

## **AN-2233 TPS92311 Evaluation Module**

---

---

---

### **1 Introduction**

The TPS92311 EVM-8W evaluation module is a constant current output LED driver supporting 5W–8W applications. The design focuses on applications that require small form factor and minimal number of external components. The actual PCB dimension of the module is only 22mm x 55mm x 19mm (L x W x H). The module can work with AC line input from 90 to 132V<sub>RMS</sub> or 180 to 264V<sub>RMS</sub> and supplying 350mA current into a single string of LEDs, typically 6-7 LEDs in series. The evaluation board is carefully designed to comply with major industrial EMC and safety requirements. The user can make use of the information provided in the *TPS92311 Off-Line Primary Side Sensing Converter with PFC* ([SNVS811](#)) data sheet and application notes to design its specific end product easily.

### **2 Description**

The TPS92311 EVM-8W is developed with the TPS92311 converter IC. The TPS92311 is a single-stage AC/DC converter dedicated for LED Lighting applications. The converter uses a primary-side current sense configuration to control the LED current at secondly side. The system works in Critical Conduction Mode (CRM) with flyback topology and it employs a constant on time modulation scheme. Inherently, systems with this configuration can achieve greater than 0.90 Power Factor (PF) easily. The Power Factor (PF) and line current harmonic performances of the evaluation board are tested and reported in this document. The TPS92311 also integrated various protection features: Over-Voltage Protection (OVP), Thermal Shut Down (TSD) and cycle-by-cycle Over-Current Protection (OCP). With these features in place, the system is well protected against open and short circuit of the LEDs string. Considering with the EMI problem, the TPS92311 integrates an internal delay timer to improve it. The delay time can be programmed through an external resistor, it can ensures the converter switch ON the internal MOSFET only when the MOSFET's drain voltage at its lowest point. The Quasi-resonant switching operation improves the EMI and system efficiency significantly.

### **3 Typical Applications**

LED Lamps:

- A19 (E26/27, E14)
- PAR30/38
- GU10

Domestic and Office SSL solutions:

- Down Light
- LED Panel Light
- Ceiling Lamp Troffer
- T8 Tube

**Features**

- Integrated 600V Power MOSFET
- Regulates LED current without secondary side sensing
- Critical-Conduction-Mode (CRM) with Zero-Current Detection (ZCD) for valley switching
- Adaptive ON-time control with inherent PFC
- Programmable power MOSFET turn ON delay
- Programmable Constant ON-Time (COT) and Peak Current Mode (PCM) Control
- Over temperature protection

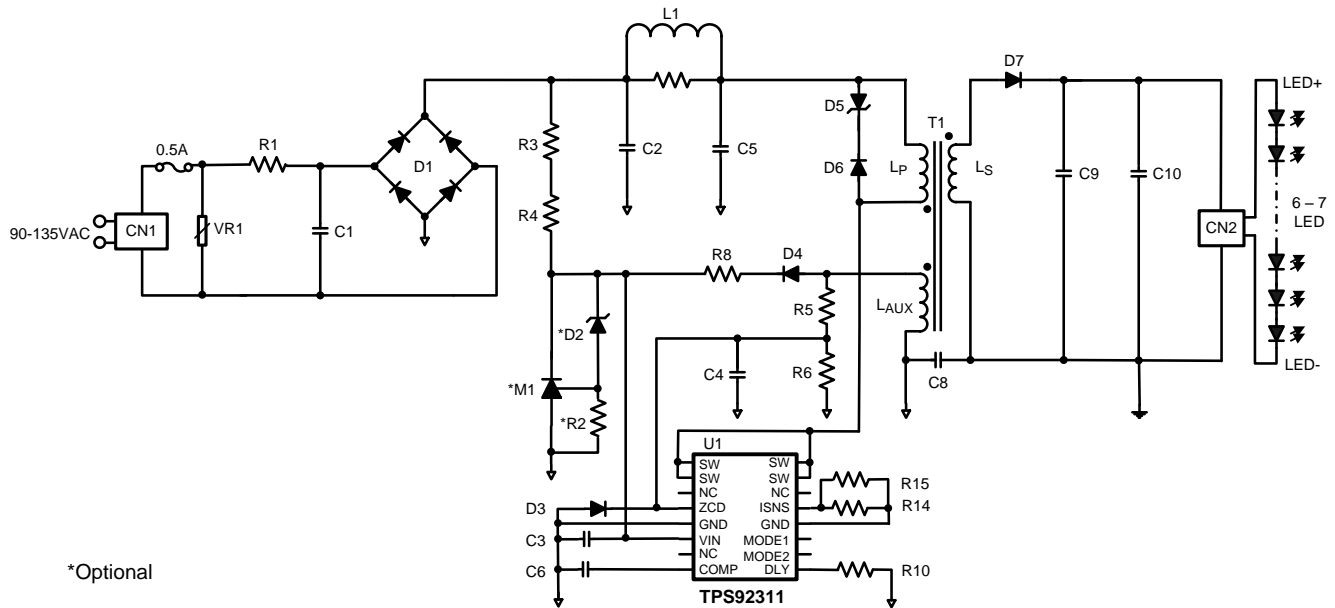
**4 Electrical Performance Specifications**
**Table 1. 230VAC Evaluation Board (TPS92311 230V EVM)**

PARAMETER	TEST CONDITIONS	Min	Typ	Max	Units
Input Characteristics					
	Voltage range	180		264	$V_{RMS}$
	Input current when VAC = 230V <sub>RMS</sub> , $V_{LED} = 20V$	-	38	-	mA
Output Characteristics					
	Output voltage, $V_{LED}$		21		V
	Output load current, $I_{LED}$	330	350	370	mA
	Output over voltage	-	26	-	V
Systems Characteristics					
	Full load efficiency ( $P_{IN} = 8W$ )	83	85	-	%
	Full load Power Factor ( $P_{IN} = 8W$ ) 230V@50Hz	-	>0.9	-	

**Table 2. 120VAC Evaluation Board (TPS92311 120V EVM)**

PARAMETER	TEST CONDITIONS	Min	Typ	Max	Units
Input Characteristics					
	Voltage range	90		132	$V_{RMS}$
	Input current when VAC = 120V <sub>RMS</sub> , $V_{LED} = 20V$	-	75	-	mA
Output Characteristics					
	Output voltage, $V_{LED}$		21		V
	Output load current, $I_{LED}$	330	350	370	mA
	Output over voltage	-	26	-	V
Systems Characteristics					
	Full load efficiency ( $P_{IN} = 8W$ )	82	85	-	%
	Full load Power Factor ( $P_{IN} = 8W$ ) 120V@60Hz	-	>0.9	-	

**5 Schematic ( TPS92311 120V EVM / TPS92311 230V EVM )**



**Figure 1. Standard Schematic for the TPS92311 Evaluation Board**

**5.1 Test Equipment**

**Voltage Source:** Start at  $90V_{RMS}$ - $132V_{RMS}$  or  $180V_{RMS}$ - $264V_{RMS}$ ; AC source: PCR500LA (KIKUSUI)

**Multimeter:** Agilent 34401A

**Power meter:** WT210 Digital Power Meter (YOKOGAWA)

**Output Load:** 7 LEDs in series ( LED forward voltage =3.0 V at 350 mA ) or  $V_{LED} = 21V$

**Oscilloscope:**TDS3054C (TEKTRONIX )

**Operation temperature :** 25°C

## 6 Board Connection

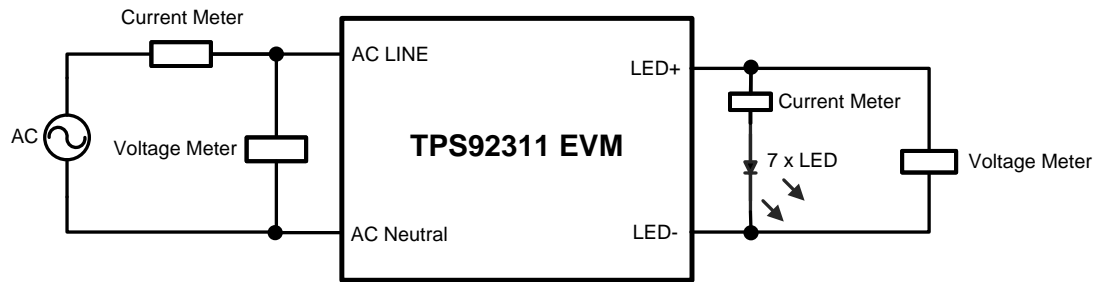


Figure 2. Typical Connection Block Diagram



Figure 3. TPS92311EVM\_8W

Terminal Designation	Description
AC Live	Connect 230V <sub>AC</sub> or 120V <sub>AC</sub> to the board (TPS92311 120V EVM = 120V <sub>AC</sub> , TPS92311 230V EVM = 230V <sub>AC</sub> )
AC Neutral	
LED+	Connect to the LED + of the LED string
LED-	Connect to the LED – of the LED string

## 7 TPS92311 Evaluation Board 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.

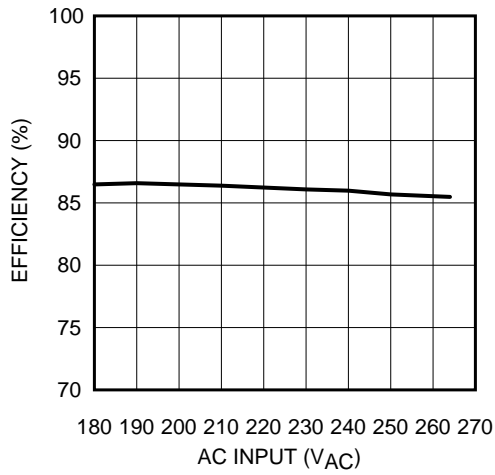
**Table 3. Connections**

Step	Operation	Remarks
1	Confirm the demo boards version. (120V <sub>AC</sub> TPS92311 120V EVM or 230V <sub>AC</sub> TPS92311 230V EVM)	Check the demo board.
2	Connect the AC source to AC line	AC source voltage is 230V <sub>AC</sub> (TPS92311 230V EVM ) or/120V <sub>AC</sub> (TPS92311 120V EVM)
3	Connect the LED light or electronic load to connector LED+ and LED- ( <a href="#">Figure 2</a> ).	If use electronic load, set the electronic load is 21V with CV mode. And make sure the LED + connect to electronic load + and LED- connection electronic load GND.

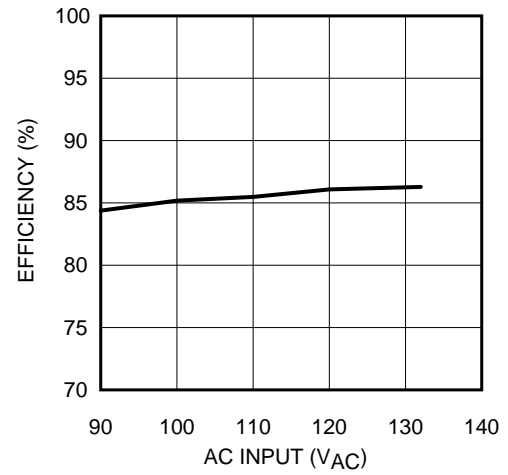
**Table 4. Functional AC Input Test**

Step	Operation	Remarks
4	Switch the power switch on the setup to ON position.	Please confirm the AC1 and AC2 connection are correct.
5	The LEDs lights up within 2 sec. Measure the convertor output voltage.	The LED voltage is 21V. I <sub>LED</sub> current is 350mA +/- 5% (electronic load loading value). V <sub>LED</sub> start up <2 second, Power Factor >0.9 and I <sub>LED</sub> between 330mA to 370mA
6	Switch off the power source.	Don't touching any connection within 2 second after power off.

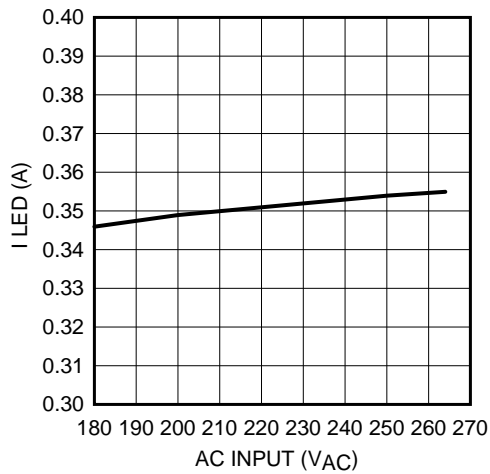
## 8 Typical Performance Characteristics (TPS92311 230V EVM (230VAC) / TPS92311 120V EVM (120VAC))



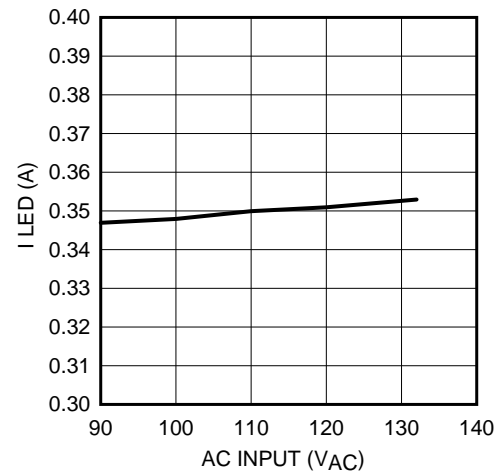
**Figure 4. Efficiency vs AC Input**



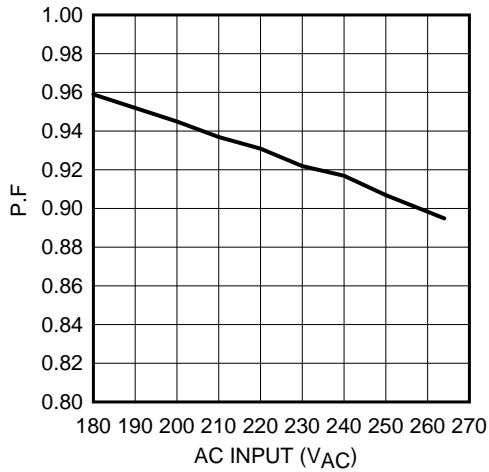
**Figure 5. Efficiency vs AC Input**



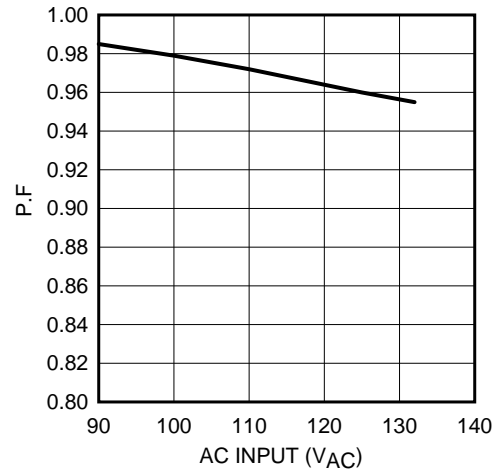
**Figure 6. Line Regulation**



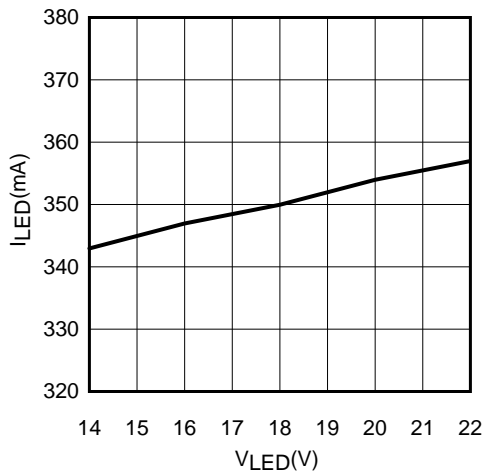
**Figure 7. Line Regulation**



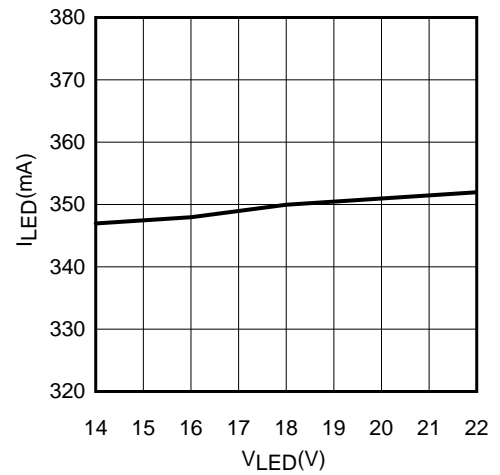
**Figure 8. Power Factor**



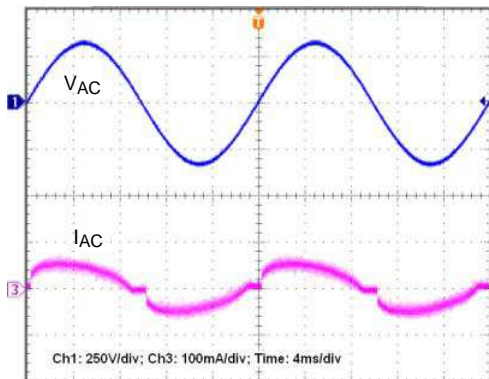
**Figure 9. Power Factor**



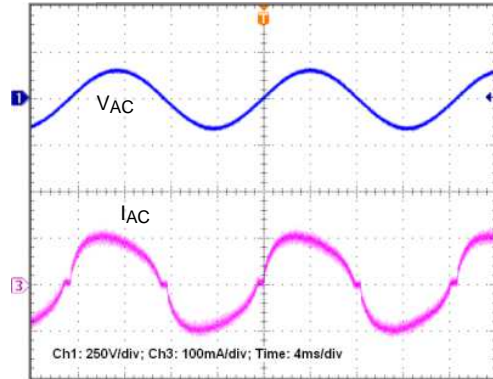
**Figure 10. Load Regulation (230VAC)**



**Figure 11. Load Regulation (120VAC)**



**Figure 12. Input Voltage and Input Current (230VAC)**



**Figure 13. Input Voltage and Input Current (120VAC)**

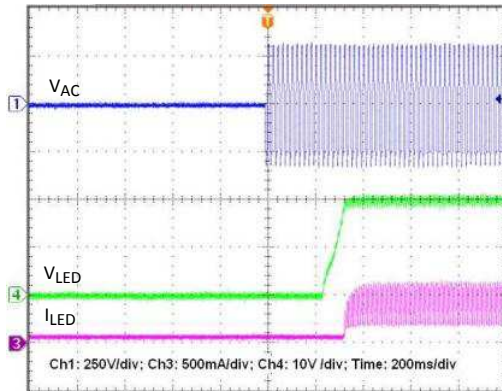


Figure 14. Power Up Output Voltage and Current (230VAC)

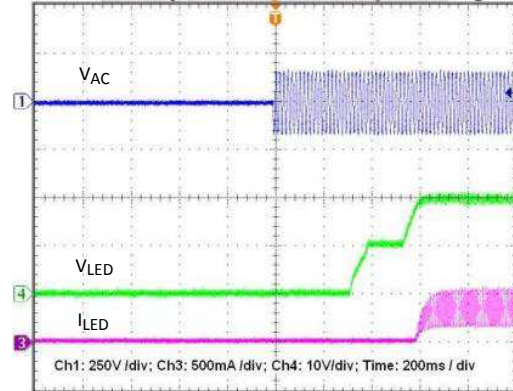


Figure 15. Power Up Output Voltage and Current (120VAC)

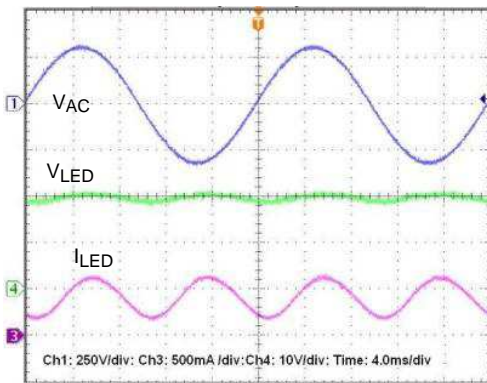


Figure 16. Output Current and Voltage Waveforms (230VAC)

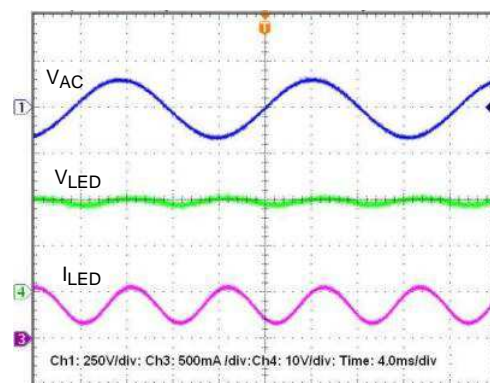


Figure 17. Output Current and Voltage Waveforms (120VAC)

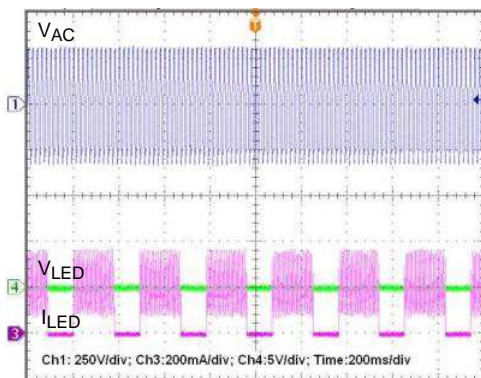


Figure 18. Output Short Circuit Waveforms (230VAC)

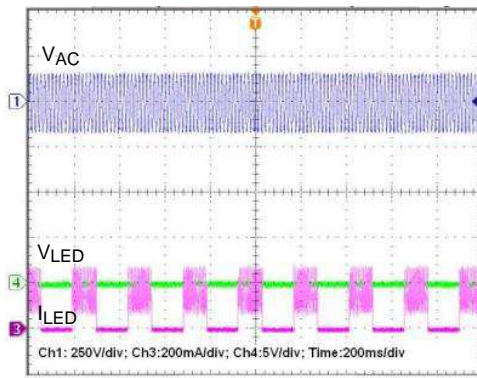
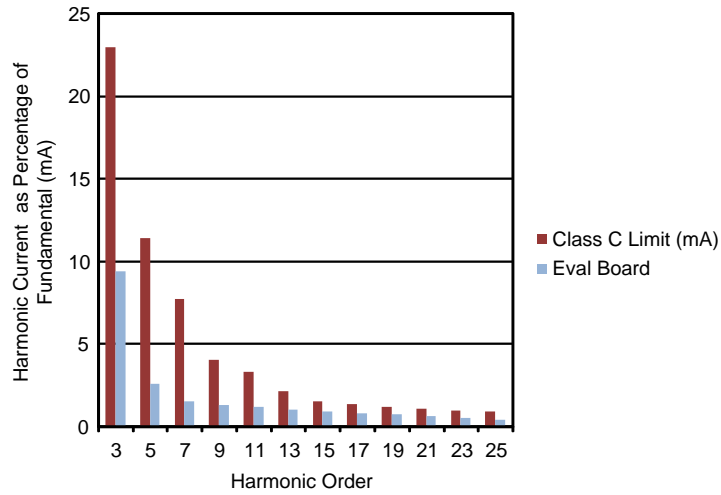


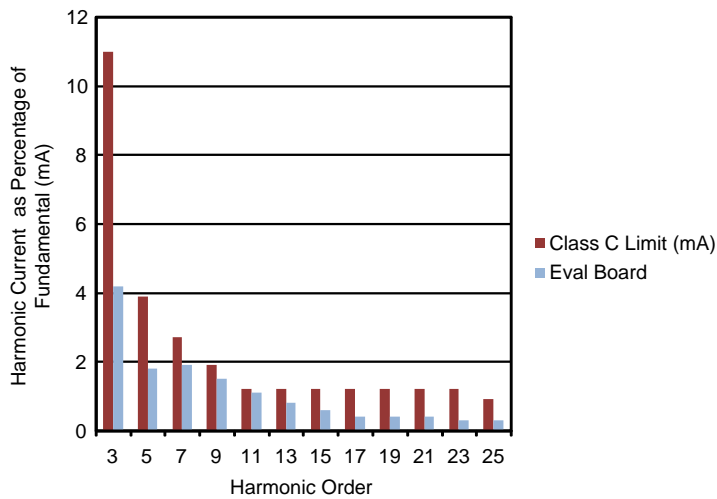
Figure 19. Output Short Circuit Waveforms (120VAC)



## 9 Current Harmonic Information



**Figure 20. TPS92311 120V EVM Current Harmonic vs IEC61000–3–2 Class C Limits**



**Figure 21. TPS92311 230V EVM Current Harmonic vs IEC61000–3–2 Class C Limits**

## 10 Electromagnetic Interference (EMI)

In order to get quick estimation of the EMI filter performance, only PEAK conductive EMI scan was measured and the data was compared with the EN 55022 Class B conducted EMI Limits. All test conditions are under  $P_{IN} = 8W$  full load.

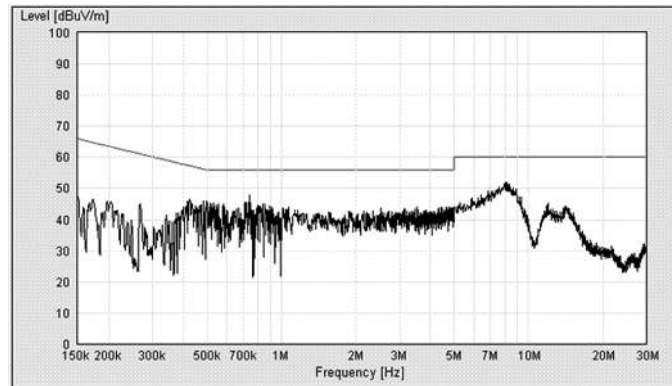


Figure 22. Peak Conductive EMI per EN55022, Class B Limits (110VAC Live)

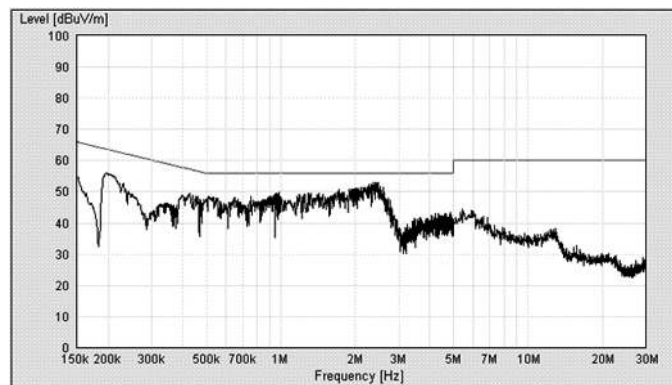


Figure 23. Peak Conductive EMI per EN55022, Class B Limits (110VAC Neutral)

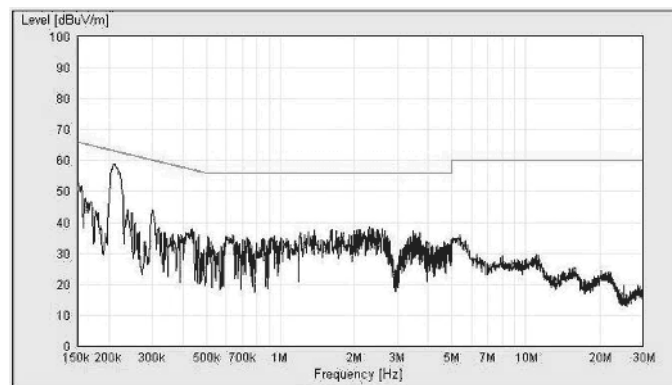


Figure 24. Peak Conductive EMI per EN55022, Class B Limits (230VAC Live)

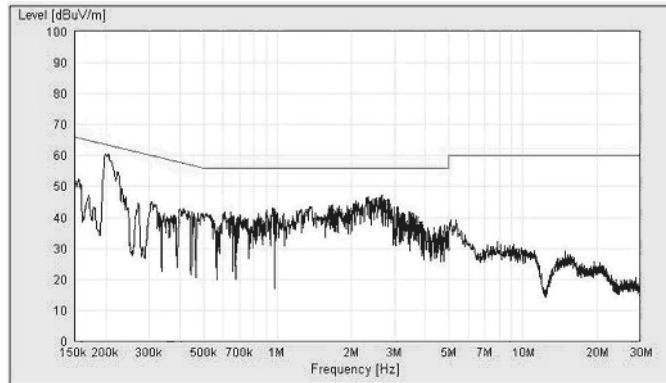


Figure 25. Peak Conductive EMI per EN55022, Class B Limits (230VAC Neutral)

11 EVM Assembly Drawing and PCB Layout

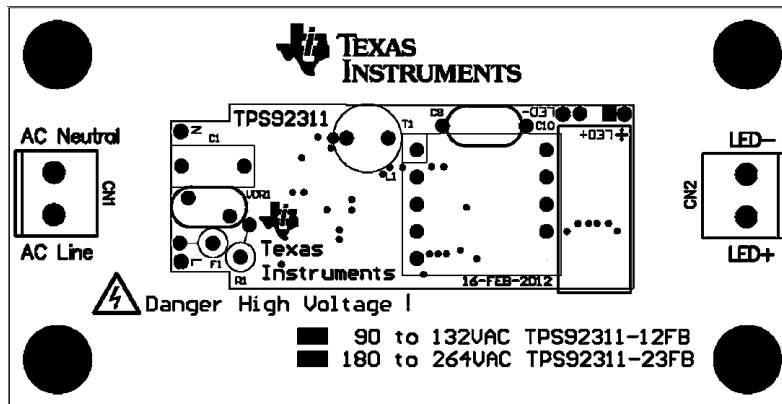


Figure 26. Top Layer Assembly Drawing (Top View)

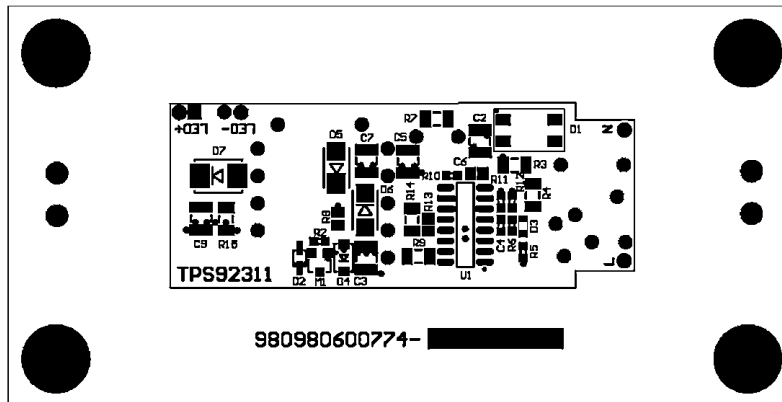


Figure 27. Bottom Layer Assembly Drawing (Bottom View)

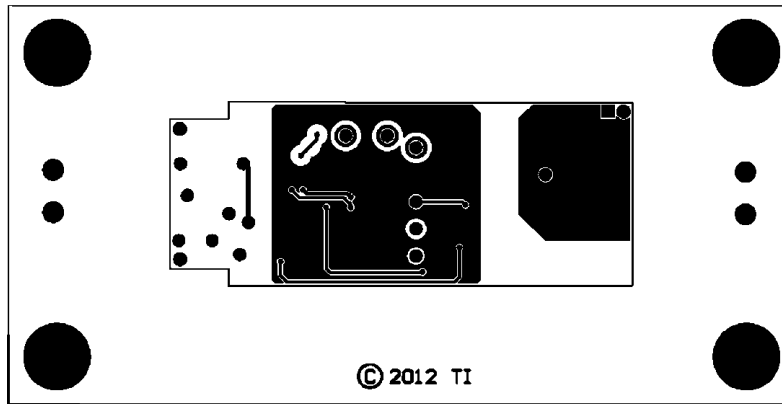


Figure 28. Top Layer Copper (Top View)

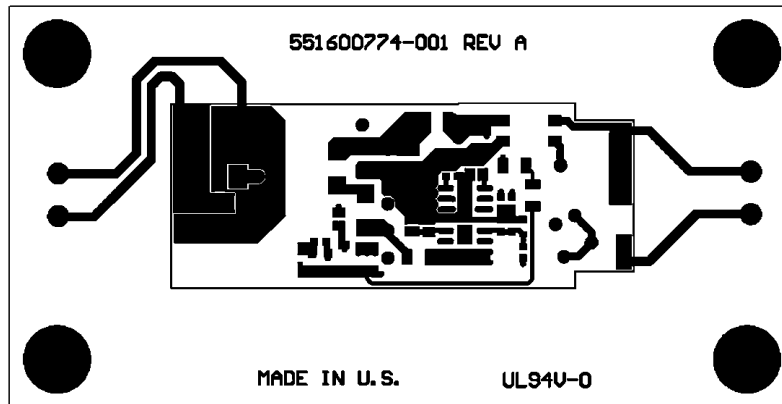


Figure 29. Bottom Layer Copper (Bottom View)

**12 Bill of Materials TPS92311 Evaluation Board (TPS92311 230V EVM)**

Item	Designator	Description	Manufacturer	Part Number
1	PCB	Printed circuit board		551600774-001 Rev A
2	U1	Primary Side Converter with Integrated FET	TI	TPS92311
3	C1	CAP 47000PF 310VAC EMI SUPPRESSN	Vishay / BC Components	BFC233920473
4	C2, C5	CAP CER 0.1 $\mu$ F 630V 10% X7R 1210	TDK	C3225X7T2J104K
5	C3, C9	CAP, CERM, 10 $\mu$ F, 50V, +/-10%, X7R, 1210	Murata	GRM32ER71H106KA12L
6	C4	CAP CER 15p 50V 0603	Murata	GRM1885C1H150JA01D
7	C6	CAP CER 4.7 $\mu$ F 16V X7R 0805	Murata	GRM21BR71C475KA73L
8	C7	NC	NC	NC
9	C8	CAP CER 2200PF 250VAC X1Y1 RAD	Murata	DE1E3KX222MA4BL01
10	C10	CAP ALUM 470 $\mu$ F 35V 20% RADIAL	Panasonic - ECG	EEU-FR1V471L
11	D1	RECT BRIDGE GP 600V 0.8A MINIDIP	Diodes Inc	HD06-T
12	D2	Zener Diode 30V, 5%, 0.25W, SOD-323	NXP	BZX384-C30,115
13	D3	DIODE SWITCHING 75V 150mA 0603	Comchip Technology	CDSU4148
14	D4	Diode 150V, 0.2A, 50nS, SOD-123	Diodes Inc	BAV20W-7-F
15	D5	Diode, TVS, 250V, 400W, SMA	Littelfuse Inc	SMAJ250ALFCT-ND
16	D6	DIODE GPP ULTRA FAST 1A 600V SMA	Vishay / General Semiconductor	US1J-E3/61T
17	D7	DIODE SCHOTTKY 100V 1A SMA	Diodes Inc	B1100-13-F
18	F1	FUSE SLOW BLOW 0.5A	Littelfuse Inc	0677.500MXE
19	L1	Power Inductor 4.7mH	Sumida	RCH895NP-472K / 00777-T049-472
20	M1	SCR 200V, 0.16A, SOT-123	Central	CMPS5062
21	R1	RES Metal Film, 22ohm, 5%, 1W, TH	Panasonic	ERG-1SJ220
22	R2	RES, 4.22k ohm, 1%, 0.1W, 0603	Vishay-Dale	CRCW06034K22FKEA
23	R3, R4	200 k ohm, 5%. 0.25W 1206	Vishay/Dale	CRCW1206200KJNEA
24	R5	RES, 66.5k ohm, 1%, 0.1W, 0603	Vishay/Dale	CRCW060366K5FKEA
25	R6	RES, 11.0k ohm, 1%, 0.1W, 0603	Vishay/Dale	CRCW060311K0FKEA
26	R7, R15	NC	NC	NC
27	R8	RES, 200.0 ohm, 1%, 0.1W, 0603	Vishay/Dale	CRCW0603200RJNEA
28	R9	RES, 0 ohm, 5%, 0.25W, 1206	Vishay/Dale	CRCW12060000Z0EA
29	R10	RES, 18.2k ohm, 1%, 0.1W, 0603	Vishay/Dale	CRCW060318K2FKEA
30	R11, R12	NC	NC	NC
31	R13	RES, 100 ohm, 1%, 0.125W, 0603	Vishay-Dale	CRCW0603100RFKEA
32	R14	RES, 3.00 ohm, 1%, 0.25W, 1206	Vishay-Dale	CRCW12063R00FKEA
33	T1	Transformer EE-16 Np:Ns = 5.6:1	Würth	750341087 REV 2.0
34	VDR1	VARISTOR 300V 30J 7MM EPCOS	EPCOS Inc	S07K300E2
35	CN1, CN2	Conn Term Block, 2POS, 5.08mm PCB	Phoenix Contact	1715721
36	TP1, TP2, TP3, TP4	Terminal, Turret, TH, Double	Keystone Electronics	1502-2

**13 Bill of Materials TPS92311 Evaluation Board (TPS92311 120V EVM)**

Item	Designator	Description	Manufacturer	Part Number
1	PCB	Printed circuit board		551600774-001 Rev A
2	U1	Primary Side converter with Integrated FET	TI	TPS92311
3	C1	CAP 47000pF 310VAC EMI SUPPRESSN	Vishay/BC Components	BFC233920473
4	C2, C5	CAP CER 0.1 $\mu$ F 630V 10% , X7R 1210	TDK	C3225X7T2J104K
5	C3, C9	CAP, CERM, 10 $\mu$ F, 50V, +/-10%, X7R, 1210	Murata	GRM32ER71H106KA12L
6	C4	CAP CER 15p 50V 0603	Murata	GRM1885C1H150JA01D
7	C6	CAP CER 4.7 $\mu$ F 16V X7R 0805	Murata	GRM21BR71C475KA73L
8	C7	CAP CER .1 $\mu$ F 630V 10% , X7R 1210	TDK	C3225X7T2J104K
9	C8	CAP CER 2200PF 250VAC X1Y1 RAD	Murata	DE1E3KX222MA4BL01
10	C10	CAP ALUM 470 $\mu$ F 35V 20% RADIAL	Panasonic - ECG	EEU-FR1V471L
11	D1	RECT BRIDGE GP 600V 0.8A MINIDIP	Diodes Inc	HD06-T
12	D2	Zener Diode 30V, 5%, 0.25W, SOD-323	NXP	BZX384-C30,115
13	D3	DIODE SWITCHING 75V 150mA 0603	Comchip Technology	CDSU4148
14	D4	Diode 150V, 0.2A, 50nS, SOD-123	Diodes Inc	BAV20W-7-F
15	D5	Diode, TVS, 250V, 400W, SMA	Littelfuse Inc	SMAJ250ALFCT-ND
16	D6	DIODE GPP ULTRA FAST 1A 600V SMA	Vishay / General Semiconductor	US1J-E3/61T
17	D7	DIODE SCHOTTKY 100V 1A SMA	Diodes Inc	B1100-13-F
18	F1	FUSE SLOW BLOW 0.5A	Littelfuse Inc	0677.500MXE
19	L1	Power Inductor 3.3mH	Sumida	RCH895NP-332K / 00777-T049-332
20	M1	SCR 200V, 0.16A, SOT-123	Central	CMPS5062
21	R1	RES Metal Film, 22ohm, 5%, 1W, TH	Panasonic	ERG-1SJ220
22	R2	RES, 4.22k ohm, 1%, 0.1W, 0603	Vishay-Dale	CRCW06034K22FKEA
23	R3, R4	RES, 100 k ohm, 5%, 0.25W 1206	Vishay/Dale	CRCW1206100KFKEA
24	R5	RES, 66.5k ohm, 1%, 0.1W, 0603	Vishay/Dale	CRCW060366K5FKEA
25	R6	RES, 11.0k ohm, 1%, 0.1W, 0603	Vishay/Dale	CRCW060311K0FKEA
26	R7, R15	NC	NC	NC
27	R8	RES, 200.0 ohm, 1%, 0.1W, 0603	Vishay/Dale	CRCW0603200RJNEA
28	R9	RES, 0 ohm, 5%, 0.25W, 1206	Vishay/Dale	CRCW12060000Z0EA
29	R10	RES, 5.49k ohm, 1%, 0.1W, 0603	Vishay/Dale	CRCW06035K49FKEA
30	R11, R12	NC	NC	NC
31	R13	RES, 27 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060327R0JNEA
32	R14	RES, 1.50 ohm, 1%, 0.25W, 1206	Vishay-Dale	CRCW12061R50FKEA
33	T1	Transformer EE-16 Np:Ns = 3.8:1	Würth	750341086 REV 2.0
34	VDR1	VARISTOR 300V 30J 7MM EPCOS	EPCOS Inc	S07K300E2
35	CN1, CN2	Conn Term Block, 2POS, 5.08mm PCB	Phoenix Contact	1715721
36	TP1, TP2, TP3, TP4	Terminal, Turret, TH, Double	Keystone Electronics	1502-2

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Applications Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

### TI E2E Community

[e2e.ti.com](http://e2e.ti.com)