Using the TPS92314A19120VEVM

User's Guide

Literature Number: SLUUA13A
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Non-Dimmable LED Lighting Driver

1 Introduction

The TPS92314A19120VEVM evaluation module is a constant-current, non-dimmable 8-W LED driver. It is designed to drive six LEDs at 330 mA and is rated for an AC input of 85 V_{RMS} to 135 V_{RMS}.

2 Description

The TPS92314 family of general LED lighting PWM controllers contain control and drive circuitry required for off-line isolated or non-isolated LED lighting applications. The TPS92314A19120VEVM evaluation module uses the TPS92314 as an isolated PFC flyback controller; more specifically it is an isolated primary-side controlled critical conduction mode PFC flyback. The controller operates in critical conduction valley switching, with minimal external parts count.

2.1 Typical Applications

- Commercial and Household LED Lighting
- LED Lamps: A19 (E26,E27 and E14)

2.2 Features

- Regulates LED Current without Secondary Side Sensing
- Critical Conduction Mode (CCM) (with Zero current detection for valley switching)
- Adaptive ON-Time Control with Inherent PFC
- Programmable Switch Turn-On Delay
- Over Temperature Protection

3 Electrical Performance Specifications

Table 1. TPS92314A19120VEVM Electrical Performance Specifications

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Input Characteristics					
Voltage range		85	120	135	V
Maximum input current			75		mA
Output Characteristics					
Output voltage, V_{OUT}		18	20	22	V
Output load current, I_{OUT}		330	350	370	mA
Output current ripple	VIN = 120 VAC		280		mApp
Output over voltage	Primary side bias		36		V
Systems Characteristics					
Switching frequency			75		kHz
Full load efficiency	VIN = 120 VAC		85%		
Power factor			>.09		

4 Schematic

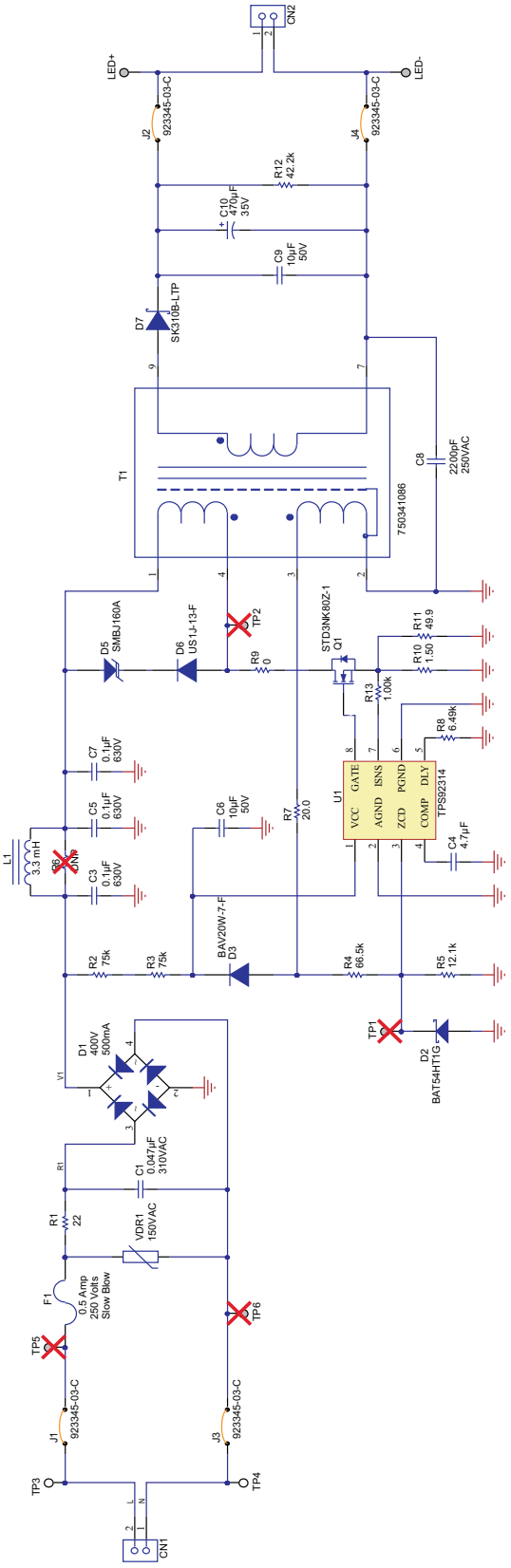

Figure 1. TPS92314A19120VEVM Schematic

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 equipment is highly recommended.

5.1 Test Equipment

Voltage Source: 85 V_{RMS} to 135 V_{RMS} isolated AC source capable of at least 20 W.

Multimeters: Two voltmeters and two ammeters for up to 1 A each.

Output Load: Six LEDs in series (V_F = 3.4 V at 350 mA per LED)

Oscilloscope: Four channel 100 MHz with high voltage probe rated for at least 600 V.

Recommended Wire Gauge: 18 AWG not more than two feet long.

5.2 TPS92314A19120VEVM Recommended Test Setup

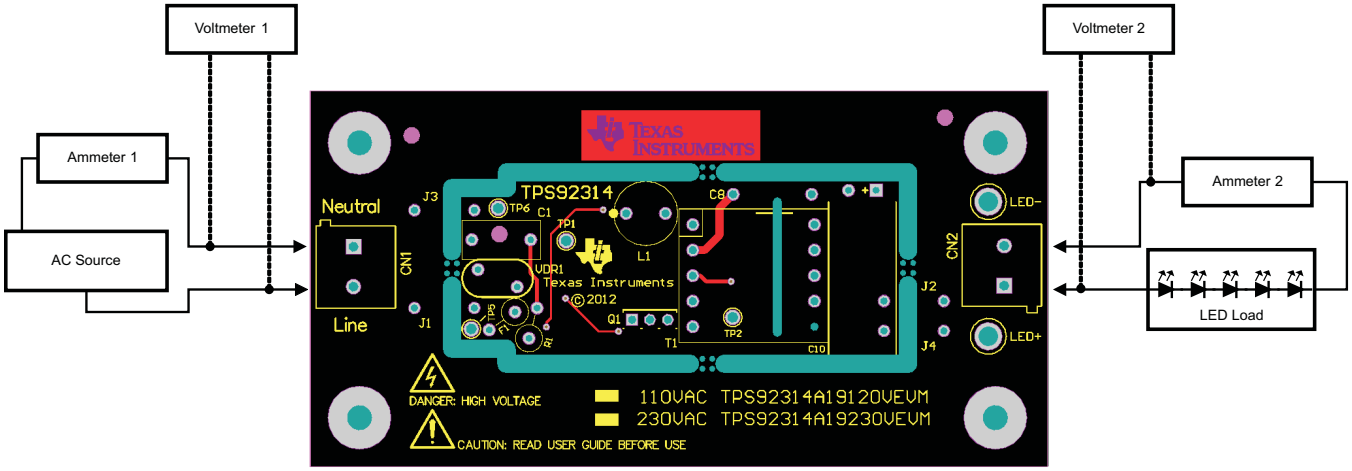

Figure 2. Recommended Test Set Up

5.3 List of Test Points

Table 2. Test Point Functions

TEST POINTS	NAME	DESCRIPTION
TP7	LED+	LED output
TP8	LED-	LED return point
TP1	ZCD	ZCD pin of TPS92314
TP3, TP5	Line	AC line input
TP6, TP4	Neutral	AC neutral input
TP2	Q1-D	Transformer, Q1 Drain

6 Test Procedure

All tests should use the set up described in Section 5 of this user guide.

WARNING

High voltage levels are present on this evaluation module whenever it is energized. Proper precautions must be observed whenever working with this module. Serious injury can occur if proper safety procedures are not followed.

6.1 Line and Load Regulation, Efficiency Measurement Procedure

1. Connect EVM per Figure 2 above. An external LED load must be used to start up the EVM.
2. Prior to turning on the AC source, set the voltage to 85 V_{RMS}.
3. Turn on the AC source.
4. Record the output voltage and current readings from Voltmeter 2 and output current reading from Ammeter and input voltage reading from Voltmeter 1 and Ammeter 1.
5. Increase output voltage by 5 V_{RMS}.
6. Repeat steps 4 and 5 until you reach 135 V_{RMS}.
7. Refer to Section 6.2 for shutdown procedure.

6.2 Equipment Shutdown

1. Turn off the AC source.
2. Make sure that output capacitors are fully discharged.

7 Performance Data and Typical Characteristic Curves

Figure 3 through Figure 16 present typical performance curves for TPS92314A19120VEVM.

7.1 Efficiency

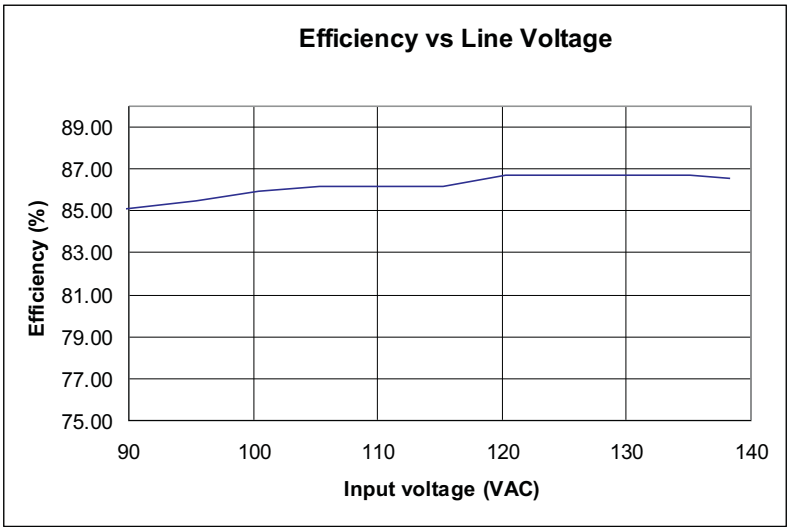

Figure 3. Efficiency

7.2 Input Voltage vs. Power Factor

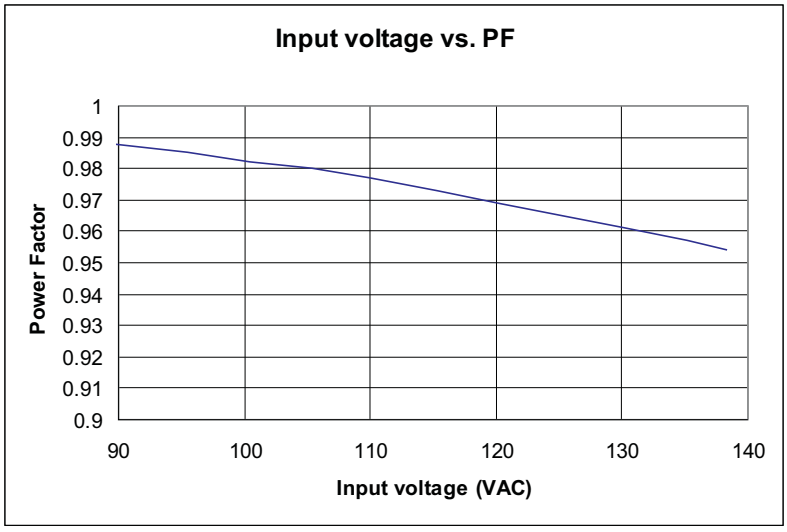

Figure 4. PF Variation

7.3 Input Voltage vs. Output Current

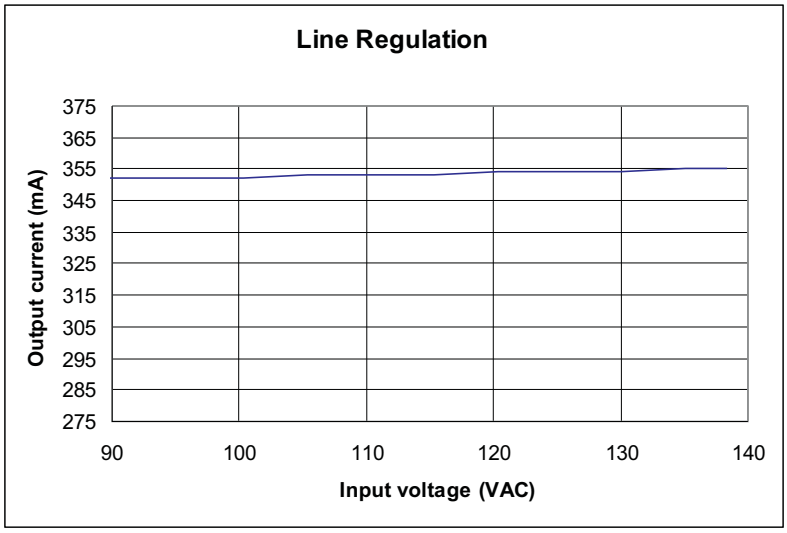

Figure 5. Current Variation with Respect to Input Voltage

7.4 Input Power vs. Input Voltage

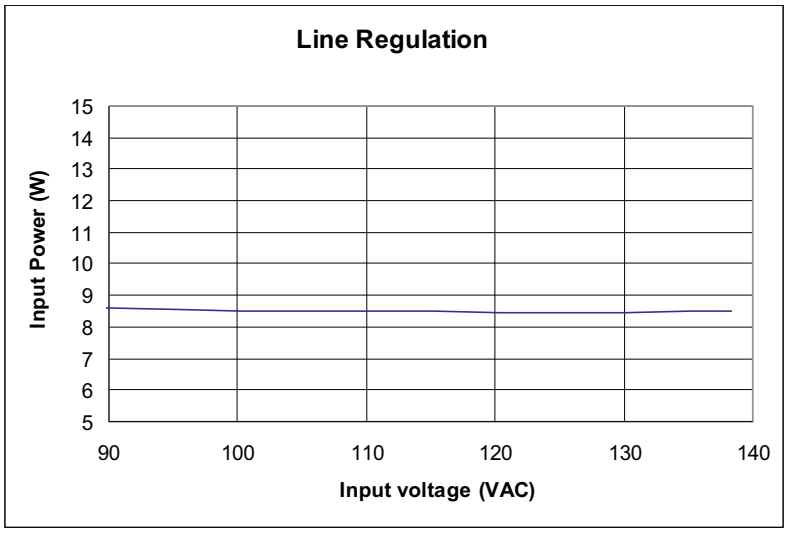

Figure 6. Input Power Variation with Respect to Input Voltage

7.5 Ithd% vs. Input Voltage

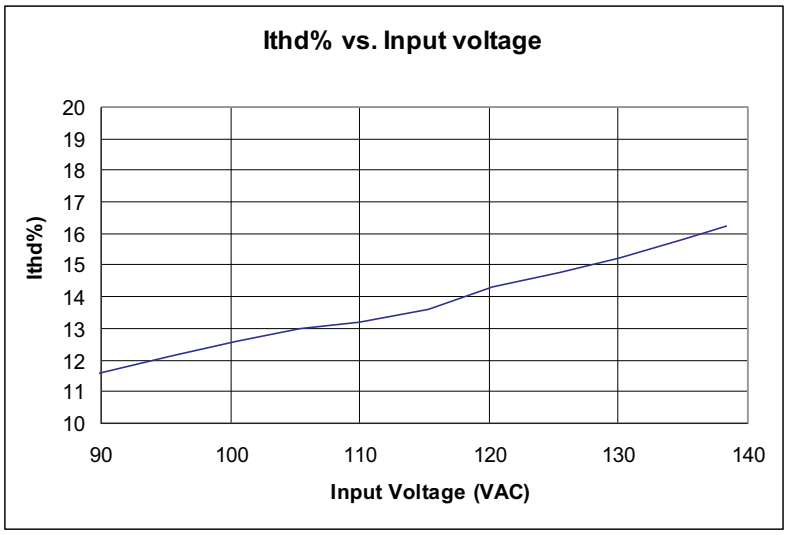

Figure 7. Ithd% vs Input Voltage

7.6 Output Ripple

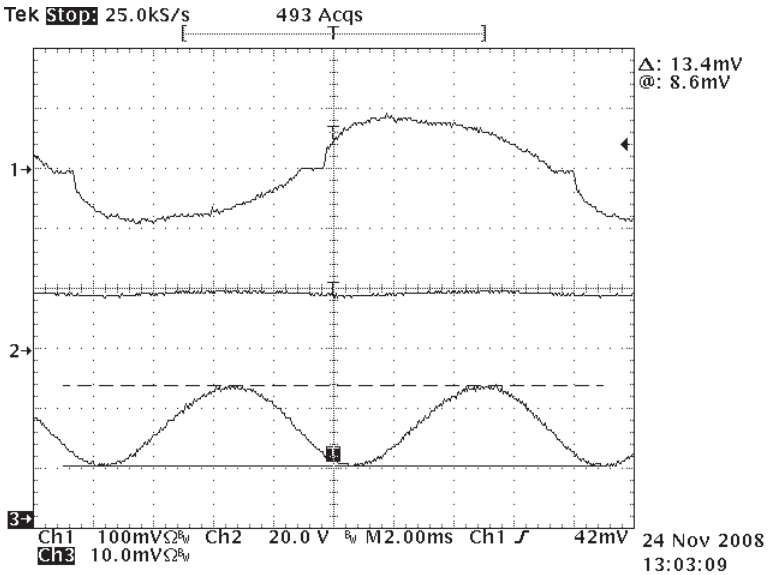

Figure 8. Output Ripple
(Ch1 - Input Current Ch2 - LED Voltage Ch3 - LED Current (200 mA/div))

7.7 Input and Output Waveforms

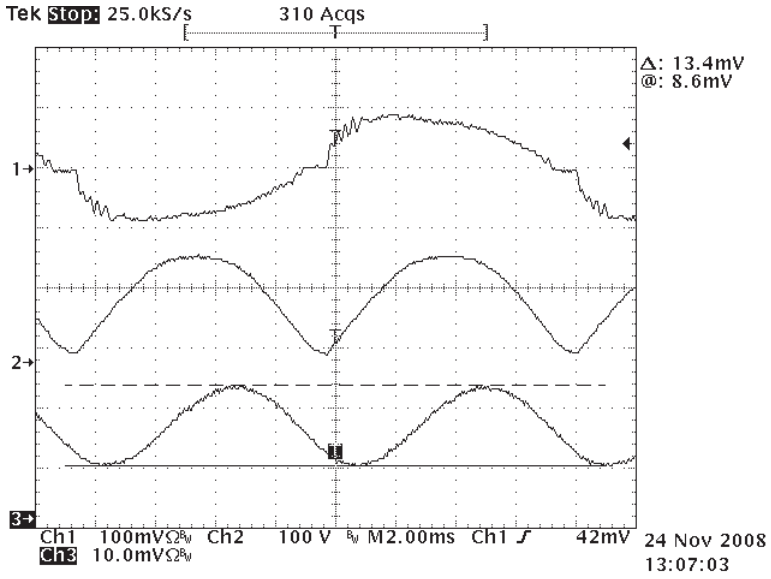

Figure 9. Input/Output Waveforms
(Ch1 - Input current Ch2 - Rectified Line Voltage Ch3 - LED Current (200 mA/div))

7.8 Switch Node Voltage

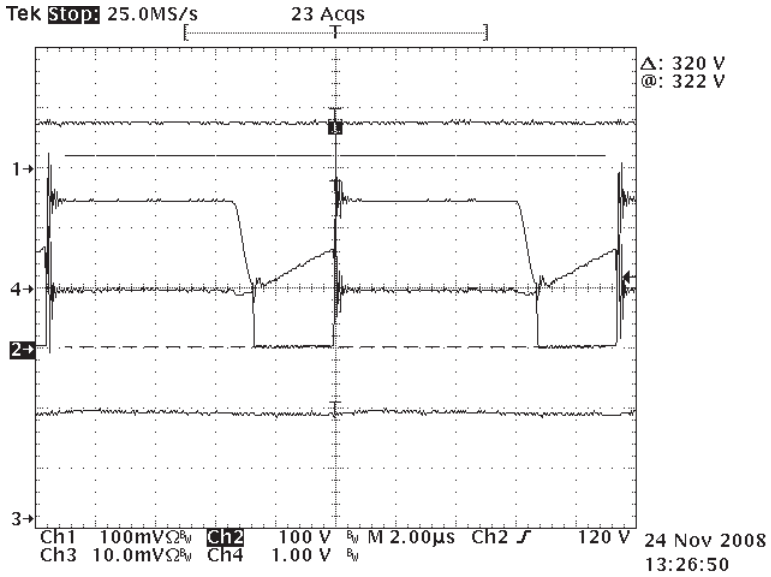

Figure 10. Switching Node Waveform
(Ch2 - Switch Node Voltage Ch3 - LED Current (200 Ma/div) Ch4 - Current Sense Voltage)

7.9 Current Sense

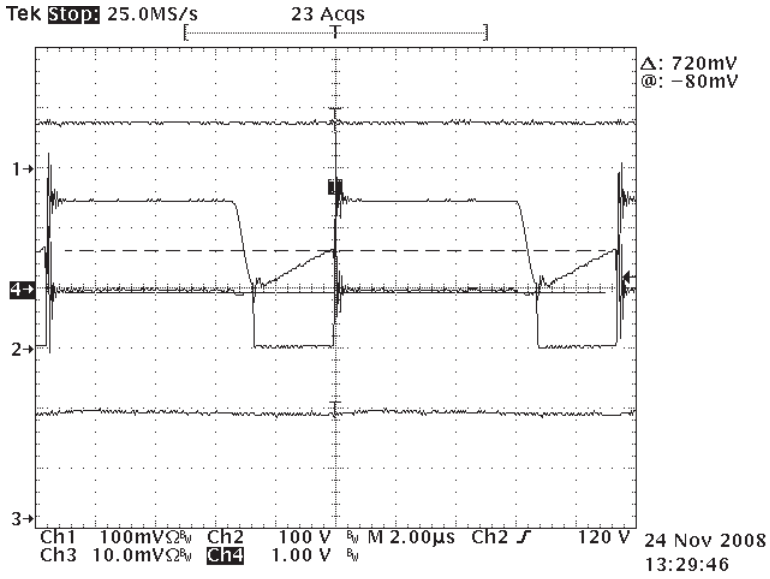

Figure 11. Current Sense Waveform
(Ch2 - Switch Node Voltage Ch3 - LED Current (200 Ma/div) Ch4 - Current Sense Voltage)

7.10 Timing Waveform (10.24 µs)

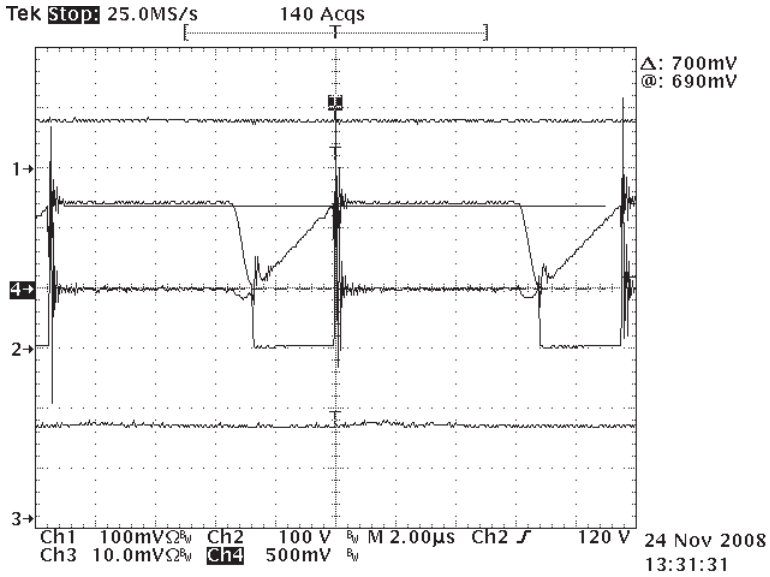

Figure 12. Timing Waveform
(Ch2 - Switch Node Voltage Ch3 - LED Current (200 mA/div) Ch4 - Current Sense Voltage)

7.11 Turn-On Waveforms

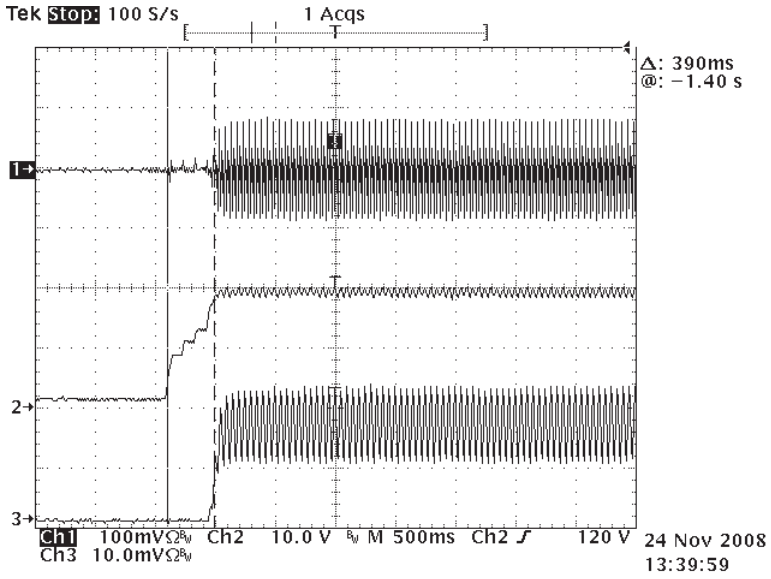

Figure 13. Enable Turn-On Delay
(Ch1 - Input Current Ch2 - LED Voltage Ch3 - LED Current (200 mA/div))

7.12 LED Open Circuit and Short Circuit Waveforms

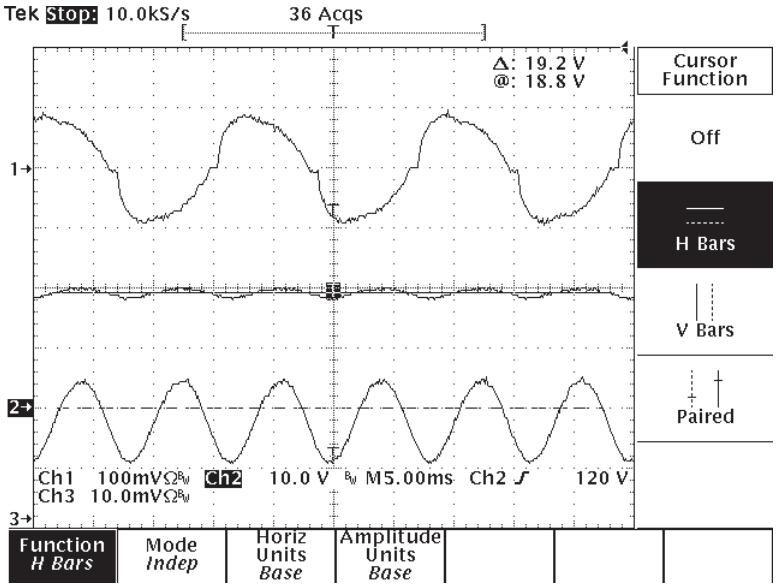

Figure 14. Pre-Open and Short Circuit Waveforms
(Ch1 - Input current Ch2 - LED Voltage Ch3 - LED Current (200 mA/div))

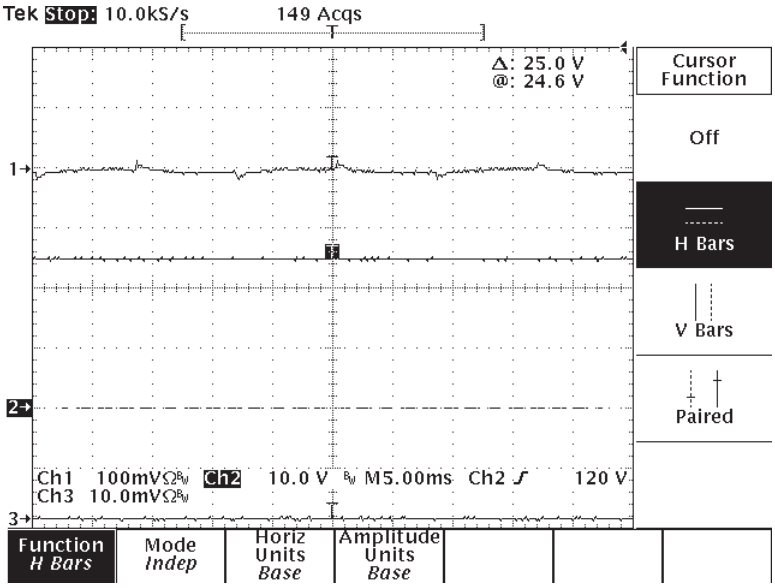

Figure 15. LED Open Circuit Waveforms
(Ch1 - Input current Ch2 - LED Voltage Ch3 - LED Current (200 mA/div))

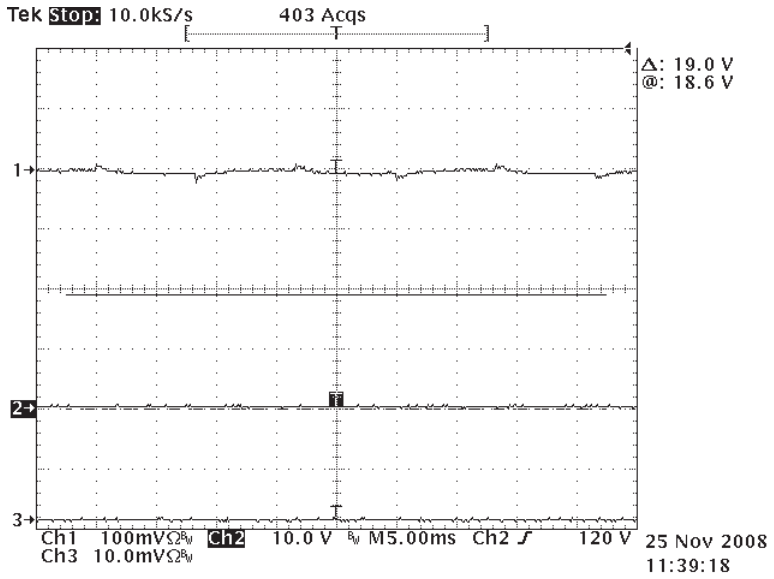

Figure 16. LED Short Circuit Waveforms
(Ch1 - Input current, Ch2 - LED Voltage, Ch3 - LED Current (200 mA/div))

7.13 EMI Plots (Line and Neutral, Average Detector Scan, FCC Class B Limits Shown)

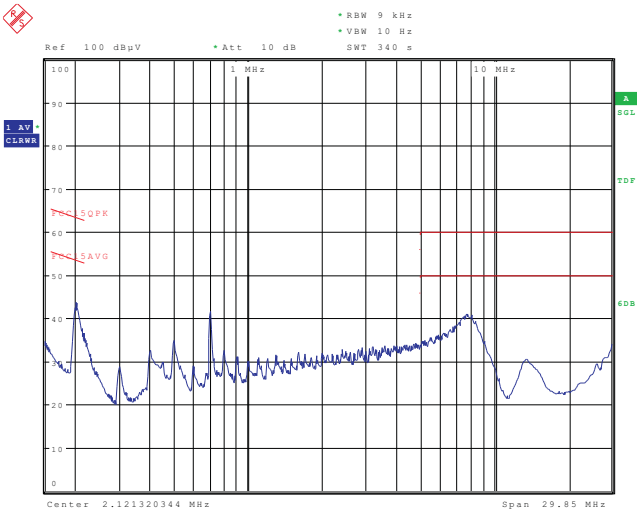

Figure 17.

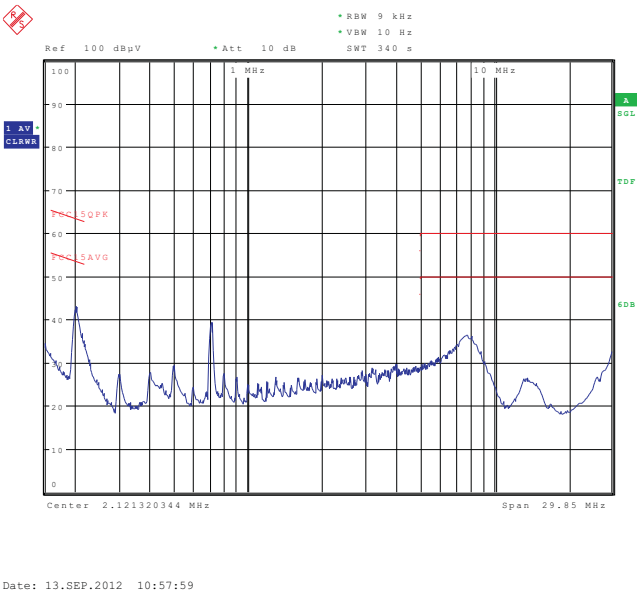

Figure 18.

7.14 Transformer Specification

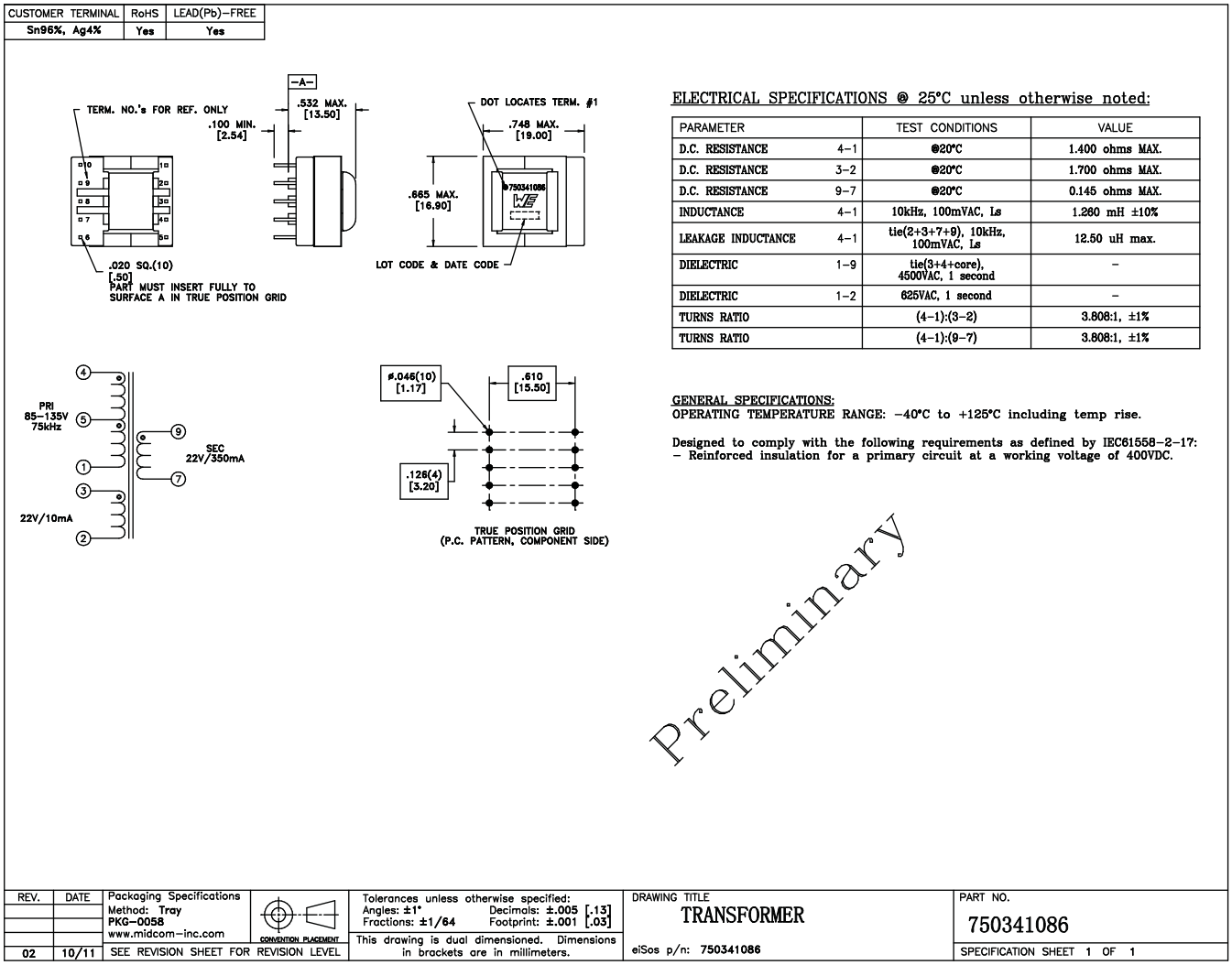

Figure 19.

8 TPS92314A19120VEVM PCB Layout

The following figures (Figure 20 and Figure 21) show the design of the TPS92314A19120VEVM printed circuit board.

NOTE: Board markings may vary slightly.

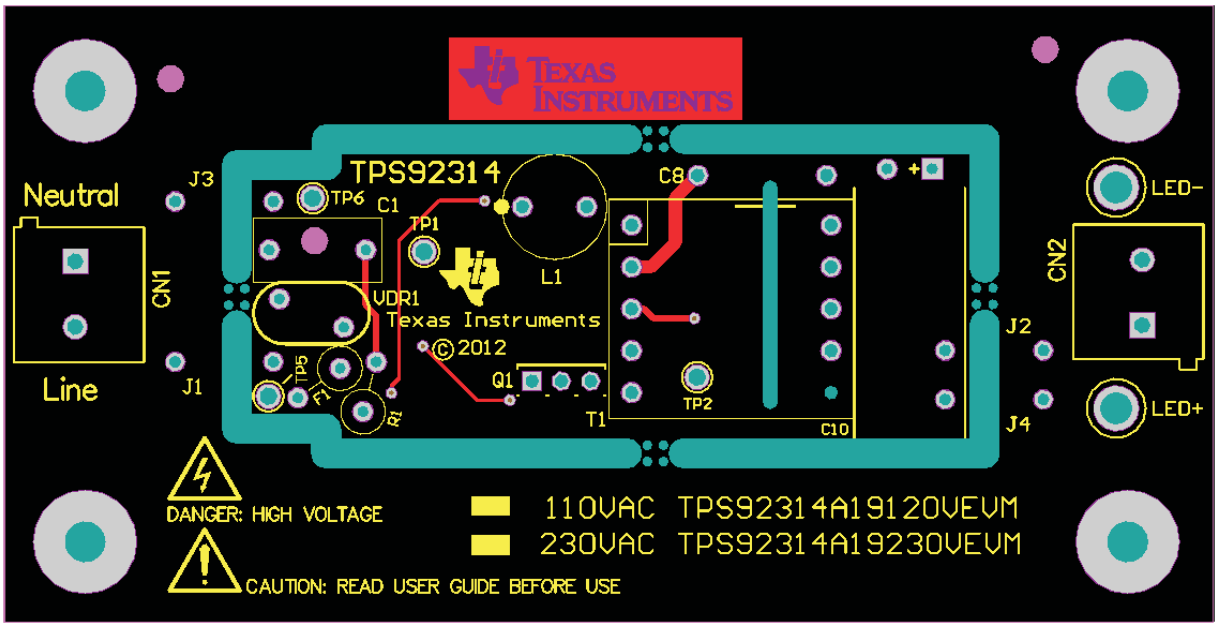

Figure 20. Top Copper (top view)

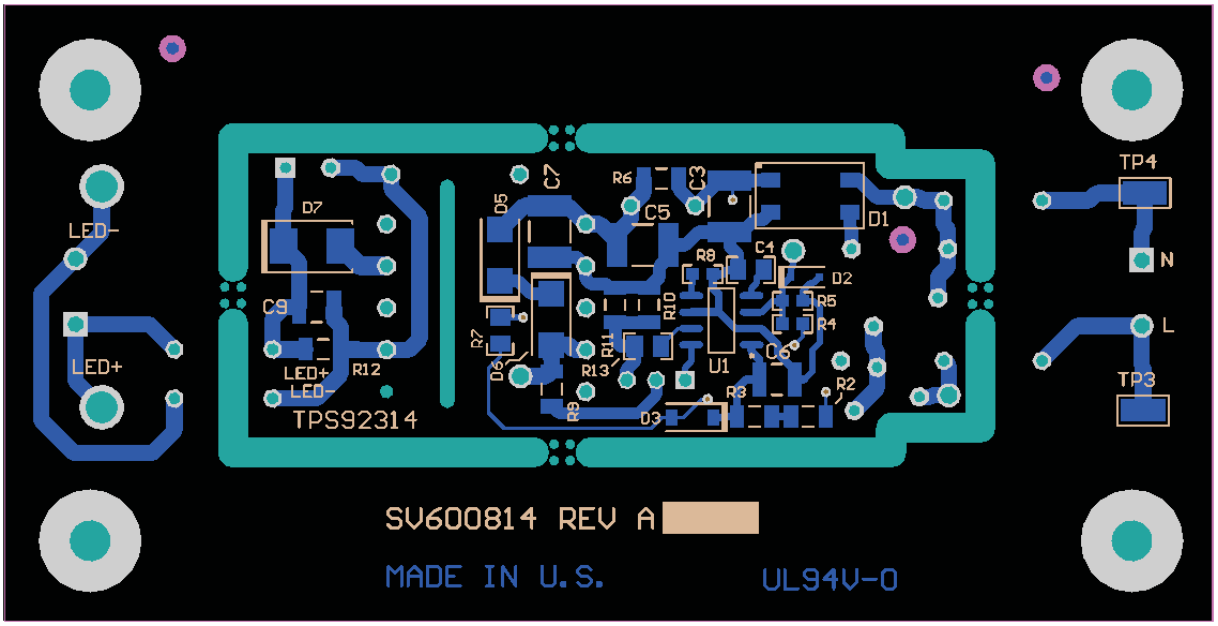

Figure 21. Bottom Copper (bottom view)

9 Lists of Materials

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

Table 3. TPS92314A19120VEVM List of Materials

QTY	REF DES	DESCRIPTION	MFG	PART NUMBER
1	C1	Capacitor, film, 0.047 µF, 630 VDC, 20%, radial	Vishay BC Components	BFC233920473
2	C3, C5	Capacitor, ceramic, 0.1 µF, 630 V, ±10%, X7R, 1812	Murata Electronics North America	GRM43DR72J104KW01L
1	C4	Capacitor, ceramic, 4.7 µF, 16 V, ±10%, X7R, 0805	MuRata	GRM21BR71C475KA73L
2	C6, C9	Capacitor, ceramic, 10 µF, 50 V, ±10%, X7R, 1210	Murata Electronics North America	GRM32ER71H106KA12L
1	C7	Capacitor, ceramic, 0.1 µF, 630 V, ±10%, X7R, 1812	Murata Electronics North America	GRM43DR72J104KW01L
1	C8	Capacitor, ceramic, 2200 pF, 250 VAC, X1Y1, TH	Murata Electronics North America	DE1E3KX222MA4BL01
1	C10	Capacitor aluminum, 470 µF, 35 V, ±20%, radial	Panasonic Electronic Components	EEU-FR1V471LB
2	CN1, CN2	Conn terminal block, 2 positive, 5.08 mm PCB	Phoenix Contact	1715721
1	D1	Diode, Switching Bridge, 400 V, 0.5 A, MiniDip	Diodes Inc	RH04-T
2	D2	Diode, Schottky, 30 V, 0.2 A, SOD-323	ON Semiconductor	BAT54HT1G
1	D3	Diode 150 V, 0.2 A, 50 ns, SOD-123	Diodes Inc	BAV20W-7-F
1	D5	Diode, TVS, 160 V, 600 W, SMB	Littelfuse Inc	SMBJ160A
1	D6	Diode, Ultrafast, 600 V, 1 A, SMA	Diodes Inc	US1J-13-F
1	D7	Diode, Schottky, 100 V, 1 A, SMB	Micro Commercial Co	SK310B-LTP
1	F1	Fuse, 500 mA, 250 V, Axial	Littelfuse	0875.500MXEP
3	FID1, FID2, FID3	Fiducial mark. There is nothing to buy or mount.	N/A	N/A
4	H1, H2, H3, H4	Machine screw, round, #4-40 x 1/4, nylon, philips panhead	B&F Fastener Supply	NY PMS 440 0025 PH
4	H5, H6, H7, H8	Standoff, hex, 0.5"L #4-40 nylon	Keystone	1902C
4	J1, J2, J3, J4	Jumper wire, 300 mil spacing, orange, pkg of 200	3M	923345-03-C
1	L1	Inductor, drum ferrite 3.3 mH 0.15 A, 11 Ω, TH1	Sumida	RCH895NP-332K
1	Q1	MOSFET N-channel, 2.5 A, 800 V, 4.5 Ω, 19 nC	STMicroelectronics	STD3NK80Z-1

Table 3. TPS92314A19120VEVM List of Materials (continued)

QTY	REF DES	DESCRIPTION	MFG	PART NUMBER
1	R1	Resistor, 22 Ω, 5%, 1 W, Axial	Panasonic Electronic Components	ERG-1SJ220
2	R2, R3	Resistor, 75 kΩ, 1%, 0.25 W, 1206	Vishay-Dale	CRCW120675K0FKEA
1	R4	Resistor, 66.5 kΩ, 1%, 0.1 W, 0603	Vishay-Dale	CRCW060366K5FKEA
1	R5	Resistor, 12.1 kΩ, 1%, 0.1 W, 0603	Vishay-Dale	CRCW060312K1FKEA
0	R6	DNP	n/a	n/a
1	R7	Resistor, 20.0 Ω, 1%, 0.125 W, 0805	Vishay-Dale	CRCW080520R0FKEA
1	R8	Resistor, 6.49 kΩ, 1%, 0.1 W, 0603	Vishay-Dale	CRCW06036K49FKEA
1	R9	Resistor, 0 Ω, 5%, 0.25 W, 1206	Vishay-Dale	CRCW12060000Z0EA
1	R10	Resistor, 1.50 Ω, 1%, 0.25 W, 1206	Vishay-Dale	CRCW12061R50FKEA
1	R11	Resistor, 49.9 Ω, 1%, 0.25 W, 1206	Vishay-Dale	CRCW120649R9FKEA
1	R12	Resistor, 42.2 kΩ, 1%, 0.125 W, 0805	Vishay-Dale	CRCW080542K2FKEA
1	R13	Resistor, 1.00 kΩ, 1%, 0.125 W, 0805	Vishay-Dale	CRCW08051K00FKEA
1	T1	Transformer EE-16	WE	750341086
0	TP1, TP2, TP5, TP6	PCB pin, solderless press fit	Mill-Max	0952-0-00-15-00-00-03-0
4	TP3, TP4, TP7, TP8	Test point, SMT, miniature	Keystone	5015
1	U1	Off-Line Primary Side Sensing with PFC	TI	TPS92314
1	VDR1	Varistor, 150 VAC, 200 VDC, 7 mm, radial	EPCOS	S07K150E2
1	AA1	Printed circuit board	TI	551600814-003 REV A

EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions:

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.

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REGULATORY COMPLIANCE INFORMATION

As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment 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: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. 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 Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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 not expressly approved by the party responsible for compliance 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 his 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.

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.

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.

【Important Notice for Users of this Product in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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EVALUATION BOARD/KIT/MODULE (EVM)
WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure that any interfaces (electronic and/or mechanical) between the EVM 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.
3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. 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 as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to defend, indemnify and hold TI, its 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 use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI 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 you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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