Using the UCC28810EVM-002

User's Guide

Literature Number: SLUU355A
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A 0.9-A Constant Current Supply with PFC for 100-W LED Lighting Applications

1 Introduction

The UCC28810EVM-002 is a constant current non-isolated power supply for LED lighting applications. It will convert universal mains (90 VRMS to 264 VRMS) to a 0.9-A constant current into a 100-W load. This evaluation module will allow the customer evaluate the UCC28810/11 in a typical LED lighting application.

2 Description

The evaluation module uses a two stage approach to controlling the output current.

The first stage is a transition mode PFC circuit. This ensures the design meets the harmonic current or power factor requirements set out by various standards, such as EN61000-3-2. The PFC circuit converts the AC input to a regulated DC voltage. This DC voltage can be configured in one of two ways. The default configuration of the module is that of a boost follower type PFC. The boost follower PFC is where the PFC regulated output DC voltage tracks the AC input peak voltage. The second configuration requires removing some components and changing a resistor value see below for more details. This second configuration removes the tracking element of the PFC circuit. The PFC DC output voltage will then be regulated to a fixed value in the region of 396 VDC.

The second stage also uses transition mode but is configured as a buck converter. It converts the PFC output voltage to a fixed constant current. This circuit is capable of supplying 0.9 A into a 100-W load. It also accepts PWM dimming inputs. Alternatively the user can use the PWM circuit on the module to see the dimming function.

This module will work with most high brightness LED's (HB-LED) that operate with 0.9 A and a total string voltage drop of between 55 V and 110 V.

2.1 Typical Applications

- AC Input General Lighting Applications Using HB-LED's
- Industrial, Commercial and Residential Lighting Fixtures
- Outdoor Lighting: Street, Roadway, Parking, Construction and Ornamental LED Lighting Fixtures

2.2 Features

- 90 VRMS to 264 VRMS operation
- Boost Follower or Fixed Output PFC Stage
- PFC Disable
- Output Current Disable
- External or Internal PWM Dimming

3 Electrical Performance Specifications

Table 1. UCC28810EVM-002 Electrical Performance Specifications

SYMBOL	PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
INPUT CHARACTERSTICS						
V_{IN}	Input voltage		90		264	V_{RMS}
I_{IN}	Input current		0.175		1.1	A_{RMS}
PF	Power factor	P_{OUT} = 80 W to 100 W	0.95	0.97		
OUTPUT CHARACTERSTICS						
PFC Stage						
V_{OUT}	PFC output voltage		235		415	VDC
LED Driver Stage						
P_{OUT}	Output power		45	80	100	W
I_{OUT}	Output current		0.84	0.9	0.96	A
	Line regulation				0.03	
	Frequency		60		128	kHz
SYSTEMS CHARACTERSTICS						
η	Full load efficiency		90%	93%		
PWM Dimming (1)						
	Threshold		0.72		1.3	V
	Frequency range		200		1000	Hz
	Duty cycle		0%		90%	

(1) The PWM dimming signal is inverted, 0% duty cycle is 100% LED current.

4 Schematic

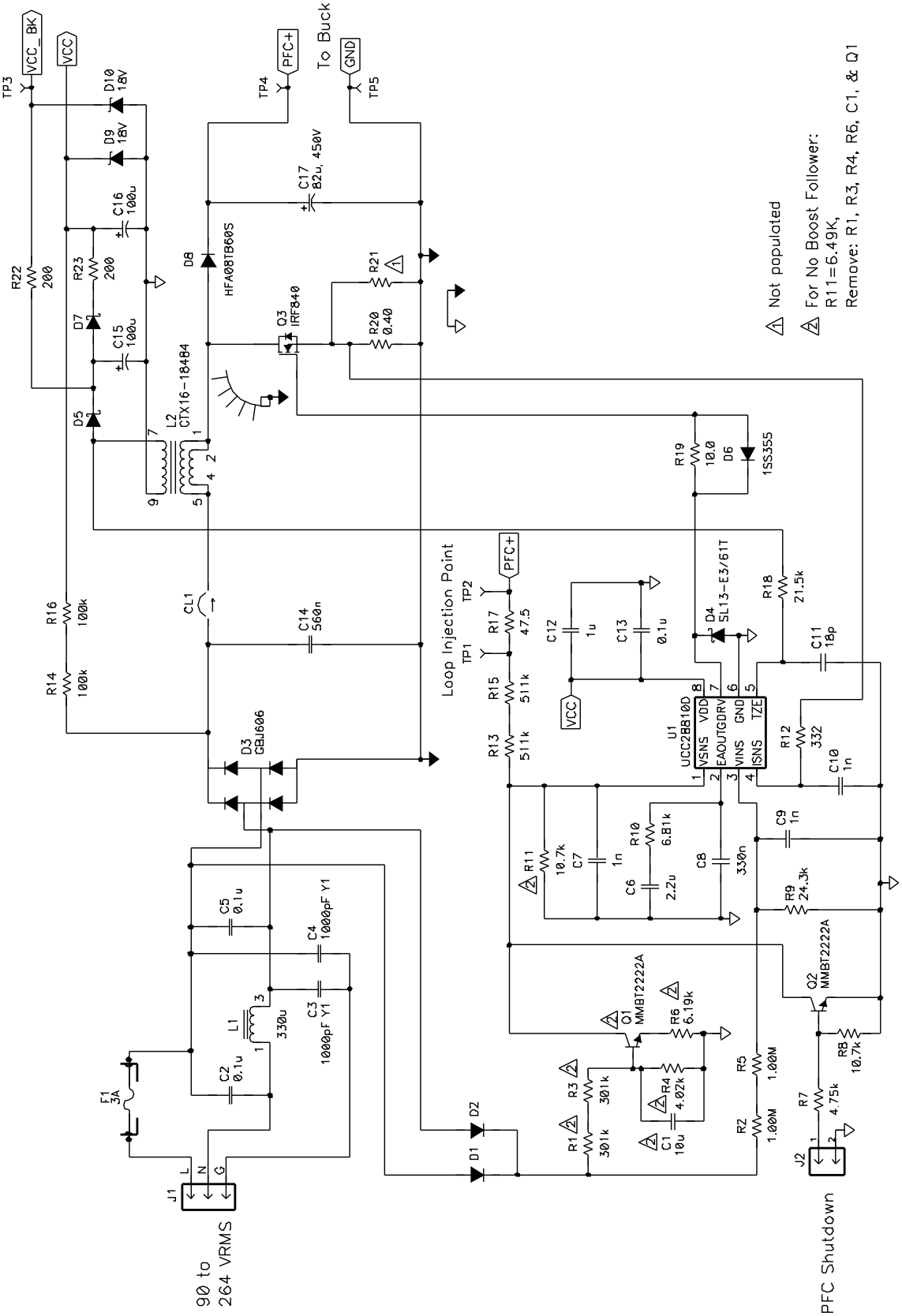

Figure 1. UCC28810EVM-002 PFC Stage Schematic

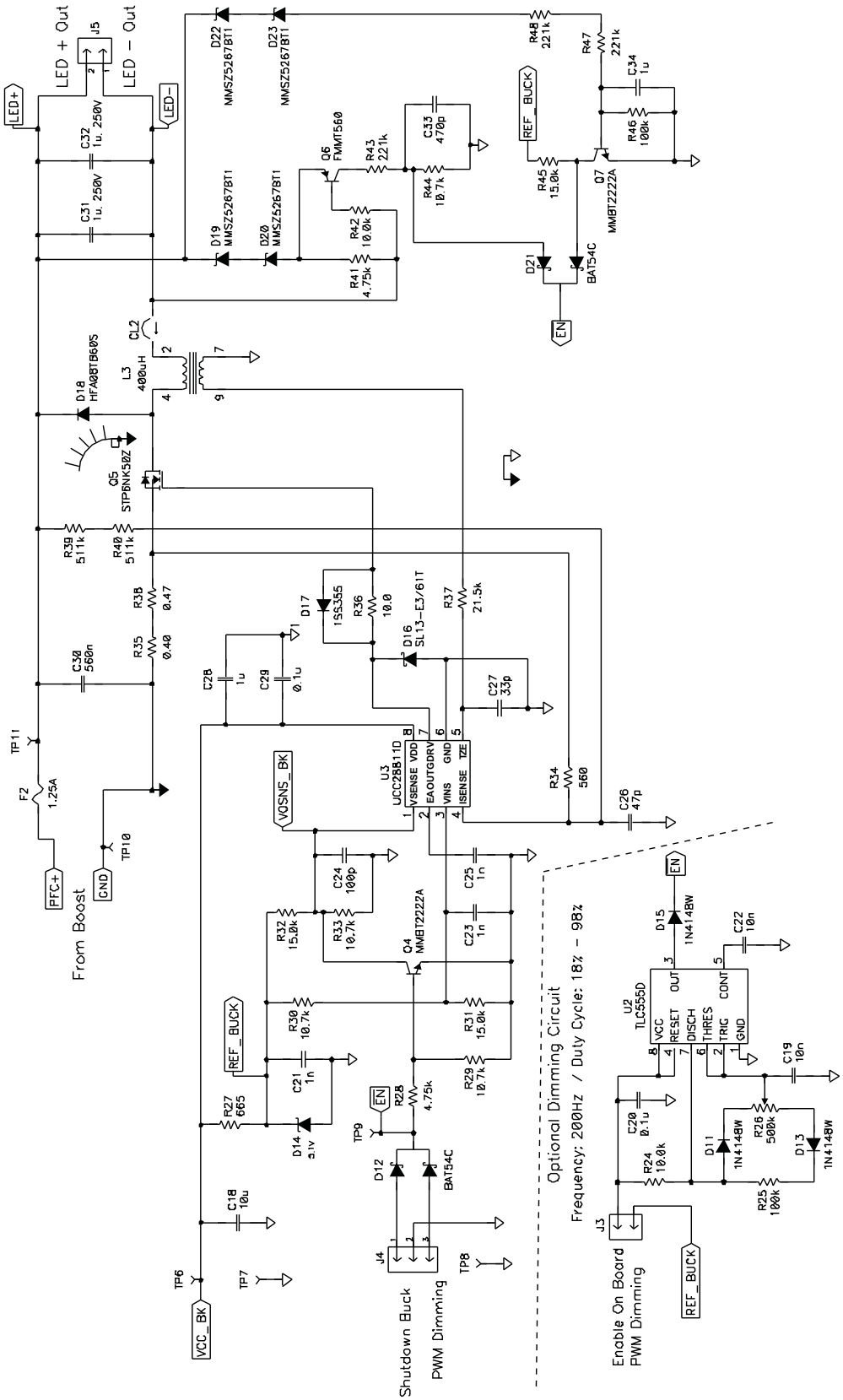

Figure 2. UCC28810EVM-002 Buck Stage Schematic

5 Test Setup

WARNING

High voltages, that may cause injury, exist on this evaluation module (EVM). Please ensure all safety procedures are followed when working on this EVM. Never leave a powered EVM unattended. The use of isolated test equipment is highly recommended.

5.1 Test Equipment

See Figure 3 for recommended test set up.

5.1.1 Voltage Source:

- **Source 1:** Isolated AC voltage source or VARIAC, capable of 90 VRMS to 264 VRMS at 150 W.
- **Source 2:** A 3.3-V DC source capable of 100 mA.

5.1.2 Multimeters

Three digital multimeters are recommend, one for current measurement, A1, and two for voltage measurements, V1 and V2.

5.1.3 Output Load

It is recommended that actual high brightness LED's (HB-LED's) are used for the load. They should be rated at 0.9 A. The HB-LED's should be connected in series. Their voltage drop should be between 55 VDC and 110 VDC. Alternatively a constant voltage electronic load could be used. If using a constant voltage electronic load a 1000-µF/250 VDC capacitor is required at the input to the electronic load. The 1000 µF capacitor should not be used if using HB-LED's as the load.

5.1.4 Oscilloscope

A digital or analog oscilloscope with current probe is required to view the AC current in the PFC inductor or buck inductor.

5.1.5 Signal Generator

A signal generator that can produce a square wave pulse train at between 200 Hz and 1 kHz is required to do external PWM dimming.

5.1.6 Fan

Forced air cooling is not required

5.1.7 Recommended Wire Gauge

A minimum of 18 AWG wire is recommended. Also the wire connections between the AC source and the EVM, and the EVM and load should be less than two feet long. The AC input connector accepts a standard IEC320-C13 connector with ground pin.

5.2 Recommended Test Setup

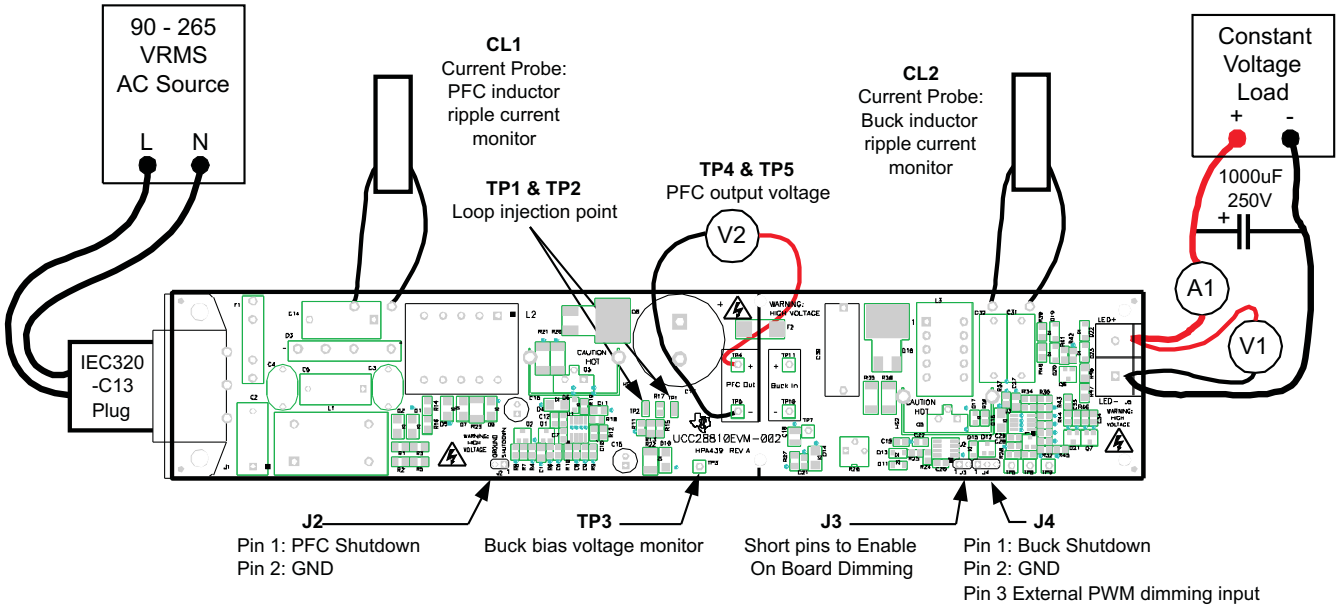

Figure 3. UCC28810EVM-002 Recommended Test Set Up

Note: The 1000-µF/250-V capacitor on the output is not required if the load is a string of HB-LED's.

5.3 List of Test Points

Table 2. Test Point Functions

TEST POINTS	NAME	DESCRIPTION
TP1		Loop injection point
TP2		Loop injection point, PFC output
TP3	VCC_BK	Buck bias voltage output
TP4	PFC+	PFC output voltage
TP5	PFC-	PFC output voltage ground
TP6	VCC_BK	Buck bias voltage input
TP7	GND	Buck bias voltage ground
TP8	GND	Ground connection
TP9	EN	Buck enable
TP10	GND	Buck input voltage ground
TP11	BK_IN	Buck input voltage
J2-1	PFC shutdown	Apply 3.3 V to this pin to shutdown PFC stage
J2-2	GND	
J4-1	BK_Shutdown	Apply 3.3 V to this pin to shutdown buck stage
J4-2	GND	
J4-3	PWM Dim	Input for external PWM dimming
J3	On board dim	Short the two pins on J3 to enable on board PWM diming. R26 varies dimming duty cycle

6 Test Procedure

All tests will use the set up described in Section 5 of this user guide. Ensure potentiometer R26 is rotated completely clockwise.

WARNING

HIGH VOLTAGE levels are present on this evaluation module whenever it is energized. Proper precautions must be observed whenever working with this module. There is an energy storage capacitor (C17) on this module which must be discharged before the board can be handled. Serious injury can occur if proper safety procedures are not followed.

6.1 Applying Power to the EVM

1. Set up the EVM as described in Section 5 of this user guide.
2. Ensure the AC source is off.
3. Ensure potentiometer R26 is rotated completely clockwise.
4. Set constant voltage load to between 55 V and 110 V. If using a HB-LED string ensure the voltage drop, when operating, is between 55 V to 110 V nominal. Note the 1000-µF/250 V capacitor is not required on the output if using a HB-LED string.
5. Set AC source to 90 VRMS.
6. Turn on AC source.
7. Monitor PFC output voltage at TP4 and TP5, V2.
8. Monitor output current at A1.
9. Monitor output voltage at V1.
10. The EVM is now ready for testing.

6.2 Line/Load Regulation and Efficiency Measurement Procedure

1. Apply power to the EVM per Section 6.1.
2. Vary the constant voltage load from 110 V to 55 V.
3. Observe output current on A1 stays constant.
4. Vary AC source from 90 VRMS to 264 VRMS.
5. Observe output current on A1 stays constant.
6. PFC inductor ripple current can be measured at CL1 using an oscilloscope and current probe.
7. The buck output inductor current can be measured at CL2 using an oscilloscope and current probe.
8. See Section 7 for some typical test results.

6.3 PFC Disable

1. Ensure the AC source is off.
2. Connect a DC source to J2.
3. Set DC source to 0 V.
4. Apply power to the EVM per Section 6.1.
5. Increase DC source to 3.3 V. This input can accept up to 12 V.
6. Observe PFC output voltage reduces, V2.
7. PFC inductor ripple current looses high frequency component.

6.4 Buck Disable

1. Ensure the AC source is off.
2. Connect a DC source to J4, pins 1 and 2.
3. Set DC source to 0 V.
4. Apply power to the EVM per Section 6.1.
5. Increase DC source to 3.3 V. This input can accept up to 12 V.
6. Observe output current, A1, drops to zero.
7. PFC voltage, V2, does not change.

6.5 Internal Dimming Function

1. Ensure the AC source is off.
2. Ensure jumper is present on J3.
3. Apply power to the EVM per Section 6.1.
4. Rotate R26 potentiometer slowly anti clockwise.
5. Observe output current on A1 reduce from nominal 0.9 A to 0.1 A. If LED string is attached observe LED's dim.

6.6 External Dimming Function

1. Ensure the AC source is off.
2. Ensure jumper is removed from J3.
3. Connect signal generator to J4, pins 3 and 2.
4. Set signal generator to generator a pulse from 0 V to 3.3 V at 200 Hz with variable duty cycle. Note when the PWM signal is high the LED light is reduced. 100% duty cycle will turn LED off.
5. Apply power to the EVM per Section 6.1.
6. Vary the duty cycle of the signal generator output.
7. Observe output current, A1, changes. If an LED string is attached observe LED's dim.

6.7 Configuring the PFC Stage for Fixed Output

The EVM ships configured as a boost follower PFC. Using a soldering iron some simple component modifications can change the PFC configuration from boost follower to fixed output voltage.

1. Remove R1, R3, R4, R6, C1 and Q1.
2. Change R11 to 6.49 kΩ.
3. The EVM now uses a fixed output voltage PFC stage. Repeat tests to see functionality.

6.8 Equipment Shutdown

1. If DC sources are connected to shutdown pins, J2 and J4, ensure they are set to 0 V.
2. Ensure load is at maximum, this will help discharge C17.
3. Turn off AC source.
4. Monitor PFC output voltage V2. Do not handle EVM until V2 reads less than 50 VDC.

7 Performance Data and Typical Characteristic Curves

Figure 4 through Figure 8 present some typical performance curves for the UCC28810EVM-002 with 30 Cree XRE LED's at 900 mA.

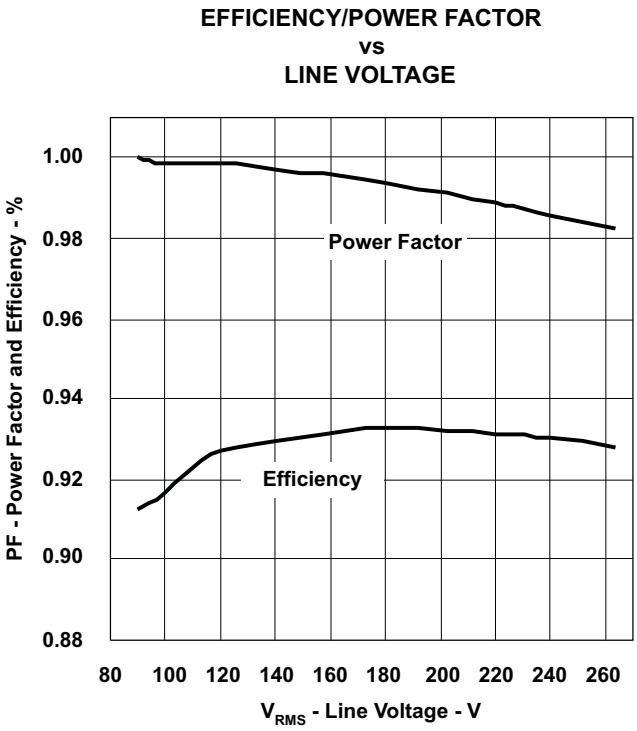

Figure 4.

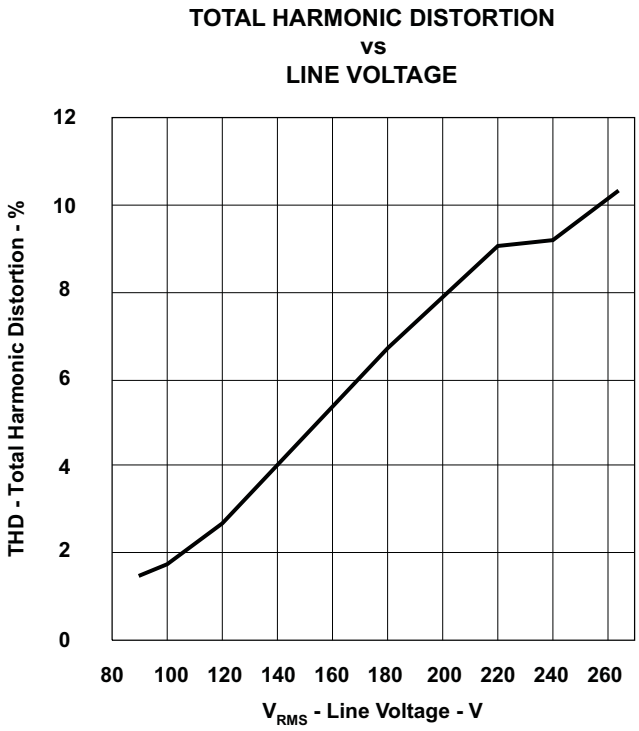

Figure 5.

7.1 Transient

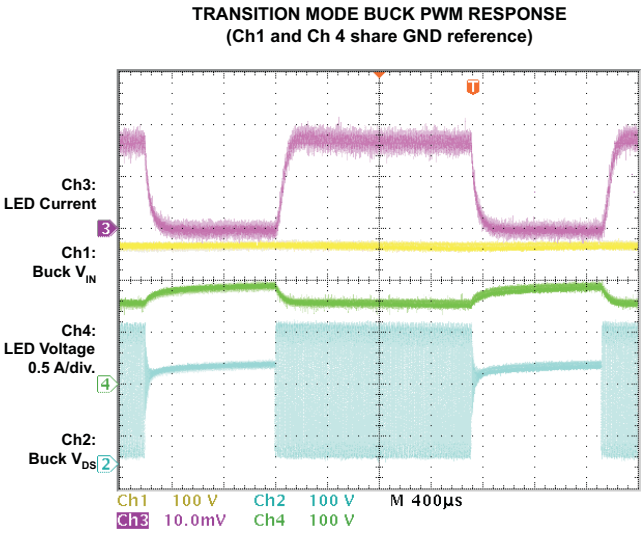

Figure 6.

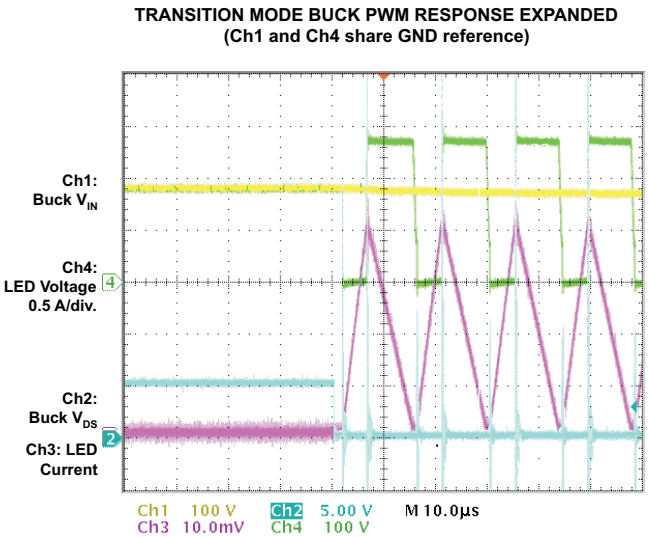

Figure 7.

7.2 Input Current

TRANSITION MODE BUCK PWM AND LINE INPUT CURRENT
(Ch1 and Ch4 share GND reference)

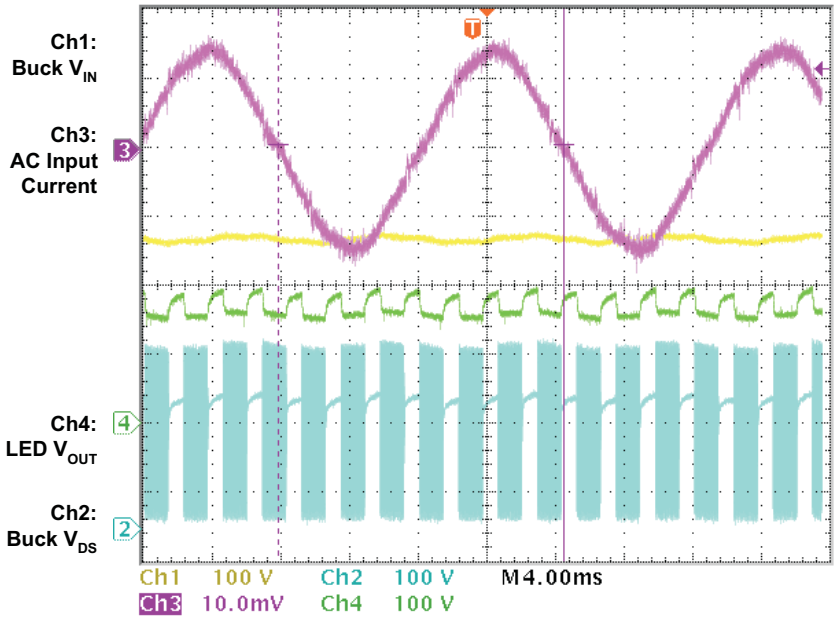

Figure 8.

8 EVM Assembly Drawing and PCB layout

Figure 9 through Figure 11 show the design of the UCC28810EVM-002 printed circuit board.

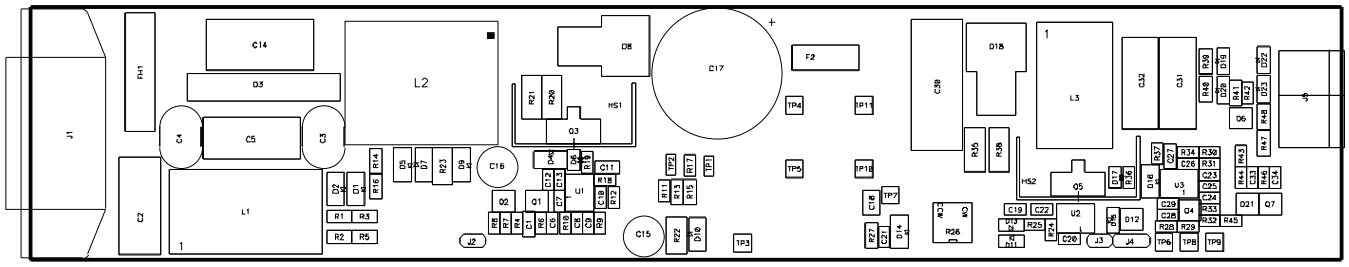

Figure 9. UCC28810EVM-002 Top Layer Assembly Drawing (top view)

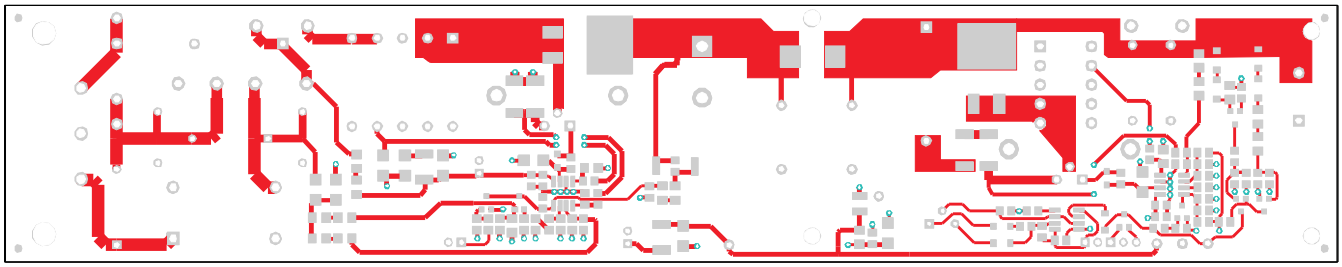

Figure 10. UCC28810EVM-002 Top Copper (top view)

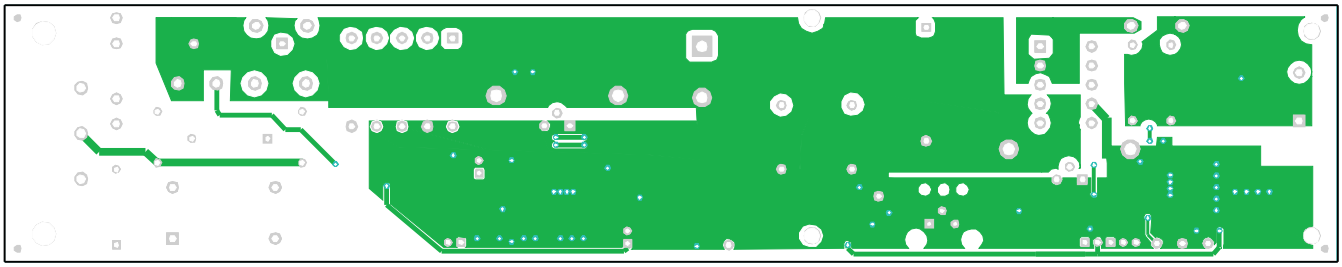

Figure 11. UCC28810EVM-002 Bottom Layer (viewed through top layer)

9 List of Materials

The EVM components list according to the schematic shown in Figure 1 and Figure 2.

Table 3. List of Materials

QTY	REF DES	DESCRIPTION	MFR	PART NUMBER
1	C1	Capacitor, ceramic, 10 µF, 25 V, X5R, 20%, 1206	Std	Std
2	C2, C5	Capacitor, metallized polyester film, 0.1 µF, 275 VAC, 10%, X2, 17.5 mm x 5.5 mm	Std	Std
2	C3, C4	Capacitor, ceramic disc, 1 nF, 250 V, Y1/X1	Panasonic	ECK-ANA102MB
1	C6	Capacitor, ceramic, 2.2 µF, 25 V, X7R, 10%, 0805	Std	Std
6	C7, C9, C10, C21, C23, C25	Capacitor, ceramic, 1 nF, 50 V, NPO, 5%, 0805	Std	Std
1	C8	Capacitor, ceramic, 330 nF, 16 V, X7R, 10%, 0805	Std	Std
1	C11	Capacitor, ceramic, 18 pF, 50 V, NPO, 5%, 1206	Std	Std
3	C12, C28, C34	Capacitor, ceramic, 1 µF, 25 V, X5R, 10%, 0805	Std	Std
3	C13, C20, C29	Capacitor, ceramic, 0.1 µF, 25 V, X7R, 10%, 0805	Std	Std
1	C14	Capacitor, polypropylene film, 0.56 µF, 400 V, 5%	Panasonic	ECW-F4564JL
2	C15, C16	Capacitor, aluminum electrolytic, 100 µF, 35 V, 20%, 6.3 mm x 11.5 mm	Std	Std
1	C17	Capacitor, aluminum electrolytic, 82 µF, 450 V, TS-HB	Panasonic	ECO-S2WB820BA
1	C18	Capacitor, ceramic, 10 µF, 25 V, X7R, 10%, 1210	Std	Std
2	C19, C22	Capacitor, ceramic, 10 nF, 50 V, X7R, 10%, 0805	Std	Std
1	C24	Capacitor, ceramic, 100 pF, 200 V, NPO, 5%, 0805	Std	Std
1	C26	Capacitor, ceramic, 47 pF, 50 V, NPO, 5%, 0805	Std	Std
1	C27	Capacitor, ceramic, 33 pF, 50 V, NPO, 5%, 1206	Std	Std
1	C30	Capacitor, polypropylene film, 0.56 µF, 630 V, 5%	Panasonic	ECW-F6564JL
2	C31, C32	Capacitor, metallized polyester film, 1.0 µF, 250 V, 10%	Panasonic	ECQ-E2105KF
1	C33	Capacitor, ceramic, 470 pF, 50 V, NPO, 5%, 0805	Std	Std
2	CL1, CL2	Current loop, wire, 20 AWG., stranded, 3.0 in.	Std	NA
2	D1, D2	Diode, 1.5 A, 600 V	Std	BYG10J
1	D3	Diode, bridge rectifier, 6 A, 600 V	Std	GBJ606
2	D4, D16	Diode, Schottky, 1.5 A, 30 V	Std	SL13-E3/61T
2	D5, D7	Diode, Schottky, 1 A, 90 V	Std	BYS11-90-E3/TR
2	D6, D17	Diode, switching, 90 V, 225 mA Ifm, high speed	Rohm	1SS355
2	D8, D18	Diode, ultra fast, 8 A, 600 V	IR	HFA08TB60S
2	D9, D10	Diode, Zener, 18 V, 1 W	Std	SMAZ18-13
3	D11, D13, D15	Diode, signal, 300 mA, 75 V, 35 mW	Std	1N4148W
2	D12, D21	Diode, dual Schottky, 200 mA, 30 V	Std	BAT54C
1	D14	Diode, Zener, 5.1 V, 1 W	Std	SMAZ5V1-13-F
4	D19, D20, D22, D23	Diode, Zener, 500 mW, 75 V	Std	MMSZ5267BT1

Table 3. List of Materials (continued)

QTY	REF DES	DESCRIPTION	MFR	PART NUMBER
1	F1	Fuse, SMP, 1.25 A	Bel	SMP 1.25
1	F1	Fuse 250 V UL fast 5 X 20 MM	Std	Std
2	FH1	Fuse clip, 5 x 20 mm, PC mount	Wickmann	01000056H
2	HS1, HS2	Heatsink, TO-220, vertical mount, 15°C/W	Aavid	593002
1	J1	Connector, AC receptacle, board mount, R/A, 9 mm	Qualtek Electronics	703W-00/54
2	J2, J3	Header, male 2 pin, 100-mil spacing, (36-pin strip)	Sullins	PTC36SAAN
1	J4	Header, male 3 pin, 100-mil spacing, (36-pin strip)	Sullins	PTC36SAAN
1	J5	Terminal block, 2 pin 9.52-mm spacing	OST	OSTT7022150
1	L1	Inductor, thru hole, 1.3 A, 126 mΩ	muRata	33331C
1	L2	Transformer, 1 prim, 1 sec, 1 mH, 3.1 A	Coiltronics	CTX16-18484
1	L3	Transformer, 1 prim, 1 sec, 400 µH, 2 A	Coiltronics	CTX33-18428
4	Q1, Q2, Q4, Q7	Transistor, NPN, 75 V, 500 mA	Std	MMBT2222A
1	Q3	MOSFET, N-channel , 400 V, 10 A	IR	IRF840
1	Q5	MOSFET, N-channel, 500 V, 6 A	ST	STP6NK50Z
1	Q6	Bipolar, PNP, -500 V, -500 mA	Zetex	FMMT560
2	R1, R3	Resistor, chip, 301 kΩ, 1/4 W, 1%, 1206	Std	Std
2	R2, R5	Resistor, chip, 1.00 MΩ, 1/4 W, 1%, 1206	Std	Std
1	R4	Resistor, chip, 4.02 kΩ, 1/8 W, 1%, 0805	Std	Std
1	R6	Resistor, chip, 6.19 kΩ, 1/8 W, 1%, 0805	Std	Std
2	R7, R28	Resistor, chip, 4.75 kΩ, 1/8 W, 1%, 0805	Std	Std
6	R8, R11, R29, R30, R33, R44	Resistor, chip, 10.7 kΩ, 1/8 W, 1%, 0805	Std	Std
1	R9	Resistor, chip, 24.3 kΩ, 1/8 W, 1%, 0805	Std	Std
1	R10	Resistor, chip, 6.81 kΩ, 1/8 W, 1%, 0805	Std	Std
1	R12	Resistor, chip, 332 Ω, 1/8 W, 1%, 0805	Std	Std
4	R13, R15, R39, R40	Resistor, chip, 511 kΩ, 1/4 W, 1%, 1206	Std	Std
2	R14, R16	Resistor, chip, 100 kΩ, 1/4 W, 1%, 1206	Std	Std
1	R17	Resistor, chip, 47.5 Ω, 1/8 W, 1%, 0805	Std	Std
2	R18, R37	Resistor, chip, 21.5 kΩ, 1/8 W, 1%, 0805	Std	Std
2	R19, R36	Resistor, chip, 10.0 Ω, 1/8 W, 1%, 0805	Std	Std
2	R20, R35	Resistor, chip, 0.40 Ω, 1 W, 1%, 2512	Std	Std
2	R22, R23	Resistor, chip, 200Ω, 1/2 W, 1%, 1812	Std	Std
2	R24, R42	Resistor, chip, 10.0 kΩ, 1/8 W, 1%, 0805	Std	Std
2	R25, R46	Resistor, chip, 100 kΩ, 1/8 W, 1%, 0805	Std	Std
1	R26	Potentiometer, 3/8 cermet, single turn, flat	Bourns	3362P-504
1	R27	Resistor, chip, 665 Ω, 1/4 W, 1%, 1206	Std	Std

Table 3. List of Materials (continued)

QTY	REF DES	DESCRIPTION	MFR	PART NUMBER
3	R31, R32, R45	Resistor, chip, 15.0 kΩ, 1/8 W, 1%, 0805	Std	Std
1	R34	Resistor, chip, 560 Ω, 1/8 W, 1%, 0805	Std	Std
1	R38	Resistor, chip, 0.47 Ω, 1 W, 1%, 2512	Std	Std
1	R41	Resistor, chip, 4.75 kΩ, 1/4 W, 1%, 1206	Std	Std
1	R43	Resistor, chip, 221 kΩ, 1/8 W, 1%, 0805	Std	Std
2	R47, R48	Resistor, chip, 221 kΩ, 1/4 W, 1%, 1206	Std	Std
1	U1	LED Lighting Power Controller	TI	UCC28810D
1	U2	Timer, Low-Power CMOS	TI	TLC555D
1	U3	LED Lighting Power Controller	TI	UCC28811D
1	--	PCB, 10.4 in x 2 in x 0.062 in	Any	HPA439 REVA
2		Washer, #4, shoulder, nylon	Keystone	
2		Heatpad TO-220 0.009" SP900	Bergquist	SP900S-90
2		Washer, #4 split, ss	Std	Std
2		Nut, #4-40, ss	Std	Std
2		Screw, #4 - 40, SS, 0.5 in.	Std	Std
1	JP1	Connector, jumper, shorting, gold, 0.100"	Sullens	

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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 90 VRMS to 264 VRMS and the output voltage range of 55 VRMS to 110 VRMS.

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 60°C. The EVM is designed to operate properly with certain components above 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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