

Using the TPS92510EVM-011

User's Guide



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JULY 2012–Revised September 2013

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1.5-A, Constant-Current, Non-Synchronous Buck Converter for High-Brightness LEDs with Integrated Thermal Foldback

1 Introduction

The TPS92510EVM-011 evaluation module (EVM) helps designers evaluate the operation and performance of the TPS92510 DC/DC converter, a high-brightness light emitting diode (LED) driver. The converter is a wide input voltage (3.5 V to 60 V), 2.5-MHz, non-synchronous, externally compensated, step down converter capable of 1.5 A of output current.

2 Description

The TPS92510EVM-011 provides a high-brightness LED driver based on the TPS92510. The EVM is designed to operate from a nominal 48 VDC $\pm 10\%$ input voltage source. This input voltage range is typical for input supplies derived from AC/DC sources. The EVM provides an output current of 740 mA with an output voltage sufficient to drive four to ten off-board LEDs.

2.1 Typical Applications

This converter design describes an application of the TPS92510 as an LED driver with the specification below. For applications with a different input voltage range or different numbers of LEDs, refer to the application report, *How to Design an LED Driver Using the TPS92510* (TI Literature Number [SLUA628](#)).

2.2 Features

2.2.1 Connector Description

This section describes the jumpers and connectors on the EVM and how to properly connect, setup and use the TPS92510EVM-011.

2.2.1.1 J1 (GND, VIN)

This header is the return and positive input voltage supply to the converter. The leads to the input supply should be twisted and kept as short as possible to minimize EMI transmission. Additional bulk capacitance should be added between J1 and J2 if the supply leads are greater than six inches. An additional 1.0- μ F or greater ceramic capacitor improves the transient response of the TPS92510 and helps to reduce ringing on the input when long supply wires are used.

2.2.1.2 J5 (PDIM, GND)

This header is for dimming using pulse width modulation. PDIM is connected to the PDIM pin of the TPS92510. The average LED current and subsequent brightness is proportional to the applied PDIM signal duty cycle. When PDIM is greater than 1.35 V, the device drives current through the LEDs. When less than 0.9 V, the TPS92510 turns off and stops driving current through the LEDs. The PDIM frequency should be between 120 Hz and 1 kHz.

2.2.1.3 J3-1 (LED+)

Connect anode to LED+.

2.2.1.4 J3-2 (LED-)

Connect anode to LED-.

2.2.1.5 J6,TP10 (SYNC Enable)

Connect the shorting jumper on JP16 to use the external clock. As shown in Figure 1, synchronizing multiple TPS92510 LED drivers requires additional circuitry.

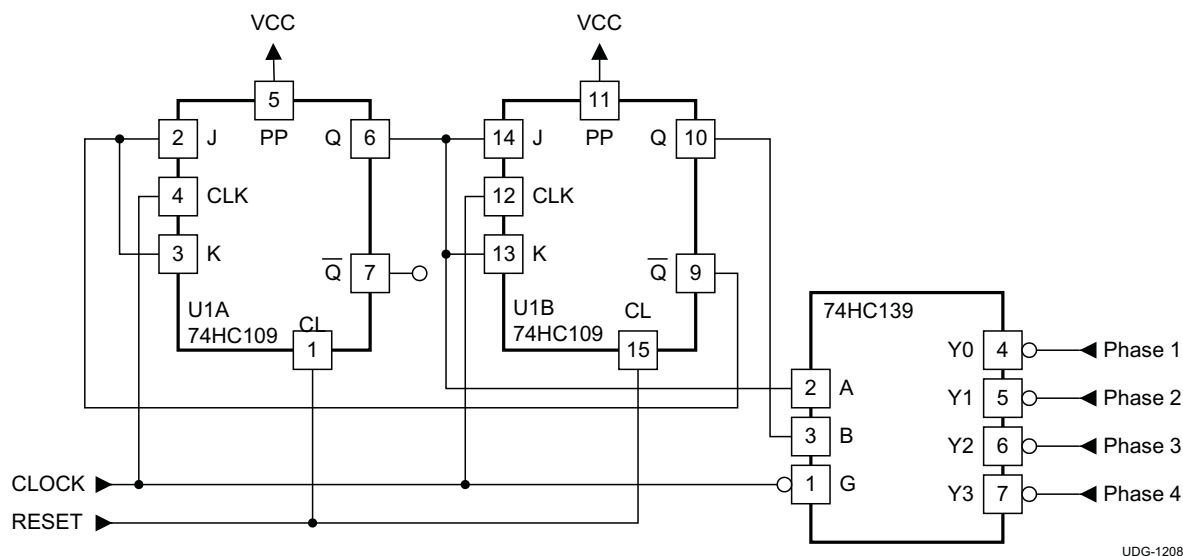


Figure 1. 4-Phase Clock Generator

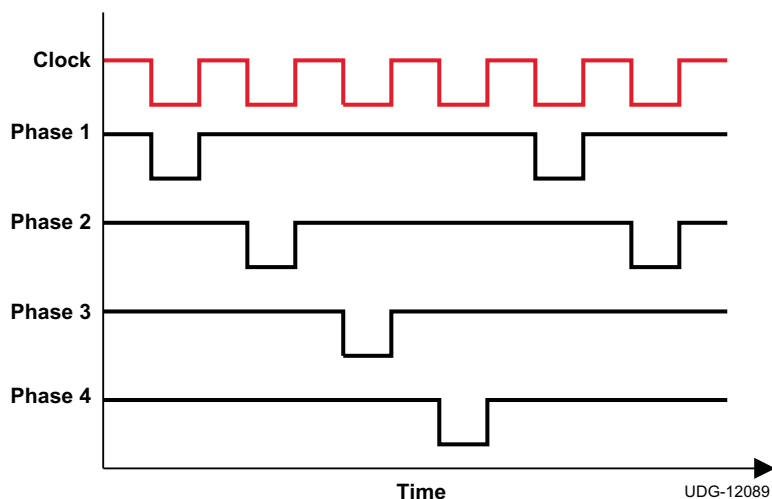


Figure 2. 4-Phase Clock Waveforms

2.2.1.6 J2,J4,TP15 (NTC,GND)

Connect external NTC thermistor from LED heatsink for thermal foldback. R14 along with J6 can be used either as a trim for the external thermistor or for stand-alone testing if no external thermistor is used.

2.2.1.7 Test Points

Table 1 lists the test points provided to monitor the TPS92510EVM-011 performance

Table 1. Test Points

TEST POINT	FUNCTION
VIN	Input voltage monitor
PDIM	LED dimming with external PWM signal
LED+	LED voltage monitor
LED-	
SYNC	Synchronization function access
VNTC	External thermistor monitor
Q1 GATE	Output enable control
LOOP_A	Control loop channel A injection and measurement point
ISENSE	Control loop channel B injection and current measurement point
PH	Switch node monitor
GND	Multiple grounds for signal references

3 Electrical Performance Specifications

Table 2 provides a summary of the converters specifications. The converter is designed and tested for an input voltage of 48 V $\pm$ 10%. Operation at other input voltages is possible but some performance specifications vary compared to those shown. The ambient temperature is 25°C for all measurements, unless otherwise noted.

Table 2. TPS92510EVM-011 Converter Specifications

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
V _{IN} Input voltage range		43	48	53	V
I _{OUT} Output current			740		mA
V _{OUT} Output voltage	Load between 4 and 12 LEDs	13.8		38.4	V
Loop bandwidth			20		kHz
Phase margin			90		°
f _{SW} Switching frequency			370		kHz
η Efficiency	V _{IN} = 48 V, I _{OUT} = 740 mA, Load 10 LEDs		96%		
V _{TURN-ON} Converter enable voltage ⁽¹⁾	V _{IN} rising, I _{OUT} = 740 mA		42.2		V
V _{TURN-OFF} Converter disable voltage	V _{IN} falling, I _{OUT} = 740 mA		40.8		
t _{RISE} Output current rise time	V _{IN} = 12 V		100		μs

⁽¹⁾ Converter enable disable voltage should be adjusted relative to number of LED threshold to be 3 V_{DC} greater than maximum forward voltage of the string. See the TI Design Guide (TI Literature Number [SLVA628](#)) to determine values for R4 and R5.

4 Schematic

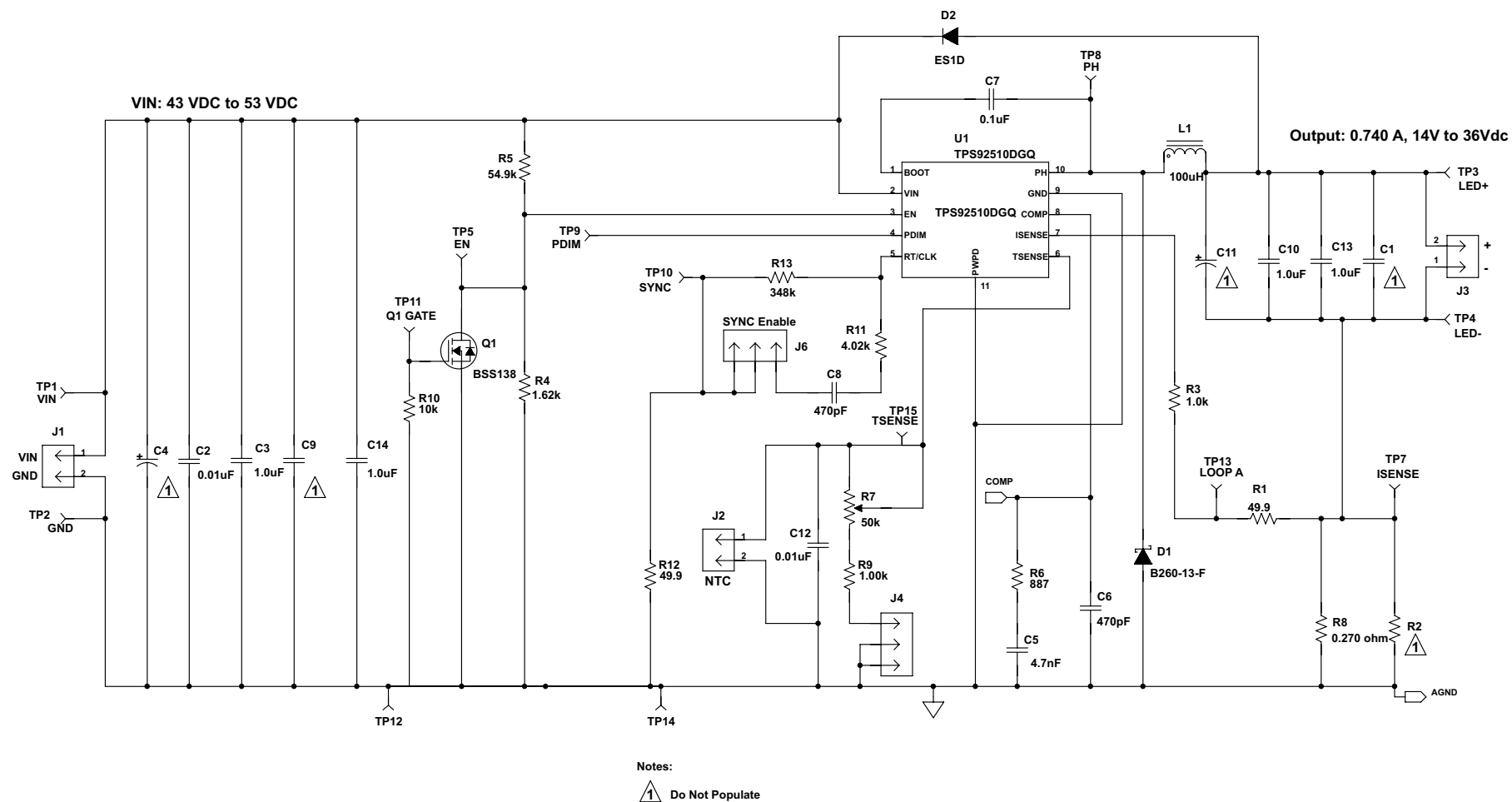


Figure 3. TPS92510EVM-011 Application Schematic

5 Performance Data and Typical Characteristic Curves

Figure 4 through Figure 20 present typical performance curves for TPS92510EVM-011.

5.1 Efficiency

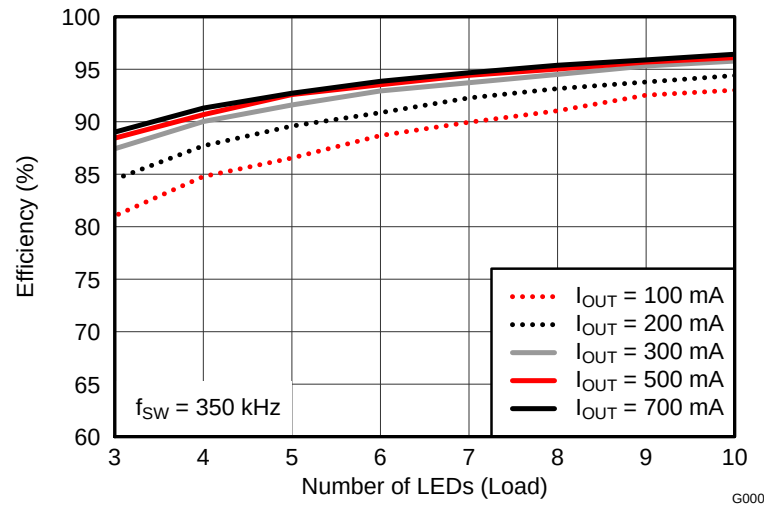


Figure 4. Efficiency vs. Number of LEDs (I_{OUT})

5.2 Input Voltage Ripple

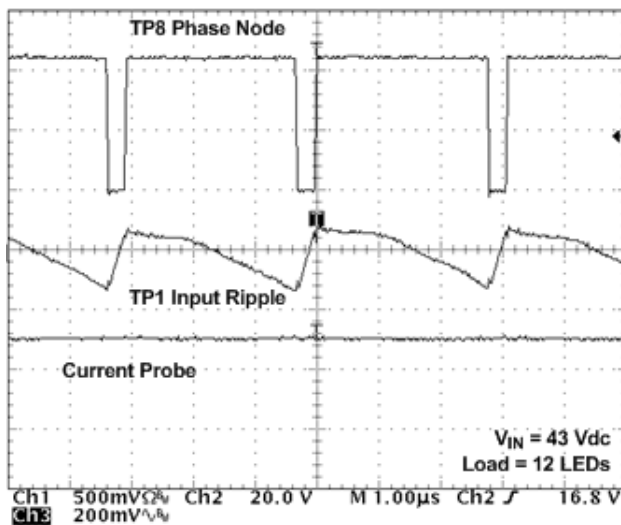


Figure 5. Input Voltage Ripple, $V_{IN} = 43\text{ Vdc}$

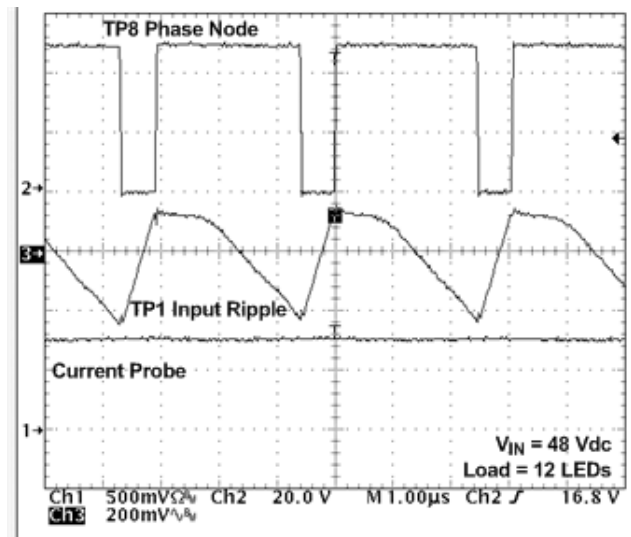


Figure 6. Input Voltage Ripple, $V_{IN} = 48\text{ Vdc}$

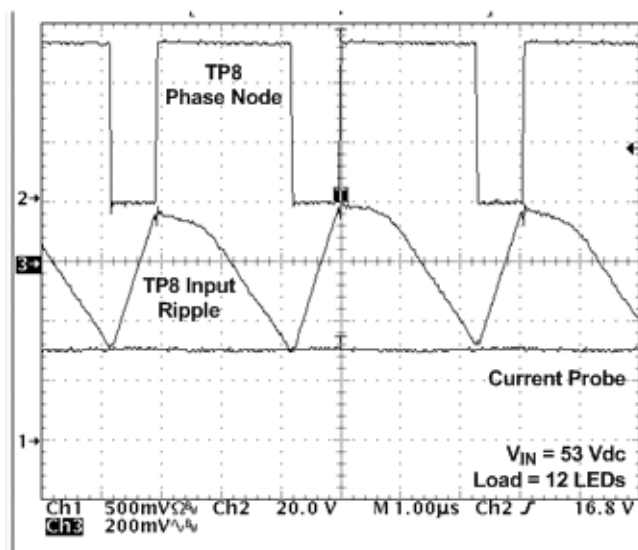


Figure 7. Input Voltage Ripple, $V_{IN} = 53 \text{ Vdc}$

5.3 Inductor Ripple Current

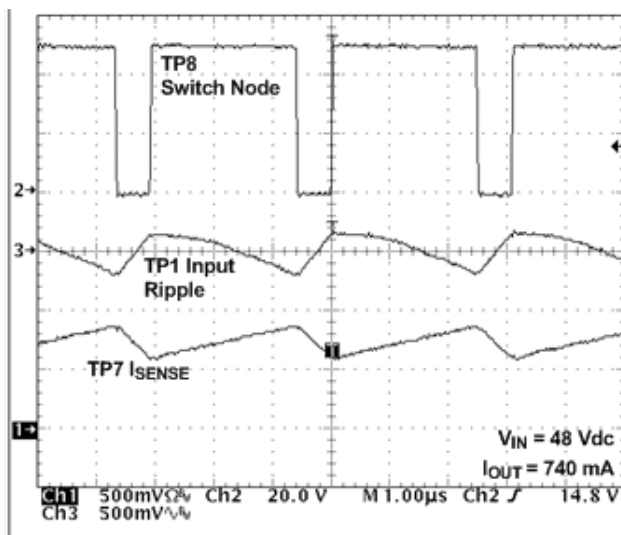


Figure 8. Input Voltage Ripple and Inductor Current

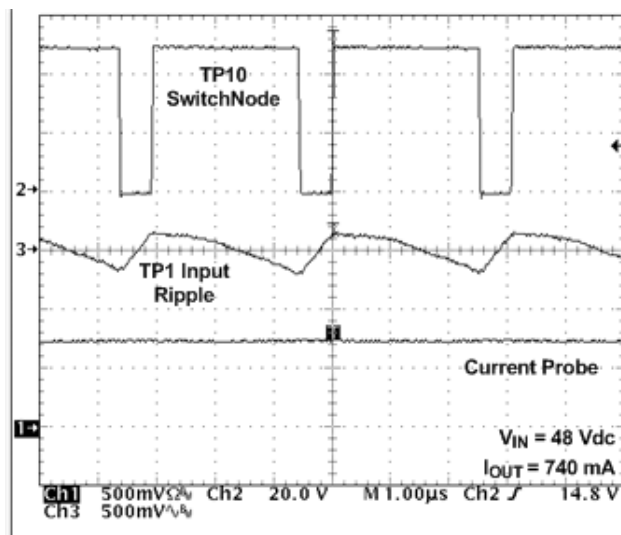


Figure 9. Input Voltage Ripple and LED Current

5.4 Bode Plot

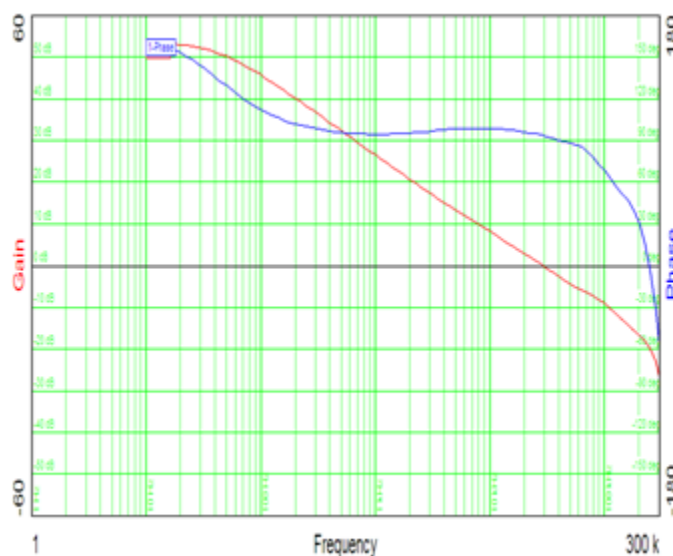


Figure 10. Loop Response Gain and Phase

5.5 Start-Up Response Relative to Enable

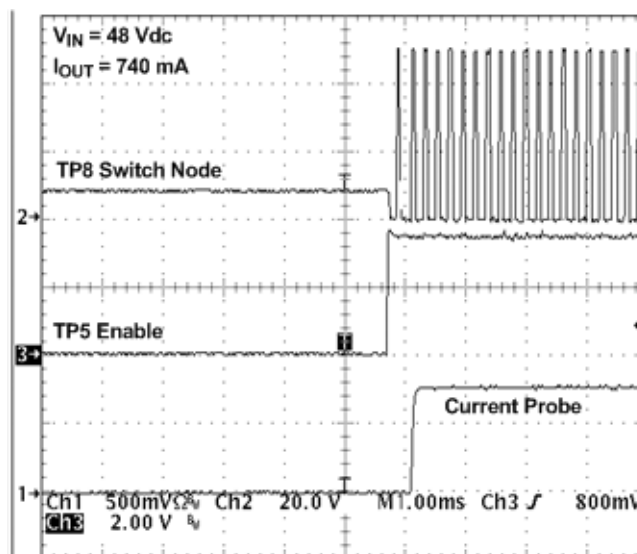


Figure 11. Start-Up Response Relative to Enable

5.6 Clock Signal and Switch Node Voltage

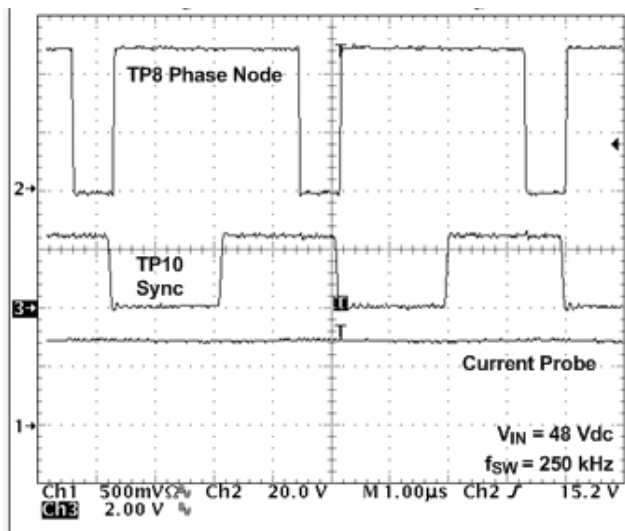


Figure 12. External Clock Synchronization,
 $f_{sw} = 250 \text{ kHz}$

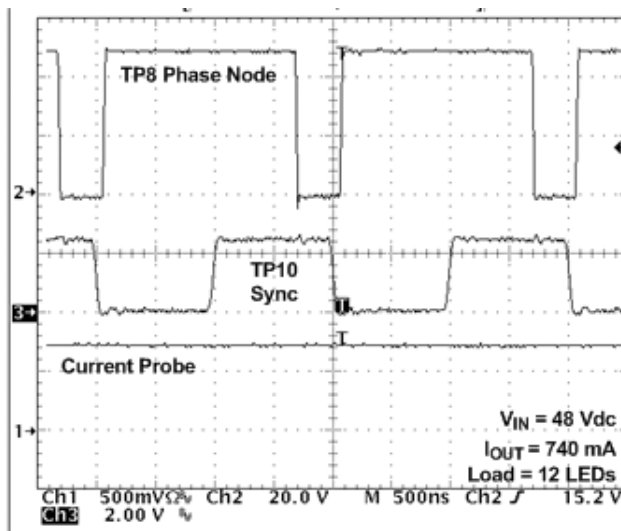


Figure 13. External Clock Synchronization,
 $f_{sw} = 500 \text{ kHz}$

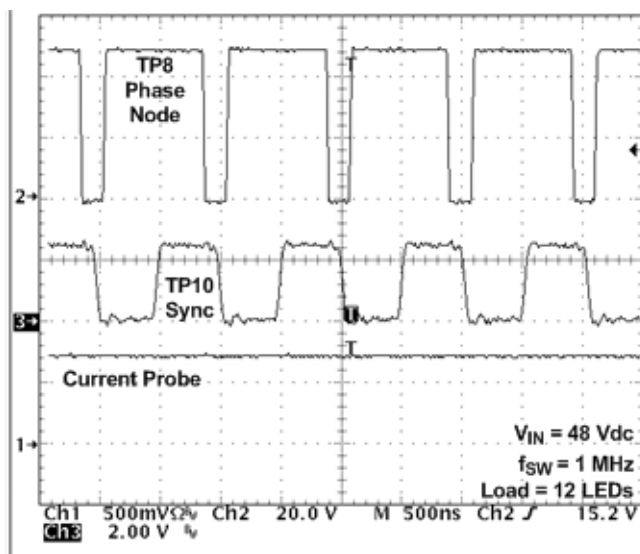


Figure 14. External Clock Synchronization,
 $f_{sw} = 1 \text{ MHz}$

5.7 PWM Dimming

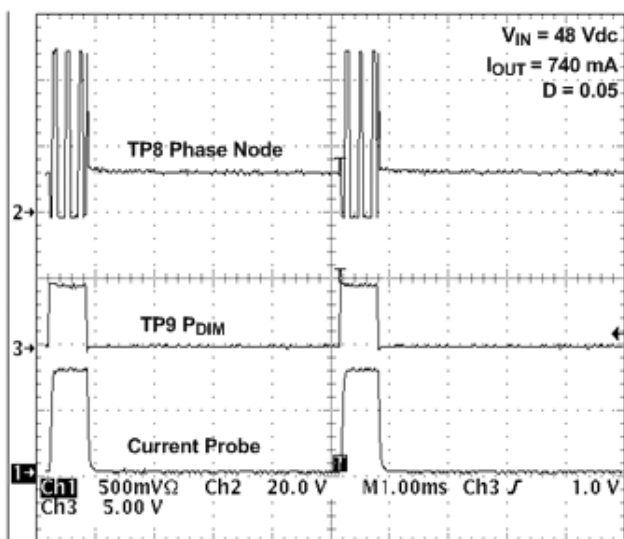


Figure 15. PWM Dimming,
 $f_{PWM} = 200$ Hz, Duty Cycle = 5%

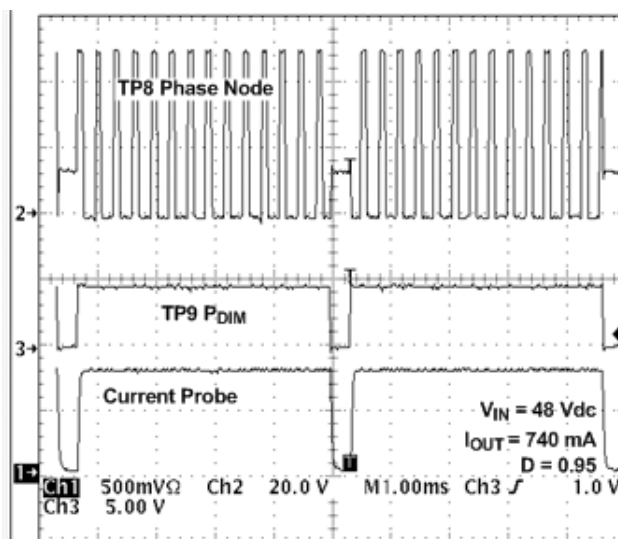


Figure 16. PWM Dimming,
 $f_{PWM} = 200$ Hz, Duty Cycle = 95%

5.8 Thermal Foldback Using a 50-K Potentiometer

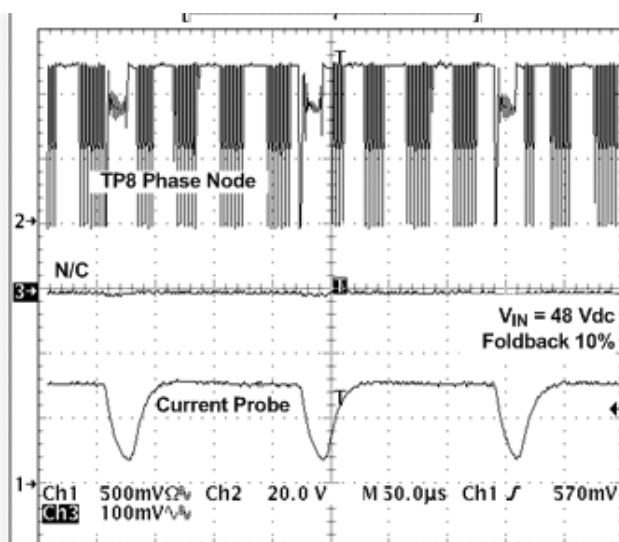


Figure 17. Thermal Foldback

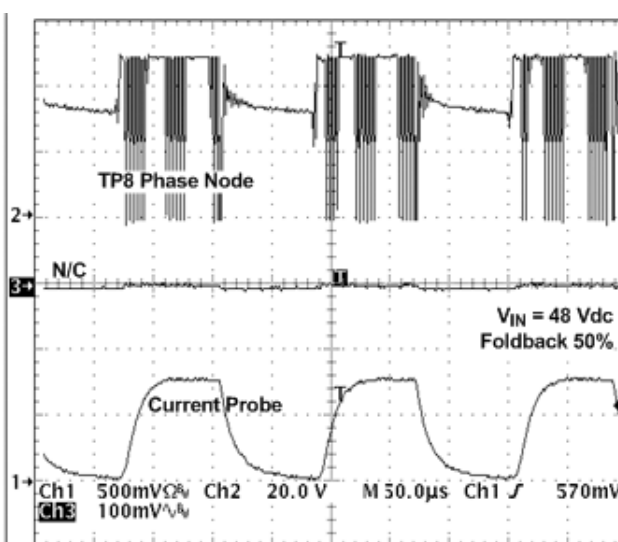


Figure 18. Thermal Foldback

5.9 Error Amplifier Sample and Hold vs. PWM Dimming at 200 Hz

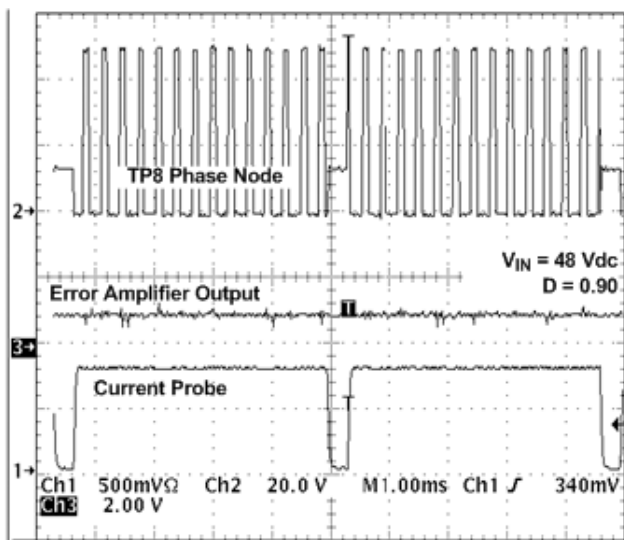


Figure 19. Error Amplifier S/H, Duty Cycle = 90%

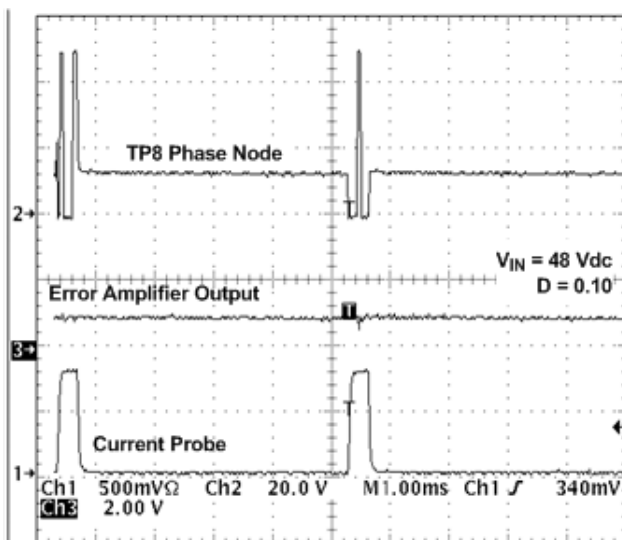


Figure 20. Error Amplifier S/H, Duty Cycle = 10%

5.10 Thermal Performance

Figure 21 and Figure 22 show the thermal performance of the EVM under the following conditions:

- Load of 12 LEDs
- $I_{OUT} = 740$ mA
- $V_{IN} = 48$ Vdc

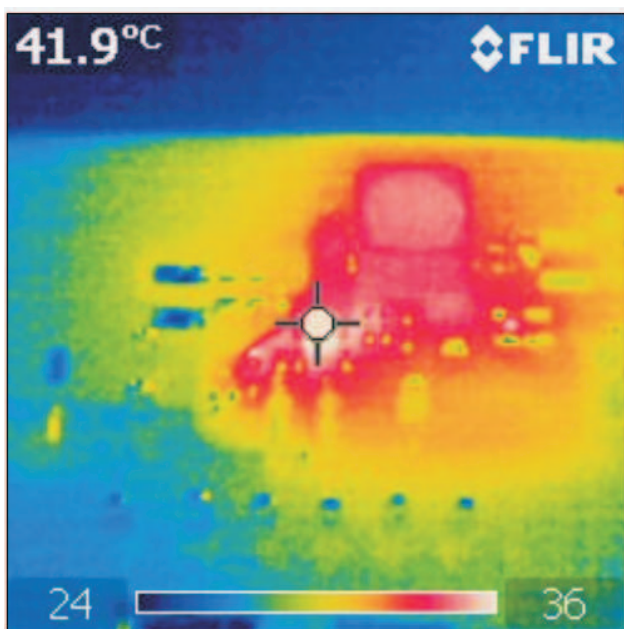


Figure 21. Top Thermal Performance

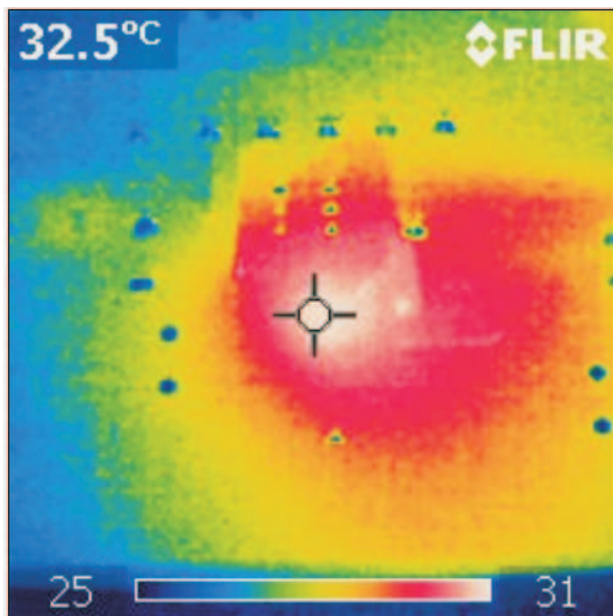


Figure 22. Bottom Thermal Performance

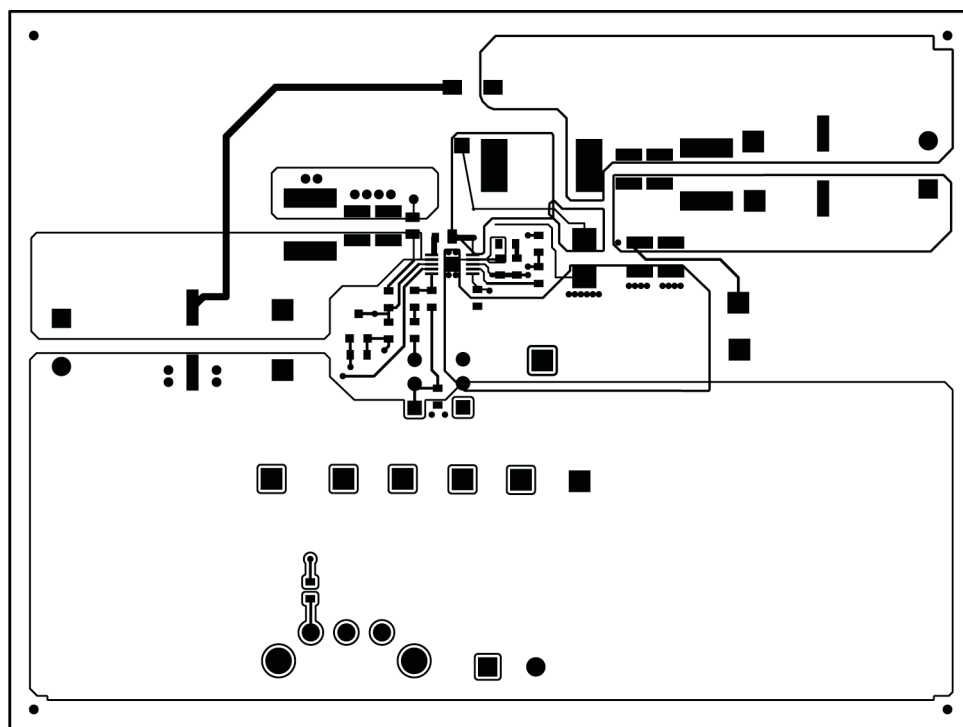


Figure 25. TPS92510EVM-011 Top Copper (Top View)

Table 3. List of Materials

REFERENCE DESIGNATOR	QTY	VALUE	DESCRIPTION	SIZE	PART NUMBER	MFR
U1	1		DC-DC Converter	MSOP-10	TPS92510DGQ	TI
C13, C3, C14, C10	4	1.0 μ F	Capacitor, Ceramic, 100V, X5R, 20%	2220	Std	Std
C2,C12	1	0.01 μ F	Capacitor, Ceramic, 100 V, X7R, 10%	0603	Std	Std
C5	1	4700 pF	Capacitor, Ceramic, 50 V, X7R, 10%	0603	Std	Std
C6,C8	1	470 pF	Capacitor, Ceramic, 50 V, 10%	0603	Std	Std
C7	1	0.1 μ F	Capacitor, Ceramic, 25 V, X5R, 10%	0603	Std	Std
D1	1	B260-13-F	Diode, Schottky, 60 V, 2 A	SMB	B260-13-F	Vishay
L1	1	100 μ H	Inductor, SMT, Power choke	12mm $\times$ 12mm	74477020	Würth
R1,R12	2	49.9 Ω	Resistor, Chip, 1/16W, 1%	0603	Std	Std
R3,R9	2	1 k Ω	Resistor, Chip, 1/16W, 1%	0603	Std	Std
R4	1	1.62 k Ω	Resistor, Chip, 1/16W, 1%	0603	Std	Std
R5	1	54.9 k Ω	Resistor, Chip, 1/16W, 1%	0603	Std	Std
R6	1	887 Ω	Resistor, Chip, 1/16W, 1%	0603	Std	Std
R7	1	50 k Ω	Potentiometer		296UD503B1N	CTS
R8	1	270 m Ω	Resistor, Chip, 1W, 1%	1206	Std	Std
R11	1	4.02 k Ω	Resistor, Chip, 1/16W, 1%	0603	Std	Std
R13	1	34.8 k Ω	Resistor, Chip, 1/16W, 1%	0603	Std	Std
D2	1	B260-13-F	Diode, Schottky, 60 V, 2 A	SMB	B260-13-F	Vishay
Q1	1	BSS138	MOSFET, N-channel, 50 V, 220 mA	SMB	BSS138	Fairchild
R10	1	10.0 k Ω	Resistor, Chip, 1/16W, 1%	0603	Std	Std

Revision History

Changes from Original (July 2012) to A Revision Page

- Replaced [Figure 3](#) with better quality image [7](#)

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

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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 EVMs for RF Products 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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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. Since the EVM is not a completed product, it may not meet all applicable regulatory and safety compliance standards (such as UL, CSA, VDE, CE, RoHS and WEEE) which may normally be associated with similar items. You assume full responsibility to determine and/or assure compliance with any such standards and related certifications as may be applicable. 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.

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