Isolated 240-W Offline LED Driver Using UCC28810, UCC28811 and TPS92020

User's Guide

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1 Introduction

This reference design is an isolated offline 240-W LED driver with Power Factor Correction (PFC), using UCC28810, UCC28811 and TPS92020

2 Description

This driver is comprised of three stages, including PFC stage, Buck stage, and Isolation stage. Both PFC and Buck stage operate in critical conduction mode. The isolation stage is a half-bridge resonant current converter with an option to adopt the multi-transformer design. A constant current is controlled by the Buck stage to provide 3 A to the LED strings, with output voltage range from 70 V to 85 V.

2.1 Typical Applications

- High Bay Lighting
- Street Lighting

2.2 Features

- 108 V_{RMS} to 265 V_{RMS} Offline Operation
- Power Factor Correction
- Boost Follower
- Constant Current Control
- Output Isolation
- Onboard or External PWM Dimming

3 Electrical Performance Specifications

Table 1. Isolated 240-W LED Driver Electrical Performance Specifications

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Input Characteristics					
Voltage range		108		265	V_{RMS}
PF		0.99			
Output Characteristics					
Output voltage, V_{OUT}	Output current = 3 A	70		85	V
Output load current, I_{OUT}			3		A
Output current ripple	C_O = 2.2 µF x 2		300		mA_{PP}
Systems Characteristics					
Efficiency	V_{OUT} = 70 V to 85 V	87%			

4 Schematics

4.1 PFC Stage

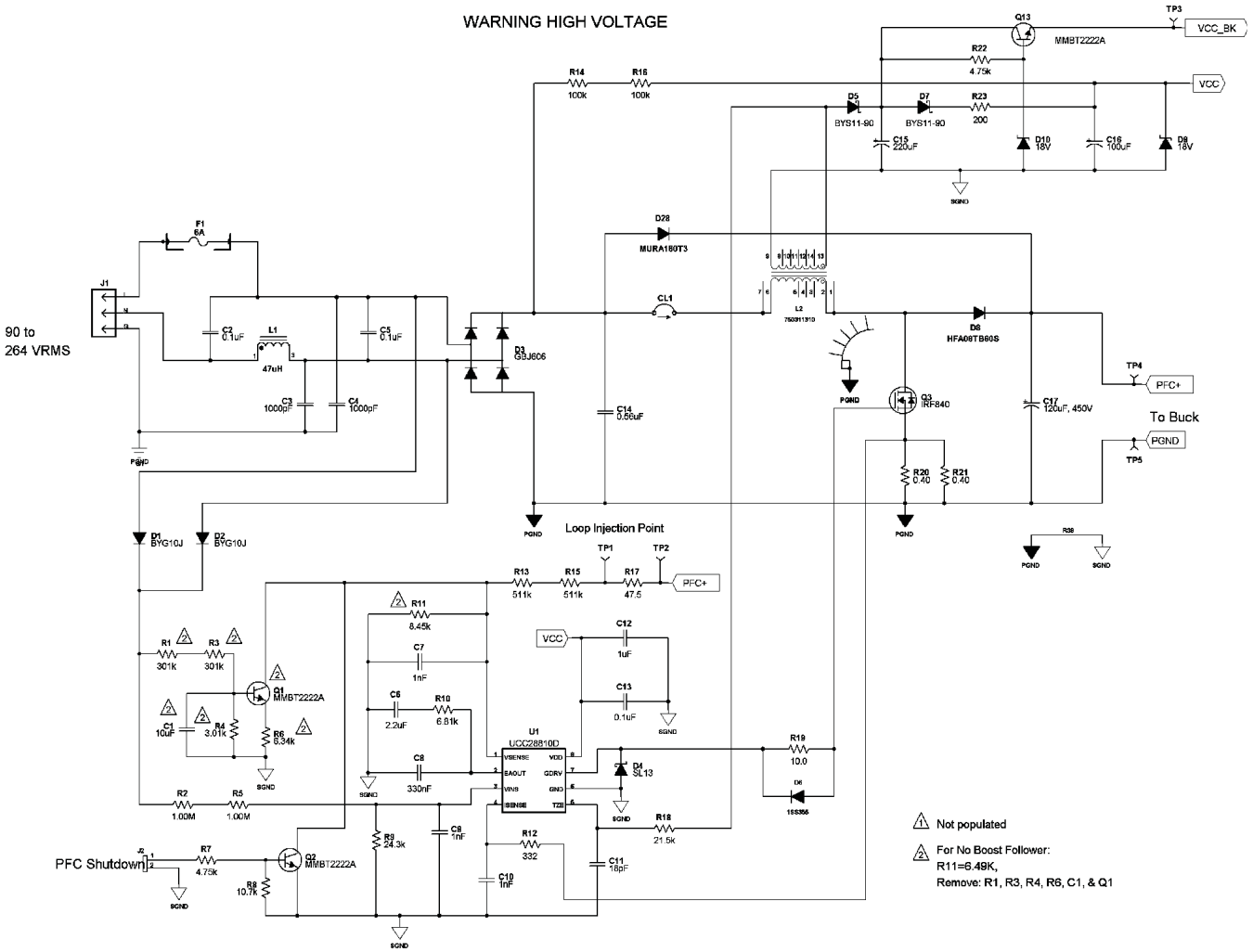

Figure 1. Isolated 240-W LED Driver Schematic, (PFC stage)

4.2 Buck Stage

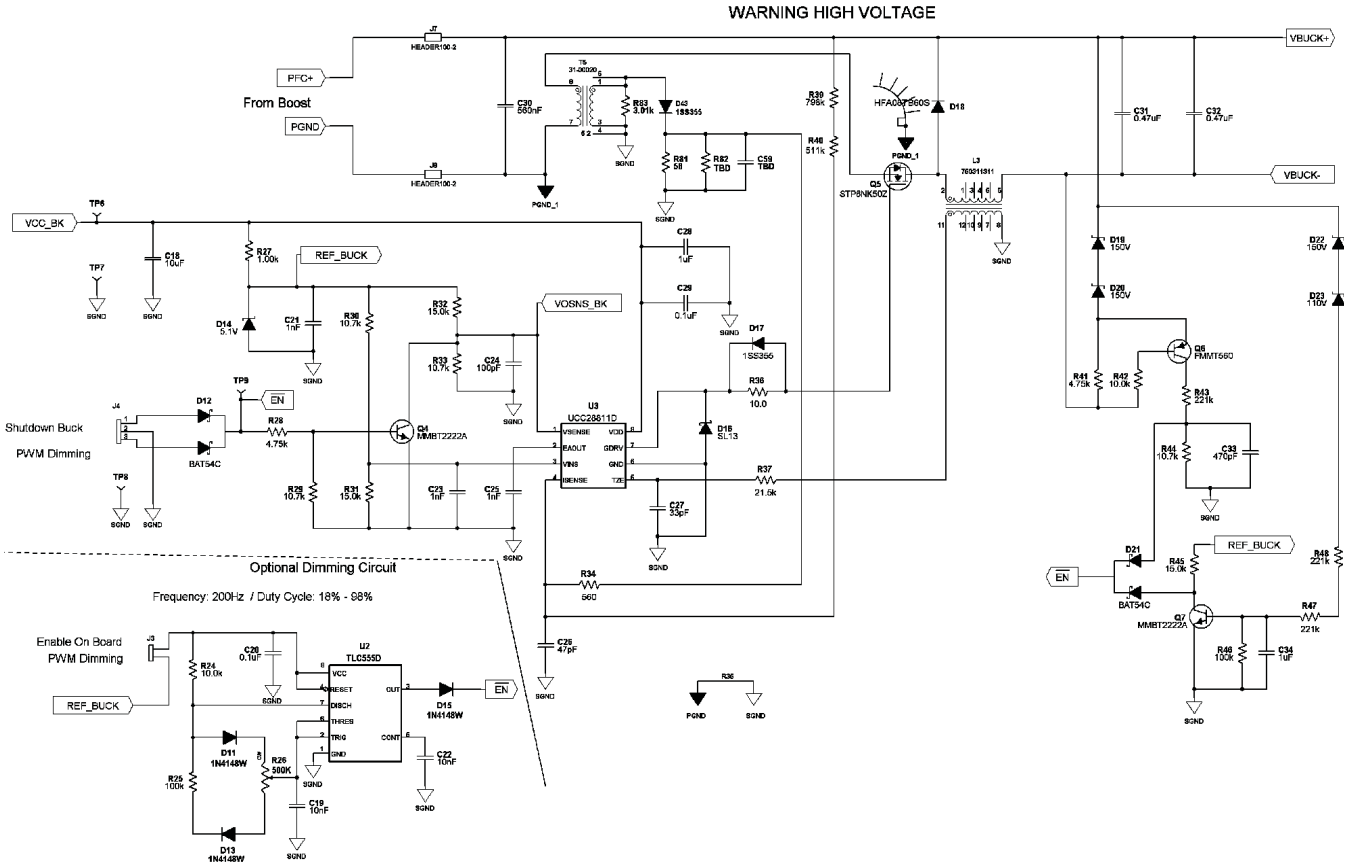

Figure 2. Isolated 240-W LED Driver Schematic, (constant current buck stage)

4.3 Isolation Stage

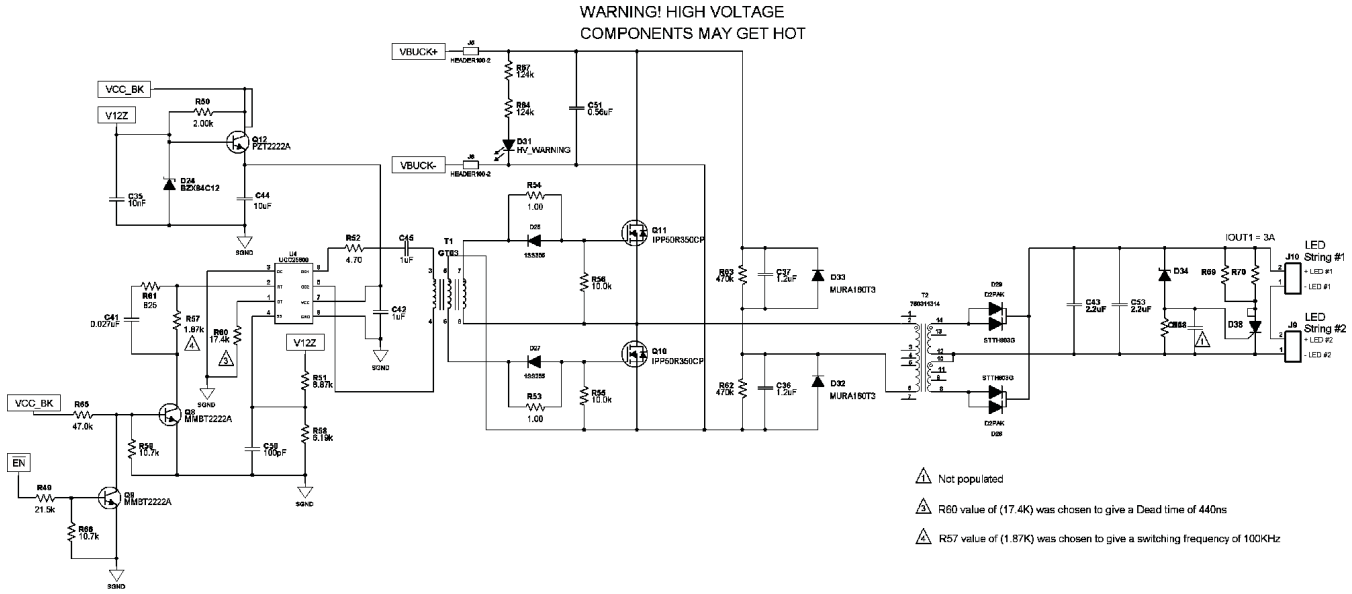

Figure 3. Isolated 240-W LED Driver Schematic, (isolation stage)

5 Performance Data and Typical Characteristic Curves

Figure 4 through Figure 13 present typical performance curves for isolated 240-W LED driver.

5.1 Power Factor (PF)

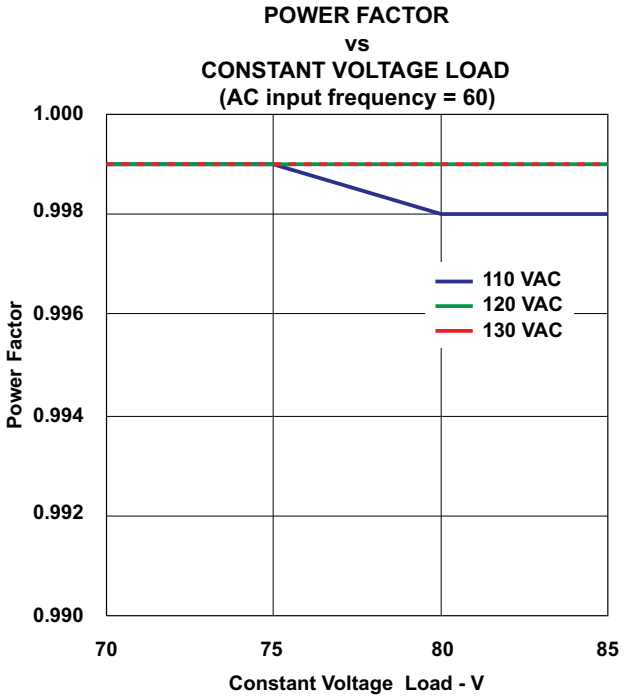

Figure 4. Isolated 240-W LED Driver Power Factor

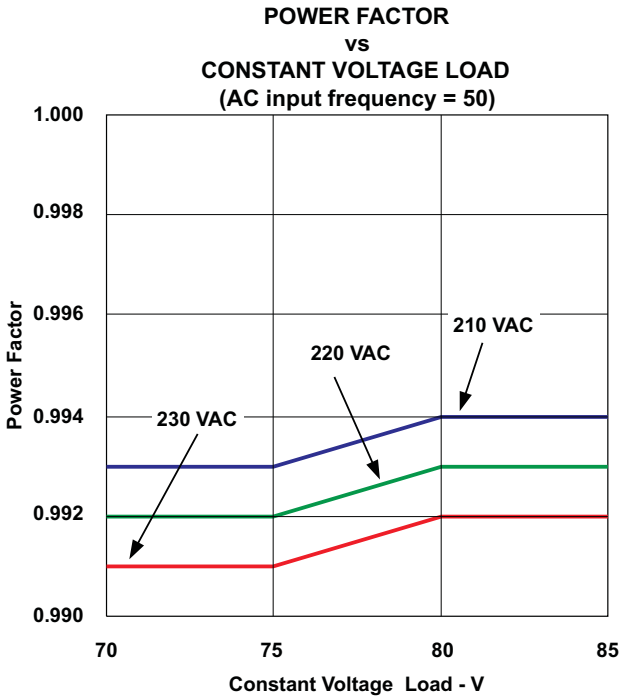

Figure 5. Isolated 240-W LED Driver Power Factor

5.2 Efficiency

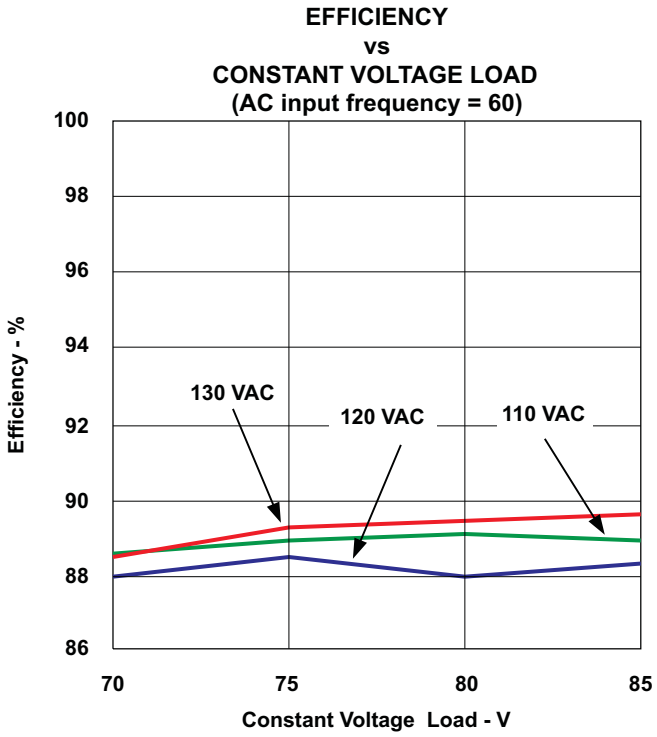

Figure 6. Isolated 240-W LED Driver Efficiency

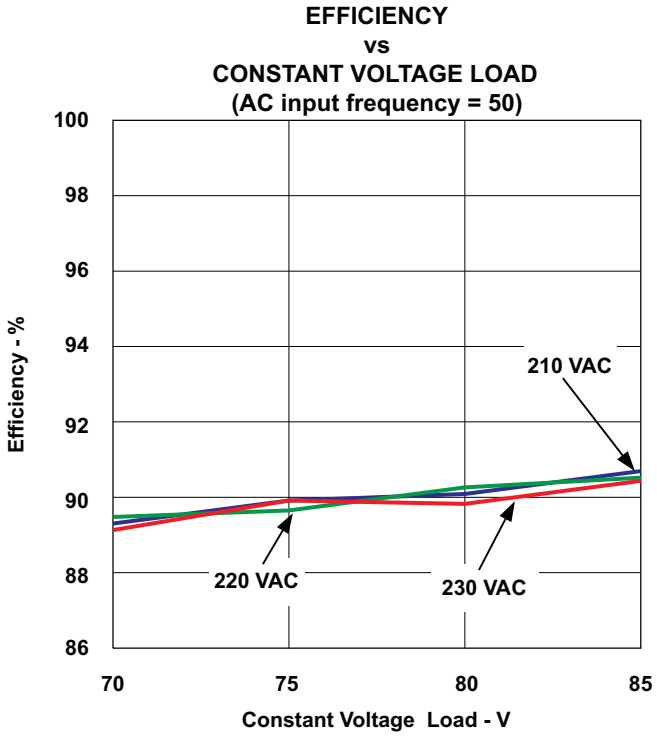

Figure 7. Isolated 240-W LED Driver Efficiency

5.3 Load Regulation

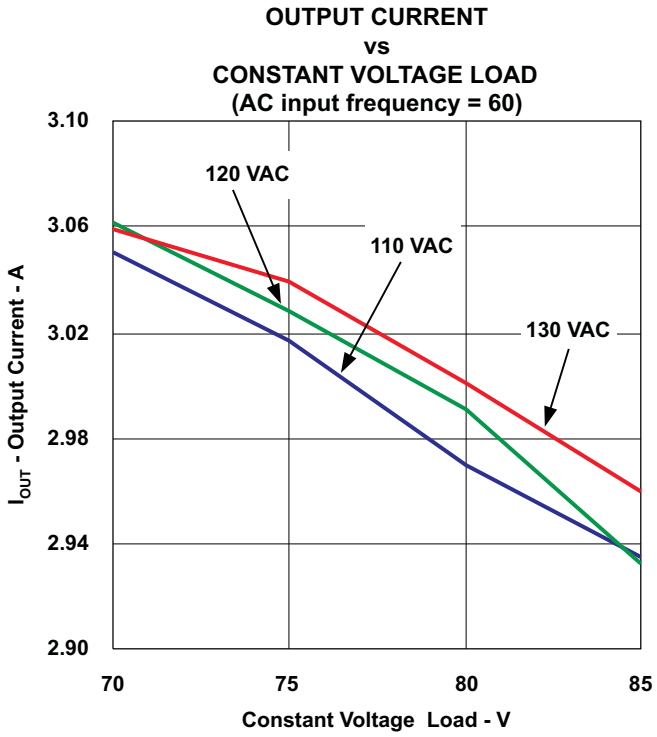

Figure 8. Isolated 240-W LED Driver Load Regulation

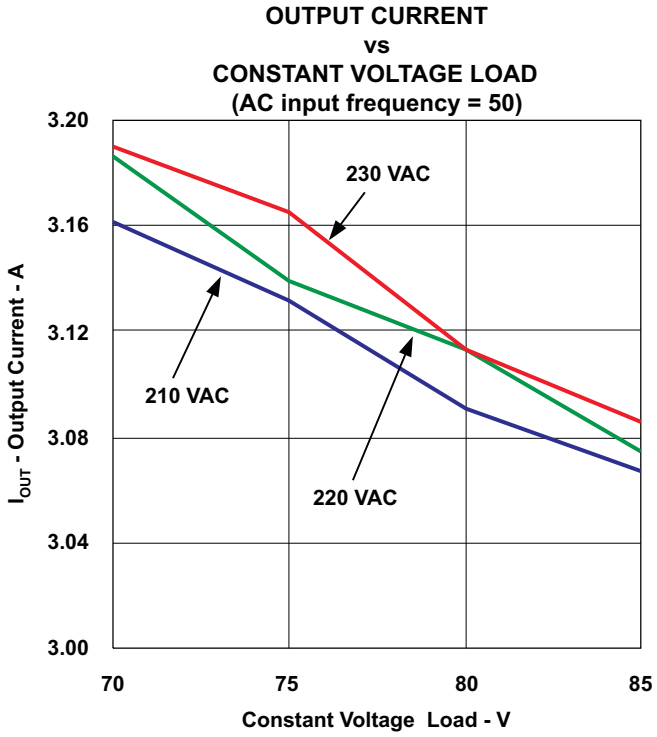

Figure 9. Isolated 240-W LED Driver Load Regulation

5.4 PFC Stage

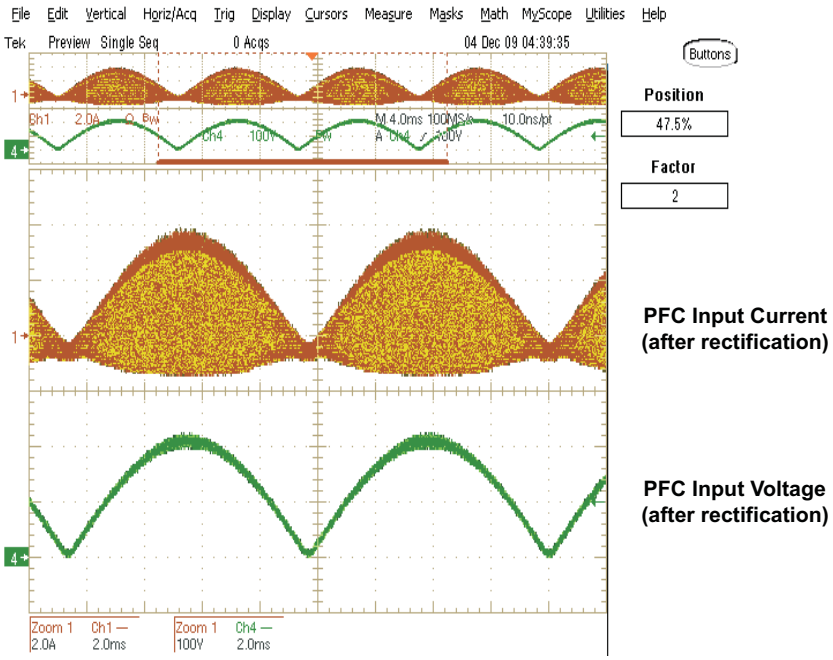

Figure 10. Isolated 240-W LED Driver PFC Stage Waveforms

5.5 Buck Stage

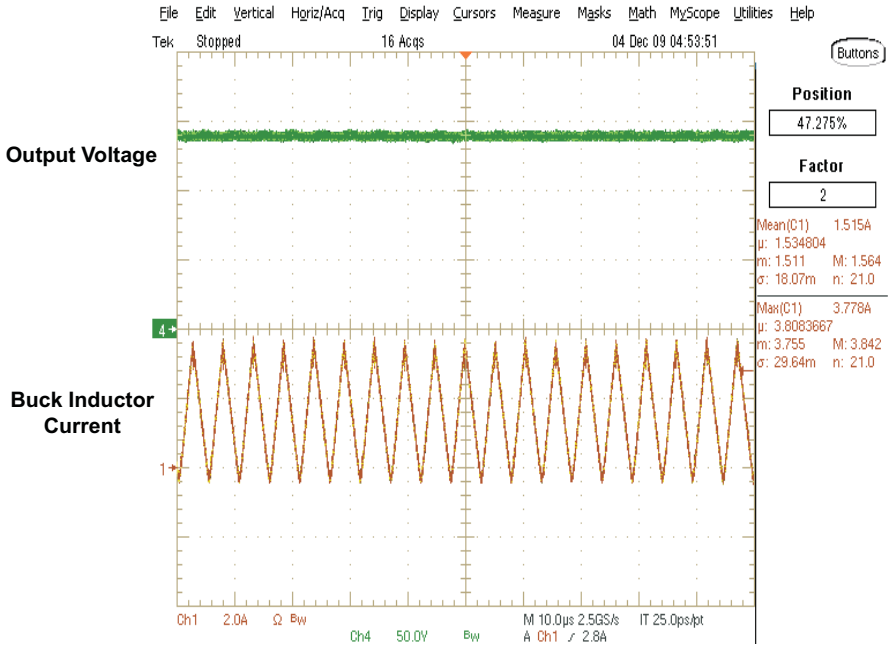

Figure 11. Isolated 240-W LED Driver Buck Stage Waveforms

5.6 Isolation Stage

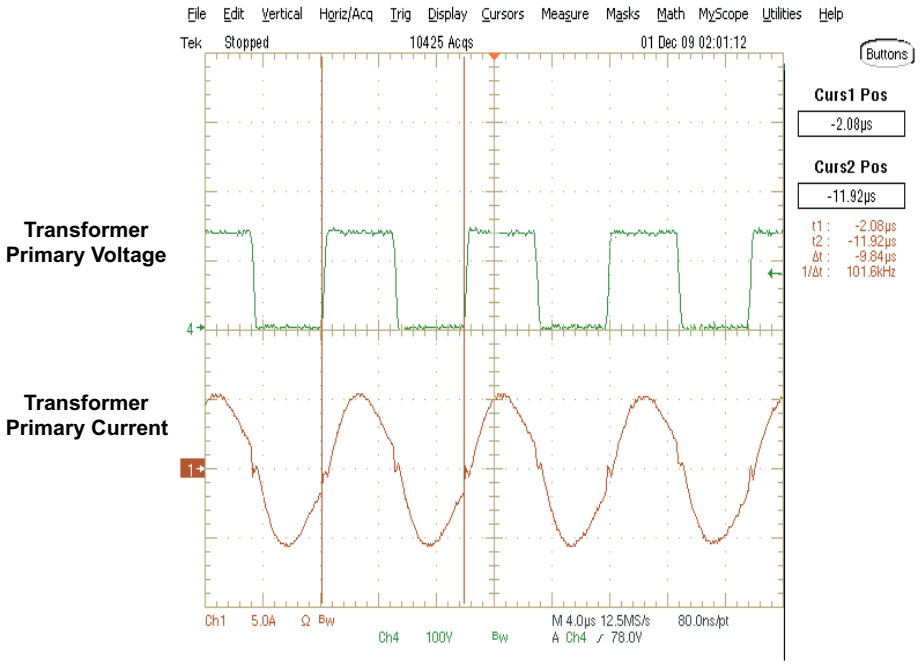

Figure 12. Isolated 240-W LED Driver Isolation Stage Waveforms

5.7 Output Ripple

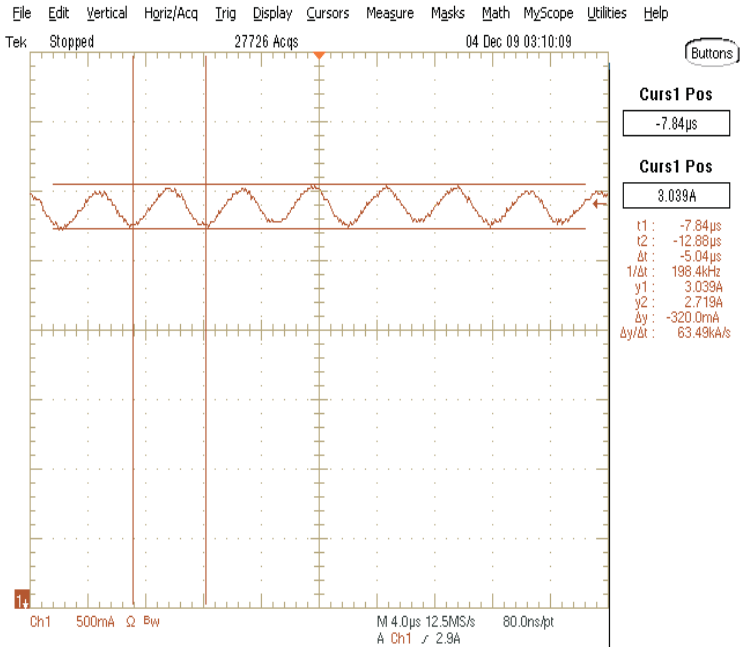

Figure 13. Isolated 240-W LED Driver Output Ripple Waveform

5.8 Assembly Drawing and PCB layout

The following figures (Figure 14 through Figure 15) show the design of the isolated 240-W LED Driver printed circuit board.

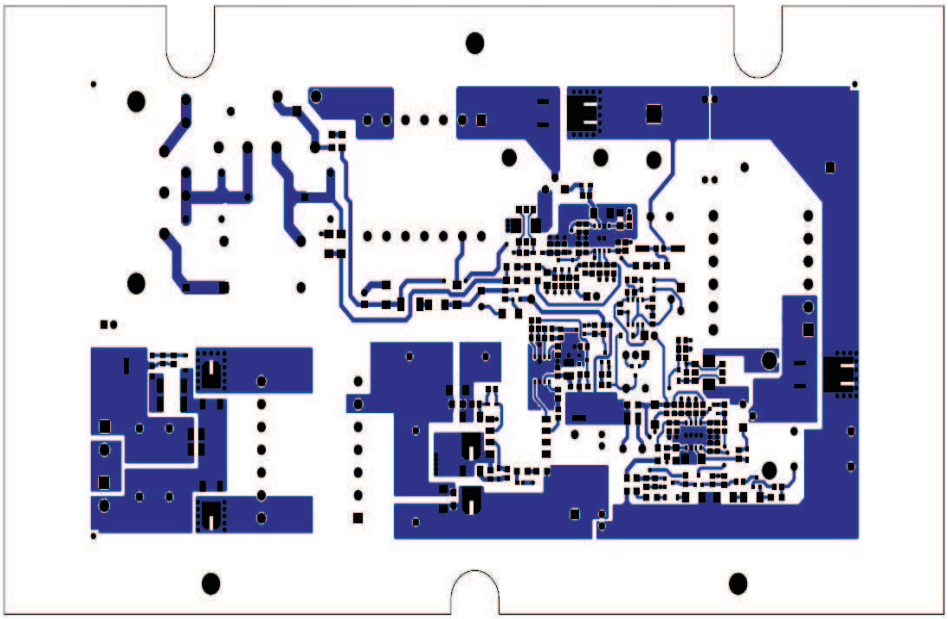

Figure 14. Isolated 240-W LED Driver PCB (top view)

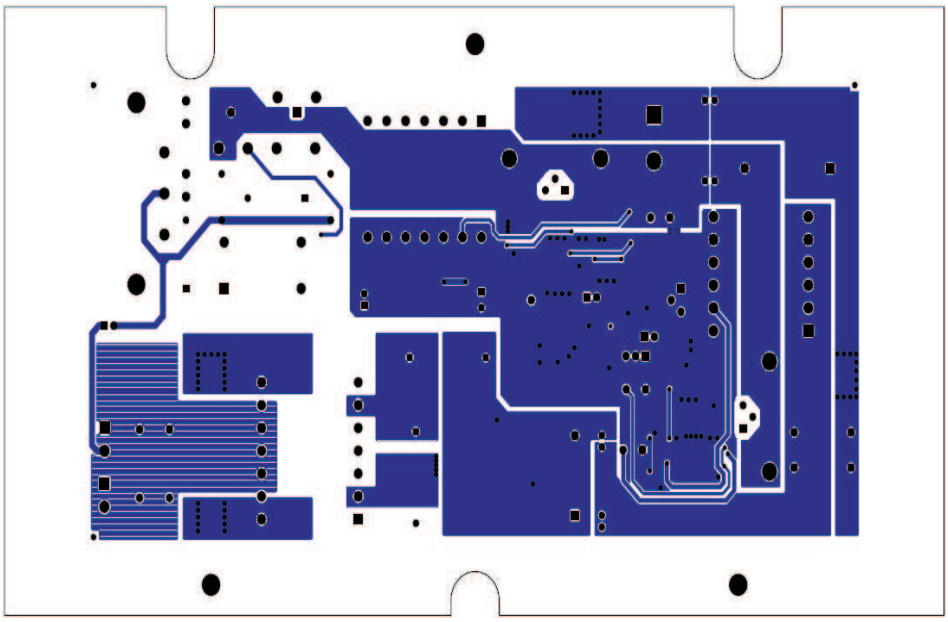

Figure 15. Isolated 240-W LED Driver PCB (bottom view)

6 List of Materials

Components list according to the schematic shown in Figure 1 to Figure 3.

Table 2. Isolated 240-W LED Driver Components List

QTY	REFDES	DESCRIPTION	MFR	PART NUMBER
1	C1	Capacitor, ceramic, 10 µF, 25 V, X5R, ±20%	Std	Std
2	C2, C5	Capacitor, metallized polyester film, 0.1 µF, 275 VAC, ±10%	Panasonic	ECQ-U2A104ML
2	C3, C4	Capacitor, ceramic disc, 1 nF, 250 V, Y1/X1	Panasonic	ECK-ANA102MB
1	C6	Capacitor, ceramic, 2.2 µF, 25 V, X7R, ±10%	Std	Std
6	C7, C9, C10, C21, C23, C25	Capacitor, ceramic, 1 nF, 50 V, NPO, ±5%	Std	Std
1	C8	Capacitor, ceramic, 330 nF, 16 V, X7R, ±10%	Std	Std
1	C11	Capacitor, ceramic, 18 pF, 50 V, NPO, ±5%	Std	Std
5	C12, C28, C34, C42, C45	Capacitor, ceramic, 1 µF, 25 V, X5R, ±10%	Std	Std
3	C13, C20, C29	Capacitor, ceramic, 0.1 µF, 25 V, X7R, ±10%	Std	Std
1	C14	Capacitor, polypropylene film, 0.56 µF, 400 V, ±55%	Panasonic	ECW-F4564JL
1	C15	Capacitor, aluminum electrolytic, 220 µF, 35 V, ±20%	Std	Std
1	C16	Capacitor, aluminum electrolytic, 100 µF, 35 V, ±20%	Std	Std
1	C17	Capacitor, aluminum electrolytic, 120- µF, 450 V, TS-HB	Panasonic	ECO-S2WB121BA
2	C18, C44	Capacitor, ceramic, 10 µF, 25 V, X7R, ±10%	Std	Std
3	C19, C22, C35	Capacitor, ceramic, 10 nF, 50 V, X7R, ±10%	Std	Std
2	C24, C50	Capacitor, ceramic, 100 pF, 50 V, NPO, ±5%	Std	Std
1	C26	Capacitor, ceramic, 47 pF, 50 V, NPO, ±5%	Std	Std
1	C27	Capacitor, ceramic, 33 pF, 50 V, NPO, ±5%	Std	Std
1	C30	Capacitor, polypropylene film, 0.56 µF, 630 V, ±5%	Panasonic	ECW-F6564JL
2	C31, C32	Capacitor, metallized polyester film, 0.47 µF, 400 V, ±10%	Panasonic	ECQ-E4474KF
1	C33	Capacitor, ceramic, 470 pF, 50 V, NPO, ±5%	Std	Std
2	C36, C37	Capacitor, polypropylene film, 1.2 µF, 250 V, ±5%	Panasonic	ECW-F2125JB
2	C43, C53	Capacitor, metallized polyester film, 2.2 µF, 250 V, 10%	Panasonic	ECQ-E2225KF
1	C41	Capacitor, ceramic, 0.027 µF, 50 V, X7R, ±10%	Std	Std
1	C51	Capacitor, polypropylene film, 0.56 µF, 400 V, ±5%	Panasonic	ECW-F4564JL
2	CL1, CL2	Current loop, wire, 20 ga, stranded, 3.0 in.	Std	NA
2	D1, D2	Diode, 1.5 A, 600 V	Vishay	BYG10J
1	D3	Diode, bridge rectifier, 6 A, 600 V	Diodes	GBJ606
2	D4, D16	Diode, Schottky, 1.5 A, 30 V	Vishay	SL13-E3/61T
2	D5, D7	Diode, Schottky, 1 A, 90 V	Vishay	BYS11-90-E3/TR
5	D6, D17, D25, D27, D43	Diode, switching, 90 V, 225 mA Ifm, high speed	Rohm	1SS355
2	D8, D18	Diode, ultra fast, 8 A, 600 V	IR	HFA08TB60S
2	D9, D10	Diode, Zener, 18 V, 1 W	Diodes	SMAZ18-13

Table 2. Isolated 240-W LED Driver Components List (continued)

QTY	REFDES	DESCRIPTION	MFR	PART NUMBER
3	D11, D13, D15	Diode, signal, 300 mA, 75 V, 350 mW	Vishay	1N4148W
2	D12, D21	Diode, dual Schottky, 200 mA, 30 V	Vishay	BAT54C
1	D14	Diode, Zener, 5.1 V, 1 W	Vishay	SMAZ5V1-13-F
3	D19, D20, D22	Diode, Zener, 150 V, 1.5 W	Vishay	BZG03C150G
1	D23	Diode, Zener, 500 mW, 110 V	Onsemi	MMSZ5272BT1
1	D24	Diode, Zener, 12 V, 20 mA, 225 mW, 5%	Vishay	BZX84C12LT1G
2	D26, D29	Diode, fast recovery, 300 V, 8 A	ST	STTH803G
1	D31	Diode, LED, red, 2.1 V, 20 mA, 6 mcd	Lite On	LTST-C190CKT
3	D28, D32, D33	Rectifier, SMD ultrafast power, 600 V, 1 A	Onsemi	MURA160T3
1	F1	Fuse, slow, 5 mm x 20 mm, 3.15 A, 250 V	Std	Std
1	FH1	Fuse clip, 5 mm x 20 mm, PC mount	Wickmann	01000056H
2	HS1, HS2	Heatsink, TO-220, vertical-mount, 15°C/W	Aavid	593002B03400G
1	J1	Connector, AC receptacle, board mount, R/A, 9 mm	Qualtek	703W-00/54
2	J2, J3	Header, male 2 pin, 100-mil spacing, (36-pin strip)	Sullins	PTC36SAAN
1	J4	Header, male 3 pin, 100-mil spacing, (36-pin strip)	Sullins	PTC36SAAN
4	J7, J8, J9, J10	Terminal block, 2 pin, 15 A, 5.1 mm	OST	D120/2DS
1	L1	Inductor, thru hole, 47 µH, 3.50 A, 48 mΩ	muRata	33470C
1	L2	Transformer, 1 primary, 1 secondary, 100 µH, 6 A	WE	750311310
1	L3	Transformer, 1 primary, 1 secondary, 100 µH, 3 A	WE	750311311
7	Q1, Q2, Q4, Q7, Q8, Q9, Q13	Transistor, NPN, 75 V, 500 mA	Fairchild	MMBT2222A
2	Q3, Q5	MOSFET, N-channel, 650 V, 21 A, 165 mΩ	Infineon	IPP60R165CP
1	Q6	Bipolar, PNP, 500 V, 500 mA	Zetex	FMMT560
2	Q10, Q11	MOSFET, N-channel, 550 V, 22 A, 350 mΩ	Infineon	IPP50R350CP
1	Q12	Trans, GP NPN amplifier, 40 V_{CEO}, 1 A	Fairchild	PZT2222A
2	R1, R3	Resistor, chip, 301 kΩ, 1/4 W, 1%	Std	Std
2	R2, R5	Resistor, chip, 1.00 MΩ, 1/4 W, 1%	Std	Std
1	R4	Resistor, chip, 3.01 kΩ, 1/8 W, 1%	Std	Std
1	R6	Resistor, chip, 6.49 kΩ, 1/8 W, 1%	Std	Std
3	R7, R22, R28	Resistor, chip, 4.75 kΩ, 1/8 W, 1%	Std	Std
5	R8, R29, R30, R33, R44	Resistor, chip, 10.7 kΩ, 1/8 W, 1%	Std	Std
1	R9	Resistor, chip, 24.3 kΩ, 1/8 W, 1%	Std	Std
1	R10	Resistor, chip, 6.81 kΩ, 1/8 W, 1%	Std	Std
1	R11	Resistor, chip, 8.45 kΩ, 1/8 W, 1%	Std	Std
1	R12	Resistor, chip, 332 Ω, 1/8 W, 1%	Std	Std
3	R13, R15, R40	Resistor, chip, 511 kΩ, 1/4 W, 1%	Std	Std
2	R14, R16	Resistor, chip, 100 kΩ, 1/4 W, 1%	Std	Std

Table 2. Isolated 240-W LED Driver Components List (continued)

QTY	REFDES	DESCRIPTION	MFR	PART NUMBER
1	R17	Resistor, chip, 47.5 kΩ, 1/8 W, 1%	Std	Std
3	R18, R37, R49	Resistor, chip, 21.5 kΩ, 1/8 W, 1%	Std	Std
2	R19, R36	Resistor, chip, 10.0 Ω, 1/8 W, 1%	Std	Std
2	R20, R21	Resistor, chip, 0.40 Ω, 1 W, 1%	Std	Std
1	R23	Resistor, chip, 200 Ω,1/2 W, 5%	Std	Std
4	R24, R42, R55, R56	Resistor, chip, 10.0 kΩ, 1/8 W, 1%	Std	Std
2	R25, R46	Resistor, chip, 100 kΩ, 1/8 W, 1%	Std	Std
1	R26	Potentiometer, 3/8 cermet, singleturn, flat	Bourns	3362P-504
1	R27	Resistor, chip, 1.00 kΩ, 1/4 W, 1%	Std	Std
3	R31, R32, R45	Resistor, chip, 15.0 kΩ, 1/8 W, 1%	Std	Std
1	R34	Resistor, chip, 560 Ω, 1/8 W, 1%	Std	Std
1	R39	Resistor, chip, 798 kΩ, 1/4 W, 1%	Std	Std
1	R41	Resistor, chip, 4.75 kΩ, 1/4 W, 1%	Std	Std
1	R43	Resistor, chip, 221 kΩ, 1/8 W, 1%	Std	Std
2	R47, R48	Resistor, chip, 221 kΩ, 1/4 W, 1%	Std	Std
1	R50	Resistor, chip, 2.00 kΩ, 1/8 W, 1%	Std	Std
1	R51	Resistor, chip, 8.87 kΩ, 1/8 W, 1%	Std	Std
3	R52, R53, R54	Resistor, chip, 4.70 kΩ, 1/8 W, 1%	Std	Std
1	R57	Resistor, chip, 1.87 kΩ, 1/8 W, 1%	Std	Std
1	R58	Resistor, chip, 6.19 kΩ, 1/8 W, 1%	Std	Std
2	R59, R66	Resistor, chip, 10.7 kΩ, 1/8 W, 1%	Std	Std
1	R60	Resistor, chip, 17.4 kΩ, 1/8 W, 1%	Std	Std
1	R61	Resistor, chip, 825 Ω, 1/8 W, 1%	Std	Std
2	R62, R63	Resistor, chip, 470 kΩ, 1/4 W, 1%	Std	Std
2	R64, R67	Resistor, Chip, 124 kΩ, 1/4 W, 1%	Std	Std
1	R65	Resistor, chip, 47.0 kΩ, 1/8 W, 1%	Std	Std
1	R81	Resistor, 56 Ω, 0603	Std	Std
1	R83	Resistor, 3.01 kΩ, 0603	Std	Std
1	T1	Xfmr, center tapped, voice over IP	ICE	GT03-111-110-A
1	T2	Transformer, half bridge, 200 µH	WE	750311314
1	T5	XFMR: current sense 1:100	Xfmrs	031-00020
2	TP1, TP2	Test point, SMT	Keystone	5015
4	TP3, TP4, TP6, TP9	Test point, white, thru hole color keyed	Keystone	5002
3	TP5, TP7, TP8	Test point, black, thru hole color keyed	Keystone	5001
1	U1	LED Lighting Power Controller	TI	UCC28810D
1	U2	Timer, Low-Power CMOS	TI	TLC555D
1	U3	LED Lighting Power Controller	TI	UCC28811D
1	U4	Resonant Mode Controller	TI	TPS92020

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