Literature Number: SLUU505
May 2011

User's Guide
SLUU505–May 2011

Buck PFC Pre-Regulator in Power Factor Correction Applications

1 Introduction

This EVM is to help evaluating UCC29910A buck PFC pre-regulator controller device in Power Factor Correction (PFC) applications especially targeting notebook computer charger area with universal AC input voltages.

2 Description

The EVM is a 100-W buck PFC pre-regulator with universal AC input between 90 V_{AC} and 264 V_{AC}, input frequency between 47 Hz and 63 Hz, and output voltage nominal 84 V_{DC} and maximum load current 1.2 A.

2.1 Typical Applications

- High Efficiency AC-DC Adapters
- Low Profile and High Density Adapters

2.2 Features

- Universal Line Input AC Voltage (between 90 V_{AC} and 264 V_{AC}, with frequency range 47 Hz and 63 Hz)
- Regulated Output DC Voltage (84 V_{DC} with maximum 1.2-A load current)
- Output Voltage Regulation From no Load to Full Load, and From Low Line to High Line
- High Efficiency 96% Peak and 95% at Full Load
- High Power Factor Over 0.9
- Double Sided PCB Layout
- Buck PFC Technology
- Non-Latching Input Under Voltage Protection
- Over Current Protection
- Test Points to Facilitate Device and Topology Evaluation

3 Electrical Performance Specifications

Table 1. UCC29910AEVM-730 Electrical Performance Specifications

Symbol	Parameter	Condition	MIN	TYP	MAX	UNITS
Input Characterstics						
V_{IN}	Input Voltage		90	115	264	Vac
f_{AC}	Input Frequency		47		63	Hz
I_{IN}	Input Current	V_{IN} = nom, I_{OUT} = max			1.5	Arms
V_{IN}_UVLO	Input UVLO	I_{OUT} = min to max	-	-	80	Vac
V_{IN}_OV	Input OV	I_{OUT} = min to max	265	-	-	Vac
P_F	Power Factor	V_{IN} = nom, 50% load	0.9	-	-	N/A
Output Characterstics						
V_{OUT}	Output Voltage(1)	V_{IN} = nom, I_{OUT} = nom	82.3	84	85.7	V
Reg_LN	Line Regulation(2)	V_{IN} = min to max, I_{OUT} = nom	-	-	5.0	%
Reg_LD	Load Regulation(2)	V_{IN} = nom, I_{OUT} = min to max	-	-	5.0	%
V_{OUT_ripple}	Output Voltage Ripple	V_{IN} = nom, I_{OUT} = max	-	-	6	Vpp
I_{OUT}	Output Current	V_{IN} = min to max	0	-	1.20	A
IOCP	Output Over Current	V_{IN} = nom, I_{OUT} = I_{OUT} - 5%	1.30	-	-	A
Systems Characterstics						
f_{SW}	Switching Frequency		-	100	-	kHz
Eff_Peak	Peak Efficiency	V_{IN} = nom, I_{OUT} = min to max	-	96	-	%
Eff_FL	Full Load Efficiency	V_{IN} = nom, I_{OUT} = max	-	95	-	%
Top	Operating Temperature Range	V_{IN} = min to max, I_{OUT} = min to max	-	25	-	°C

(1) Start up is normally with load current not greater than 0.2 A. Start up with no load, or less than 0.2-A load, may make output voltage higher and can be as high as 88 V. Start up with load current greater than 0.2 A may trigger over current protection and may make output voltage in hiccup operation.

(2) Load step down to zero may make output voltage higher and can be as high as 90 V.

4 Schematic

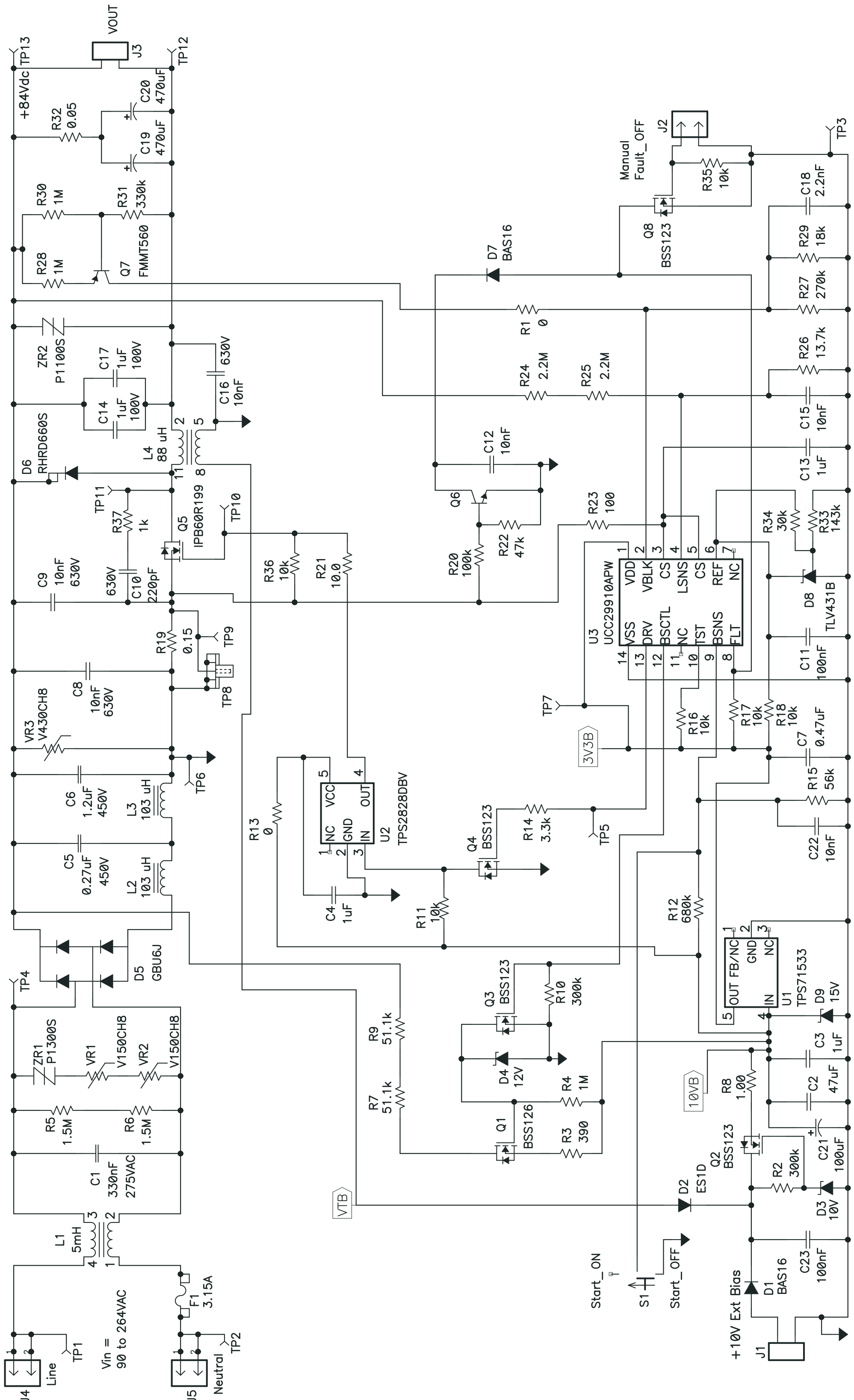

Figure 1. Schematic

5 Test Setup

5.1 Test Equipment

Voltage Source (Main): 90 V_{AC} to 265 V_{AC}, 2.0 A_{AC}, such as Agilent 6813B AC Power Source/Analyzer, or equivalent.

Voltage Source (Bias): 10 V_{DC}/0.2 A.

Multimeters: 100 V_{DC}/1.5 A_{DC} four-digit display meters, such as Fluke 45 Dual Display Multimeter, or equivalent.

Output Load: 100 V_{DC}/1.5 A_{DC} load such as TDI RBL488 Electronic Load 100-120-800, or equivalent.

Fan: 200 LFM minimum.

Recommended Wire Gauge: AWG #18 for input voltage connection and output load connection.

5.2 Recommended Test Setup

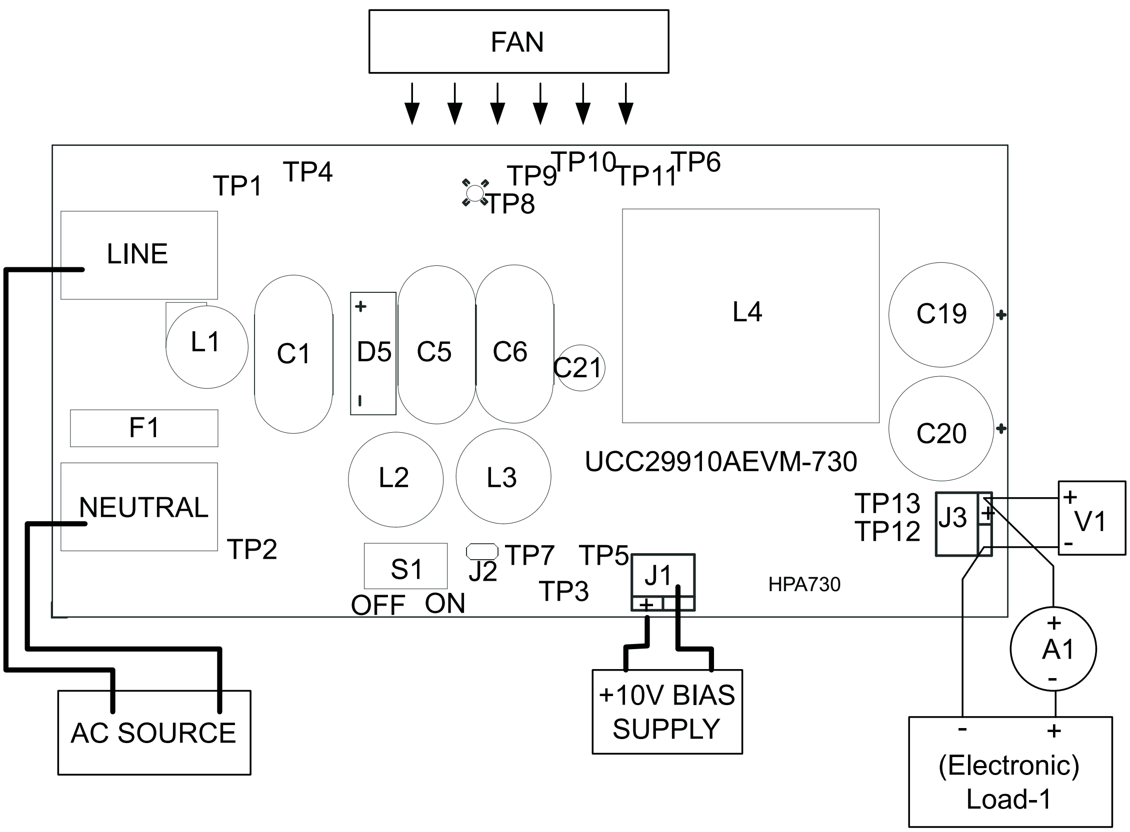

Figure 2. UCC29910AEVM-730 Recommended Test Set Up

5.3 List of Test Points

Table 2. Test Point Function

TEST POINTS	NAME	DESCRIPTION
TP1	LINE input	AC Input voltage LINE connection
TP2	NEUTRAL input	AC input voltage NEUTRAL connection
TP3	GND	Reference ground for signal
TP4	Rectifier Input	Input after common mode choke
TP5	FET Drive	U3 (UCC29910A) Pin 13
TP6	GND	Reference ground for power
TP7	3V3B	3.3-V bias and U3 (UCC29910A) Pin 1
TP8	Current Monitor	Q5 drain current monitoring
TP9	Current Monitor	Q5 drain current monitoring
TP10	Drive	Q5 gate
TP11	Drain	Q5 drain
TP12	VO-	Output voltage negative terminal
TP13	VO+	Output voltage positive terminal
J1	Bias	External 10-V bias
J2	Fault	Manual Fault Input to trigger fault protection from external circuit
J3	Vout	Output power terminal

6 Test Procedure

Set up the EVM per Figure 2.

> **CAUTION**
>
> High voltage and high temperature present when the EVM is in operation!
>
> High voltage present for some time after power down of the EVM. Check output terminals with a voltmeter before handling the EVM!

6.1 Power Factor and Efficiency Measurement Procedure

1. Check the switch S1 at **ON** position. If S1 is not at ON position, switch S1 to the position ON.
2. Turn on the ventilation fan and keep the fan in operation during the time of test.
3. Set the AC source voltage to 115 V_{AC} and frequency to 60 Hz. But keep the AC source powered off
4. Prior to connecting the AC source, set the current to 2.5-A peak and 2.5-A limit. Connecting AC source to **LINE** and **NEUTRAL** terminals as shown in Figure 2.
5. Connect voltmeter V1 across the J3 as shown in Figure 2.
6. Connect ammeter A1 to J3 positive terminal and connect ammeter A1 to Load-1. Then connect Load-1 negative terminal to J3 negative terminal.
7. Connect 10-V Bias to J1, turn on 10-V Bias.
8. Set Load-1 to constant current mode to sink 0.2 A_{DC} and set Load-1 at 100 V_{DC} input range before turning on the AC source.
9. Turn on the AC source.
10. Varying the load current from 0.2 A to 1.2 A, along with the load current variation:
    (a) Read input voltage, input real power, and power factor from the AC source.
    (b) Read output voltage and output current from V1 and A1.
11. Turn off the AC source.
12. Set the AC source voltage to 230 V_{AC} and frequency to 50 Hz.
13. Repeat step 8 and 10.

NOTE: Start up is normally with load current not greater than 0.2A.

Start up with no load, or less than 0.2-A load, may make output voltage higher and can be as high as 88 V.

Start up with load current greater than 0.2 A may trigger over current protection and may make output voltage in hiccup operation.

Load step down to zero may make output voltage higher and can be as high as 90 V.

6.2 Equipment Shutdown

1. Shut down the AC source
2. Shut down the 10-V Bias
3. Shut down the load
4. Shut down the FAN

> **CAUTION**
>
> High voltage may present after power down of the EVM for some time. Check output terminals with a voltmeter before handling the EVM!

7 Performance Data and Typical Characteristic Curves

7.1 *Efficiency at 115 V_{AC} and 230 V_{AC}*

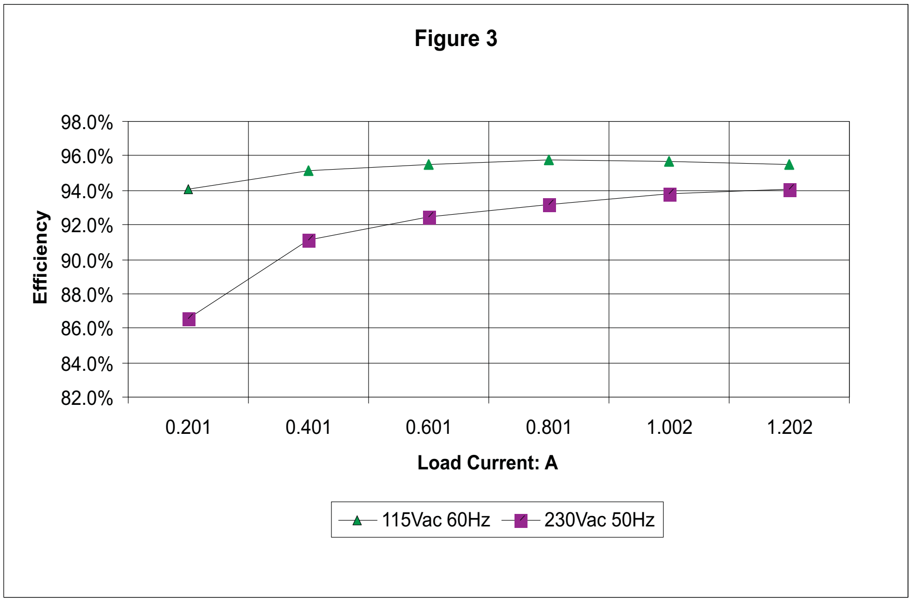

Figure 3. Efficiency with 115 V_{AC} and 230 V_{AC} (Test Points: TP1, TP2, TP12 and TP13)

7.2 *Efficiency at Full Load with Respect to Input Voltage*

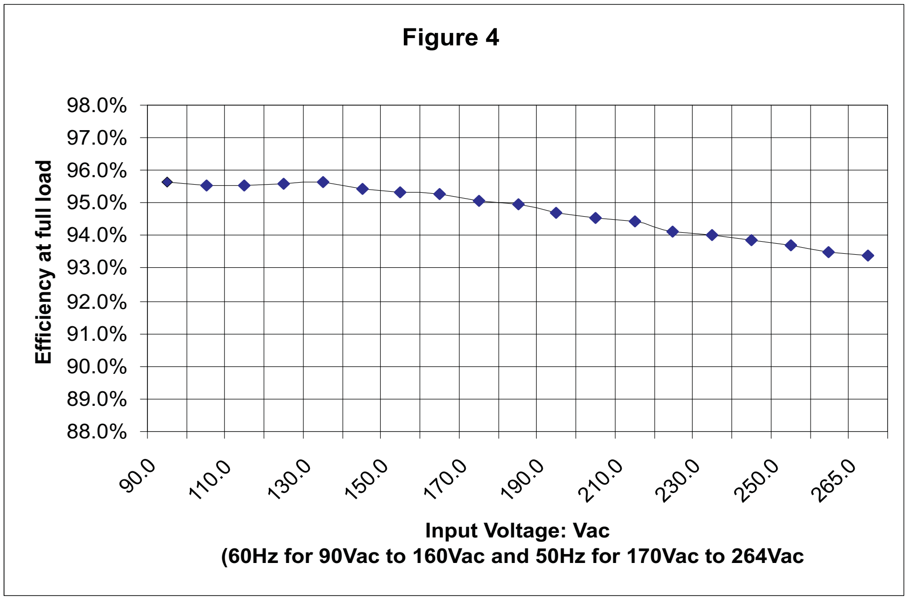

Figure 4. Efficiency at Full Load (Test Points: TP1, TP2, TP12 and TP13)

7.3 Power Factor at 115 V_{AC} and 230 V_{AC}

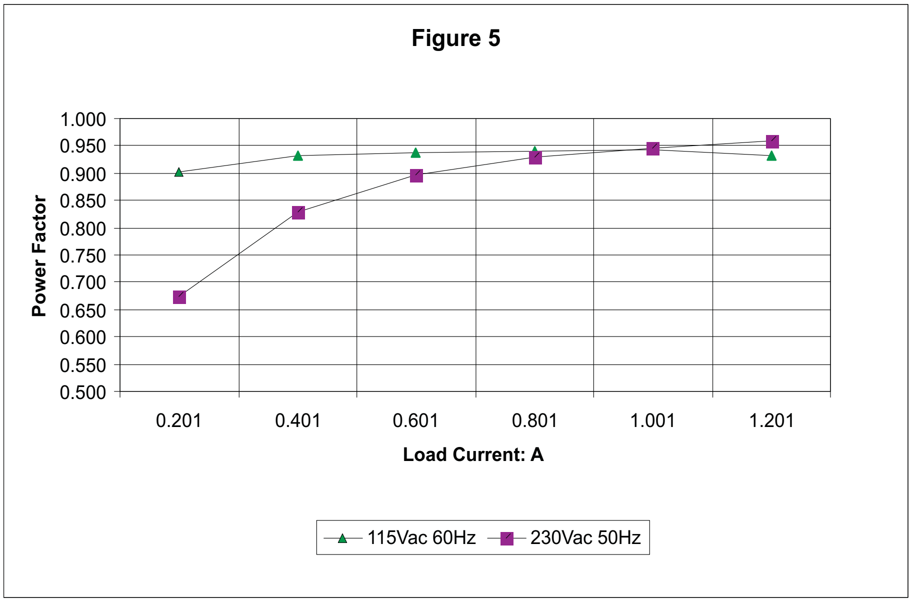

Figure 5. PF with 115 V_{AC} and 230 V_{AC} (Test Points: TP1, TP2, TP12 and TP13)

7.4 Power Factor at Full Load with Respect to Input Voltage

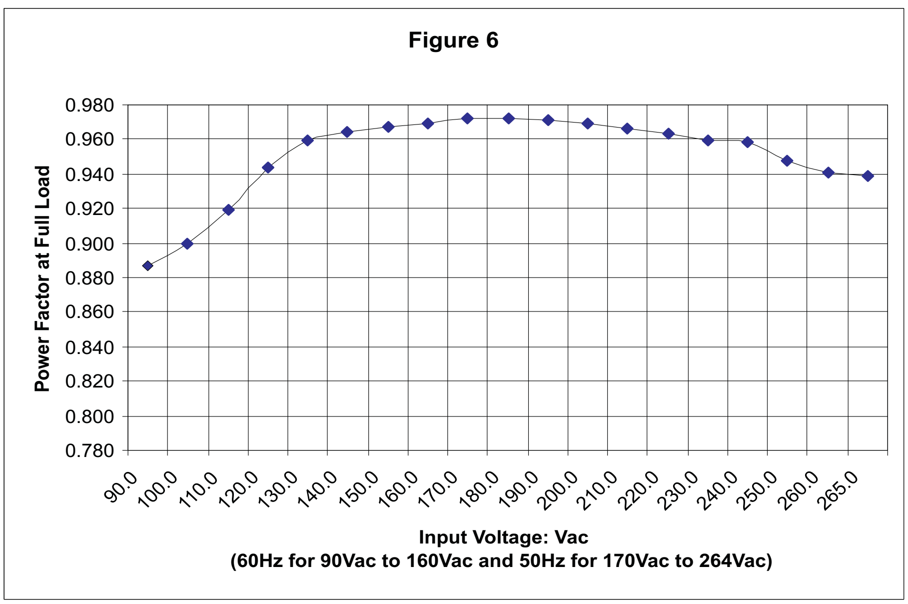

Figure 6. PF at Full Load (Test Points: TP1, TP2, TP12 and TP13)

7.5 Input Current Harmonic Content (IEC EN61000-3-2 Limits for Class D Equipment)

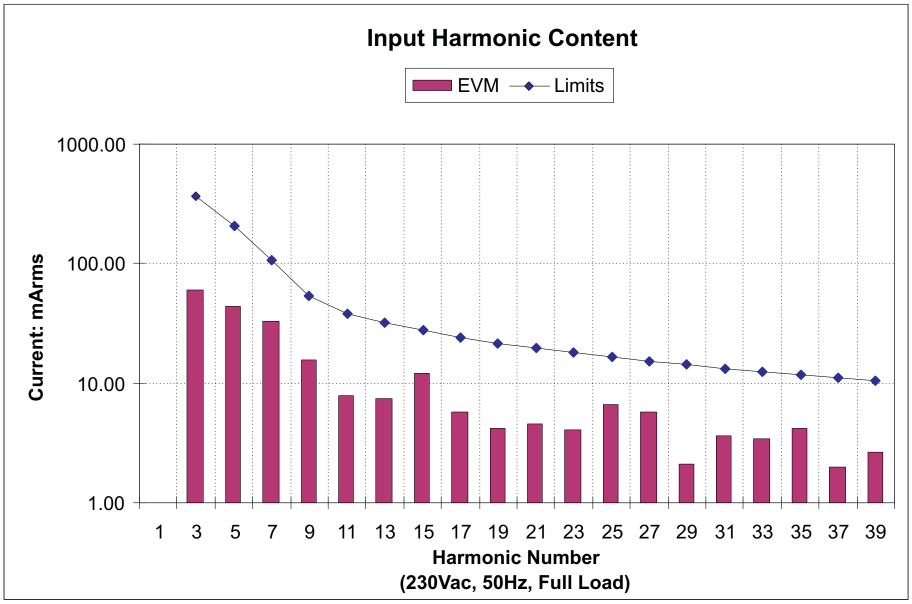

Figure 7. Harmonic Content with 230Vac Input (Vin = 230Vac at 50Hz, Io = 1.2A Test Points: TP1, TP2, TP12 and TP13)

7.6 Input Current Harmonic Content (JIS61000-3-2 Limits for Class D Equipment)

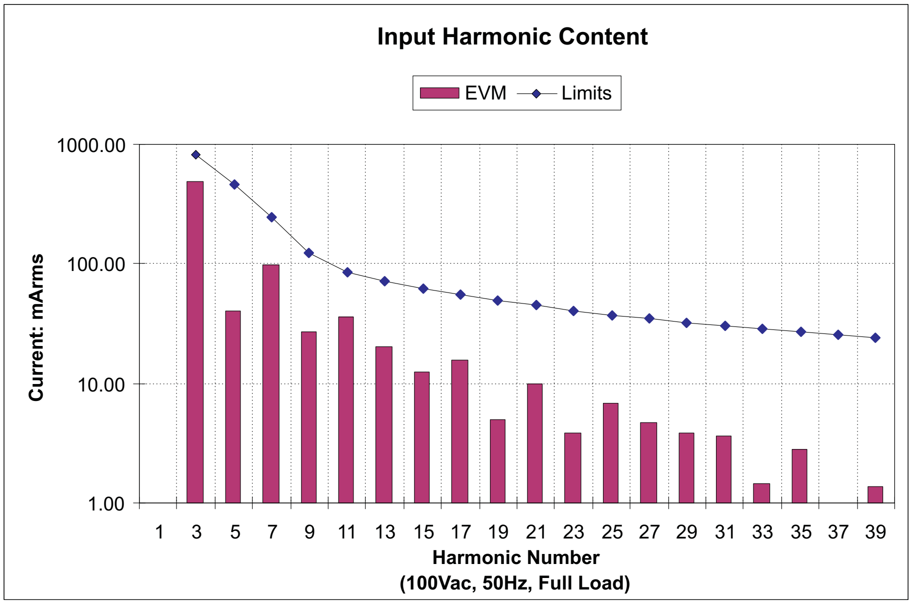

Figure 8. Harmonic Content with 100 V_{AC} Input (V_{IN} = 100 V_{AC} at 50 Hz, I_O = 1.2 A Test Points: TP1, TP2, TP12 and TP13)

7.7 No-Load Output Turn On

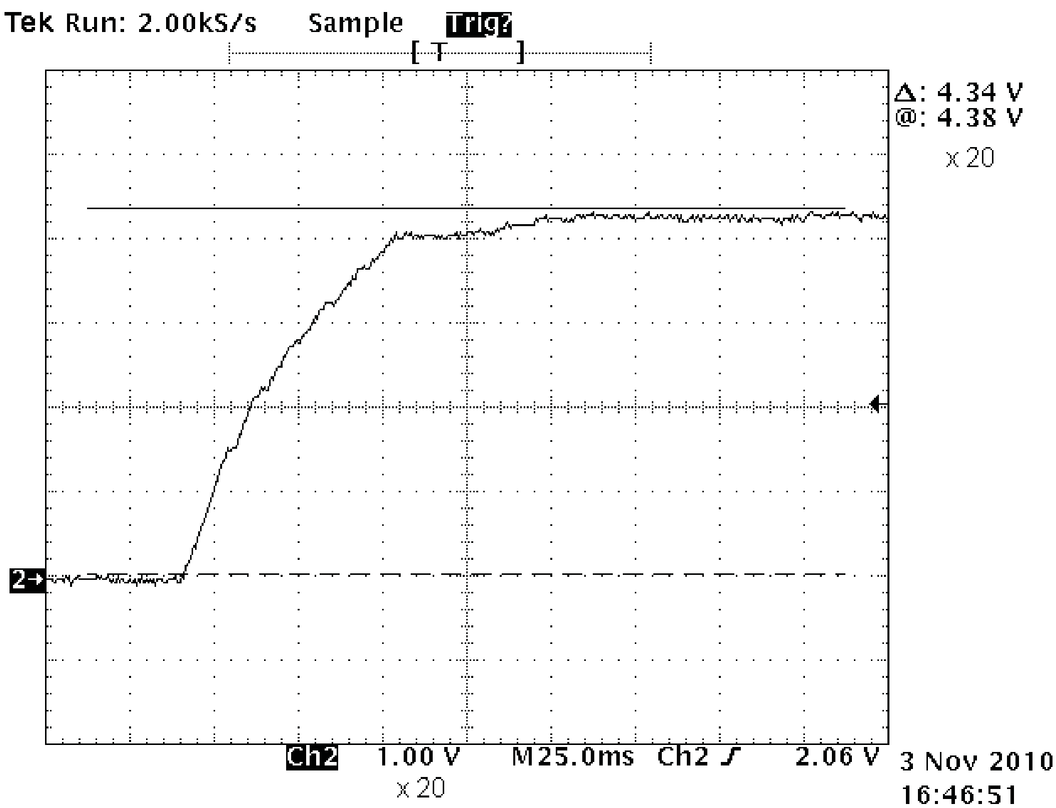

Figure 9. No-Load Turn On (V_{IN} = 230 V_{AC} at 50 Hz, I_O = 0 A Test Points: TP12 and TP13)

7.8 Output Voltage Ripple

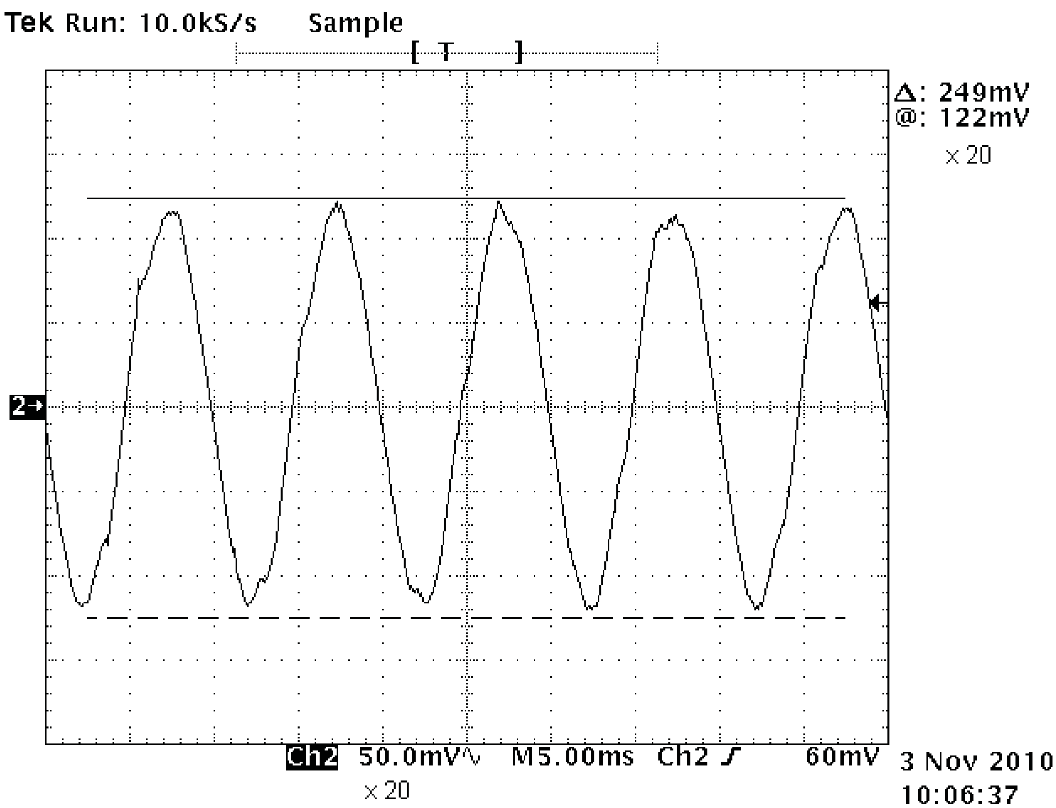

Figure 10. Output Voltage Ripple (V_{IN} = 230 V_{AC} at 50 Hz, I_O = 1.2 A Test Points: TP12 and TP13)

7.9 Input Voltage and Current

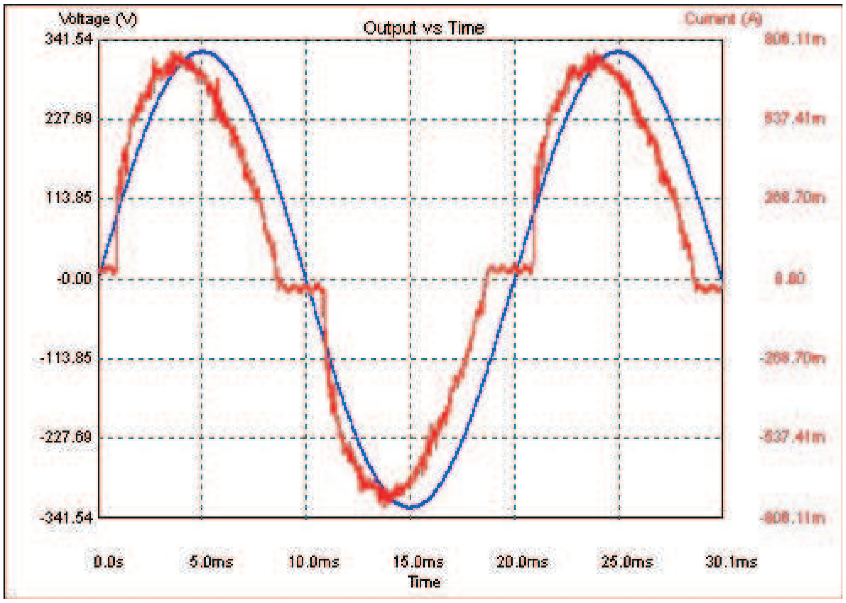

Figure 11. Input Waveforms (V_{IN} = 230 V_{AC} at 50 Hz, I_O = 1.2 A Test Points: TP1 and TP2)

7.10 EMI Performance Achievable on a Full 90-W Adapter Design (reference to SEM1900 topic 4)

NOTE: This EVM is not designed to meet the EMI standard. A reference design shown in SEM1900 does.

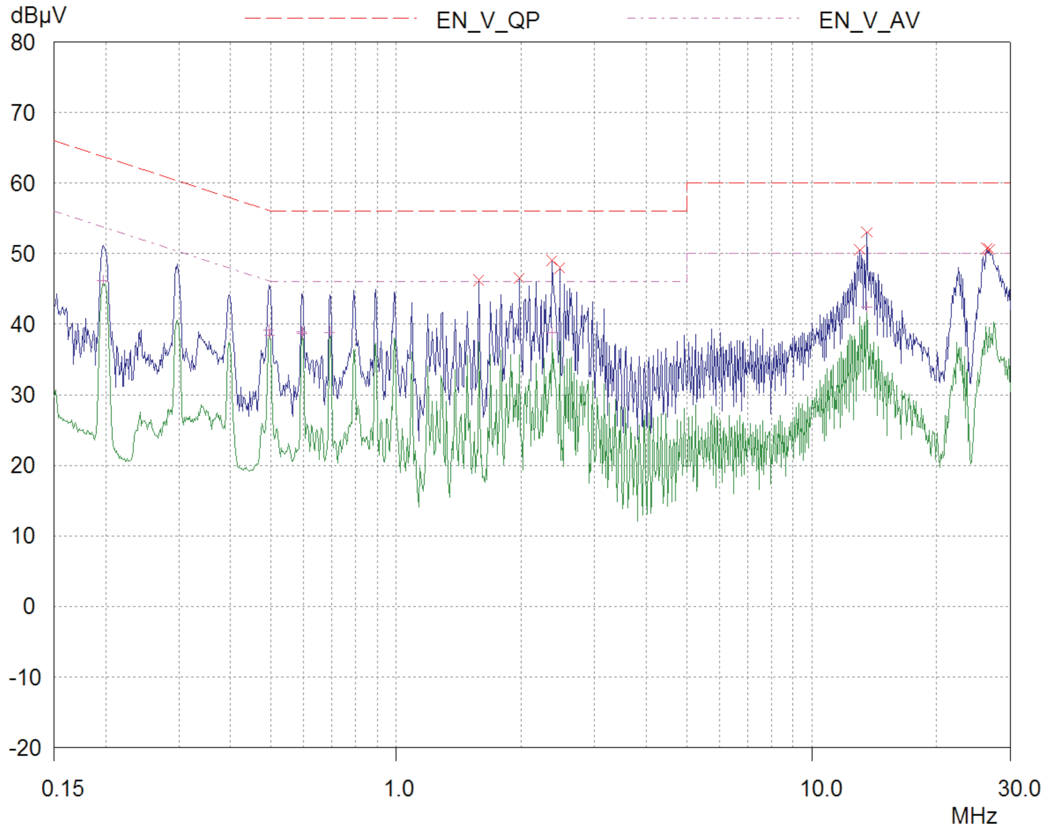

Figure 12. EMI Conducted Emission Test (Vin = 230Vac at 50Hz, Io = 1.2A)

8 EVM Assembly Drawing and PCB layout

The following figures (Figure 13 through Figure 18) show the design of the UCC29910AEVM-730 printed circuit board. PCB dimensions: L x W = 6.1 inch x 3.0 inch, four layers and 2-oz copper on outer layers and 1-oz copper on inner layers.

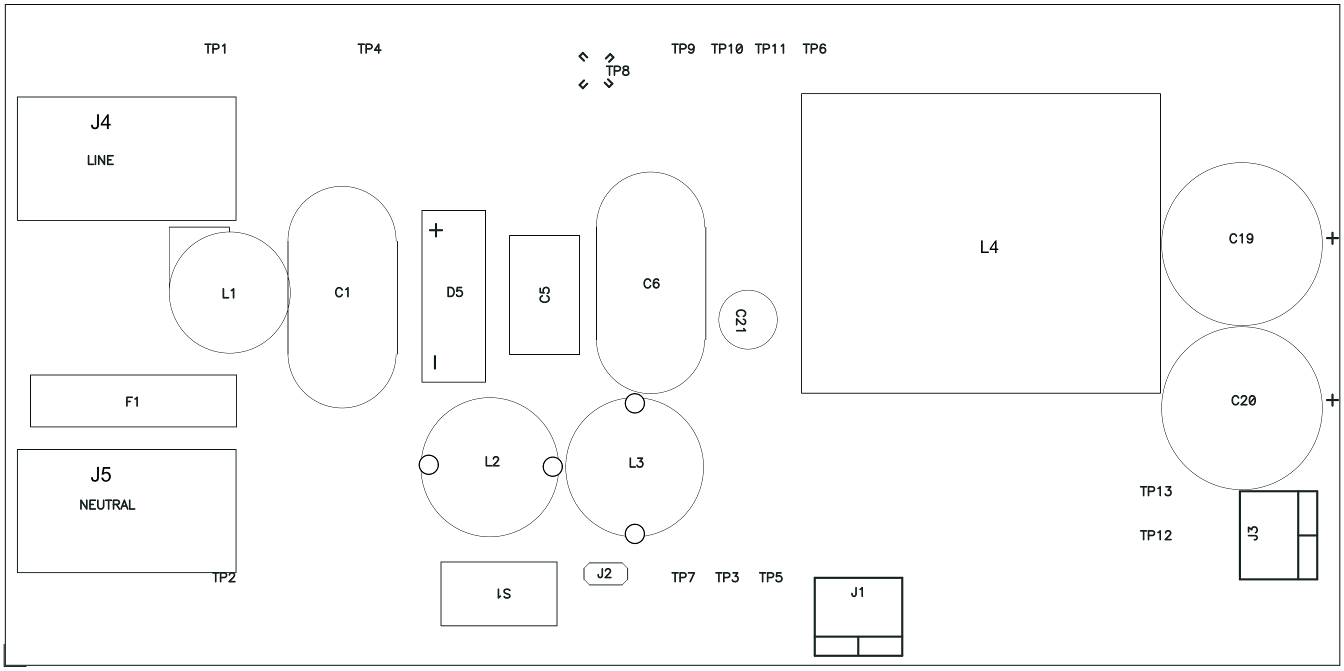

Figure 13. UCC29910AEVM-730 Top Layer Assembly Drawing (top view)

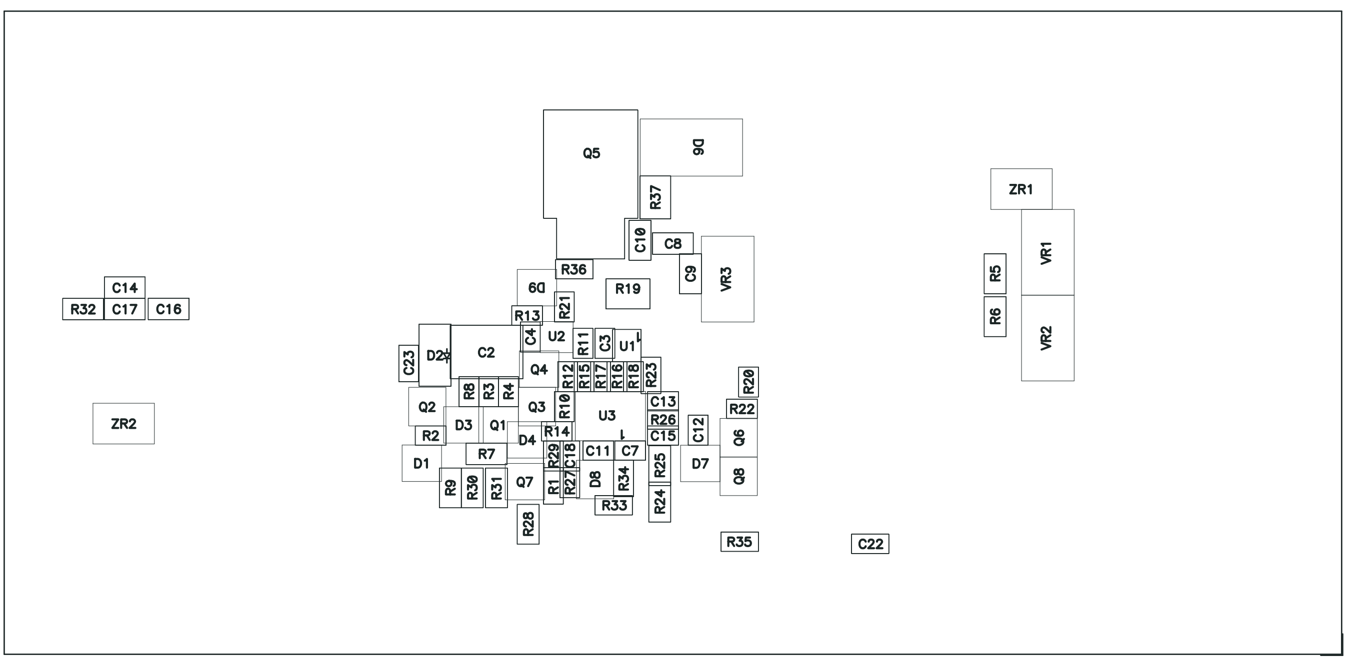

Figure 14. UCC29910AEVM-730 Bottom Assembly Drawing (bottom view)

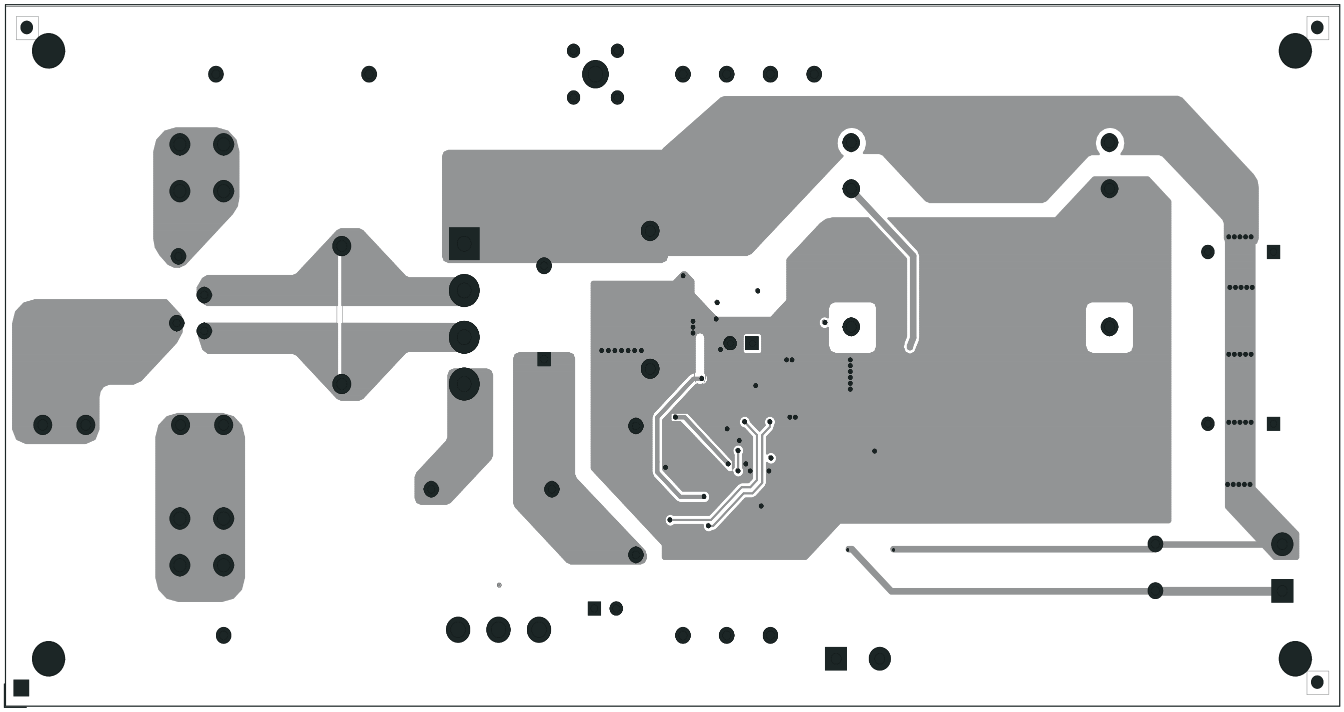

Figure 15. UCC29910AEVM-730 Top Copper (top view)

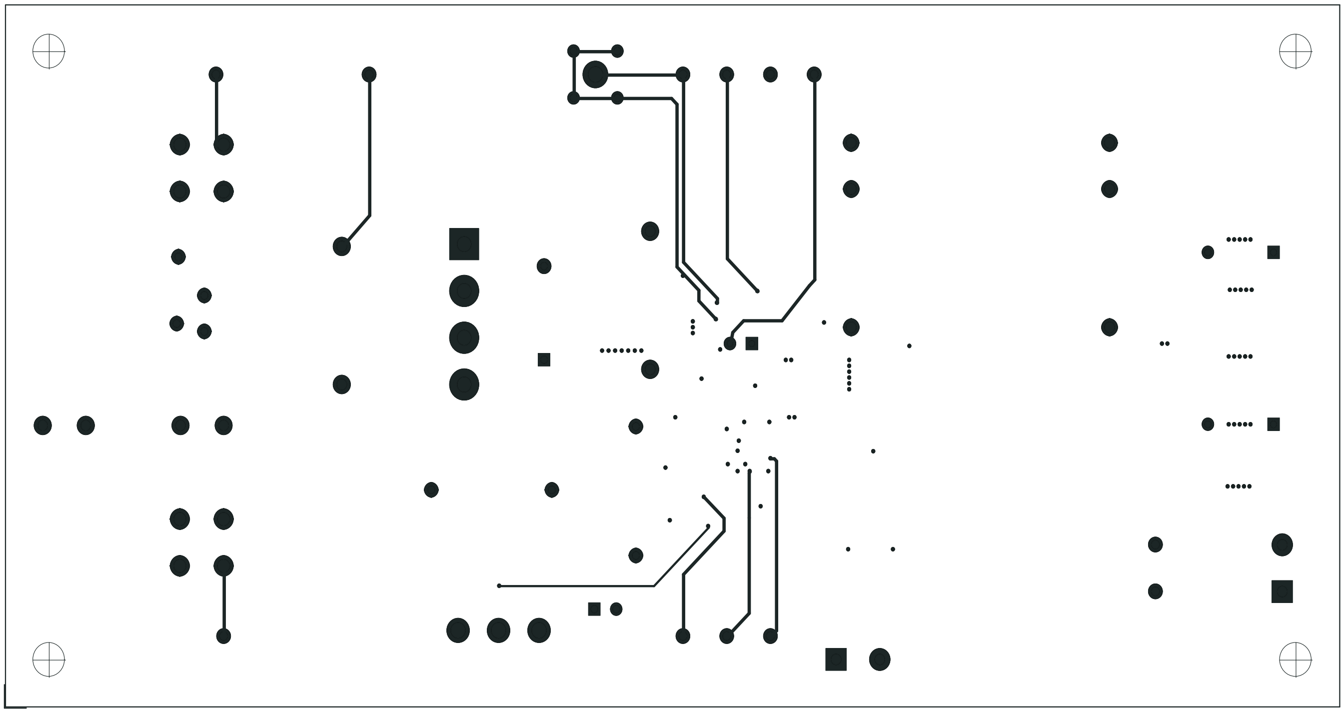

Figure 16. UCC29910AEVM-730 Internal Layer 1 (top view)

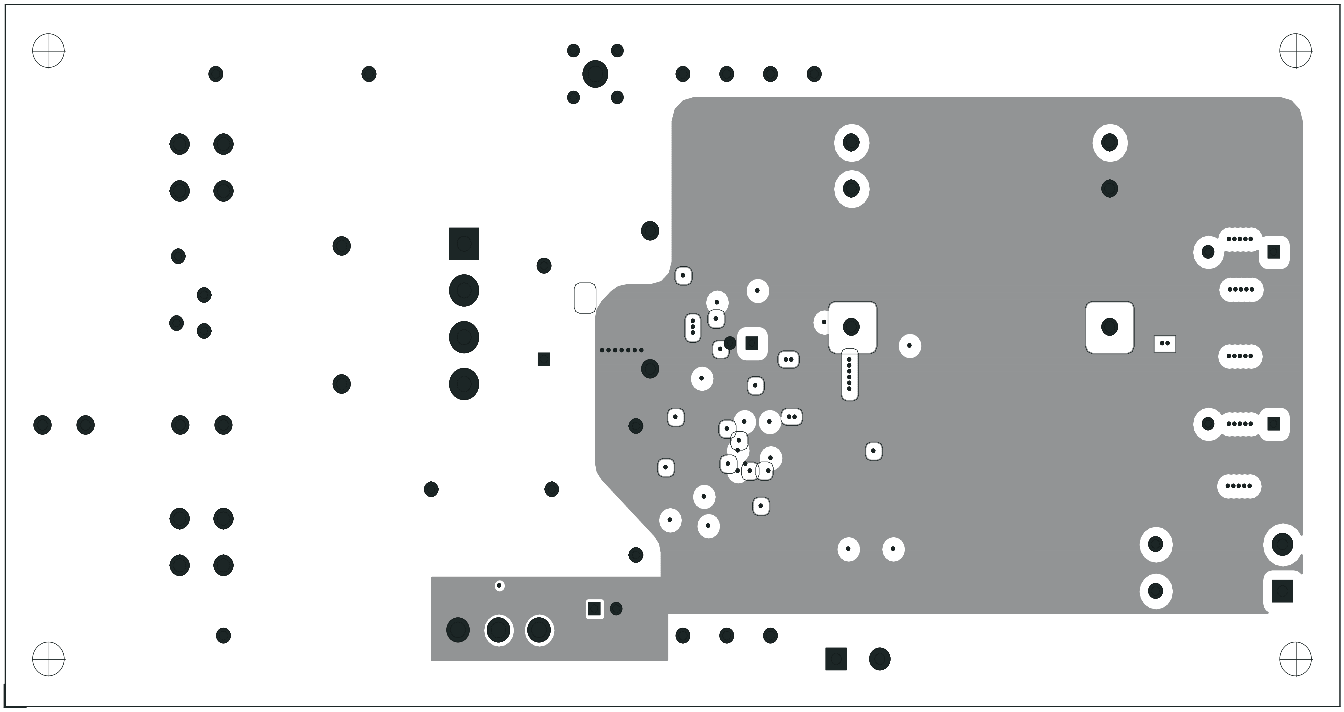

Figure 17. UCC29910AEVM-730 Internal Layer 2 (top view)

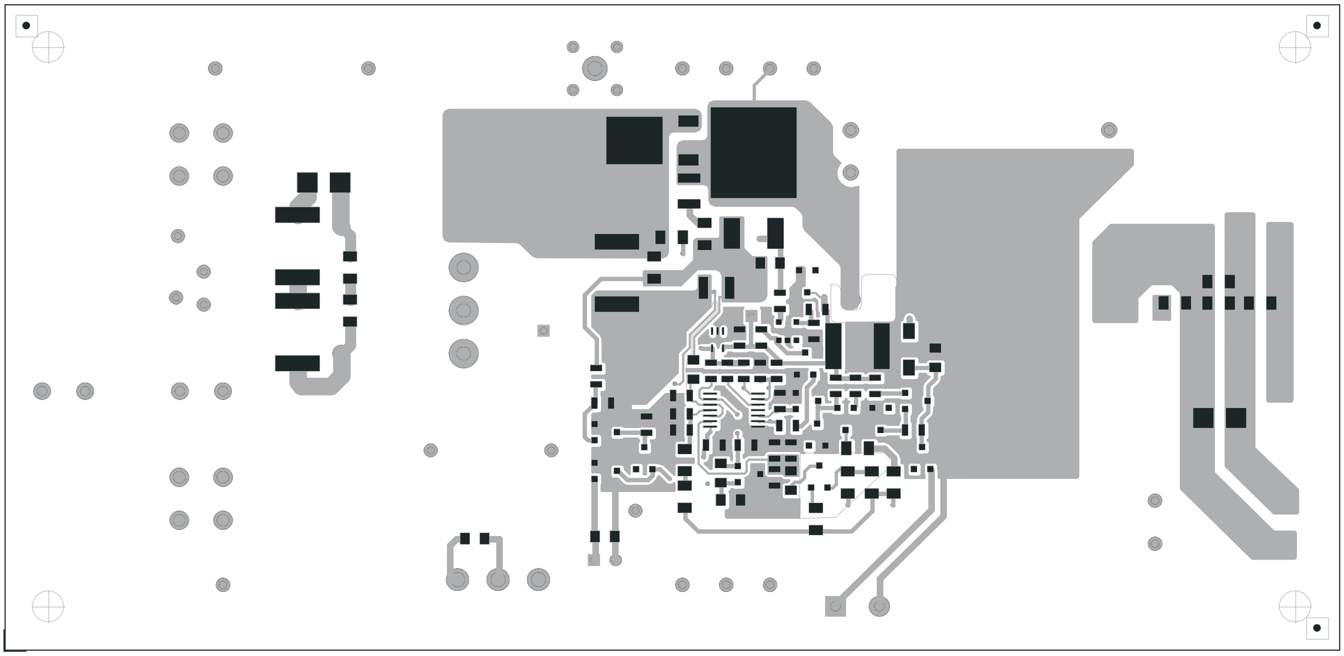

Figure 18. UCC29910AEVM-730 Bottom Copper (top view)

9 List of Materials

Table 3. The EVM Components List (according to the schematic shown in)

REF DES	QTY	DESCRIPTION	PART NUMBER	MFR
C1	1	Capacitor, metallized polyester film, 275 V_{AC}, 20%, 330 nF	ECQ-U2A334ML	Panasonic
C10	1	Capacitor, ceramic, 630 V, 20%, 1206, 220 pF	std	std
C11	1	Capacitor, ceramic, 16 V, X7R, ±10%, 0805, 100 nF	std	std
C12, C15, C22	3	Capacitor, ceramic, 16 V, X7R, ±10%, 0805, 10 nF	std	std
C14, C17	2	Capacitor, ceramic, 100 V, ±10%, 1206, 1 µF	std	std
C18	1	Capacitor, ceramic, 16 V, X7R, ±10%, 0805, 2.2 nF	std	std
C19, C20	2	Capacitor, aluminum, 100 V, 20%, 470 µF	EEU-FC2A471	Panasonic
C2	1	Capacitor, ceramic, 25 V, X7R, 20%, 47 µF	CKG57NX5R1E476M	TDK
C21	1	Capacitor, aluminum, 16 V, 20%, 100 µF	ECA1CM101	Panasonic
C23	1	Capacitor, ceramic, 50 V, X7R, ±10%, 0805, 100 nF	std	std
C3, C4,C13	3	Capacitor, ceramic, 16 V, X7R, ±10%, 0805, 1 µF	std	std
C5	1	Capacitor, metallized polyproplene film, 450 V_{DC}, 20%, 0.27 µF	ECW-F2W274JAQ	Panasonic
C6	1	Capacitor, metallized polyester film, 450 V_{DC}, 20%, 1.2 µF	ECW-F2W125JA	Panasonic
C7	1	Capacitor, ceramic, 16 V, X7R, ±10%, 0805, 0.47 µF	std	std
C8, C9, C16	3	Capacitor, ceramic, 630 V, 20%, 1206, 10 nF	std	std
D1, D7	2	Diode, switching, 150 mA, 75 V, 350 mW	BAS16	Onsemi
D2	1	Diode, super fast rectifier, 200 V, 1.0 A	ES1D	Fairchild
D3	1	Diode, Zener, 10 V, 20 mA, 225 mW, 5%, 10 V	BZX84C10LT1G	Onsemi
D4	1	Diode, Zener, 12 V, 20 mA, 225 mW, 5%, 12 V	BZX84C12LT1G	Onsemi
D5	1	Diode, bridge, 6 A, 600 V,	GBU6J	Vishay
D6	1	DIODE, hyperfast 6 A, 600 V	RHRD660S	Fairchild
D8	1	Adjustable precision shunt regulator, 0.5%	TLV431BQDBZT	TI
D9	1	Diode, Zener, 10 V, 20 mA, 225 mW, 5%, 15 V	BZX84C15LT1G	Onsemi
F1	1	Fuse, 3.15 A, 250 V, Slo-Blo, cartridge, 3.15 A	0213 002.	Littlefuse
J1, J3	2	Terminal block, 2 pin, 15 A, 5.1 mm,	ED500/2DS	OST
J2	1	Header, male 2-pin, 100mil spacing,	PEC02SAAN	Sullins
L1	1	Inductor, ± 3% at 100 kHz, 5 mH	750311982	WE
L2, L3	2	Inductor, ±10% at 100 kHz, 103 µH	750311983	WE
L4	1	Transformer, ±15%, 88 µH	750311885	WE
Q1	1	MOSFET, N-channel, 600 V, 7 mA	BSS126	Infineon
Q2, Q3, Q4, Q8	4	MOSFET, N-channel, 100 V, 0.17 A	BSS123	Fairchild
Q5	1	MOSFET, N-channel, 650 V, 16 A, 0.199 Ω	IPB60R199CP	Infineon
Q6	1	Bipolar, NPN, 40 V_{CEO}, 600 mA, 350 mW	MMBT2222AK	Fairchild
Q7	1	Transistor, PNP, -500 V_{CEO}, -5 V_{EBO}, 50 mA	FMMT560	Zetex

Table 3. The EVM Components List (according to the schematic shown in) (continued)

REF DES	QTY	DESCRIPTION	PART NUMBER	MFR
R1, R13	2	Resistor, chip, 1/8 W, 1%, 0805, 0 Ω	std	std
R11, R16, R17, R18, R35, R36	6	Resistor, chip, 1/8 W, 1%, 0805, 10 kΩ	std	std
R12	1	Resistor, chip, 1/8 W, 1%, 0805, 680 kΩ	std	std
R14	1	Resistor, chip, 1/8 W, 1%, 0805, 3.3 kΩ	std	std
R15	1	Resistor, chip, 1/8 W, 1%, 0805, 56 kΩ	std	std
R32	1	Resistor, chip, 1/4 W, 1%, 1206, 0.05 Ω	std	std
R19	1	Resistor, chip, 1/2 W, 1%, 1210, 0.15 Ω	std	std
R2, R10	2	Resistor, chip, 1/8 W, 1%, 0805, 300 kΩ	std	std
R20	1	Resistor, chip, 1/8 W, 1%, 0805, 100 kΩ	std	std
R21	1	Resistor, chip, 1/8 W, 1%, 0805, 10 Ω	std	std
R22	1	Resistor, chip, 1/8 W, 1%, 0805, 47 kΩ	std	std
R24, R25	2	Resistor, chip, 1/4 W, 1%, 1206, 2.2 MΩ	std	std
R26	1	Resistor, chip, 1/8 W, 1%, 0805, 13.7 kΩ	std	std
R27	1	Resistor, chip, 1/8 W, 1%, 0805, 270 kΩ	std	std
R28, R30	2	Resistor, chip, 1/4 W, 1%, 1206, 1 MΩ	std	std
R29	1	Resistor, chip, 1/8 W, 1%, 0805, 18 kΩ	std	std
R3	1	Resistor, chip, 1/8 W, 1%, 0805, 390 Ω	std	std
R31	1	Resistor, chip, 1/4 W, 1%, 1206, 330 kΩ	std	std
R33	1	Resistor, chip, 1/8 W, 1%, 0805, 143 kΩ	std	std
R34	1	Resistor, chip, 1/8 W, 1%, 0805, 30 kΩ	std	std
R4	1	Resistor, chip, 1/8 W, 1%, 0805, 1 MΩ	std	std
R5, R6	2	Resistor, chip, 1/4 W, 1%, 1206, 1.5 MΩ	std	std
R7, R9	2	Resistor, chip, 1/4 W, 1%, 1206, 51.1 kΩ	std	std
R8	1	Resistor, chip, 1/8 W, 1%, 0805,	std	std
R37	1	Resistor, chip, 1/2 W,1%, 1210, 1 kΩ	std	std
R23	1	Resistor, chip, 1/8 W,1%, 0805, 100 Ω	std	std
U1	1	50-mA LDO, 3.0 V_O	TPS71533DCKR	TI
U2	1	MOSFET driver, inverting	TPS2828DBV	TI
U3	1	Buck PFC	UCC29910APW	TI
VR1, VR2	2	Varistor, 95 V_{AC}	V150CH8	Littelfuse
VR3	1	Varistor, 369 V_{DC}	V430CH8	Littelfuse
ZR1	1	Sidactor, 160 V_S, 2.2A	P1300SCLRP	Littelfuse
ZR2	1	Sidactor, 130 V_S, 2.2A	P1100SCLRP	Littelfuse

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 90 VAC to 264 VAC and the output voltage range of 83 VDC to 87 V_{DC} .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 50° C. The EVM is designed to operate properly with certain components above 50° C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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