TPS61160EVM-243/TPS61161EVM-243

This user's guide describes the characteristics, operation, and use of the TPS6116xEVM-243 evaluation module (EVM). This EVM contains the Texas Instruments TPS61160 or TPS61161 boost converter, configured with external components to regulate current through a string of WLEDs. This user's guide includes EVM specifications, recommended test setup, test results, bill of materials, and a schematic diagram.

Contents

List of Figures

List of Tables

1 Introduction

The Texas Instruments TPS6116xEVM-243 evaluation module contains a TPS61160 or TPS61161 integrated circuit (IC), supporting active and passive components and either 6 or 10 white light-emitting diodes (WLEDs) in series. The goal of this EVM is to facilitate evaluation of the TPS61160 or TPS61161 in a typical WLED application.

1.1 Performance Specification Summary

Table 1 provides a summary of the TPS6116xEVM-243 performance specifications. All specifications are given for an ambient temperature of 25°C.

Table 1. Typical Performance Specification Summary

	CONDITION	MIN	TYP	MAX	UNITS
V_{IN} supply		9		18	V
TPS61161 V_{OUT}	CTRL=VIN, JP2 shorted		29.5		V
	CTRL=VIN, JP2 open	37	38	39	V
TPS61160 V_{OUT}	CTRL=VIN, JP2 shorted		17.7		
	CTRL=VIN, JP2 open	25	26	27	
I_{OUT}	JP2 shorted	19	20	21	mA

1.2 Modifications

To aid user customization of the EVM, the board was designed with devices having 0603 or larger footprints. A real-world implementation should occupy less total board space.

The inductor and compensation components (R1, C2) were designed for the V_{IN} range shown in Table 1. Using a different input voltage range may require resizing of the inductor and/or the compensation components. Also, changing components can improve or degrade EVM performance. For example, using inductors with larger dc resistances lowers efficiency of the solution.

The other members of the TPS6116x IC family have the same footprint.

NOTE: When modifying the REV A version of this PCB, it is strongly recommended that you heat the PCB on a hot plate before using a soldering iron to remove/replace components, especially the input capacitor and inductor. Otherwise, the expansion when soldering and contraction when cooling of the wide traces/places connecting these components to the IC pins can damage the IC. For further explanation and guidance, see the TI application report *QFN/SON PCB Attachment* (SLUA271).

2 Setup and Test Results

2.1 Input/Output Connections

The connection points are described in the following paragraphs.

2.1.1 J1-VIN

This header is the positive connection to the input power supply. Twist the leads to the input supply, and keep them as short as possible.

2.1.2 J2-GND

This header is the return connection to the input power supply.

2.1.3 J3-VOUT

This header is the positive voltage output for the device.

2.1.4 J4-GND

This header is the return connection for the load.

2.1.5 J5-USB-TO-GPIO Connector

This connector is for the 10-pin ribbon cable that connects the EVM to the USB-TO-GPIO interface box. It is only used when the software is used to perform dimming.

2.1.6 J6-FB

This header connects to the FB pin of the IC through resistor R4. Resistor R4 is unpopulated.

2.1.7 JP1-ON/CTRL

Installing this jumper ties the CTRL pin to V_{IN}, and enables the device. Removing the jumper allows the internal pulldown resistor to pull CTRL to ground, which disables the device. The jumper should be removed if using an external signal to perform dimming.

2.1.8 JP2-Open LED

Installing this jumper places the WLEDs in the boost converter feedback path and allows current to flow through the WLEDs. Removing the jumper removes the WLEDs from the boost converter feedback path. With this jumper removed and jumper JP1 installed, the overvoltage protection circuit of the IC clamps the boost converter output to 38 V (typ).

WARNING

This EVM has white LEDs that shine very brightly. Protective eye wear and/or a diffuser to cover the white LED is recommended.

2.2 Hardware Requirements

This EVM requires an external power supply capable of providing 3 V to 18 V at 1 A.

To change the default current value (i.e., implement dimming), the user can apply either a PWM or digital control signal to CTRL. Both signals change the feedback voltage at the FB pin of the IC so that the IC performs analog dimming. A function generator capable of driving the CTRL pin with 1.2 V to VIN amplitude and 5-kHz to 100-kHz PWM signal is required for PWM-controlled dimming. The user also can implement dimming by using a digital control signal. The EVM kit includes a PC software compact disk (CD) and USB-TO-GPIO interface box which, when installed on a personal computer (PC) and connected to the EVM, allows the user to communicate with the EVM via a GUI interface. The minimum PC requirements are:

- Windows® 2000 or Windows XP operating system
- USB port
- Minimum of 30 MB of free hard disk space (100 MB recommended)
- Minimum of 256 MB of RAM

2.3 Hardware Setup

After connecting the power supply between J1 and J2, turning on the power supply, and installing JP1 and JP2, the EVM regulates the default current per Table 1 through the WLEDs. Additional input capacitance may be required in order to mitigate the inductive voltage droop that occurs at start-up and/or during a load transient event.

In order to implement analog dimming via a PWM signal, remove the jumper on JP1 and the 10-pin ribbon cable from J5, if installed, and perform the following steps in any sequence:

- Connect the power supply between J1 and J2 and turn on the power supply.
- Make sure that JP2's jumper is installed.
- Connect the appropriately configured function generator to the CTRL side of JP1.

The PWM signal's duty cycle is directly proportional to the regulated current.

To implement analog dimming by sending the digital control via a PC running the TPS6116x Controller software and USB-TO-GPIO interface box, remove the jumper or the function generator on JP1, and perform the following steps in any sequence:

- Connect one end of the USB-TO-GPIO box to the PC using the USB cable and the other end to J5 of the TPS6116xEVM using the supplied 10-pin ribbon cable as shown in the following illustration. The connectors on the ribbon cable are keyed to prevent incorrect installation.
- Connect the power supply between J1 and J2 and turn on the power supply.
- Make sure that JP2's jumper is installed.
- Run the software as explained in the next section.

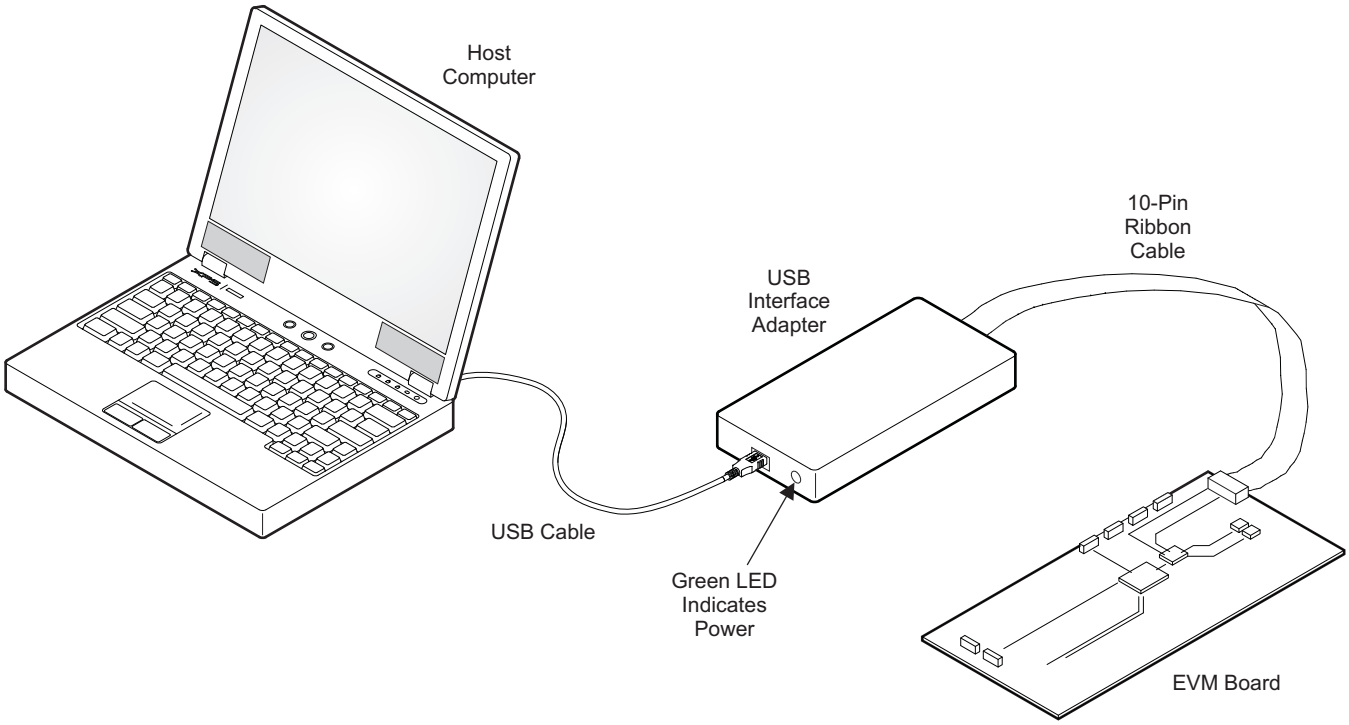


Figure 1. USB Interface Adapter

2.4 Software Installation and Operation

If installing from a CD, insert the CD and run Setup.exe; follow all the prompts to install the software. The software from the CD may not function well on Windows 7 OS. You can install an updated version compatible with Windows 7 from the TI Web site. Go to the URL: SLVC422A.

NOTE: This installation page is best viewed with the Microsoft™ Internet Explorer browser (It may not work correctly with other browsers)

Click on the install button; your PC gives you a security warning and asks if you want to install this application. Select Install to proceed. If a pre-release or Beta version is currently installed on your PC, you must uninstall this version of the software before installing the final version from either the CD or the TI Web site.

With both types of installation, the software attempts to install the Microsoft Dot Net Framework 2.0 (if it is not already installed) This framework is required for the software to run.

Immediately following installation, the software automatically runs.

To run the software after installation, go to

Start → all programs → Texas Instruments, Inc. → TPS6116x Controller EVM Software.

At start-up, the software first checks the firmware version of the USB-TO-GPIO adapter box. If an incorrect firmware version is installed, the software automatically searches on the Internet (if connected) for updates. If a new update is available, the software notifies the user of the update, and downloads and installs the software. Note that after the firmware is updated, the user must disconnect and then reconnect the USB cable between the adapter and PC, as instructed during the installation process. The host PC software also automatically searches on the Internet (if connected) for updates. If a new update is available, the software notifies the user of the update, downloads and installs it.

NOTE: VeriSign™ Code Signing is used to prevent any malicious code from changing this application. If at any time in the future the binaries are modified, the code will no longer attempt to run.

The TPS6116x IC has a 5-bit register that stores the feedback voltage to which the error amplifier will regulate the FB pin. Using the EasyScale™ protocol, the user can program a separate digital IC to generate a signal that changes this register to one of 32 discrete settings, thereby changing the FB voltage and subsequent regulated WLED current. The software provides a GUI interface which allows the user to change the bits directly or by a drop-down box. After changing the bits, the WRITE button must be pressed. See a screen shot of the software in Figure 2.

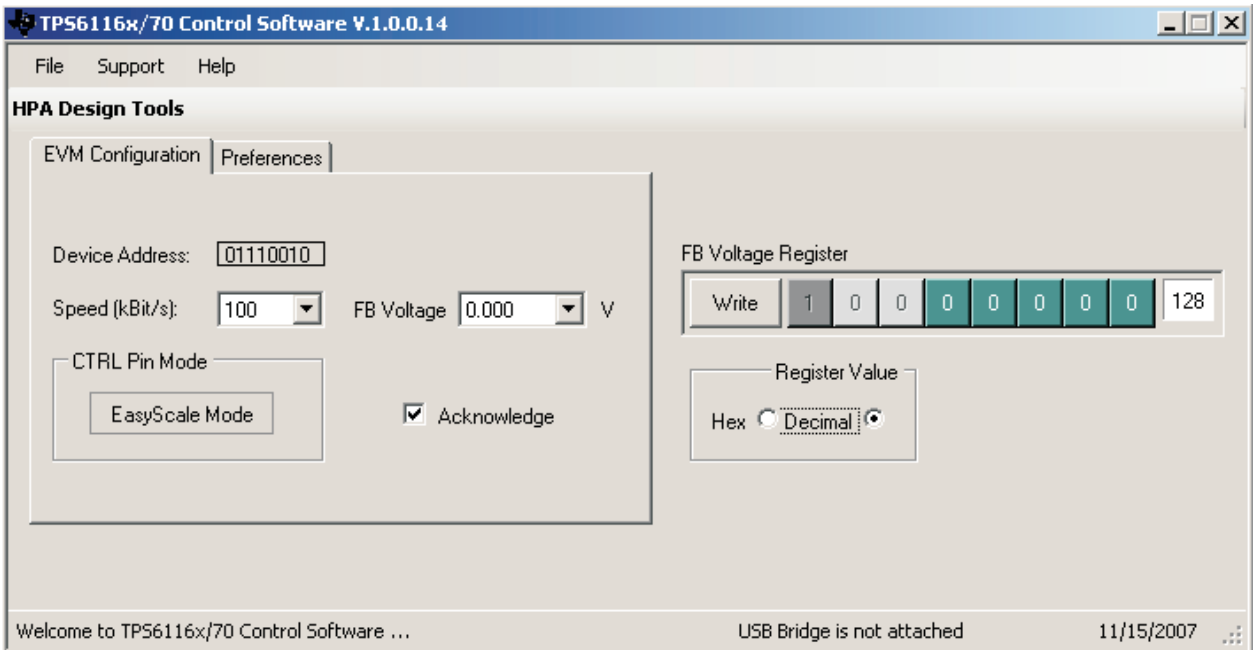


Figure 2. Screen Capture of TPS6116x Controller Software GUI Interface

2.5 Test Results

This section provides typical efficiency for the TPS6116xEVM-243 board.

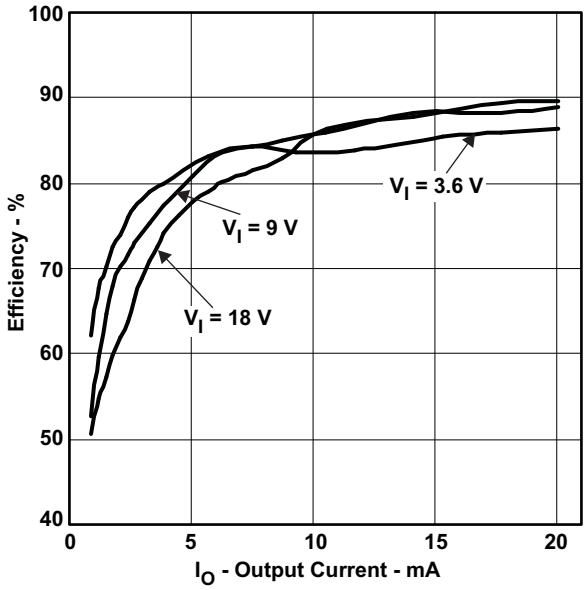


Figure 3. TPS61161 Efficiency vs Output Current

3 Board Layout

This section provides the TPS6116xEVM-243 board layout and illustrations.

Board layout is critical for all high-frequency, switch-mode power supplies. Figure 4 through Figure 4 show the board layout for the TPS6116xEVM-243 printed circuit board (PCB). The nodes with high-switching frequencies and currents are kept as short as possible to minimize trace inductance. Careful attention Was given to the routing of high-frequency current loops: a single-point grounding scheme is used. See the data sheet for specific layout guidelines.

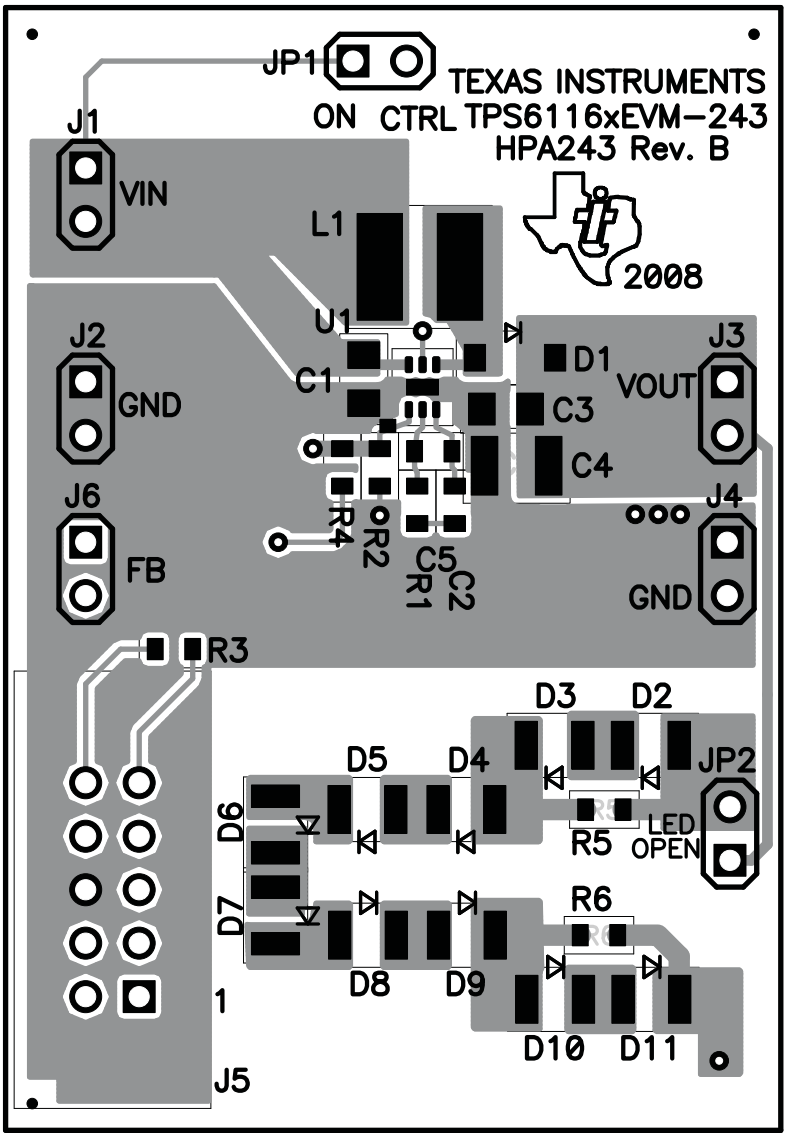


Figure 4. Assembly Layer

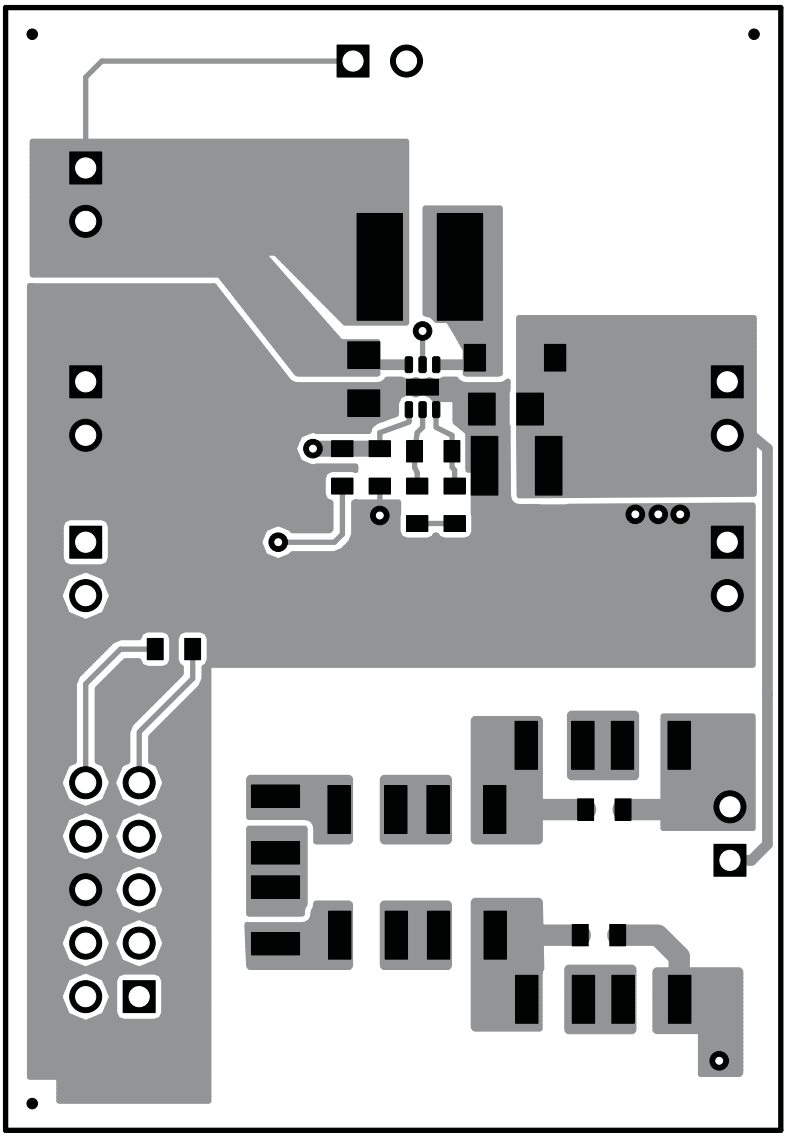
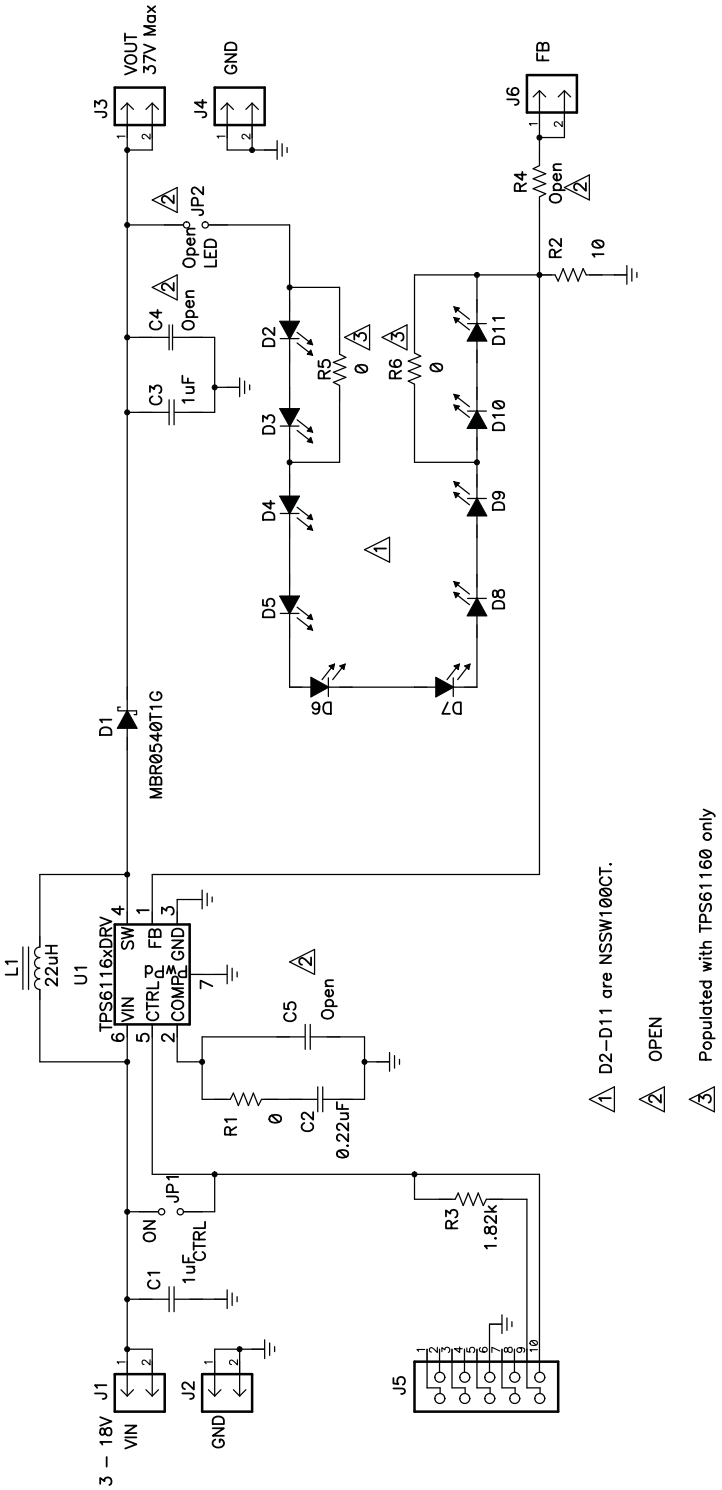


Figure 5. Bottom Layer

4 Schematics and Bill of Materials

This section provides the TPS6116xEVM-243 schematic and bill of materials.

4.1 TPS6116xEVM-243 Schematic



4.2 Bill of Materials

Table 2. HPA243 Bill of Materials

Version		RefDes	Value	Description	Size	Part Number	MFR
61	60						
1	1	C1	1µF	Capacitor, Ceramic, 25V, X5R, 10%	0805	Std	Std
1	1	C2	0.22µF	Capacitor, Ceramic, 10V, X5R, 10%	0603	C1608X5R1A224K	TDK
1	1	C3	1µF	Capacitor, Ceramic, 50V, X7R, 10%	0805	GRM21BR71H474KA88L	Murata
0	0	C4	Open	Capacitor, Ceramic	1812	Std	Std
0	0	C5	Open	Capacitor, Ceramic	0603	Std	Std
1	1	D1	MBR0540T1G	Diode, Schottky, 0.5A, 40V	SOD-123	MBR0540T1G	On Semi
4	0	D2, D3, D10, D11	NSSW100CT	Diode. LED, White	0.079 x 0.118 inch	NSSW100CT	Nichia
6	6	D4–D9	NSSW100CT	Diode. LED, White	0.079 x 0.118 inch	NSSW100CT	Nichia
5	5	J1–J4, J6	PTC36SAAN	Header, 2 pin, 100mil spacing, (36-pin strip)	0.100 inch x 2	PTC36SAAN	Sullins
1	1	J5	2510-6002UB	Connector, Male Straight 2x5 pin, 100mil spacing, 4 Wall	0.338 x 0.788 inch	2510-6002UB	3M
2	2	JP1, JP2	PTC36SAAN	Header, 2 pin, 100mil spacing, (36-pin strip)	0.100 inch x 2	PTC36SAAN	Sullins
1	1	L1	22µH	Inductor, SMT, 0.58A, 311mΩ	0.157 x 0.157 inch	VLCF5020T-220MR75-1	TDK
1	1	R1	0	Resistor, Chip, 1/16W, 5%	0603	Std	Std
1	1	R2	10	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	1	R3	1.82k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
0	0	R4	Open	Resistor, Chip, 1/16W, 1%	0603	Std	Std
0	2	R5, R6	0	Resistor, Chip, 1/16W, 5%	0603	Std	Std
0	1	U1	TPS61160DRV	IC, 1200 kHz/0.7A PWM/38V OVP	SON-6	TPS61160DRV	TI
1	0	U1	TPS61161DRV	IC, 1200 kHz/0.7A PWM/26V OVP	SON-6	TPS61161DRV	TI
1	1	–		PCB, 2.1 In x 1.43 In x 0.062 In		HPA243	Any
2	2	–		Shunt, 100 mil, Black	0.1	929950-00	

4.3 Related Documentation From Texas Instruments

TPS61160, TPS61161, White LED Driver With Digital and PWM Brightness Control in 2mm x 2mm QFN Package for up to 10 LEDs in Series data sheet (SLVS791)

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.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used. TI currently deals with a variety of customers for products, and therefore our arrangement with the user is not exclusive. TI assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.

REGULATORY COMPLIANCE INFORMATION

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 this Product 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

【ご使用にあたっての注】

本開発キットは技術基準適合証明を受けておりません。

本製品のご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。

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. 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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

IMPORTANT NOTICE

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

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

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

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

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

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

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

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

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

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

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

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265