THE DATASHEET OF

TPS61166EVM-446

TPS92410EVM-002 Offline LED Driver Evaluation Module

User's Guide

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Contents

1 Introduction **4**
2 Warnings and Cautions **4**
3 Description **5**
3.1 Typical Applications 5
3.2 Connector Descriptions 5
4 Electrical Performance Specifications **6**
5 TPS92410EVM-002 Schematic **7**
6 Performance Data and Typical Characteristic Curves **8**
6.1 Power Factor 8
6.2 Line Regulation 8
6.3 Output Current 9
6.4 Drain Overvoltage (DOV) Event (160-V Stack Shorted then Released) 9
6.5 Input Voltage and Input Current 10
6.6 Linear Regulator Drain Voltage and Input Current 10
6.7 Triac Dimming Waveforms 11
6.8 EMI Performance 14
7 TPS92410EVM-002 PCB Layout **15**
8 Bill of Materials **16**

List of Figures

1 TPS92410EVM-002 Schematic 7
2 Power Factor Versus Input Voltage 8
3 Input (Linear Regulator) Current Versus Input Voltage 8
4 160-V Stack (Top), 80-V Stack (Middle), and 40-V Stack (Bottom) 9
5 Drain Voltage (Top), DOV Pin Voltage (Middle), and Input Current (Bottom) 9
6 Input Voltage (Top) and Input Current (Bottom) 10
7 Drain Voltage (Top) and Input Current (Bottom) 10
8 Forward Phase Triac Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Full 11
9 Forward Phase Triac Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Half 11
10 Forward Phase Triac Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Low 12
11 Reverse Phase Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Full 12
12 Reverse Phase Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Half 13
13 Reverse Phase Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Low 13
14 Conducted EMI Performance 14
15 Top Layer and Top Overlay (Top View) 15
16 Bottom Layer and Bottom Overlay (Bottom View) 15

List of Tables

1 TPS92410EVM-002 Electrical Performance Specifications 6
2 TPS92410EVM-002 Bill of Materials 16

Switch Controlled Direct Drive Linear Controller for Offline LED Drivers

1 Introduction

The TPS92410EVM-002 evaluation module (EVM) helps designers evaluate the operation and performance of the TPS92410 direct drive linear controller designed for use with the TPS92411 in offline LED-drive applications. The TPS92410 is designed to control the drive of high-brightness light emitting diodes (LEDs) and features a wide input voltage range (9.5 V to 400 V), thermal foldback, analog dimming capability, and linear FET overvoltage protection.

2 Warnings and Cautions

Observe the following precautions when using the TPS92410EVM-002.

WARNING

High Voltage

CAUTION

DO NOT STARE DIRECTLY INTO THE LED LIGHT SOURCE. Intense light sources have a high secondary blinding effect. A temporary reduction in visual acuity and afterimages can occur, leading to irritation, annoyance, visual impairment, and even accidents – depending on the situation. Always consider the use of light filtering and darkening protective eyewear and be fully aware of surrounding laboratory type set-ups when viewing intense light sources to minimize or eliminate such risks in order to avoid accidents related to temporary blindness.

WARNING

Do not stare at the operating LED – (Risk Group 1 (RG1)). See IEC32471-1 ed1.0:2009-08 for risk group definitions.

3 Description

The TPS92410EVM-002 provides a high-brightness LED driver based on the TPS92410 in conjunction with the TPS92411 direct drive switch. It is designed to operate with an input voltage in the range of 190 VAC to 260 VAC with a 230 VAC nominal input voltage. This input voltage range is typical for offline applications. The EVM is set up for a default input current of 50 mA for 11.5 W total power and 3 LED voltage stacks of 40 V, 80 V, and 160 V. The TPS92410 helps provide high efficacy, good power factor, low THD, and flicker-free triac and phase dimming, due to its dimmer detect function that switches the input current mode to a DC level.

3.1 Typical Applications

This converter design describes an application of the TPS92410 as an LED driver controller with the specifications listed in Section 4. For applications with a different input voltage range or different output voltage range, refer to the TPS92410 datasheet (SLUSBW9) and the TPS92411 datasheet (SLUSBQ6).

3.2 Connector Descriptions

This section describes the connectors and test points on the EVM and how to properly connect, setup, and use the TPS92410EVM-002.

3.2.1 J1

The screw down connector J1 is for the input voltage supply to the LED driver. The leads to the input supply should be twisted and kept as short as possible to minimize voltage drop, inductance, and EMI transmission. The input is not polarized. Line and neutral may be connected to either terminal.

3.2.2 VPx, VSx, ISx

The test points VP1, VS1, IS1, VP2, VS2, IS2, VP3, VS3, and IS3 are for testing the different LED stack voltages and currents. For example, connect a voltmeter from VP1 to IS1 across the 1-Ω resistor, R2, to measure the current in the top (160 V) LED string (1 mV = 1 mA). Connect a voltmeter from VP1 to VS1 to measure the top stack voltage. The middle and lower stack currents and voltages can be measured in the same way using the test points labeled with 2 and 3, respectively.

3.2.3 ADIM

The test point ADIM connects directly to the ADIM pin of the TPS92410. The voltage range is 0 V to 3 V. Applying a voltage between 1.5 V and 3 V allows the internal reference to take over, resulting in a 1.5-V reference at the CS pin. Applying a voltage below 1.5 V results in the applied voltage being the reference at the CS pin down to 50 mV. Below 50 mV, the linear regulator is disabled and the GDL pin is pulled to ground.

4 Electrical Performance Specifications

Table 1 contains the electrical performance specifications for the EVM.

Table 1. TPS92410EVM-002 Electrical Performance Specifications

Parameter	Test Conditions	MIN	TYP	MAX	Units
Input Characteristics					
Voltage range		190	230	260	VAC
Maximum input current			50		mA
Output Characteristics					
Output voltage, V_{OUT}	Upper LED stack		160		V
	Middle LED stack		80		
	Lower LED stack		40		
Flicker Index			0.03		
Output current ripple percent			12		%
Output current ripple	Each stack		12		mApp
Overvoltage protection level	Each individual TPS92411P		100		V
Linear FET overvoltage protection level			51		V
Systems Characteristics					
Efficiency	Input voltage = 230 VAC, No triac dimmer		80		%
Power factor	Input voltage = 230 VAC, No triac dimmer		0.97		
THD	Input voltage = 230 VAC, No triac dimmer		10.5		%

5 TPS92410EVM-002 Schematic

Figure 1 illustrates the TPS92410EVM-002 schematic.

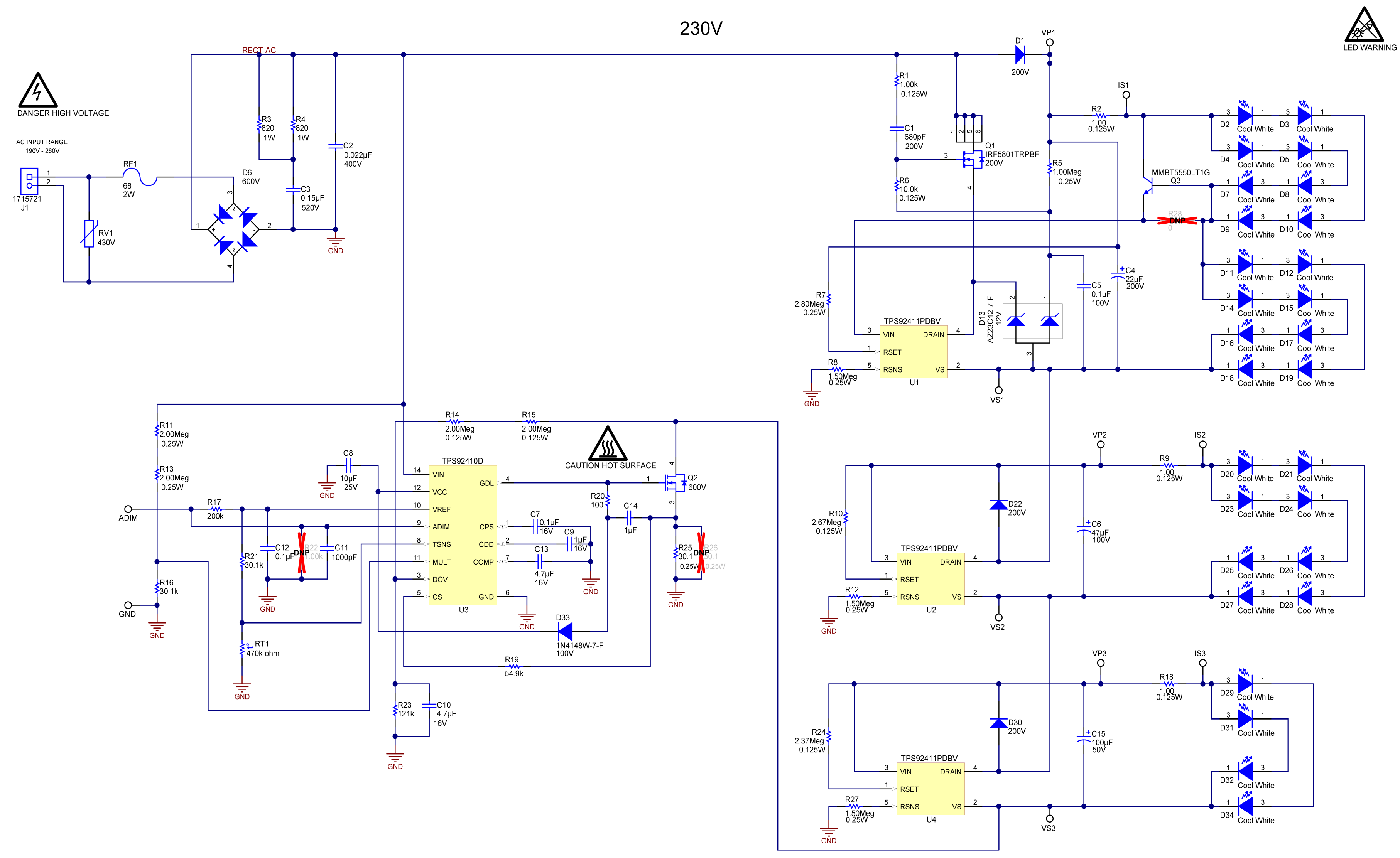

Figure 1. TPS92410EVM-002 Schematic

6 Performance Data and Typical Characteristic Curves

Figure 2 through Figure 13 present typical performance curves for the TPS92410EVM-002.

6.1 Power Factor

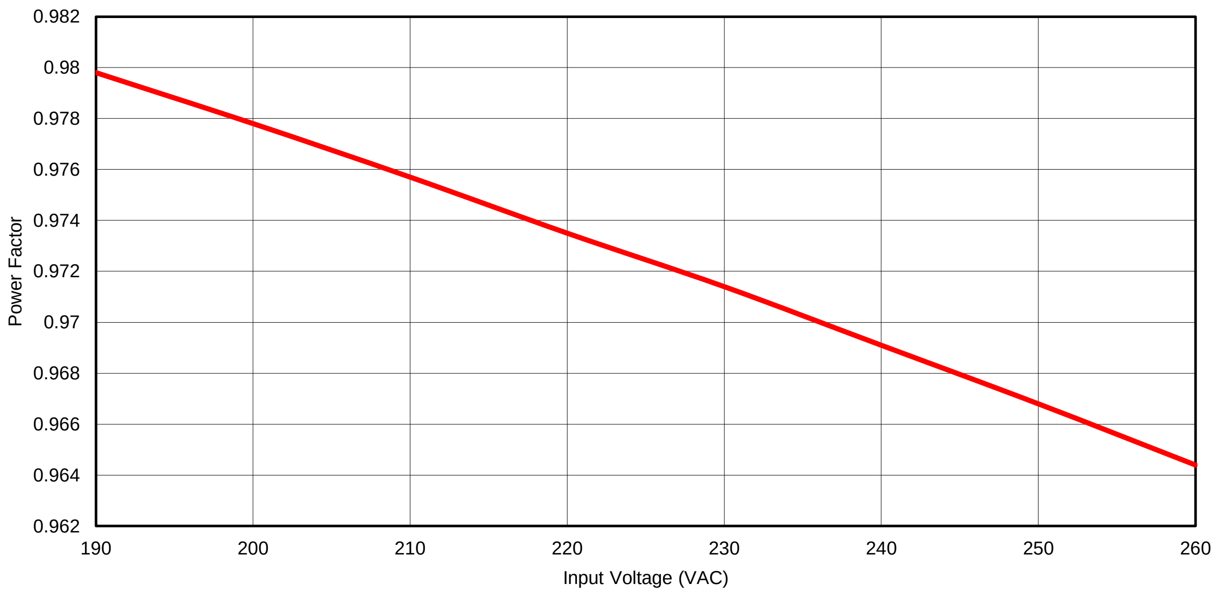

Figure 2. Power Factor Versus Input Voltage

6.2 Line Regulation

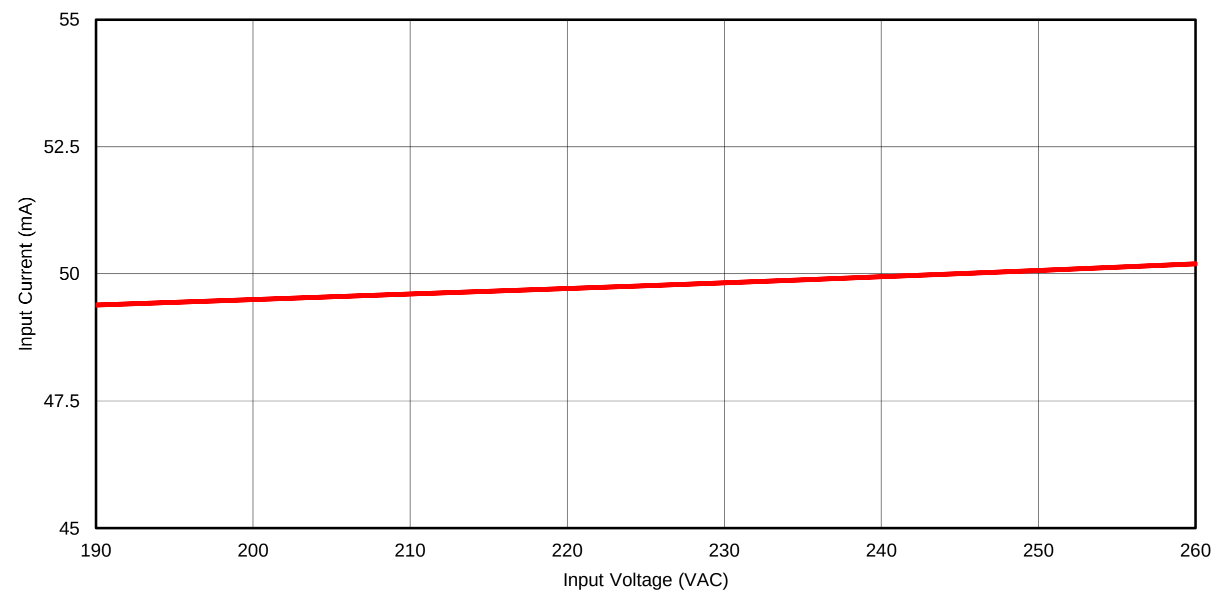

Figure 3. Input (Linear Regulator) Current Versus Input Voltage

6.3 Output Current

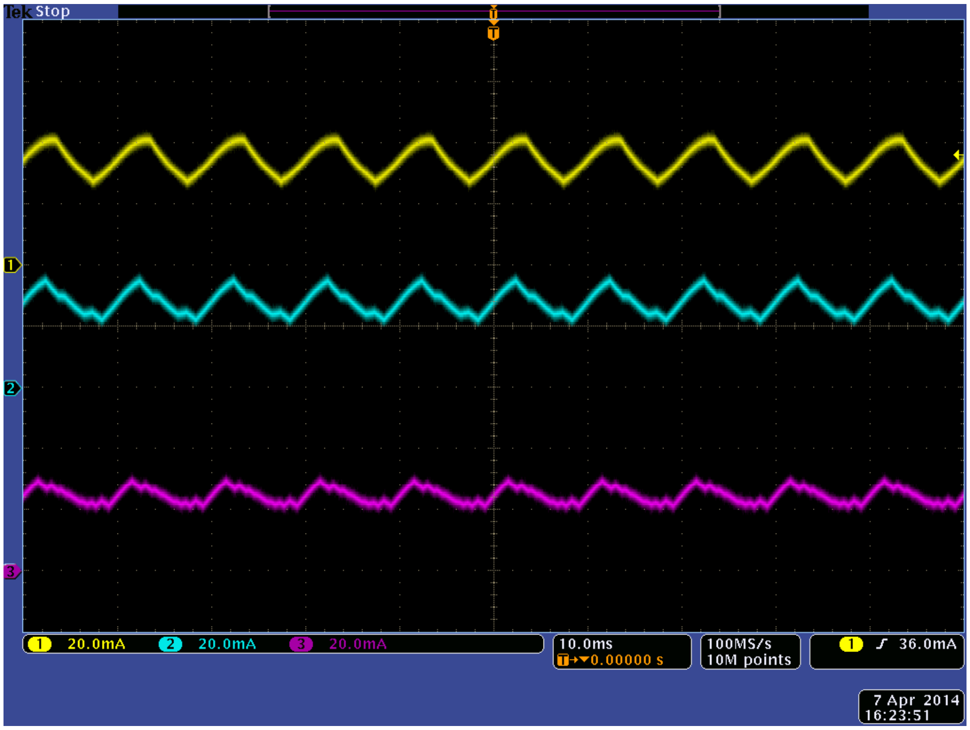

Figure 4. 160-V Stack (Top), 80-V Stack (Middle), and 40-V Stack (Bottom)

6.4 Drain Overvoltage (DOV) Event (160-V Stack Shorted then Released)

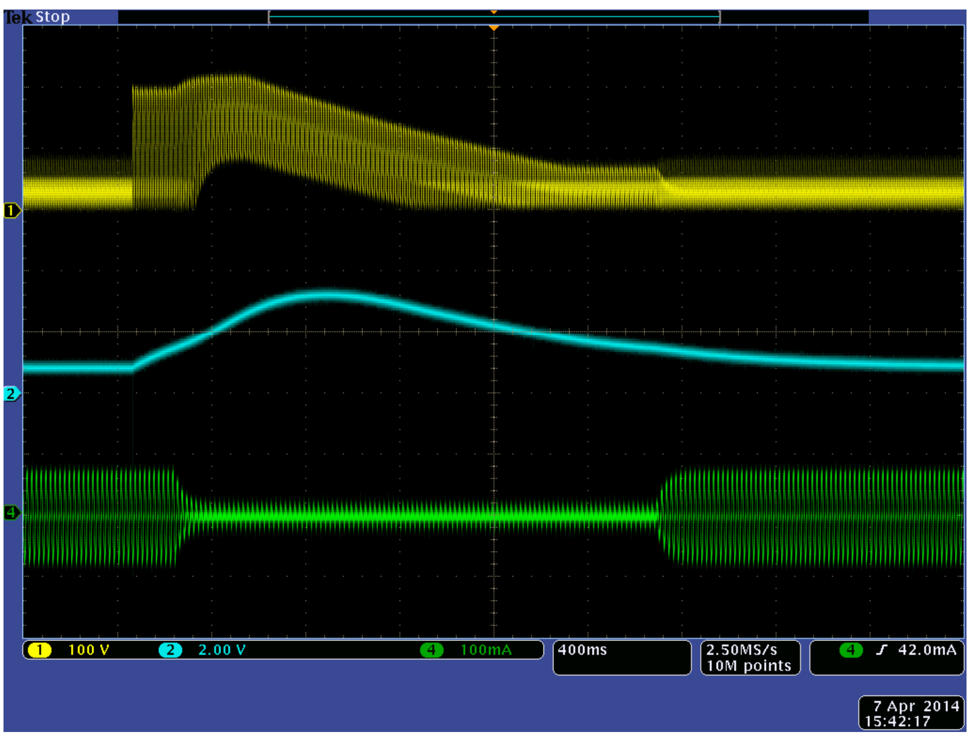

Figure 5. Drain Voltage (Top), DOV Pin Voltage (Middle), and Input Current (Bottom)

6.5 Input Voltage and Input Current

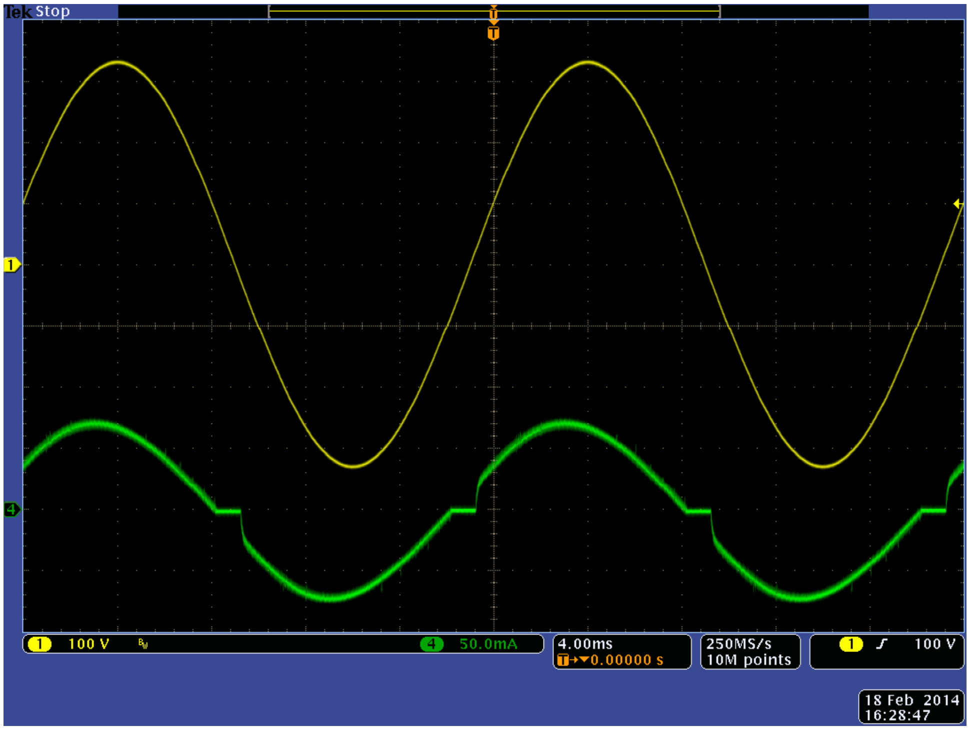

Figure 6. Input Voltage (Top) and Input Current (Bottom)

6.6 Linear Regulator Drain Voltage and Input Current

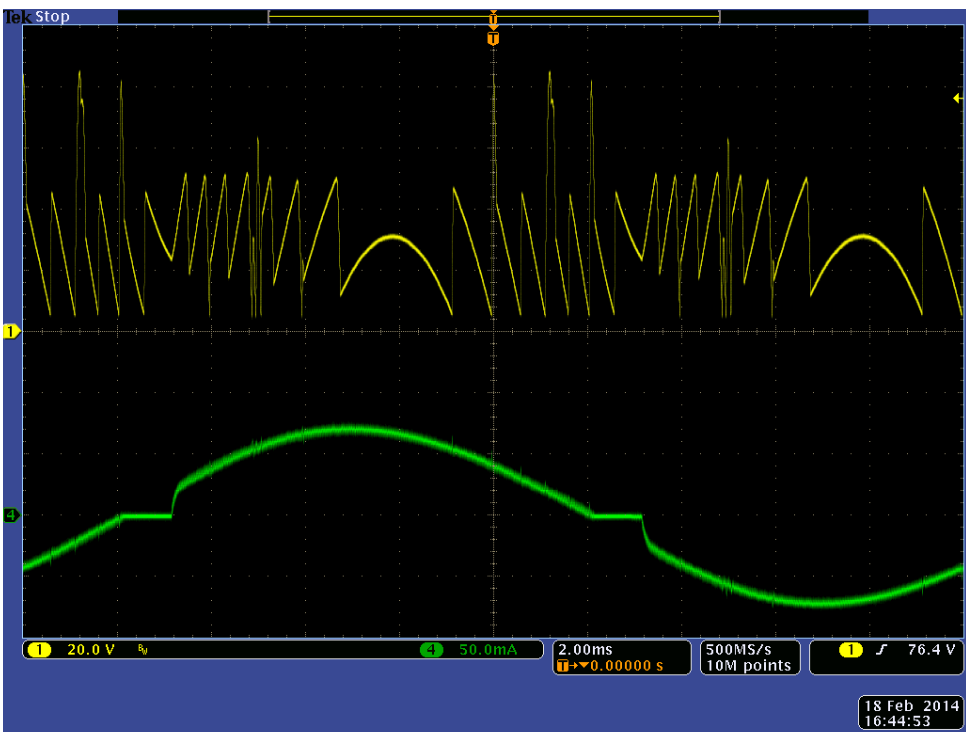

Figure 7. Drain Voltage (Top) and Input Current (Bottom)

6.7 Triac Dimming Waveforms

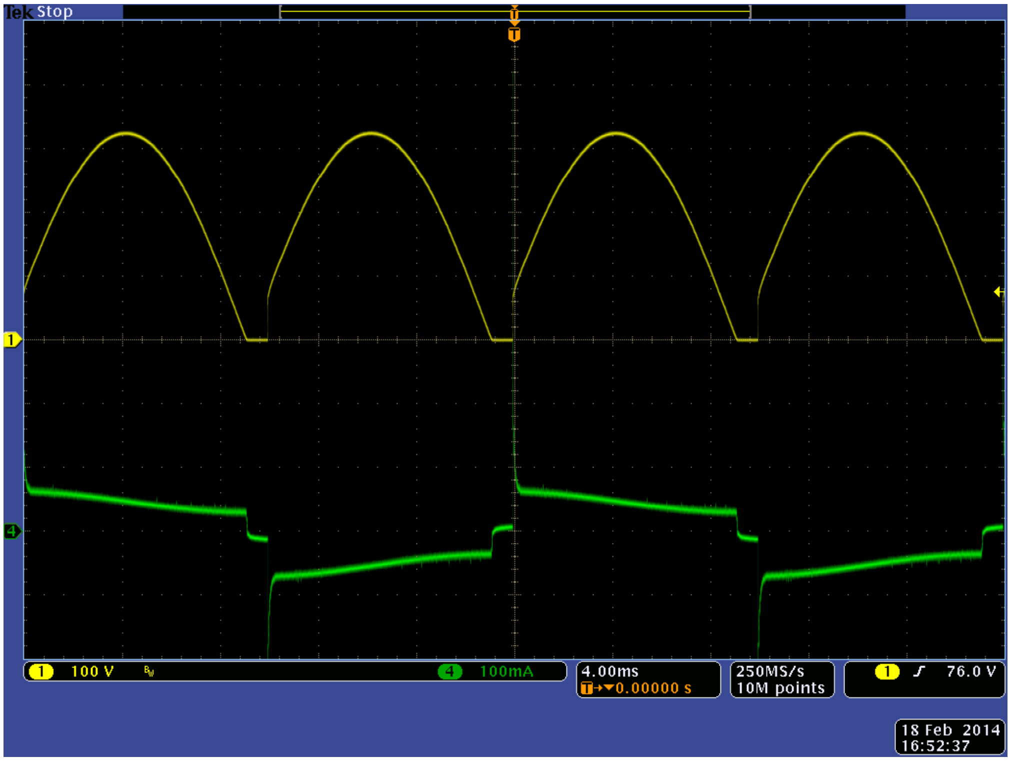

Figure 8. Forward Phase Triac Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Full

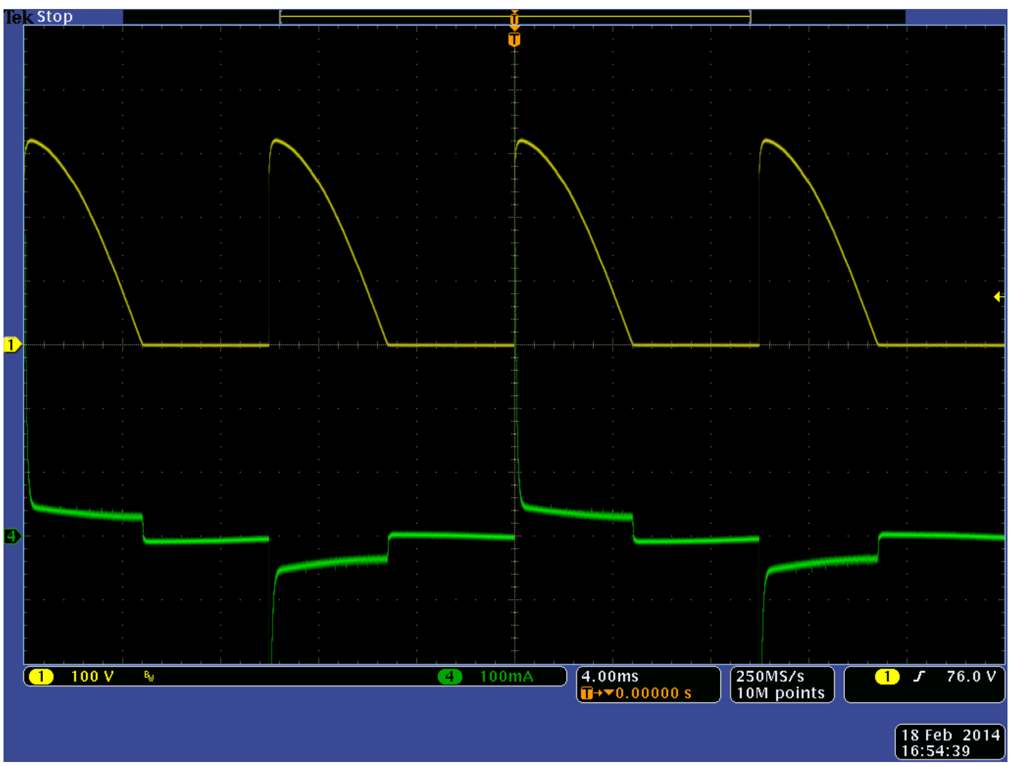

Figure 9. Forward Phase Triac Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Half

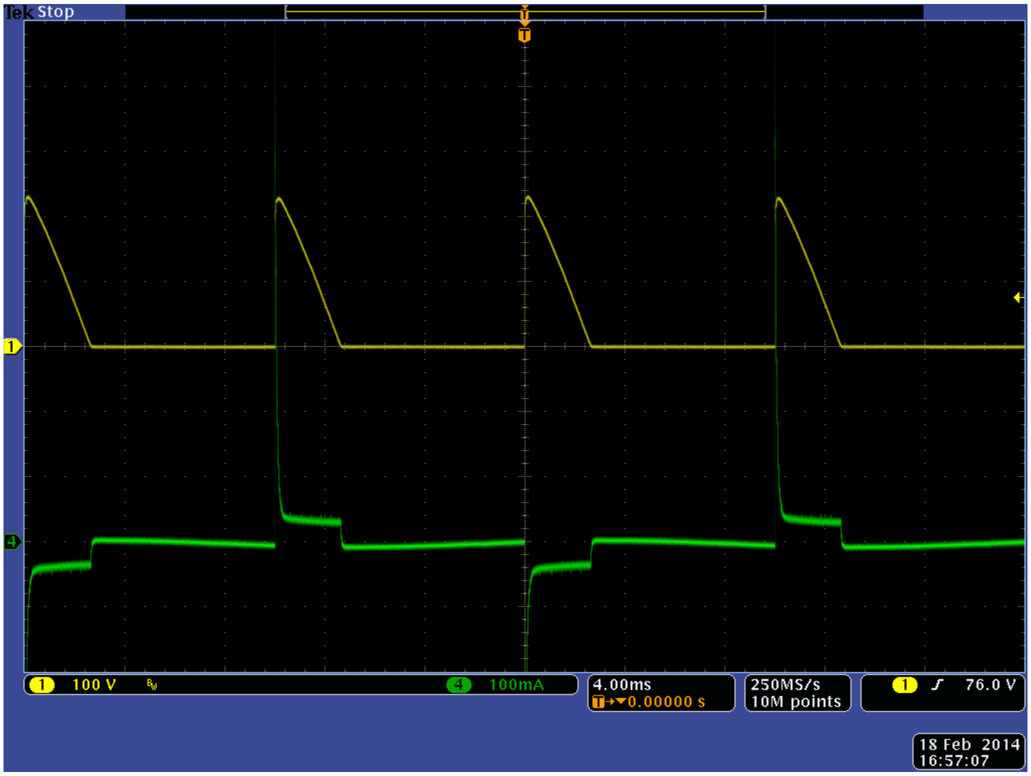

Figure 10. Forward Phase Triac Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Low

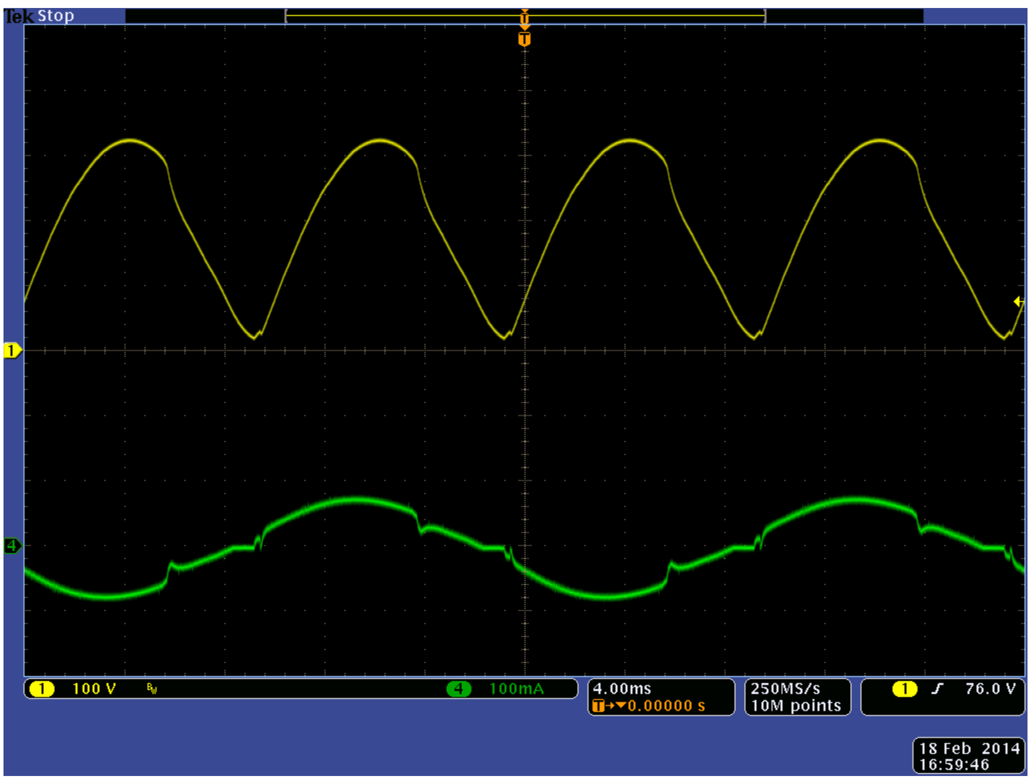

Figure 11. Reverse Phase Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Full

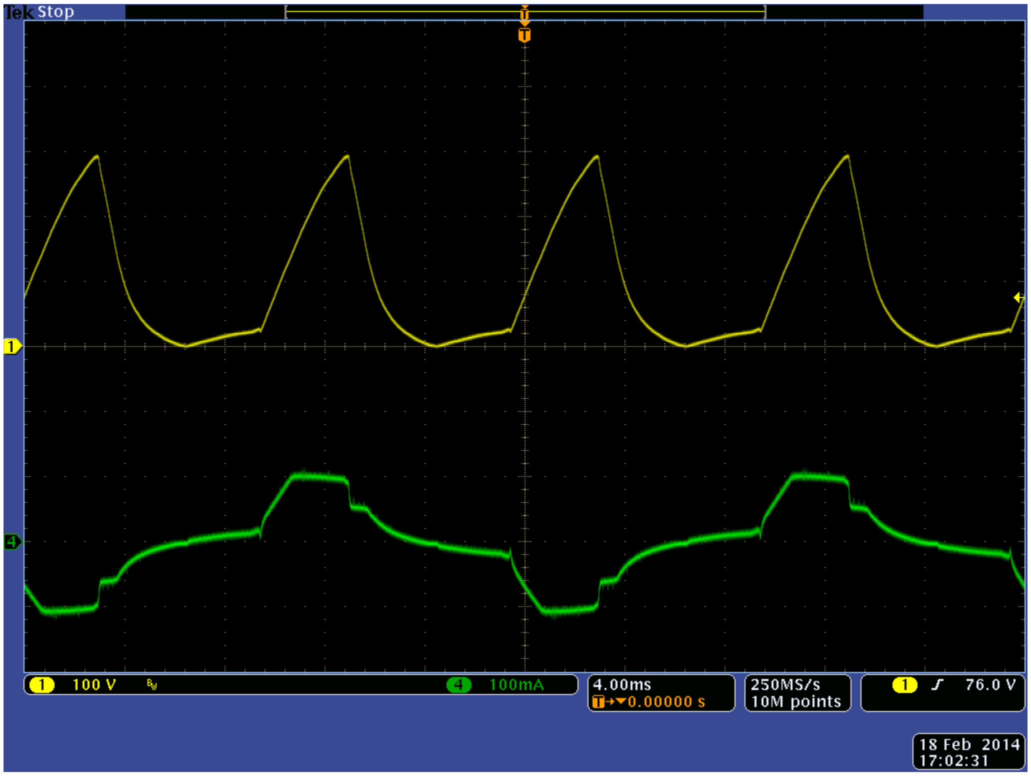

Figure 12. Reverse Phase Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Half

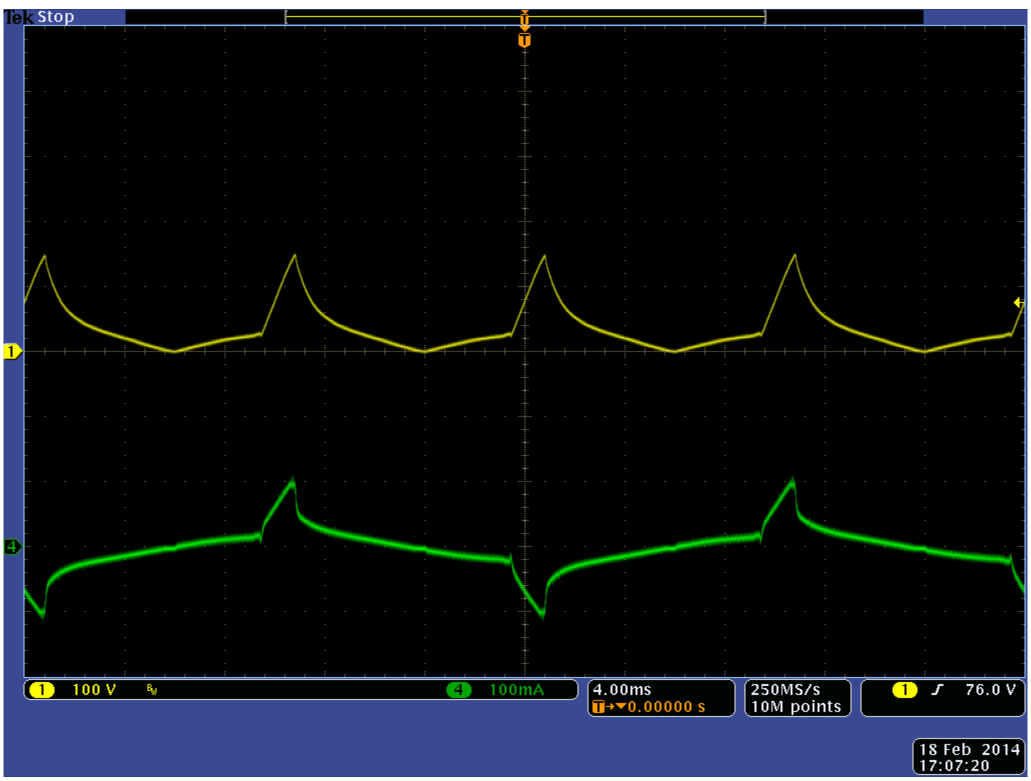

Figure 13. Reverse Phase Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Low

6.8 EMI Performance

Figure 14 shows the conducted EMI performance of the EVM under the following conditions:

- P_{IN} = 11.5 W
- V_{IN} = 230 VAC
- *QP* = quasi-peak limit line
- *A* = average limit line
- Blue trace = peak scan
- Black trace = average scan

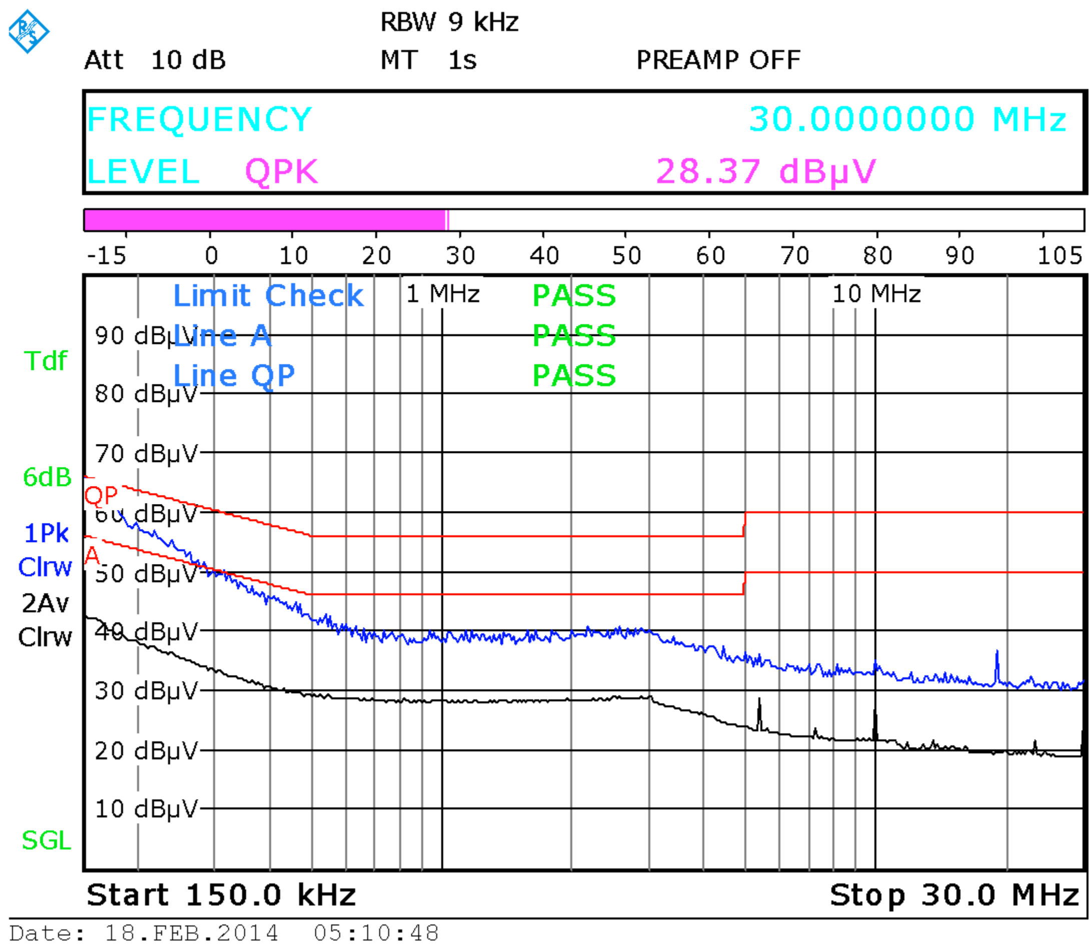

Figure 14. Conducted EMI Performance

7 TPS92410EVM-002 PCB Layout

Figure 15 and Figure 16 show the design of the TPS92410EVM-002 printed circuit board.

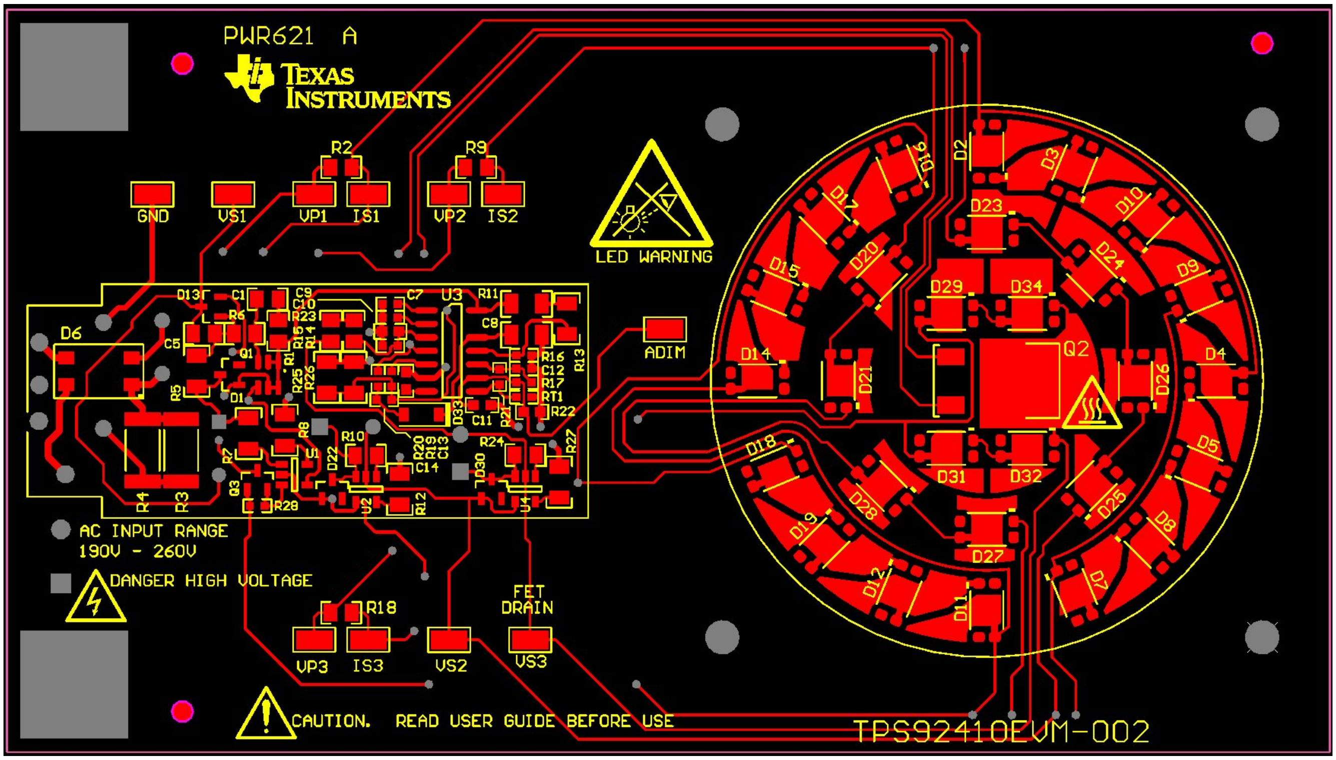

Figure 15. Top Layer and Top Overlay (Top View)

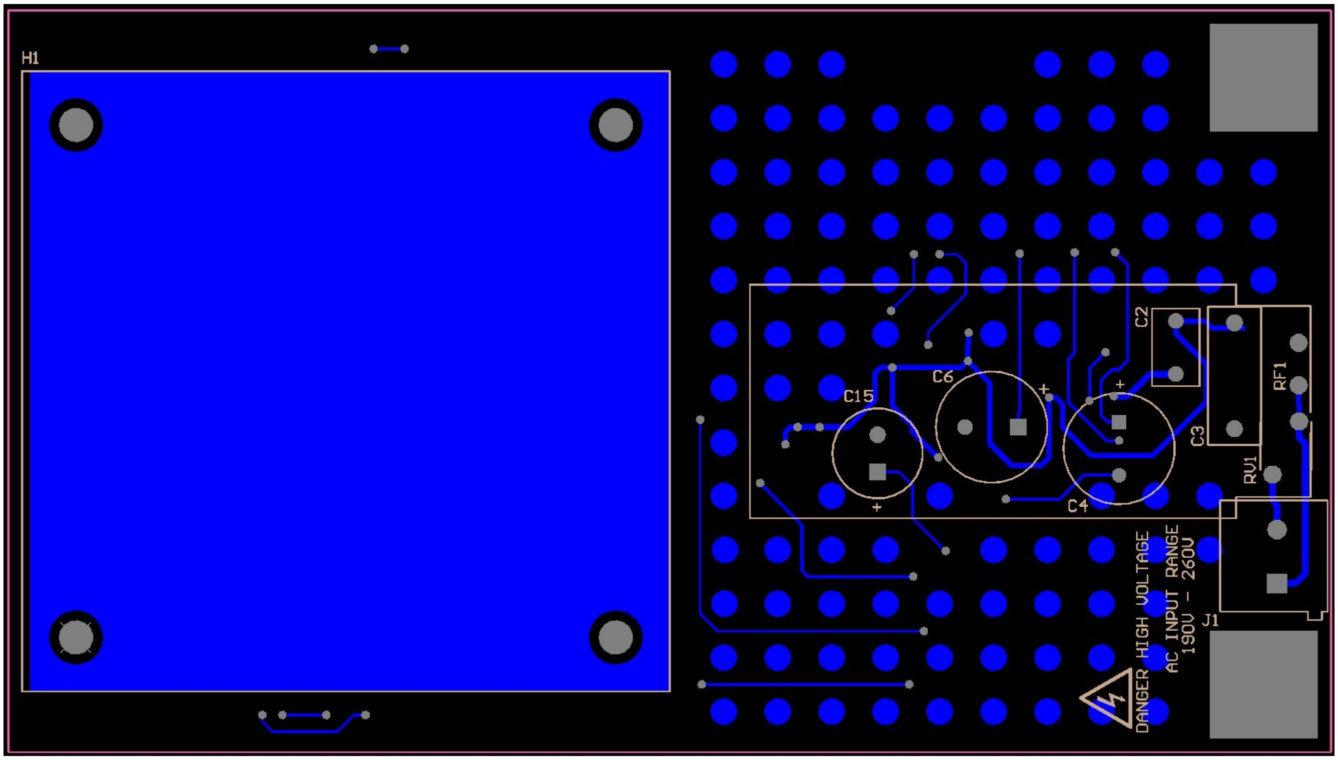

Figure 16. Bottom Layer and Bottom Overlay (Bottom View)

8 Bill of Materials

Table 2 contains the TPS92410EVM-002 components list according to the schematic shown in Figure 1.

Table 2. TPS92410EVM-002 Bill of Materials

Reference Designator	QTY	Value	Description	Size	Part Number	MFR
C1	1	680pF	CAP, CERM, 680pF, 200V, +/-10%, X7R	0805	CC0805KRX7RABB681	Yageo America
C2	1	0.022µF	Cap, Film, 0.022µF, 400VDC	Radial	B32529C6223J	EPCOS Inc
C3	1	0.15µF	CAP, Film, 0.15µF, 520V, +/-10%	13x11x5mm	B32671P5154K	EPCOS Inc
C4	1	22µF	CAP, Alum, 22µF, 200V, +/-20%	10x20mm	UPW2D220MPD	Nichicon
C5	1	0.1µF	CAP, CERM, 0.1µF, 100V, +/-10%, X7R	0805	CL21B104KCFSFNE	Samsung
C6	1	47µF	CAP, Alum, 47µF, 100V, +/-20%, 0.43 ohm	10x12.5mm	UHE2A470MPD	Nichicon
C7, C12	2	0.1µF	CAP, CERM, 0.1µF, 16V, +/-5%, X7R	0603	C0603C104J4RACTU	Kemet
C8	1	10µF	CAP, CERM, 10µF, 25V, +/-10%, X7R	1206	GRM31CR71E106KA12L	MuRata
C9, C14	2	1µF	CAP, CERM, 1µF, 16V, +/-10%, X7R	0603	C1608X7R1C105K	TDK
C10, C13	2	4.7µF	CAP, CERM, 4.7µF, 16V, +/-10%, X5R	0603	GRM188R61C475KAAJ	MuRata
C11	1	1000pF	CAP, CERM, 1000pF, 50V, +/-10%, X7R	0603	GRM188R71H102KA01D	MuRata
C15	1	100µF	CAP, Alum, 100µF, 50V, +/-20%	8.0x10.5 mm	UHE1H101MPD	Nichicon
D1, D22, D30	3	200V	Diode, Switching, 200V, 0.2A	SOT-23	BAS21-7-F	Diodes Inc.
D2, D3, D4, D5, D7, D8, D9, D10, D11, D12, D14, D15, D16, D17, D18, D19, D20, D21, D23, D24, D25, D26, D27, D28, D29, D31, D32, D34	28	Cool White	LED, Cool White, SMD	3x.75x5.2 mm	SAW8KG0B-Y1Z4-CA	Seoul Semiconductor
D6	1		Diode, Switching-Bridge, 600V, 0.8A	MiniDIP	HD06-T	Diodes Inc.
D13	1	12V	Diode, Zener, 12V, 300mW	SOT-23	AZ23C12-7-F	Diodes Inc.
D33	1	100V	Diode, Ultrafast, 100V, 0.15A	SOD-123	1N4148W-7-F	Diodes Inc.
J1	1	2x1	Conn Term Block, 2POS, 5.08mm	2POS Terminal Block	1715721	Phoenix Contact
Q1	1	200V	MOSFET, N-CH, 200V, 0.6A	TSOP-6	IRF5801TRPBF	International Rectifier
Q2	1	600V	MOSFET, N-CH, 600V, 2A	DPAK	AOD2N60	AOS
Q3	1	0.25V	Transistor, NPN, 140V, 0.6A	SOT-23	MMBT5550LT1G	ON Semiconductor
R1	1	1.00k	RES, 1.00k ohm, 1%, 0.125W	0805	CRCW08051K00FKEA	Vishay-Dale
R2, R9, R18	3	1.00	RES, 1.00 ohm, 1%, 0.125W	0805	RMCF0805FT1R00	Stackpole Electronics Inc
R3, R4	2	820	RES, 820 ohm, 5%, 1W	2512	CRCW2512820RJNEG	Vishay Dale
R5	1	1.00Meg	RES, 1.00Meg ohm, 1%, 0.25W	1206	CRCW12061M00FKEA	Vishay-Dale
R6	1	10.0k	RES, 10.0k ohm, 1%, 0.125W	0805	CRCW080510K0FKEA	Vishay-Dale
R7	1	2.80Meg	RES, 2.80Meg ohm, 1%, 0.25W	1206	CRCW12062M80FKEA	Vishay-Dale
R8, R12, R27	3	1.50Meg	RES, 1.50Meg ohm, 1%, 0.25W	1206	RC1206FR-071M5L	Yageo America
R10	1	2.67Meg	RES, 2.67Meg ohm, 1%, 0.125W	0805	CRCW08052M67FKEA	Vishay-Dale
R11, R13	2	2.00Meg	RES, 2.00Meg ohm, 1%, 0.25W	1206	CRCW12062M00FKEA	Vishay-Dale

Table 2. TPS92410EVM-002 Bill of Materials (continued)

Reference Designator	QTY	Value	Description	Size	Part Number	MFR
R14, R15	2	2.00Meg	RES, 2.00Meg ohm, 1%, 0.125W	0805	CRCW08052M00FKEA	Vishay-Dale
R16, R21	2	30.1k	RES, 30.1k ohm, 1%, 0.1W	0603	CRCW060330K1FKEA	Vishay-Dale
R17	1	200k	RES, 200k ohm, 1%, 0.1W	0603	CRCW0603200KFKEA	Vishay-Dale
R19	1	54.9k	RES, 54.9k ohm, 1%, 0.1W	0603	CRCW060354K9FKEA	Vishay-Dale
R20	1	100	RES, 100 ohm, 1%, 0.1W	0603	CRCW0603100RFKEA	Vishay-Dale
R23	1	121k	RES, 121k ohm, 1%, 0.1W	0603	CRCW0603121KFKEA	Vishay-Dale
R24	1	2.37Meg	RES, 2.37Meg ohm, 1%, 0.125W	0805	CRCW08052M37FKEA	Vishay-Dale
R25	1	30.1	RES, 30.1 ohm, 1%, 0.25W	1206	CRCW120630R1FKEA	Vishay-Dale
RF1	1	68	RES, 68 ohm, 10%, 2W, Fusible	Axial resistor	EMC2-68RKI	TT Electronics/IRC
RT1	1	470k	Thermistor NTC, 470k ohm, 5%	0603	NCP18WM474J03RB	MuRata
RV1	1	430V	Metal Oxide Varistor	9.00 mm Diameter	MOV-07D431K	Bourns
U1, U2, U4	3		Switch Controlled Direct Drive Switch for Offline LED Drivers	SOT23-5	TPS92411PDBV	Texas Instruments
U3	1		Switch Controlled Direct Drive Linear Controller for Offline LED Drivers	SOIC-13	TPS92410D	Texas Instruments
R22	0		DNP			
R26	0		DNP			
R28	0		DNP			

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Caution

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. Changes or modifications could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at its own expense.

FCC Interference Statement for Class B EVM devices

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Industry Canada Compliance (English)

For EVMs Annotated as IC – INDUSTRY CANADA Compliant:

This Class A or B digital apparatus complies with Canadian ICES-003.

Changes or modifications not expressly approved by the party responsible for compliance could void the user’s authority to operate the equipment.

Concerning EVMs Including Radio Transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concerning EVMs Including Detachable Antennas

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Canada Industry Canada Compliance (French)

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

Concernant les EVMs avec appareils radio

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

Important Notice for Users of EVMs Considered "Radio Frequency Products" in Japan

EVMs entering Japan are NOT certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If user uses EVMs in Japan, user is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after user obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after user obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless user gives the same notice above to the transferee. Please note that if user does not follow the instructions above, user will be subject to penalties of Radio Law of Japan.

http://www.tij.co.jp

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1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
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IMPORTANT NOTICE

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