TPS92410EVM-001 Offline LED Driver Evaluation Module

User's Guide

Literature Number: SLVUA49
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Contents

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List of Figures

List of Tables

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Switch Controlled Direct Drive Linear Controller for Offline LED Drivers

1 Introduction

The TPS92410EVM-001 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-001.

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.

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3 Description

The TPS92410EVM-001 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 90 VAC to 135 VAC with a 120 VAC nominal input voltage. This input voltage range is typical for offline applications. The EVM is set up for a default input current of 58 mA for 6.8 W total power and 3 LED voltage stacks of 20 V, 40 V, and 80 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 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-001.

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, R1, to measure the current in the top (80 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.

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4 Electrical Performance Specifications

Table 1 contains the electrical performance specifications for the EVM.

Table 1. TPS92410EVM-001 Electrical Performance Specifications

Parameter	Test Conditions	MIN	TYP	MAX	Units
Input Characteristics					
Voltage range		90	120	135	VAC
Maximum input current			58		mA
Output Characteristics					
Output voltage, V_{OUT}	Upper LED stack		80		V
	Middle LED stack		40		
	Lower LED stack		20		
Flicker Index			0.03		
Output current ripple percent			12		%
Output current ripple	Each stack		23		mApp
Overvoltage protection level	Each individual TPS92410		100		V
Linear FET overvoltage protection level			51		V
Systems Characteristics					
Efficiency	Input voltage = 120 VAC, No triac dimmer		79.5		%
Power factor	Input voltage = 120 VAC, No triac dimmer		0.99		
THD	Input voltage = 120 VAC, No triac dimmer		7.5		%

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5 TPS92410EVM-001 Schematic

Figure 1 illustrates the TPS92410EVM-001 schematic.

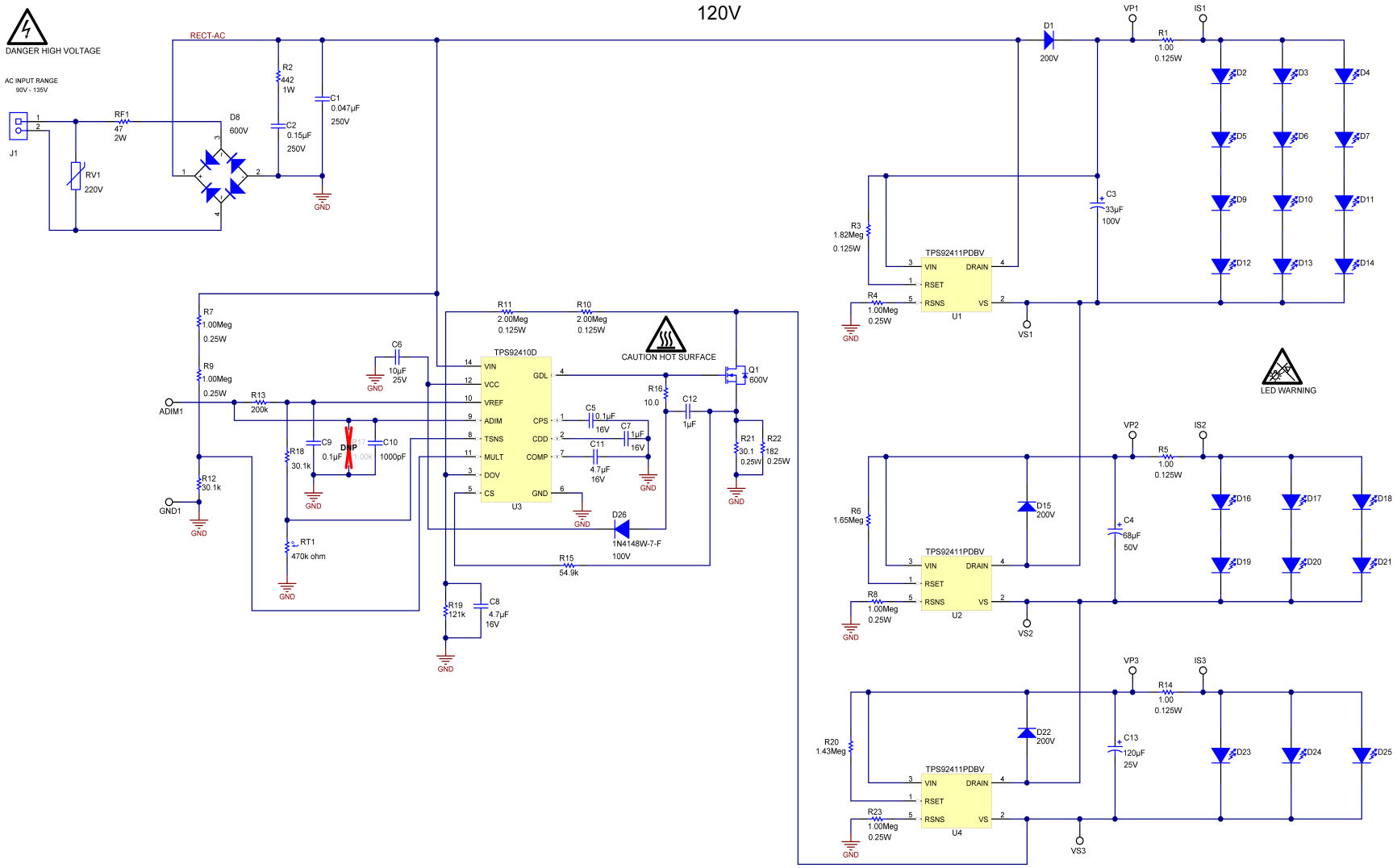

Figure 1. TPS92410EVM-001 Schematic

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6 Performance Data and Typical Characteristic Curves

Figure 2 through Figure 13 present typical performance curves for the TPS92410EVM-001.

6.1 Power Factor

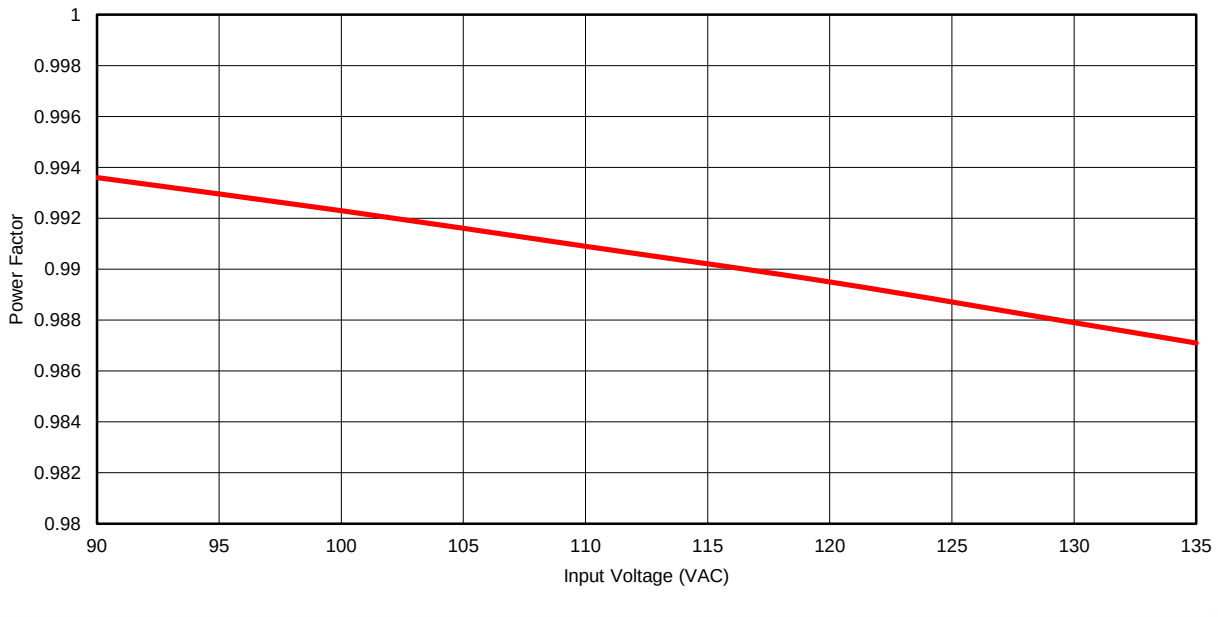

Figure 2. Power Factor Versus Input Voltage

6.2 Line Regulation

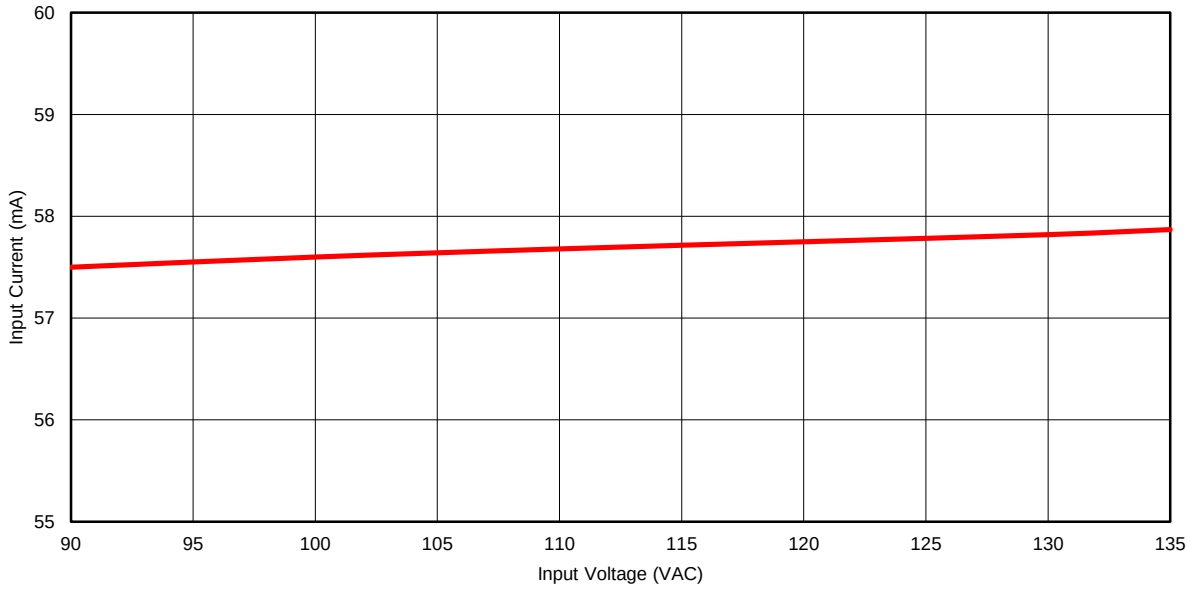

Figure 3. Input (Linear Regulator) Current Versus Input Voltage

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6.3 Input Voltage and Input Current

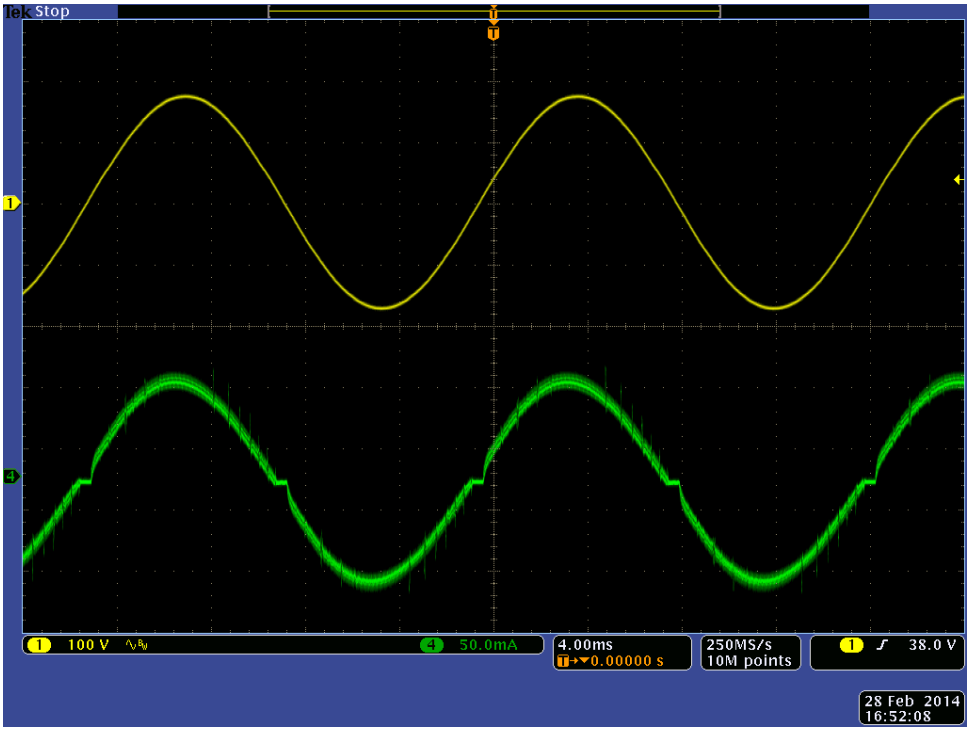

Figure 4. Input Voltage (Top) and Input Current (Bottom)

6.4 Linear Regulator Drain Voltage and Input Current

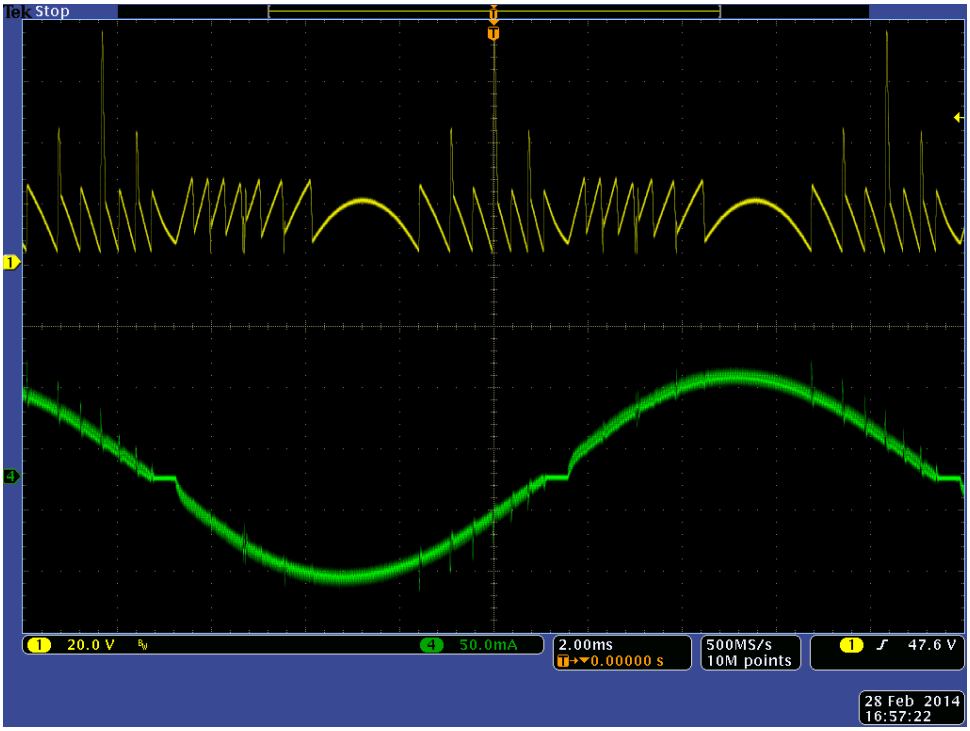

Figure 5. Drain Voltage (Top) and Input Current (Bottom)

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6.5 Output Current

Figure 6. 80-V Stack (Top), 40-V Stack (Middle), and 20-V Stack (Bottom)

6.6 Drain Overvoltage (DOV) Event (80-V Stack Shorted then Released)

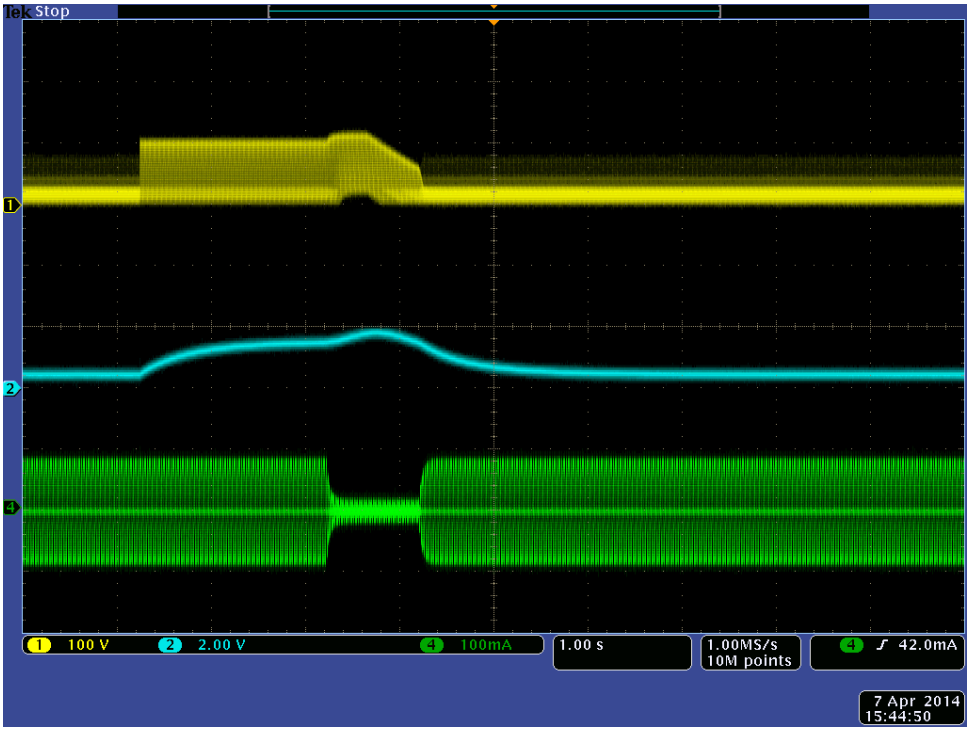

Figure 7. Drain Voltage (Top), DOV Pin Voltage (Middle), and Input Current (Bottom)

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6.7 Triac Dimming Waveforms

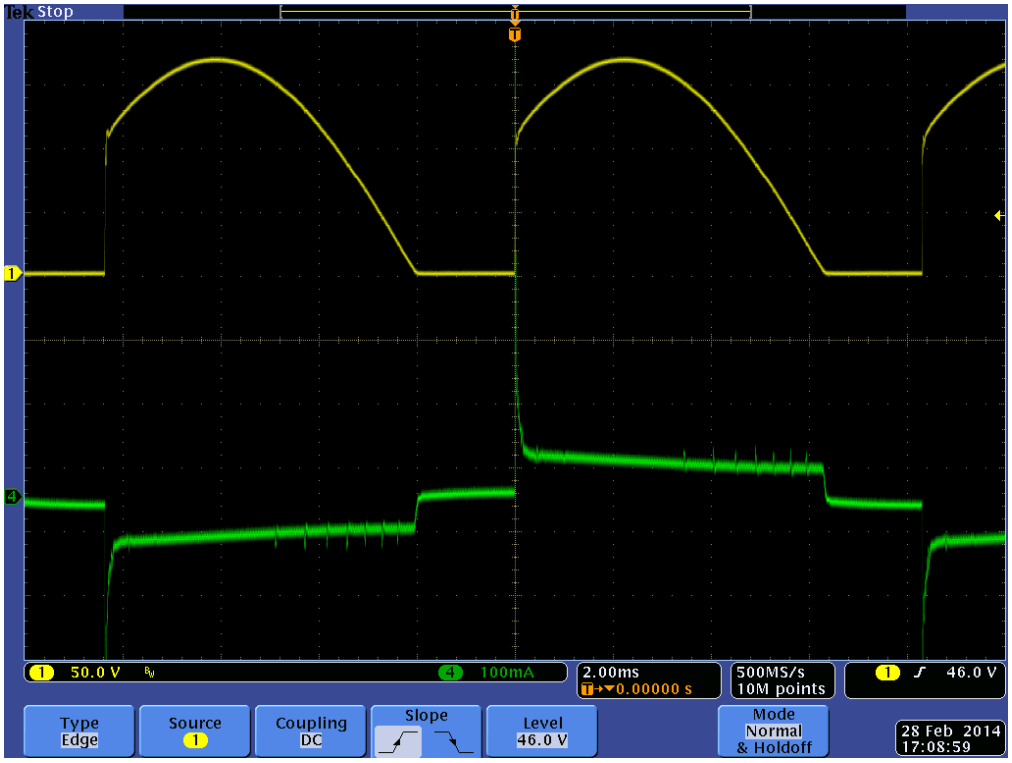

Figure 8. Forward Phase Triac Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Full

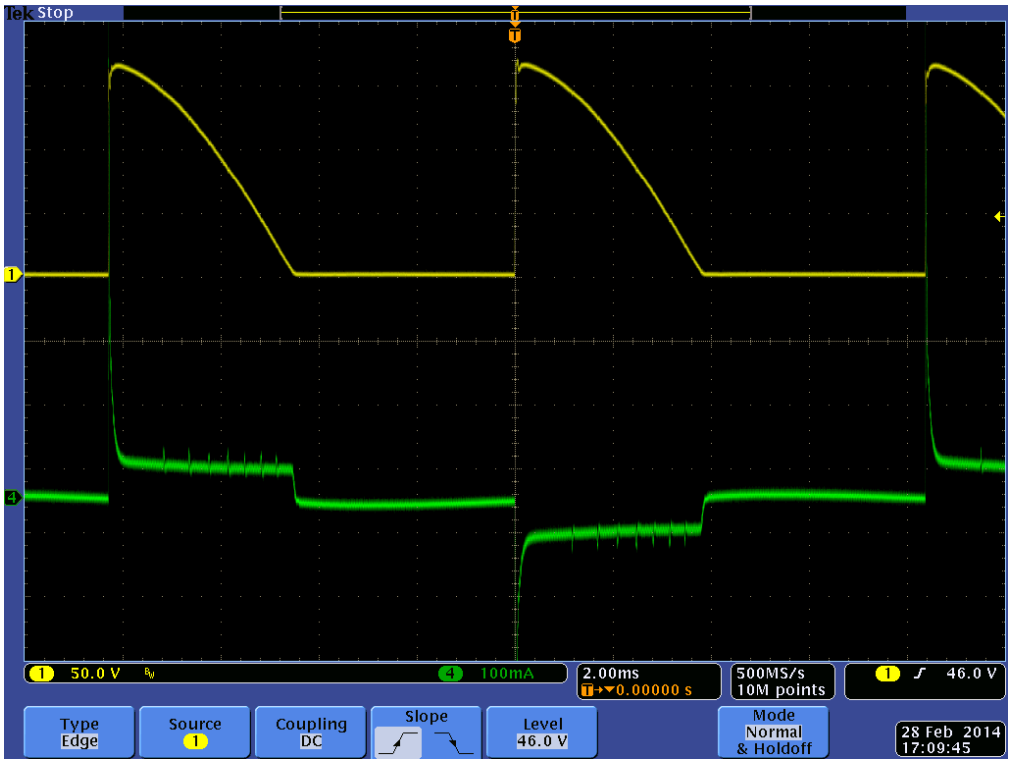

Figure 9. Forward Phase Triac Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Half

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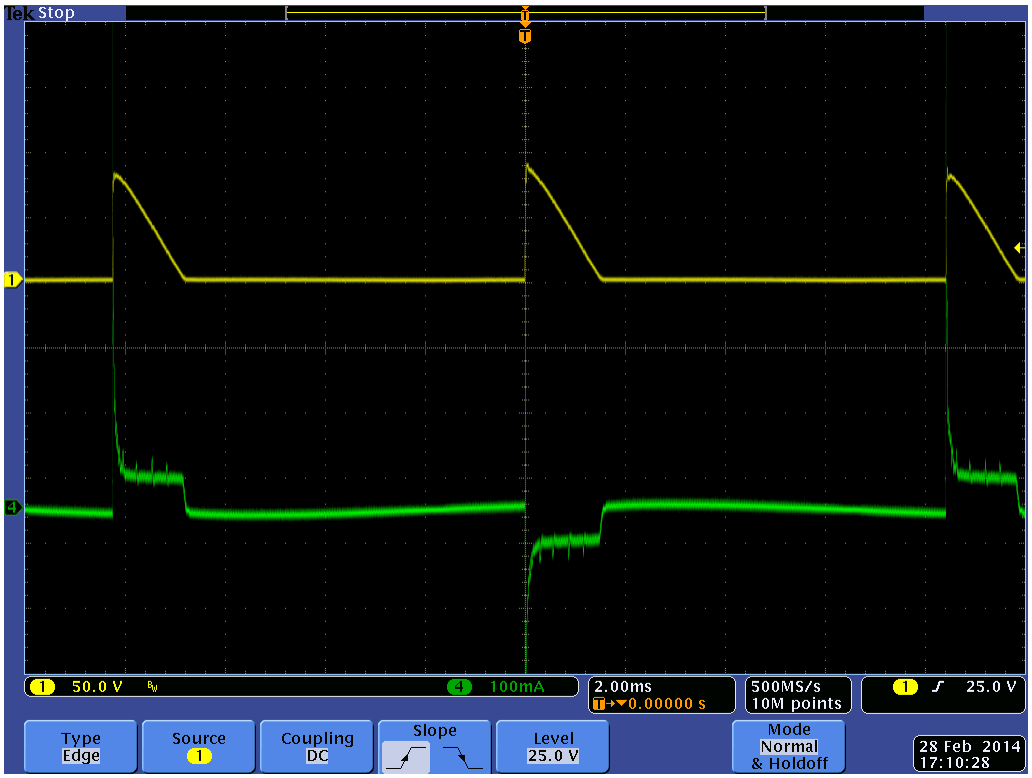

Figure 10. Forward Phase Triac Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Low

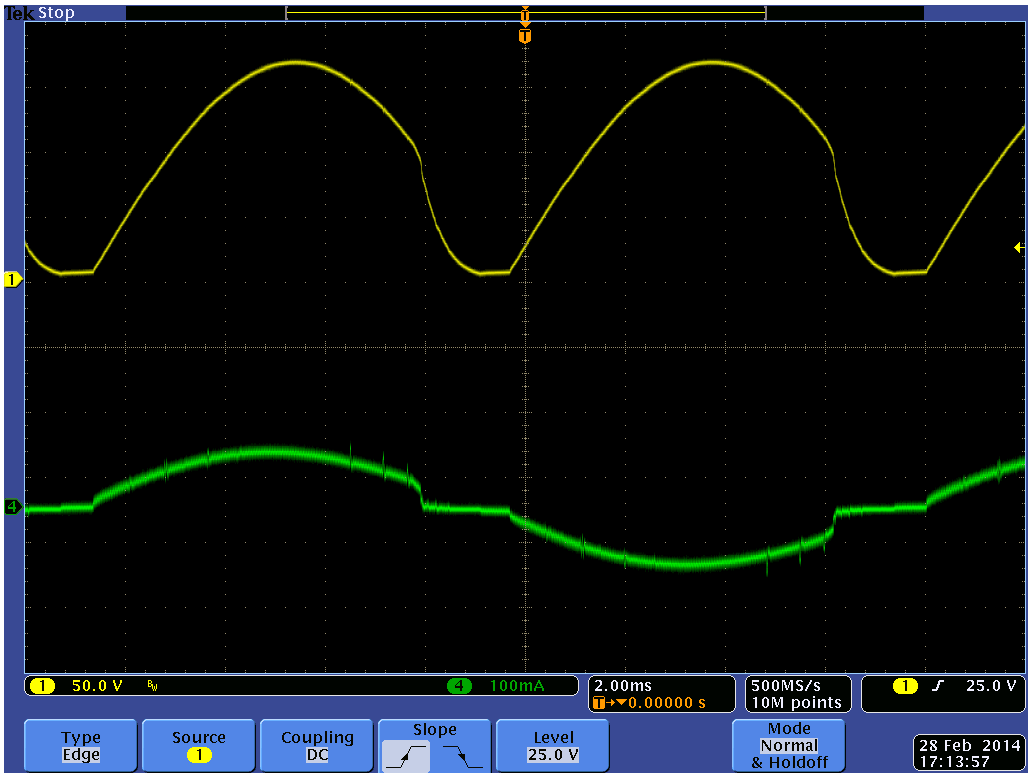

Figure 11. Reverse Phase Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Full

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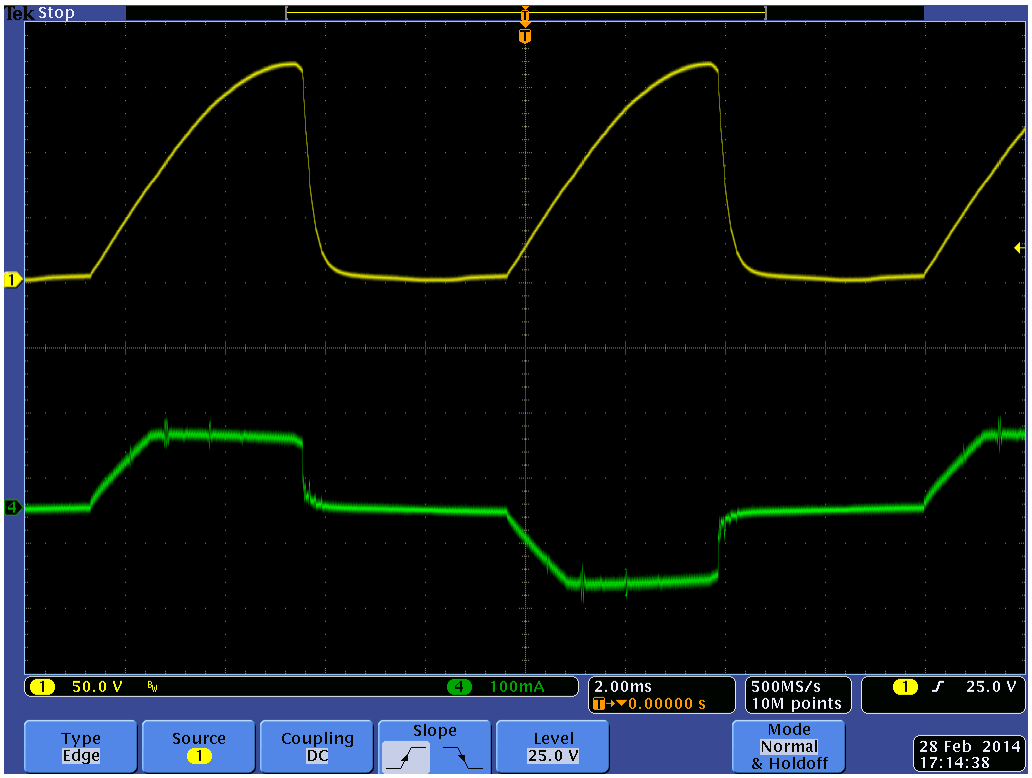

Figure 12. Reverse Phase Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Half

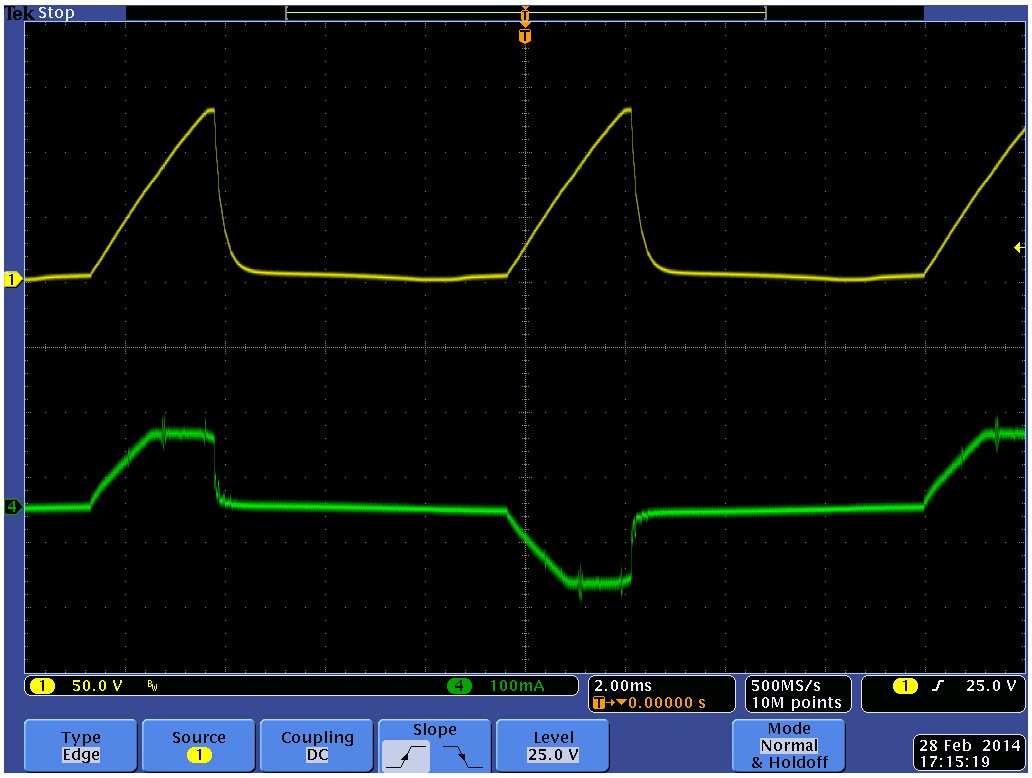

Figure 13. Reverse Phase Dimming: Rectified Input Voltage (Top) and Input Current (Bottom) – Low

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6.8 EMI Performance

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

- P_{IN} = 6.8 W
- V_{IN} = 120 VAC
- *QP* = quasi-peak limit line
- *A* = average limit line
- Blue trace = peak scan
- Black trace = average scan

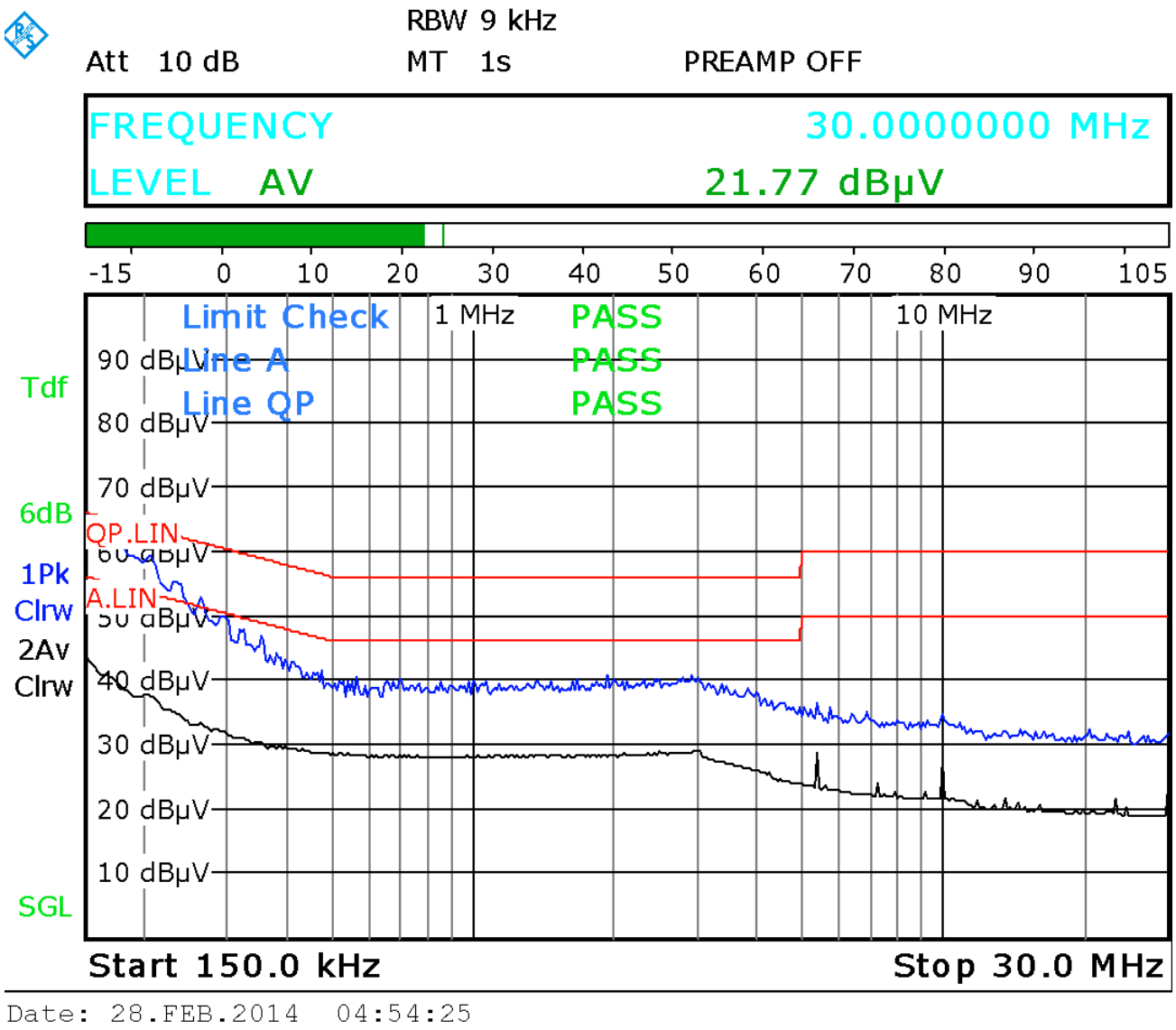

Figure 14. Conducted EMI Performance

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7 TPS92410EVM-001 PCB Layout

Figure 15 and Figure 16 show the design of the TPS92410EVM-001 printed circuit board.

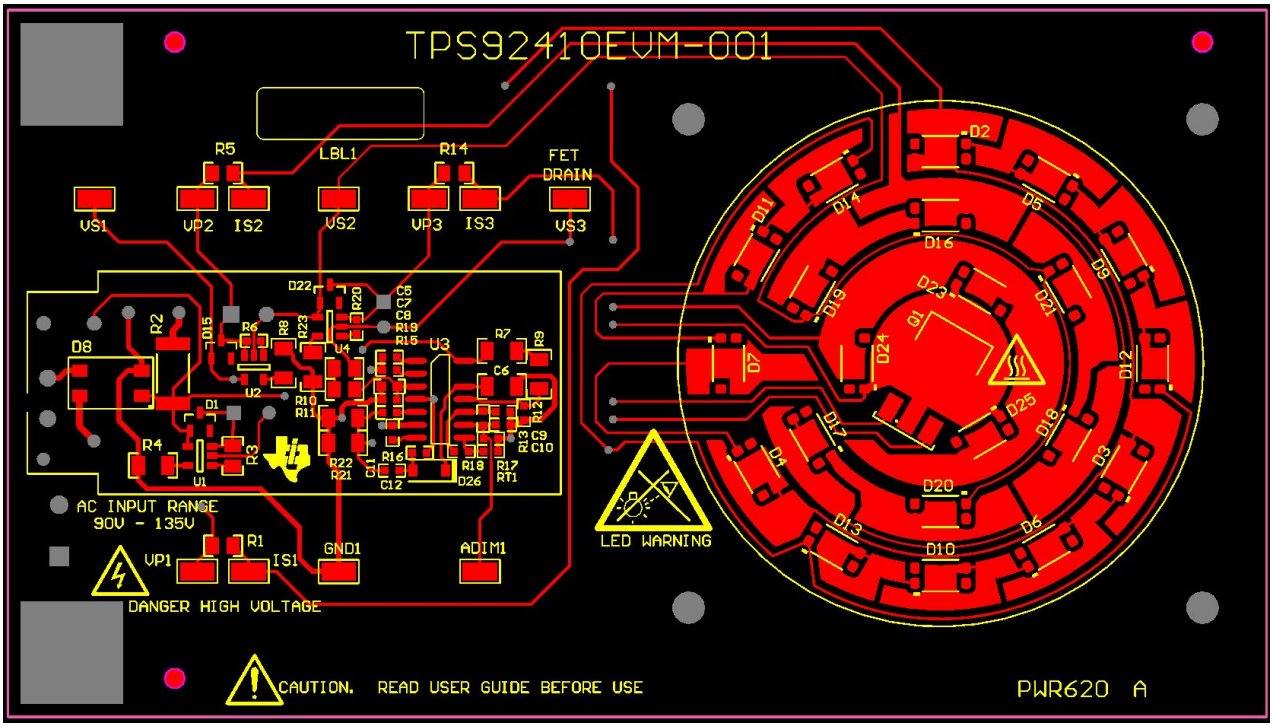

Figure 15. Top Layer and Top Overlay (Top View)

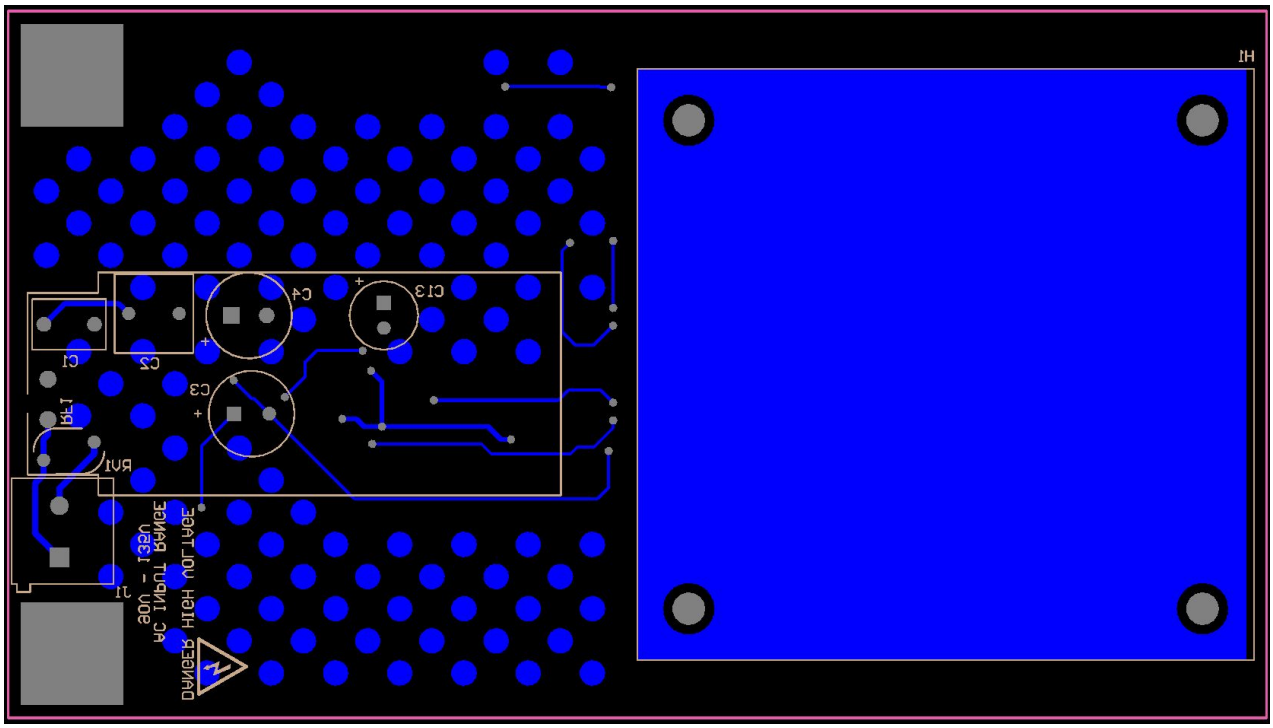

Figure 16. Bottom Layer and Bottom Overlay (Bottom View)

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8 Bill of Materials

Table 2 contains the TPS92410EVM-001 components list according to the schematic shown in Figure 1.

Table 2. TPS92410EVM-001 Bill of Materials

Reference Designator	QTY	Value	Description	Size	Part Number	MFR
C1	1	0.047µF	CAP, Film, 0.047µF, 250VDC	Radial	B32529C3473K189	EPCOS Inc
C2	1	0.15µF	CAP, Film, 0.15µF, 250VDC	Radial	B32529C3154J	EPCOS Inc
C3	1	33µF	CAP, AL, 33µF, 100V, +/-20%, 0.45 ohm	8x15mm	UPW2A330MPD6	Nichicon
C4	1	68µF	CAP, AL, 68µF, 50V, +/-20%, 0.234 ohm	8x11.5mm	EEU-FC1H680	Panasonic
C5, C9	2	0.1µF	CAP, CERM, 0.1µF, 16V, +/-5%, X7R	0603	C0603C104J4RACTU	Kemet
C6	1	10µF	CAP, CERM, 10µF, 25V, +/-10%, X7R	1206	GRM31CR71E106KA12L	MuRata
C7, C12	2	1µF	CAP, CERM, 1µF, 16V, +/-10%, X7R	0603	C1608X7R1C105K	TDK
C8, C11	2	4.7µF	CAP, CERM, 4.7µF, 16V, +/-10%, X5R	0603	GRM188R61C475KAAJ	MuRata
C10	1	1000pF	CAP, CERM, 1000pF, 50V, +/-10%, X7R	0603	GRM188R71H102KA01D	MuRata
C13	1	120µF	CAP, AL, 120µF, 25V, +/-20%, 0.23 ohm	6.3x15mm	UPW1E121MED	Nichicon
D1, D15, D22	3	200V	Diode, Switching, 200V, 0.2A	SOT-23	BAS21-7-F	Diodes Inc.
D2, D3, D4, D5, D6, D7, D9, D10, D11, D12, D13, D14, D16, D17, D18, D19, D20, D21, D23, D24, D25	21	Cool White	LED, Cool White, SMD	3x.75x5.2mm	SAW8KG0B-Y1Z4-CA	Seoul Semiconductor
D8	1		Diode, Switching-Bridge, 600V, 0.8A	MiniDIP	HD06-T	Diodes Inc.
D26	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	600V	MOSFET, N-CH, 600V, 2A	DPAK	AOD2N60	AOS
R1, R5, R14	3	1.00Ω	RES, 1.00 ohm, 1%, 0.125W	0805	RMCF0805FT1R00	Stackpole Electronics Inc
R2	1	442 Ω	RES, 442 ohm, 1%, 1W	2512	CRCW2512442RFKEG	Vishay-Dale
R3	1	1.82MΩ	RES, 1.82Meg ohm, 1%, 0.125W	0805	CRCW08051M82FKEA	Vishay-Dale
R4, R7, R8, R9, R23	5	1.00MΩ	RES, 1.00Meg ohm, 1%, 0.25W	1206	CRCW12061M00FKEA	Vishay-Dale
R6	1	1.65MΩ	RES, 1.65Meg ohm, 1%, 0.1W	0603	CRCW06031M65FKEA	Vishay-Dale
R10, R11	2	2.00MΩ	RES, 2.00Meg ohm, 1%, 0.125W	0805	CRCW08052M00FKEA	Vishay-Dale
R12, R18	2	30.1kΩ	RES, 30.1k ohm, 1%, 0.1W	0603	CRCW060330K1FKEA	Vishay-Dale
R13	1	200kΩ	RES, 200k ohm, 1%, 0.1W	0603	CRCW0603200KFKEA	Vishay-Dale
R15	1	54.9kΩ	RES, 54.9k ohm, 1%, 0.1W	0603	CRCW060354K9FKEA	Vishay-Dale
R16	1	10.0Ω	RES, 10.0 ohm, 1%, 0.1W	0603	CRCW060310R0FKEA	Vishay-Dale
R19	1	121kΩ	RES, 121k ohm, 1%, 0.1W	0603	CRCW0603121KFKEA	Vishay-Dale
R20	1	1.43MΩ	RES, 1.43Meg ohm, 1%, 0.1W	0603	CRCW06031M43FKEA	Vishay-Dale
R21	1	30.1Ω	RES, 30.1 ohm, 1%, 0.25W	1206	CRCW120630R1FKEA	Vishay-Dale
R22	1	182Ω	RES, 182 ohm, 1%, 0.25W	1206	CRCW1206182RFKEA	Vishay-Dale
RF1	1	47Ω	RES, 47 ohm, 10%, 2W	Axial	EMC2-47RKI	TT Electronics/Welwyn
RT1	1	470kΩ	Thermistor NTC, 470k ohm, 5%	0603	NCP18WM474J03RB	MuRata

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Table 2. TPS92410EVM-001 Bill of Materials (continued)

Reference Designator	QTY	Value	Description	Size	Part Number	MFR
RV1	1	220V	Varistor, 220V, 600A	Disc 10x7mm	ERZ-V05D221	Panasonic
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
R17	0	DNP				

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10. User has sole responsibility to ensure the safety of any activities to be conducted by it and its employees, affiliates, contractors or designees, with respect to handling and using EVMs. Further, user is responsible to ensure that any interfaces (electronic and/or mechanical) between EVMs and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard.
11. User shall employ reasonable safeguards to ensure that user's use of EVMs will not result in any property damage, injury or death, even if EVMs should fail to perform as described or expected.
12. User shall be solely responsible for proper disposal and recycling of EVMs consistent with all applicable federal, state, and local requirements.

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Agreement to Defend, Indemnify and Hold Harmless. User agrees to defend, indemnify, and hold TI, its directors, officers, employees, agents, representatives, affiliates, licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of, or in connection with, any handling and/or use of EVMs. User's indemnity shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if EVMs fail to perform as described or expected.

Safety-Critical or Life-Critical Applications. If user intends to use EVMs in evaluations of safety critical applications (such as life support), and a failure of a TI product considered for purchase by user for use in user's product would reasonably be expected to cause severe personal injury or death such as devices which are classified as FDA Class III or similar classification, then user must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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For EVMs not including a radio and not subject to the U.S. Federal Communications Commission (FCC) or Industry Canada (IC) regulations, TI intends EVMs to be used only for engineering development, demonstration, or evaluation purposes. EVMs are not finished products typically fit for general consumer use. EVMs may nonetheless generate, use, or radiate radio frequency energy, but have not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or the ICES-003 rules. Operation of such EVMs may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: For EVMs including a radio, the radio included in such EVMs is intended for development and/or professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability in such EVMs and their development application(s) must comply with local laws governing radio spectrum allocation and power limits for such EVMs. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by TI unless user has obtained appropriate experimental and/or development licenses from local regulatory authorities, which is the sole responsibility of the user, including its acceptable authorization.

U.S. Federal Communications Commission Compliance

For EVMs Annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant

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.

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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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