

TPS61165EVM-283

This user's guide describes the characteristics, operation, and use of the TPS61165EVM-283 evaluation module (EVM). This EVM contains the Texas Instruments TPS61165 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.

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1 Introduction

The Texas Instruments TPS61165EVM-283 evaluation module contains a TPS61165 IC, supporting active and passive components and three white light-emitting diodes (WLEDs) in series. The goal of this EVM is to facilitate evaluation of the TPS61165 in a typical WLED application.

1.1 Performance Specification Summary

[Table 1](#) provides a summary of the TPS61165EVM-283 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		4.5	5	5.5	V
V _{OUT}	CTRL=VIN, JP2 shorted		9.5		V
	CTRL=VIN, JP2 open	37	38	39	V
I _{OUT}	CTRL=VIN, JP2 shorted	347	357	368	mA

The EVM was designed and tested for an input voltage of 5 V +/-10%. Lower input voltages may result in the part entering current limit and therefore not providing the regulated current in the specification table. Input voltages greater than the drop across the sum of D2-D4 but less than the 18-V maximum do not damage the IC but cause the IC to stop switching and regulating current. At this time, the input voltage, less the drop across D1, is applied across D2-D4, setting the current to that as shown in [Equation 1](#).

$$I_{LED} = \frac{[V_{IN} - (V_{D1} + V_{D2} + V_{D3} + V_{D4})]}{R2} \quad (1)$$

Currents higher than the LEDs' 500-mA maximum rating can damage the LEDs.

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 would likely occupy less total board space.

The inductor and compensation components (R1, C2) were designed for the VIN range 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. Therefore, the TPS61165 IC may be replaced on the TPS61165EVM-283 PCB with either the TPS61160 or TPS61161.

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.

EasyScale is a trademark of Texas Instruments.

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2.1.1 J1-VIN

This header is the positive connection to the input power supply. The leads to the input supply should be twisted and kept 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 output for the device.

2.1.4 J4-FB

This header connects to the IC's FB pin through resistor R4. The EVM does not have resistor R4 populated.

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-GND

This header is the return connection for the load.

2.1.7 JP1-ENable

Installing this jumper ties the EN pin to V_{IN} , thereby enabling the device. Removing the jumper allows the internal pulldown resistor to pull EN to ground, thereby disabling the device. The shorting jumper must be removed when using EasyScale™ control.

2.1.8 JP2-Open LED

Installing this jumper places the WLEDs in the boost converter's 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 IC's overvoltage protection circuit clamps the boost converter output to 38 V (typ).

WARNING

This EVM has a white LED that shines 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 5 V at 1.5 A.

In order 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 IC's FB pin, 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 can also implement dimming using a digital control signal. The EVM kit includes a PC software CD and USB-TO-GPIO interface box which, when installed on a 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.
- Ensure that JP2 is installed.
- Remove the shorting jumper from JP1, and 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.

In order 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 TPS61165EVM using the supplied 10-pin ribbon cable per [Figure 1](#). 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.
- Ensure that JP2's jumper is installed.
- Run the software as explained in the following section.

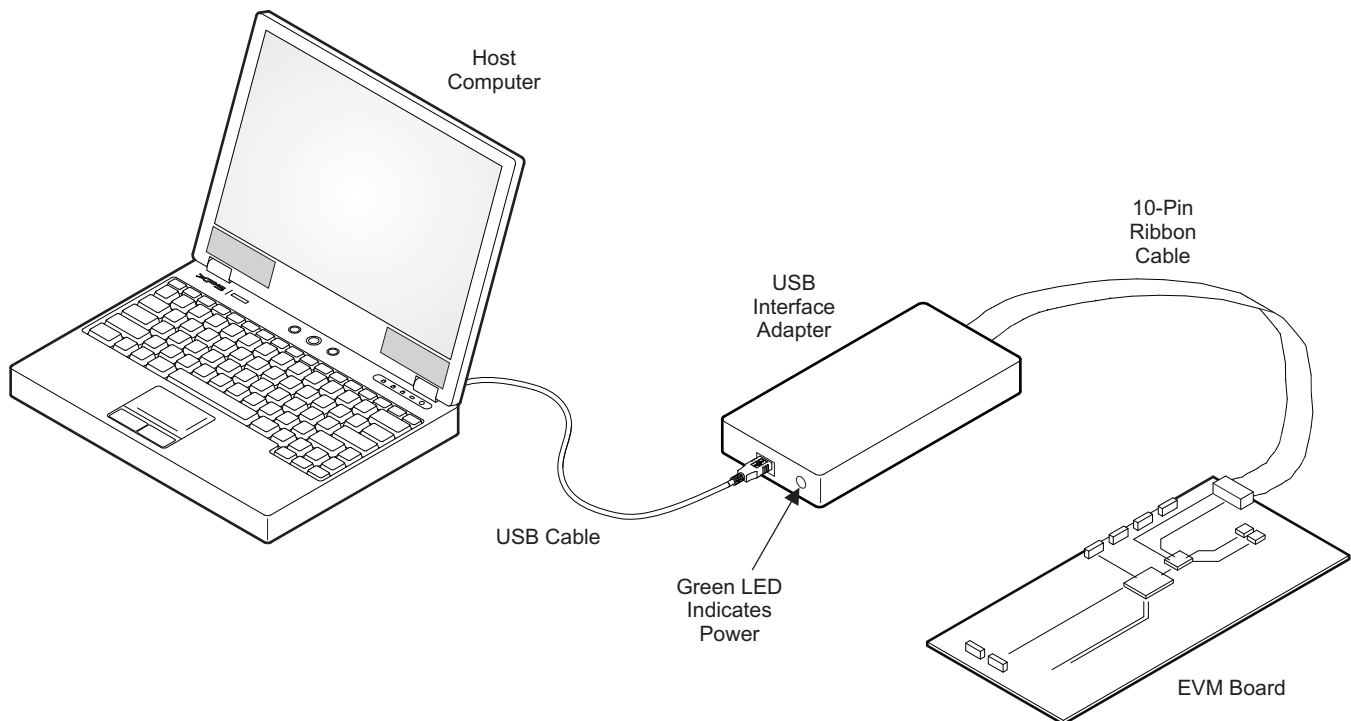


Figure 1. USB Interface Adapter Quick Connection Diagram

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, 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 install 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 no longer attempts to run.

The TPS6116x IC has a 5-bit register that stores the feedback voltage to which the error amplifier regulates 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, press the WRITE button. See a screen shot of the software in [Figure 2](#).

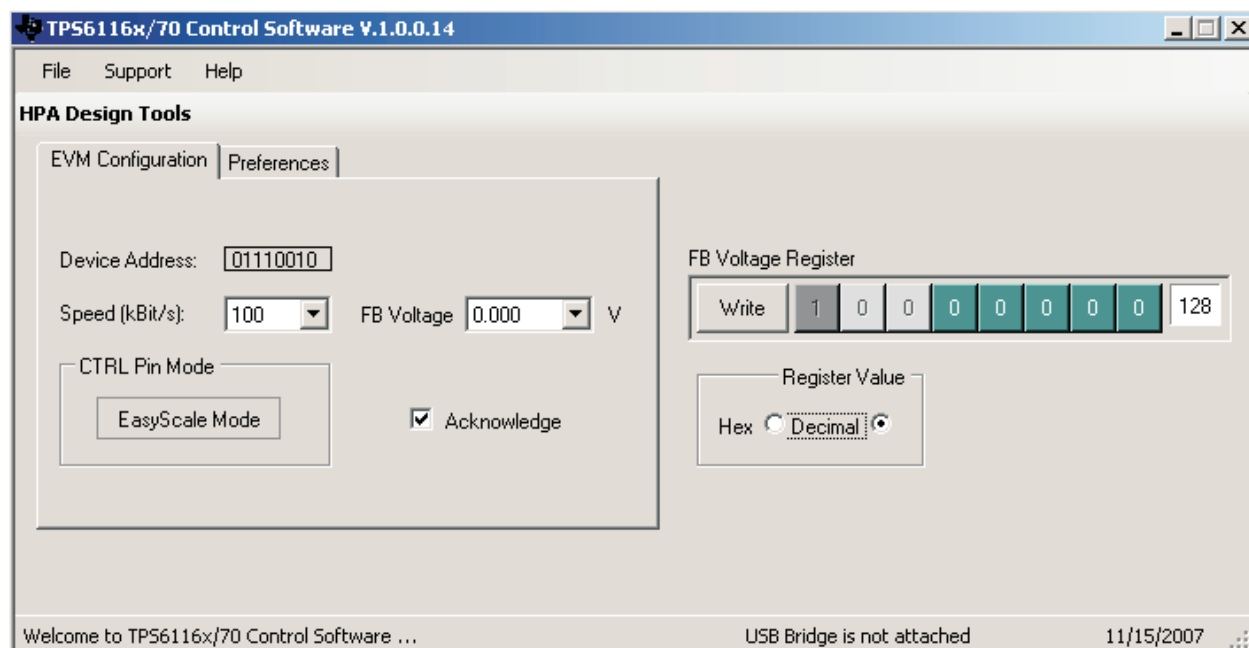


Figure 2. Screen Capture of TPS6116x Controller Software GUI Interface

2.5 Test Results

This section provides typical performance characteristics for the TPS61165EVM-283 board.

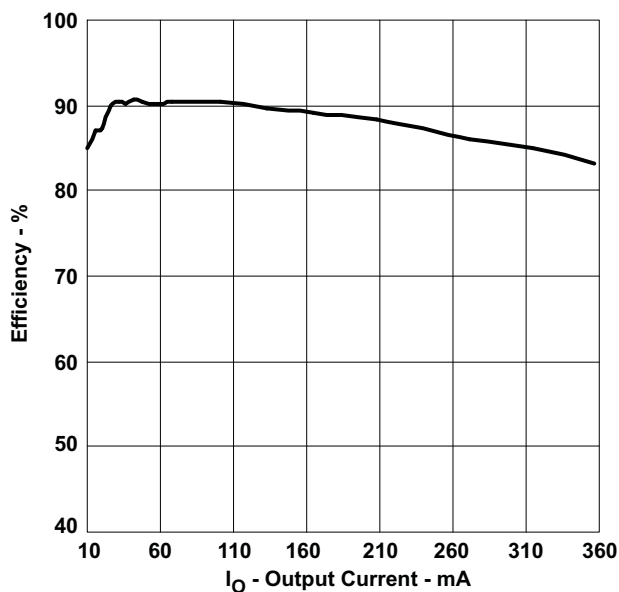


Figure 3. LED Efficiency vs Output Current

3 Board Layout

This section provides the TPS61165EVM-283 board layout and illustrations.

Board layout is critical for all high-frequency, switch-mode power supplies. Figure 4 through Figure 6 show the board layout for the TPS61165EVM-283 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 and a single-point grounding scheme is used. See the data sheet for specific layout guidelines.

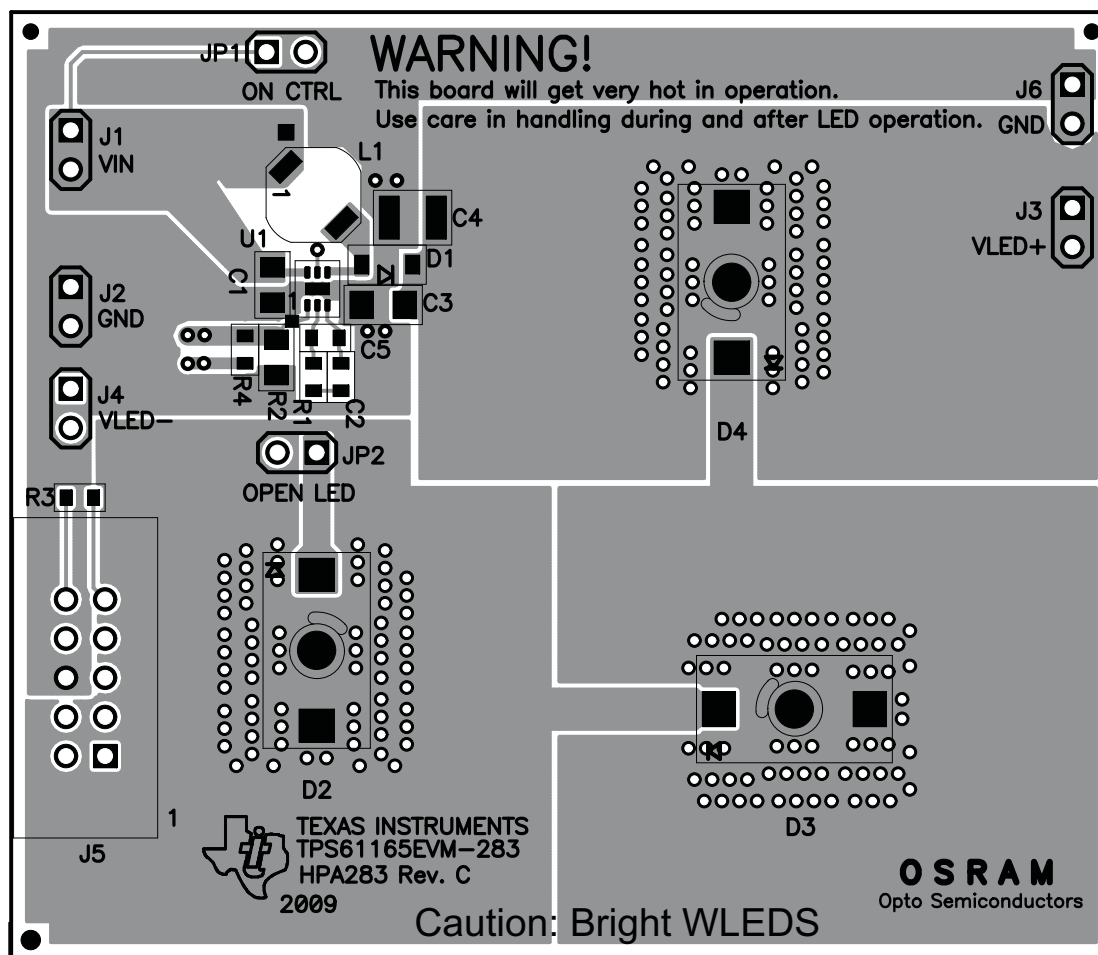


Figure 4. Assembly Layer

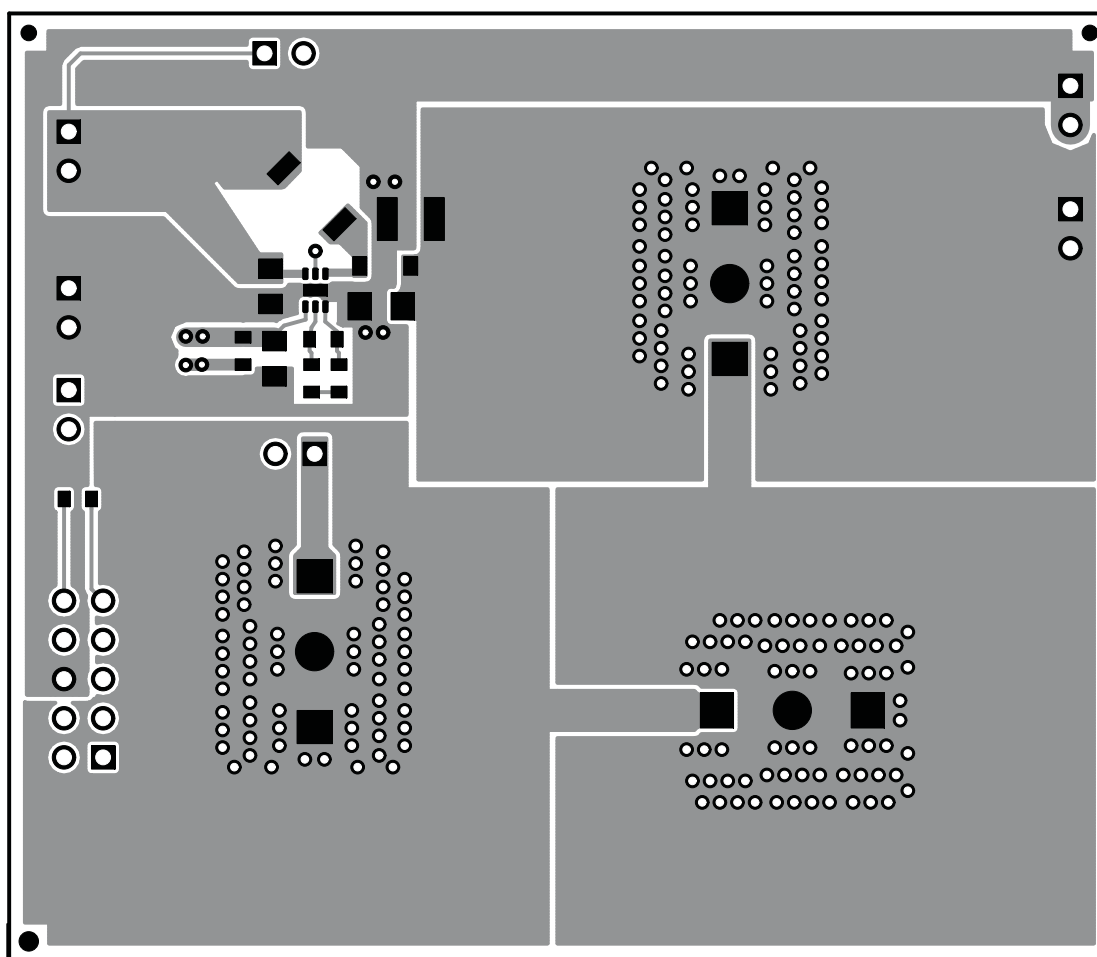


Figure 5. Top-Side Layer

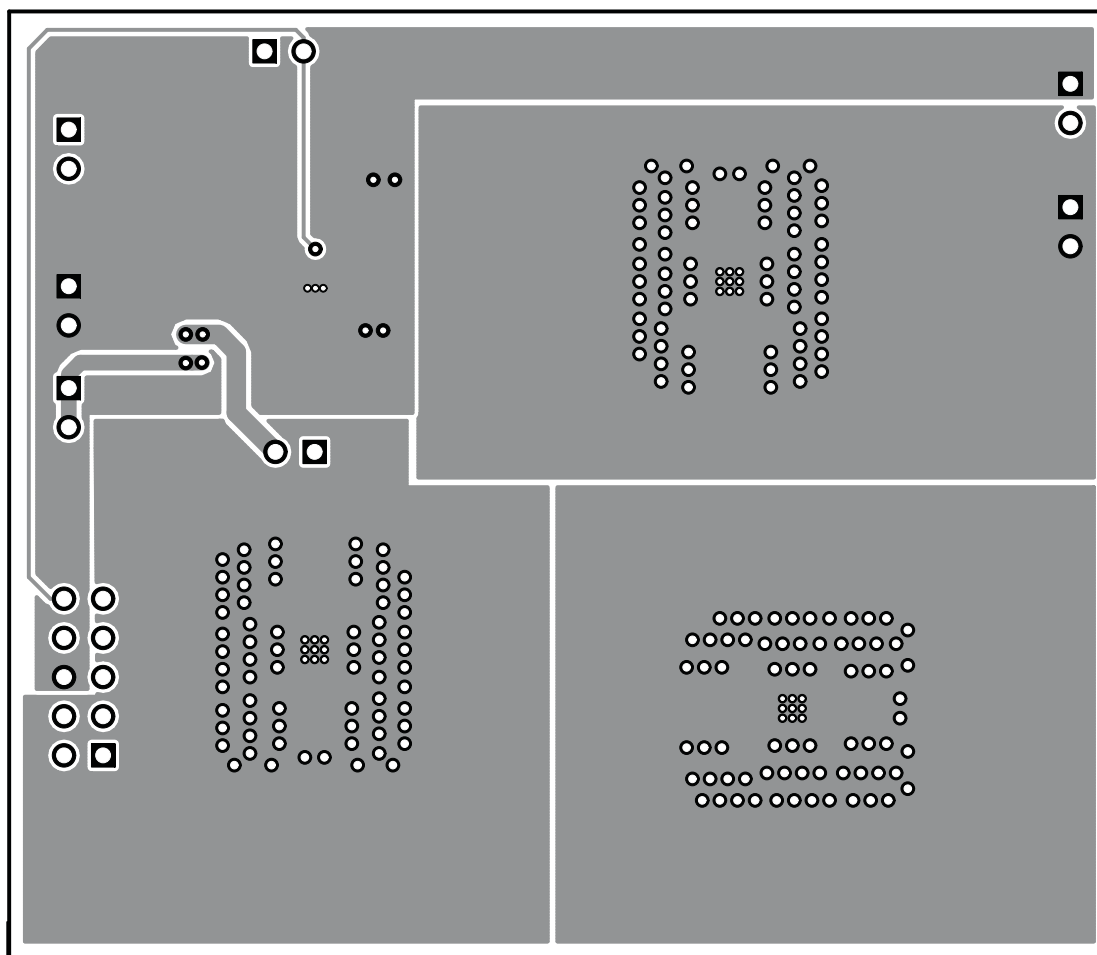
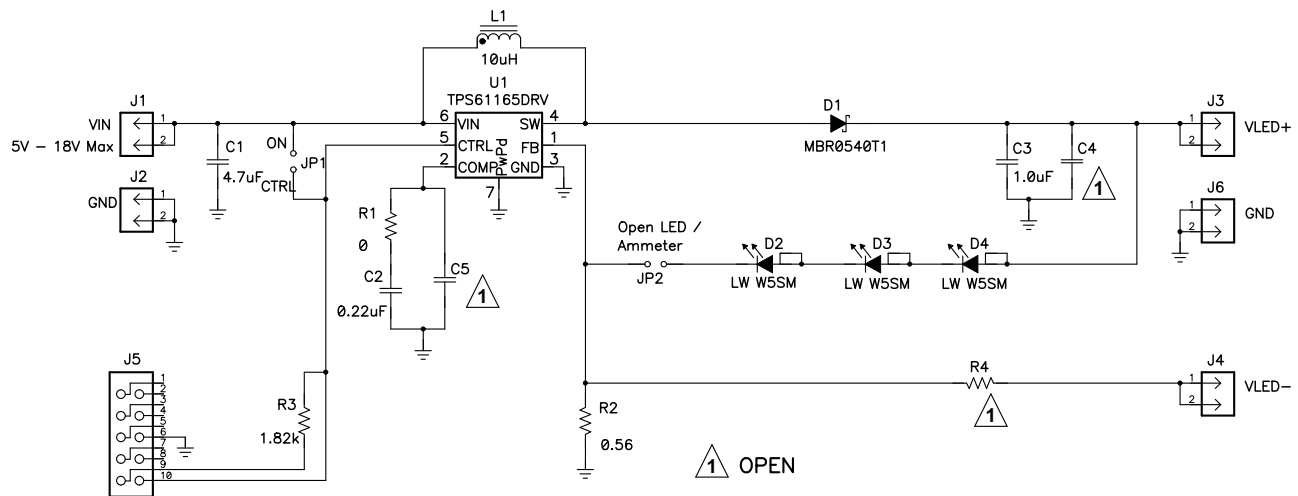


Figure 6. Bottom-Side Layer

4 Schematics and Bill of Materials

This section provides the TPS61165EVM-283 schematic and bill of materials. The EVM was designed and tested assuming the input voltage is 5 V $\pm 10\%$. Lower input voltages may result in the part entering current limit and therefore not providing the regulated current in the specification table. Input voltages greater than the drop across the sum of D2-D4 but less than the 18-V maximum does not damage the IC but causes the IC to stop switching and regulating current. At this time, the input voltage, less the drop across D1, is applied across D2-D4, potentially damaging the diodes.

4.1 TPS61165EVM-283 Schematic



4.2 Bill of Materials

Table 2. HPA283 Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
1	C1	4.7 μF	Capacitor, Ceramic, 25V, X5R, 10%	0805	TMK212BJ475KG-T	Taiyo Yuden
1	C2	0.22 μF	Capacitor, Ceramic, 10V, X5R, 10%	0603	C1608X5R1A224K	TDK
1	C3	1.0 μF	Capacitor, Ceramic, 50V, X7R, 10%	1206	C3216X7R1H105K	TDK
0	C4	Open	Capacitor, Ceramic	1210	Std	Vishay
0	C5	Open	Capacitor, Ceramic	0603	Std	Vishay
1	D1	MBR0540T1	Diode, Schottky, 500-mA, 40-V	SOD123	MBR0540T1	OnSemi
3	D2, D3, D4	LW W5SM-HYJZ-5K8L-Z LW W5SM-JXJY-5K8L-Z LW W5SM-JXJZ-5K8L-Z (see Note 5)	Diode, LED White, 500-mA, 17000-mcd	0.244 × 0.441 inch	LW W5SM-HYJZ-5K8L-Z LW W5SM-JXJY-5K8L-Z LW W5SM-JXJZ-5K8L-Z (see Note 5)	Osram
5	J1, J2, J3, J4, J6	PEC02SAAN	Header, 2 pin, 100mil spacing	0.100 inch x 2	PEC02SAAN	Sullins
1	J5	2510-6002UB	Connector, Male Straight 2×5 pin, 100mil spacing, 4 Wall	0.338 × 0.788 inch	2510-6002UB	3M
2	JP1, JP2	PEC02SAAN	Header, 2 pin, 100mil spacing	0.100 inch × 2	PEC02SAAN	Sullins
1	L1	10 μH	Inductor, 67 mΩ, ±20%	0.205 x 0.205 inch	A915AY-100M	Toko
1	R1	0	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R2	0.56	Resistor, Chip, 1/8W, 1%	0805	Std	Std
1	R3	1.82k	Resistor, Chip, 1/16W, 1%	0603		
0	R4	Open	Resistor, Chip, 1/16W, 1%	0603		
1	U1	TPS61165DRV	IC, 1200KHz/1.2A PWM	SON-6	TPS61165DRV	TI
1	—		PCB, 2.42 In × 2.81 In × 0.062 In		HPA283	Any
2	—		Shunt, 100 mil, Black	0.100	929950-00	3M

- Notes: 1. These assemblies are ESD sensitive, ESD precautions shall be observed.
2. These assemblies must be clean and free from flux and all contaminants. Failure to use clean flux is unacceptable.
3. These assemblies must comply with workmanship standards IPC-A-610 Class 2.
4. Reference designators marked with an asterisk (***) cannot be substituted. All other components can be substituted with equivalent MFG's components.
5. D2, D3, D4 can be any LW W5SM. The last eight characters of the orderable number are don't cares.

4.3 **Related Documentation From Texas Instruments**

TPS61165, High Brightness White LED Driver in 2mm x 2mm QFN Package data sheet ([SLVS790](#))

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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.

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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.

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