Using the TPS61194xEVM Evaluation Module

User's Guide



Literature Number: SNVU492
January 2016

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TPS61194xEVM Evaluation Module

1 Preface

1.1 About this Manual

This user's guide describes the module used to evaluate characteristics, operation, and use of the TPS61194 high-performance 4-channel LED driver for industrial backlighting, test and measurement equipment, and TPS61194-Q1 for automotive lighting. This document includes a schematic diagram, PCB layout, and bill of materials (BOM).

1.2 Related Documentation from Texas Instruments

TPS61194 (SNVSAF5) and TPS61194-Q1 (SNVSAE9) data sheets.

1.3 FCC Warning

This equipment is intended for use in a laboratory test environment only. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to subpart J of part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user, at their own expense, will be required to take whatever measures may be required to correct this interference.

1.4 If You Need Assistance

Contact your local TI sales representative.

2 Introduction

The Texas Instruments TPS61194xEVM evaluation module (EVM) helps designers to evaluate the operation and performance of the TPS61194 or TPS61194-Q1 device. The TPS61194xEVM uses the TPS61194 or TPS61194-Q1 to drive up to 4 LED strings for LCD backlighting with high efficiency. Information about output voltage and current ratings of the TPS61194 or TPS61194-Q1 can also be found in the device data sheets (SNVSAF5 and SNVSAE9).

A power supply connection for the V_{IN} and test points for each signal can be found on the evaluation board. A separate LED board can be used as a load; it is also possible to connect LCD panel to the output connectors.

For evaluation purposes, the EVMs have been tested over a 4.5-V to 40-V input range. This voltage range is within the recommended operating range for input voltage of the TPS61194 or TPS61194-Q1. Users are cautioned to evaluate their specific operating conditions and choose components with the appropriate voltage ratings before designing this circuitry into a final product.

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3 Description of the TPS61194 or TPS61194-Q1 Device

The TPS61194 or TPS61194-Q1 is an automotive high-efficiency LED driver with integrated boost/SEPIC converter. It has 4 high-precision current sinks that can be controlled by a PWM input signal.

The boost converter has adaptive output voltage control based on the LED current sink headroom voltages. This feature minimizes the power consumption by adjusting the voltage to lowest sufficient level in all conditions. Boost controller supports spread spectrum for switching frequency and an external synchronization with a dedicated pin. The high switching frequency allows the TPS61194 or TPS61194-Q1 to avoid disturbance for AM radio band.

The input voltage range for the TPS61194 or TPS61194-Q1 is from 4.5 V to 40 V to support automotive stop/start and load dump condition. The TPS61194 or TPS61194-Q1 device supports PWM brightness dimming ratio up to 10 000:1 for input PWM frequency of 200 Hz. The device integrates extensive safety and protection features.

3.1 Features

- Four High-Precision Current Sinks
  - Current Matching 1% (typical)
  - Output Current up to 100 mA/Channel
  - Dimming Ratio 10 000:1 at 200-Hz PWM input
- Integrated Boost/SEPIC for LED String Power
  - Output Voltage up to 45 V
  - Switching Frequency 300 kHz to 2.2 MHz
  - Boost Synchronization Input
  - Spread Spectrum
- Input Voltage Operating Range 4.5 V to 40 V
- Power-Line FET Control for Inrush Current Protection and Standby Energy Saving
- Extensive Safety and Fault Tolerance Features
  - Fault Output
  - Input Voltage OVP and UVLO
  - Open and Shorted LED Fault Detection
  - Thermal Shutdown
- Minimum Number of External Components

3.2 Applications

- Industrial Backlighting Systems in Control Panels (TPS61194)
- Test and Measurement Equipment (TPS61194)
- Automotive Infotainment, Instrument Clusters, and Backlighting System (TPS61194-Q1)

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4 Hardware Setup

Figure 1 shows connectors and main components on the TPS61194 or TPS61194-Q1 board.

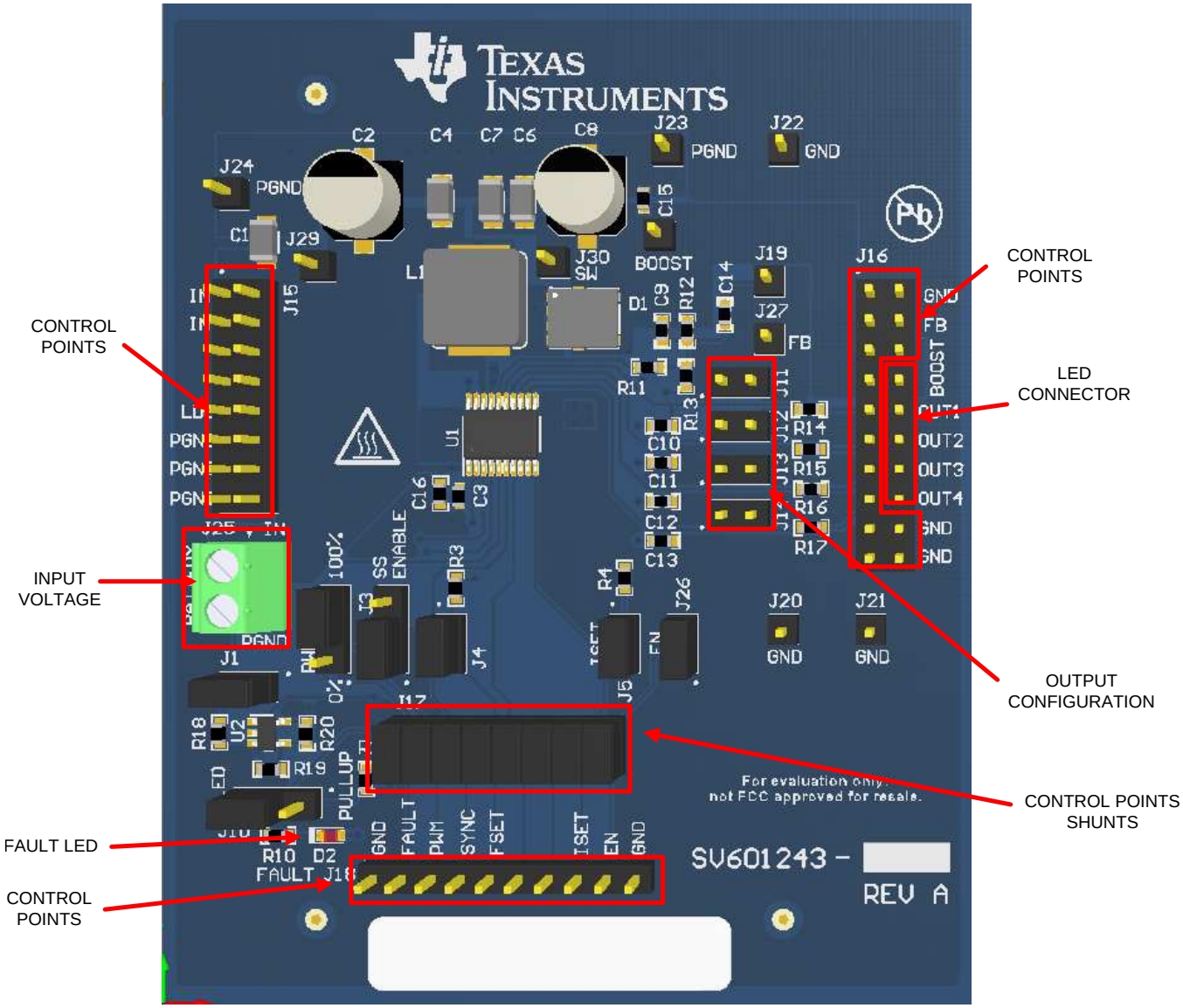


Figure 1. Evaluation Board Connectors and Setup

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5 Board Layout

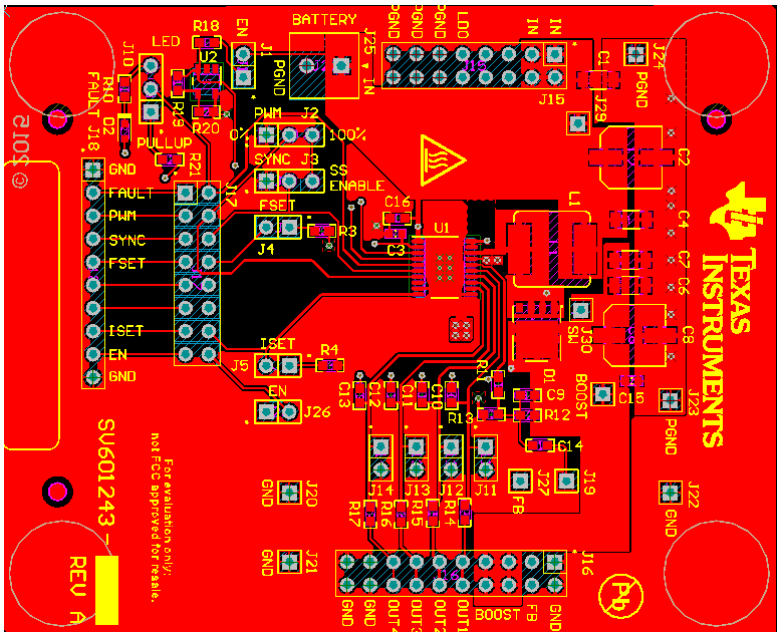


Figure 2. Top Layer

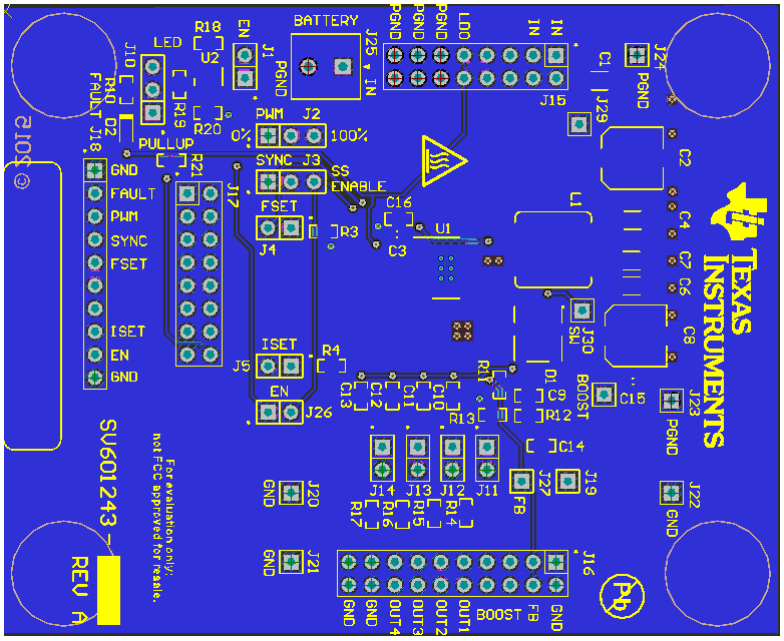


Figure 3. Bottom Layer (GND)

See the TPS61194 (SNVSAF5) or TPS61194-Q1 (SNVSAE9) datasheet for PCB layout guidelines.

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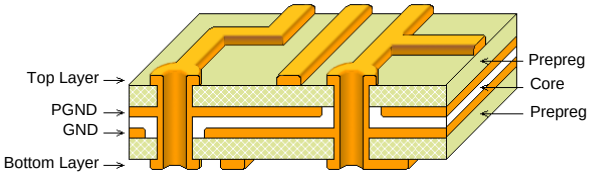


Figure 4. Evaluation Board Stackup

- 4-layer board FR4
- Material thickness 1.616 ± 10% mm
- Surface finish immersion gold

6 Start-Up of the EVM and Power Sequences

The TPS61194xEVM is set up for easy start-up:

- Connect LEDs to OUT1 - OUT4 of connector J16. (Note: LED current default is 100 mA, and maximum boost voltage default is 37 V. LED outputs that are not used must be grounded via jumpers J11 to J14.)
- Connect input (BATTERY) voltage 12 V to connector J25.

The LEDs turn on immediately because the jumpers on the EVM are set up for PWM input of 100% duty cycle. For connector and jumper positions, see Figure 1 and Figure 8.

Input (BATTERY) voltage range is 4.5 V to 40 V.

The TPS61194 or TPS61194-Q1 has a dual function VDDIO/EN pin. By default, VDDIO/EN = 3.3 V is generated automatically on the EVM from battery input voltage via jumpers J1 and J26. VDDIO/EN acts as enable for the device as well as supply/reference voltage for IO logic. The device starts when V_{IN} voltage is present and above the V_{IN} UVLO voltage level (4 V), and the VDDIO/EN voltage is set above threshold voltage (1.2 V).

By default, boost switching frequency is 400 kHz (jumper J4 connecting R3 = 160 kΩ to FSET) and boost maximum voltage is 37 V (R12 = 750 kΩ and R13 = 130 kΩ). See Section 7.1 and Section 7.3 for description on how to change boost settings.

By default, LED current is 100 mA per string (jumper J5 connecting R4 = 24 kΩ to ISET). See Section 8.2 for the description on how to change LED current setting.

Alternatively to internal LDO, device circuitry can be powered from external power supply (4.4 V to 5.25 V) connected to the LDO pin. Internal LDO are disabled in this case.

6.1 PWM Input to Initiate Start-up Sequence

The backlight is started by setting PWM input high. By default, the TPS61194xEVM has PWM input set high (100% duty cycle), which is connected to VDDIO through jumper J2. Alternatively, an external PWM signal can be connected by removing jumper J2 , shorting pins 3 and 4 on jumper J17, and connecting the external PWM to connector J18.

6.2 Shutdown Sequence

The backlight is shut down (LEDs turned off) by setting PWM input low or when VDDIO/EN = 0. If VDDIO/EN is set low, the TPS61194 or TPS61194-Q1 enters low-power mode with internal LDO disabled.

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7 Boost Converter

7.1 Switching Frequency

Switching frequency for boost is defined as 300 kHz to 2.2 MHz. However, frequency from 250 kHz to 2.2 MHz can be set by the external resistor connected to the FSET pin, thus allowing the device to be synchronized with the lowest external frequency of 300 kHz (see details in Section 7.2).

Switching frequency is defined by resistor R3 connected to FSET pin:

$$f_{SW} = 67600 / (R_{FSET} + 6.4) \quad (1)$$

where

- f_{SW}: switching frequency, kHz
- R_{FSET}: frequency setting resistor, kΩ

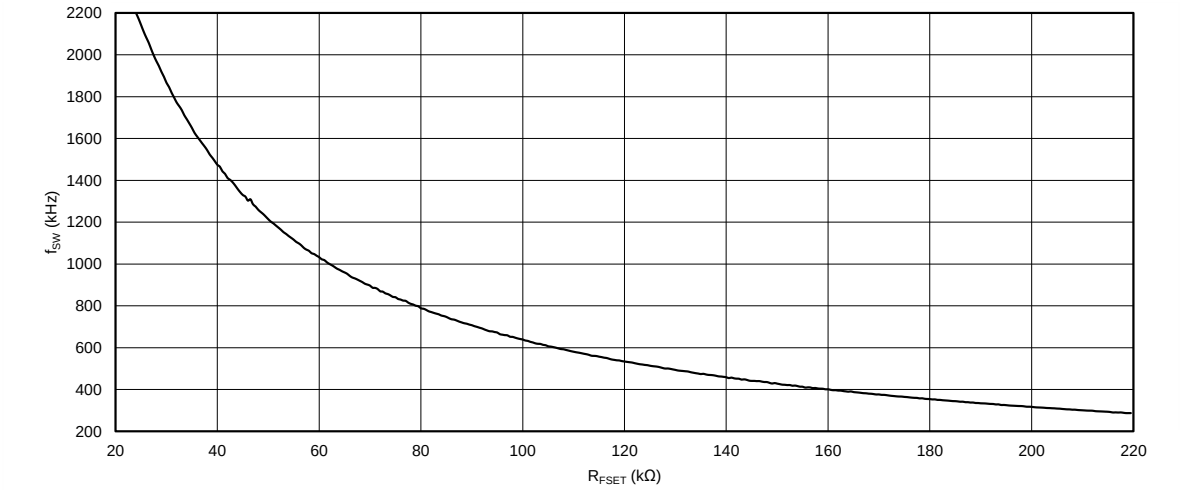


Figure 5. Switching Frequency vs R_{FSET}

By default, jumper J4 is installed on the board connecting R3 = 160 kΩ to the FSET pin which sets the boost at 400 kHz. An external resistor can be connected to change the switching frequency: remove jumper J4, short pins 7 and 8 on jumper J17, and connect the external resistor to connector J18. Boost internal parameters are adjusted automatically according to chosen frequency during start-up.

7.2 Spread Spectrum and Synchronization

The SYNC pin is used to enable boost spread spectrum or, alternatively, to synchronize boost switching with an external frequency. To disable spread-spectrum functionality this pin should be connected to ground; to enable spread spectrum SYNC should be connected to VDDIO/EN. Selection is done with jumper J3. When spread spectrum is enabled, boost switching frequency is modulated ±3% from set frequency with 1.875 kHz modulation frequency.

If an external frequency is detected at SYNC pin, the TPS61194 or TPS61194-Q1 starts to synchronize boost with this frequency. Frequency must be higher than the switching frequency set by R_{FSET} resistor and be in range 1.2 V to 1.5 V × $f_{SW\ SET}$.

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7.3 Voltage Control

Maximum boost converter voltage is defined by the feedback voltage divider R12 and R13. Recommended value for R13 is 130 kΩ. R12 value can be calculated with the following equation:

$$V_{MAX\ BOOST} = \left(\frac{V_{BG}}{R13} + 0.0387 \right) \times R12 + V_{BG} \quad (2)$$

where

- V_{BG} = 1.2 V
- R12, R13 values are in kΩ

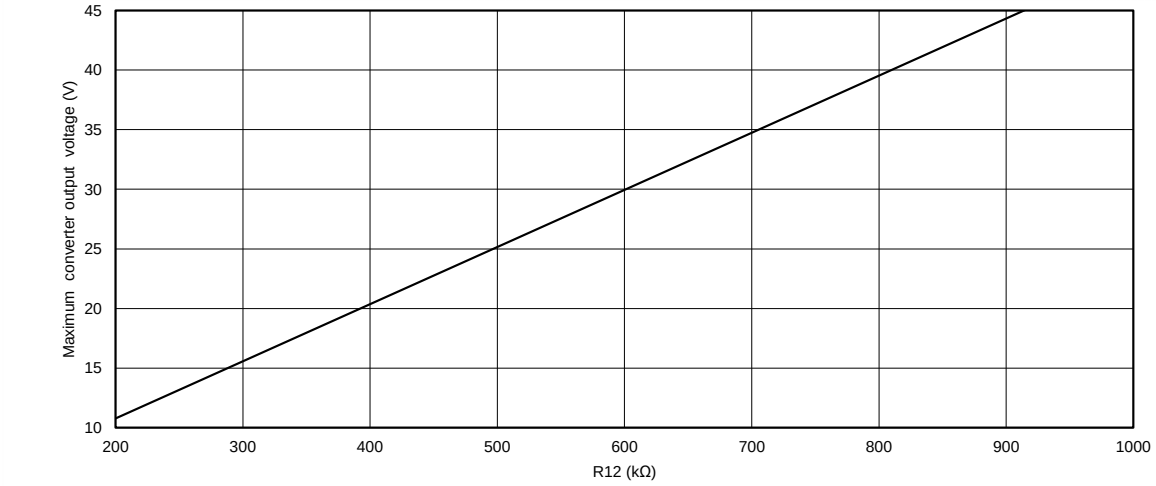


Figure 6. Converter Maximum Output Voltage vs R12

Maximum voltage should be chosen based on the maximum voltage required for LED strings. Recommended maximum voltage is about 30% higher than maximum LED string voltage. Initial boost voltage is about 88% of maximum voltage. Boost output voltage is adjusted automatically based on LED current sink headroom voltage.

Default setting for boost maximum voltage is 37 V (R12 is 750 kΩ).

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8 LED Current Sinks

8.1 Output Configuration

The TPS61194 or TPS61194-Q1 detects LED output configuration during start-up. Any output connected to ground is disabled and excluded from adaptive boost control and fault detections. Non-used LED outputs must be grounded with jumpers J11 through J14.

8.2 Current Setting

Maximum current for the LED outputs is controlled with an external resistor (R4) connected to the ISET pin. Maximum current can be calculated as follows:

$$I_{LED} = \frac{2000 \times V_{BG}}{R_{ISET}} \quad (3)$$

where

- V_{BG} = 1.2 V
- R_{ISET}: current setting resistor (R4), kΩ
- I_{LED}: output current per output, mA

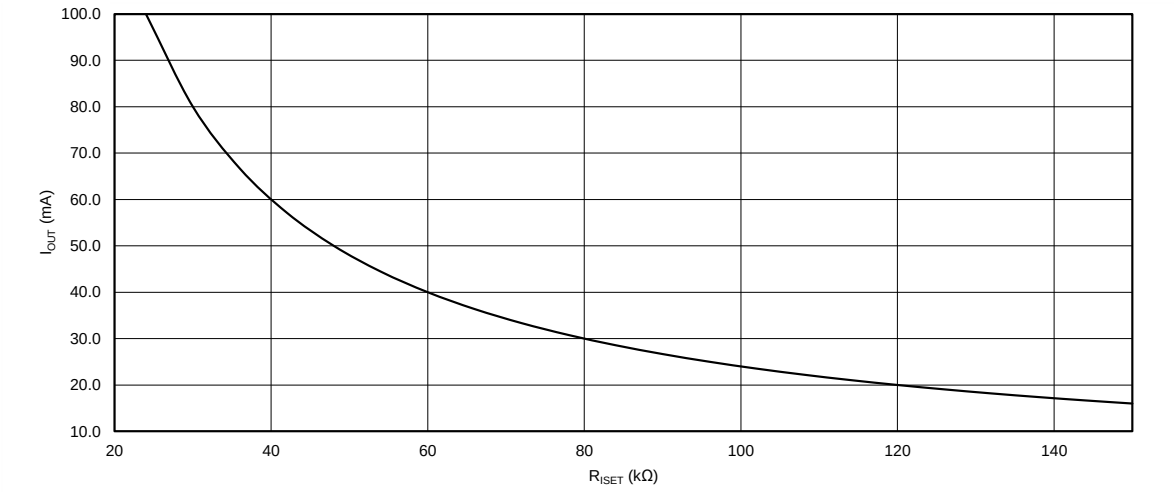


Figure 7. Output Current vs R_{ISET}

8.3 Brightness Control

The TPS61194 or TPS61194-Q1 controls the brightness of the display with conventional PWM. Output PWM will directly follow the input PWM. Input PWM frequency can be in the range of 100 Hz to 20 kHz.

An external digital PWM signal can be connected to connector J18. For test purposes the PWM input of the TPS61194 or TPS61194-Q1 can be connected to ground to turn off LEDs or connected to VDDIO/EN to set up 100% brightness using jumper J2.

9 Fault Detection

9.1 Fault Indicator

The TPS61194 or TPS61194-Q1 has fault detection for LED open and short, V_{IN} input overvoltage, VIN undervoltage lockout, boost overcurrent, and thermal shutdown. Open-drain FAULT pin indicates faults. Fault pin can be connected to LED D2 for indication (jumper J10).

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10 Evaluation Board Schematic

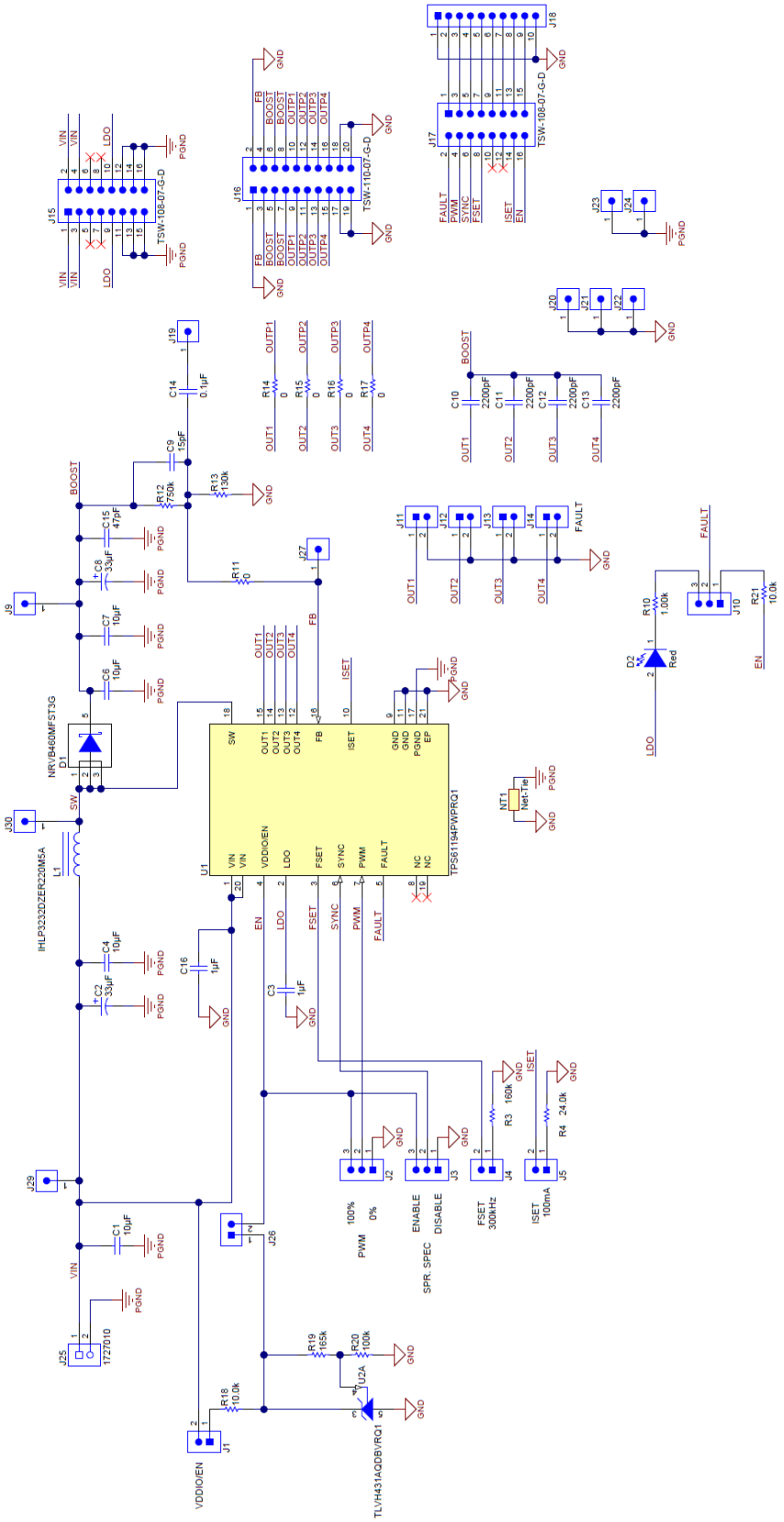


Figure 8. Evaluation Board Schematic

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11 Bill of Materials

The following is the bill of materials for the TPS61194xEVM:

DESIGNATOR	DESCRIPTION	MANUFACTURER	PART NUMBER	Qty
C1, C4, C6, C7	CAP, CERM, 10uF, 50V, +/-10%, X5R, 1206_190	TDK	CGA5L3X5R1H106K160AB	5
C2, C8	CAP, AL, 33uF, 50V, +/-20%, 40 mohm, SMD	Panasonic	EEHZC1H330XP	2
C3	CAP, CERM, 1uF, 10V, +/-10%, X5R, 0603	Kemet	C0603C105K8PACTU	1
C9	CAP, CERM, 15pF, 50V, +/-5%, C0G/NP0, 0603	Kemet	C0603C150J5GACTU	1
C15	CAP, CERM, 47pF, 50V, +/-5%, C0G/NP0, 0603	Kemet	C0603C470J5GACTU	1
C10, C11, C12, C13	CAP, CERM, 2200pF, 50V, +/-10%, X7R, 0603	Kemet	C0603C222K5RACTU	4
C14	CAP, CERM, 0.1uF, 50V, +/-10%, X7R, 0603	MuRata	GRM188R71H104KA93D	1
C16	CAP, CERM, 1 µF, 50 V, +/- 10%, X7R, 0603	Taiyo Yuden	UMK107AB7105KA-T	1
D1	Diode, Schottky, 60V, 4A, 6.15x1.00x5.15mm	ON Semiconductor	NRVB460MFST3G	1
D2	LED, Red, SMD	Rohm	SML-311UTT86	1
J1, J4, J5, J11, J12, J13, J14, J26	Header, TH, 100mil, 2x1, Gold plated, 230 mil above insulator	Samtec	TSW-102-07-G-S	12
J2, J3, J10	Header, TH, 100mil, 3x1, Gold plated, 230 mil above insulator	Samtec	TSW-103-07-G-S	4
J9, J19, J20, J21, J22, J23, J24, J27, J29, J30	CONN HEADER 1POS .100" SNGL TIN, TH	Samtec	TSW-101-17-T-S	9
J15, J17	Header, TH, 100mil, 8x2, Gold plated, 230 mil above insulator	Samtec	TSW-108-07-G-D	2
J16	Header, TH, 100mil, 10x2, Gold plated, 230 mil above insulator	Samtec	TSW-110-07-G-D	1
J18	Header, TH, 100mil, 10x1, Gold plated, 230 mil above insulator	Samtec	TSW-110-07-G-S	1
J25	Conn Term Block, 2POS, 3.81mm, TH	Phoenix Contact	1727010	1
L1	Inductor, Shielded, 22uH, 3.7A, 0.103 ohm, SMD	Vishay-Dale	IHLP3232DZER220M5A	1
R3	RES, 160 k, 1%, 0.1 W, 0603	Vishay-Dale	CRCW0603160KFKEA	1
R4	RES, 24.0k ohm, 1%, 0.1W, 0603	Yageo America	RC0603FR-0724KL	1
R10	RES, 1.00k ohm, 1%, 0.1W, 0603	Yageo America	RC0603FR-071KL	1
R11, R14, R15, R16, R17	RES, 0 ohm, 5%, 0.1W, 0603	Rohm	MCR03EZPJ000	5
R12	RES, 750 k, 1%, 0.1 W, 0603	Vishay-Dale	CRCW0603750KFKEA	1
R13	RES, 130 k, 1%, 0.1 W, 0603	Vishay-Dale	CRCW0603130KFKEA	1
R18	RES, 10.0 k, 1%, 0.1 W, 0603	Vishay-Dale	CRCW060310K0FKEA	1
R20	RES, 100k ohm, 1%, 0.1W, 0603	Vishay-Dale	CRCW0603100KFKEA	1
R19	RES, 165 k, 1%, 0.1 W, 0603	Yageo America	RC0603FR-07165KL	1
R21	RES, 10.0k ohm, 1%, 0.1W, 0603	Yageo America	RC0603FR-0710KL	1
U1	Low-EMI, High-Performance 4-Channel LED Driver for Automotive Lighting	Texas Instruments	TPS61194PWPQ1 or TPS61194PWP depending on version	1
U2	LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATOR, DBV0005A	Texas Instruments	TLVH431AQDBVRQ1	1

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12 Appendix A: LED Load Board

The LED board is intended for use as the load for LED drivers and can configured for up to 6 strings and up to 20 LEDs in the string (number of LEDs in use is defined by jumpers). Cree Xlamp ML-B LEDs with maximum current 175 mA and maximum forward voltage 3.5 mA at 80 mA (3.3 V typical) are used on the board. For the TPS61194 or TPS61194-Q1 4 strings are assembled.

NOTE: The LED board is not included with the EVM -- contact your local TI sales representative if board is needed.

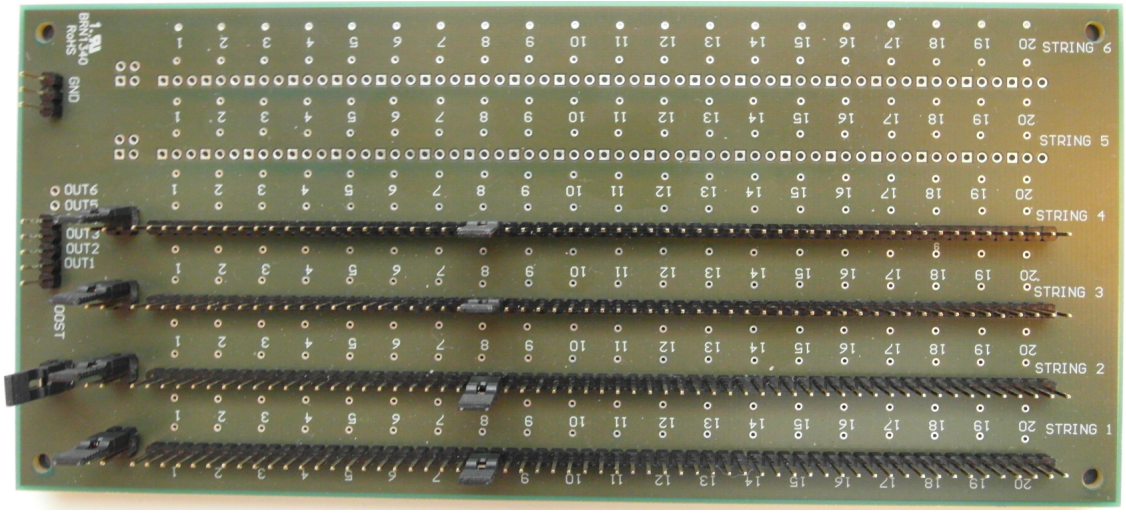


Figure 9. LED Load Board - Top Side

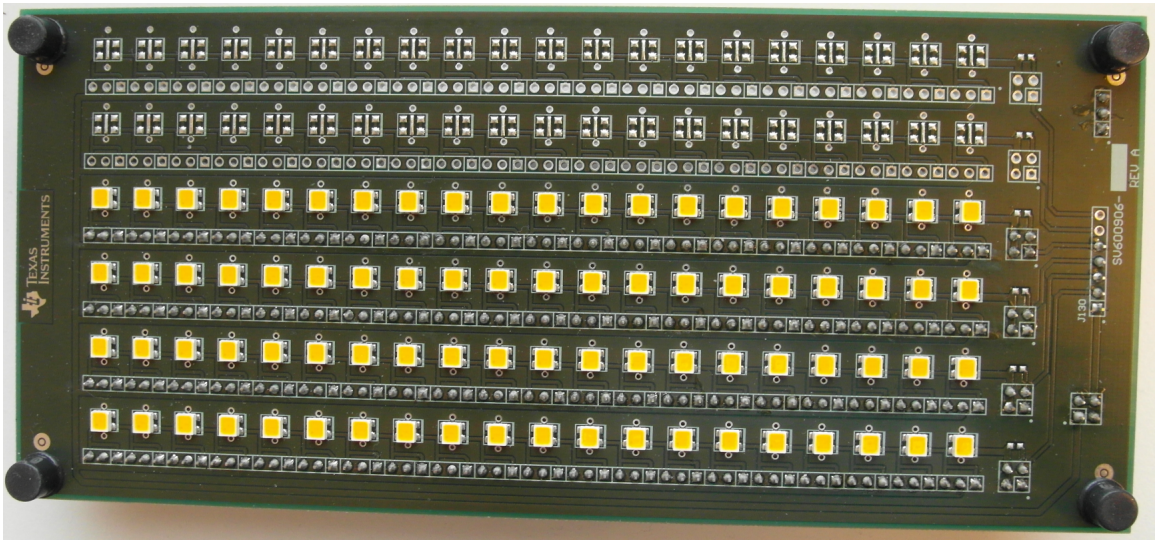


Figure 10. LED Load Board - Bottom View

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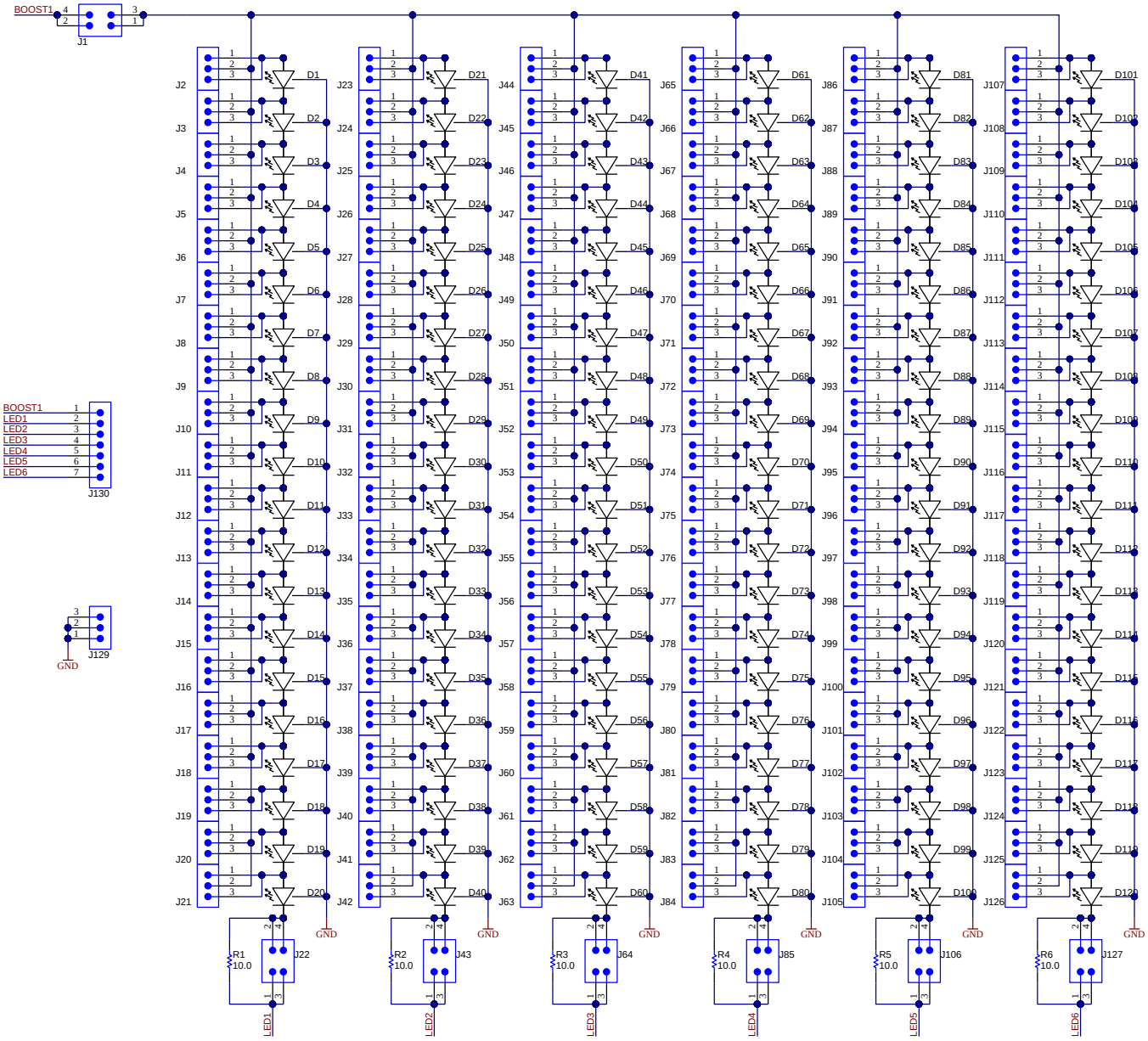


Figure 11. LED Load Board - Schematic Diagram

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Table 1. Bill of Materials for LED Load Board

DESIGNATOR	DESCRIPTION	MANUFACTURER	PART NUMBER	QTY
R1, R2, R3, R4, R5, R6	Resistor 10.0 ohm, 1%, 0.1W, 0603 (not assembled)	Vishay-Dale	CRCW060310R0FKEA	6
J1, J22, J43, J64, J85,J106, J127	Header, 100mi, 2x2	Samtec	TSW-102-07-G-D	7
J2...J21, J23...J42, J44...J63, J65...J84 , J86...J105, J107...J126, J129	Header, 100mi, 3x1	Samtec	TSW-103-07-G-S	121
J130	Header, 100mi, 7x1	Samtec	TSW-107-07-G-S	1
D1...D120	Cool White SMD LED XLamp mL-B	Cree	MLBAWT-A1-0000-000W51	120

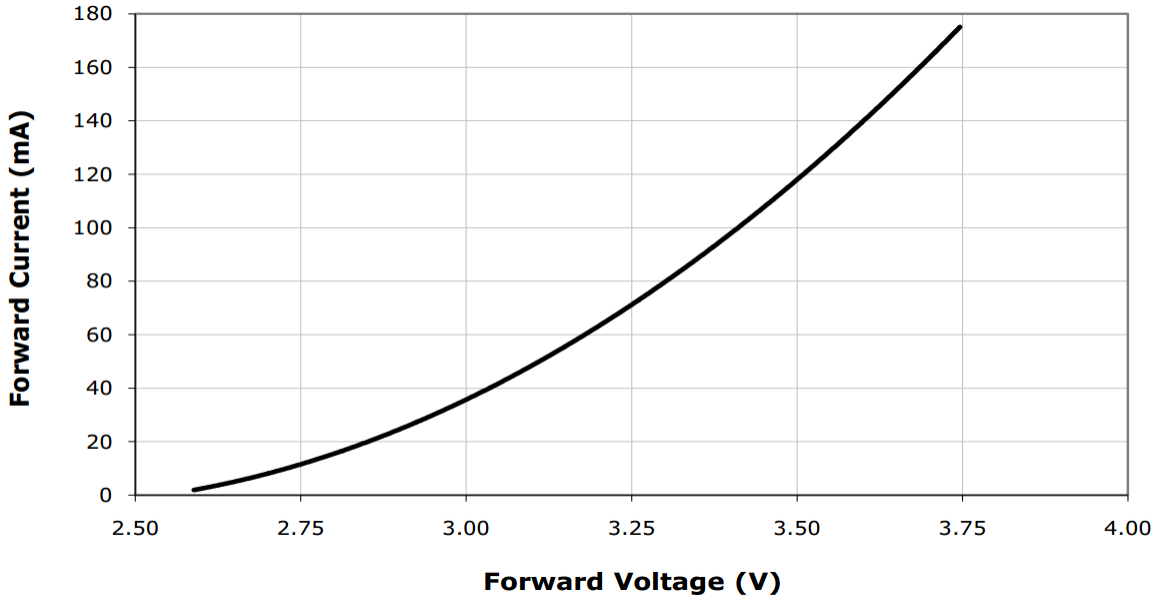


Figure 12. Forward Voltage for Cree Xlamp ML-B LEDs

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STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

3 *Regulatory Notices:*

   3.1 *United States*

      3.1.1 *Notice applicable to EVMs not FCC-Approved:*

      This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

      3.1.2 *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

      NOTE: 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

NOTE: 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.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-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.

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.

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.

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

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs 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 EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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2. 実験局の免許を取得後ご使用いただく。
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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should 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 also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user 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, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure 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. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

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