Using the TPS92001EVM-645

User's Guide

Literature Number: SLUU510
August 2011

Non-Dimmable LED Lighting Driver Controller

1 Introduction

The TPS92001EVM-645 evaluation module is a constant-current, non-dimmable LED driver. It is designed to drive 9 LEDs at 330 mA and is rated for an AC input of 105 V_{RMS} to 135 V_{RMS}.

2 Description

The TPS92001/2 family of general LED lighting PWM controllers contains control and drive circuitry required for off-line isolated or non-isolated LED lighting applications. The TPS92001EVM-645 evaluation module uses the TPS92001 as a non-isolated buck controller; more specifically it is an inverting buck topology. The controller operates in fixed-frequency, current-mode switching with minimal external parts count. In LED illumination applications there is typically no need for the LED load to be referenced to ground. This utilizes the inverted buck which moves the controller and FET to the low side of the circuit, referenced to the lowest voltage, while the LED load is floated (referenced to the highest voltage). With an appropriately designed bias regulator for the controller, we can now use a much lower voltage controller which is more economical.

2.1 Typical Applications

- Commercial/Household LED lighting

2.2 Features

- Non-Dimmable, Non-Isolated LED Driver with Minimum External Part Count
- Wide Duty Cycle Range for Wide-Input Voltage
- Convenient 5-V Reference Output
- Test Points for Output Voltage/Current

3 Electrical Performance Specifications

Table 1. TPS92001EVM-645 EVM-001 Electrical Performance Specifications

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Input Characteristics					
Voltage range		105	120	135	V
Maximum input current			115		mA
Output Characteristics					
Output voltage, V_{OUT}		26	30	34	V
Output load current, I_{OUT}		290	330	370	mA
Output current ripple	V_{IN} = 120 V_{AC}		280		mApp
Output over Voltage			36		V
Systems Characteristics					
Switching frequency			133		kHz
Full load efficiency	V_{IN} = 120 V_{AC}		88%		
Power factor			0.87		

Copyright © 2011, Texas Instruments Incorporated

4 Schematic

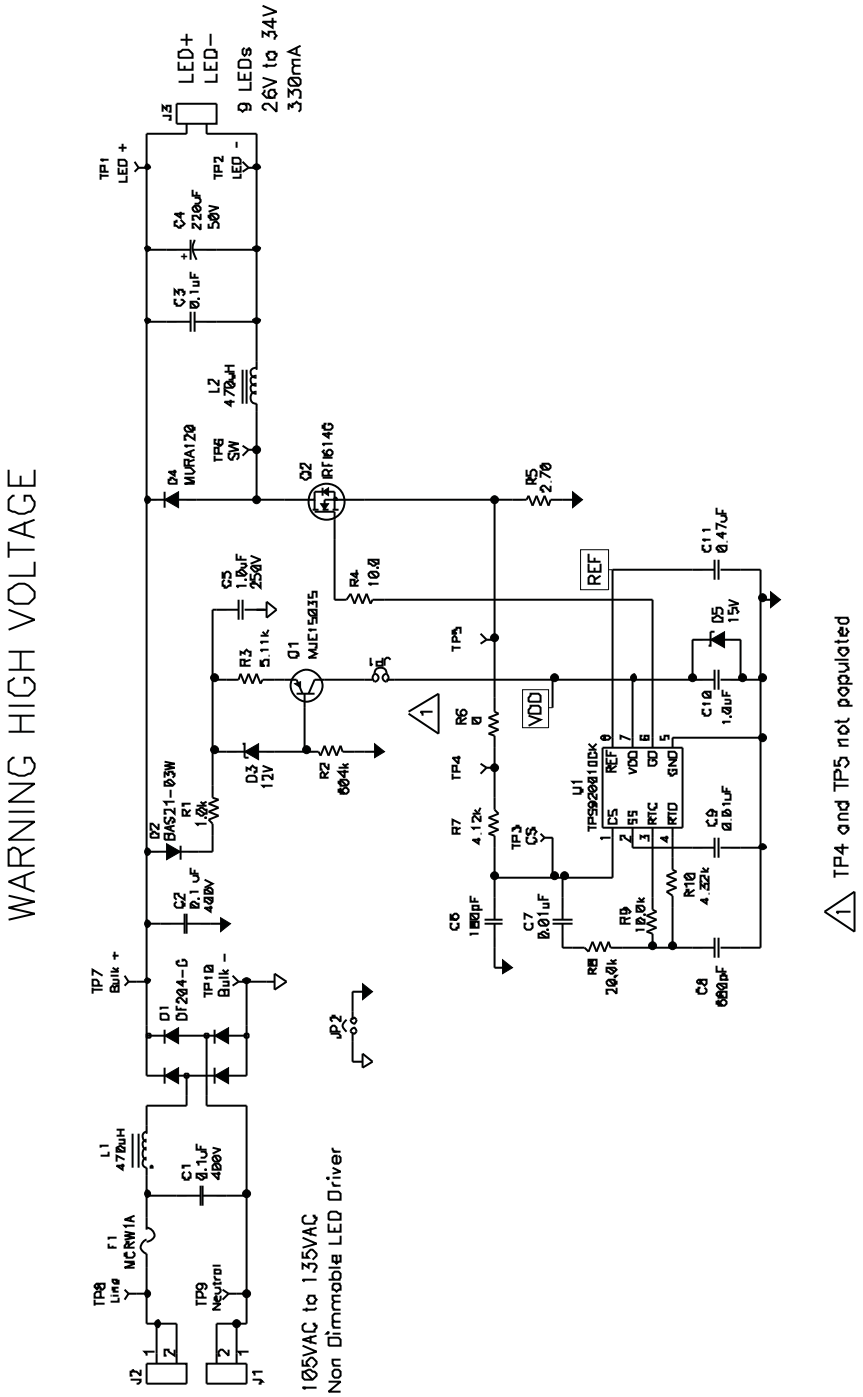


Figure 1. TPS92001EVM-645 Schematic

Copyright © 2011, Texas Instruments Incorporated

5 Test Setup

WARNING

High voltages that may cause injury exist on this evaluation module (EVM). Please ensure all safety procedures are followed when working on this EVM. Never leave a powered EVM unattended. The use of isolated equipment is highly recommended.

5.1 Test Equipment

Voltage Source: 105 V_{RMS} to 135 V_{RMS} isolated AC source capable of at least 20 W.

Multimeters: Two Voltmeters for measuring up to 35 V_{DC} each and two ammeters for up to 1 A each.

Output Load: 9 LEDs in series (V_F = 3.4 V at 350 mA per LED)

Oscilloscope: 4 channel 100 MHz with high voltage probe rated for at least 600 V.

Recommended Wire Gauge: 18 AWG not more than two feet long.

5.2 TPS92001EVM-645 Recommended Test Setup

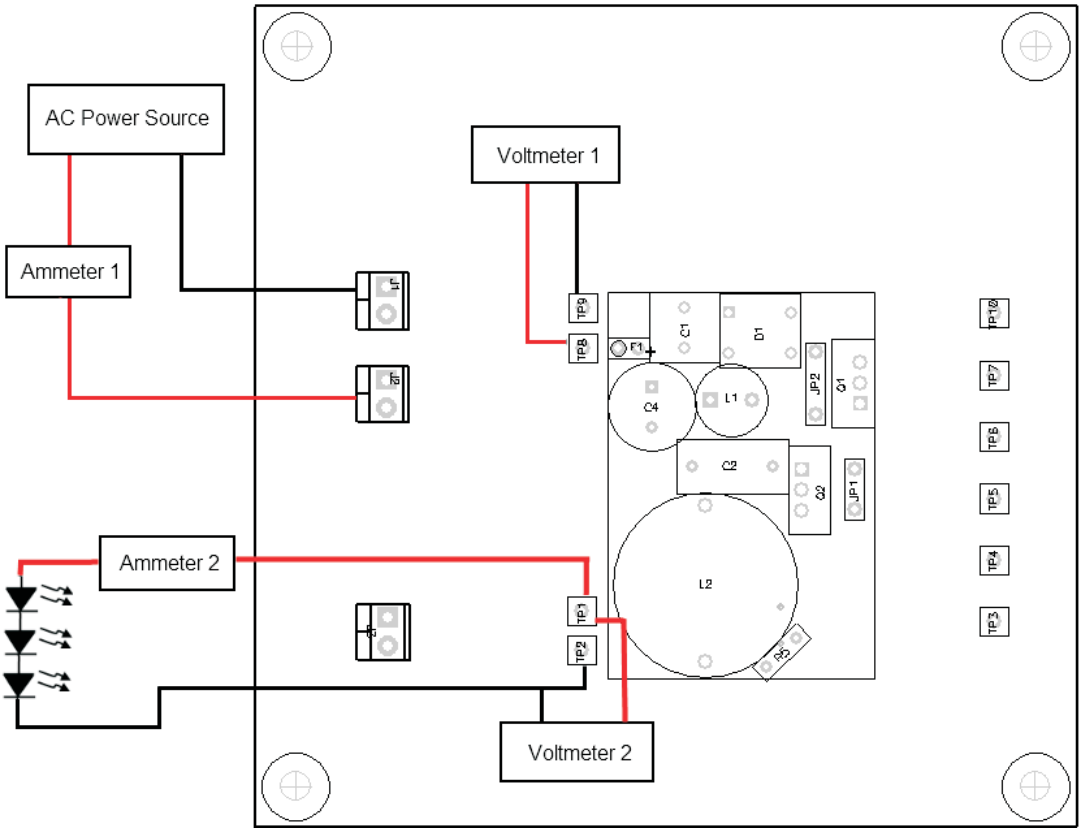


Figure 2. Recommended Test Set Up

Copyright © 2011, Texas Instruments Incorporated

5.3 List of Test Points

Table 2. Test Point Functions

TEST POINTS	NAME	DESCRIPTION
TP1	LED +	LED output
TP2	LED -	LED return point
TP3	CS	Feedback pin of TPS92001
TP6	SW	Buck switch node
TP7	Bulk +	Rectified AC positive input
TP8	Line	AC line input
TP9	Neutral	AC neutral input
TP10	Bulk -	Rectified AC negative input

Copyright © 2011, Texas Instruments Incorporated

6 Test Procedure

All tests should use the set up described in Section 5 of this user guide.

WARNING

High voltage levels are present on this evaluation module whenever it is energized. Proper precautions must be observed whenever working with this module. Serious injury can occur if proper safety procedures are not followed.

6.1 Line/Load Regulation and Efficiency Measurement Procedure

1. Connect EVM per Figure 2 above. An external LED load must be used to start up the EVM.
2. Prior to turning on the AC source, set the voltage to 105 V_{RMS}.
3. Turn on the AC source.
4. Record the output voltage and current readings from Voltmeter 2 and output current reading from Ammeter 2 and input voltage reading from Voltmeter 1 and Ammeter 1.
5. Increase output voltage by 5 V_{RMS}
6. Repeat steps 4 and 5 until you reach 135 V_{RMS}
7. Refer to Section 6.2 for shutdown procedure.

6.2 Equipment Shutdown

1. Turn off the AC source.
2. Make sure that output capacitors are fully discharged.

Copyright © 2011, Texas Instruments Incorporated

7 Performance Data and Typical Characteristic Curves

Figure 3 through 12 present typical performance curves for TPS92001EVM-645.

7.1 Efficiency

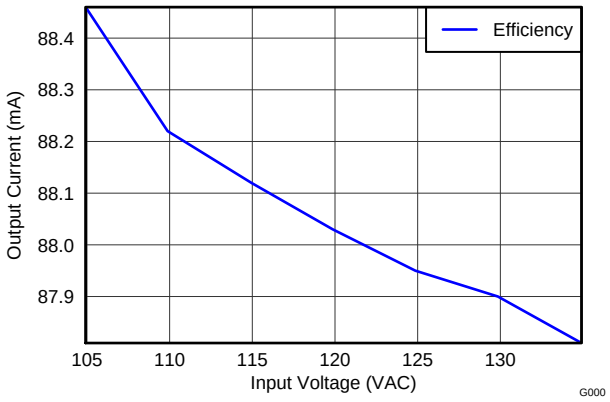


Figure 3. Efficiency

7.2 Input Voltage vs. Power Factor

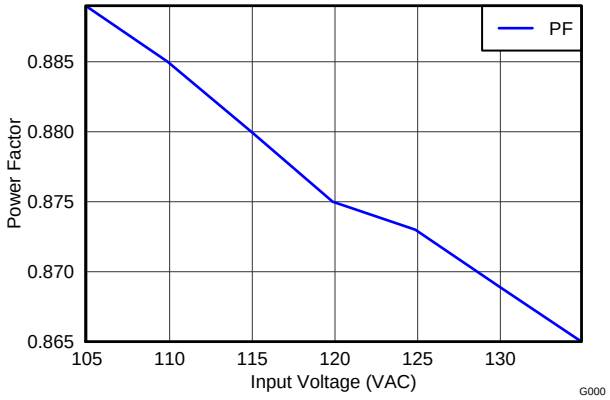


Figure 4. PF Variation

7.3 Input Voltage vs. Output Current

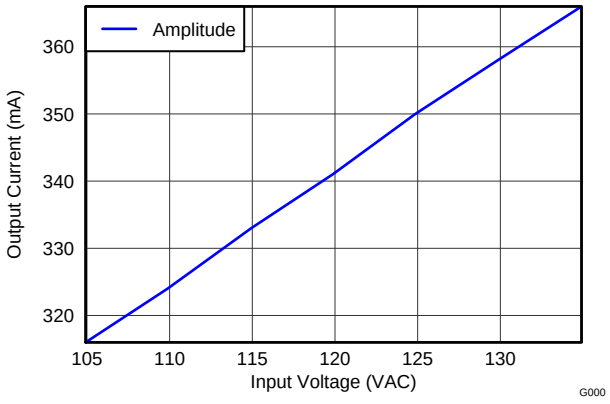


Figure 5. Output Current variation with Respect to Input Voltage

Copyright © 2011, Texas Instruments Incorporated

7.4 Output Ripple

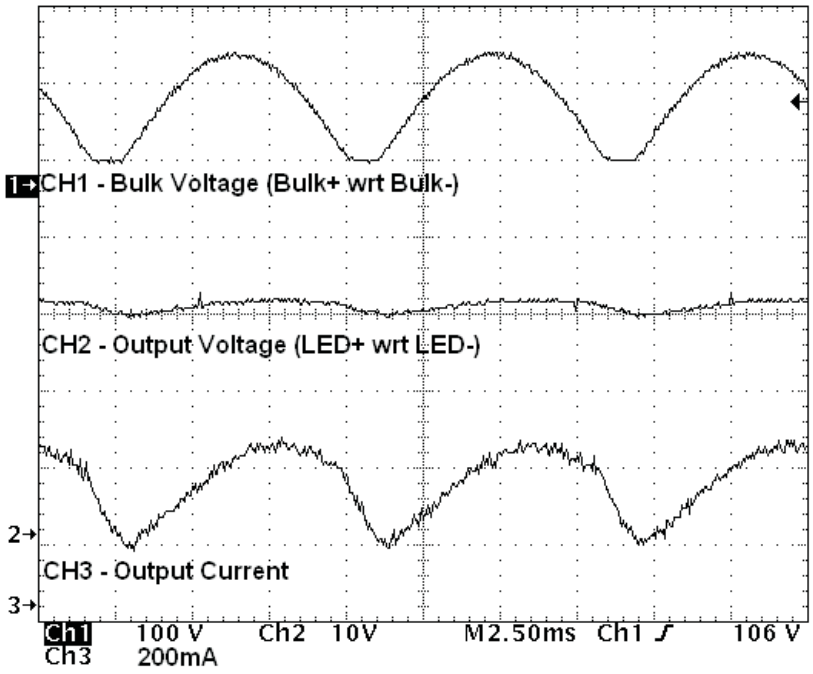


Figure 6. Output Ripple

7.5 Input Waveforms

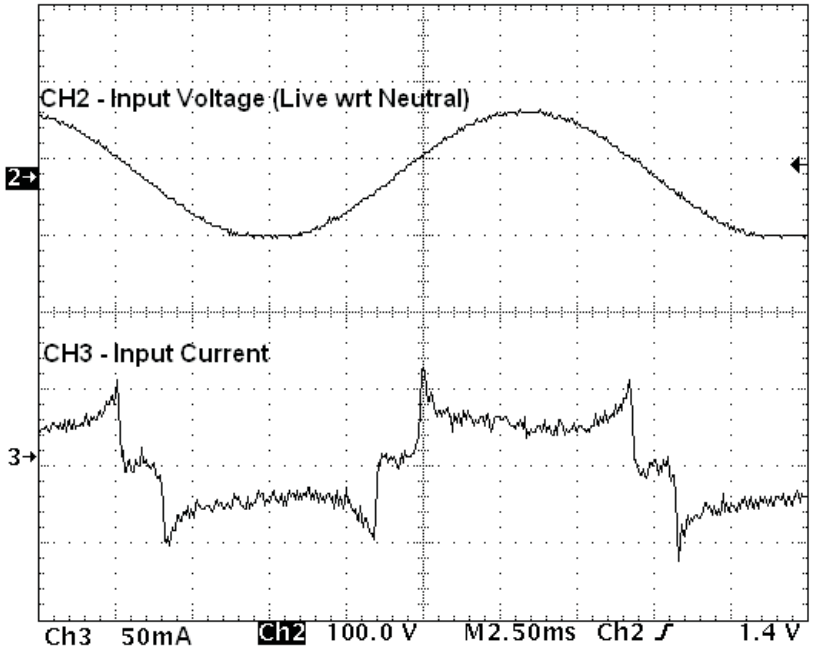


Figure 7. Input Waveform

Copyright © 2011, Texas Instruments Incorporated

7.6 Clock Signal and Switch Node Voltage

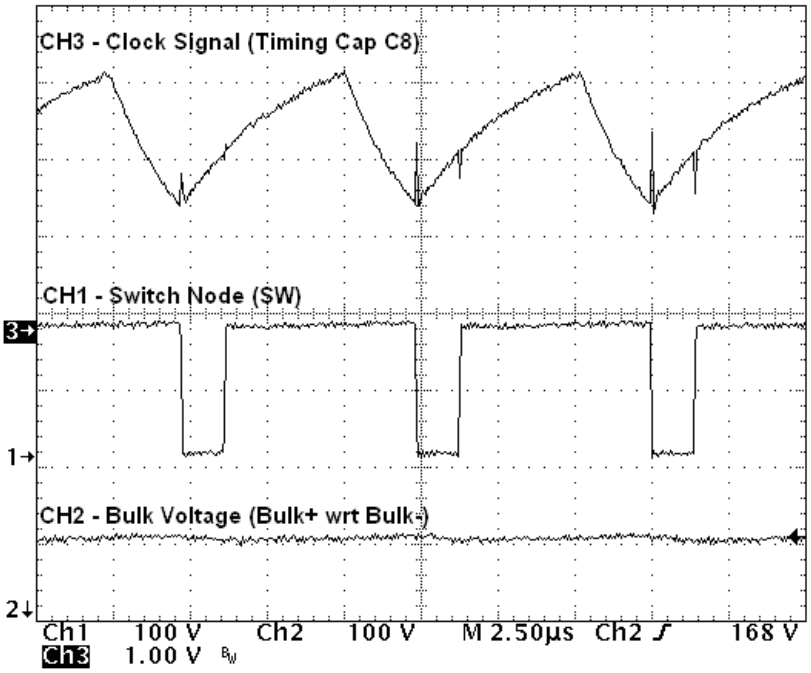


Figure 8. Clock Signal and Switching Node Waveform

7.7 Current Sense

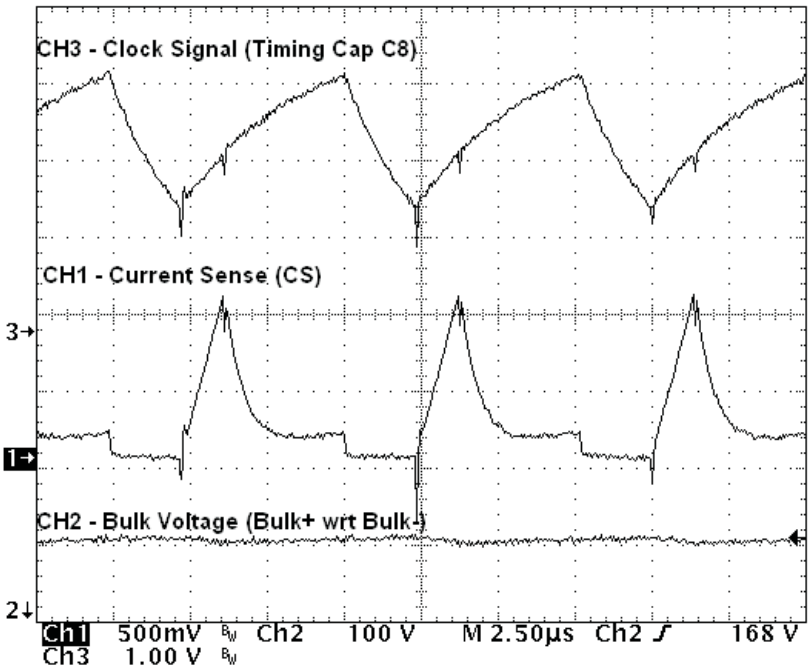


Figure 9. Clock Signal and Current Sense Waveform

Copyright © 2011, Texas Instruments Incorporated

7.8 Turn-On Waveform

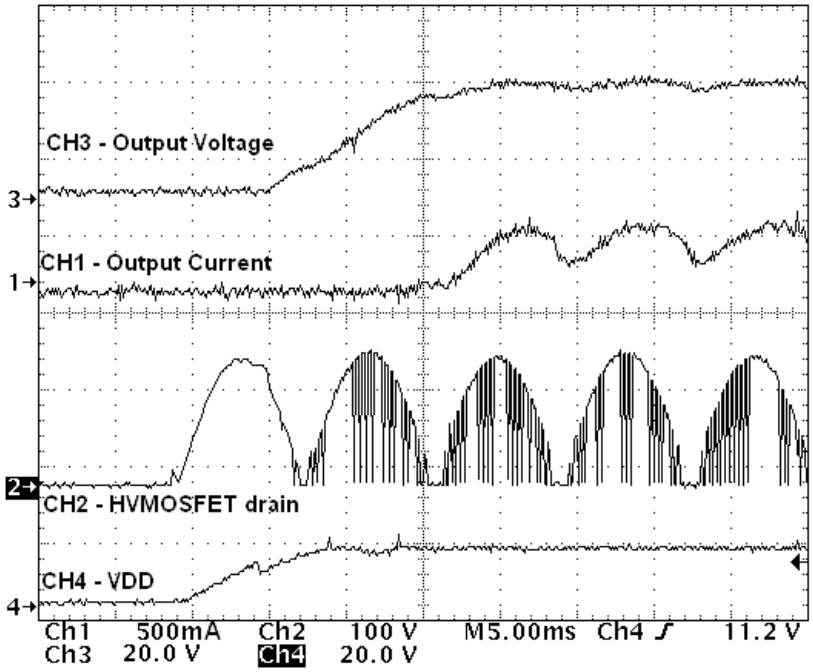


Figure 10. Enable Turn On Waveforms

7.9 Turn-Off Waveform

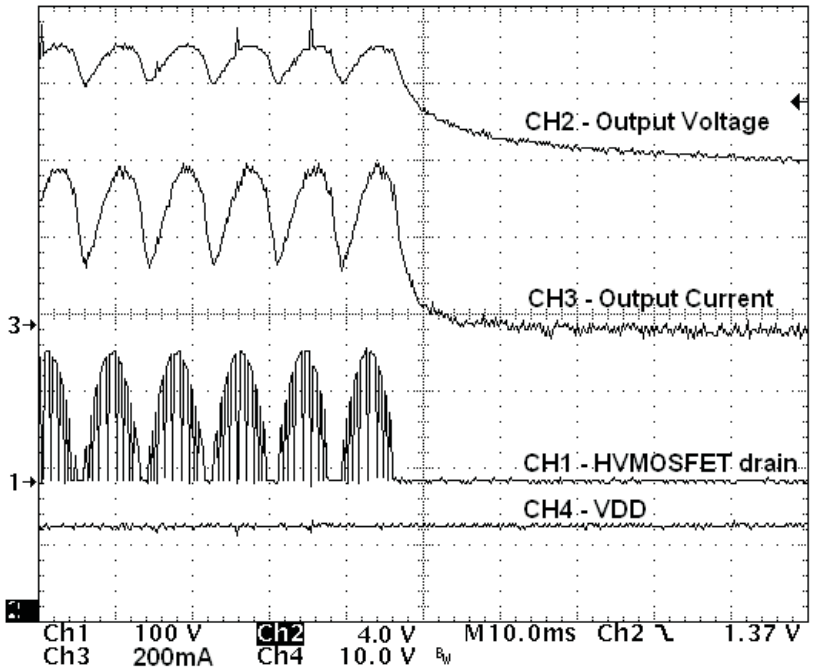


Figure 11. Enable Turn Off Waveforms

Copyright © 2011, Texas Instruments Incorporated

8 TPS92001EVM-645 EVM Assembly Drawing and PCB layout

The following figures (Figure 12 through Figure 14) show the design of the TPS92001EVM-645 printed circuit board.

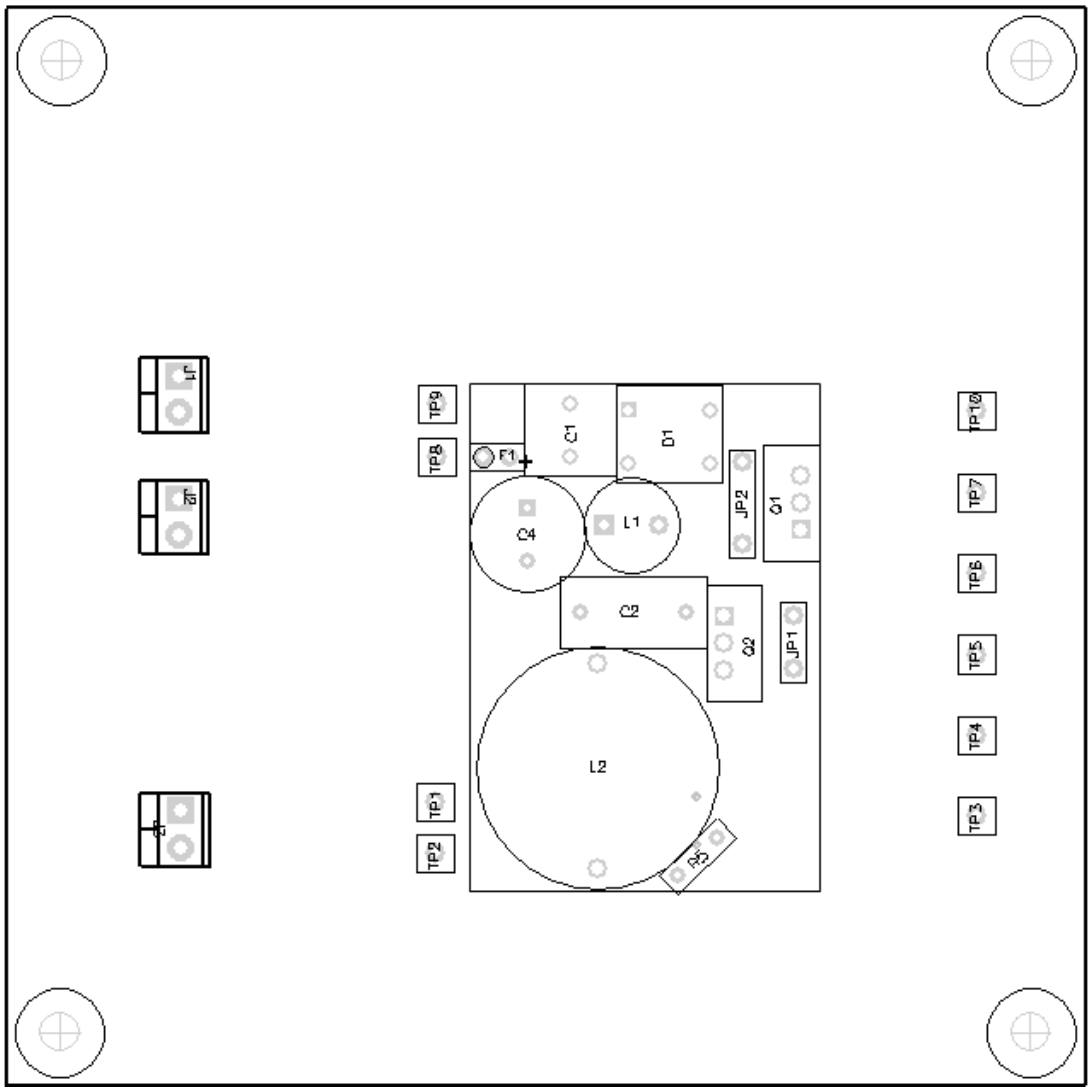


Figure 12. Top Layer Assembly Drawing (top view)

Copyright © 2011, Texas Instruments Incorporated

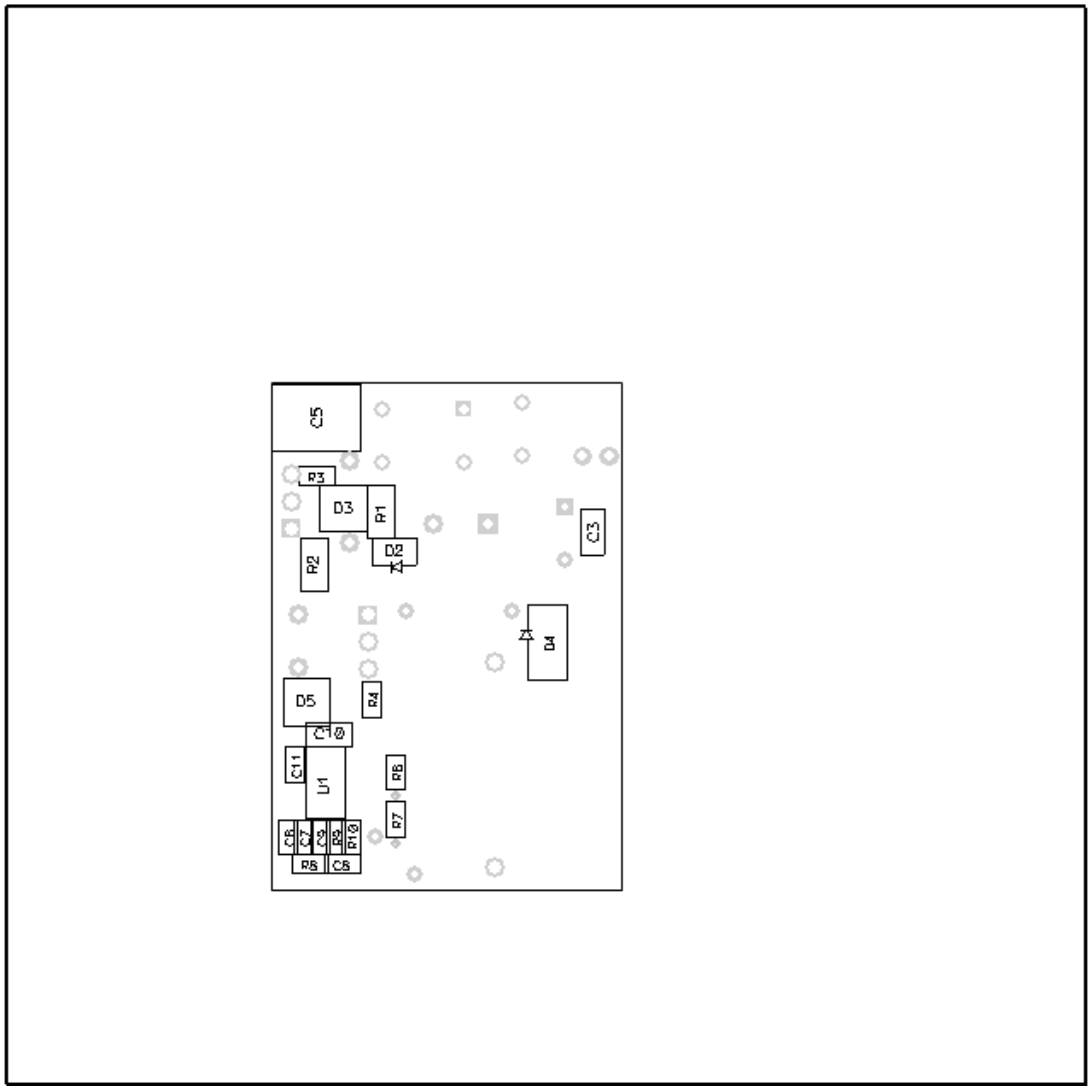


Figure 13. Bottom Assembly Drawing (bottom view)

Copyright © 2011, Texas Instruments Incorporated

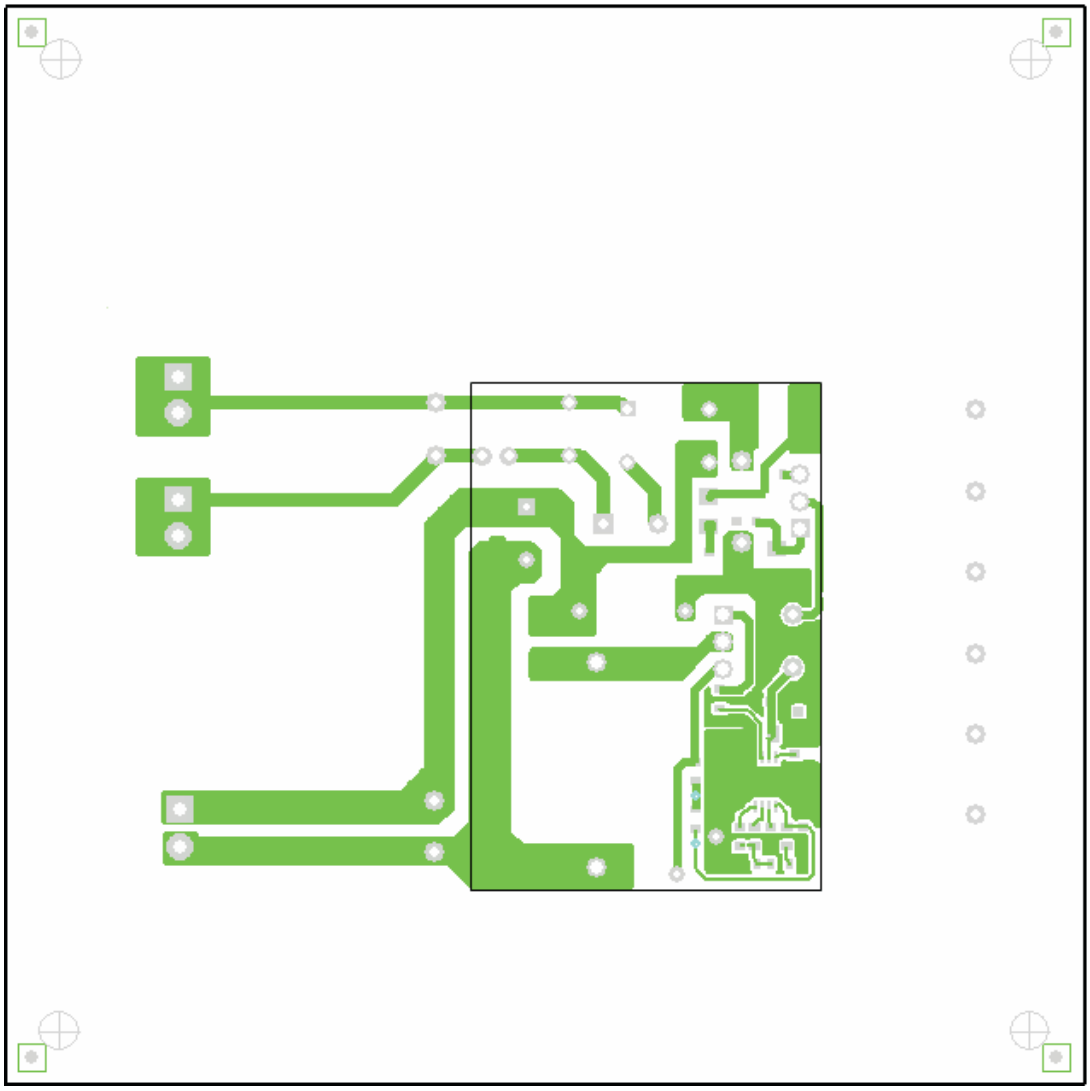


Figure 14. Bottom Copper (top view)

Copyright © 2011, Texas Instruments Incorporated

9 List of Materials

The EVM components list according to the schematic shown in Figure 1.

Table 3. TPS92001EVM-645 List of Materials

QTY	REF DES	DESCRIPTION	PART NUMBER	MFR
1	C1	Capacitor, leaded, metalized film, 400 VDC, 125°C, 20 ±%, 0.1 µF, 0.310 inch x 0.310 inch	B32529D6104M	Epcos
1	C10	Capacitor, ceramic, 25 V, X7R, 10%, 1.0 µF, 0805	Std	Std
1	C11	Capacitor, ceramic, 10 V, X7R, 10%, 0.47 µF, 0603	Std	Std
1	C2	Capacitor, poly film, 200 VAC, ±20%, 0.1 µF, 6.00 mm x 13.00 mm	B32521C6104J	Epcos
1	C3	Capacitor, ceramic, 100 V, X7R, 10%, 0.1 µF, 0805	std	Std
1	C4	CAP, aluminum elec, 220 µF, 50 V, radial, 5000 hrs at 105°C, 850-mA ripple, 10 mm x 16 mm	UPW1H221MPD	Rubycon/Nichicon
1	C5	Capacitor, ceramic, 250 V, X7R, 20%, 1.0 µF, 2220	"C5750X7R2E105M orGRM55DR72E105K W01L"	"TDK or Murata"
1	C6	Capacitor, ceramic, 50 V, X7R, 10%, 180 pF, 0603	Std	Std
2	C7, C9	Capacitor, ceramic, 25 V, X7R, 10%, 0.01 µF, 0603	Std	Std
1	C8	Capacitor, ceramic, 50 V, X7R, 10%, 680 pF, 0603	Std	Std
1	D1	Diode, bridge, 2.0 A, 400 V, 4 EDIP	DF204-G	Comchip
1	D2	Diode, high-speed switching, 250 mA, 200 V, SOD-323	BAS21-03W	Infineon
1	D3	Diode, Zener, 12 V, 20 mA, 225 mW, 5%, 12 V, SOT23	MMBZ5242BLT1	Motorola
1	D4	Rectifier, ultrafast power, 200 V, 1 A, 403D	MURA120T3G	On Semi
1	D5	Diode, Zener, 15 V, 20 mA, 225 mW, 5%, 15 V, SOT23	MMBZ5245BLT1	Motorola
1	F1	1-A fuse, subminiature fast acting, 0.125 diameter	MCRW1A	Bussmann
1	JP1	Jumper, 0.200 inch length, PVC insulation, AWG 22, 0.035 inch diameter	923345-02-C	3M
1	JP2	Jumper, 0.300 inch length, PVC insulation, AWG 22	923345-03-C	3M
1	L1	Inductor, radial, 470 µH, 310 mA, 10%, 70°C, 470 µH, 0.315 inch diameter	22R474C	Murata
1	L2	Inductor toroid 470 µH, 15%, horizontal, 470 µH, 0.860 inch x 0.450 inch	2100LL-471-H-RC	Bourns
1	Q1	Transistor, power bipolar PNP, 350 V, 4 A, TO-220	MJE15035G	On Semi
1	Q2	Transistor, NFET, 250 V, 2.1 A, 2 Ω, TO-220	IRFI614GPBF	Vishay
1	R1	Resistor, 1/4 W, ± 5%, 1.0 kΩ, 1206	Std	Std
1	R10	Resistor, chip, 1/16 W, 1%, 4.32 kΩ, 0603	Std	Std
1	R2	Resistor, 1/4 W, ± 5%, 604 kΩ, 1206	Std	Std
1	R3	Resistor, chip, 1/16 W, 1%, 5.11 kΩ, 0603	Std	Std
1	R4	Resistor, chip, 1/16 W, 1%, 10 Ω, 0603	Std	Std
1	R5	Resistor, SM, 3/4 W, 1%, 2.7 Ω, 2010	Std	Std
1	R6	Resistor, chip, 1/16 W, 5%, 0 Ω, 0603	Std	Std
1	R7	Resistor, chip, 1/16 W, 1%, 4.12 kΩ, 0603	Std	Std
1	R8	Resistor, chip, 1/16 W, 1%, 20.0 kΩ, 0603	Std	Std
1	R9	Resistor, chip, 1/16 W, 1%, 10.0 kΩ, 0603	Std	Std
1	U1	G.P LED Lighting PWM Controller, MSOP-8	TPS92001DGK	TI
1	--	PCB, 4 inch x 4 inch x 0.062 inch	HPA645	Any

Copyright © 2011, Texas Instruments Incorporated

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 105 V to 135 V and the output voltage range of 26 V to 34 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 50° C. The EVM is designed to operate properly with certain components above 50° 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 © 2011, 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		**Applications**	
Audio	www.ti.com/audio	Communications and Telecom	www.ti.com/communications
Amplifiers	amplifier.ti.com	Computers and Peripherals	www.ti.com/computers
Data Converters	dataconverter.ti.com	Consumer Electronics	www.ti.com/consumer-apps
DLP® Products	www.dlp.com	Energy and Lighting	www.ti.com/energy
DSP	dsp.ti.com	Industrial	www.ti.com/industrial
Clocks and Timers	www.ti.com/clocks	Medical	www.ti.com/medical
Interface	interface.ti.com	Security	www.ti.com/security
Logic	logic.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Power Mgmt	power.ti.com	Transportation and Automotive	www.ti.com/automotive
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com	Wireless	www.ti.com/wireless-apps
RF/IF and ZigBee® Solutions	www.ti.com/lprf		
	TI E2E Community Home Page		e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2011, Texas Instruments Incorporated