Using the TPS92010EVM-592 TRIAC Dimmable 6-W LED Driver

The TPS92010EVM-592 is a TRIAC dimmable LED driver. It can provide a 0.325-A constant current to four or five high-brightness LEDs. The EVM includes a five-LED load. It is powered from the mains which is rated at 100 Vrms to 130 Vrms. The output current can be modified for constant levels from 0.2 A to 0.7 A.

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1 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 is sensed directly via a resistor and operational-amplifier. 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. When 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 LEDs. It also applies a current path at the input to ensure the TRIAC triggers correctly and maintains triggered condition.

1.1 Typical Applications

- Household light bulb replacement

1.2 Features

- TRIAC compatible dimming
- Low-cost line powered LED driver solution
- Includes 5 HB-LEDs as a sample load
- Allows easy use of user own LED load
- Test points for LED voltage and current
- Accurate current sensing to maintain constant current to LEDs
- Modifiable output current from 0.2 A to 0.7 A, 0.325 A is default

2 Electrical Performance Specifications

Table 1 gives the EVM performance specifications and qualifications.

Table 1. TPS92010EVM-592 Electrical Performance Specifications

SPECIFICATION		TEST CONDITIONS	MIN	TYP	MAX	UNITS
INPUT						
V_{IN}	Input voltage range		100		130	V_{RMS}
I_{MAX}	Maximum input current			132		mA_{RMS}
OUTPUT						
V_{OUT}	Output voltage		14		18	V_{DC}
I_{OUT}	Output current		310	325	340	mA_{DC}
SYSTEM						
η	Efficiency			84%		

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3 Schematic

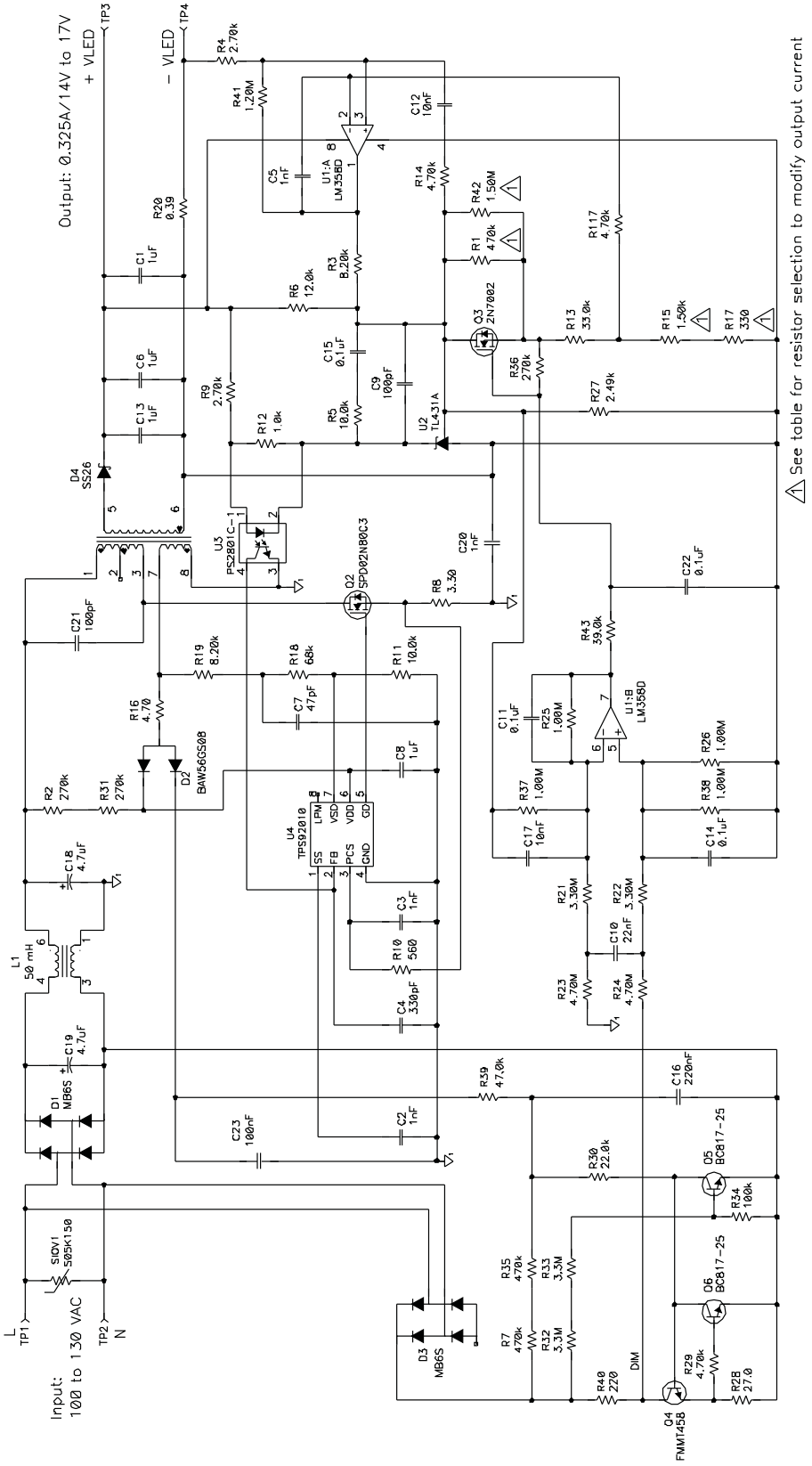


Figure 1. TPS92010EVM-592 PSU (HPA594) Schematic

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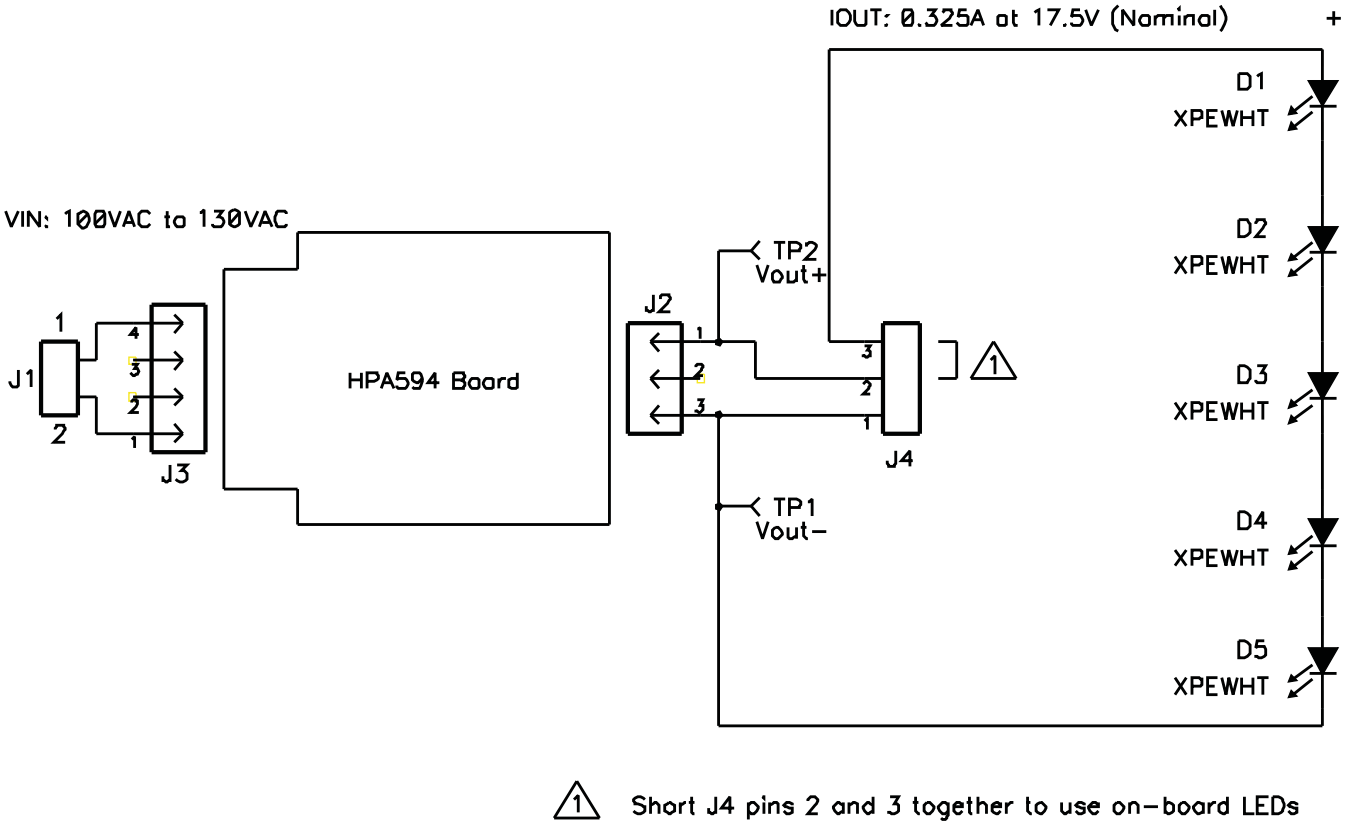


Figure 2. TPS92010EVM-592 LED Load Board Schematic

4 Test Setup

4.1 Test Equipment

Connect test equipment and TPS51125AEVM board as shown in Section 4.3.

4.1.1 Voltage Source

100 Vrms to 130 Vrms AC source.

4.1.2 Multimeters

Voltmeter for up to 20 Vdc and an ammeter for up to 1 A.

4.1.3 Ouptut Load

Load provided or LED load that sinks 0.325 Adc and has a voltage drop between 14 Vdc to 18 Vdc.

4.1.4 Recommended Wire Gauge

18 AWG.

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4.2 Configuring the Output Current

The TPS92010EVM-592 can be configured for different output current levels by soldering the 0402 parts. 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

MAXIMUM OUTPUT CURRENT (mA)	MINIMUM OUTPUT CURRENT (mA)	R15 (kΩ)	R17 (Ω)	R1 (kΩ)	R42 (MΩ)
200	10	1.00	150	330	1.00
225	10	1.20	86	390	1.00
250	10	1.20	220	470	1.00
275	10	1.00	560	680	0.68
300	10	1.50	220	680	0.68
325[1]	10	1.50	330	470	1.50
350	10	1.00	1000	820	1.00
400	10	1.80	470	1000	1.00
450	10	2.20	390	1500	1.00
500	12	2.70	220	1500	1.00
600	12	3.30	150	1500	1.50
700	13	3.90	270	2200	1.50

(1) EVM default setting.

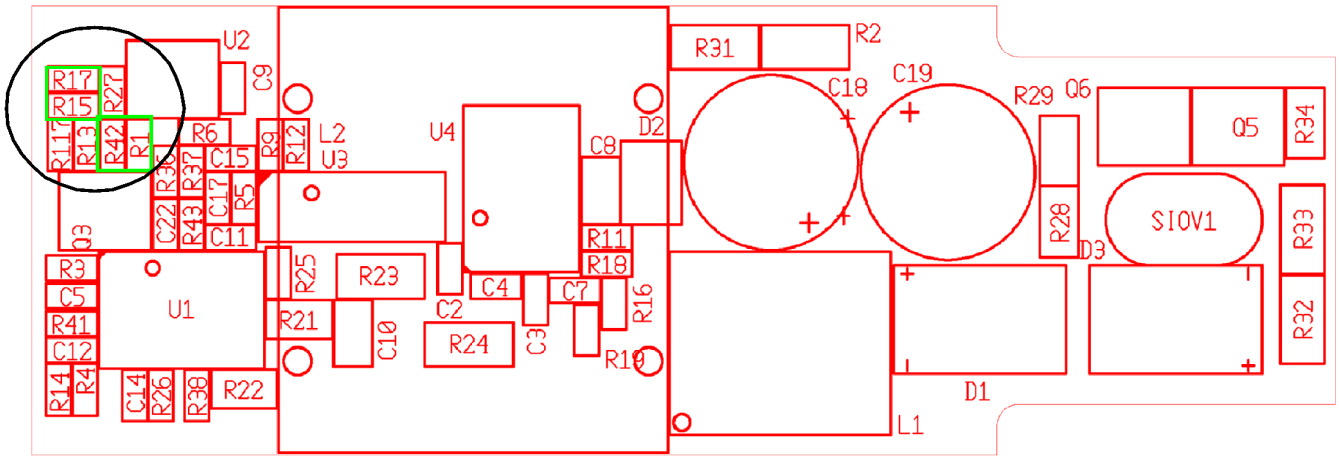


Figure 3. Resistor Locations Modify Output Current

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4.3 Recommended Test Setup

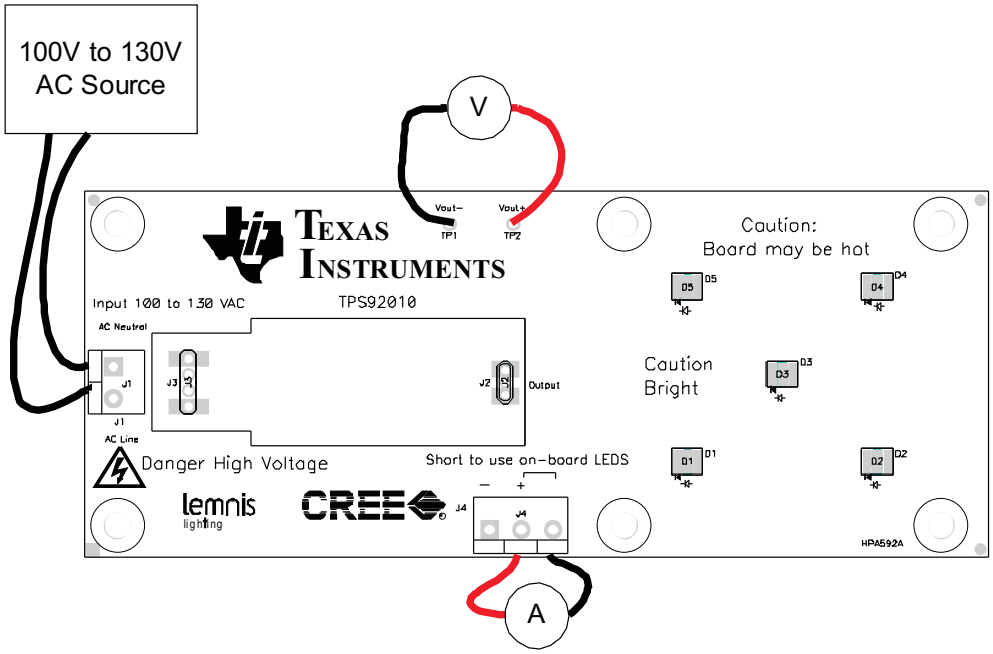


Figure 4. Recommended Test Set-Up Using Internal Load

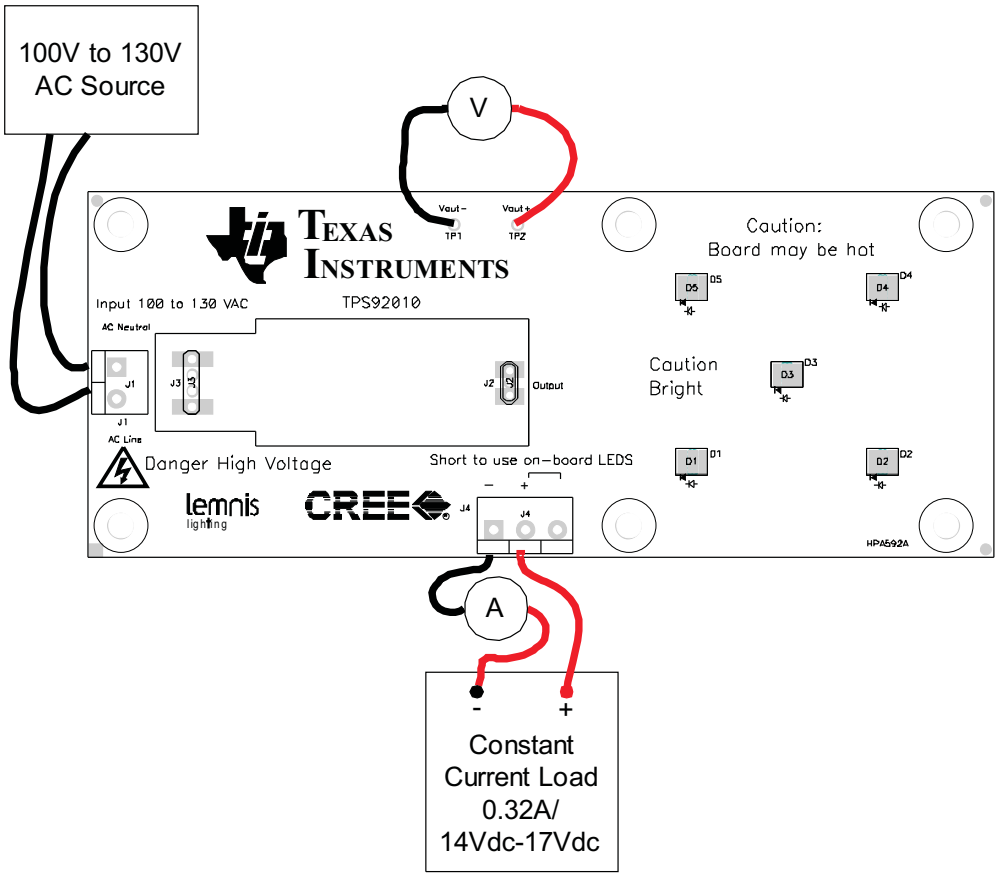


Figure 5. Recommended Test Set-Up using External Load

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5 Test Procedure

CAUTION

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

The user can set up the EVM in two different ways, with either an internal load or with an external load.

5.1 Internal Load

The EVM provides five on-board LEDs. A short or ammeter must be connected between pins 2 and 3 of J4, see Figure 3.

5.2 External Load

To validate the EVM with an external 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.

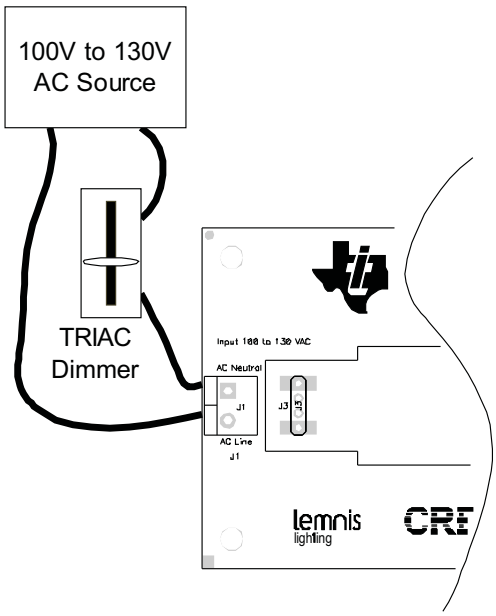
5.3 Line Regulation and Efficiency Measurement Procedure

1. Connect EVM per Figure 4 or Figure 5 .
2. Set AC source to 100 Vrms.
3. Turn on AC source.
4. Record output voltage reading from voltmeter and output current reading from ammeter
5. Increase output voltage by 5 Vrms
6. Repeat steps 4 and 5 until 130 Vrms is reached
7. Shutdown equipment per Figure 5 .

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5.4 Verifying Dimming Function

Figure 6 shows the recommended test set-up usig the TRIAC dimmer.



Recommended Dimmers

Brand	Model
Leviton	6615-POW
Leviton	decora
Lutron	D-603PH-DK
Lutron	S-600PEH-WH
Leviton	057
Lutron	DL-600PL
Lutron	DV-603P
Leviton	6631-LW

Figure 6. Recommended Test Set-Up Using TRIAC Dimmer

5.4.1 Equipment Start-Up

1. Set up the EVM per Figure 4 or Figure 5.
2. Add TRIAC dimmer to the input as shown in Figure 6.
3. Set AC source to 120 Vrms.
4. Set TRIAC to maximum output.
5. Measure output current.
6. Slowly slide TRIAC dimmer to minimum output.
7. Observe output current reduces.

5.4.2 Equipment Shut-Down

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

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6 Performance Data and Typical Characteristic Curves

Figure 7 through Figure 10 show typical performance curves for the TPS92010EVM-592.

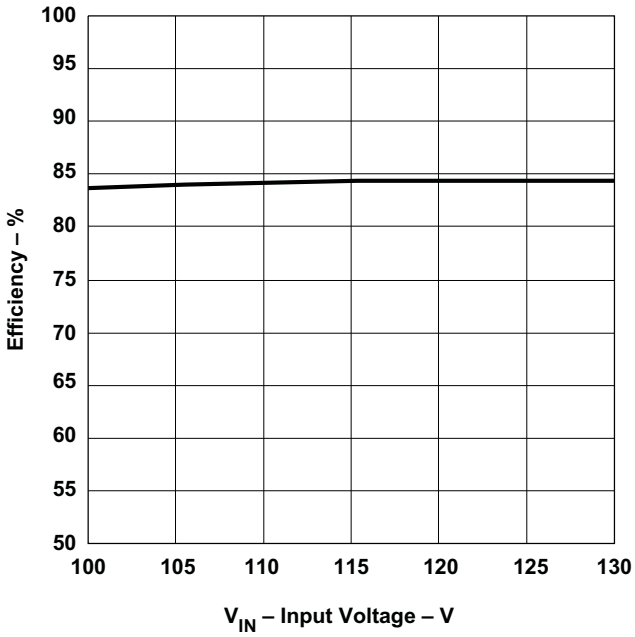


Figure 7. Efficiency vs. Input Voltage

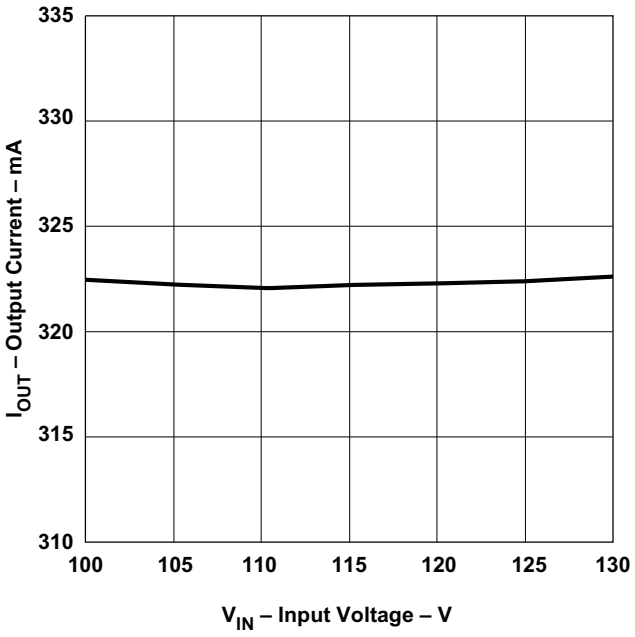


Figure 8. Line Regulation

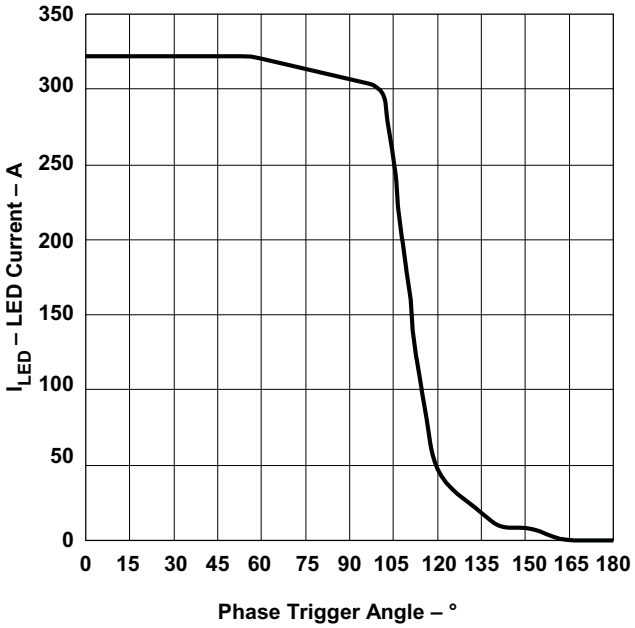


Figure 9. TPS92010EVM-592 Output Current vs Dimmer Phase Angle

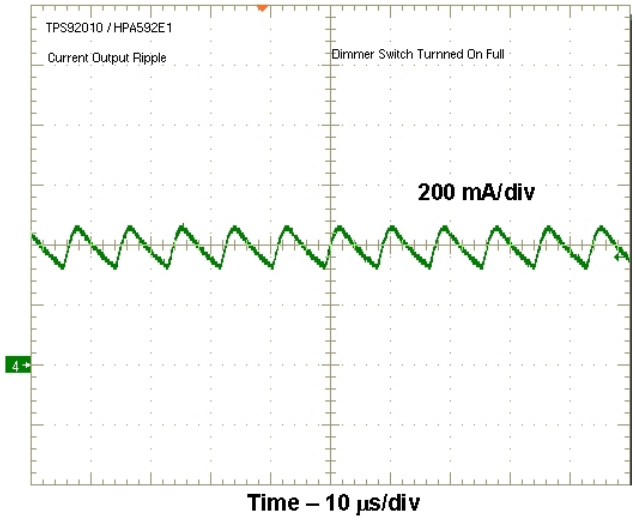


Figure 10. TPS92010EVM-592 Output Current Ripple with Dimmer at 0% Dim

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7 List of Materials

List of materials for the TPS92010EVM-592.

Table 3. TPS92010EVM-592 List of Materials

REFERENCE DESIGNATOR	QTY	DESCRIPTION	MANUFAC	PART NUMBER
C1, C6, C13	3	Capacitor, ceramic, 1 µF, 100 V, X7R, 10%, 1210	Std	Std
C2, C3, C5	3	Capacitor, ceramic, 1 nF, 50 V, X7R, 10%, 0402	Std	Std
C4	1	Capacitor, ceramic, 330 pF, 50 V, X7R, 10%, 0402	Std	Std
C7	1	Capacitor, ceramic, 47 pF, 50 V, COG, 5%, 0402	Std	Std
C8	1	Capacitor, ceramic, 1 µF, 25 V, X7R, 10%, 0805	Std	Std
C9	1	Capacitor, ceramic, 100 pF, 50 V, COG, 5%, 0402	Std	Std
C10	1	Capacitor, ceramic, 22 nF, 100 V, X7R, 10%, 0805	Std	Std
C11, C14, C15	3	Capacitor, ceramic, 0.1 µF, 16 V, X5R, 10%, 0402	Std	Std
C12, C17	2	Capacitor, ceramic, 10 nF, 50 V, X7R, 10%, 0402	Std	Std
C16	1	Capacitor, ceramic, 220 nF, 16 V, X7R, 10%, 0603	Std	Std
C18, C19	2	Capacitor, Aluminum, 4.7 µF, ±20%, 250V, , 8 x 11.5 mm	Rubycon	250BXC4.7M8X11.5
C20	1	Capacitor, ceramic, 1 nF, X1Y2, 5kV, X7R, 10%, 1808	Std	Std
C21	1	Capacitor, ceramic, 100 pF, 1000 V, COG, 5%, 1206	Std	Std
C22	1	Capacitor, ceramic, 0.1 µF, 100 V, X5R, 10%, 0402	Std	Std
C23	1	Capacitor, ceramic, 100 nF, 50 V, X7R, 10%, 0603	Std	Std
D1, D3	2	Diode, bridge rectifier, 0.5 A, x 00 V	Fairchild	MB6S
D2	1	Diode, dual , 250-mA, 70 V	Vishay-Liteon	BAW56GS08
D4	1	Diode, Schottky, 2-A, 60-V	STD	STD
L1	1	Inductor, common choke, ±10%	Wurth	750310784
L2	1	Xfmr, flyback	Wurth	750310787
Q2	1	MOSFET, N-channel, 800 V, 2.0 A, 2.7 Ω	Infineon	SPD02N80C3
Q3	1	MOSFET, N-channel, 60 V, 115 mA, 1.2 Ω	Diodes	2N7002
Q4	1	Transistor, NPN	Diodes	FMMT458TA
Q5, Q6	2	Transistor, NPN	Std	BC817-25
R1	1	Resistor, chip, 470 kΩ, 1/16W, 1%, 0402	Std	Std
R10	1	Resistor, chip, 560 Ω, 1/16W, 1%, 0402	Std	Std
R12	1	Resistor, chip, 1.0 Ωk, 1/16W, 5%, 0402	Std	Std
R13	1	Resistor, chip, 33.0 kΩ, 1/16W, 1%, 0402	Std	Std
R14, R117	2	Resistor, chip, 4.70 kΩ, 1/16W, 1%, 0402	Std	Std
R15	1	Resistor, chip, 1.50 kΩ, 1/16W, 1%, 0402	Std	Std
R16	1	Resistor, chip, 4.7 Ω, 1/16W, 5%, 0402	Std	Std
R17	1	Resistor, chip, 330 Ω, 1/16W, 1%, 0402	Std	Std
R18	1	Resistor, chip, 68 kΩ, 1/16W, 5%, 0402	Std	Std
R2, R31	2	Resistor, chip, 270 kΩ, 1/4W, 5%, 1206	Std	Std
R20	1	Resistor, chip, 0.39 Ω, 1/10W, 1%, 0805	Std	Std
R21, R22	2	Resistor, chip, 3.30 MΩ, 1/10W, 1%, 0805	Std	Std
R23, R24	2	Resistor, chip, 4.70 MΩ, 1/4W, 1%, 1206	Std	Std
R25, R26, R37, R38	4	Resistor, chip, 1.00 MΩ, 1/16W, 1%, 0402	Std	Std
R27	1	Resistor, chip, 2.49 kΩ, 1/16W, 1%, 0402	Std	Std
R28	1	Resistor, chip, 27 Ω, 1/16W, 5%, 0603	Std	Std
R29	1	Resistor, chip, 4.70 kΩ, 1/16W, 1%, 0603	Std	Std
R3, R19	2	Resistor, chip, 8.20 kΩ, 1/16W, 1%, 0402	Std	Std
R30	1	Resistor, chip, 22.0 kΩ, 1/16W, 1%, 0402	Std	Std

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Table 3. TPS92010EVM-592 List of Materials (continued)

REFERENCE DESIGNATOR	QTY	DESCRIPTION	MANUFAC	PART NUMBER
R32, R33	2	Resistor, chip, 3.3 MΩ, 1/4W, 5%, 1206	Std	Std
R34	1	Resistor, chip, 100 kΩ, 1/16W, 1%, 0603	Std	Std
R7, R35	2	Resistor, chip, 470 kΩ, 1/4W, 5%, 1206	Std	Std
R36	1	Resistor, chip, 270 kΩ, 1/16W, 1%, 0402	Std	Std
R39	1	Resistor, chip, 47.0 kΩ, 1/4W, 1%, 1206	Std	Std
R4, R9	2	Resistor, chip, 2.70k, 1/16W, 1%, 0402	Std	Std
R40	1	Resistor, chip, 220 Ω, 1/16W, 5%, 0603	Std	Std
R41	1	Resistor, chip, 1.20 MΩ, 1/16W, 1%, 0402	Std	Std
R42	1	Resistor, chip, 1.50 MΩ, 1/16W, 1%, 0402	Std	Std
R43	1	Resistor, chip, 39.0 kΩ, 1/16W, 1%, 0402	Std	Std
R5, R11	2	Resistor, chip, 10.0 kΩ, 1/16W, 1%, 0402	Std	Std
R6	1	Resistor, chip, 12.0 kΩ, 1/16W, 1%, 0402	Std	Std
R8	1	Resistor, chip, 3.3 Ω, 1/16W, 5%, 0603	Std	Std
SIOV1	1	Varistor, disk, 150 V, 1W, TA @ 85C°	Epcos	SIOV-S05K150
U1	1	IC, dual operational amplifiers	TI	LM358AD
U2	1	Diode, adjustable shunt regulator, 2.49 V to 36 V, 20 mA	TI	TL431A
U3	1	IC, high-isolation voltage photocoupler	CEL	PS2801C-1-A
U4	1	IC, 8-pin high-efficiency, offline LED lighting controller	TI	TPS92010
--	1	PCB, 60 mm x 20.6 mm x 1.62 mm	Any	HPA594
LOAD MATERIALS				
D1, D2, D3, D4, D5	5	HB-LED, 0.7 A (maximum), 3.9 Vdc	Cree	XPEWHT-L1-0000-00BE7

8 References

TPS92010 Datasheet, High Efficiency Offline LED Lighting Driver Controller (SLUSA14)

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