

# 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<sub>RMS</sub> to 135 V<sub>RMS</sub>.

### **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 |
|---------------------------------------|---------------------------------------|-----|------|-----|-------|
| <b>Input Characteristics</b>          |                                       |     |      |     |       |
| Voltage range                         |                                       | 105 | 120  | 135 | V     |
| Maximum input current                 |                                       |     | 115  |     | mA    |
| <b>Output Characteristics</b>         |                                       |     |      |     |       |
| Output voltage, V <sub>OUT</sub>      |                                       | 26  | 30   | 34  | V     |
| Output load current, I <sub>OUT</sub> |                                       | 290 | 330  | 370 | mA    |
| Output current ripple                 | V <sub>IN</sub> = 120 V <sub>AC</sub> |     | 280  |     | mApp  |
| Output over Voltage                   |                                       |     | 36   |     | V     |
| <b>Systems Characteristics</b>        |                                       |     |      |     |       |
| Switching frequency                   |                                       |     | 133  |     | kHz   |
| Full load efficiency                  | V <sub>IN</sub> = 120 V <sub>AC</sub> |     | 88%  |     |       |
| Power factor                          |                                       |     | 0.87 |     |       |

## 4 Schematic

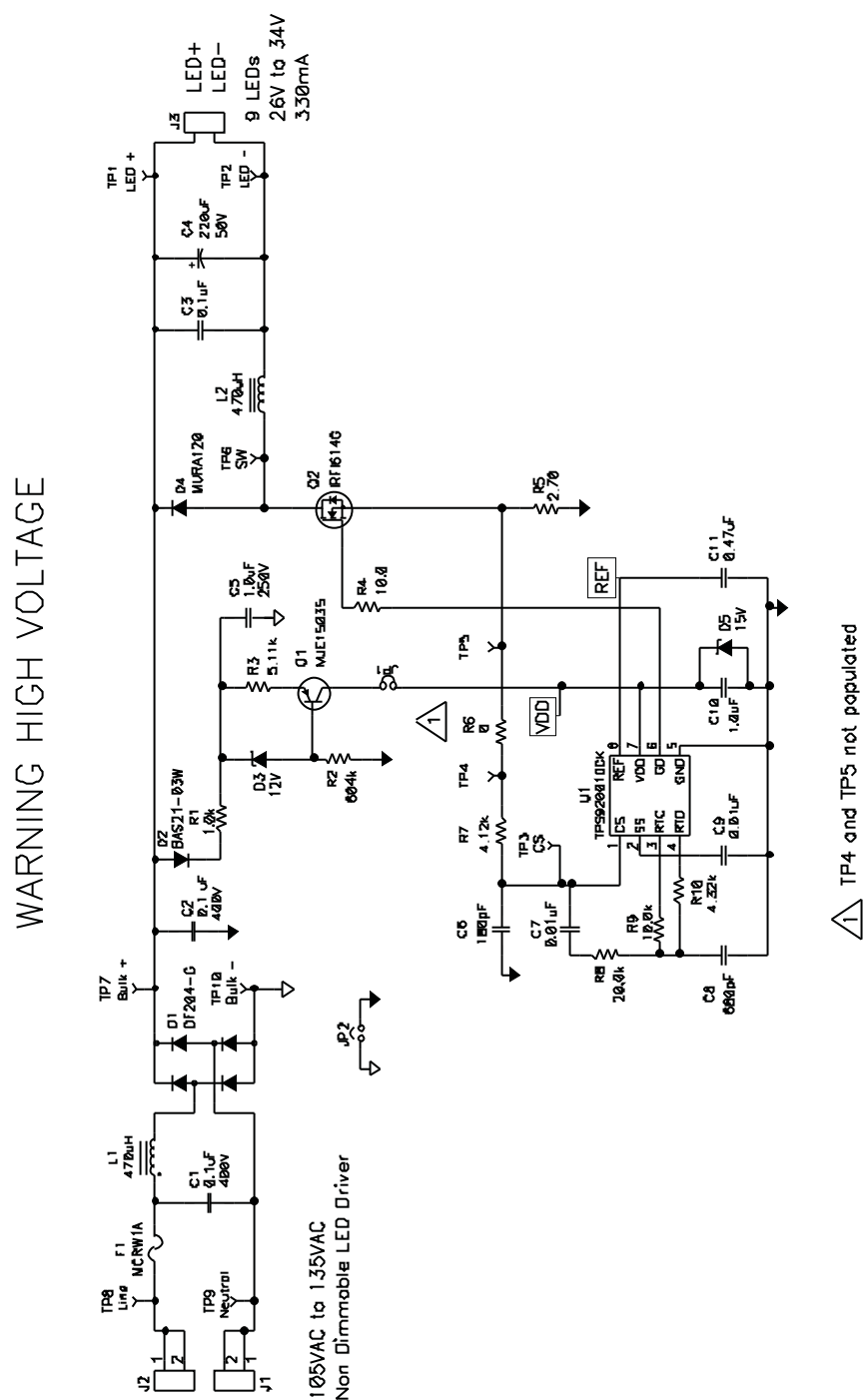


Figure 1. TPS92001EVM-645 Schematic

## 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

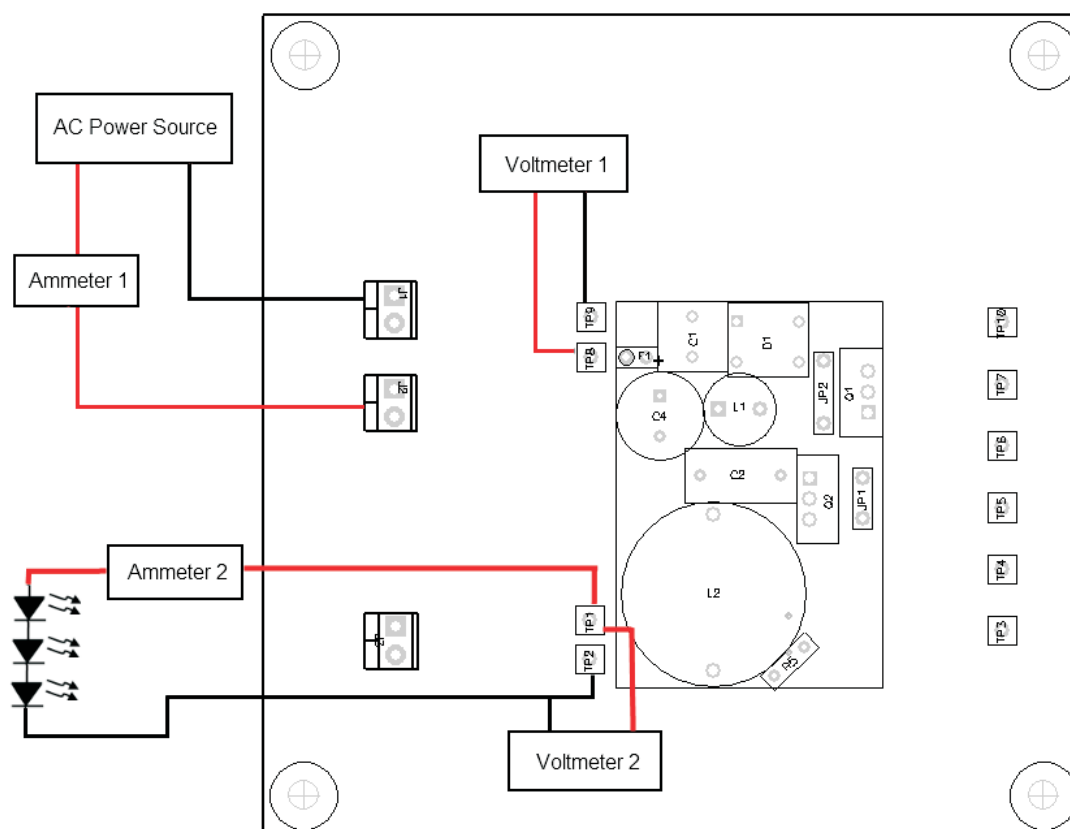


Figure 2. Recommended Test Set Up

### 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 |

## 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<sub>RMS</sub>.
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<sub>RMS</sub>.
6. Repeat steps 4 and 5 until you reach 135 V<sub>RMS</sub>.
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.

## 7 Performance Data and Typical Characteristic Curves

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

### 7.1 Efficiency

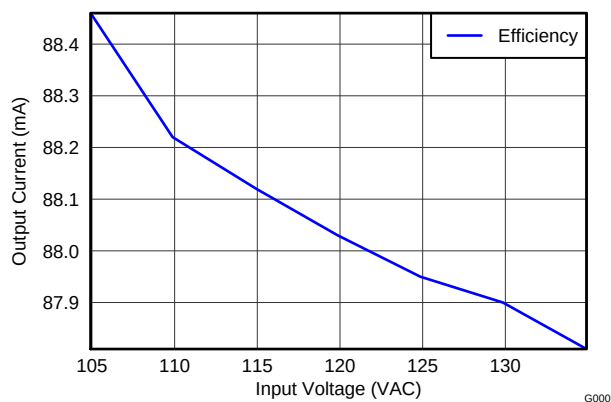


Figure 3. Efficiency

### 7.2 Input Voltage vs. Power Factor

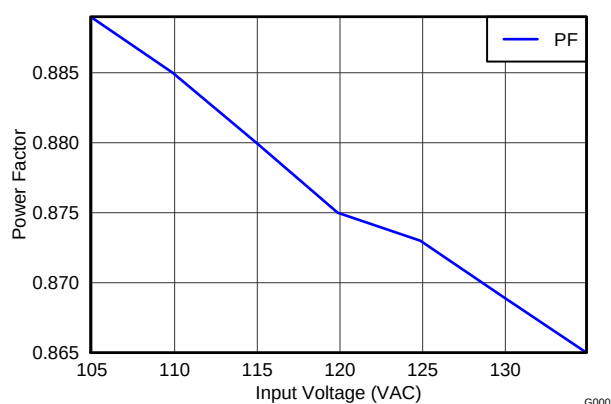


Figure 4. PF Variation

### 7.3 Input Voltage vs. Output Current

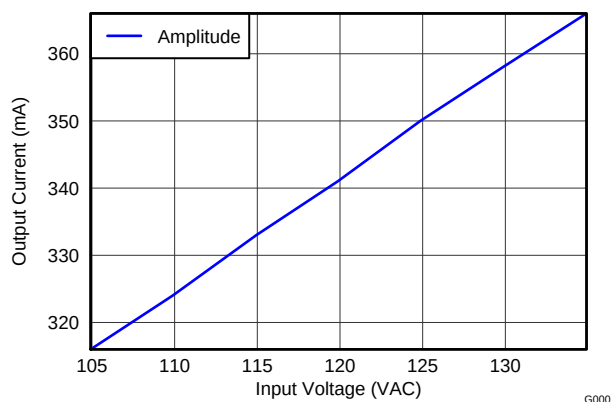


Figure 5. Output Current variation with Respect to Input Voltage

## 7.4 Output Ripple

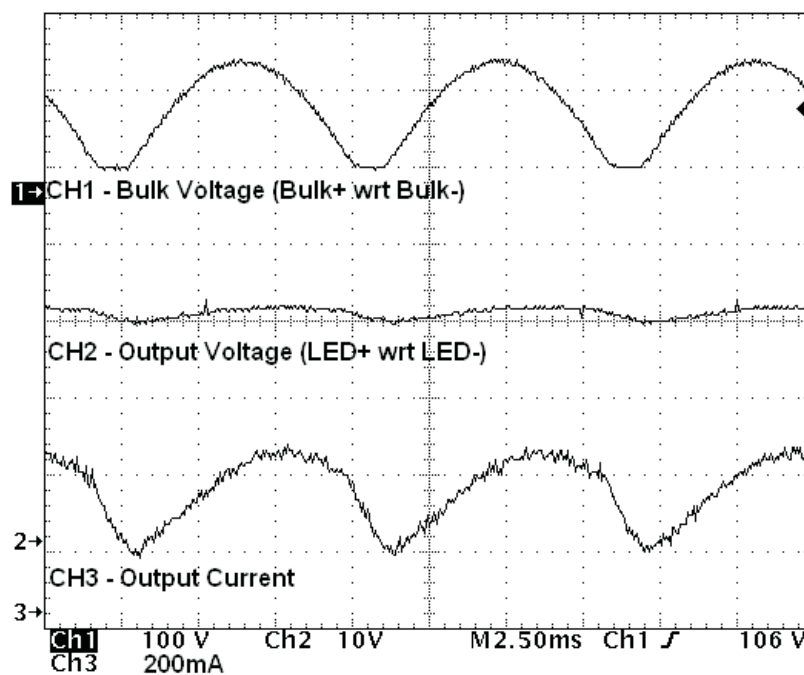


Figure 6. Output Ripple

## 7.5 Input Waveforms

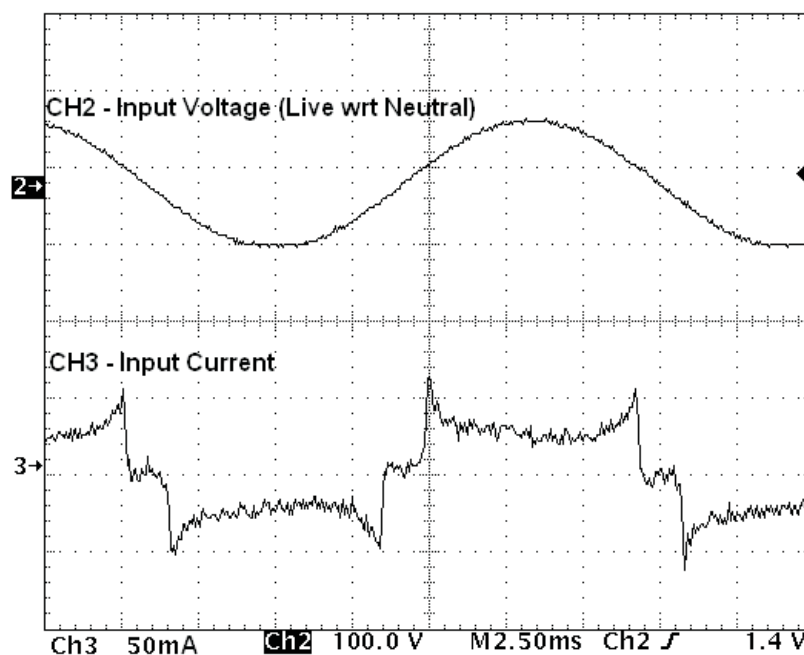


Figure 7. Input Waveform



## 7.6 Clock Signal and Switch Node Voltage

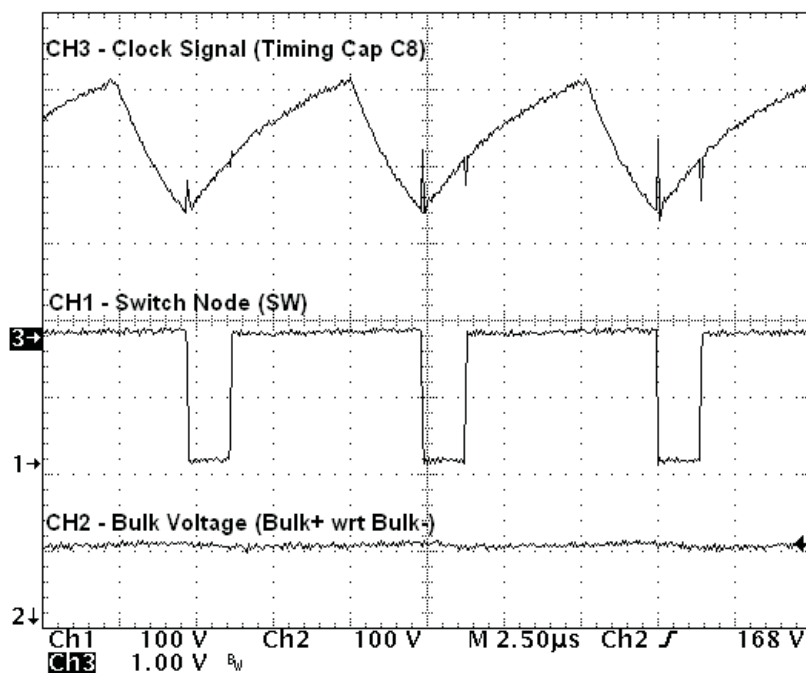


Figure 8. Clock Signal and Switching Node Waveform

## 7.7 Current Sense

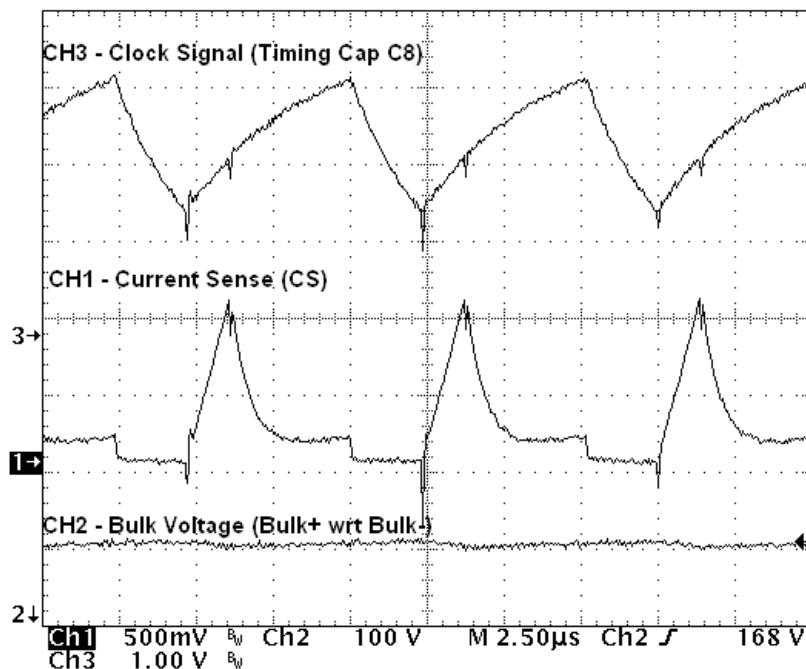


Figure 9. Clock Signal and Current Sense Waveform

## 7.8 Turn-On Waveform

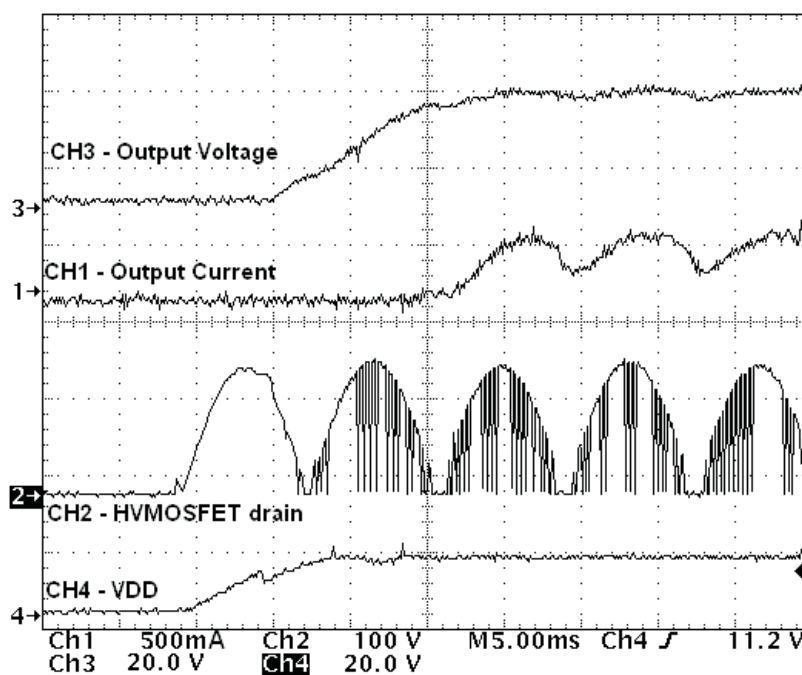


Figure 10. Enable Turn On Waveforms

## 7.9 Turn-Off Waveform

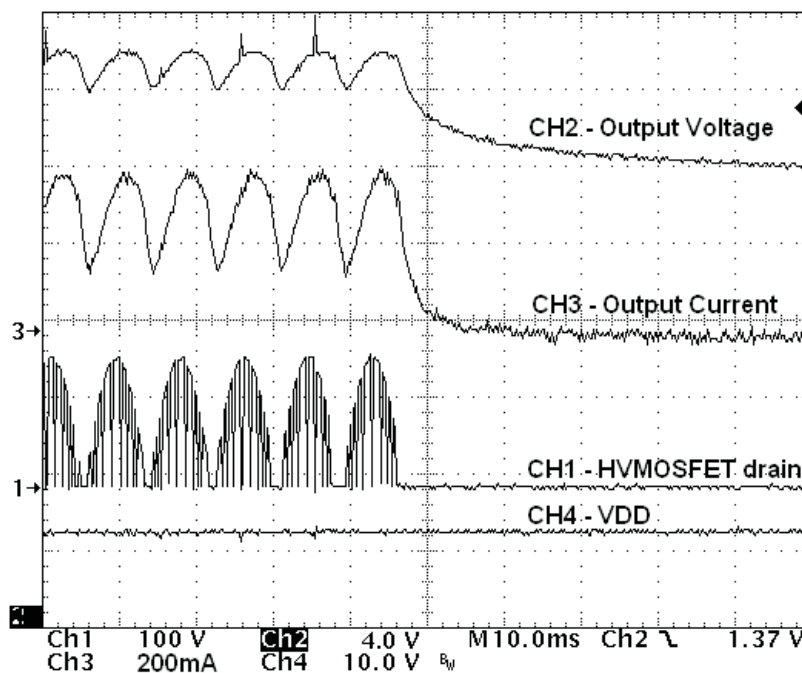
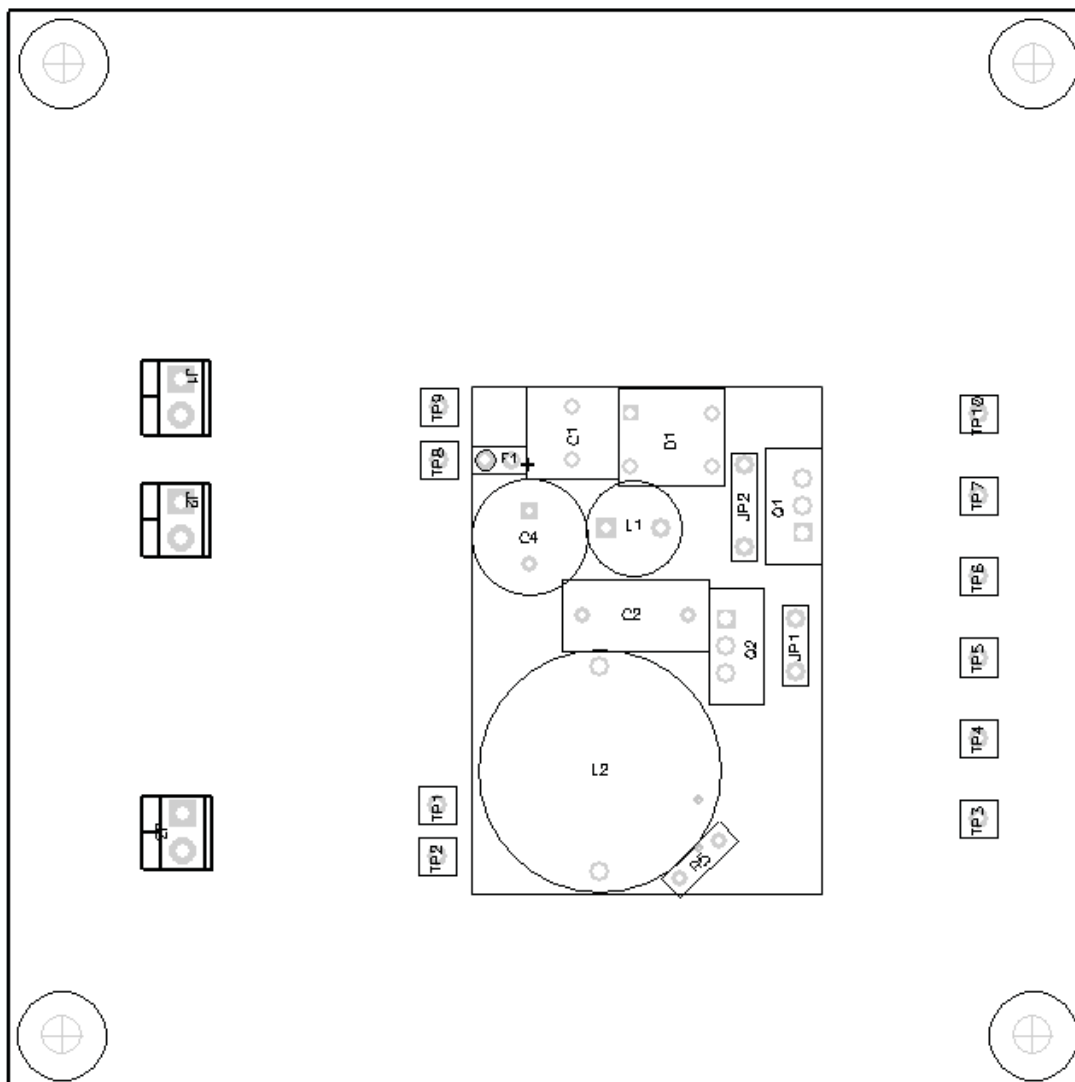


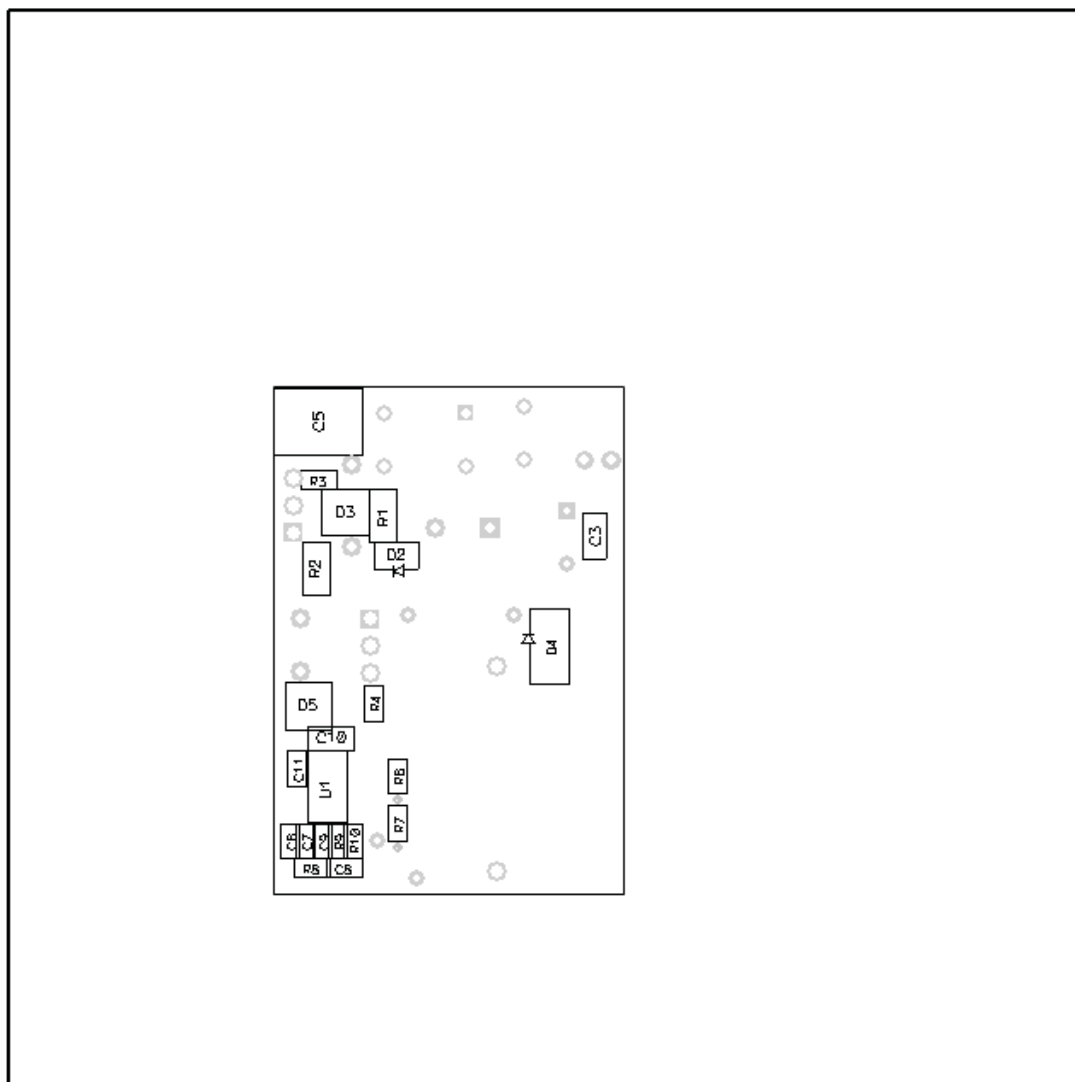
Figure 11. Enable Turn Off Waveforms

## 8 TPS92001EVM-645 EVM Assembly Drawing and PCB layout

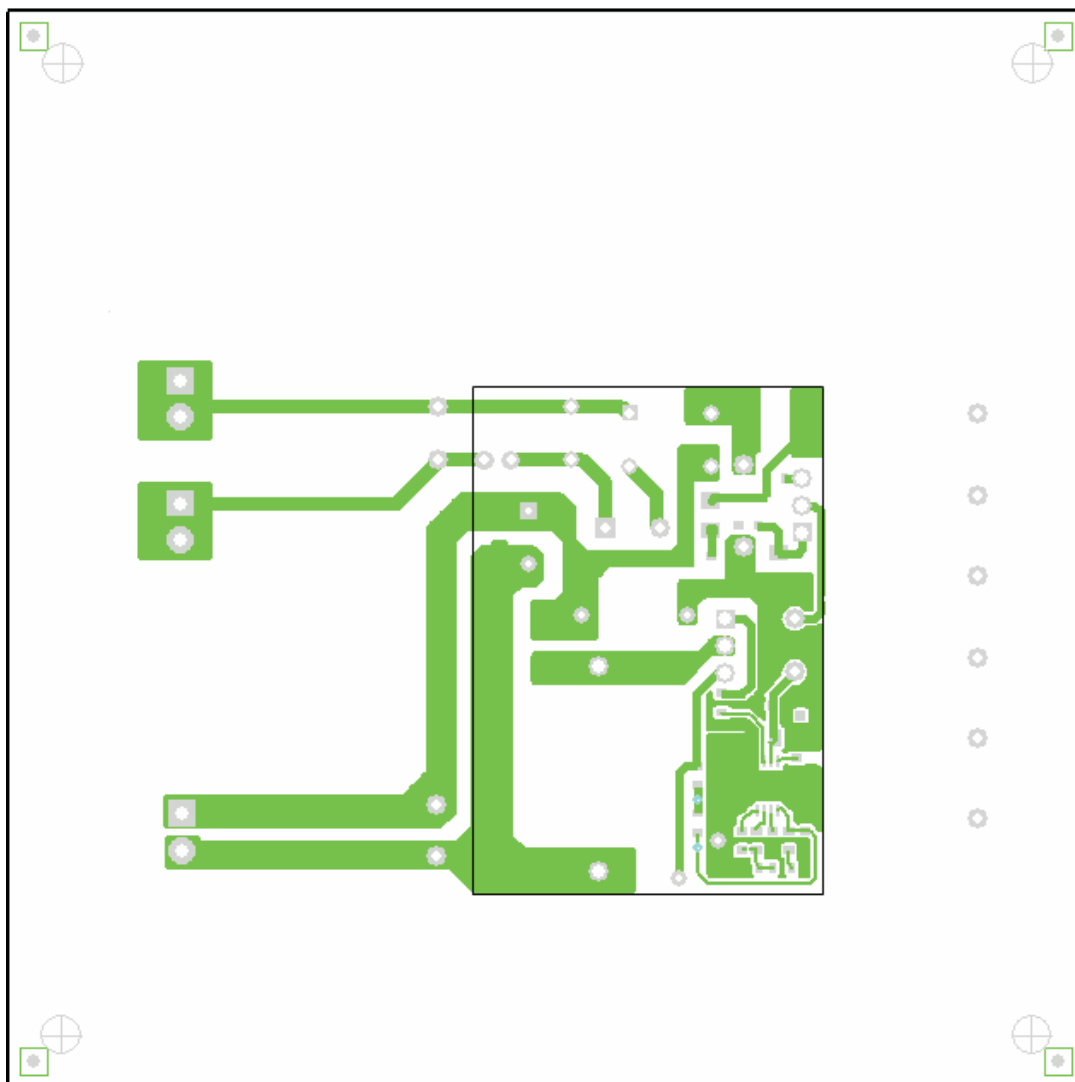
The following figures (Figure 12 through Figure 14) show the design of the TPS92001EVM-645 printed circuit board.



**Figure 12. Top Layer Assembly Drawing (top view)**



**Figure 13. Bottom Assembly Drawing (bottom view)**



**Figure 14. Bottom Copper (top view)**

## 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 or GRM55DR72E105K 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              |

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## 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.

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| RF/IF and ZigBee® Solutions | <a href="http://www.ti.com/lprf">www.ti.com/lprf</a>               |

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|                               |                                                                                          |
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| Consumer Electronics          | <a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>                   |
| Energy and Lighting           | <a href="http://www.ti.com/energy">www.ti.com/energy</a>                                 |
| Industrial                    | <a href="http://www.ti.com/industrial">www.ti.com/industrial</a>                         |
| Medical                       | <a href="http://www.ti.com/medical">www.ti.com/medical</a>                               |
| Security                      | <a href="http://www.ti.com/security">www.ti.com/security</a>                             |
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