Using the TPS92510EVM-011

User's Guide

Literature Number: SLUU977A
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 ±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-µF 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.

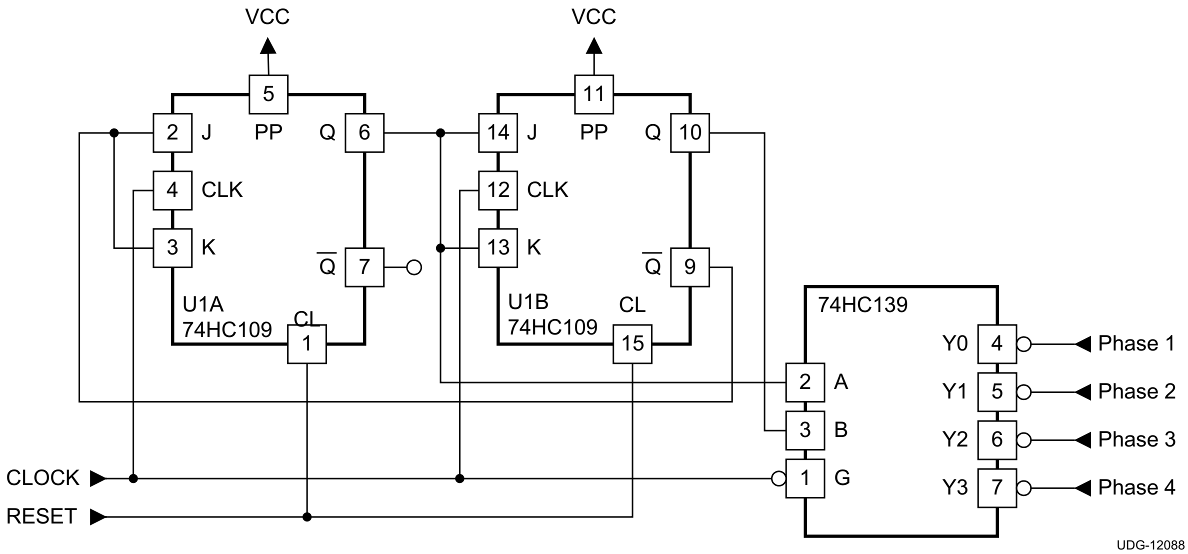

Figure 1. 4-Phase Clock Generator

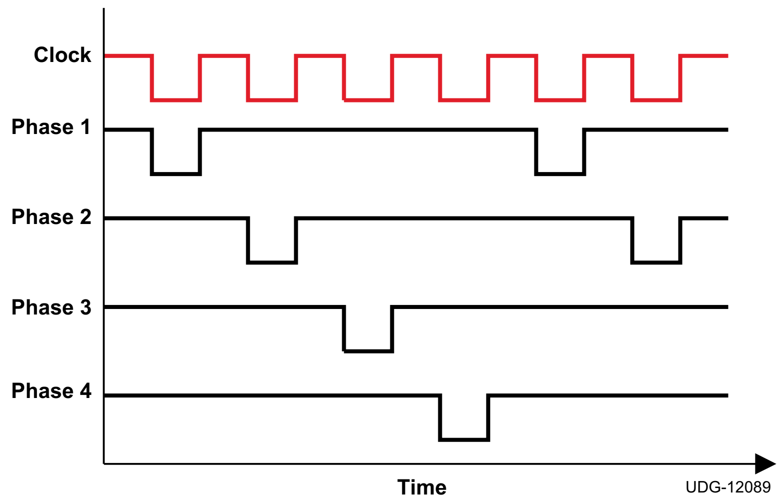

Figure 2. 4-Phase Clock Waveforms

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 injectionand 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±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

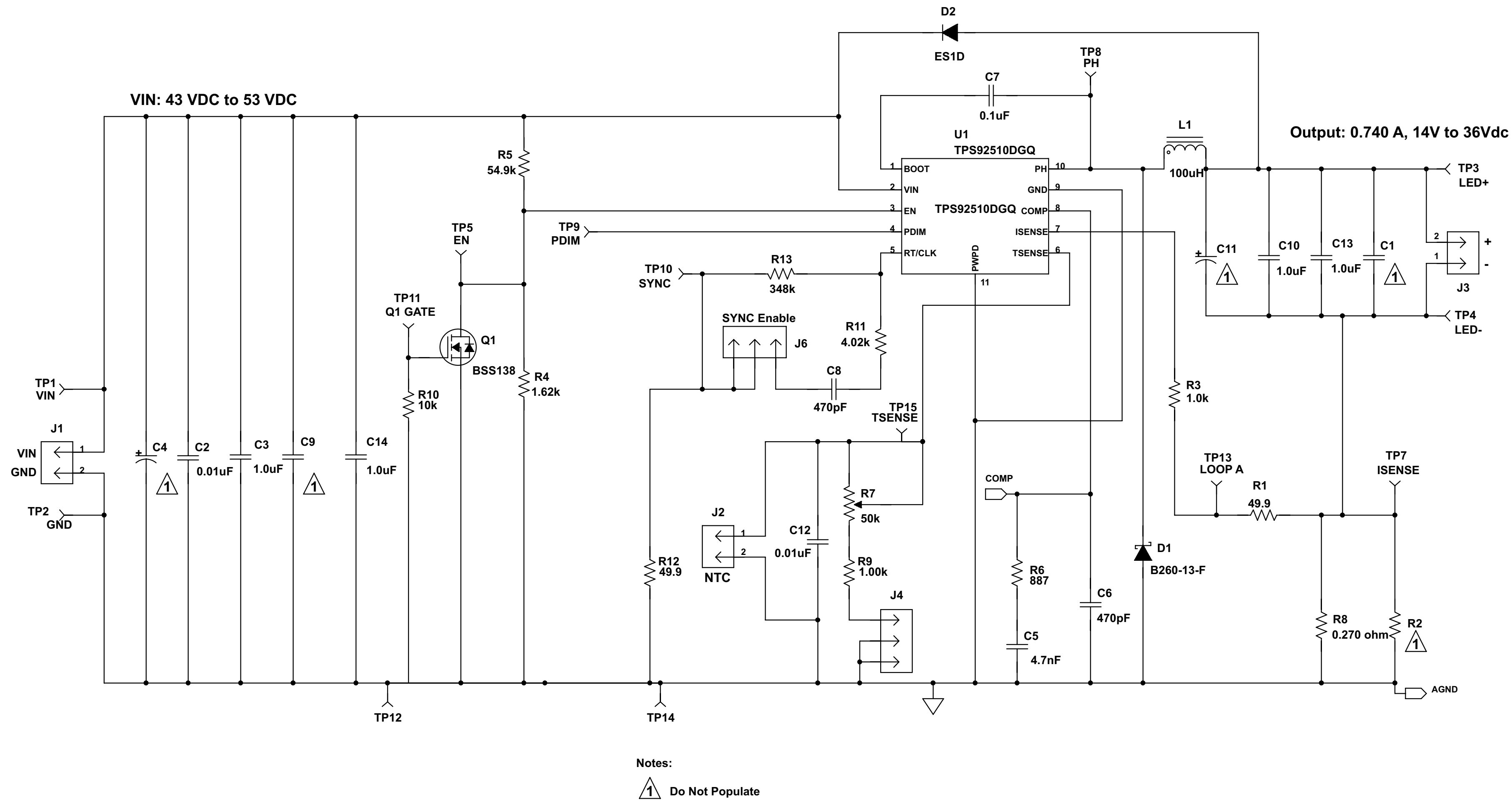

Figure 3. TPS92510EVM-011 Application Schematic

5 Performance Data and Typical Characteristic Curves

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

5.1 Efficiency

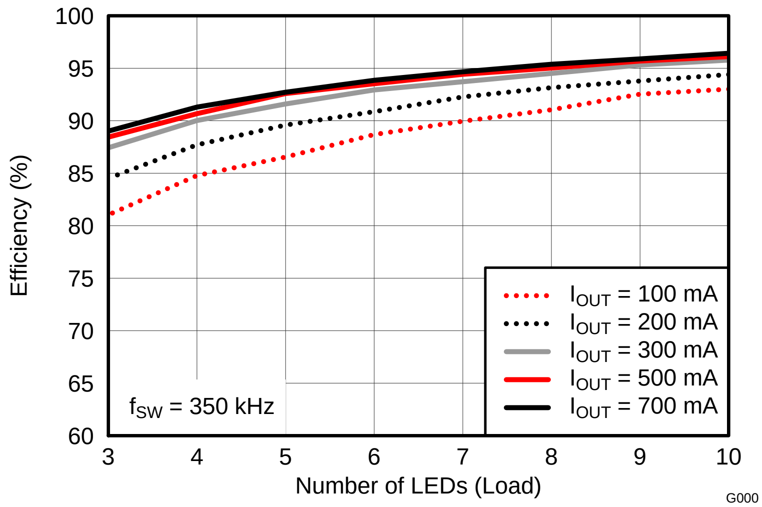

Figure 4. Efficiency vs. Number of LEDs (I_{OUT})

5.2 Input Voltage Ripple

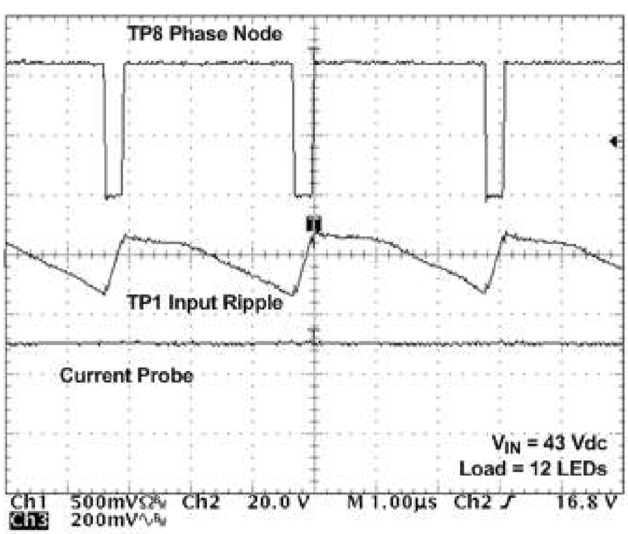

Figure 5. Input Voltage Ripple, V_{IN} = 43 Vdc

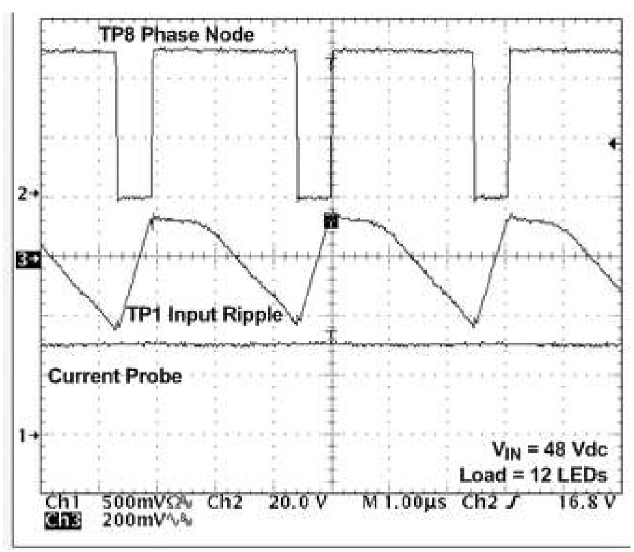

Figure 6. Input Voltage Ripple, V_{IN} = 48 Vdc

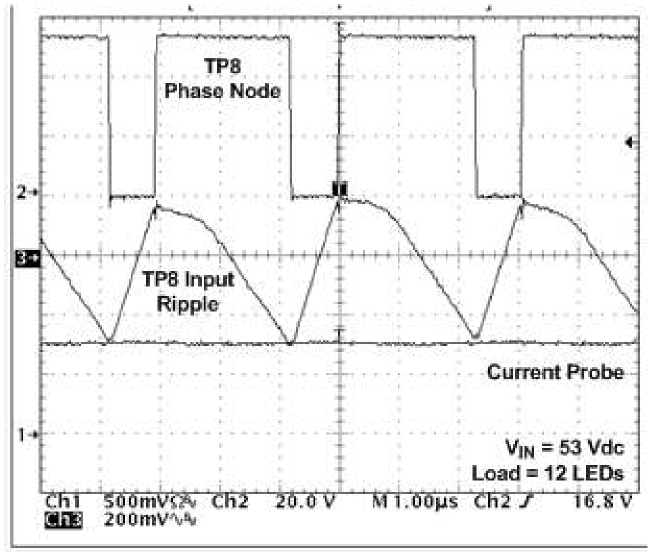

Figure 7. Input Voltage Ripple, V_{IN} = 53 Vdc

5.3 Inductor Ripple Current

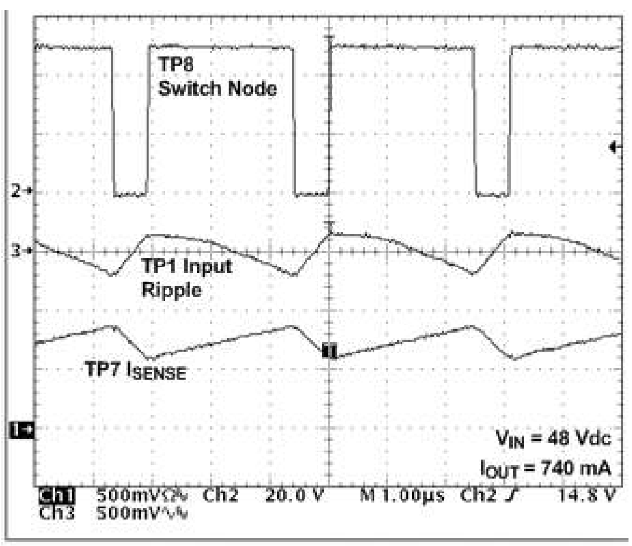

Figure 8. Input Voltage Ripple and Inductor Current

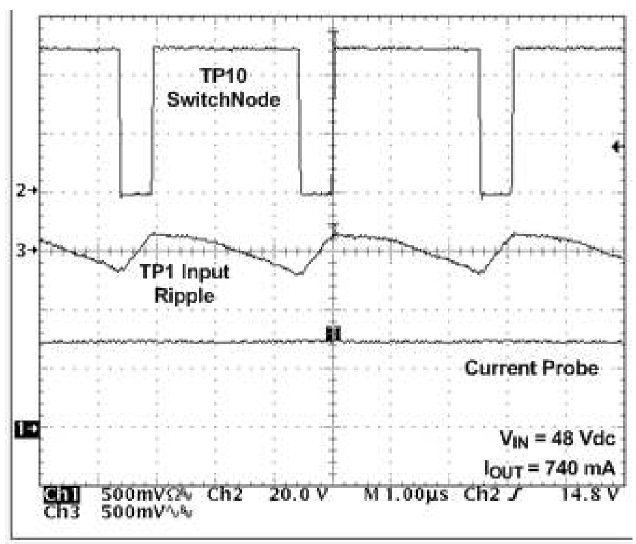

Figure 9. Input Voltage Ripple and LED Current

5.4 Bode Plot

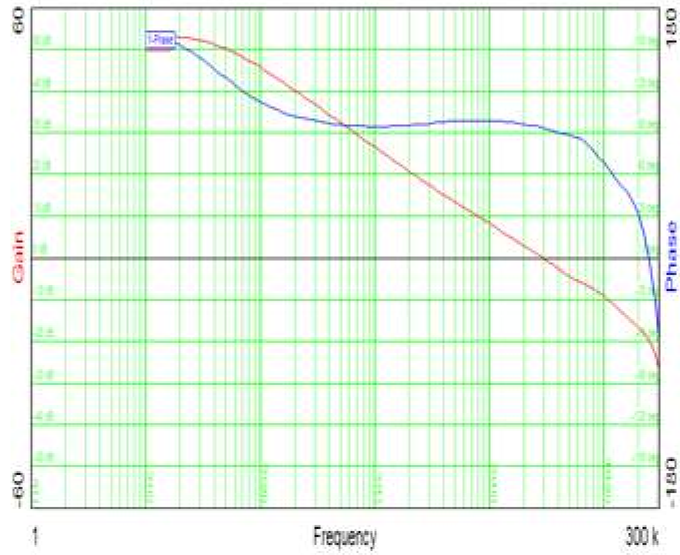

Figure 10. Loop Response Gain and Phase

5.5 Start-Up Response Relative to Enable

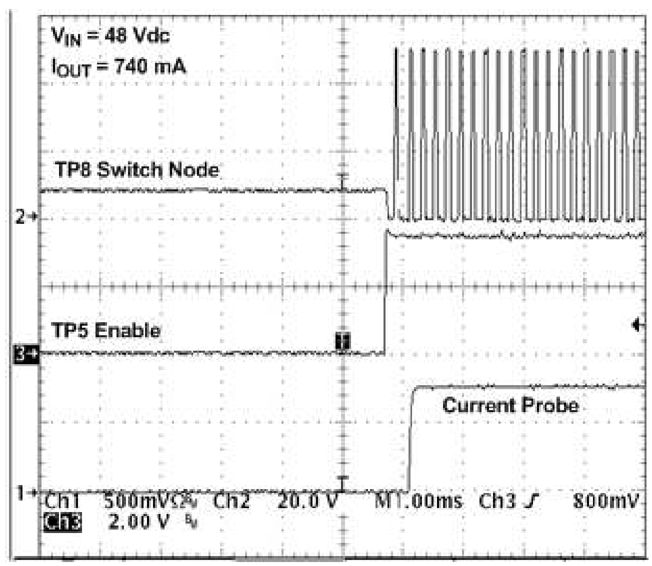

Figure 11. Start-Up Response Relative to Enable

5.6 Clock Signal and Switch Node Voltage

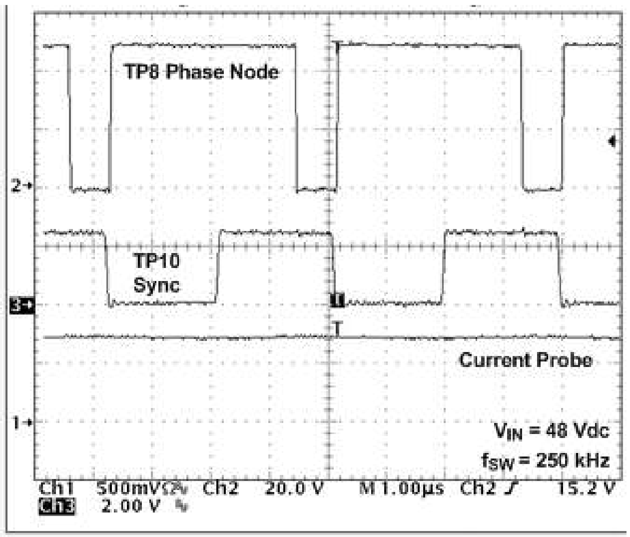

Figure 12. External Clock Synchronization, f_{sw} = 250 kHz

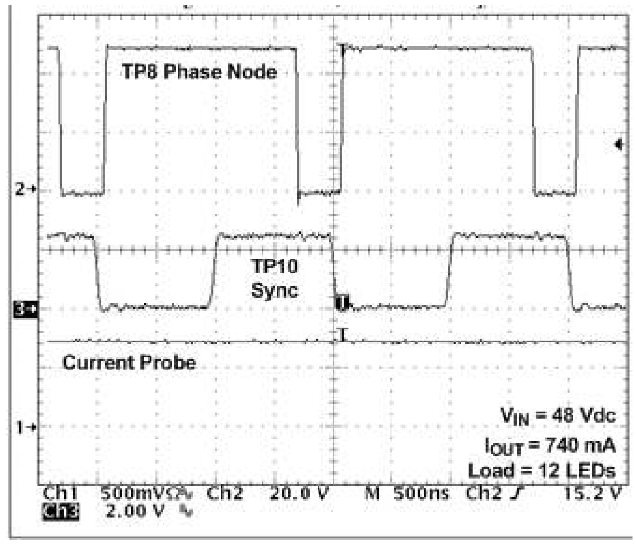

Figure 13. External Clock Synchronization, f_{sw} = 500 kHz

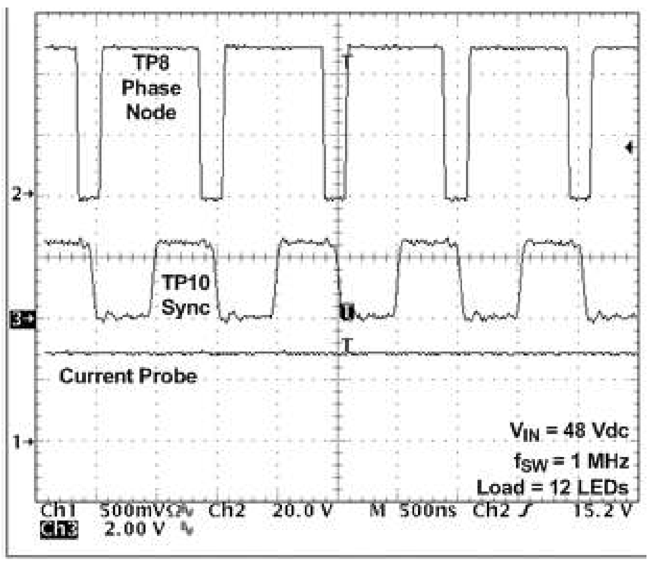

Figure 14. External Clock Synchronization, f_{sw} = 1 MHz

5.7 PWM Dimming

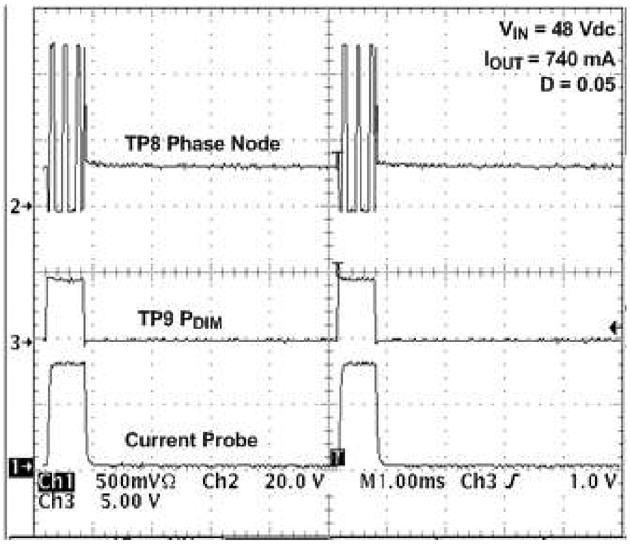

Figure 15. PWM Dimming, f_{PWM} = 200 Hz, Duty Cycle = 5%

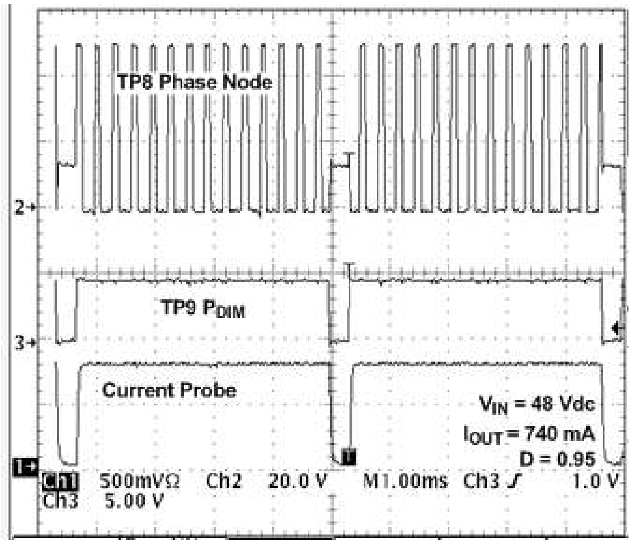

Figure 16. PWM Dimming, f_{PWM} = 200 Hz, Duty Cycle = 95%

5.8 Thermal Foldback Using a 50-K Potentiometer

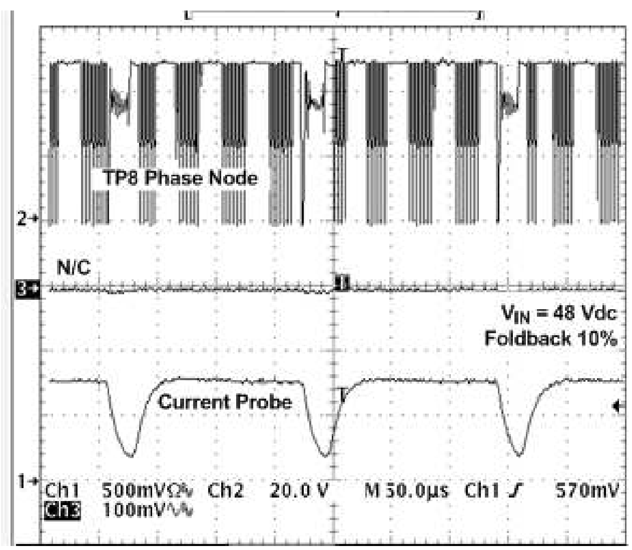

Figure 17. Thermal Foldback

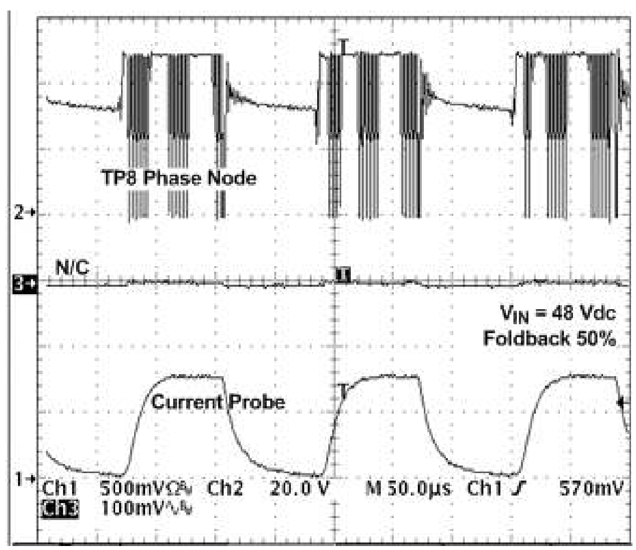

Figure 18. Thermal Foldback

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

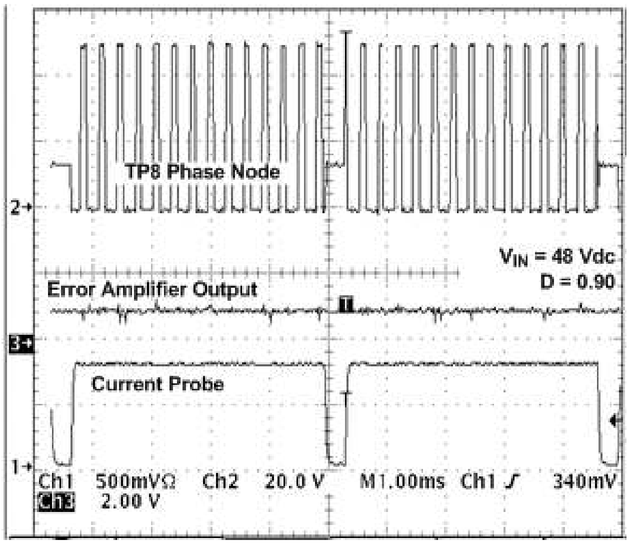

Figure 19. Error Amplifier S/H, Duty Cycle = 90%

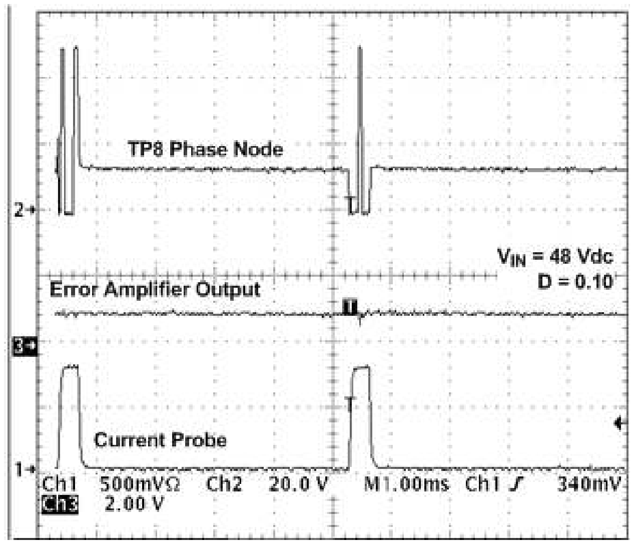

Figure 20. Error Amplifier S/H, Duty Cycle = 10%

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

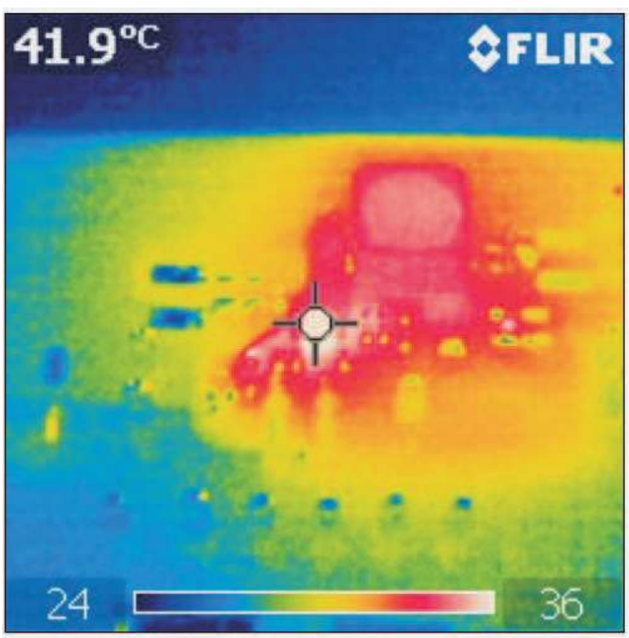

Figure 21. Top Thermal Performance

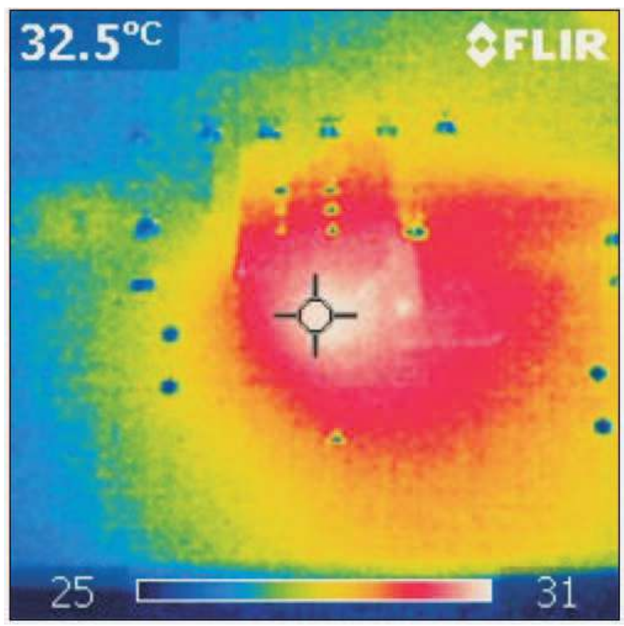

Figure 22. Bottom Thermal Performance

6 Assembly Drawing and PCB Layout

The following figures (Figure 23 through Figure 25) show the design of the printed circuit board

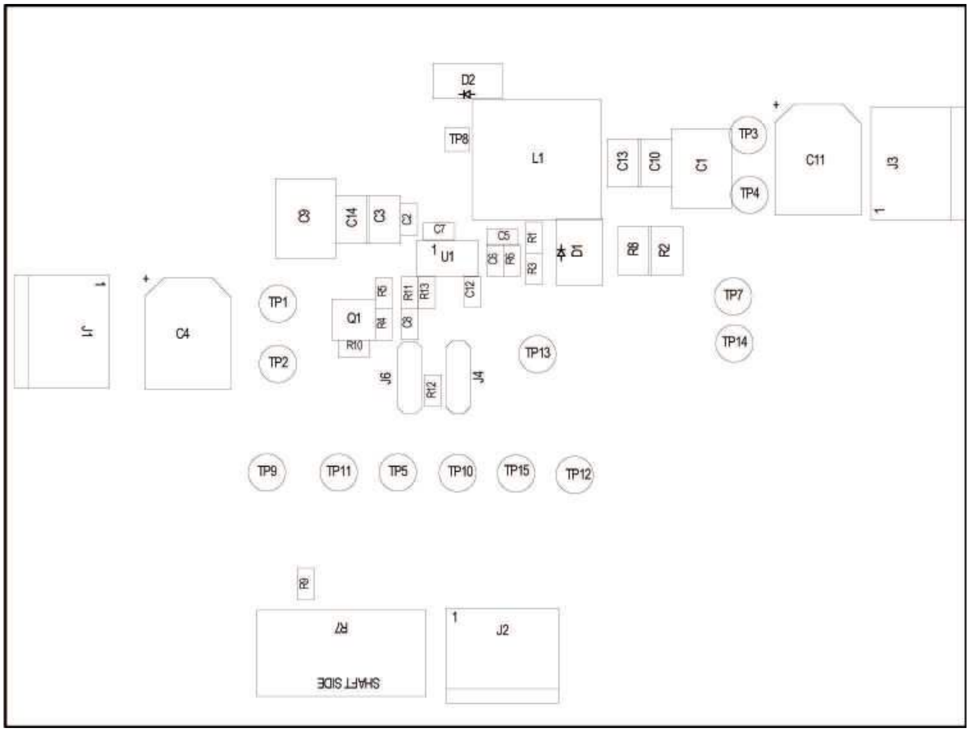

Figure 23. TPS92510EVM-011 Top Layer Assembly Drawing

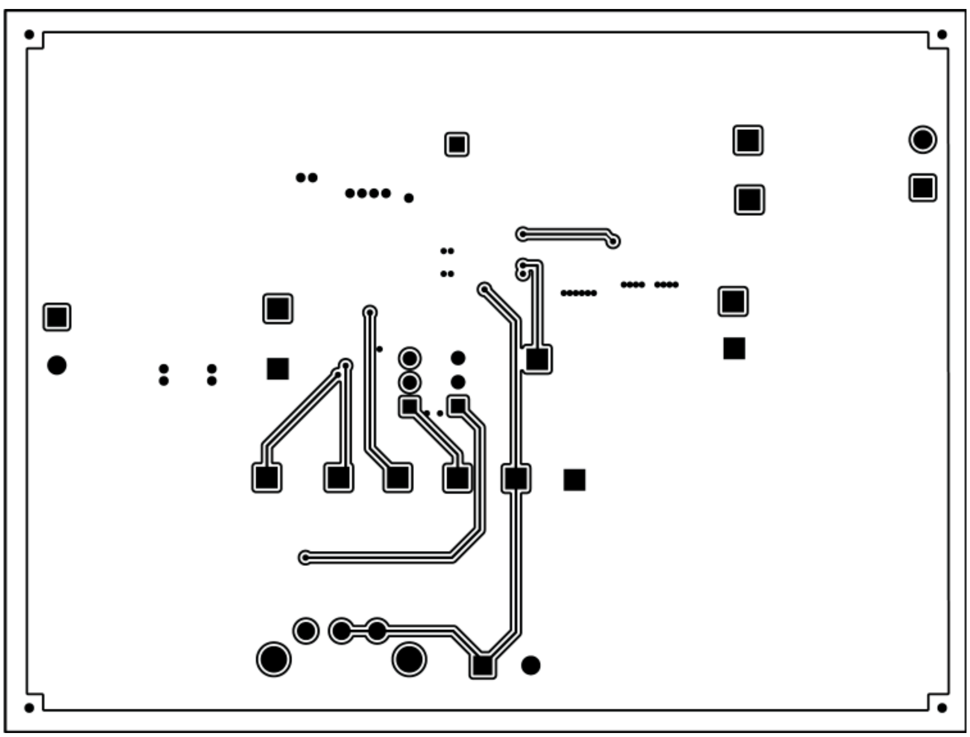

Figure 24. TPS92510EVM-011 Bottom Copper (Bottom View)

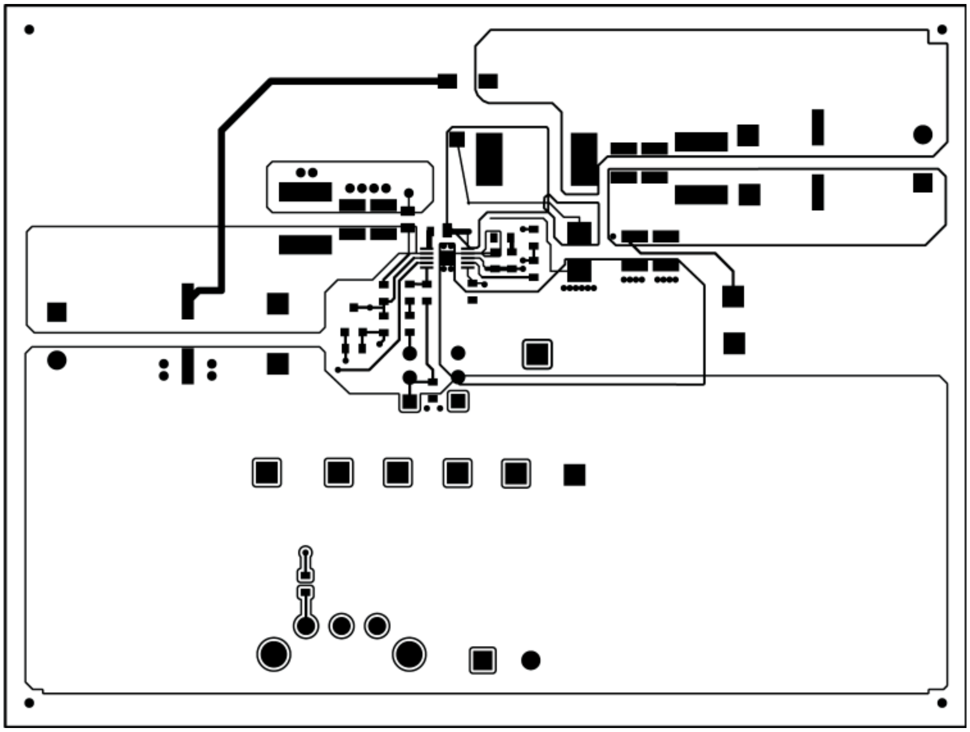

Figure 25. TPS92510EVM-011 Top Copper (Top View)

Table 3. List of Materials

REFERNCE DESIGNATOR	QTY	VALUE	DESCRIPTION	SIZE	PART NUMBER	MFR
U1	1		DC-DC Converter	MSOP-10	TPS92510DGQ	TI
C13, C3, C14, C10	4	1.0 µF	Capacitor, Ceramic, 100V, X5R, 20%	2220	Std	Std
C2,C12	1	0.01 µF	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 µF	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 µH	Inductor, SMT, Power choke	12mm×12mm	74477020	Wurth
R1,R12	2	49.9 Ω	Resistor, Chip, 1/16W, 1%	0603	Std	Std
R3,R9	2	1 kΩ	Resistor, Chip, 1/16W, 1%	0603	Std	Std
R4	1	1.62 kΩ	Resistor, Chip, 1/16W, 1%	0603	Std	Std
R5	1	54.9 kΩ	Resistor, Chip, 1/16W, 1%	0603	Std	Std
R6	1	887 Ω	Resistor, Chip, 1/16W, 1%	0603	Std	Std
R7	1	50 kΩ	Potentiometer		296UD503B1N	CTS
R8	1	270 mΩ	Resistor, Chip, 1W, 1%	1206	Std	Std
R11	1	4.02 kΩ	Resistor, Chip, 1/16W, 1%	0603	Std	Std
R13	1	34 8 kΩ	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 kΩ	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.

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.

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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 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.

Texas Instruments Japan Limited
(address) 24-1, Nishi-Shinjuku 6 chome, Shinjuku-ku, Tokyo, Japan

http://www.tij.co.jp

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日本テキサス･インスツルメンツ株式会社
東京都新宿区西新宿６丁目２４番１号
西新宿三井ビル
http://www.tij.co.jp

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. 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.

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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