumed to be 100 kHz on average. Also the duty cycle factor will not be constant. For simplicity it can be assumed to be 50%.

A simplified but sufficient equation to calculate the dynamic and ohmic portion is given in equation (39) and (40) respectively.

$$I_{Gdyn} = C_G * f * U_{Gmax} = 2nF * 100kHz * 12V = 2mA \quad (39)$$

$$I_{Gohm} = \frac{U_{Gmax}}{R_G} * T = \frac{12V}{20k\Omega} * 0{,}5 = 0{,}3mA \quad (40)$$

Total current consumption calculates according to equation (41).

$$I_{VDD} = I_{stat} + I_{Gdyn} + I_{Gohm} = 0{,}45mA + 2mA + 0{,}3mA = 2{,}75mA \quad (41)$$

From that the capacitance of C_{VVD} can be calculated:

$$C_{VDD} = \frac{I_{VDD} * t_{VDD}}{V_{ST} - V_{LO}} = \frac{2{,}75mA * 10ms}{22V - 8V} = 2\mu F \quad (42)$$

The help winding on the transformer has to provide between 20 ... 25V DC.

The Transformation Ration (TR) can be calculated according to equation (43):

$$TR = \frac{V_{out}}{V_{VDD}} = \frac{405V}{22V} = 18{,}4 \quad (43)$$

4.8 EMI and Driver SlewRate

PE4201/PE4301

The driver slew rate can be influenced a network according to figure 3.

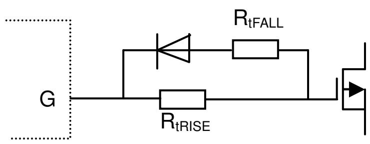


Figure 3: Network for Driver Slew Rate

R_{tFALL} determines the Slew Rate of the falling edge. The diode can be a standard Si-diode.
R_{tRISE} determines the Slew Rate of the rising edge.
Those values vary between the used power-MOSFET. Caution has to be taken to meet EMI regulations.

4.9 Start-Up Bypass Rectifier

PE4201/PE4301

A diode (D_{BYPASS}) in parallel to the coil and the boost diode (D_{BOOST}) reduces the current through the coil during start-up. It also pre-charges the bypass capacitor on the output to the peak input voltage.

This reduces over voltage peaks and currents in the coil and so improves EMI parameters. It also protects the power-MOSFET from over voltage damage. To reduce the current through the diode a series resistor shall be used.

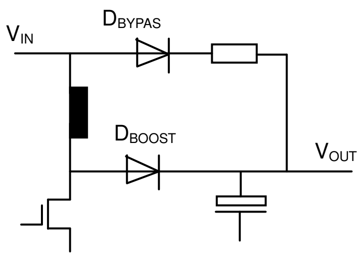


Figure 4: Bypass Rectifier

5 Description

The EVA4301-300 was designed to help understand and evaluate the features of the PE4201/PE4301 Power Factor Correction IC. Used external devices are standard components chosen for safe operation and do not represent a completely fine-tuned OEM application. The BOM (bill of material) for a final application may look slightly different.

The PE4201 is a wide input range controller IC for active power factor correction converters in CRMode with voltage mode PWM control.

The PE4301 is a wide input range controller IC for active power factor correction converters in CCMode with voltage mode frequency and PWM control.

Please take caution since the board operates at 405V DC.

5.1 Evaluation Board Specifications

AC Line Input voltage ....85 Vac - 265 VAC
AC Line Frequency ....47 – 65 Hz
Switching Frequency..............................40 – 170 kHz
Output voltage..405V DC
Output Load ....150W at 85V, 400W at 265V
Over Voltage Threshold ....416V DC
Efficiency (@85V / 200W)......................92%
Power Factor (@85V / 200W)................0.998
Operating Ambient Temp Range............0 – 40 °C

5.2 Wire bridges

The board has been designed to provide evaluation support for the PE4301 as well as the PE4201 PFC ICs. For that reason the following wire bridges and components will have to be set properly.

	PE4201	PE4301
JP1	2_3	1_2
JP2	2_3	1_2
R2*,R5*,C7*	on Board	open
R5**,C10**,C1**	open	on Board
R1*,R1**	0,03 Ohm	0,12 Ohm

5.3 Schematic

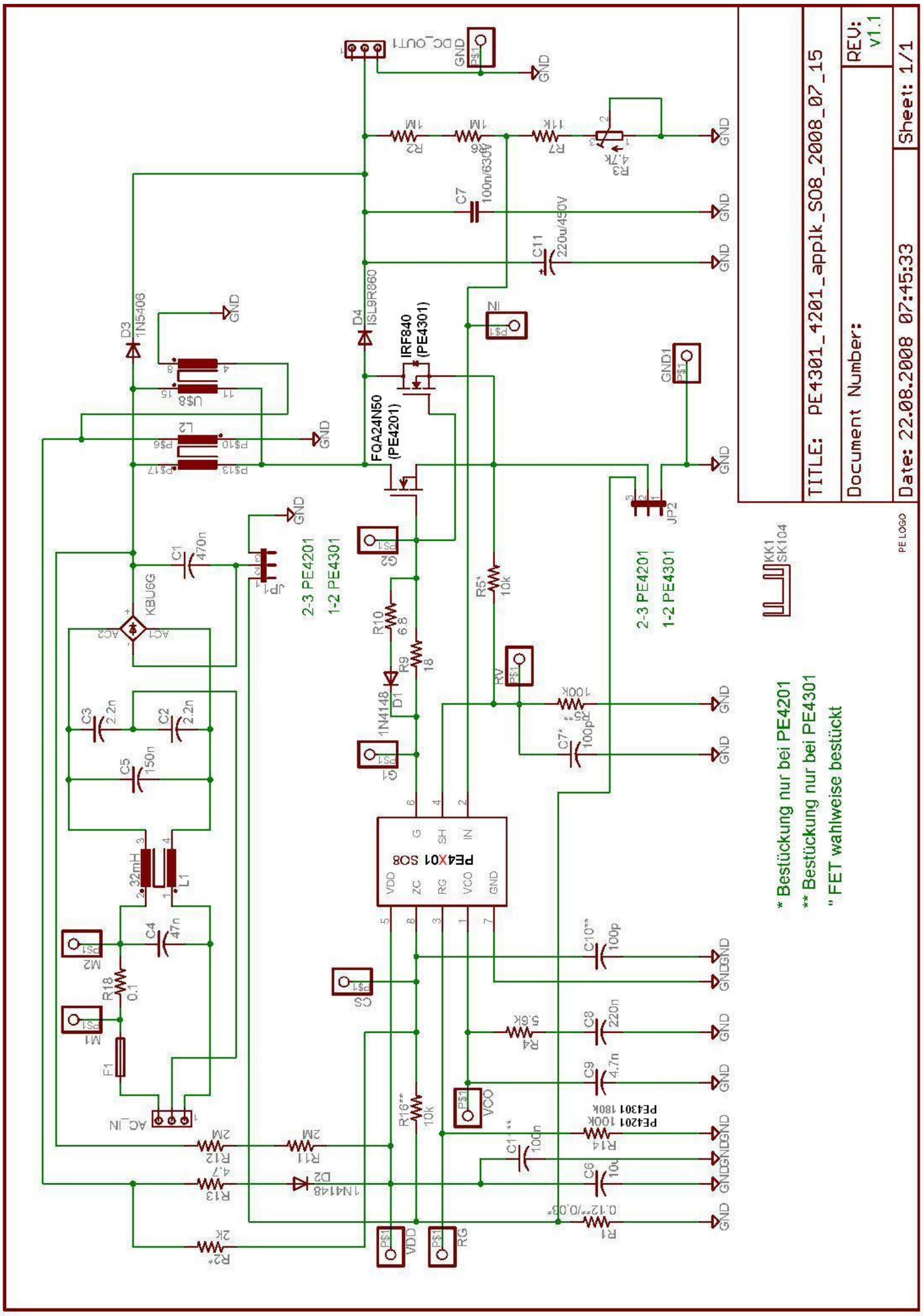
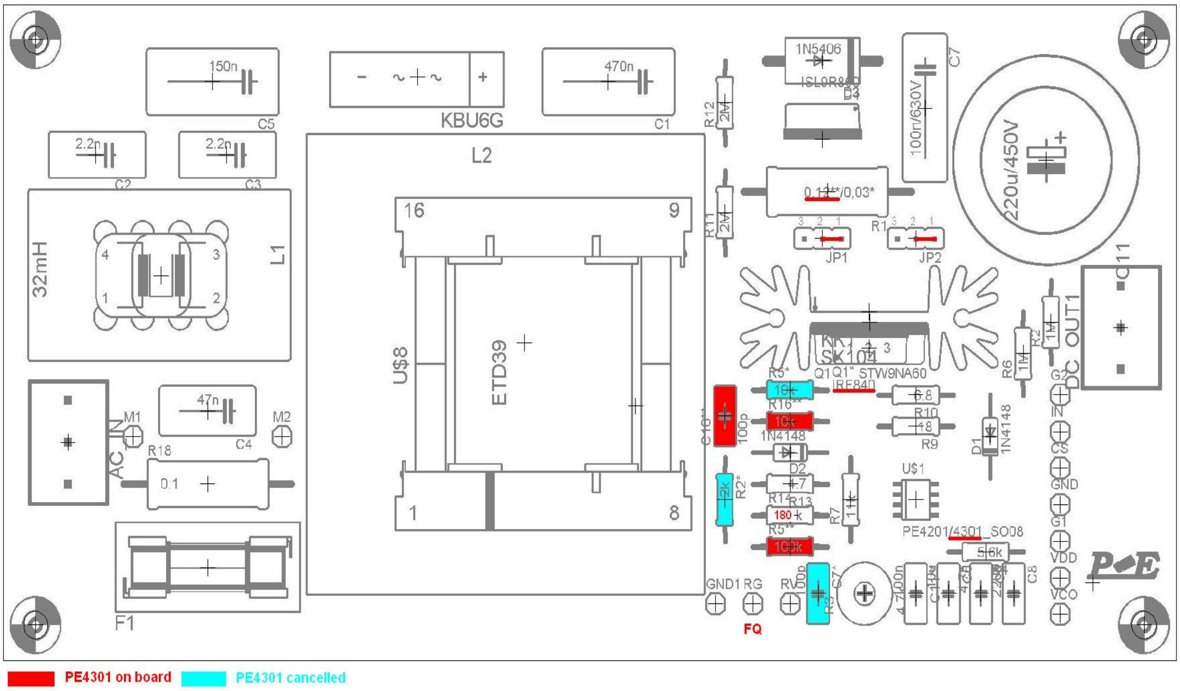


Figure 5: Board Schematic

5.4 Component Placement



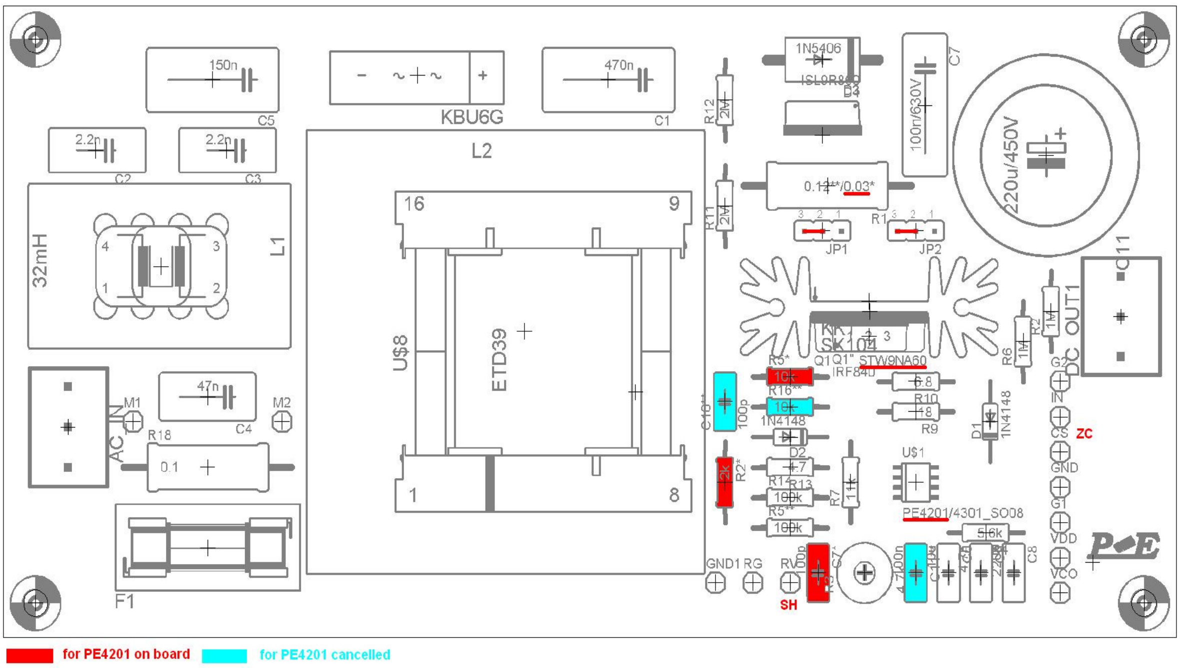


Figure 6: Board device population

5.5 Board Picture and Layout

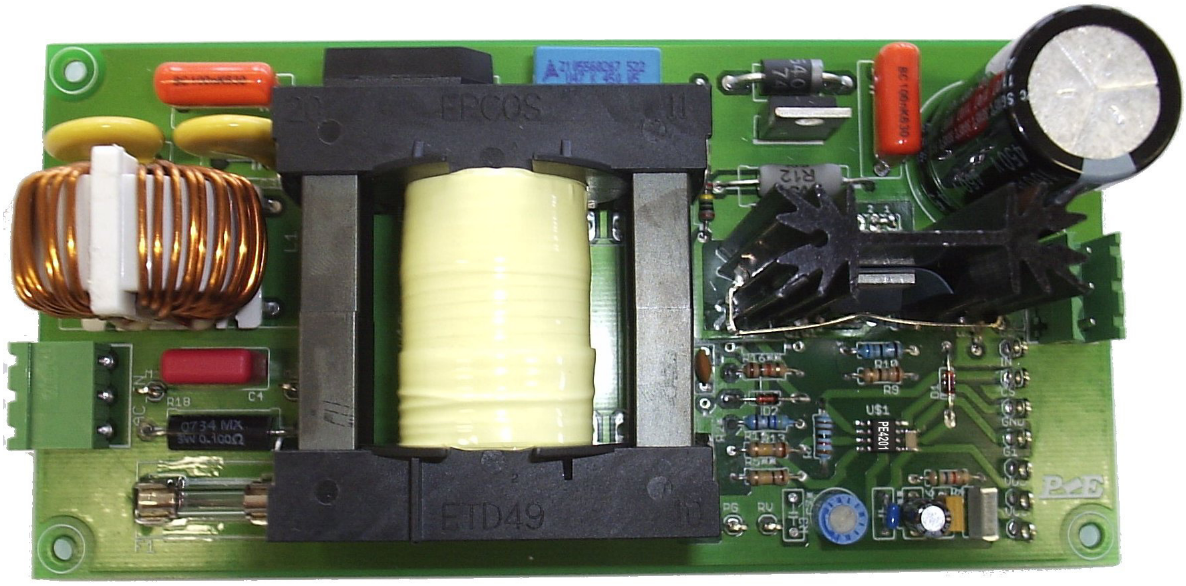


Figure 7: Board photograph

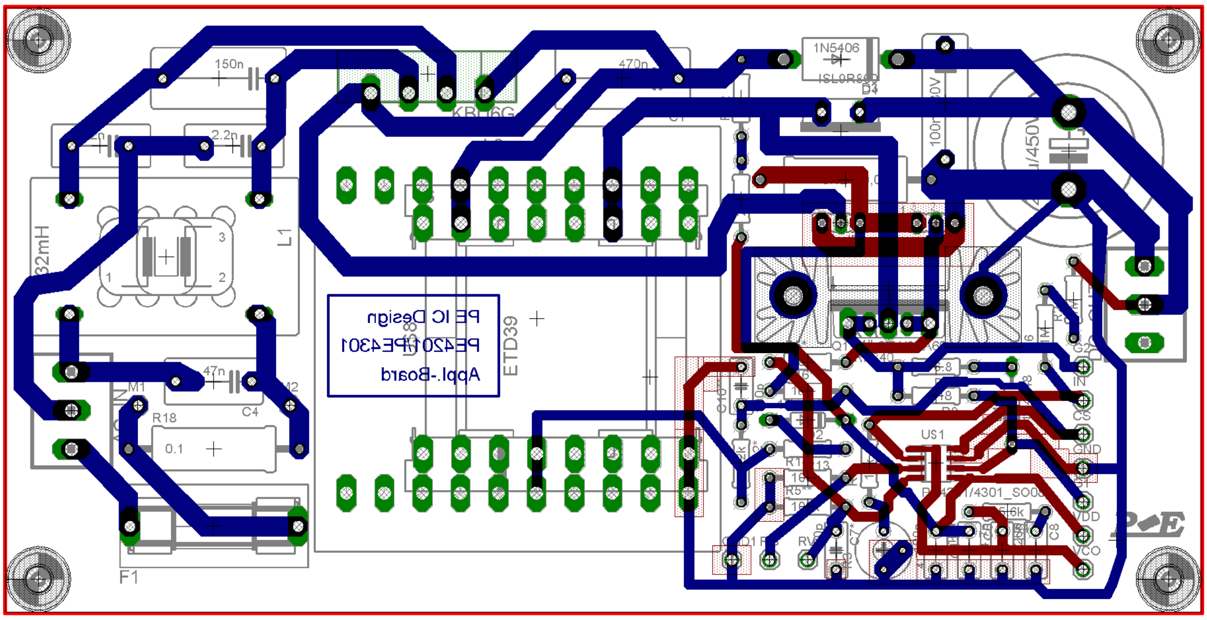


Figure 8: PCB Layout

5.6 Bill of Material

Nr.	Reference	Used	Description	Vendor
1	IC1		PE4201/PE4301	PE GmbH
2	R1*		0.03 Ω 3W	
2	R1**		0.12 Ω 3W	
3	R2		1 MΩ 1/4W	
3	R2*		2 kΩ 1/4W	
4	R3		4.7 kΩ variable resistor	
5	R4		5.6 kΩ 1/4W	
6	R5*		10 kΩ 1/4W	
6	R5**		100 kΩ 1/4W	
7	R6		1MegΩ 1/4W	
8	R7		11 kΩ 1/4W	
9	R9	Opt.	18 Ω 1/4W	
10	R10	Opt.	6.8 Ω 1/4W	
11	R11		2 MΩ 1/4W	
12	R12		2 MΩ 1/4W	
13	R13		4.7 Ω 1/4W	
14	R14		100 kΩ 1/4W	
15	R16**		10 kΩ 1/4W	
16	R17		2 kΩ 1/4W	
18	C1		470 nF 630V	
19	C2		2.2 nF 3kV	
20	C3		2.2 nF 3kV	
21	C4		47 nF 250VAC	
22	C5		150 nF 250VAC	
23	C6		10 µF 40V Elko	
24	C7		100 nF 630V	
25	C7*		100 pf 63V	
26	C8		220nF 63V	
27	C9		4.7nF 63V	
28	C10		100 pF 100V	
29	C11		220µF 450V Elko	
30	C11**		100 nF 63V	
31	D1	Opt.	1N4148	
32	D2		1N4148	
33	D3	Opt.	1N5406	
34	D4		ISL9R860	
35	Rect		KBU6G	
36	Q1		FQA24N50 (PE4201), IRF840 (PE4301)	
37	L1		Line Filter 32mH 6A	
38	L2		Boost inductor ETD39/ETD49	
39	F1		Fuse 6A	

6 Operating

6.1 Caution

The Evaluation board has been designed to operate between 85VAC and 256VAC input power grid voltages and 405VDC output voltage.
Powering the board outside specified operating conditions will destroy devices and might cause severe damage and harm people.
The board has been designed for a maximum load of 300VA. Overloading the output will cause overheating and destruction of devices.
Devices can heat up to 50°C in normal operation mode. Take caution to not burn your fingers.
Security measures for high voltage operation have to be taken.

6.2 Load

Resistive and electronic continuous loads up to 300VA at 450VDC can be applied on the output. The load can be applied on the DC-OUT terminal. Pay attention to the polarity and wire diameter.

6.3 AC-Input

The Input voltage has to be applied on the AC-IN terminal. An isolation transformer is required, especially when other power grid supplied measurement devices (oscilloscope, voltmeter) are being used to prevent from electrical shock or device damage. Avoid personal contact with the board when powered. Be aware that capacitors hold charges even when power will be turned off. Discharge the output capacitor through the load or a high ohmic load resistor after power off.

6.4 Power-up Sequence

Before input voltage will be turned on, all measurement devices should be connected. It is recommended to slowly turn up the input voltage with a regulation transformer, usually in combination with a separation transformer. Be aware that capacitors hold charges even when power will be turned off. Make sure they will be discharged before disconnecting the measurement devices.

6.5 Measure points

The board has several measuring points. They are marked on the board by names.

M1 / M2:	input current through a 0,1Ω measurement resistor
GND:	Ground, reference potential for all measuring points but M1 and M2
VDD:	supply voltage for PE4201/4301, 0..30V
ZC (PE4201):	AC help winding voltage through 2kOhm, -50..25V
CS (PE4301):	negative voltage of current sensor (-0,9.. -1,0V)
RG (PE4201):	voltage on RG, 1,03V
FQ (PE4301):	voltage on FQ, 1,03V
VCO:	voltage on output of regulation amplifier, 0 ... 5,5V
SH (PE4201):	voltage over Shunt resistor, 0 ... 0,5V
RV (PE4301):	adjust slew rate of the duty cycle
IN:	voltage in loop back, V_{OUT}/160, 0 ... 2,65V
G1:	voltage at IC-Pin G, power-MOSFET Gate driver voltage, 0 ... 12V
G2:	voltage at Gate of power-MOSFET, 0 ... 12V

Measuring points CS/CZ, RG/FQ, SH/RV on the board are identical; there is always only one of the two markings on the board.

7 EVA4201 board changes to support difficult DC-DC converters

Powering DC-DC converters from the output of the EVA4201-300 board may cause the output voltage to drop to zero, pulse and interrupt irregularly. This can especially be observed at low load conditions below 100W. The reason is that the supply voltage for the PE4201 power factor controller IC may fall below the minimal operating voltage due to the fact that the board transformer is supposed to not only provide output power but also the supply voltage for the PE4201. As the power transistor will be turned on at a lower frequency at low load condition VDD for the PE4201 might not be high enough anymore to keep normal operation alive. Another reason can also be that the output voltage of the board raises above the OVP (over voltage protection) level of the PE4201 and this will cause the power FET to be turned off. In conclusion the PE4201 will not be powered any more sufficiently. At this point the operation power for the board will be provided through R11 and R12 and the IC will power up again, causing the same cycle to start all over again and again. Some minor changes have to be done on the board to prevent such observation.

7.1 What can be done?

It is essential to always have sufficient operating voltage on VDD. The number of windings transforming this voltage can be increased to 3. This way to supply voltage does not even in worst case conditions drop below 8V. The board is fully operational at 50% load even on 110V line voltage. At full load the supply voltage for the PE4201 stays below 28V.
The internal voltage stabilization tolerates input voltages from 8V to 30V. To reduce the ripple and provide storage capacity the capacitor on VDD should be increased to 22µF and the resistor R13 should be increased to 47Ohm.
To improve the timing the resistor on “RG” should be changed from 100kOhm to 68kOhm. This reduces the on-times under no load condition. The capacitor on “VCO” should be changed from 220nF to 470nF. This improves the soft start behavior after zero crossing.
An additional capacitor of 330pF on “IN” to “GND” reduces load spikes potentially influencing the “IN” voltage.
The startup time has been decreased be reducing R11 and R12 from 2x2.2MOhm to 2x470kOhm.

7.2 Results after the board changes

The board starts up at no-load condition and has no hick-ups. It immediately provides 400V output voltage. Softly adding full load to the output, which is typically done due to EMI regulations anyway, does not cause the board to enter “pulse-mode”. It operates completely normally and ensures a very good power factor from almost zero load to full load and beyond. The board has been tested at 400W output load. Even when the load will be turned on quickly in a µs-range, which surely causes EMI, some input current half waves will show up in current mode. After that the board operates normally.

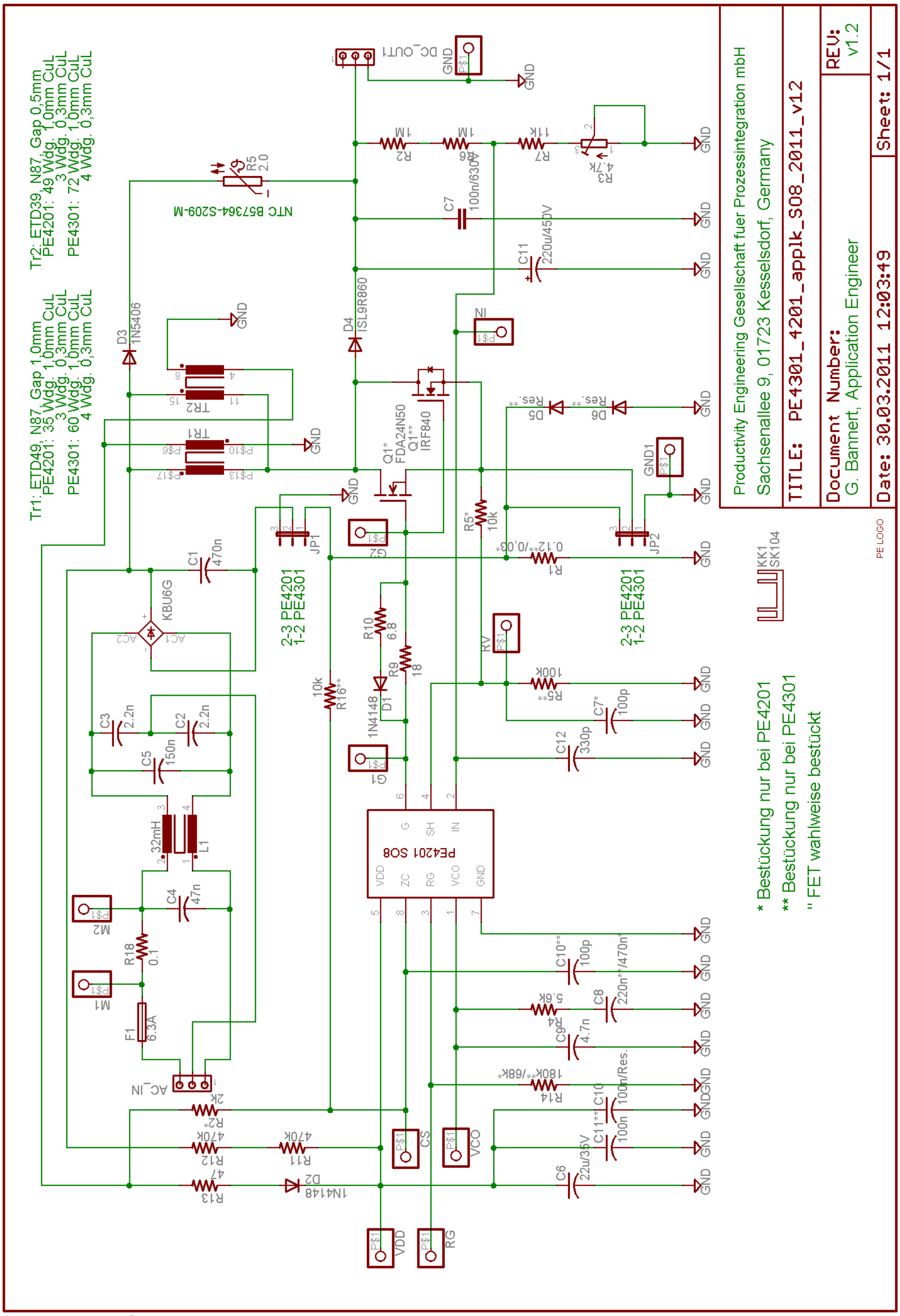


Figure 9: PFC-Board with relevant changes

8 Abbreviation

Abbreviation	Explanation
AC-IN	Input Voltage
AC_{Lin}	Input Current
BOM	Bill of material
CCM	Constant Conduction Mode
C_{EMI}	Capacitor for EMI
C_G	Capacity of the gate (MOSFET)
C_{HF}	Capacitor for reduction of HF- transmitting
C_{out}	Output Capacitor
C_{out2}	Output Capacitor
C_{SP}	Cap. For
C_{VVD}	Cap. On Pin VDD
C_Z	Cap. On Current Sense
CRM	Critical Conduction Mode
D_{BOOST}	Boost- Diode
D_{BYPASS}	Bypass- Diode
DCM	Discontinuous Conduction Mode
DC-OUT	Output Voltage
EMI	Electromagnetic Interferences
ESR	Equivalent series resistance
G	Output to Gate (MOSFET)
IN	Feedback- Input for Output- Voltage
I_{OCP}	Max. Current for switching of MOSFET
I_{VCOmax}	Max. VCO- Voltage
I_{VDD}	IC- Current
$L_{(CCM)}$	Inductivity in CCM
$L_{(CRM)}$	Inductivity in CRM
L_{EMI}	Inductor to reduce EMI
PFC	Powerfactor- Correction
P_{in}	Input- Power
P_{out}	Output- Power
PWM	Pulse- Width- Modulation
R_G	Clamping Resistor
R_{STUP}	Start-Up Resistor
R_{tFALL}	Fall-Time of Voltage on Gate
R_{tRISE}	Rise- Time of Voltage on Gate
THD	Total Harmonic Distortion
TR	Transformation Ration
t_{VDD}	Time for Starting the IC
U_{Gmax}	Max. Voltage on Gate
VCO	Voltage Controlled Oscillator
V_{CSPCP}	Voltage of Peak- Current- Protection
VDD	Operating Voltage of the IC
V_{in}	Voltage on Pin “IN”
V_{LO}	Lock Out Voltage
V_{out}	Output Voltage
V_{RREF}	Internal Reference of the IC
V_{SHPCP}	Max. Voltage on Input Current Protection
V_{ST}	Start UP Voltage

9 Notes

9. Contact Addresses

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