

Low Cost, Single Inductor Non-Isolated AC/DC LED Driver Design using TPS92314A

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Lighting Power Products

ABSTRACT

The control principle of the TPS92310/11/12/14 is to provide constant current line and load regulation for primary-side sensing flyback configurations operating in critical conduction mode (CRM), removing the opto-coupler used for secondary-side feedback.

The new application circuit uses a single inductor rather than a bulky transformer, saving board space and BOM cost while still meeting the standard performance specifications of an LED driver.

This application report describes how to design a non-isolated AC/DC buck LED driver with an integrated PFC control using the TPS92314A from Texas Instruments. This application report includes schematics, switch node waveforms and test results to help the user better understand how to retain a very tight line and load regulation when applying the IC as a buck regulator with the help of external add-on circuitry that modifies the control equation of the TPS92314A. In this way, tighter line and load regulation specifications required by certain applications can be met.

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1 Design Specifications:

Table 1. Design Specifications

Input Voltage Range (Vin)	Universal, 90V-276V AC RMS
Output Voltage (Vout)	29V
Load Current (Iout)	230mA
Power Factor	Greater than 0.9 in Vin range
Current Total Harmonic Distortion (ITHD)	Less than 25% at 220V AC RMS
Output Short Circuit Protection	Yes
Output Open Circuit Protection	Yes

4 Experimental Results and Performance Characteristics

4.1 Switch Node Waveform at VAC = 110V

- Channel 1 (Inductor Switch node)
- Channel 2 (Inductor Peak current)
- Channel 3 (Output LED current)

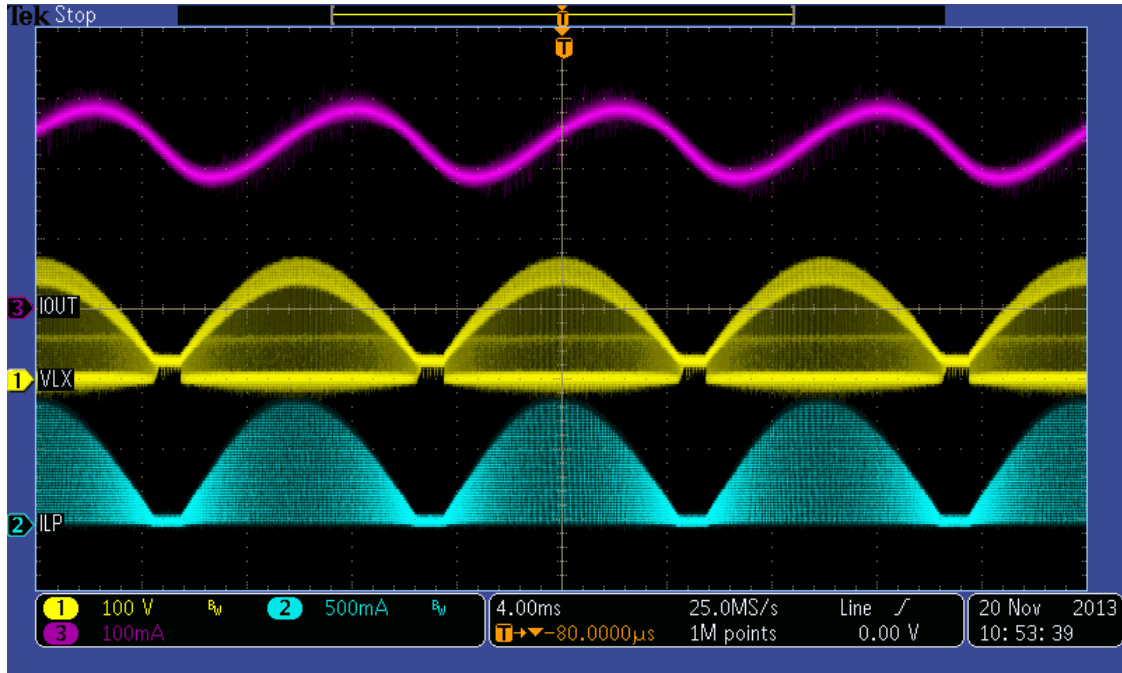


Figure 2. Switch Node Waveform

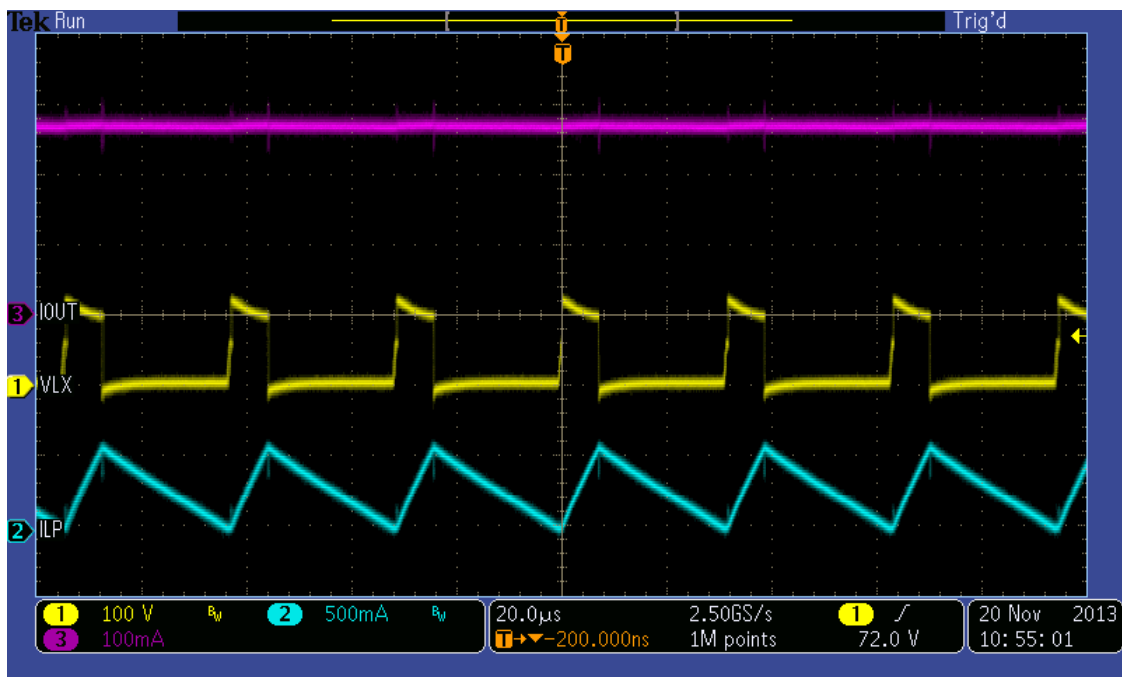


Figure 3. Switch Node Waveform

4.2 Switch Node Waveform at VAC = 220V

- Channel 1 (Inductor Switch node)
- Channel 2 (Inductor Peak current)
- Channel 3 (Output LED current)

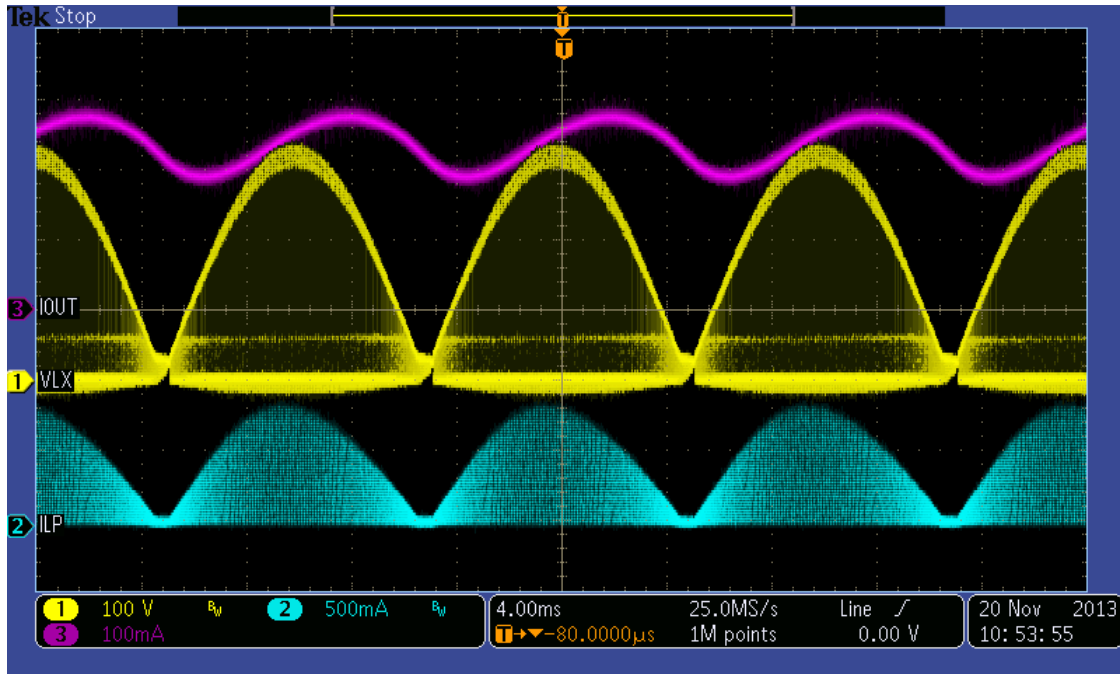


Figure 4. Switch Node Waveform

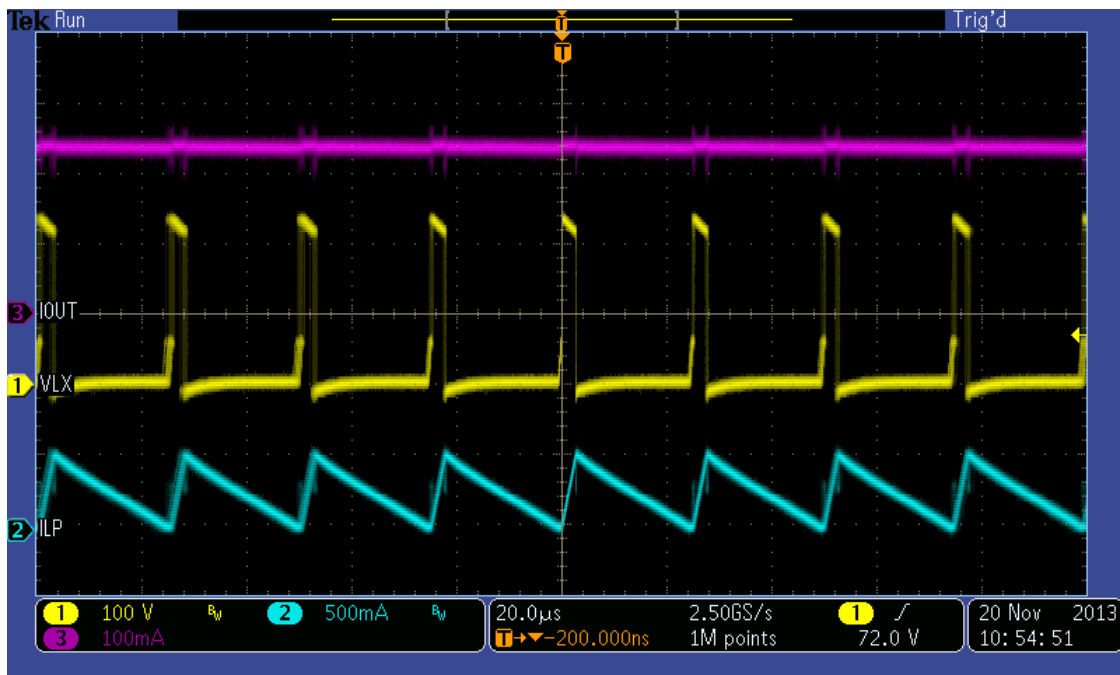


Figure 5. Switch Node Waveform

4.3 Output Current Variation with Respect to Input Voltage

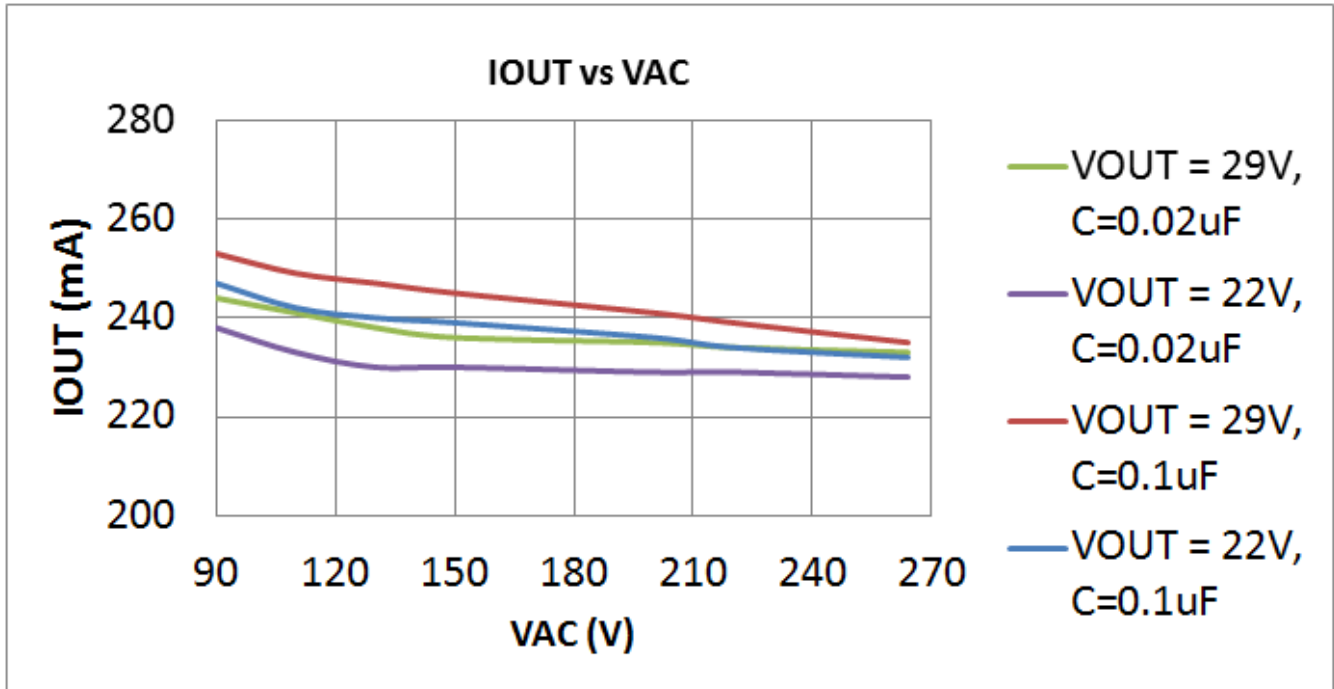


Figure 6. Output Current Variation with Respect to Input Voltage

4.4 Power Factor Variation with Respect to Input Voltage

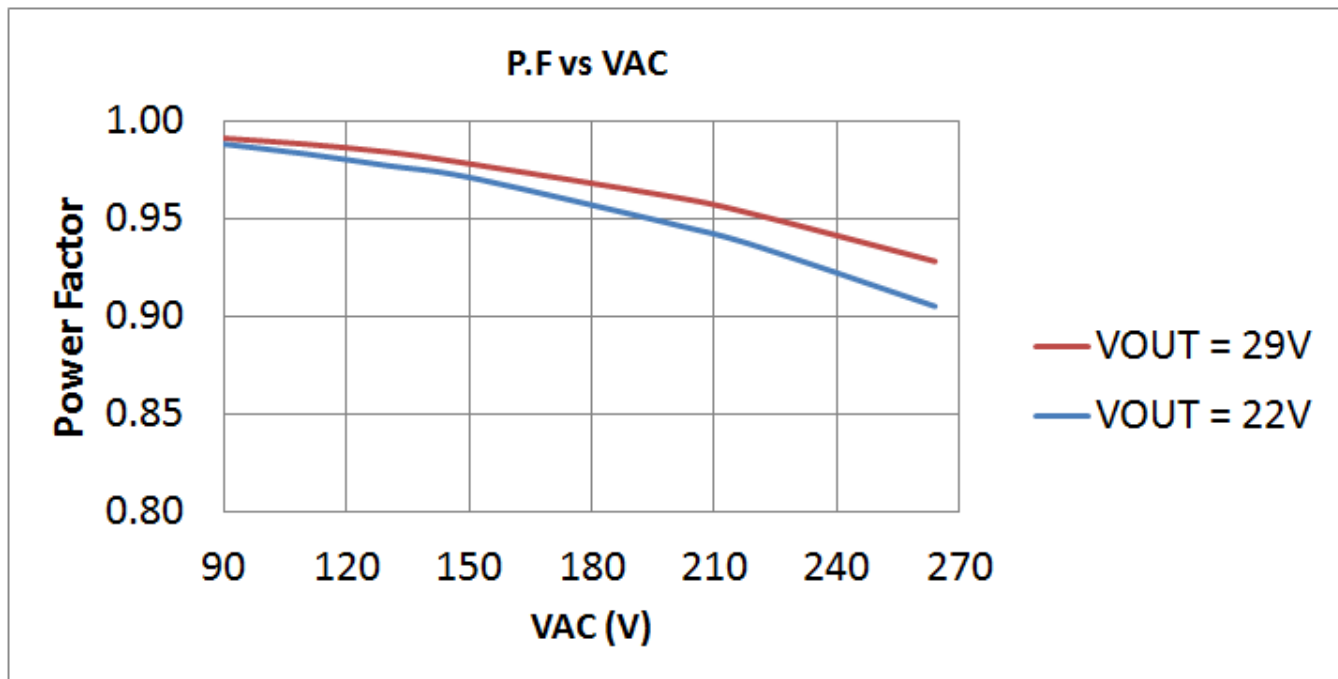


Figure 7. Power Factor Variation with Respect to Input Voltage

4.5 Detailed Test Results for 7W Design

Table 2. Performance Characteristics of Single Inductor, Non Isolated Design Based on TPS92314

Input Voltage (VAC)	90	110	130	150	200	220	260
Input Current (mA)	91.1	72.8	61.2	52.7	40.1	36.9	31.4
Input Power (W)	8.2	8.01	7.95	7.9	8.02	8.12	8.29
Output Current (mA)	244	241	238	236	235	234	233
Output Voltage (V)	29.04	29.02	28.9	28.86	28.8	28.8	28.78
Efficiency (%)	86.4	87.3	86.5	86.2	84.4	83.0	80.9
Power Factor	0.991	0.988	0.984	0.978	0.961	0.952	0.928

5 External Add On Circuit to Meet Tighter Line and Load Regulation Specification

In general fly-back convertor at CRM operation, the output current is as follows:

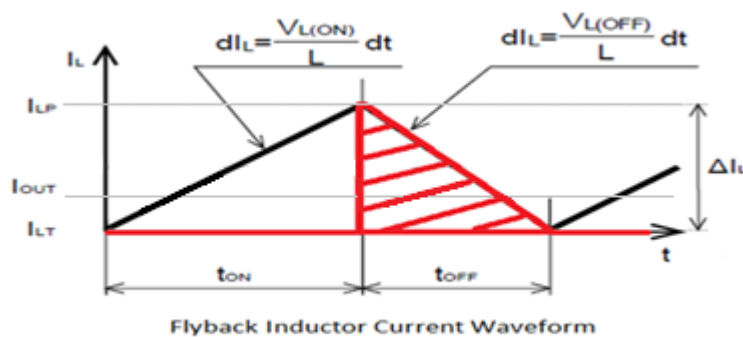


Figure 8. Output Current in Flyback at Critical Conduction Mode

In buck convertor, the output current is as follows:

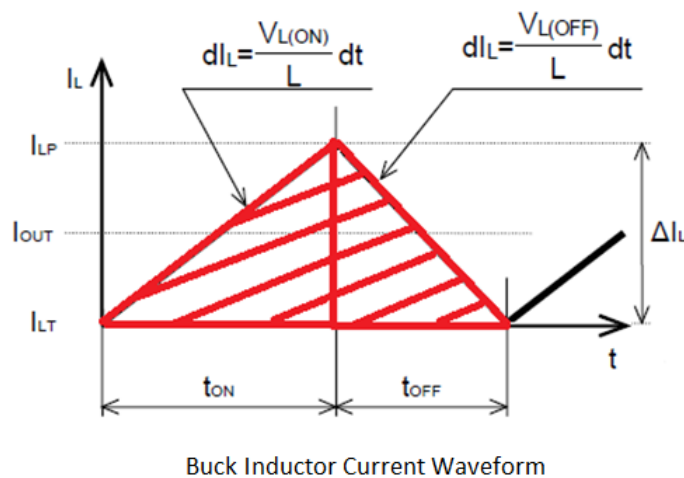


Figure 9. Inductor Current Waveform in Buck Converter at Critical Conduction Mode

In comparing fly-back and buck convertor current waveforms, fly-back output current is observed at tOFF time only due to the flyback action of the transformer. In buck convertor, the output current is observed during tON + tOFF time. For waveforms for both topologies, the tOFF time inductor current is the same at CRM operation. Thus after blanking time, the inductor current at ON time tON in both flyback and buck convertor will be at the same level.

A modified, non-isolated buck LED driver with the TPS92314 controller is as follows:

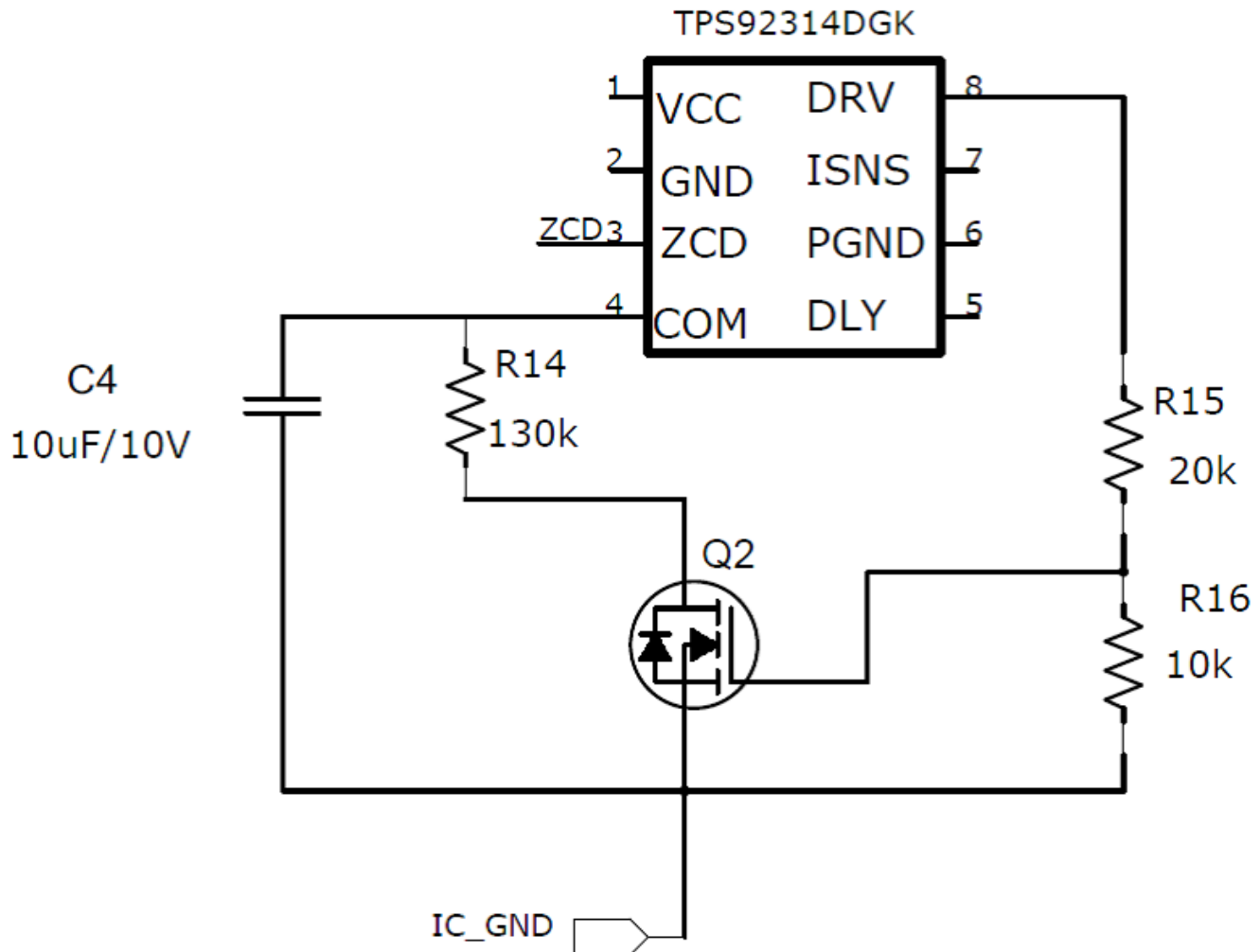


Figure 10. External Add On Circuit to meet Tighter Line and Load Regulation Specifications

This implementation meets tighter line and load regulation specifications for a non-isolated buck application with the TPS92314 controller by drawing the internal reference current when the gate driver is turned on (TON time) through small signal MOSFET Q2. The blanking timer appears to blank the input current at TON time in CRM buck operation. The user can meet the line regulation specifications by modifying the discharge current through small signal MOSFET Q2. Theoretically, if the discharge current is same as the compensation pin internal reference current (27uA), a controller output current can be controlled with the same level.

In [Figure 10](#), the COMP voltage VCOMP is dependent on the TON time and is nearly constant in close loop operation. MOSFET Q2 is driven through the resistor divider from the gate drive pin (pin 8 of TPS92314) R15 and R16. The value of resistor R14 can be calculated as:

$$\frac{(V_{COMP} - V_{DS(ON)Q2})}{R14} = 27\mu A \quad (3)$$

The value of resistor R14 is application-dependent and can be tweaked to set the desired current drawn from the compensation pin capacitor and meet required line regulation.

Though this circuit achieves good line and load regulation, the circuit affects the power factor. Use of this circuit is a tradeoff between performance specifications and varies from application to application.

6 Conclusion

A detailed application report with test results is presented for a 7W single inductor, non-isolated AC/DC LED driver based on the TPS92314A off-line primary side switching AC/DC controller from Texas Instruments. Use of the single inductor helps to reduce complexity, solution size and overall system cost. The inductor meets all the necessary performance specifications such as power factor (>0.9), protection features (Open LED, Output Short Circuit), and efficiency of up to 88% for an 8W application.

7 References

1. [TPS92314A Off-Line Primary Side Sensing Controller with PFC in 8-SOIC datasheet](#)
2. [SLVA057: Understanding Buck Power Stage sin Switchmode Power Supplies application report](#)

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