Texas Instruments

PR320 UCC28050 100-W PFC Ballast Pre-Regulator

Reference Design

PR320 UCC28050 100-W PFC Ballast Pre-Regulator

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Power Supply Control Products

Contents

1 Introduction

The UCC28050 100-W PFC ballast pre-regulator is a power converter that converts a line voltage of 108 V to 300 V RMS to a 467-V, 100-W, regulated dc output with power factor correction (PFC). This design was done on a single sided copper PCB and was specifically designed as a ballast pre-regulator.

2 Description

The pre-regulator uses the UCC28050 transition mode power factor correction (PFC) controller from Texas Instruments. This control device is an economical 8-pin device that enables the designer to implement PFC with zero current switching. The control device also uses a slew rate comparator to speed up large signal transient response. Please refer to the UCC28050 data sheet TI literature number SLUS515 for a detailed description of the part operation.

This PFC pre-regulator's output uses two 47-µF capacitors in series to filter the output voltage and enable the connection of down stream ballast circuitry (e.g. Royer oscillator). Please refer to the schematic for details.

3 Electrical Specifications

Table 1. Specification Table

	MIN	TYP	MAX
V_{IN} (line)	108 V_{RMS}		300 V_{RMS}
P_{OUT}	25 W		100 W
Efficiency at 100 W	90%		
V_{OUT} (output)	443 V	467 V	490 V
THD at 100 W			10%

4 Schematic

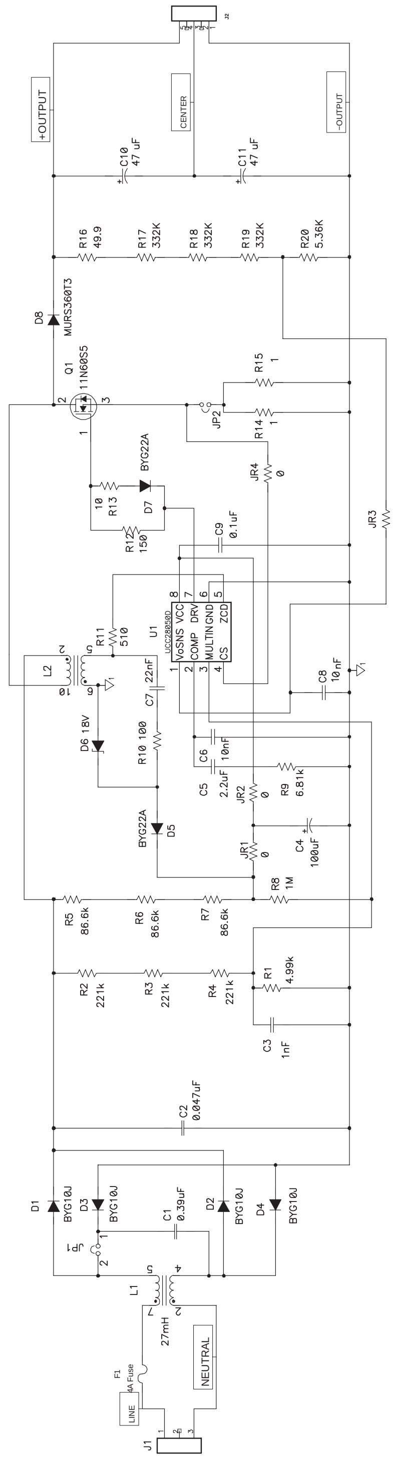


Figure 1. Schematic

5 Test Setup

There are high voltages present on the pre-regulator and it should only be handled by experienced power supply professionals. To evaluate this board as safely as possible the following test set up should be used. An isolation transformer should be connected between the source and unit. Before power is supplied a volt meter and a resistive or electronic load should be attached to the unit's output.

6 Power Up/Power Down

For the unit to come up into regulation it needs a 50-W to 75-W load connected to the output during power up and the input voltage needs to be between 108 V and 300 V RMS. The input power also needs to be applied quickly similar to a light switch, otherwise the internal boot strap circuitry does not work correctly and the unit will not come up into regulation. The unit has a slight delay on power up and could take up to 30 seconds to come up into regulation.

After powering down the unit it is important to make sure the output capacitors are completely discharged. This can be accomplished by monitoring the output voltage with a volt meter.

Note: There are very high voltages on the board and inductor L1 reaches temperatures above 50°C so caution must be taken in handling the board.

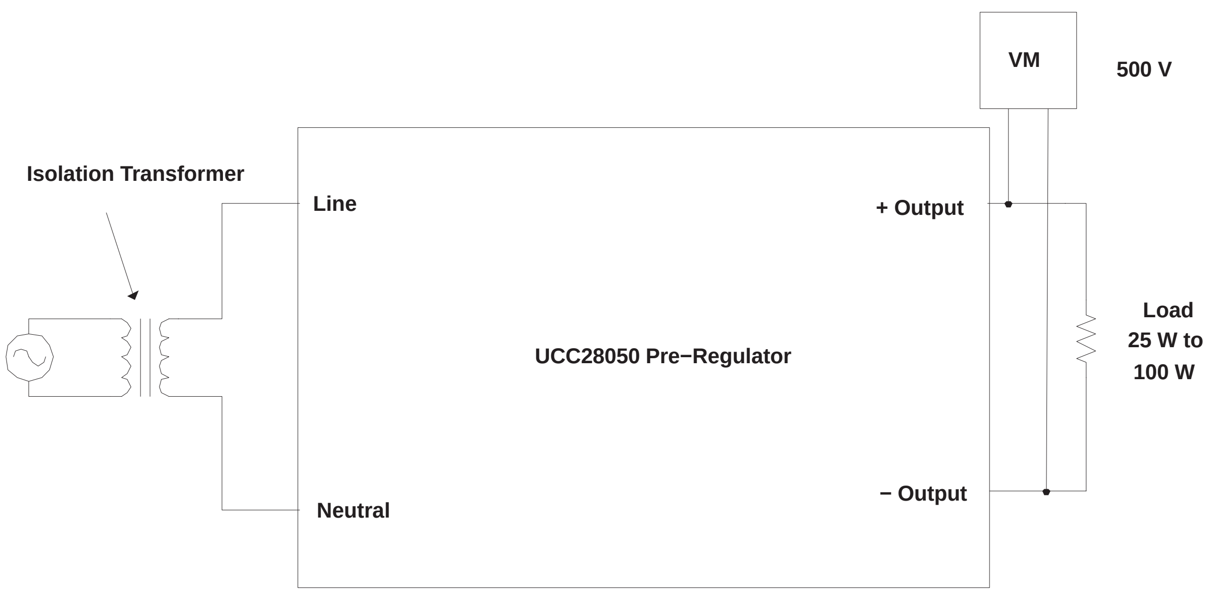


Figure 2. Setup

7 Performance Data

TOTAL HARMONIC DISTORTION
vs
OUTPUT POWER

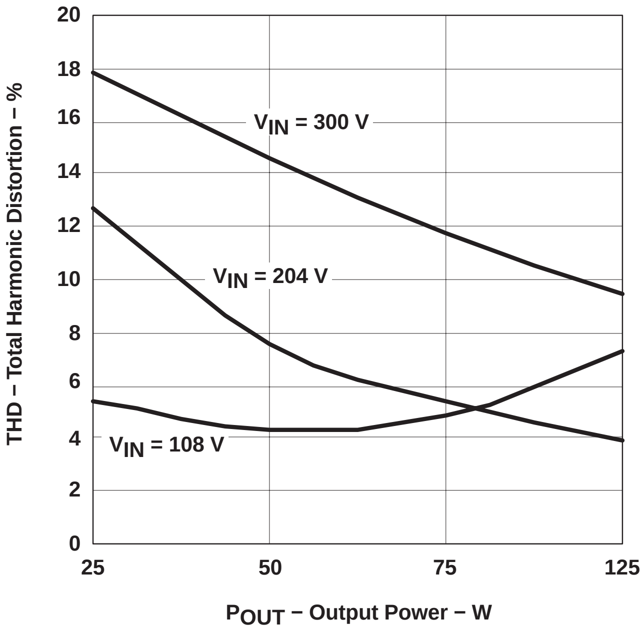


Figure 3.

PF
vs
OUTPUT POWER

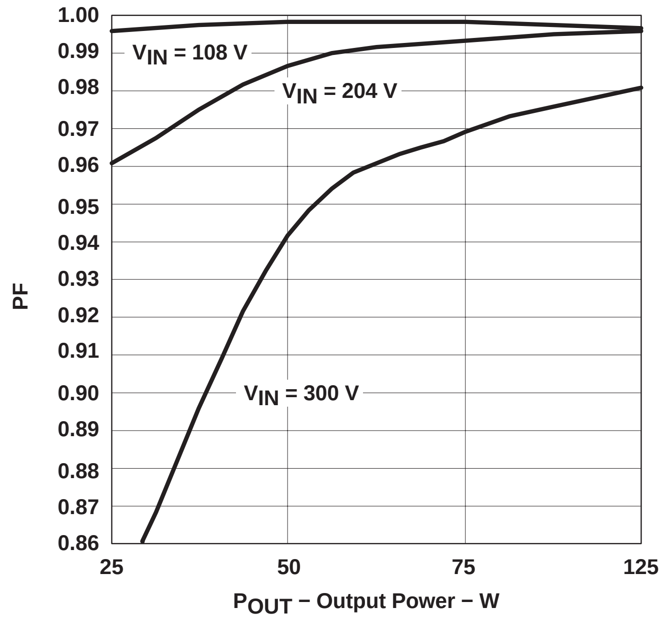


Figure 4.

EFFICIENCY
vs
OUTPUT POWER

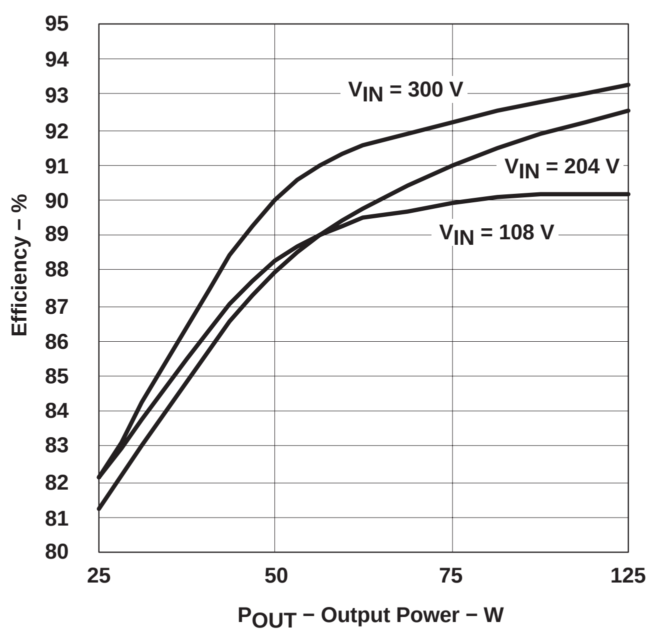
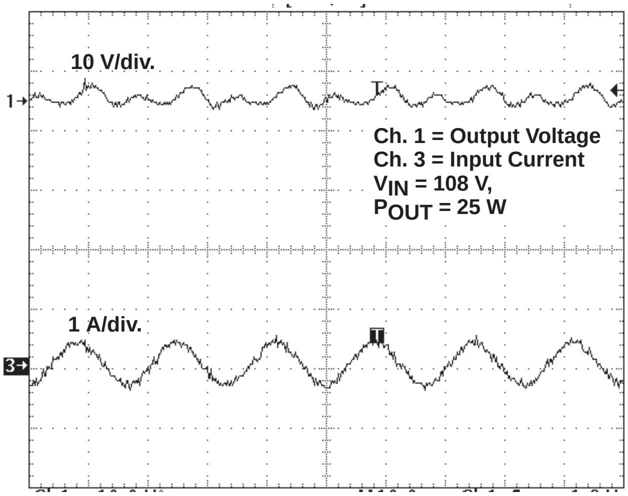


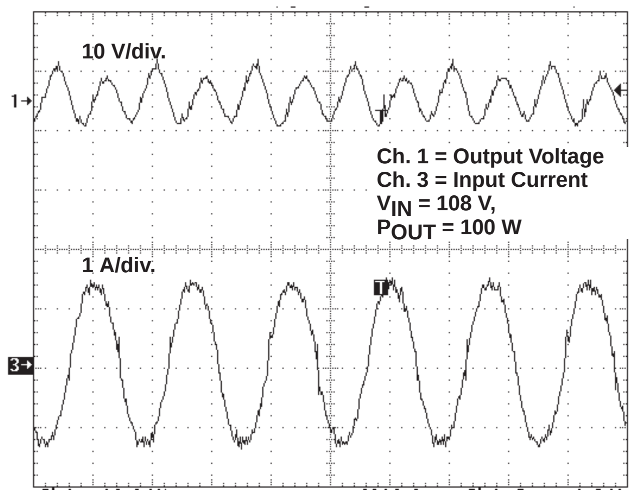
Figure 5.

7.1 Input Current and Output Voltage



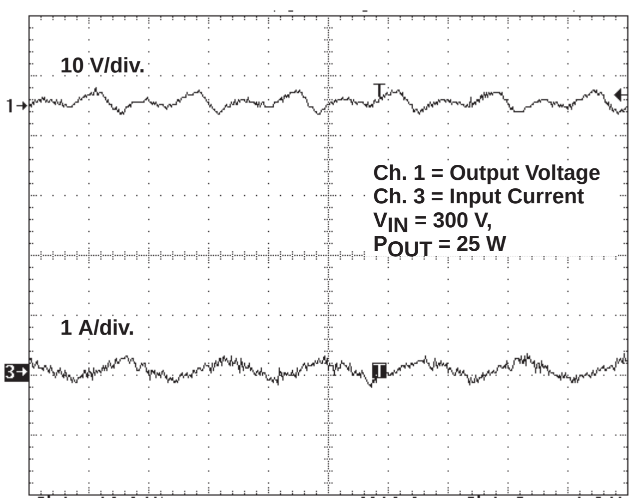
t − Time − 10.0 ms/div.

Figure 6.



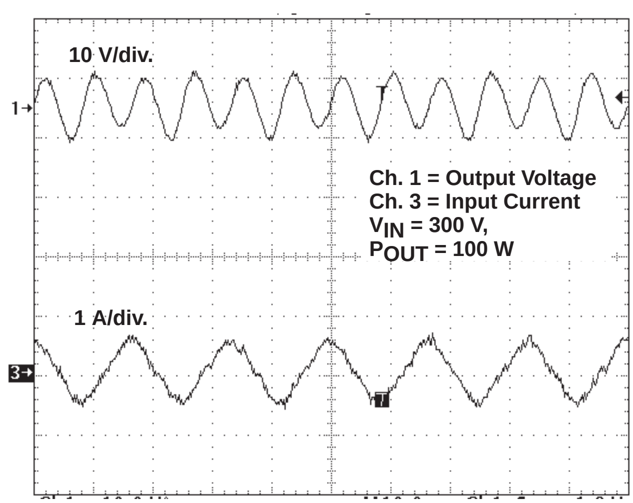
t − Time − 10.0 ms/div.

Figure 7.



t − Time − 10.0 ms/div.

Figure 8.



t − Time − 10.0 ms/div.

Figure 9.

7.2 Startup Characteristics

During startup PFC boost pre-regulators have a tendency to overshoot due to the slow bandwidth of the control loop. To reduce third harmonic distortion typically the voltage loop of a PFC boost crosses over at roughly 10 Hz or less. This means that the fastest the voltage loop can respond to a small signal transient is roughly 100 ms. However due to the size of the boost inductor and filter capacitor it can take anywhere from 500 ms to a second to recover from a large signal transient such as starting up the power converter. However the slew rate comparator allows this reference design to come back into regulation within roughly 200 ms after an over shoot during power up.

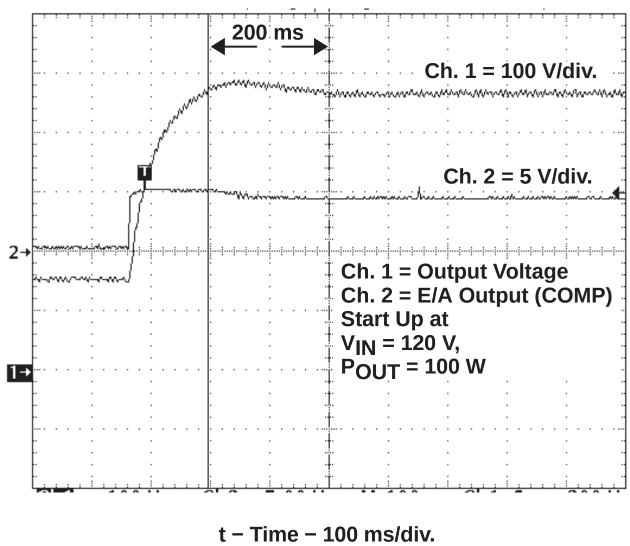


Figure 10.

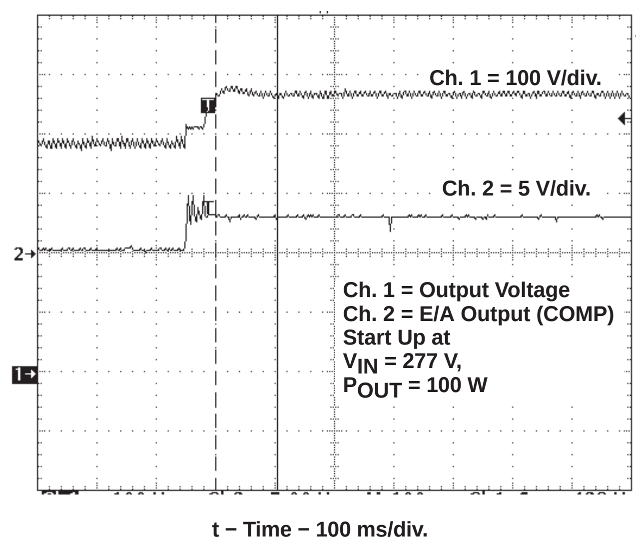


Figure 11.

7.3 Line Dropout

The unit was tested under a line dropout condition and the unit came back into regulation within 220 ms.

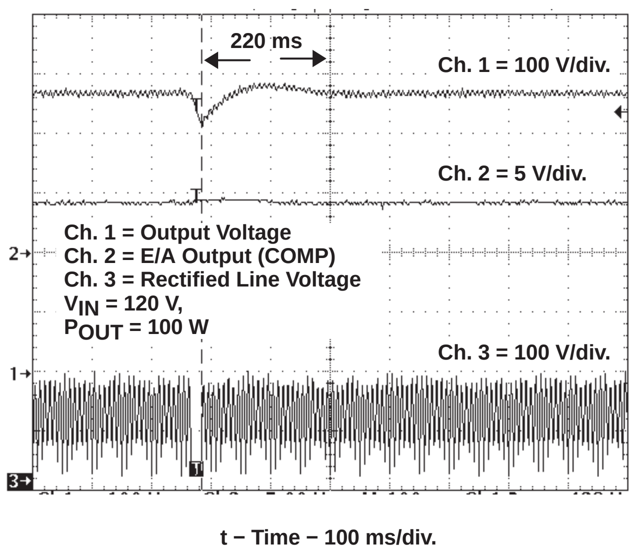


Figure 12.

7.4 Line Transient

A line transient test was conducted with an ac source on the reference design. The line was varied from 120 V to 277 V RMS and the transient response was evaluated. From the oscilloscope picture in the following figure it can be observed that the output recovered within 220 ms.

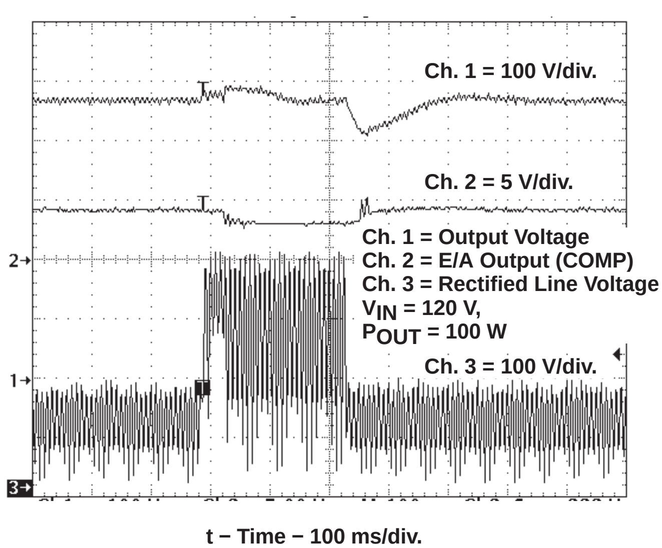


Figure 13.

8 Reference Design Assembly Drawing/Layout

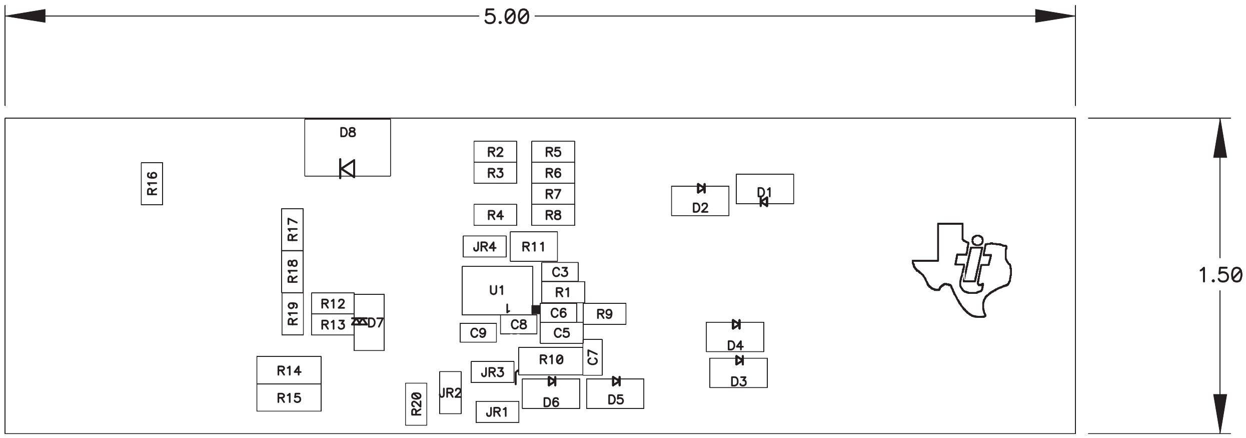


Figure 14. Bottom Assembly

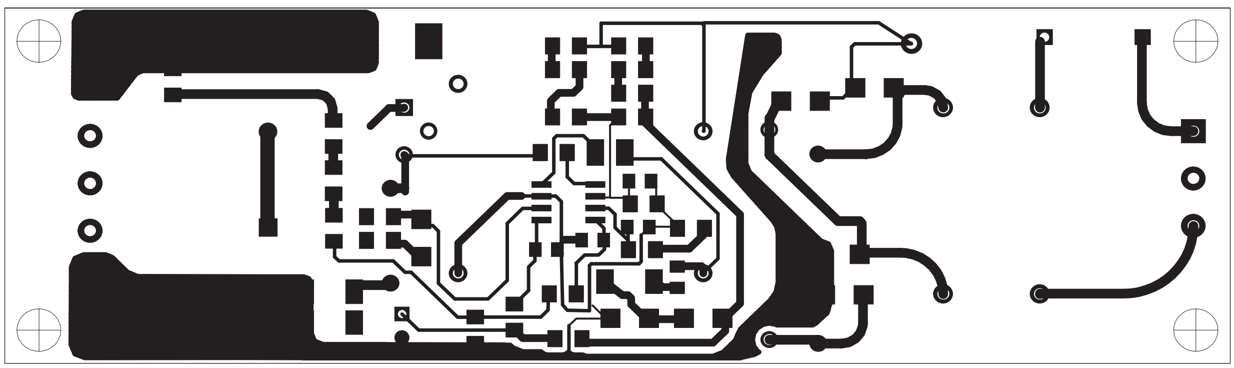


Figure 15. Bottom Layout

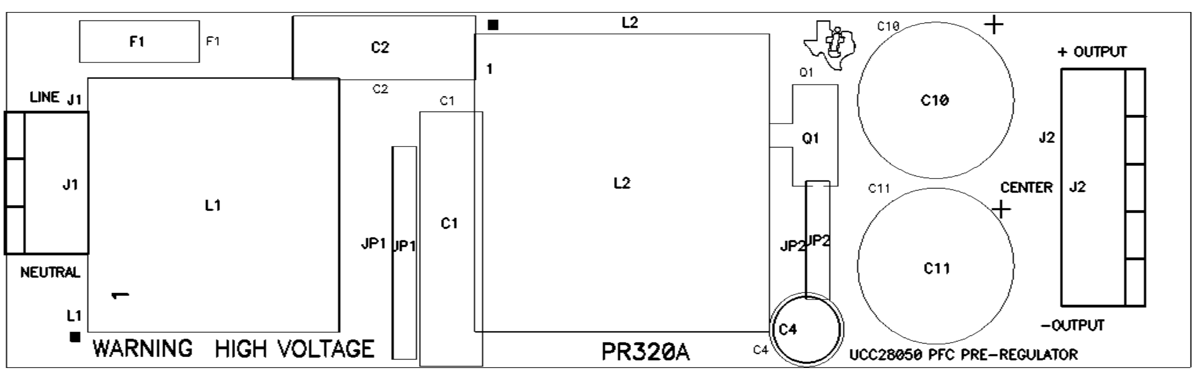


Figure 16. Top Assembly

9 List of Materials

Table 2. List of Materials

REF DES	COUNT	DESCRIPTION	MFR	PART NUMBER
C1	1	Capacitor, leaded, 0.390 µF, 630 V, 0.236 x1,043	Panasonic	ECQ−E6394KF
C10, C11	2	Capacitor, aluminum, 47 µF, 350 V, 20% , 0.630 X 0.985	Panasonic	EEU−EB2V470
C2	1	Capacitor, leaded, 0.047 µF, 630 VAC, 0.709 x 0.236	Panasonic	ECQ−E6473KF
C3	1	Capacitor, ceramic, 0.001 µF, 25 V, X7R, 10%, , 0805	std	std
C4	1	Capacitor, aluminum, 100 µF, 35V, 20%, 0.2	Panasonic	EEU−FC1V101
C5	1	Capacitor, ceramic, 2.2 µF, 16 V, X7R, 10%, 1206	std	std
C6, C8	2	Capacitor, ceramic, 0.01 µF, 16 V, X7R, 10%, , 0805	std	std
C7	1	Capacitor, ceramic, 0.022 µF, 100 V, X7R, 10%, , 0805	std	std
C9	1	Capacitor, ceramic, 0.1 µF, 25 V, X7R, 10%, 0805	std	std
D1, D2, D3, D4	4	Diode, standard rectifier, 1.5 A, 600 V, SMA	Vishay	BYG10J
D5, D7	2	Diode , fast recovery, 2 A, 50 V, SMA	Vishay	BYG22A
D6	1	Diode, zener, 1 W, 18 V, SMA	Diodes Inc.	SMAZ18−13
D8	1	Diode, 3000 mA, 600 V, SMC	On Semi	MURS360T3
F1	1	Fuse, axial, fast acting, 4 A, 250 V, 0.145 x 0.300	Littelfuse	0263004.M
J1	1	Terminal block, 3 pin, 15 A, 5.1 mm, 0.60 x 0.35	OST	ED1610
J2	1	Terminal block, 5 pin, 15 A, 5.1 mm, 1.000 x 0.354	OST	ED2228−ND
JP1, JP2	2	Jumper, 22-AWG insulated wire	std	std
JR1, JR2, JR3, JR4	4	Resistor, chip, 0 Ω, 1/8 W, 1%, 1206	std	std
**L1(L)	1	Inductor, dual winding, 27 mH at 1 kHz, 1.032 x 1.043	Cooper	CTX16−16926
**L2(L)	1	Inductor, dual winding, 800 µH at 20 kHz, turns ratio 12.7:1	Cooper	CTX16−16924
Q1	1	MOSFET, N-channel, 650 V, 11 A, 380 mΩ, TO−220 V	Infineon	11N60S5
R1	1	Resistor, chip, 4.99 kΩ, 1/8 W, 1%, 1206	std	std
R10	1	Resistor, chip, 100 Ω, 1/2 W, 5%, 2010	std	std
R11	1	Resistor, chip, 510 Ω, 1/4 W, 1%, 1210	std	std
R12	1	Resistor, chip, 150 Ω, 1/8 W, 10%, 1206	std	std
R13	1	Resistor, chip, 10 Ω, 1/8 W, 1%, 1206	std	std
R14, R15	2	Resistor, chip, 1 Ω, 1/2 W, 5%, 2010	std	std
R16	1	Resistor, chip, 49.9 Ω, 1/8 W, 1%, 1206	std	std
R17, R18, R19	3	Resistor, chip, 332 kΩ, 1/8 W, 1%, 1206	std	std
R2, R3, R4	3	Resistor, chip, 221 kΩ, 1/8 W, 1%, 1206	std	std
R20	1	Resistor, chip, 5.36 kΩ, 1/8 W, 1%, 1206	std	std
R5, R6, R7	3	Resistor, chip, 86.6 Ω, 1/8 W, 1%, 1206	std	std
R8	1	Resistor, chip, 1 MΩ, 1/8 W, 1%, 1206	std	std
R9	1	Resistor, chip, 6.81 kΩ, 1/8 W, 1%, 1206	std	std
U1	1	IC, Transistion Mode PFC Controller, SO8	TI	UCC28050D
	1	PCB	Any	PR320

10 References

1. Michael O’Loughlin, *UCC38050 100 W Critical Conduction Power Factor Correction (PFC) Pre-regulator*, TI literature number SLUU138, December 2002
2. UCC38050 Data Sheet, TI literate number SLUS515B, June 2003

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