TPS92315EVM User's Guide

The TPS92315EVM is an LED driver for GU-10 applications. The design focuses on applications that require a small form factor and a minimal number of external components, such that the dimension of the PCB is only 31 mm × 18 mm × 12 mm (L × W × H). The EVM accepts a wide AC line input range from 85 to 250 VRMS, and regulates 350-mA current into a single LED string with 3 LEDs in series. The EVM is designed for the EN 55022 class B standard. This user's guide details the specification, schematic, PCB layout, testing, results, and bill of materials of the EVM.

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1 Introduction

The TPS92315EVM is an LED driver for GU-10 applications. The design focuses on applications that require a small form factor and a minimal number of external components, such that the dimension of the PCB is only 31 mm × 18 mm × 12 mm (L × W × H). The EVM accepts a wide AC line input range from 85 to 250 VRMS, and regulates 350-mA current into a single LED string with 3 LEDs in series. The EVM is designed for the EN 55022 class B standard. This user's guide details the specification, schematic, PCB layout, testing, results, and bill of materials of the EVM.

2 Description

The TPS92315EVM is controlled by the TPS92315, which is a single-stage AC/DC controller dedicated for GU-10 applications. The circuit senses primary-side current so current sensing and feedback from the secondly side are not required. It employs the flyback topology, working in the discontinuous conduction mode (DCM) and controlling by peak current detection. To minimize the switching loss of the MOSFET, EMI, and the turn-on current spike at the sensing resistor, the TPS92315 implements a valley switching method, aimed at turning on the MOSFET when the drain-to-source voltage of the MOSFET is near the minimum. The over-voltage protection (OVP) and over-current protection (OCP) of the TPS92315 helps protect the circuit during LED open and short.

3 Typical Applications

LED lamps:

- GU-10

Features

- Universal line input: 90 VRMS – 264 VRMS
- Primary-side sensing to achieve LED current regulation
- Valley switching benefitting the EMI and efficiency
- Flyback topology with discontinuous conduction mode (DCM) and peak current control
- LED current setting with external sense resistor

4 Electrical Performance Specifications

Table 1. TPS92315EVM

Parameter		Test Conditions	Min	Typ	Max	Unit
Input Characteristics						
V_{IN}	Input Voltage		90		264	V
I_Q	Input quiescent Current	Device enable, V_{IN} = 48 V, V_{UDIM} = 1 V, no switching			3	mA
Output Characteristics						
V_{OUT}	Output Voltage	LED+ to LED-	8.5		11	V
I_{LED}	LED Current	V_{OUT} = 9 V	335	350	365	mA
SYSTEMS CHARACTERISTICS						
η	Efficiency	90 V_{AC} < V_{IN} < 264 V_{AC}, V_{OUT} = 9 V, I_{LED} = 350 mA	70		85	%

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5 Schematic

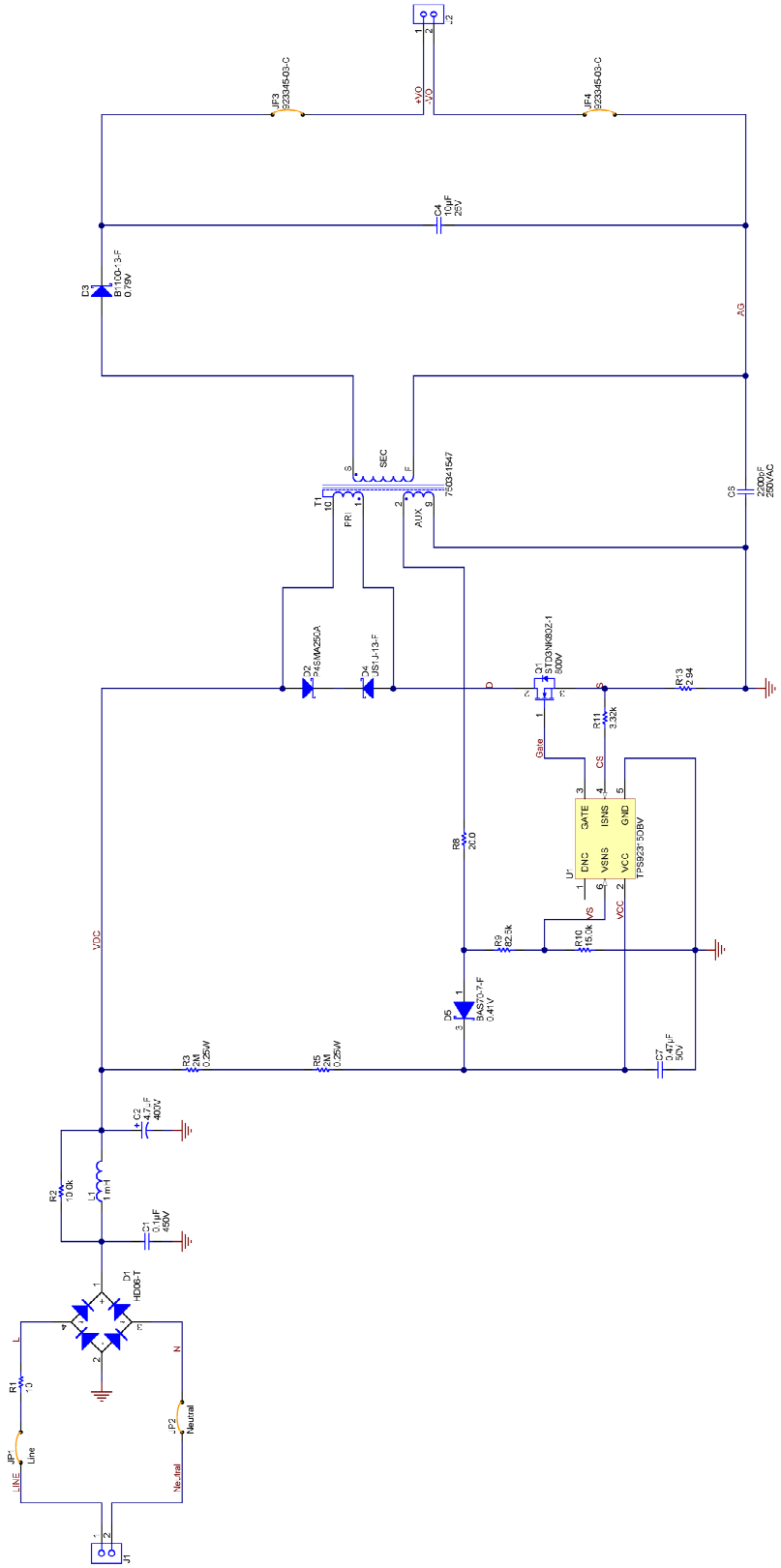


Figure 1. Schematic of the TPS92315EVM

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5.1 Test Equipment

- **Voltage Source:** Start at 90 VRMS–264 VRMS; AC source: PCR500LA (KIKUSUI)
- **Multimeter:** Agilent 34401A
- **Power meter:** WT210 Digital Power Meter (YOKOGAWA)
- **LED Load:** 3 LEDs in series (LED forward voltage = 3.0 V each at 350 mA)
- **Oscilloscope:** TDS3054C (TEKTRONIX)
- **Operation temperature:** 25°C

6 Board Connection

Figure 2 illustrates the board connections for the TPS92315EVM.

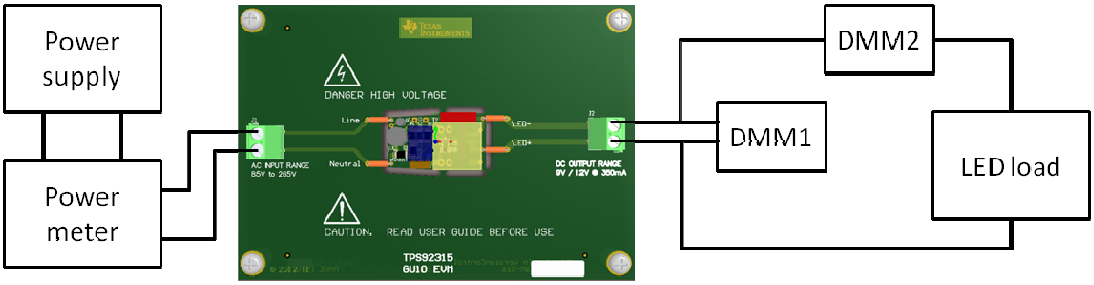


Figure 2. Typical Connection Block Diagram

Table 2. Board Connection Description

Terminal Designation	Description
AC Live	Connect to a 110 V_{AC} or 220 V_{AC} directly or through a power meter
AC Neutral	
LED+	Connect to the LED string directly or through an ammeter
LED–	

7 TPS92315EVM Test Procedure

CAUTION

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

Table 3. Connections

Step	Operation	Remarks
1	Connect the AC mains or an AC source to a power meter	The power meter can be by-passed
2	Connect the TPS92315EVM to the power meter	Connect to the line and neutral terminals of the TPS92315EVM
3	Connect the LED load to the TPS92315EVM	Connect to the LED+ and LED- terminals of the TPS92315EVM

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Table 4. Functional AC Input Test

Step	Operation	Remarks
1	Set the AC source output between 85 to 250 V_{AC}	
2	Turn on the AC power	The LED current is 350 mA ± 5%
3	Turn off the AC power	Do not touch any connection within 2 seconds after power off

8 Typical Performance Characteristics

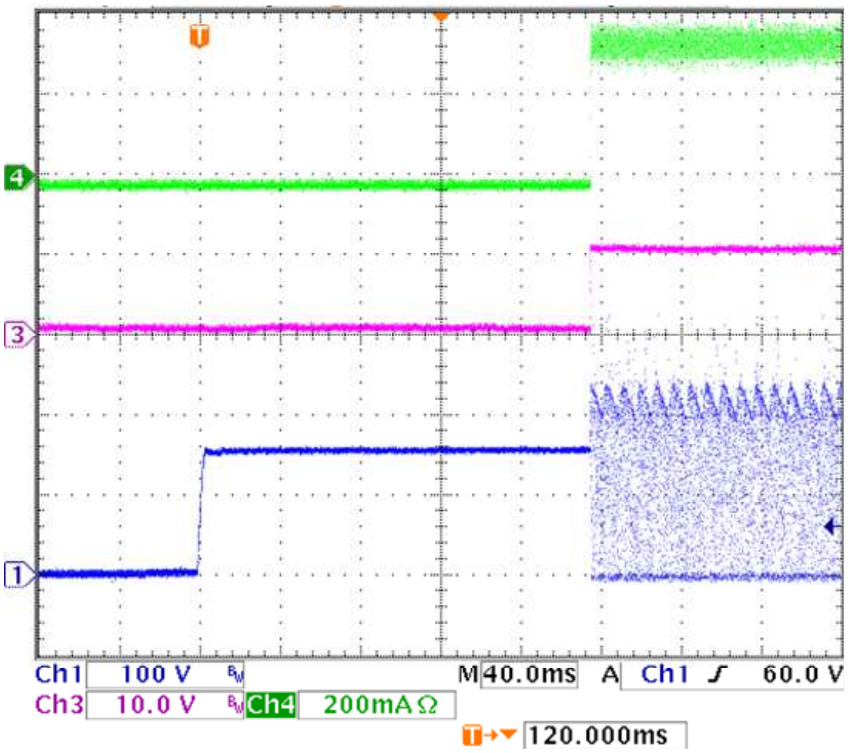


Figure 3. Waveforms of Power-up Transient of TPS92315EVM with V_{IN} = 110V_{AC} (Ch 1: Drain Voltage of Q_1; Ch 3: V_{LED}; Ch 4: I_{LED})

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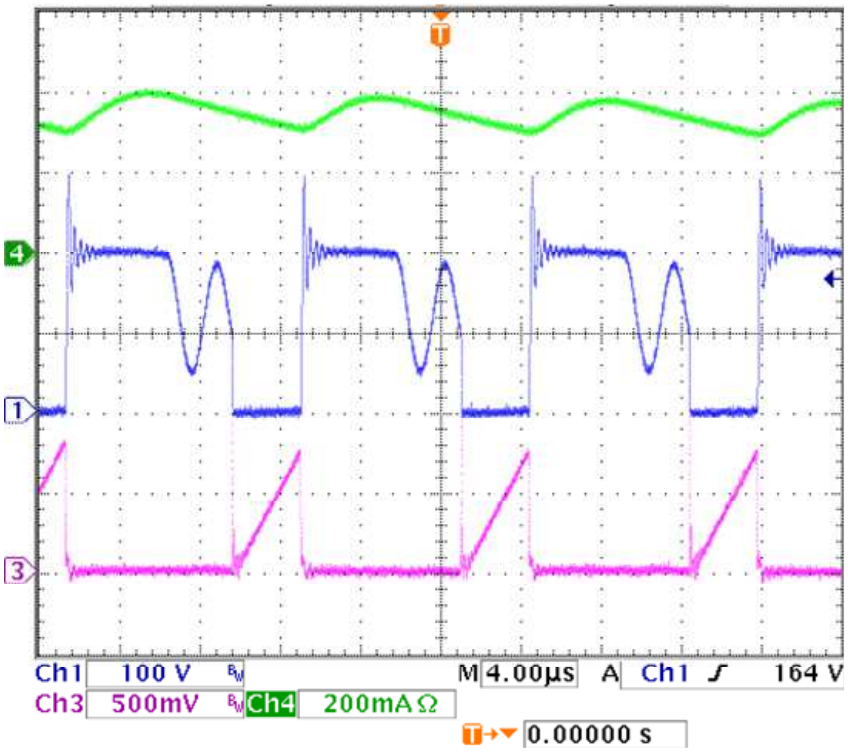


Figure 4. Waveforms of Steady State Operation of TPS92315EVM with V_{IN} = 110V_{AC} (Ch 1: Drain Voltage of Q_1; Ch 3: Source Voltage of Q_1; Ch 4: I_{LED})

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9 Electromagnetic Interference (EMI)

Figure 5 through Figure 8 show the peak conductive EMI scans. Data are compared with the EN 55022 Class B conducted EMI limits. All tests are under the conditions that the LED voltage, LED current, and output power are 9.2 V, 350 mA, and 3.2 W, respectively.

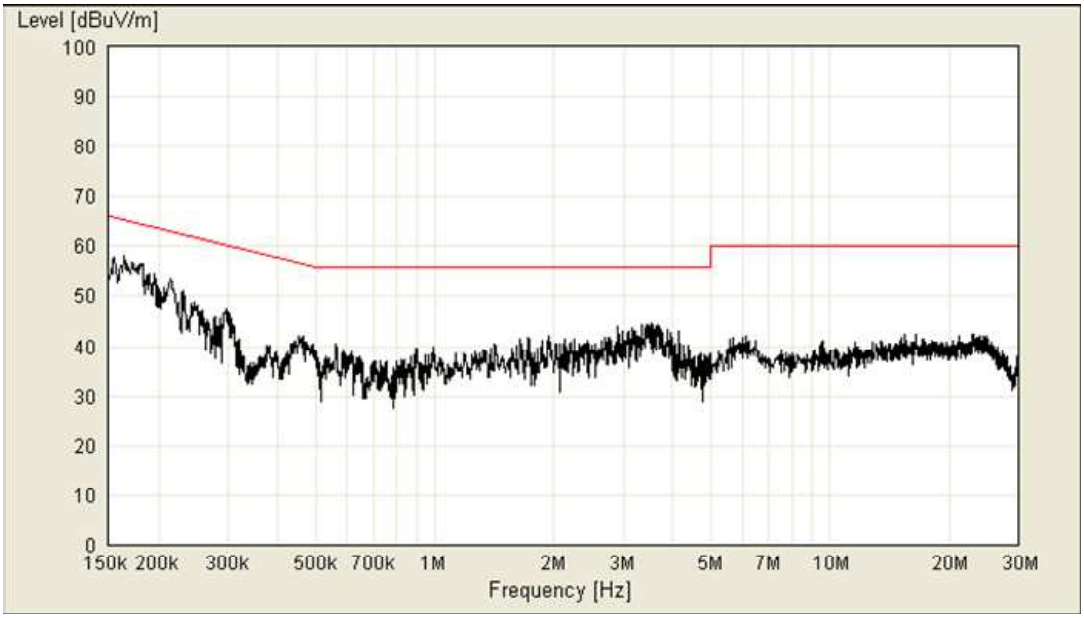


Figure 5. Peak Conductive EMI per EN55022 Class B Limits (110 VAC Live)

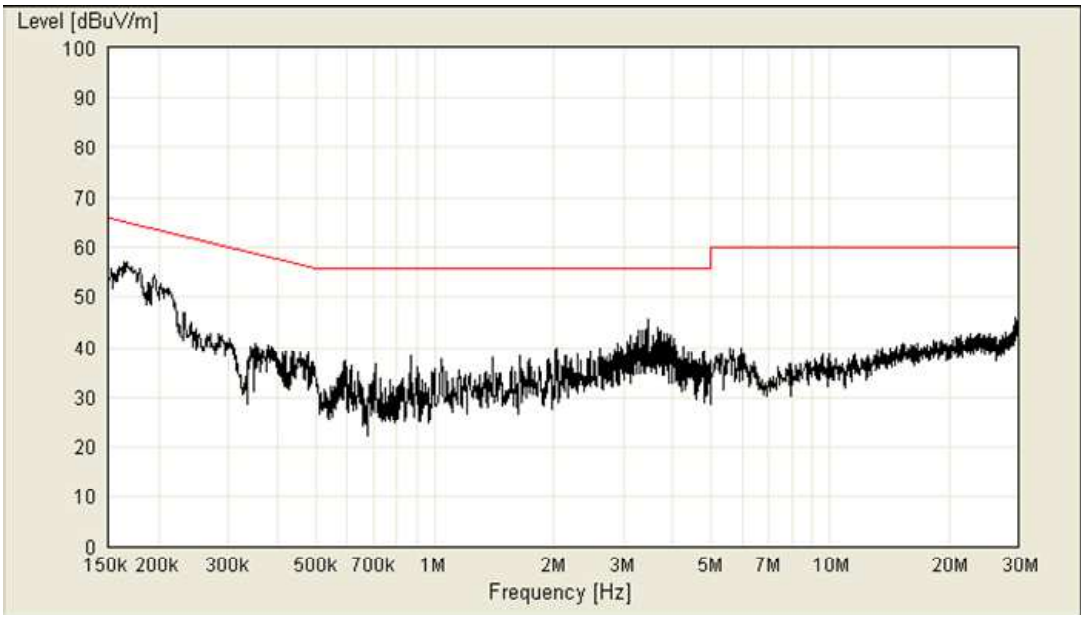


Figure 6. Peak Conductive EMI per EN55022 Class B Limits (110 VAC Neutral)

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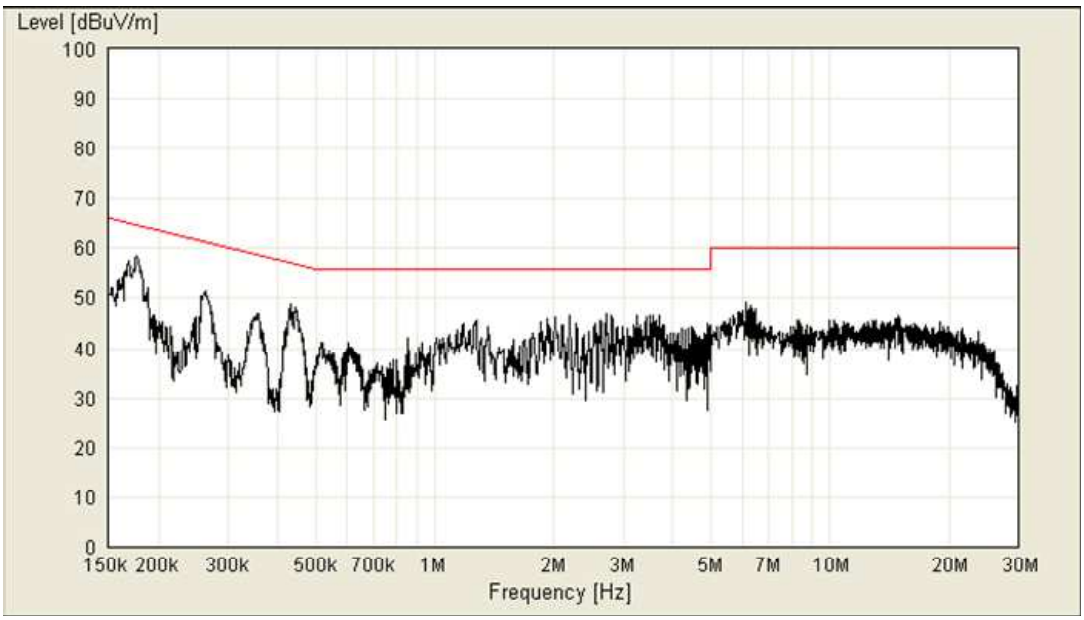


Figure 7. Peak Conductive EMI per EN55022 Class B Limits (230 VAC Live)

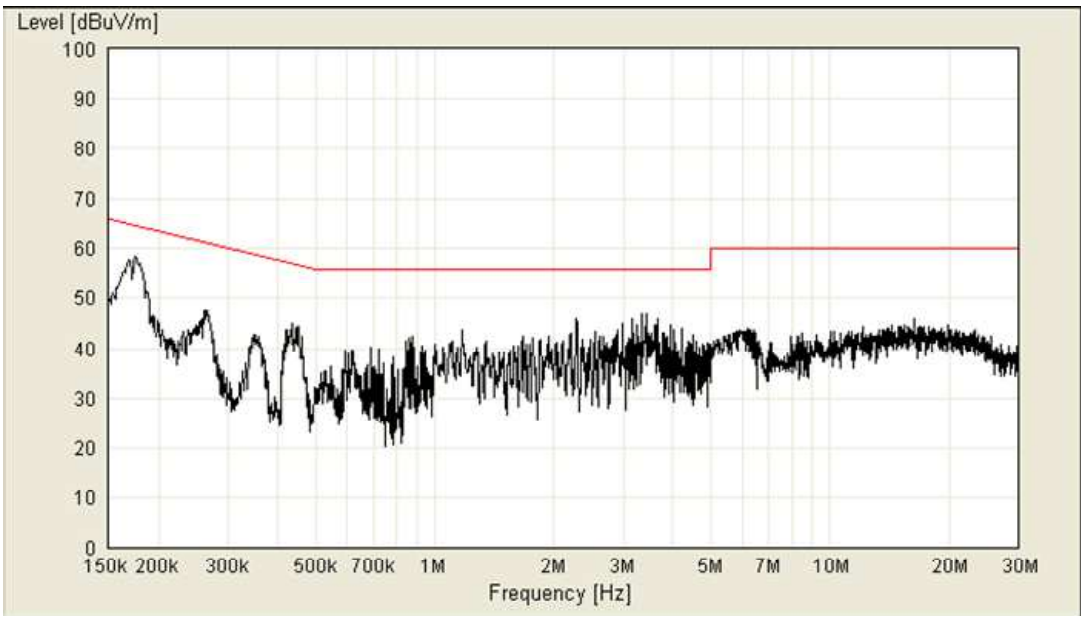


Figure 8. Peak Conductive EMI per EN55022 Class B Limits (230 VAC Neutral)

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10 Assembly Drawings and PCB Layout

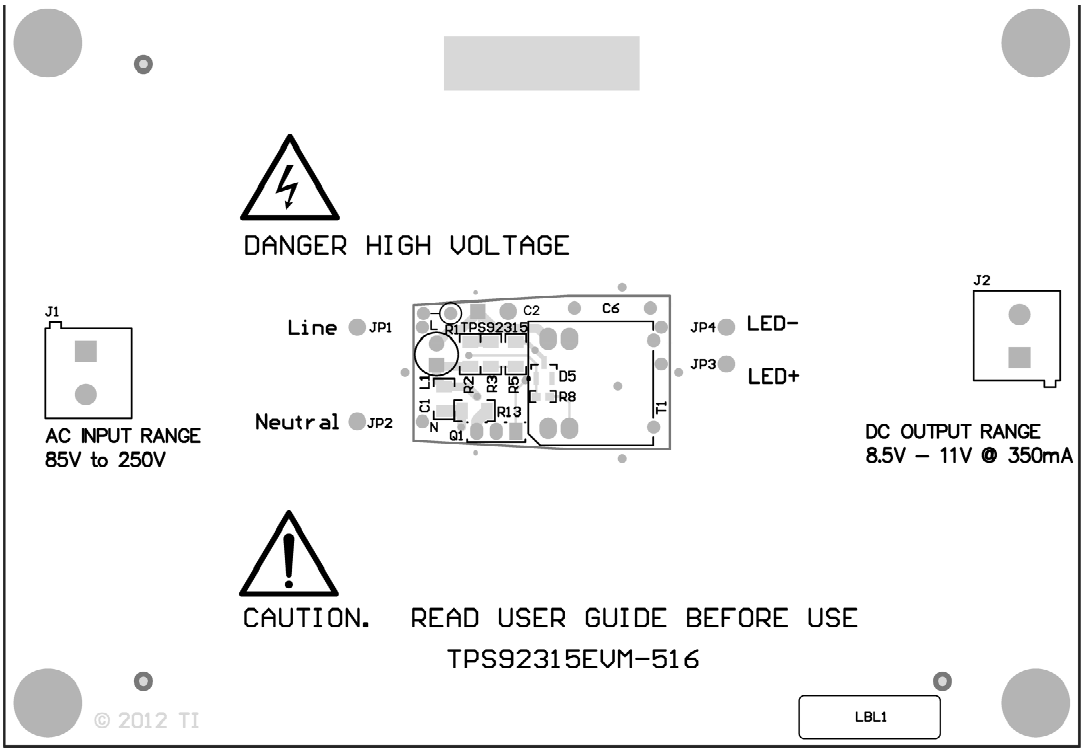


Figure 9. Top Layer PCB

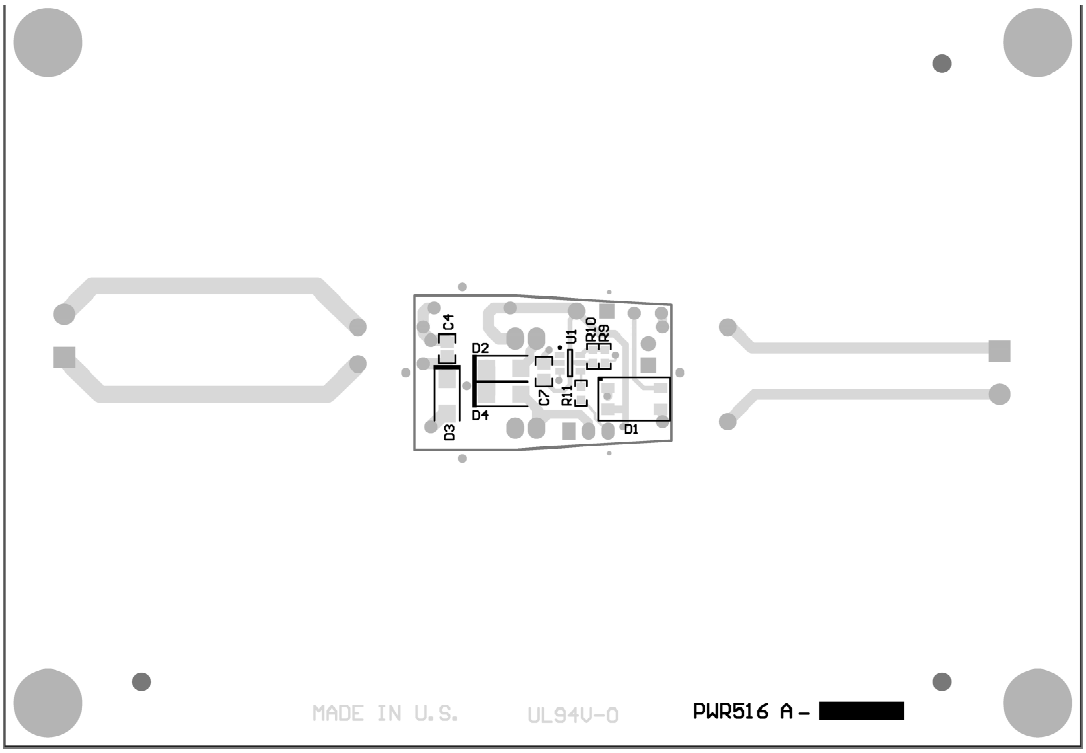


Figure 10. Bottom Layer PCB

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11 Bill of Materials

Table 5. Bill of Materials

Item	Designator	Description	Manufacturer	Part Number
1	C1	Capacitor, ceramic, 0.1µF, 450V, 10%, X7T, 1206	TDK Corporation	C3216X7T2W104K
2	C2	Capacitor, Aluminum, 4.7µF, 400V, 20%, Radial 8mm x 11.5mm	Nichicon	UVC2G4R7MPD
			Nippon Chemi-con Corporation	ECLE401ELL4R7MHB5D
3	C4	Capacitor, ceramic, 10µF, 25V, 10%, X5R, 0805	Taiyo Yuden	TMK212BBJ106KG-T
4	C6	Capacitor, ceramic, 2200pF, 250V, 20%, THT X1Y1	Murata Electronics North America	DE1E3KX222MA5BA01
5	C7	Capacitor, ceramic, 0.47µF, 50V, 10%, X7R, 0805	TDK Corporation	C2012X7R1H474K
6	D1	Diode, Switching-Bridge, 600V, 0.8A, MiniDIP	Diodes Inc	HD06-T
7	D2	Diode, TVS, 400W 250V, UNI 5%, SMD	Littelfuse Inc	P4SMA250A
8	D3	Diode, Schottky, 100V, 1A, SMA	Diodes Inc.	B1100-13-F
9	D4	Diode, Ultrafast, 600V, 1A, SMA	Diodes Inc.	US1J-13-F
10	D5	Diode, Schottky, 70V, 0.07A, SOT-23	Diodes Inc.	BAS70-7-F
11	H1, H2, H3, H4	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	B&F Fastener Supply	NY PMS 440 0025 PH
12	H5, H6, H7, H8	Standoff, Hex, 0.5"L #4-40 Nylon	Keystone	1902C
13	J1, J2	Conn Term Block, 2POS, 5.08mm PCB	Phoenix Contact	1715721
14	JP1, JP2, JP3, JP4	Jumper Wire, 300mil spacing, Orange, pkg of 200	3M	923345-03-C
15	L1	Fixed Inductors, 1mH, 0.14A, Radial Lead	Sumida	RCH4764NP-102K
16	Q1	MOSFET, N-CH, 800V, 2.5A, TO-251AB	ST Microelectronics	STD3NK80Z1
17	R1	Resistor, fusible WW, 10Ω, 1W, 5%	Yageo	FKN1WSJR52-10R
				FAE1WSJR-52-10R
18	R2	Resistor, 10.0kΩ, 1%, 0.25W, 1206	Vishay-Dale	CRCW120610K0FKEA
19	R3, R5	Resistor, 2.00MΩ, 1%, 0.25W, 1206	Yageo	RC1206FR072ML
20	R8	Resistor, 20.0Ω, 1%, 0.1W, 0603	Vishay-Dale	CRCW060320R0FKEA
21	R9	Resistor, 82.5kΩ, 1%, 0.1W, 0603	Vishay-Dale	CRCW060382K5FKEA
22	R10	Resistor, 15.0kΩ, 1%, 0.1W, 0603	Vishay-Dale	CRCW060315K0FKEA
23	R11	Resistor, 3.32kΩ, 1%, 0.1W, 0603	Vishay-Dale	CRCW06033K32FKEA
24	R13	Resistor, 2.94Ω, 1%, 0.25W, 1206	Vishay-Dale	CRCW12062R94FKEA
25	T1	Transformer EE-16, TH	Wurth Elektronik eiSos	750341547
26	U1	Off-Line Primary-Side Sensing Controller, DBV0006A	Texas Instruments	TPS92315DBV

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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.

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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.

Texas Instruments Japan Limited
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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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