Using the TPS92660EVM

Abstract

Contents

List of Figures

List of Tables

1 Introduction

The TPS92660EVM evaluation module (EVM) is a DC LED driver which can drive two strings of LEDs. The LED currents can be trimmed through an I^2C interface in the IC.

2 Description

The EVM consists of one non-synchronous constant current buck converter with input voltage up to 80 VDC and one constant current linear regulator with input voltage up to 60 VDC. The buck converter uses the constant on time control scheme to control the average LED current. The linear regulator regulates the LED current by adjusting the drain to source voltage drop across a MOSFET. Both LED currents can be trimmed by the I^2C interface. LED current PWM dimming is achieved by applying analog voltage or PWM signal on the SADJ and LADJ pins. Reference to the TPS92660 data sheet for details (SLUSBC2).

2.1 Typical Applications

- Professional lighting
- Industrial and commercial lighting
- General illumination

2.2 TPS92660 Features

- Drive two strings of LEDs for color mixing
- I^2C LED current trim to adjust the LED brightness
- Analog to PWM dimming and PWM to PWM dimming
- Output overvoltage protection
- MOSFET short protection
- Input undervoltage lockout
- 3.0 V reference voltage
- Enable on and off
- Thermal shutdown

3 Electrical Performance Specifications

Table 1 andTable 2 present the electrical performance specifications of the TPS92660 EVM.

Table 1. TPS92660EVM Buck Converter Electrical Performance Specifications

Parameter	Test Conditions	MIN	TYP	MAX	UNITS
Input Characteristics					
Voltage range		20	48	80	V
Input current			0.55		A
No-load input current			6		mA
Output Characteristics					
Output voltage, V_{OUT}	10 LEDs	30	33	36	V
Output load current, I_{OUT}		760	808	840	mA
Output current ripple	At V_{IN} = 48 V		20		mApp
Output overvoltage			40		V
Systems Characteristics					

Table 1. TPS92660EVM Buck Converter Electrical Performance Specifications (continued)

Parameter	Test Conditions	MIN	TYP	MAX	UNITS
Switching frequency			330		kHz
Full load efficiency			95		%

Table 2. TPS92660EVM Linear Regulator Electrical Performance Specifications

Parameter	Test Conditions	MIN	TYP	MAX	UNITS
Input Characteristics					
Voltage range		0	30	60	V
Input current			20		mA
No-load input current			0		mA
Output Characteristics					
Output voltage, V_{OUT}	8 to 10 LEDs	20	24	28	V
Output load current, I_{OUT}		19	20	21	mA
Systems Characteristics					
Full load efficiency			80		%

4 Schematic

Figure 1 is the EVM schematic.

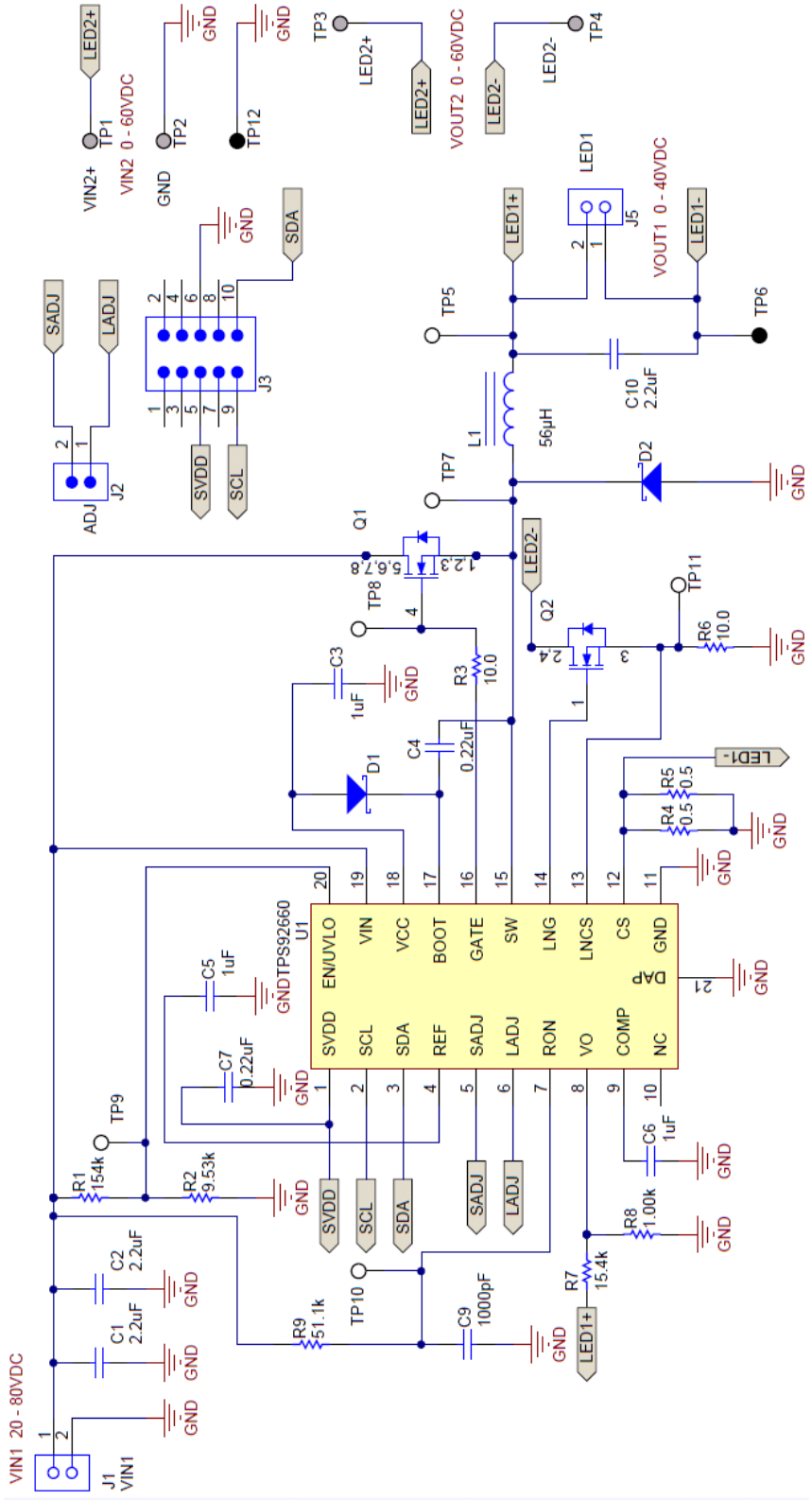

Figure 1. TPS92660EVM Schematic

5 Test Setup

5.1 Recommended Test Equipment

Voltage Source:	Two DC power supplies with an output voltage range of up to 80 VDC
Multimeters:	Three digital multimeters
Output Load1:	4 to 10 LEDs in series (Each LED is capable of handling up to 1A current)
Output Load2:	4 to 10 LEDs in series (Each LED is capable of handling up to 100mA current)
I²C Adapter:	Texas Instruments USB-to-GPIO interface adapter EVM (http://www.ti.com/tool/usb-to-gpio.)
Computer:	Personal Computer (Windows XP with .NET version 1.1)

5.2 Recommended Test Set Up

See Figure 2

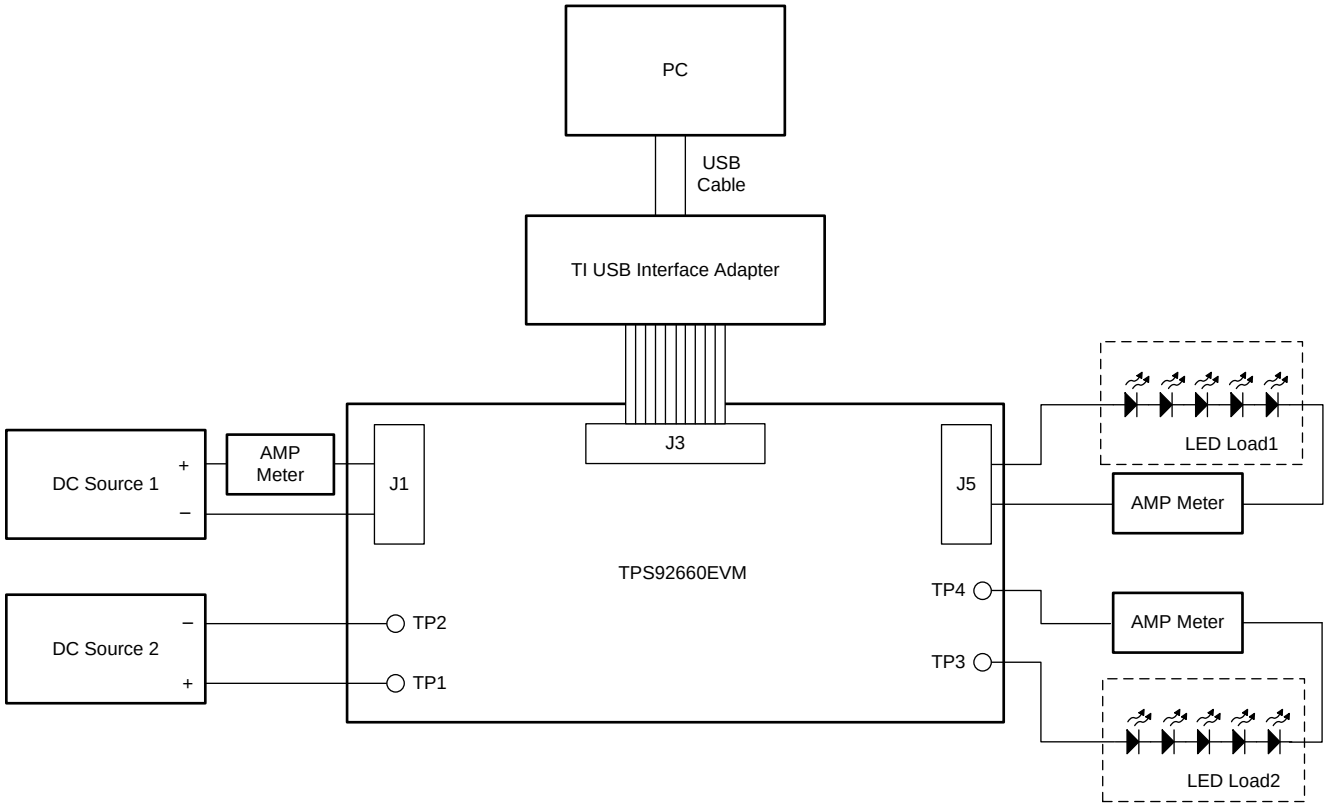

Figure 2. TPS92660EVM Recommended Test Set Up

5.3 List of Test Points

Table 3 contains the test points, their names, and a description of each.

Table 3. Test Points Functions

Test Points	Name	Description
J1-1	VIN1	Input voltage #1 positive-side connection
J1-2	GND	Input voltage #1 negative-side connection
J2-1	LADJ	Linear regulator current-adjust connection

Table 3. Test Points Functions (continued)

Test Points	Name	Description
J2-2	SADJ	Buck converter current-adjust connection
J3		I^2C interface connection
J5	LED1	LED string #1 connection
TP1	VIN2+	Input voltage #2 positive-side connection
TP2	GND	Input voltage #2 negative-side connection
TP3	LED2+	LED string #2 anode connection
TP4	LED2–	LED string #2 cathode connection
TP5	LED1+	LED string #1 anode test point
TP6	LED1–	LED string #1 cathode test point
TP7		Buck converter switch-node test point
TP8		Buck converter gate-drive test point
TP9		Input voltage #1 UVLO test point
TP10		Constant ON time timing capacitor test point
TP11		Linear regulator current sense test point
TP12	GND	Ground test point

5.4 Trim LED Current Using I^2C Adapter

Download the USB Interface Adapter GUI software from http://www.ti.com/tool/usb-to-gpio.

Open the file *USB SAA GUI.exe*. The *USB Interface Adapter GUI* window as shown in Figure 3 appears on the PC.

Enter *40* in the Device Address field.

Trim the buck converter current by entering *01* in the Cmd field and by entering hex number *00* to *3F* to trim current. See Table 4 for the trim range.

Trim the linear regulator current by entering *02* in the Cmd field and by entering hex number *00* to *0F* to trim current. See Table 5 for the trim range.

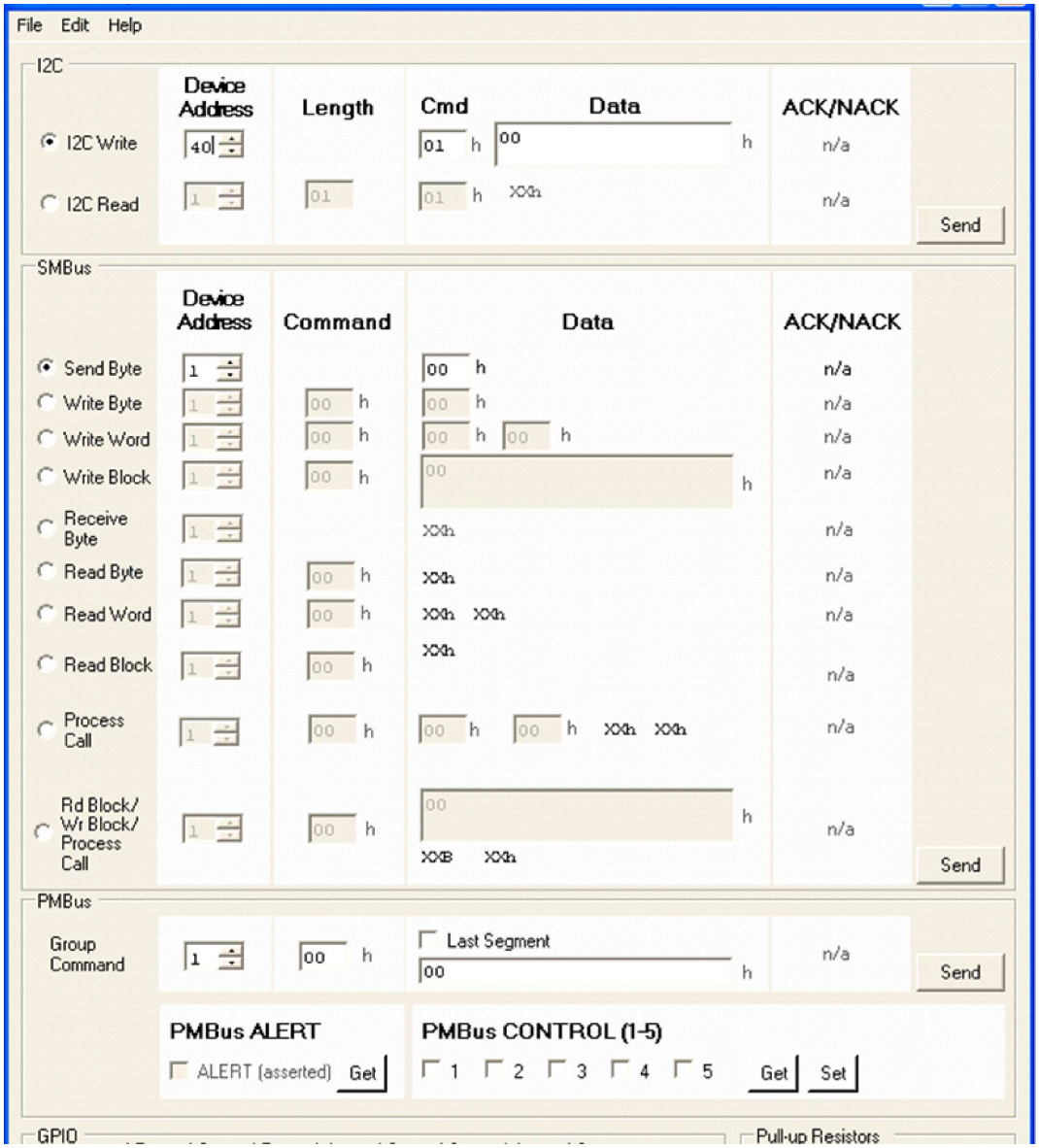

Figure 3. USB Interface Adapter GUI

Table 4. Buck Converter Current Trim Values

Cmd	Current Change	Cmd	Current Change	Cmd	Current Change	Cmd	Current Change
3f	–20.0%	2f	–10.0%	1f	0%	0f	10.0%
3e	–19.4%	2e	–9.38%	1e	0.625%	0e	10.6%
3d	–18.8%	2d	–8.75%	1d	1.25%	0d	11.3%
3c	–18.1%	2c	–8.13%	1c	1.88%	0c	11.9%
3b	–17.5%	2b	–7.50%	1b	2.50%	0b	12.5%
3a	–16.9%	2a	–6.88%	1a	3.13%	0a	13.1%
39	–16.3%	29	–6.25%	19	3.75%	09	13.8%
38	–15.6%	28	–5.63%	18	4.38%	08	14.4%
37	–15.0%	27	–5.00%	17	5.00%	07	15.0%
36	–14.4%	26	–4.38%	16	5.63%	06	15.6%

Table 4. Buck Converter Current Trim Values (continued)

35	–13.8%	25	–3.75%	15	6.25%	05	16.3%
34	–13.1%	24	–3.13%	14	6.88%	04	16.9%
33	–12.5%	23	–2.50%	13	7.50%	03	17.5%
32	–11.9%	22	–1.88%	12	8.13%	02	18.1%
31	–11.3%	21	–1.25%	11	8.75%	01	18.8%
30	–10.6%	20	–0.625%	10	9.38%	00	19.4%

Table 5. Linear Regulator Current Trim Values

Cmd	Current Change	Cmd	Current Change	Cmd	Current Change	Cmd	Current Change
0f	–25.0%	0b	–12.5%	07	0%	03	12.5%
0e	–21.9%	0a	–9.38%	06	3.13%	02	15.6%
0d	–18.9%	09	–6.25%	05	6.25%	01	18.9%
0c	–15.6%	08	–3.13%	04	9.38%	00	21.9%

6 Performance Data and Typical Characteristic Curves

Figure 4 through Figure 12 present typical performance curves for TPS92660EVM.

6.1 Efficiency

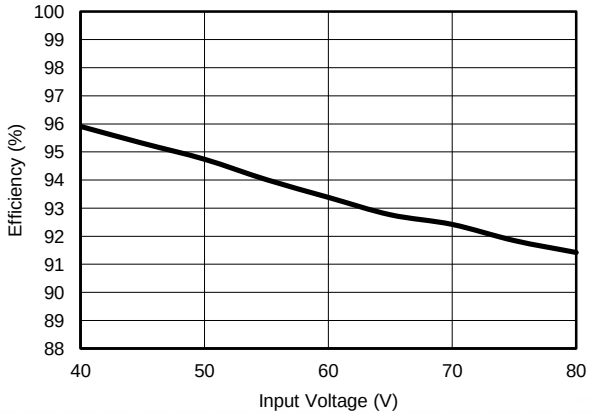

Figure 4. TPS92660EVM Efficiency with 10 LEDs

6.2 Line Regulation

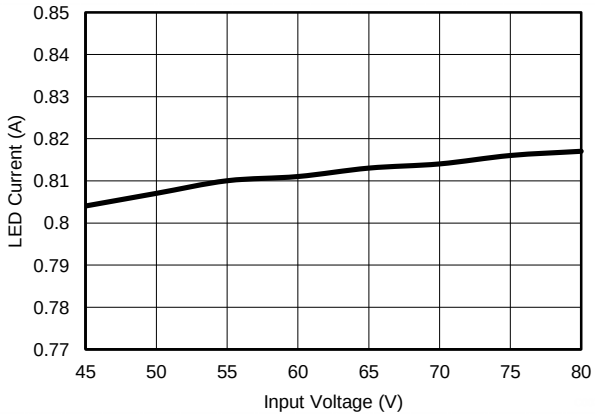

Figure 5. TPS92660EVM Buck Converter Current Line Regulation with 8 LEDs

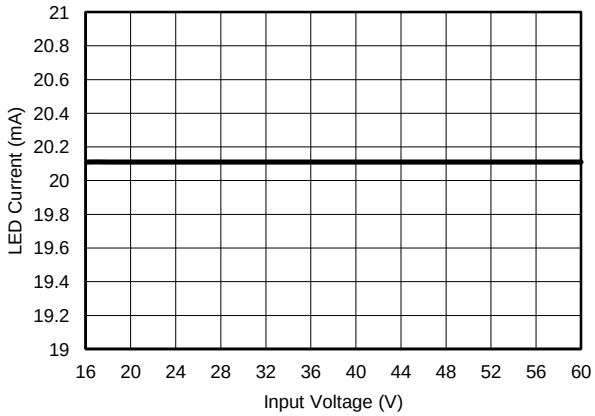

Figure 6. TPS92660EVM Linear Regulator Current Line Regulation with 4 LEDs

6.3 Switch Node Voltage and LED Current Ripple Waveforms

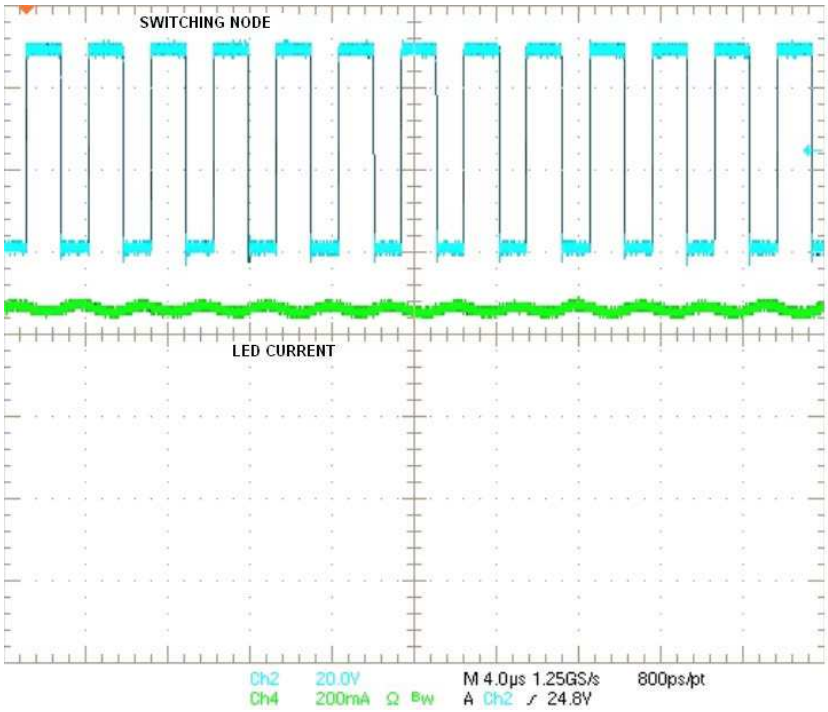

Figure 7. TPS92660EVM Buck Converter Switching Voltage and LED Current

6.4 Analog to PWM Dimming Waveforms

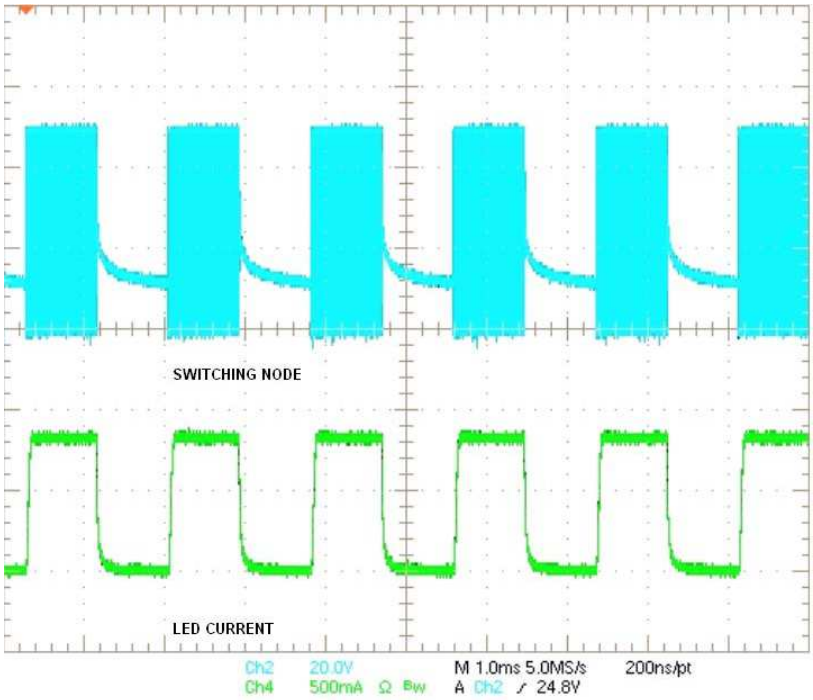

Figure 8. TPS92660EVM Buck Converter PWM Dimming, SADJ = 1.25 V

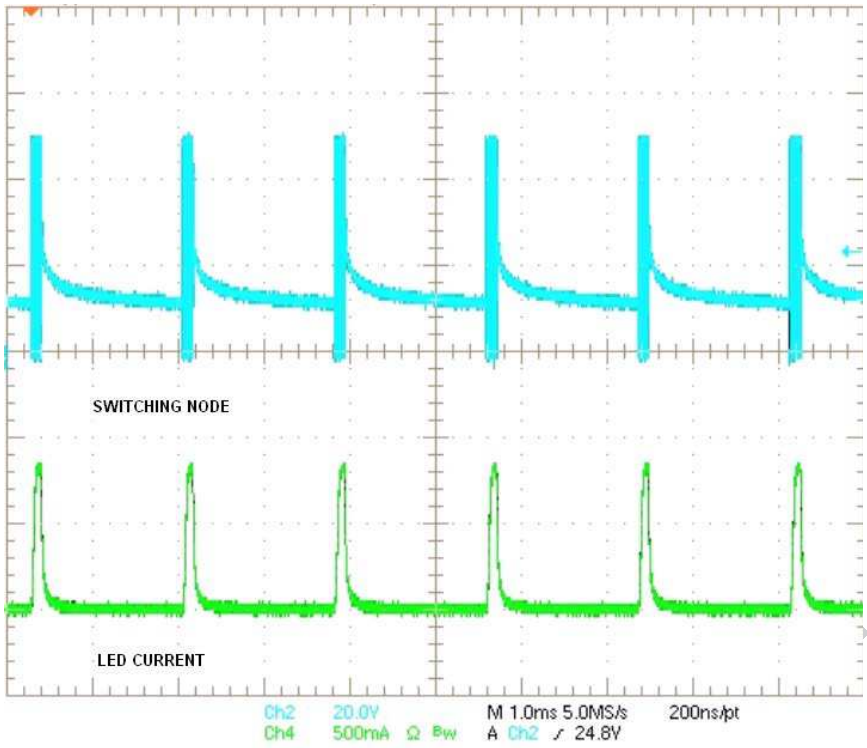

Figure 9. TPS92660EVM Buck Converter PWM Dimming, SADJ = 0.25 V

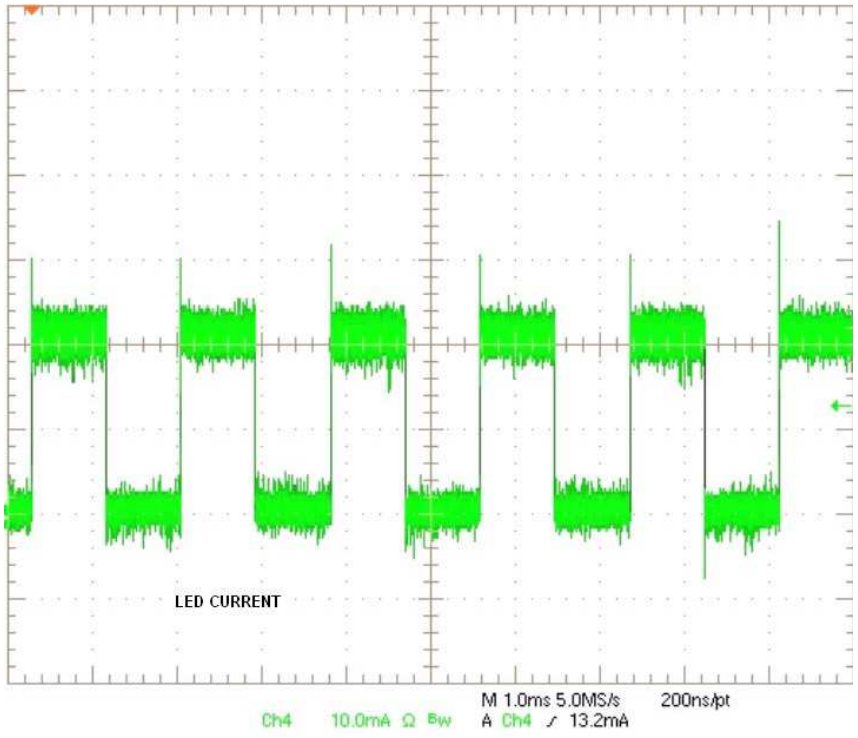

Figure 10. TPS92660EVM Linear Regulator PWM Dimming, LADJ = 1.25 V

6.5 Start-Up and Shut-down Waveforms

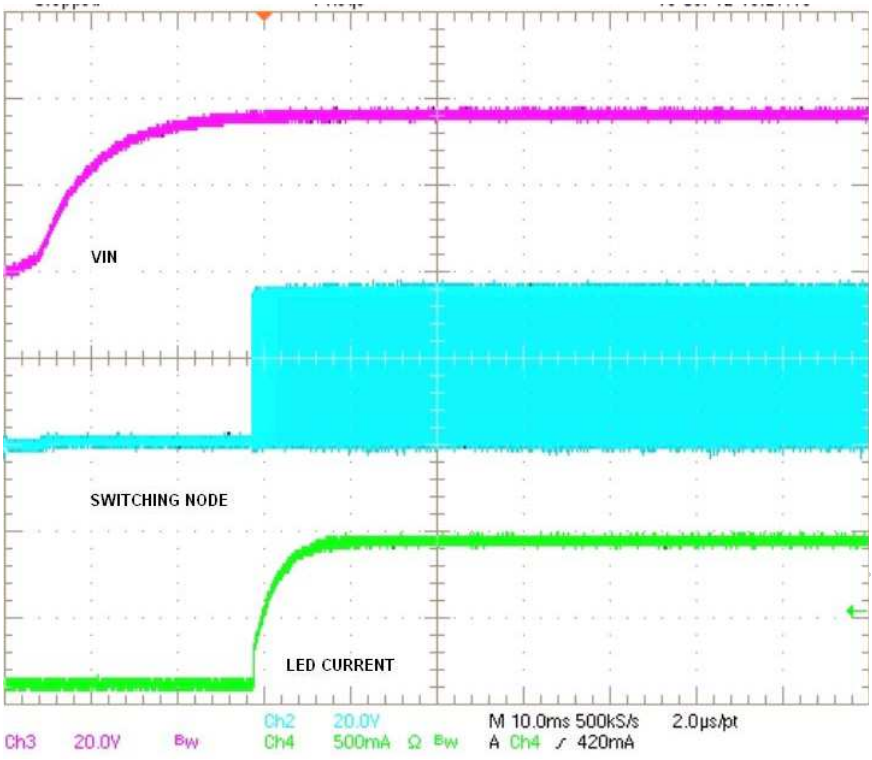

Figure 11. Buck Converter Start-Up Waveform

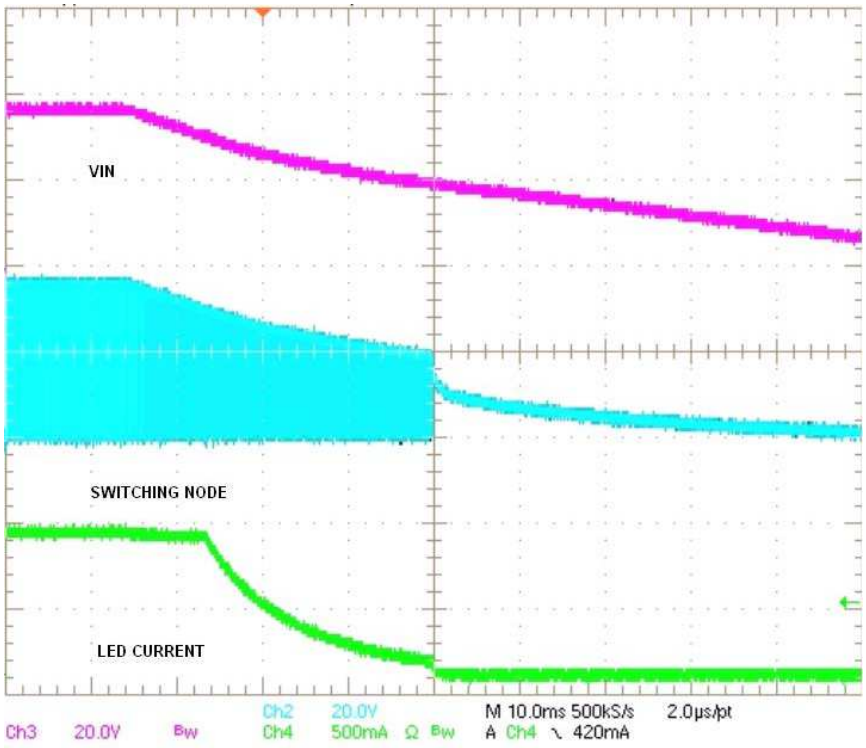

Figure 12. Buck Converter Shut-Down Waveform

7 TPS92660EVM PCB Layout

Figure 13 and Figure 14 show the TPS92660EVM printed-circuit board

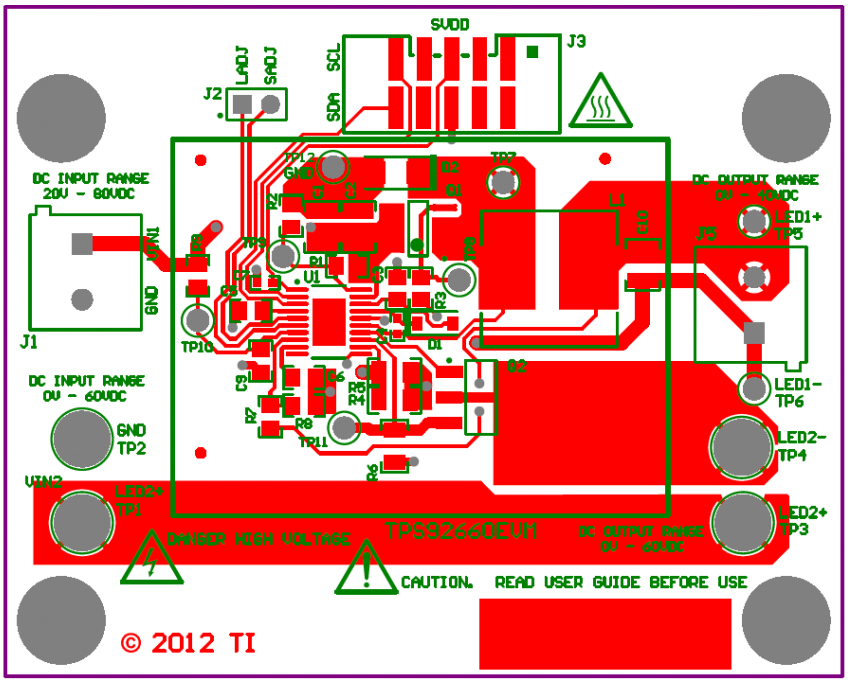

Figure 13. TPS92660EVM Top Layer and Top Overlay (Top View)

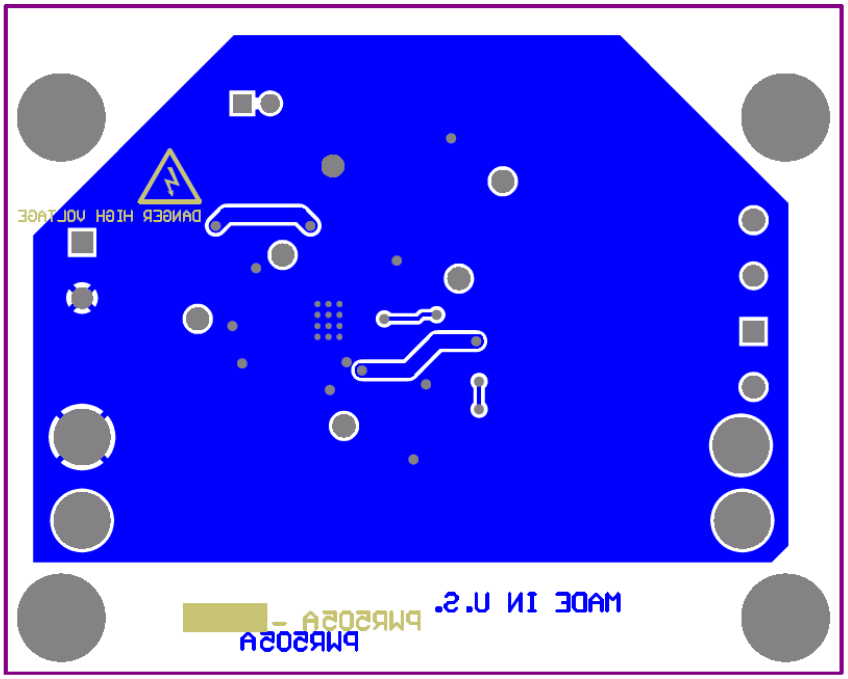

Figure 14. TPS92660EVM Bottom Layer and Bottom Overlay (Bottom View)

8 Bill of Materials (BOM)

Table 6 is the BOM according to the schematic shown in Figure 1.

Table 6. TPS92660EVM Bill of Materials

QTY	REFDES	Description	MFR	Part Number
3	C1, C2, C10	CAP, CERM, 2.2uF, 100V, +/-10%, X7R, 1210	STD	STD
3	C3, C5, C6	CAP, CERM, 1uF, 16V, +/-10%, X7R, 0805	STD	STD
2	C4, C7	CAP, CERM, 0.22uF, 16V, +/-10%, X7R, 0603	STD	STD
1	C9	CAP, CERM, 1000pF, 100V, +/-10%, X7R, 0805	STD	STD
1	D1	Diode, Schottky, 100V, 150mA, SOD-123	Diodes Inc	BAT46W-7-F
1	D2	Diode, Schottky, 150V, 2A, SMA	STMicroelectronics	STPS2150A
1	L1	Inductor, Shielded Drum Core, Ferrite, 56uH, 2.7A, 0.0802 ohm, SMD	Coilcraft	MSS1278T-563MLB
1	Q1	MOSFET, N-CH, 100V, 4.5A, SOIC-8	Fairchild Semiconductor	FDS3692
1	Q2	MOSFET, N-CH, 100V, 1.7A, SOT223	Diodes Inc	ZXMN10A11GTA
1	R1	RES, 154k ohm, 1%, 0.125W, 0805	STD	STD
1	R2	RES, 9.53k ohm, 1%, 0.125W, 0805	STD	STD
1	R3	RES, 10.0 ohm, 1%, 0.125W, 0805	STD	STD
2	R4,R5	RES, 0.50 ohm, 1%, 0.5W, 1206	STD	STD
1	R6	RES, 10.0 ohm, 1%, 0.25W, 1206	STD	STD
1	R7	RES, 15.4k ohm, 1%, 0.125W, 0805	STD	STD
1	R8	RES, 1.00k ohm, 1%, 0.125W, 0805	STD	STD
1	R9	RES, 51.1k ohm, 1%, 0.125W, 0805	STD	STD
1	U1	Two String LED Driver with I^2C Current Trim	Texas Instruments	TPS92660PWP

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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.

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

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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

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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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