Using the TPS92010EVM-631

User's Guide

Literature Number: SLUU430C
July 2010–Revised May 2011

A 230-VAC TRIAC Dimmable 6-W LED Driver

1 Introduction

The TPS92010EVM-631 is a TRIAC dimmable LED driver. It can provide 0.325-A constant current to four or five high-brightness LED's. The EVM includes a five-LED load. It is powered from the mains which is rated at 185 V_{RMS} to 265 V_{RMS}. The output current can be modified for constant levels from 0.2 A to 0.7 A.

2 Description

This EVM uses the TPS92010 high-efficiency offline LED lighting driver controller. The power topology is a quasi resonant mode flyback. This makes for a cost competitive solution. This TPS92010 EVM implements a constant current, high-efficiency, low-ripple AC-DC LED lighting driver

Current sensing is done directly via a resistor and op-amp. This in turn drives an opto-coupler which sets the PWM pulses via the TPS92010 to control the output current at a constant level. The design also incorporates a circuit to ensure compatibility with a large number of commonly available TRIAC based dimmers. This circuit monitors the line voltage for TRIAC operation. Then the TRIAC is operating the line voltage is chopped. This information is used by the circuit to reduce the constant output current level thus dimming the LED's. It also applies a current path at the input to ensure the TRIAC triggers correctly.

2.1 Typical Applications

- Household Light Bulb Replacement

2.2 Features

- TRIAC Compatible Dimming
- Low Cost Line Powered LED Driver Solution
- Includes Five HB-LED's as a Sample Load
- Allows Easy Use of Users Own LED Load
- Test Points for LED Voltage and Current
- Accurate Current Sensing to Maintain Constant Current to LED's
- Modifiable Output Current from 0.2 A to 0.7 A, 0.325 A is Default

3 Electrical Performance Specifications

Table 1. Electrical Performance Specifications

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Input Characteristics					
Voltage range (1)		185		265	V_{RMS}
Maximum input current			0.53		A_{RMS}
Output Characteristics					
Output voltage, V_{OUT}		14		17	V_{DC}
Output load current, I_{OUT}	Input voltage = 200 VAC to 265 VAC	0.31	0.325	0.34	A_{DC}
Systems Characteristics					
Efficiency			85%		

(1) Input voltages below 200 VAC may result in reduced output current.

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4 Schematic

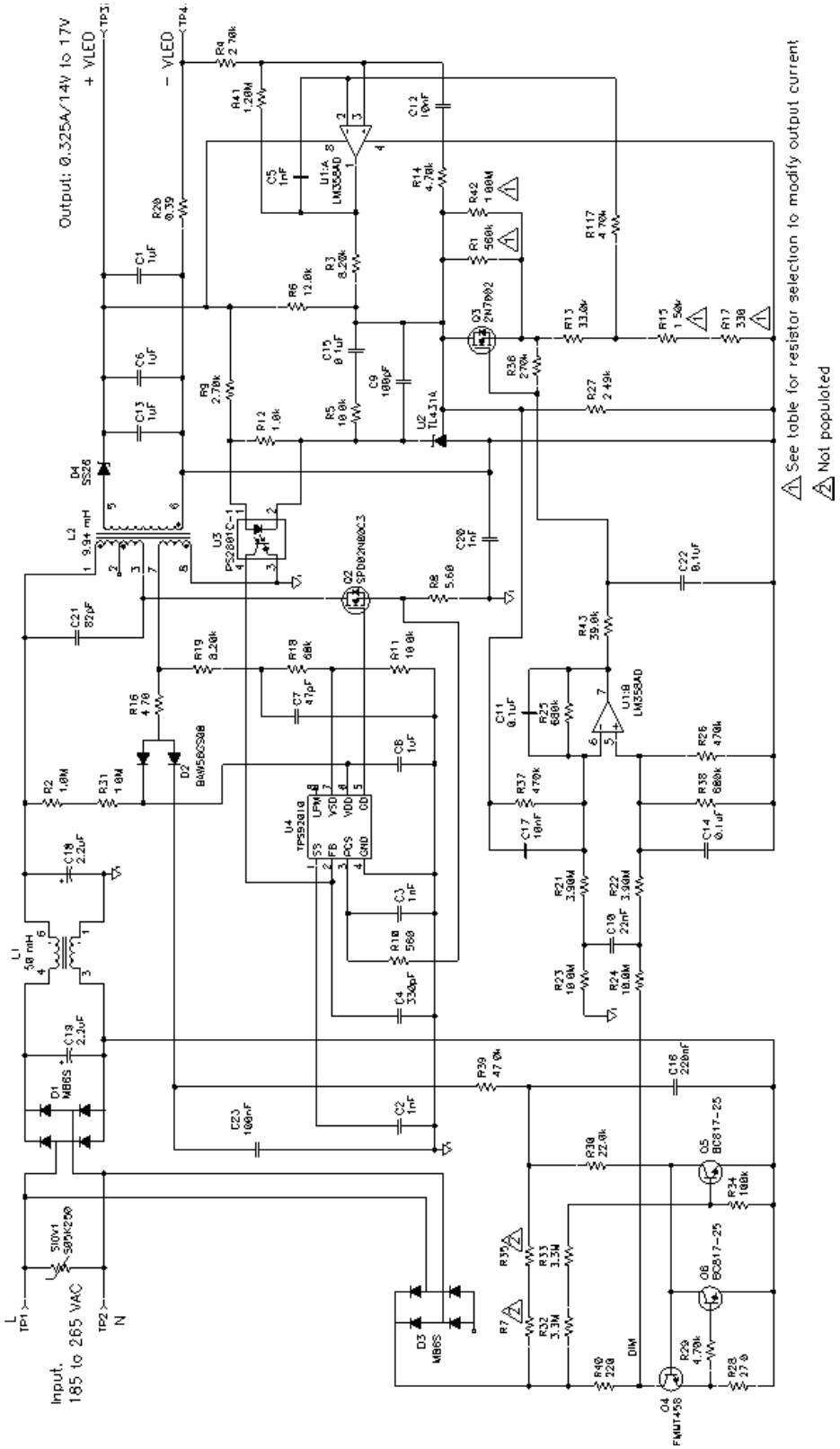


Figure 1. PSU Schematic

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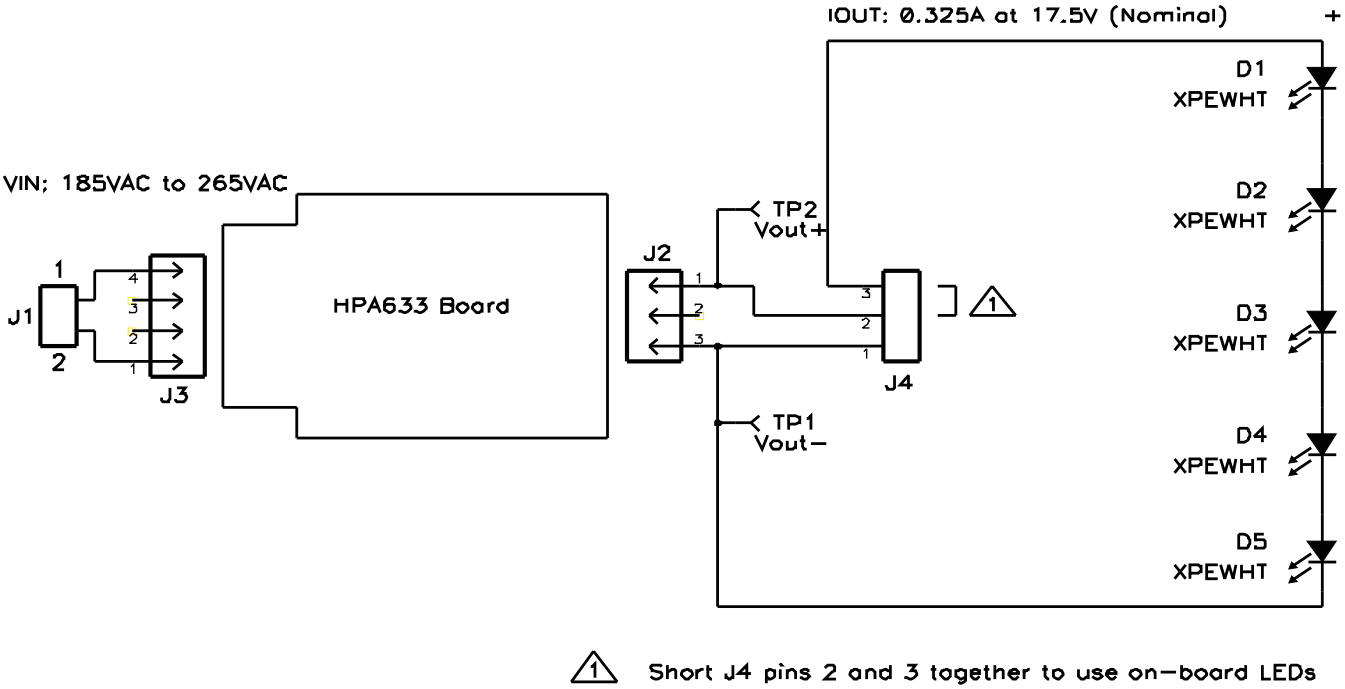


Figure 2. LED Board Schematic

5 Test Setup

5.1 Test Equipment

Voltage Source: 185-V_{RMS} to 265-V_{RMS} AC source.

Multimeters: Voltmeter for up to 20 V_{DC} and an ammeter for up to 1 A

Output Load: Load provided or LED load that sinks 0.325 A_{DC} and has a voltage drop between 14 V_{DC} to 17 V_{DC}

Recommended Wire Gauge: 18 AWG

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5.2 Configuring the Output Current

The TPS92010EVM-631 can be configured for different output current levels. Soldering of 0402 parts is required to do this. Table 2 below shows the resistor values necessary for various current levels. Figure 3 shows the location of these resistors on the top side of the PSU board.

Table 2. Resistor Values to Modify Output Current

MAX OUTPUT CURRENT (mA)	MIN OUTPUT CURRENT (mA)	R15 (Ω)	R17 (Ω)	R1 (kΩ)	R42 (kΩ)
200	10	1000	150	330	1000
225	10	1200	86	390	1000
250	10	1200	220	470	1000
275	10	1000	560	680	680
300	10	1500	220	680	680
325 (1)	10	1500	330	560	1000
350	10	1000	1000	820	1000
400	10	1800	470	1000	1000
450	10	2200	390	1500	1000
500	12	2700	220	1500	1000
600	12	3300	150	1500	1500
700	13	3900	270	2200	1500

(1) 325 mA is the default setting when the EVM is shipped.

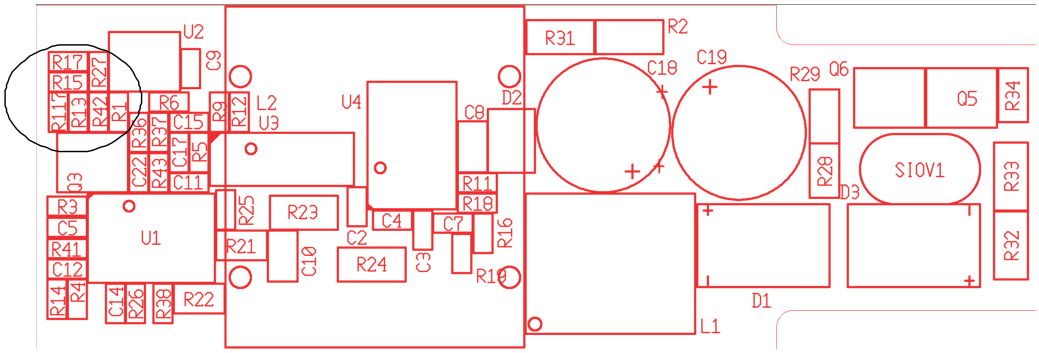


Figure 3. Resistor Locations to Modify Output Current

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5.3 Recommended Test Setup

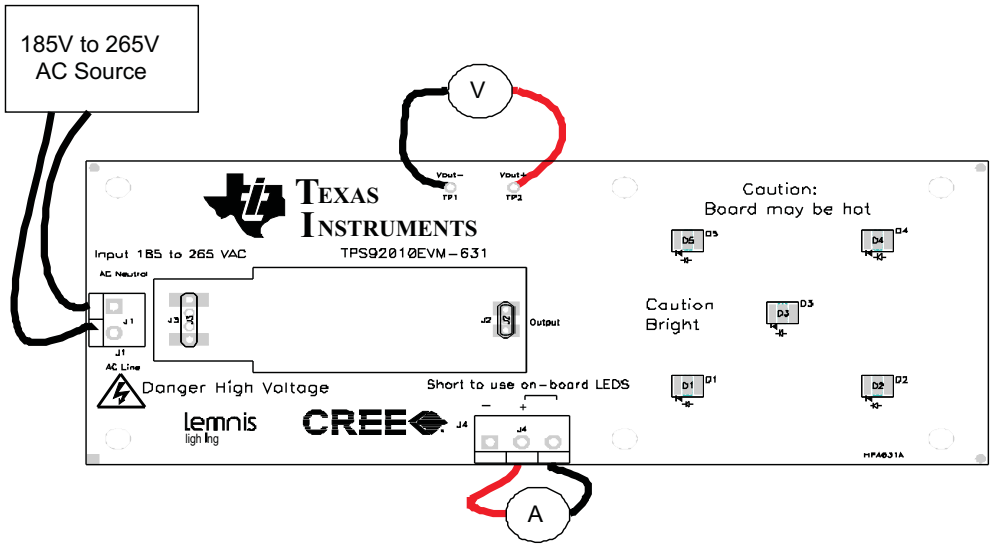


Figure 4. Recommended Test Set Up Using Internal Load

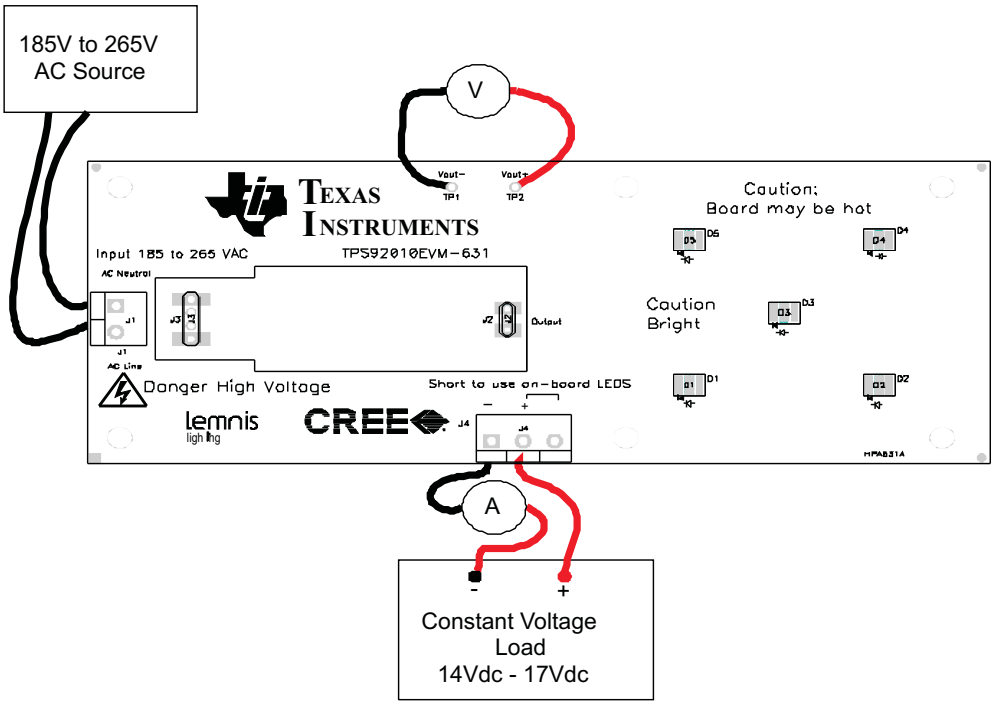


Figure 5. Recommended Test Set Up Using External Load

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6 Test Procedure

CAUTION

CAUTION: High voltages exist on this EVM. Please handle with care. Do not touch EVM when powered.

This EVM allows the user to use one of two different set ups.

1. **Internal Load:** The EVM provides five on-board LED's. To use these a short or ammeter must be connected between pins 2 and 3 of J4, see Figure 4 above
2. **External Load:** If the user wants to validate the EVM with their own load pins 1 and 2 of J4 should be used. Any short between pins 2 and 3 should be removed to avoid damaging the EVM. See Figure 5 above.

WARNING

Do not operate the EVM without a load, see points 1 and 2 above.

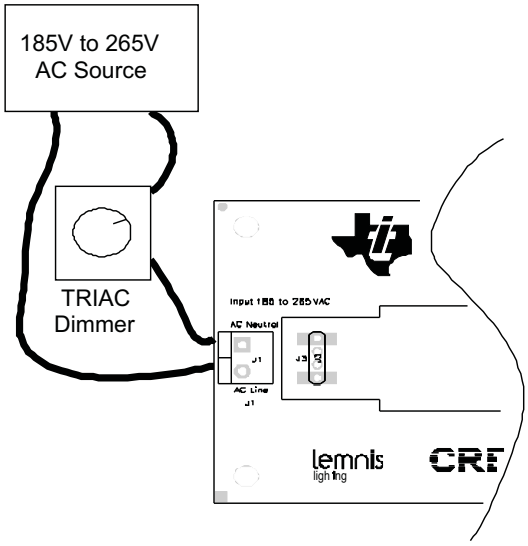
6.1 Line Regulation and Efficiency Measurement Procedure

1. Connect EVM per Figure 4 or Figure 5 above.
2. Set AC source to 185 V_{RMS}.
3. Turn on AC source.
4. Record output voltage reading from V and output current reading from A.
5. Increase output voltage by 5 V_{RMS}.
6. Repeat steps 4 and 5 until you reach 265 V_{RMS}.
7. Shutdown equipment per section 6.3.

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6.2 Verifying Dimming Function

1. Set up the EVM per Figure 4 or Figure 5.
2. Add TRIAC dimmer to the input per Figure 6.
3. Set AC source to 230 V_{RMS}.
4. Set TRIAC to maximum output.
5. Measure output current.
6. Slowly increase TRIAC dimming to minimum output.
7. Observe output current reduces.



Recommended Dimmers

Brand	Model
Gamma	Halogeen dimmer
Merten	5725
Wintop	13112
Jung	244020300
Tradim	31032
Drespa	814
Siemens	5TC8 256
Bush	2250 U
Japan Industrial Co.	FD-25
Merten	5784
Gamma	243489

Figure 6. Test Up Using TRIAC Dimmer

6.3 Equipment Shutdown

1. Turn off AC source.
2. Wait several minutes before handling the EVM.

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7 Performance Data and Typical Characteristic Curves

Figure 7 through Figure 10 present typical performance curves for TPS92010EVM-631.

7.1 Efficiency

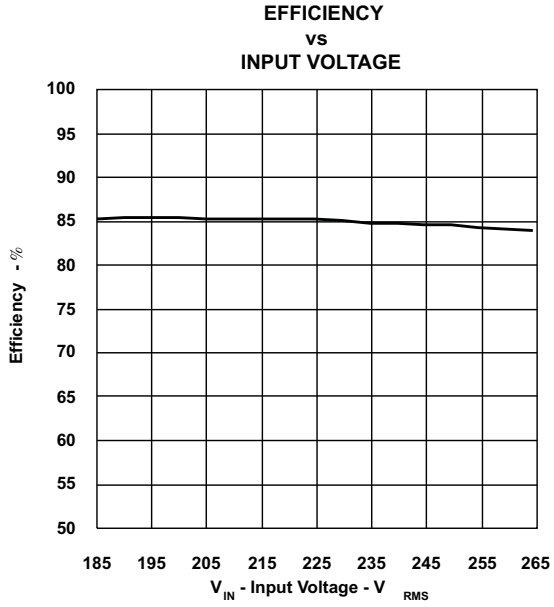


Figure 7. Efficiency

7.2 Line Regulation

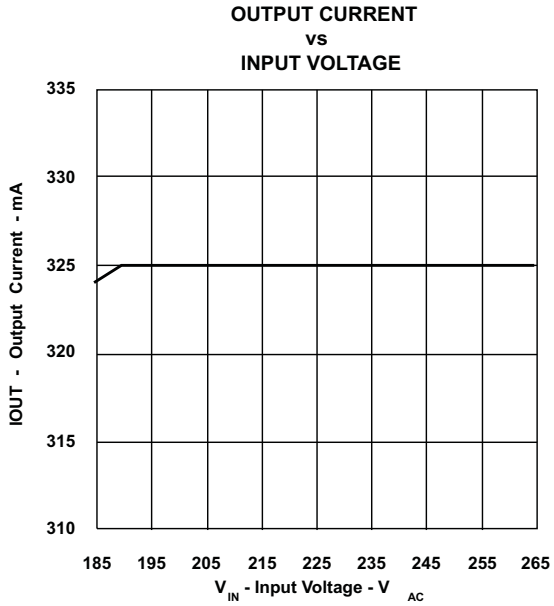


Figure 8. Line Regulation

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7.3 Dimmer Performance

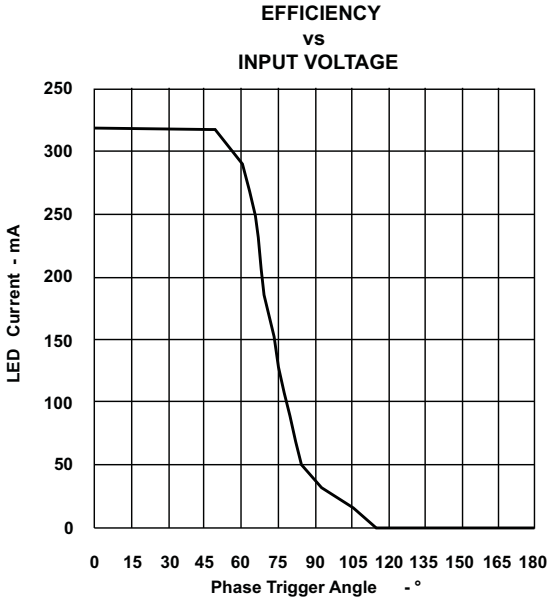


Figure 9. Output Current Versus Dimmer Phase Angle

7.4 Output Current Ripple

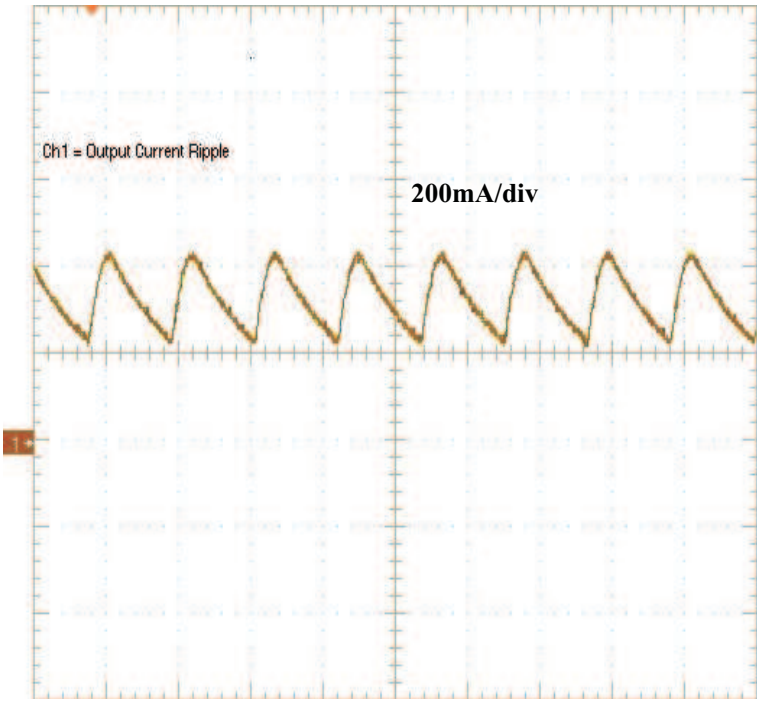


Figure 10. Output Current Ripple with Dimmer at 0% Dim, (10 µs/div.)

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8 EVM Assembly Drawing and PCB layout

The following figures (Figure 11 through Figure 14) show the design of the TPS92010EVM-631 printed circuit board.

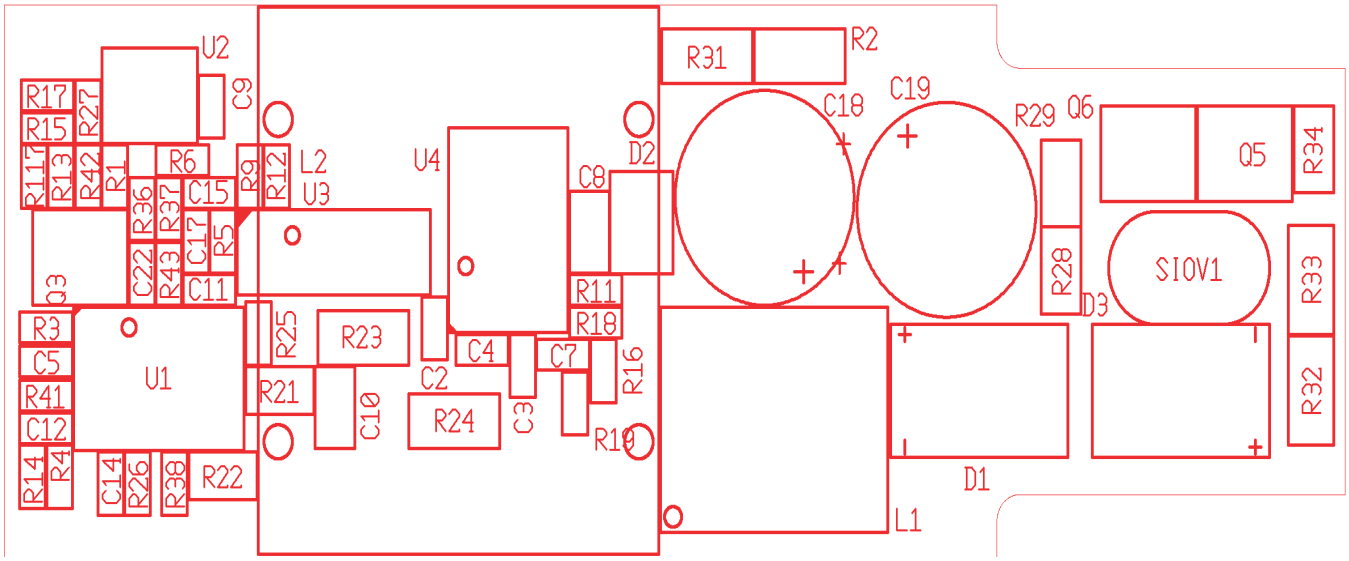


Figure 11. PSU Top Layer Assembly Drawing (top view)

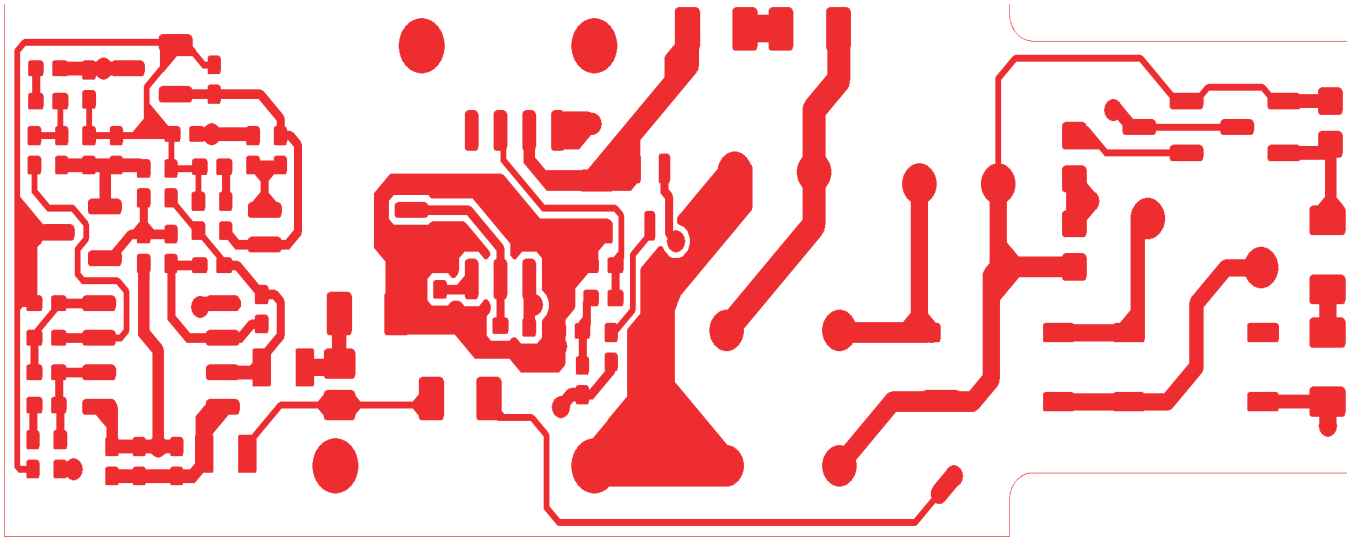


Figure 12. PSU Top Copper (top view)

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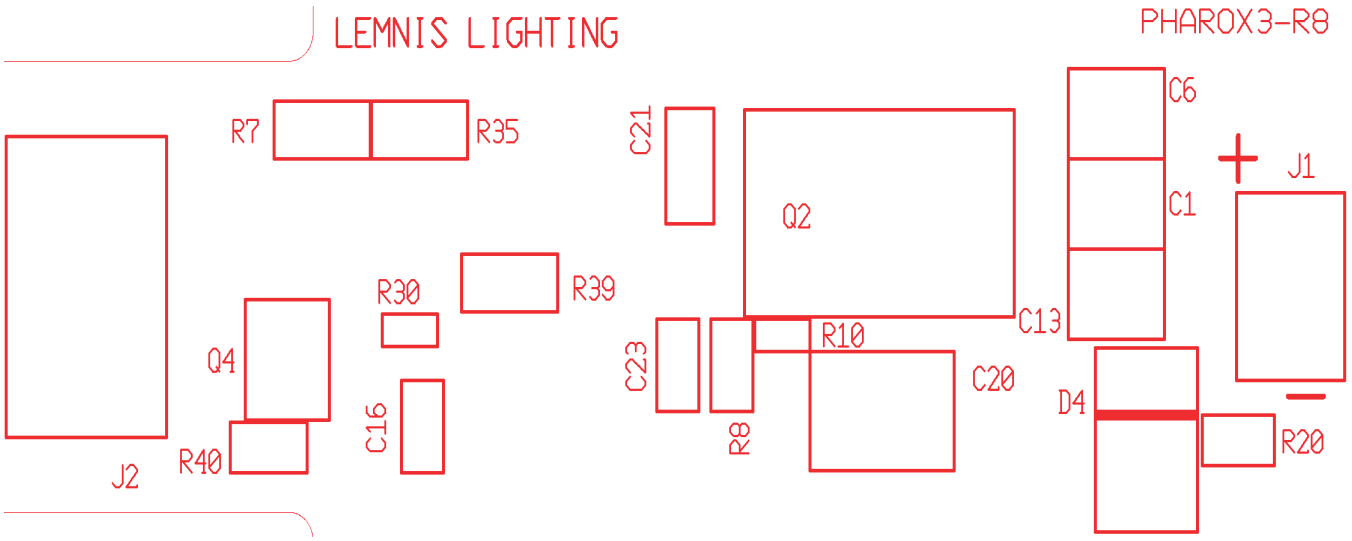


Figure 13. PSU Bottom Assembly Drawing (bottom view)

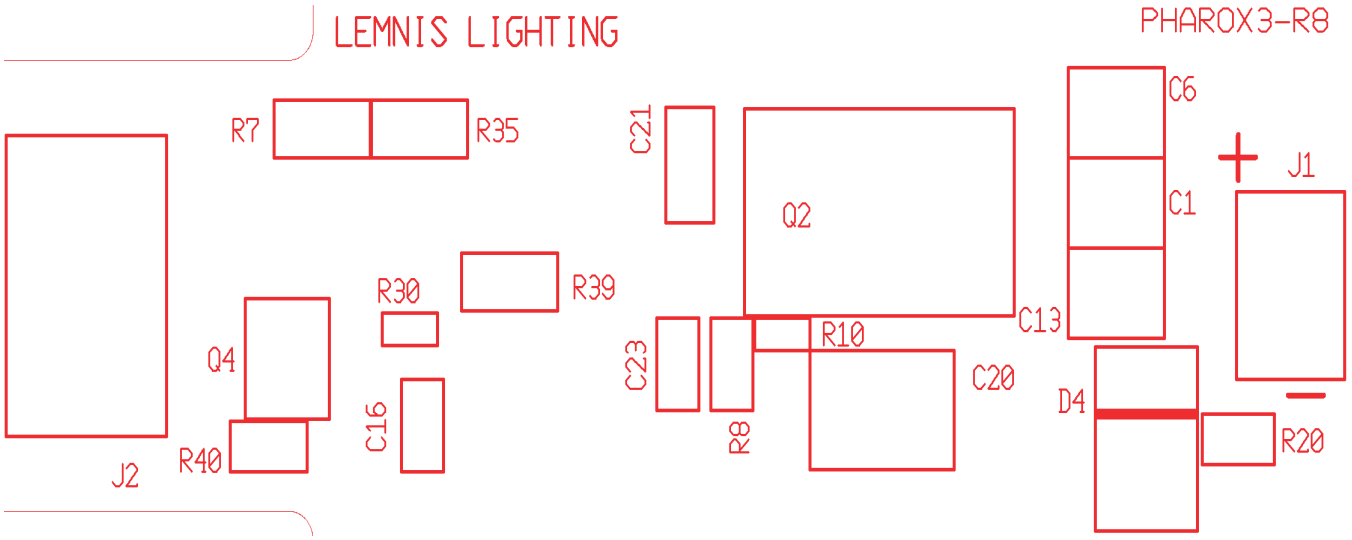


Figure 14. Bottom Copper (bottom view)

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9 List of Materials

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

Table 3. The EVM Components List

QTY	REFDES	DESCRIPTION	MFR	PART NUMBER
3	C1, C6, C13	Capacitor, ceramic, 1 µF, 180 V, X7R, 10%, 1210	Std	Std
1	C10	Capacitor, ceramic, 22 nF, 180 V, X7R, 10%, 0805	Std	Std
3	C11, C14, C15	Capacitor, ceramic, 0.1 µF, 16 V, X5R, 10%, 0402	Std	Std
2	C12, C17	Capacitor, ceramic, 10 nF, 50 V, X7R, 10%, 0402	Std	Std
1	C16	Capacitor, ceramic, 220 nF, 16 V, X7R, 10%, 0603	Std	Std
2	C18, C19	Capacitor, aluminum, 2.2 µF, ±20%, 400 V, 8 mm x 11.5 mm	Nichicon	UCS2G2R2MPDAZH
3	C2, C3, C5	Capacitor, ceramic, 1 nF, 50 V, X7R, 10%, 0402	Std	Std
1	C20	Capacitor, ceramic, 1 nF, X1Y2, 5 kV, X7R, 10%, 1808	Std	Std
1	C21	Capacitor, ceramic, 82 pF, 1000 V, COG, 5%, 1206	Std	Std
1	C22	Capacitor, ceramic, 0.1 µF, 180 V, X5R, 10%, 0402	Std	Std
1	C23	Capacitor, ceramic, 100 nF, 50 V, X7R, 10%, 0603	Std	Std
1	C4	Capacitor, ceramic, 330 pF, 50 V, X7R, 10%, 0402	Std	Std
1	C7	Capacitor, ceramic, 47 pF, 50 V, COG, 5%, 0402	Std	Std
1	C8	Capacitor, ceramic, 1 µF, 25 V, X7R, 10%, 0805	Std	Std
1	C9	Capacitor, ceramic, 100 pF, 50 V, COG, 5%, 0402	Std	Std
2	D1, D3	Diode, bridge rectifier, 0.5 A, x00 V	Fairchild	MB6S
1	D2	Diode, dual , 250 mA, 70 V	Vishay-Liteon	BAW56GS08
1	D4	Diode, Schottky, 2 A, 60 V	STD	STD
1	L1	Inductor, common choke, ±10%	Wurth	750310784
1	L2	Xfmr, flyback	Wurth	750310334
1	Q2	MOSFET, N-channel, 800 V, 2.0 A, 2.7 Ω	Infineon	SPD02N80C3
1	Q3	MOSFET, N-channel, 60 V, 115 mA, 1.2 Ω	Diodes	2N7002
1	Q4	Trans, NPN	Diodes	FMMT458TA
2	Q5, Q6	Trans, NPN	Std	BC817-25

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Table 3. The EVM Components List (continued)

QTY	REFDES	DESCRIPTION	MFR	PART NUMBER
1	R1	Resistor, chip, 560 kΩ, 1/16 W, 1%, 0402	Std	Std
1	R10	Resistor, chip, 560, 1/16 W, 1%, 0402	Std	Std
1	R12	Resistor, chip, 1.0 kΩ, 1/16 W, 5%, 0402	Std	Std
1	R13	Resistor, chip, 33.0 kΩ, 1/16 W, 1%, 0402	Std	Std
2	R14, R117	Resistor, chip, 4.70 kΩ, 1/16 W, 1%, 0402	Std	Std
1	R15	Resistor, chip, 1.50 kΩ, 1/16 W, 1%, 0402	Std	Std
1	R16	Resistor, chip, 4.7 Ω, 1/16 W, 5%, 0402	Std	Std
1	R17	Resistor, chip, 330 Ω, 1/16 W, 1%, 0402	Std	Std
1	R18	Resistor, chip, 68 kΩ, 1/16 W, 5%, 0402	Std	Std
2	R2, R31	Resistor, chip, 1.0 MΩ, 1/4 W, 5%, 1206	Std	Std
1	R20	Resistor, chip, 0.39 Ω, 1/10 W, 1%, 0805	Std	Std
2	R21, R22	Resistor, chip, 3.90 MΩ, 1/10 W, 1%, 0805	Std	Std
2	R23, R24	Resistor, chip, 10.0 MΩ, 1/4 W, 1%, 1206	Std	Std
2	R25, R38	Resistor, chip, 680 kΩ, 1/16 W, 1%, 0402	Std	Std
2	R26, R37	Resistor, chip, 470 kΩ, 1/16 W, 1%, 0402	Std	Std
1	R27	Resistor, chip, 2.49 kΩ, 1/16 W, 1%, 0402	Std	Std
1	R28	Resistor, chip, 27 Ω, 1/16 W, 5%, 0603	Std	Std
1	R29	Resistor, chip, 4.70 kΩ, 1/16 W, 1%, 0603	Std	Std
2	R3, R19	Resistor, chip, 8.20 kΩ, 1/16 W, 1%, 0402	Std	Std
1	R30	Resistor, chip, 22.0 kΩ, 1/16 W, 1%, 0402	Std	Std
2	R32, R33	Resistor, chip, 3.3 MΩ, 1/4 W, 5%, 1206	Std	Std
1	R34	Resistor, chip, 100 kΩ, 1/16 W, 1%, 0603	Std	Std
0	R7, R35	Resistor, chip, 1/4 W, 5%, 1206	Std	Std
1	R36	Resistor, chip, 270 kΩ, 1/16 W, 1%, 0402	Std	Std
1	R39	Resistor, chip, 47.0 kΩ, 1/4 W, 1%, 1206	Std	Std
2	R4, R9	Resistor, chip, 2.70 kΩ, 1/16 W, 1%, 0402	Std	Std
1	R40	Resistor, chip, 220 Ω, 1/16 W, 5%, 0603	Std	Std
1	R41	Resistor, chip, 1.20 MΩ, 1/16 W, 1%, 0402	Std	Std
1	R42	Resistor, chip, 1.50 MΩ, 1/16 W, 1%, 0402	Std	Std
1	R43	Resistor, chip, 39.0 kΩ, 1/16 W, 1%, 0402	Std	Std
2	R5, R11	Resistor, chip, 10.0 kΩ, 1/16 W, 1%, 0402	Std	Std
1	R6	Resistor, chip, 12.0 kΩ, 1/16 W, 1%, 0402	Std	Std
1	R8	Resistor, chip, 5.6 Ω, 1/16 W, 5%, 0603	Std	Std
1	SIOV1	Varistor, disk, 250 V, 1 W, T_A at 85°C	Epcos	SIOV-S05K250
1	U1	Dual Operational Amplifiers	TI	LM358AD
1	U2	Diode, Adjustable Shunt Regulator, 2.49 V to 36 V, 20 mA,	TI	TL431A
1	U3	High Isolation Voltage Photocoupler	CEL	PS2801C-1-A
1	U4	8-Pin, High-Efficiency, Offline LED Lighting Controller	TI	TPS92010
1	--	PCB, 60 mm x 20.6 mm x 1.62 mm	Any	HPA594
LED Load Board (HPA631)				
5	D1, D2, D3, D4, D5	HBLED, 0.7 A, 3.9 V	Cree	XPEWHT-L1-0000-00BE7

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 185 V to 265 V and the output voltage range of .

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 60° 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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