

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.

Contents

1	Introduction	2
2	Setup and Test Results	2
3	Board Layout	7
4	Schematics and Bill of Materials	9

List of Figures

1	USB Interface Adapter Quick Connection Diagram	4
2	Screen Capture of TPS6116x Controller Software GUI Interface	6
3	LED Efficiency vs Output Current.....	6
4	Assembly Layer	7
5	Top-Side Layer	8
6	Bottom-Side Layer	9

List of Tables

1	Typical Performance Specification Summary	2
2	HPA283 Bill of Materials.....	10

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.

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-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 IC's FB pin through resistor R4. The EVM does not have resistor R4 populated.

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 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 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 V_{IN} 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.

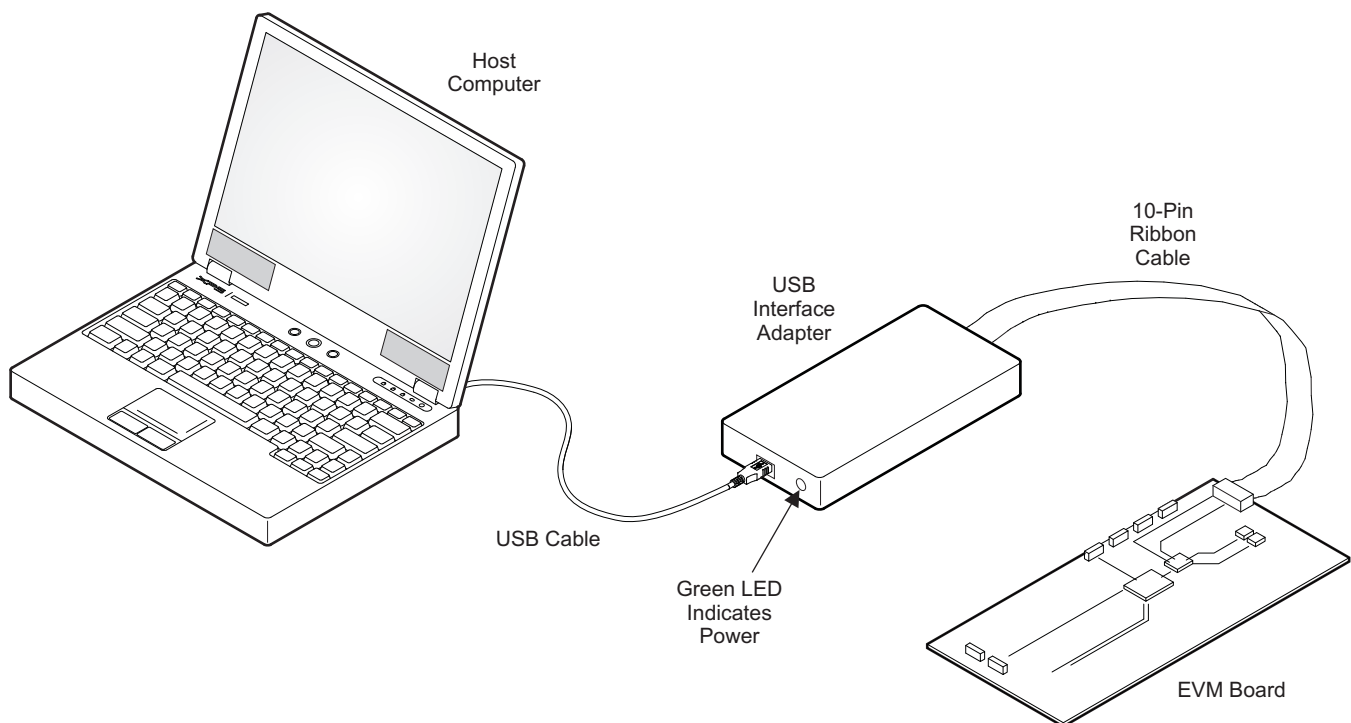


Figure 1. USB Interface Adapter Quick Connection Diagram

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.

If installing from the TI Web site, go to the URL,
<http://focus.ti.com/docs/toolsw/folders/print/tps6116xevm-sw.html>.

NOTE: This installation page is best viewed with 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](#).

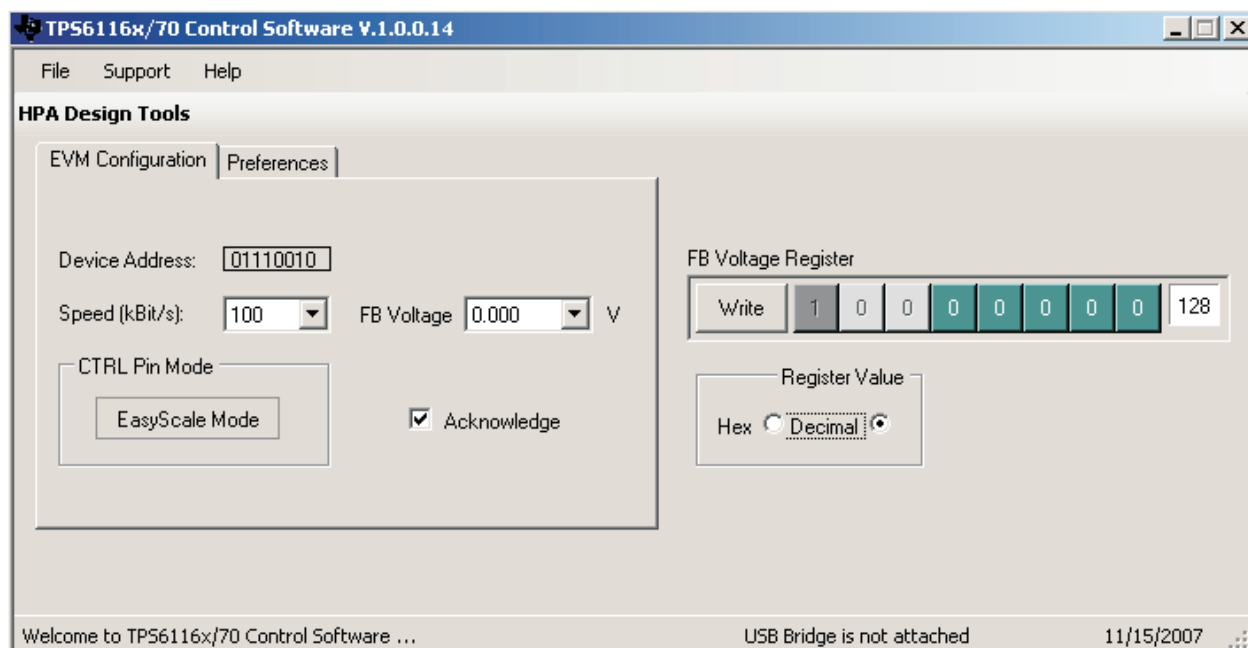


Figure 2. Screen Capture of TPS6116x Controller Software GUI Interface

2.5 Test Results

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

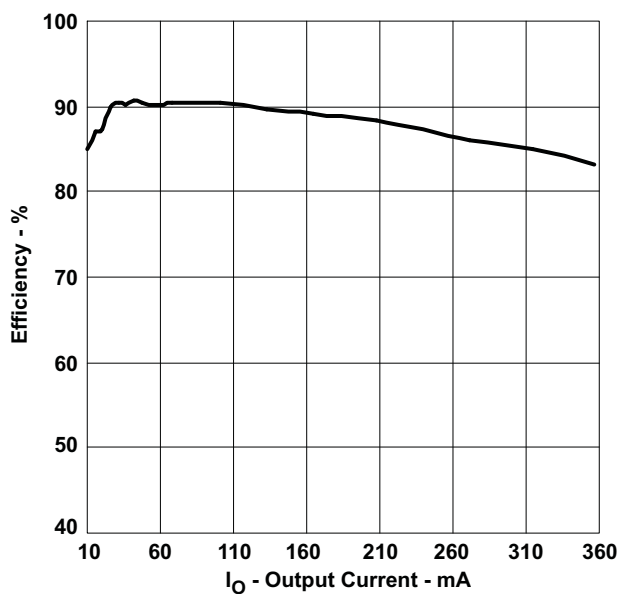


Figure 3. LED Efficiency vs Output Current

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.

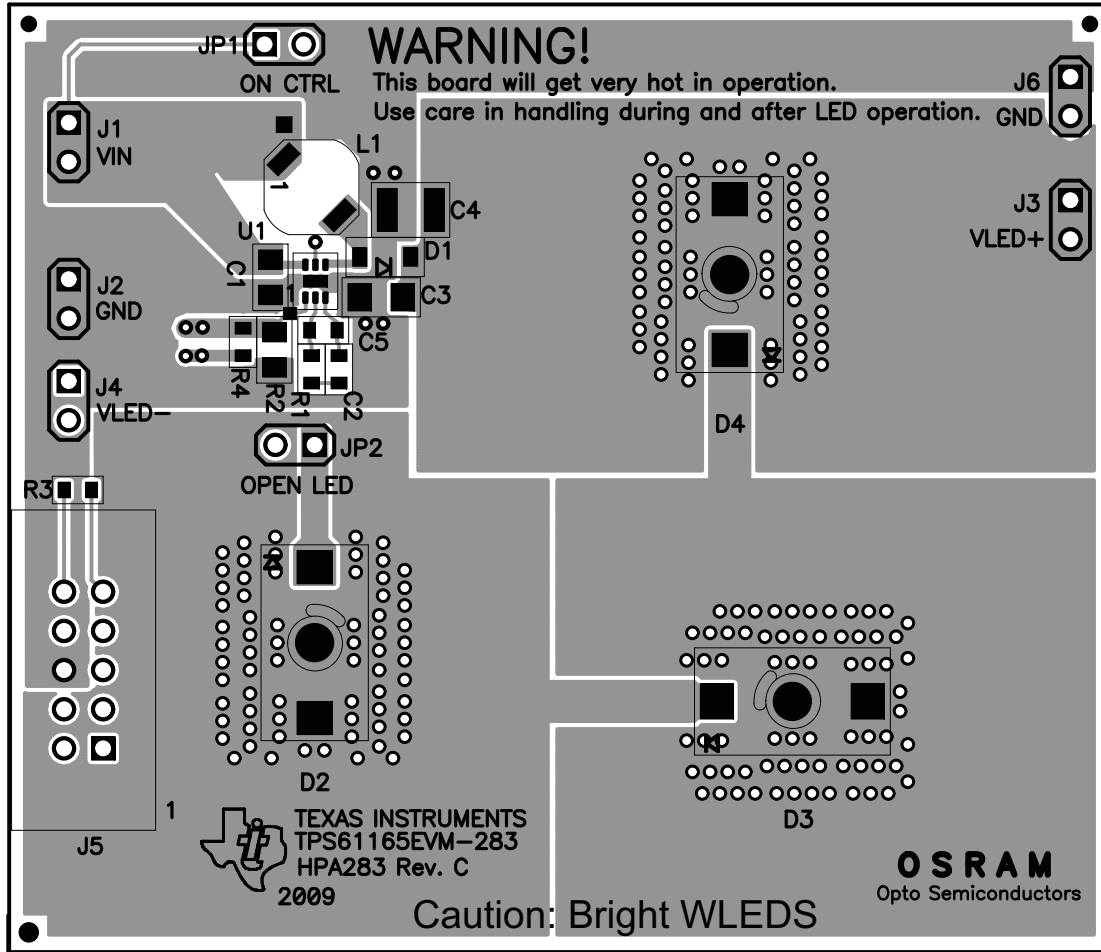


Figure 4. Assembly Layer

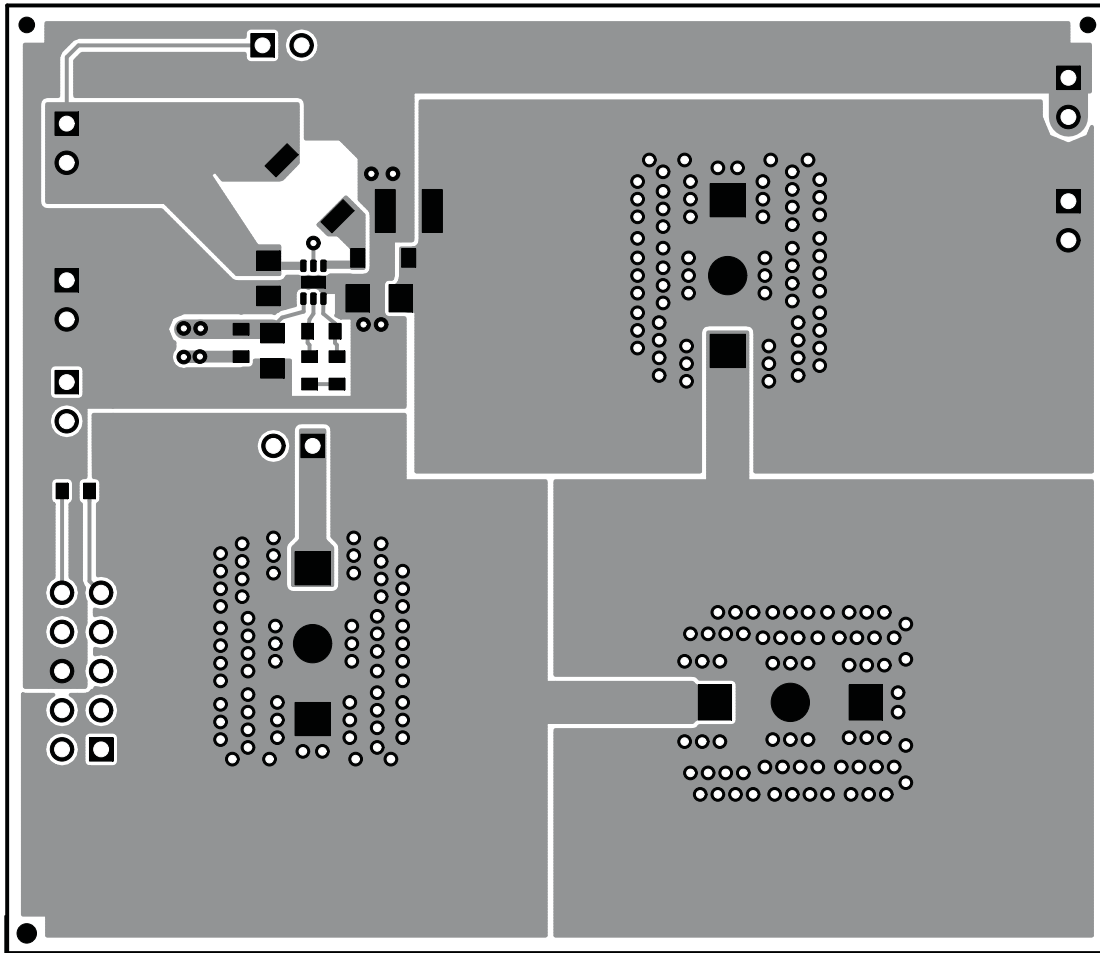


Figure 5. Top-Side Layer

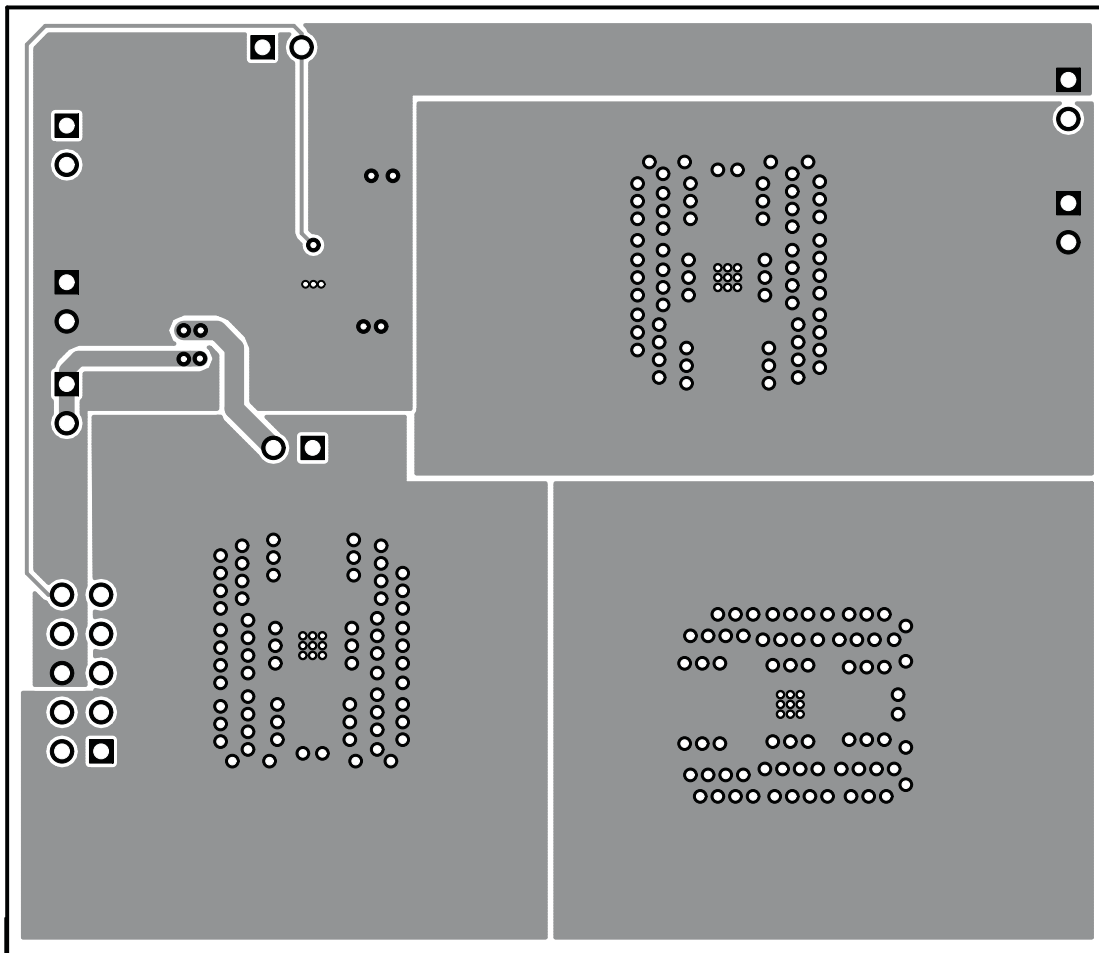
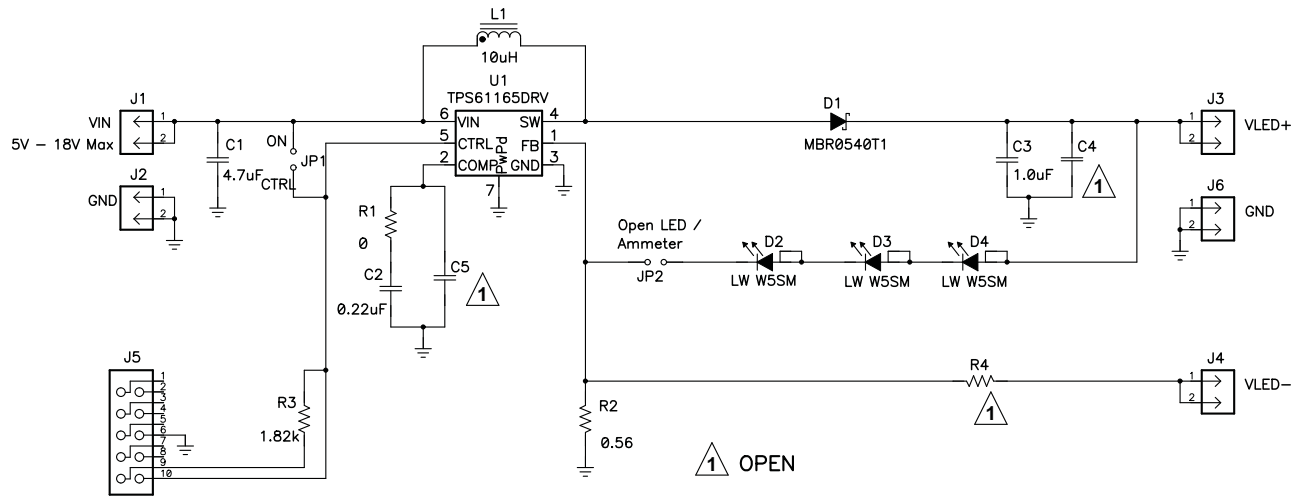


Figure 6. Bottom-Side Layer

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 $5\text{ V} \pm 10\%$. 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 μ F	Capacitor, Ceramic, 25V, X5R, 10%	0805	TMK212BJ475KG-T	Taiyo Yuden
1	C2	0.22 μ F	Capacitor, Ceramic, 10V, X5R, 10%	0603	C1608X5R1A224K	TDK
1	C3	1.0 μ F	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 x 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 2x5 pin, 100mil spacing, 4 Wall	0.338 x 0.788 inch	2510-6002UB	3M
2	JP1, JP2	PEC02SAAN	Header, 2 pin, 100mil spacing	0.100 inch x 2	PEC02SAAN	Sullins
1	L1	10 μ H	Inductor, 67 m Ω , \pm 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 x 2.81 In x 0.062 In		HPA283	Any
2	—		Shunt, 100 mil, Black	0.100	929950-00	3M

- Notes:
- These assemblies are ESD sensitive, ESD precautions shall be observed.
 - These assemblies must be clean and free from flux and all contaminants. Failure to use clean flux is unacceptable.
 - These assemblies must comply with workmanship standards IPC-A-610 Class 2.
 - Reference designators marked with an asterisk (***) cannot be substituted. All other components can be substituted with equivalent MFG's components.
 - 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](#))

EVALUATION BOARD/KIT IMPORTANT NOTICE

Texas Instruments (TI) provides the enclosed product(s) under the following conditions:

This evaluation board/kit 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. Persons handling the product(s) must have electronics training and observe good engineering practice standards. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives or other related directives.

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 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.**

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. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

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.

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.**

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 contact the TI application engineer or visit www.ti.com/esh.

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.

FCC Warning

This evaluation board/kit 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 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 his own expense will be required to take whatever measures may be required to correct this interference.

EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 3 V to 18 V and the output voltage range of V_{in} to 39 V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. 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 85°C. The EVM is designed to operate properly with certain components above 85°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2008-2009, Texas Instruments Incorporated

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

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

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI 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 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. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

TI products are not authorized for 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, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
RF/IF and ZigBee® Solutions	www.ti.com/lprf

Applications

Audio	www.ti.com/audio
Automotive	www.ti.com/automotive
Broadband	www.ti.com/broadband
Digital Control	www.ti.com/digitalcontrol
Medical	www.ti.com/medical
Military	www.ti.com/military
Optical Networking	www.ti.com/opticalnetwork
Security	www.ti.com/security
Telephony	www.ti.com/telephony
Video & Imaging	www.ti.com/video
Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2009, Texas Instruments Incorporated