CIRRUS LOGIC®

CDB1610-8W

CDB1610-8W
8 Watt Demonstration Board

Features

- Quasi-resonant Flyback with Constant-current Output
- Flicker-free Dimming
- Line Voltage 120VAC, ±10%
- Rated Input Power: 8.3W
- Rated Output Power: 7.0W
- Efficiency: 84% at 460mA, for 5×LEDs in series
- Low Component Count
- Supports Cirrus Logic Product CS1610

General Description

The CDB1610-8W reference design demonstrates the performance of the CS1610 resonant mode AC/DC dimmable LED driver IC with a 460mA output driving 5×LEDs in series. It offers best-in-class dimmer compatibility with leading-edge, trailing-edge, and digital dimmers.

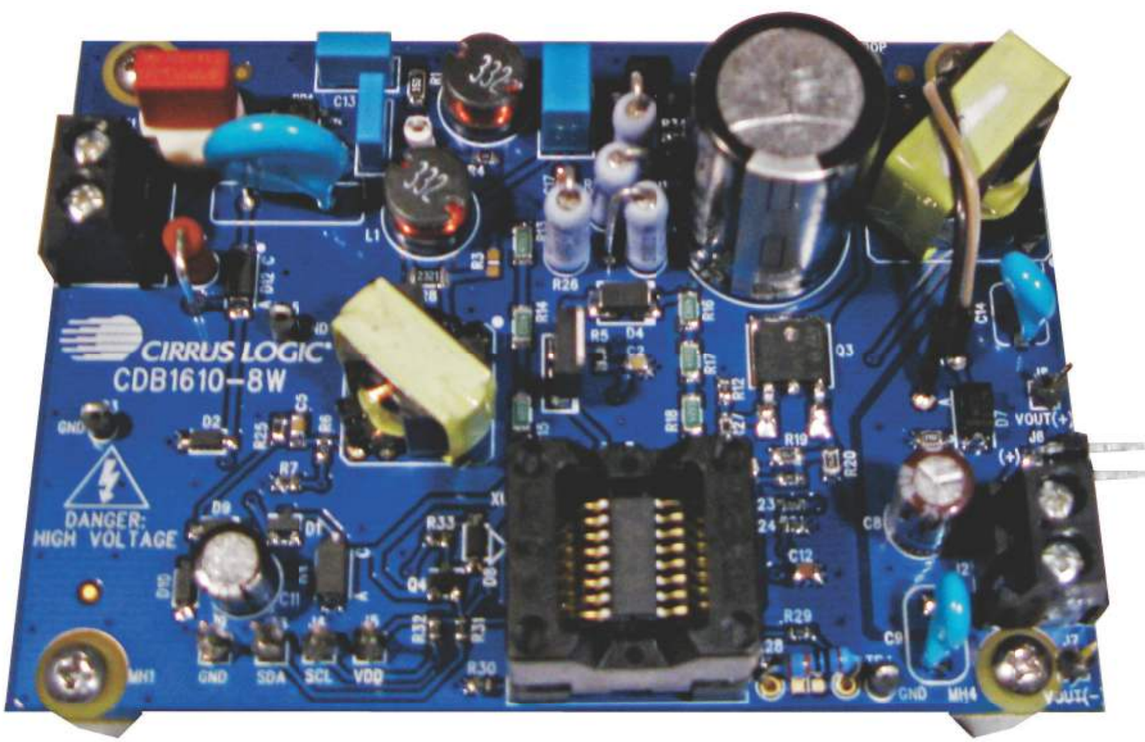
DIMENSIONS (OVERALL)

Length	Width	Height
3.62″(91.9*mm*) ×	2.54″(64.5*mm*) ×	1.108″(28*mm*)

For more information, see Figure 3.

ORDERING INFORMATION

CDB1610-8W-Z 8 Watt Reference Design
Supports CS1610



IMPORTANT SAFETY INSTRUCTIONS

Read and follow all safety instructions prior to using this demonstration board.

This Engineering Evaluation Unit or Demonstration Board must only be used for assessing IC performance in a laboratory setting. This product is not intended for any other use or incorporation into products for sale.

This product must only be used by qualified technicians or professionals who are trained in the safety procedures associated with the use of demonstration boards.

DANGER **Risk of Electric Shock**

- The direct connection to the AC power line and the open and unprotected boards present a serious risk of electric shock and can cause serious injury or death. Extreme caution needs to be exercised while handling this board.
- Avoid contact with the exposed conductor or terminals of components on the board. High voltage is present on exposed conductor and it may be present on terminals of any components directly or indirectly connected to the AC line.
- Dangerous voltages and/or currents may be internally generated and accessible at various points across the board.
- Charged capacitors store high voltage, even after the circuit has been disconnected from the AC line.
- Make sure that the power source is off before wiring any connection. Make sure that all connectors are well connected before the power source is on.
- Follow all laboratory safety procedures established by your employer and relevant safety regulations and guidelines, such as the ones listed under, OSHA General Industry Regulations - Subpart S and NFPA 70E.

WARNING Suitable eye protection must be worn when working with or around demonstration boards. Always comply with your employer's policies regarding the use of personal protective equipment.

WARNING All components and metallic parts may be extremely hot to touch when electrically active.

Contacting Cirrus Logic Support

For all product questions and inquiries contact a Cirrus Logic Sales Representative. To find the one nearest to you go to www.cirrus.com

1. INTRODUCTION

The CS1610 is a 120VAC quasi-resonant flyback mode dimmable LED controller IC. The CS1610 uses a digital control algorithm that is optimized for high efficiency and >0.9 power factor over a wide input voltage range (108VAC to 132VAC). The CS1610 integrates a critical conduction mode (CRM) boost converter that provides power factor correction and dimmer compatibility with a constant output current, quasi-resonant flyback stage. An adaptive dimmer compatibility algorithm controls the boost stage and dimmer compatibility operation mode to enable flicker-free operation to <2% output current with leading-edge, trailing-edge, and digital dimmers.

The CDB1610-8W board is optimized to deliver low system cost in a high-efficiency, flicker-free, phase-dimmable, solid-state lighting (SSL) solution for incandescent lamp replacement applications. The feedback loop is closed through an integrated digital control system within the IC. The variation in switching frequency also provides a spread-frequency spectrum, thus minimizing the conducted EMI filtering requirements. Protection algorithms such as output open/short, current-sense resistor open/short, and overtemperature thermistors protect the system during abnormal conditions. Details of these features are provided in the CS1610 data sheet.

The CDB1610-8W board demonstrates the performance of the CS1610. This reference board has been designed for an output load of 5×LEDs in series at 460mA (14.6V typical).

This document provides the schematic for the board. It includes oscilloscope screen shots that indicate various operating waveforms. Graphs are also provided that document the performance of the board in terms of Efficiency vs. Load and Power Factor vs. Load for the CS1610 dimmable LED controller IC. Extreme caution needs to be exercised while handling this board. This board is to be used by trained professionals only.

2. SCHEMATIC

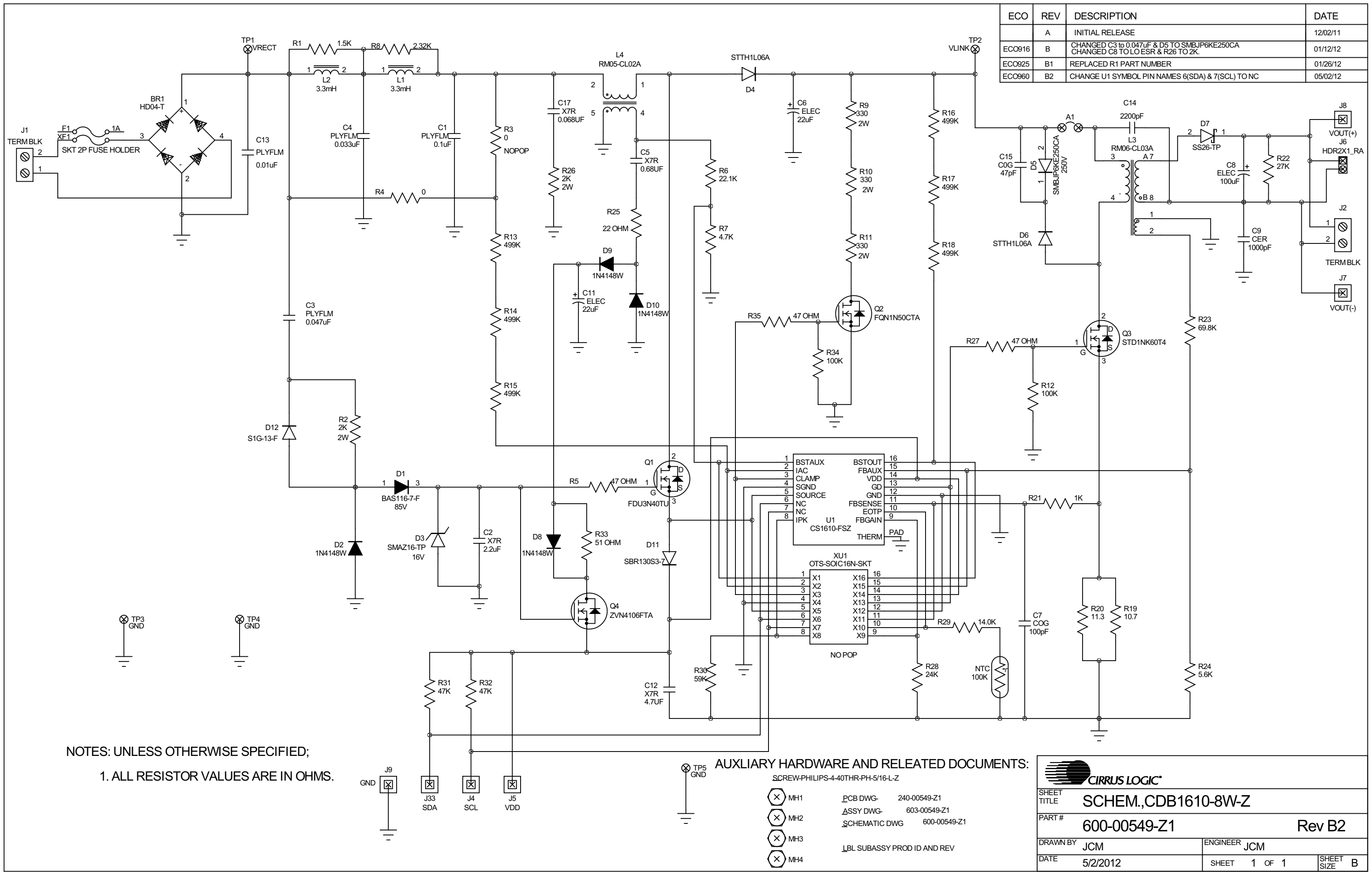


Figure 1. Schematic

3. BILL OF MATERIALS

Item	Rev	Description	Qty	Reference Designator	MFG	MFG P/N
1	A	WIRE 24 AWG SOLID PVC INS BLK NPb	1	A1	ALPHA WIRE COMPANY	3050/1 BK005
2	A	DIODE RECT 400V 0.8A NPB MINIDIP	1	BR1	DIODES INC	HD04-T
3	A	CAP 0.1uF ±10% 250V POLY NPb RAD	1	C1	EPCOS	B32529C3104K
4	A	CAP 2.2uF ±10% 25V X7R NPb 0805	1	C2	MURATA	GRM21BR71E225KA73L
5	A	CAP 0.047uF ±10% 630V POLY NPb RAD	1	C3	PANASONIC	ECQE6473KF
6	A	CAP 0.033uF ±10% 250V POLY NPb RAD	1	C4	EPCOS	B32529C3333K
7	A	CAP 0.68uF ±10% 50V X7R NPb 0805	1	C5	KEMET	C0805C684K5RAC
8	A	CAP 22uF ±20% 450V ELEC NPb RAD	1	C6	PANASONIC-ECG	EEUEB2W220
9	A	CAP 100pF ±5% 50V C0G NPb 0603	1	C7	KEMET	C0603C101J5GAC
10	A	CAP 100uF ±20% 25V EL LO ESR NPb RD	1	C8	PANASONIC	EEUFM1E101
11	A	CAP 1000pF ±10% 2000V CER NPb RAD	1	C9	MURATA	DEBB33D102KA2B
12	A	CAP 22uF ±20% 35V ELEC NPb RAD	1	C11	PANASONIC	EEA-GA1V220H
13	A	CAP 4.7uF ±10% 25V X7R NPb 0805	1	C12	TDK	C2012X7R1E475K
14	A	CAP 0.01uF ±10% 250V POLY NPb RAD	1	C13	EPCOS	B32529C3103K
15	A	CAP 2200PF +80/-20% 2KV CER NPb RAD	1	C14	MURATA	DEBE33D222ZA2B
16	A	CAP 47pF ±5% 1000V C0G NPb 1206	1	C15	JOHANSON DIELECTRICS	102R18N470JV4E
17	A	CAP 0.068uF ±10% 250V X7R NPb 1206	1	C17	KEMET	C1206C683KARAC
18	A	DIODE SWT 85V 215mA NPb SOT-23	1	D1	DIODES INC	BAS116-7-F
19	A	DIODE FAST SW 75V 350mW NPb SOD123	4	D2 D8 D9 D10	DIODES INC	1N4148W-7-F
20	A	DIODE ZENER 16V 1W NPb DO-214AC	1	D3	MICRO COMMERCIAL	SMAZ16-TP
21	A	DIODE ULT FAST 600V 1A NPb SMA	2	D4 D6	ST MICROELECTRONICS	STTH1L06A
22	A	DIODE TVS 600W 250V BIDIR NPb SMBJ	1	D5	MCC	SMBJP6KE250CA
23	A	DIODE SKY RECT 60V 2A NPb DO-214AC	1	D7	MICRO COMMERCIAL(MCC)	SS26-TP
24	A	DIODE RECT 30V 1A NPb SOD-323	1	D11	DIODES INC	SBR130S3-7
25	A	DIODE RECT 400V 1A NPb SMA	1	D12	DIODES INC	S1G-13-F
26	A	FUSE 1A 250V TLAG NPb RAD	1	F1	LITTLE FUSE	39211000440
27	A	CON 2POS TERM BLK 5.08mm SPR NPb RA	2	J1 J2	WEIDMULLER	1716020000
28	A	HDR 1x1 ML .1"CTR S NPb GLD	6	J4 J5 J7 J8 J9 J33	SAMTEC	TSW-101-07-G-S
29	A	HDR 2x1 ML .1" RA GLD NPb TH	1	J6	SAMTEC	TSW-102-08-G-S-RA
30	A	IND 3.3mH ±10% 11.8OHM DCR NPb TH	2	L1 L2	COILCRAFT	RFB0807-332L
31	A	XFMR 3.1mH 10% NPb TH	1	L3	KUNSHAN EAGERNESS	RM06-CL03A
32	A	XFMR 1.45mH 10% NPb TH	1	L4	KUNSHAN EAGERNESS	RM05-CL02A
33	A	SPCR STANDOFF 4-40 THR .875L AL NPb	4	MH1 MH2 MH3 MH4	KEYSTONE	1809
34	A	THERM 100K OHM ±5% 0.10mA NPb 0603	1	NTC	MURATA	NCP18WF104J03RB
35	A	TRAN MOSFET nCH 2A 400V NPb I-PAK	1	Q1	FAIRCHILD SEMICONDUCTOR	FDU3N40TU
36	A	TRAN MOSFET nCH 0.38A 500V NPb TO92	1	Q2	FAIRCHILD	FQN1N50CTA
37	A	TRAN MOSFET nCH 1.0A 600V NPb DPAK	1	Q3	ST MICROELECTRONICS	STD1NK60T4
38	A	TRAN MOSFET nCH 60V.2A NPb SOT23-3	1	Q4	DIODES INC	ZVN4106FTA
39	A	RES 1.5k OHM 1/4W ±5% 1206 FILM	1	R1	DALE	CRCW12061K50JNEA
40	A	RES PWR 2.0K OHM 2W ±5% NPb AXL	2	R2 R26	VISHAY	PR02000202001JR500
41	A	RES 0 OHM 1/10W ±5% NPb 0603 FILM	0	R3	DALE	CRCW06030000Z0EA
42	A	RES 0 OHM 1/10W ±5% NPb 0603 FILM	1	R4	DALE	CRCW06030000Z0EA
43	A	RES 47 OHM 1/10W ±1% NPb 0603	3	R5 R27 R35	PANASONIC	ERJ3EKF47R0V
44	A	RES 22.1k OHM 1/10W ±1% NPb 0603	1	R6	DALE	CRCW060322K1FKEA
45	A	RES 4.70K OHM 1/10W ±1% NPb 0603	1	R7	PANASONIC	ERJ3EKF4701V
46	A	RES 2.32k OHM 1/4W ±1% 1206 FILM	1	R8	DALE	CRCW12062K32FKEA
47	A	RES 330 OHM 2W ±5% MTL FLM NPb AXL	3	R9 R10 R11	Panasonic - ECG	ERG2SJ331
48	A	RES 100k OHM 1/10W ±5% NPb 0603 FLM	2	R12 R34	DALE	CRCW0603100KJNEA
49	A	RES 499K OHM 1/4W ±1% NPb 1206	6	R13 R14 R15 R16 R17 R18	VISHAY	TNPW1206499KFEEA
50	A	RES 10.7 OHM 1/8W ±1% NPb 0805 FILM	1	R19	DALE	CRCW080510R7FKEA
51	A	RES 11.3 OHM 1/8W ±1% NPb 0805	1	R20	DALE	CRCW080511R3FKEA
52	A	RES 1k OHM 1/10W ±1% NPb 0603 FILM	1	R21	DALE	CRCW06031K00FKEA
53	A	RES 27K OHM 1/8W ±1% NPb 0805	1	R22	PANASONIC	ERJ6ENF2702V
54	A	RES 69.8k OHM 1/10W ±1% NPb 0603	1	R23	DALE	CRCW060369K8FKEA
55	A	RES 5.6k OHM 1/10W ±5% NPb 0603 FLM	1	R24	DALE	CRCW06035K60JNEA
56	A	RES 22.0 OHM 1/10W ±1% NPb 0603	1	R25	PANASONIC	ERJ3EKF22R0V
57	A	RES 24k OHM 1/10W ±1% NPb 0603 FILM	1	R28	DALE	CRCW060324K0FKEA
58	A	RES 14k OHM 1/10W ±1% NPB 0603 FILM	1	R29	DALE	CRCW060314K0FKEA
59	A	RES 59k OHM 1/10W ±1% NPb 0603 FILM	1	R30	DALE	CRCW060359K0FKEA
60	A	RES 47k OHM 1/10W ±5% NPb 0603 FILM	2	R31 R32	DALE	CRCW060347K0JNEA
61	A	RES 51.0 OHM 1/10W ±1% NPb 0603	1	R33	PANASONIC	ERJ3EKF51R0V
62	A	CON TEST PT .1" TIN PLATE WHT NPb	2	TP1 TP2	KEYSTONE	5002
63	A	CON TEST PT .1"CTR TIN PLAT NPb BLK	3	TP3 TP4 TP5	KEYSTONE	5001
64	B1	IC CRUS DIMMER LED DRVR NPb SOIC16	1	U1	Cirrus Logic	CS1610-FSZ/B1
65	A	FUSE MOUNT TR5/TE5 3mm 2P NPb TH	1	XF1	Littelfuse	56000001319
66	A	SCREW 4-40X5/16" PH MACH SS NPb	4	XMH1 XMH2MXH3 XMH4	BUILDING FASTENERS	PMSSS 440 0031 PH
67	A	SKT PINCH CONTACT FOR SOIC16	0	XU1	ENPLAS	OTS-16-1.27-03

Figure 2. Bill of Materials

4. BOARD LAYOUT

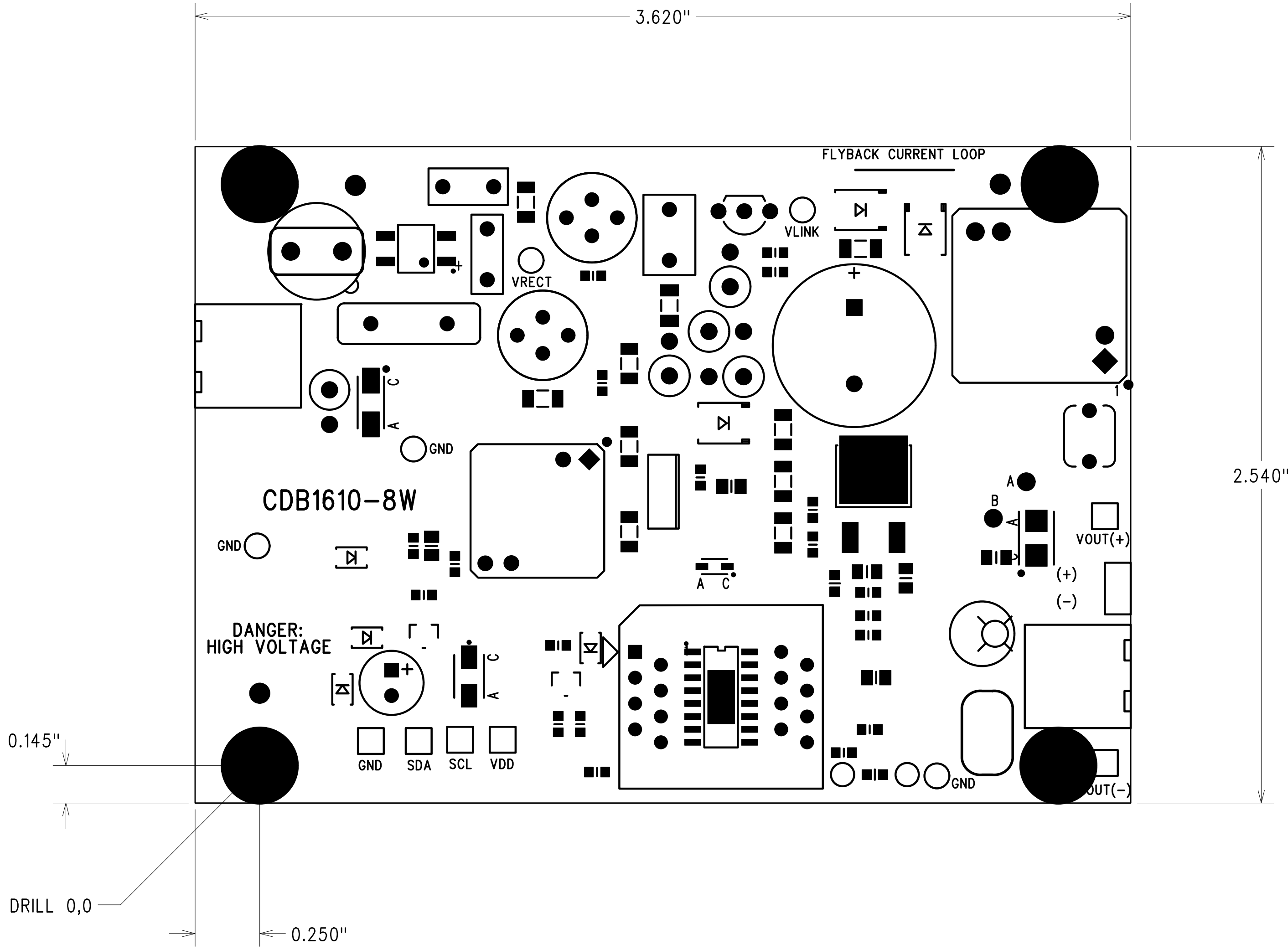


Figure 3. PCB Dimensions

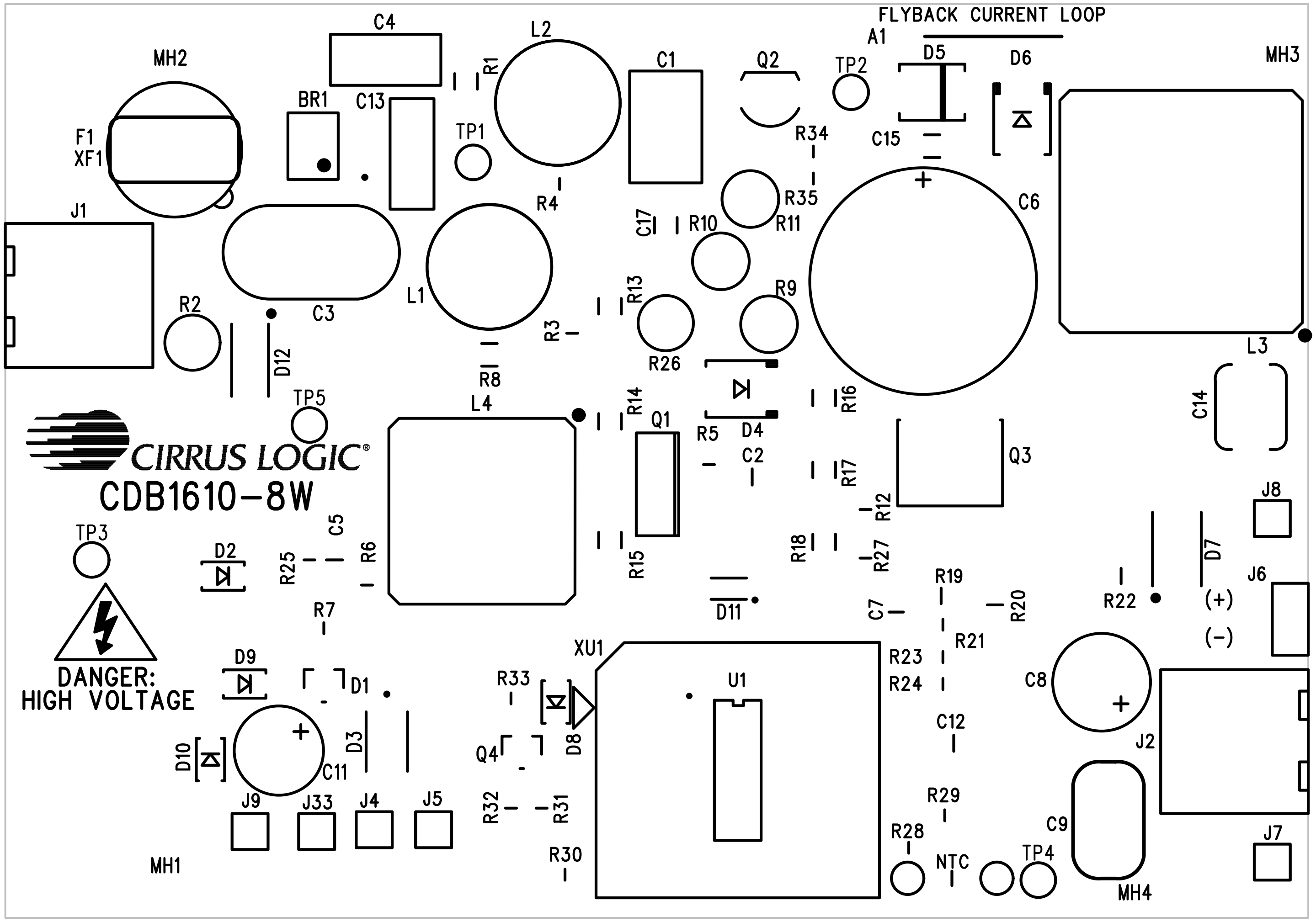


Figure 4. Top Silkscreen

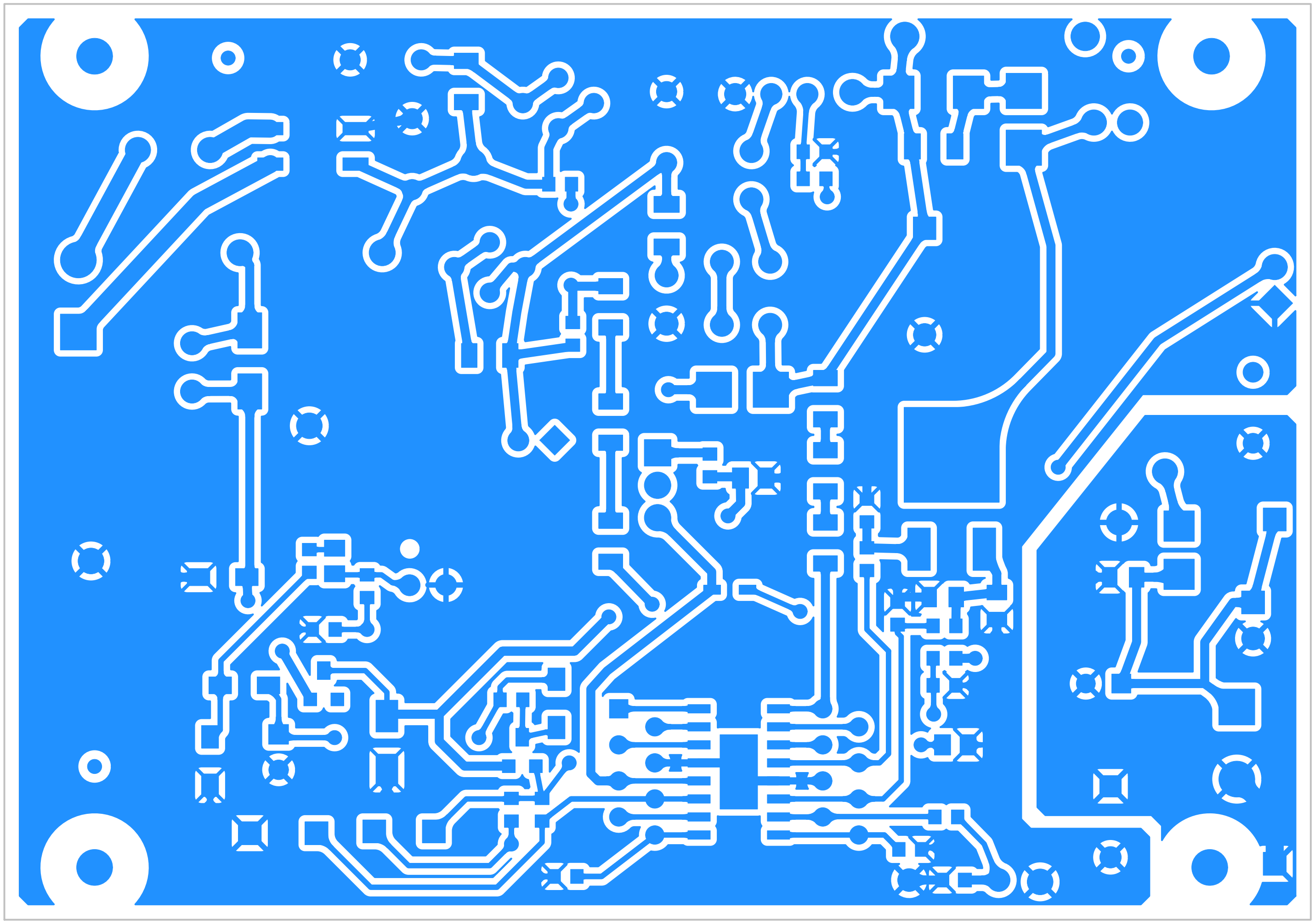


Figure 5. Top Routing

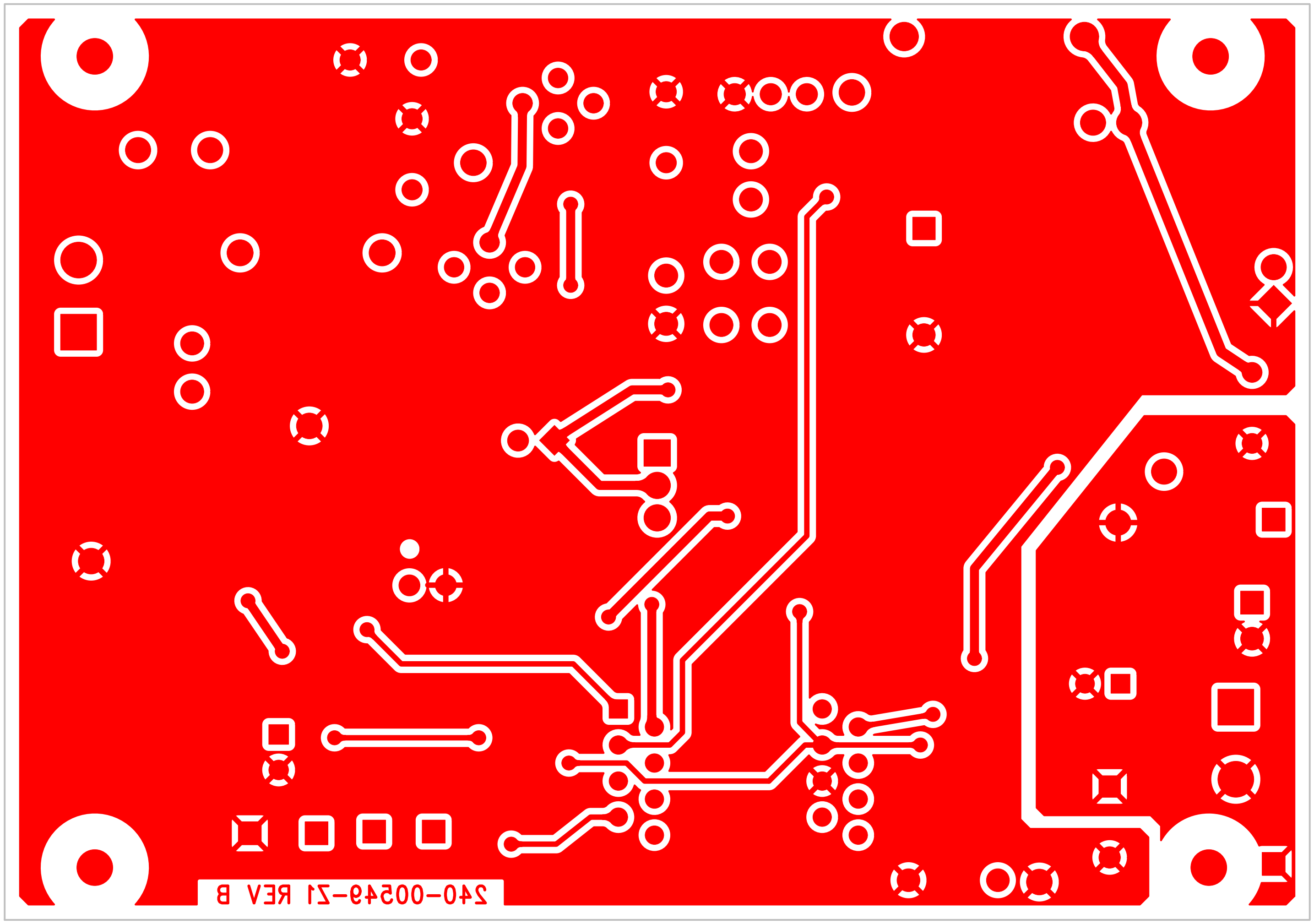


Figure 6. Bottom Routing

5. DIMMER COMPATIBILITY - CS1610 (108V - 132V)

Input Power	8.3W	Dimmer Compatibility	836/888	Efficiency	84.3%

Date	12/19/2011	**Power Factor[1,5]**	0.91
Vendor	Cirrus Logic	**EN55015 Compliant (Y/N)**	Y
Input Voltage	120V	**Nominal Input Power (W)[1,5]**	8.3
Form Factor	CRD1610-8W	**Maximum Input Power (W)[2,5]**	8.5
Model #	CDB1610-8W	**Output Voltage (V)[1,3]**	14.8
IC	CS1610	**Output Current (mA)[1,3]**	470
Topology	Boost/Flyback	**Output Current Ripple ≤ 120Hz (mA)[1,4]**	0
Isolation (Y/N)	Y	**Output Power (W)[1,5]**	7.0
Compatibility Spec.	1.0	**Efficiency (%)**	84.3

Dimmer Type	Flicker Free Steady-state			Monotonic Dimming			Max I_{out} (mA)			Min I_{out} (mA)			Total
	# of Lamps			# of Lamps			# of Lamps			# of Lamps			
	1	5	10	1	5	10	1	5	10	1	5	10	
Cooper - Leading Edge	Y	Y	Y	Y	Y	Y	470	470	469	14	14	22	23
Cooper - Leading Edge	Y	Y	Y	Y	Y	Y	470	470	470	9	9	9	24
GE - Leading Edge	Y	Y	Y	Y	Y	Y	470	469	470	9	9	9	24
Leviton - Leading Edge	Y	Y	N	Y	Y	Y	469	469	470	10	11	11	19
Leviton - Leading Edge	Y	Y	Y	Y	Y	Y	469	468	469	9	9	9	24
Leviton - Trailing Edge	Y	Y	Y	Y	Y	Y	469	469	469	11	10	9	24
Leviton - Trailing Edge	Y	Y	N	Y	Y	Y	469	469	470	63	60	56	16
Leviton - Leading Edge	Y	Y	Y	Y	Y	Y	469	469	469	9	9	9	24
Leviton - Leading Edge	Y	Y	N	Y	Y	Y	469	469	469	9	9	9	19
Leviton - Leading Edge	Y	Y	Y	Y	Y	Y	470	469	471	9	9	9	24
Leviton - Leading Edge	Y	Y	Y	Y	Y	Y	470	469	470	9	9	9	24
Leviton - Trailing Edge	Y	Y	Y	Y	Y	Y	469	469	470	9	9	9	24
Leviton - Leading Edge	Y	Y	Y	Y	Y	Y	469	470	469	9	9	9	24
Leviton - Leading Edge	Y	Y	Y	Y	Y	Y	469	469	469	56	54	51	21
Leviton - Leading Edge	Y	Y	Y	Y	Y	Y	470	470	469	9	9	9	24
Leviton - Leading Edge	Y	Y	Y	Y	Y	Y	470	469	470	12	13	11	24
Leviton - Occupancy Sensor	Y	Y	Y	Y	Y	Y	470	470	470	0	0	0	24
Leviton - Leading Edge	Y	Y	Y	Y	Y	Y	470	469	470	9	9	9	24
Lutron - Leading Edge	Y	Y	Y	Y	Y	Y	469	470	469	9	9	9	24
Lutron - Leading Edge	Y	Y	Y	Y	Y	Y	470	469	470	9	9	9	24
Lutron - Leading Edge	Y	Y	Y	Y	Y	Y	470	470	469	14	13	11	24

Dimmer Type	Flicker Free Steady-state			Monotonic Dimming			Max I_{out} (mA)			Min I_{out} (mA)			Total
	# of Lamps			# of Lamps			# of Lamps			# of Lamps			
	1	5	10	1	5	10	1	5	10	1	5	10	
Lutron - Trailing Edge	Y	Y	Y	Y	Y	Y	445	440	435	9	9	9	21
Lutron - Leading Edge	Y	Y	Y	Y	Y	Y	470	469	470	9	9	9	24
Lutron - Leading Edge	Y	Y	Y	Y	Y	Y	469	470	469	9	9	9	24
Lutron - Motion Sensor	Y	Y	Y	Y	Y	Y	470	469	470	0	0	0	24
Lutron - Leading Edge	Y	Y	Y	Y	Y	Y	470	470	470	9	9	9	24
Lutron - Leading Edge	Y	Y	Y	Y	Y	Y	433	427	421	9	9	9	21
Lutron - Leading Edge	Y	Y	Y	Y	Y	Y	470	469	470	9	9	9	24
Lutron - Leading Edge	Y	Y	Y	Y	Y	Y	469	469	469	9	9	9	24
Lutron - Leading Edge	Y	Y	Y	Y	Y	Y	469	469	470	9	9	9	24
Lutron - Trailing Edge	Y	Y	Y	Y	Y	Y	440	435	433	9	9	9	21
Lutron - Leading Edge	Y	Y	Y	Y	Y	Y	469	469	470	9	9	9	24
Lutron - Leading Edge	Y	Y	Y	Y	Y	Y	470	470	469	9	9	9	24
Lutron - Leading Edge	Y	Y	N	Y	N	N	469	470	0	9	9	0	16
Lutron - Leading Edge	Y	N	N	Y	Y	N	469	470	0	9	9	0	12
Lutron - Leading Edge	Y	Y	Y	Y	Y	Y	469	469	470	15	12	11	23
Pass & Seymour - Occupancy Sensor	Y	Y	Y	Y	Y	Y	469	469	470	0	0	0	24
												Overall Total	836

Notes:
1. Tested at nominal input voltage, nominal input frequency and without a dimmer after soaking for 15 minutes
2. Tested at nominal input voltage, nominal input frequency and with a dimmer after soaking for 15 minutes
3. Average
4. Peak-to-peak
5. Measured with Chroma 66202 Power Analyzer

6. INDUCTOR CONSTRUCTION

The CDB1610-8W includes a critical conduction mode (CRM) boost converter that provides power factor correction and dimmer compatibility with a constant output current, quasi-resonant flyback stage. The following sections describe the boost and flyback inductors installed on the CDB1610-8W.

6.1 Boost Inductor

The CS1610 uses an adaptive dimmer compatibility algorithm to control the boost inductor stage, which guarantees dimmer compatibility operation plus enables flicker-free operation with leading-edge, trailing-edge, and digital dimmers. The boost auxiliary winding is used for zero-current detection (ZCD) and supplies power to the CS1610.

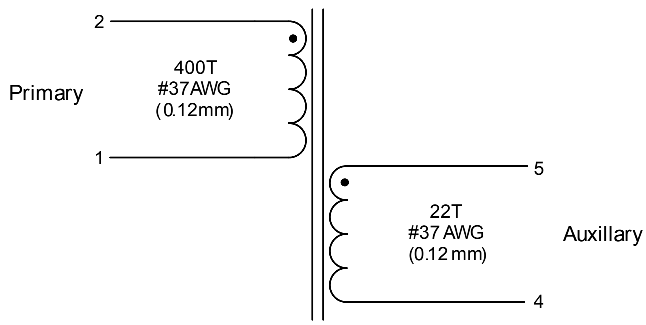


Figure 7. Boost Inductor Schematic

6.1.1 Electrical Specifications

Characteristics conditions:
- Operating temperature range: -25 °C to +120 °C (including coil heat)

Parameter	Condition	Symbol	Min	Typ	Max	Unit
Boost Inductor						
Primary Inductance (Note 6)	$f_{resonant}$=10kHz, 0.3V at 20°C	L_P	1.305	1.45	1.595	mH
Primary DC Resistance (Note 6)	t_{DCR}=20°C		3.28	4.1	4.92	Ω
Auxiliary DC Resistance (Note 7)	t_{DCR}=20°C		0.456	0.57	0.684	Ω

Notes: 6. Measured across pins 1 and 2.
7. Measured across pins 5 and 4.

6.2 Flyback Transformer

The flyback transformer stage is a quasi-resonant current-regulated DC-DC Converter capable of delivering the highest possible efficiency at a constant current while minimizing line frequency ripple. The auxiliary winding is used for zero-current detection and overvoltage protection.

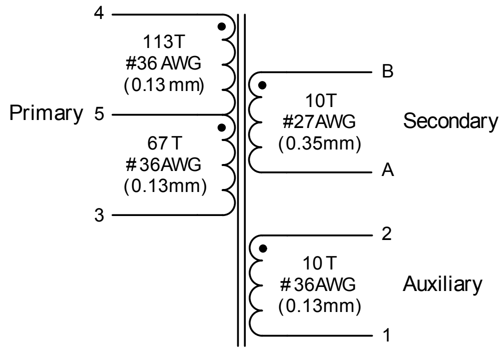


Figure 8. Flyback Transformer Schematic

6.2.1 Electrical Specifications

Characteristics conditions:

- Operating temperature range: -25 °C to +120 °C (including coil heat)

Parameter	Condition	Sym	Min	Typ	Max	Unit
Flyback Transformer						
Electrical Strength (Note 8)	$f_{operate}$=50/60Hz		-	4K	-	V_{RMS}
Primary Inductance (Note 9)	$f_{resonant}$=10kHz, 0.3V at 20°C	L_P	2.79	3.1	3.41	mH
Primary Leakage Inductance (Note 9)	$f_{resonant}$=10kHz, 0.3V at 20°C	L_K	-	-	15	µH
Primary DC Resistance (Note 9)	t_{DCR}=20°C		2.175	2.90	3.625	Ω
Secondary DC Resistance (Note 10)	t_{DCR}=20°C		-	-	0.22	Ω
Auxiliary DC Resistance (Note 11)	t_{DCR}=20°C		0.3975	0.53	0.6625	Ω

Notes: 8. Time = 2sec.
9. Measured across pins 3 and 4.
10. Measured across pins B and A.
11. Measured across pins 2 and 1.

7. PERFORMANCE PLOTS

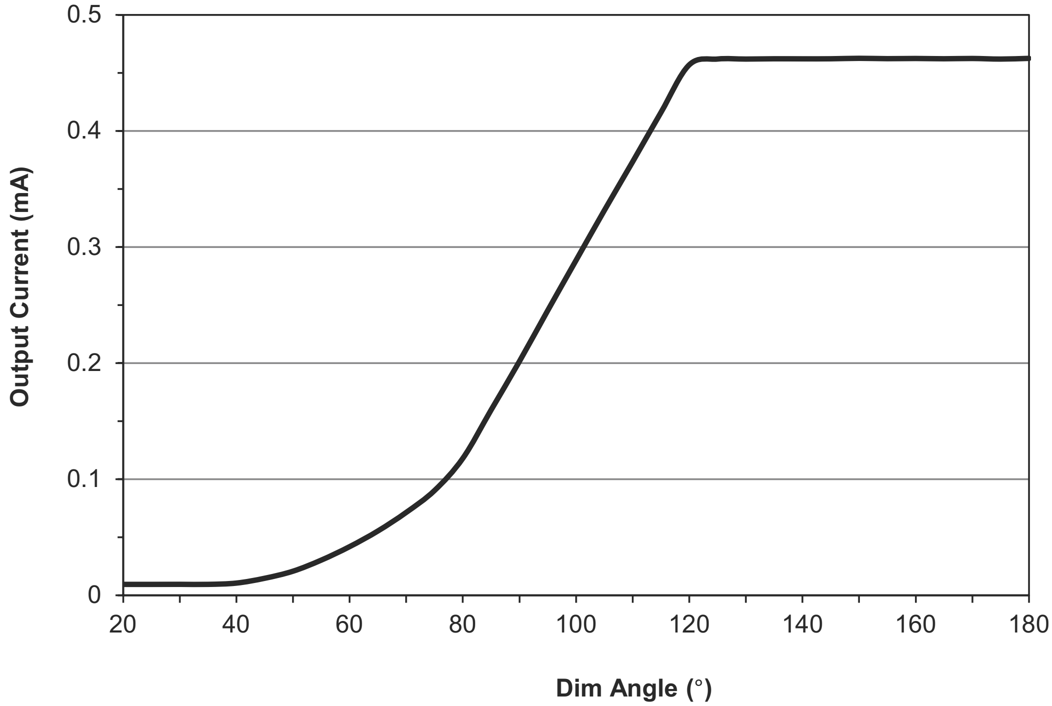


Figure 9. Typical Output Current vs. Dim Angle

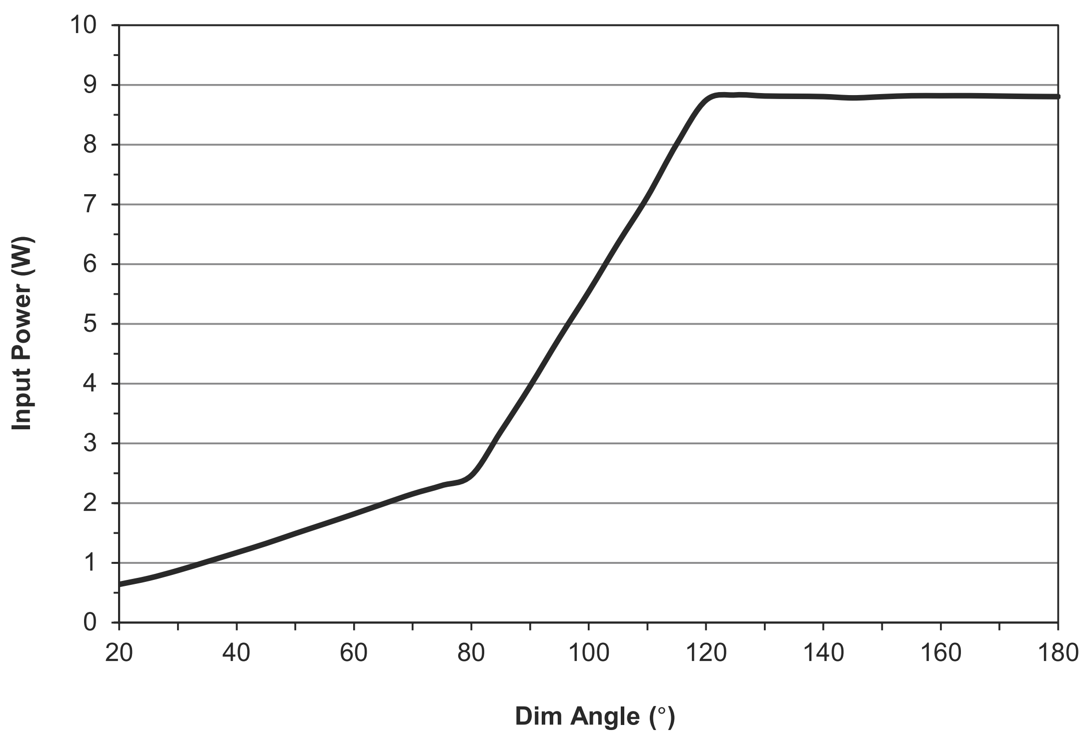


Figure 10. Typical Input Power vs. Dim Angle

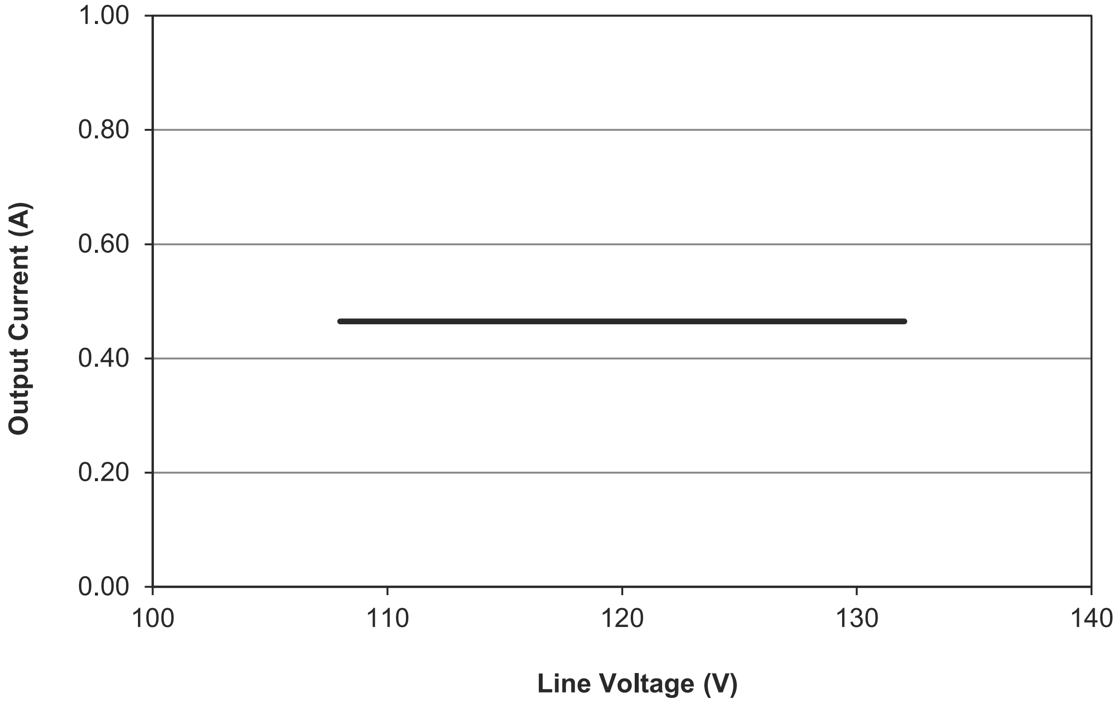


Figure 11. Output Current vs. Line Voltage, 108VAC to 132VAC

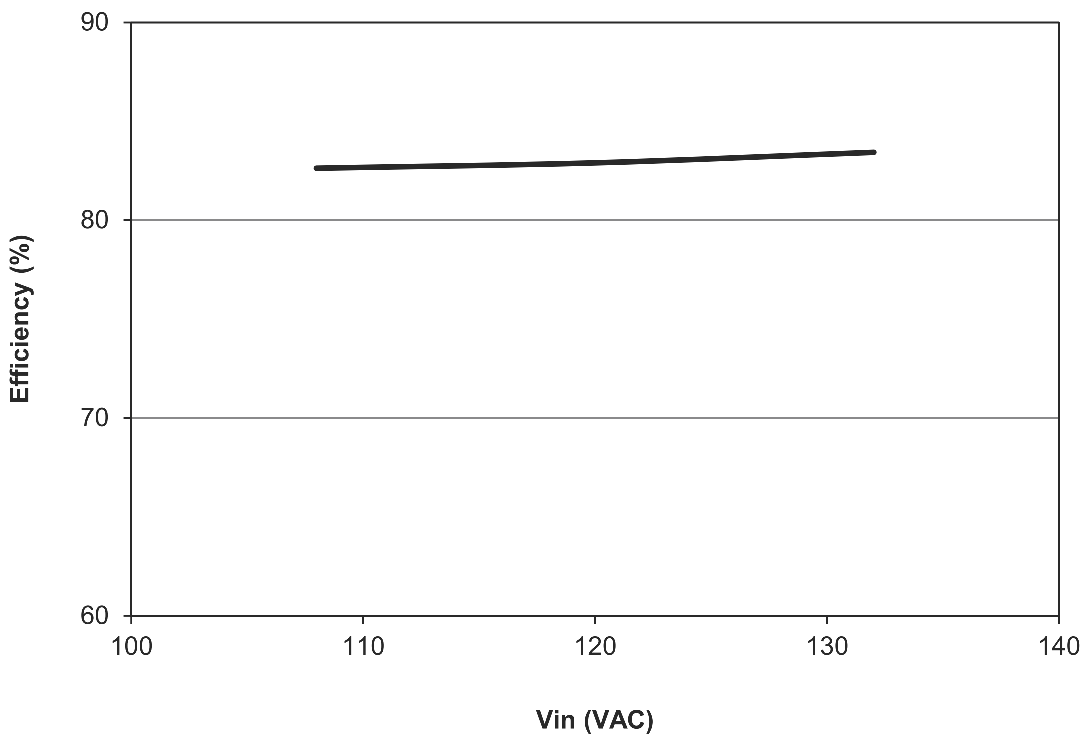


Figure 12. Typical Efficiency vs. Line Voltage, 108VAC to 132VAC

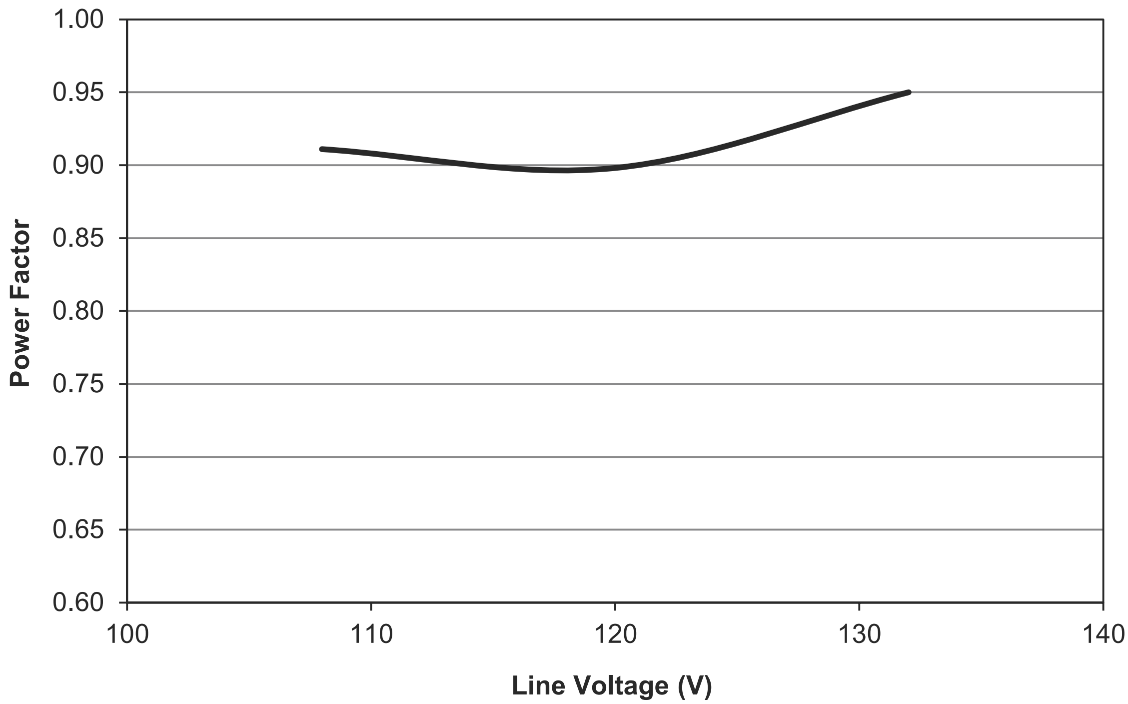


Figure 13. Power Factor vs. Line Voltage, 108VAC to 132VAC

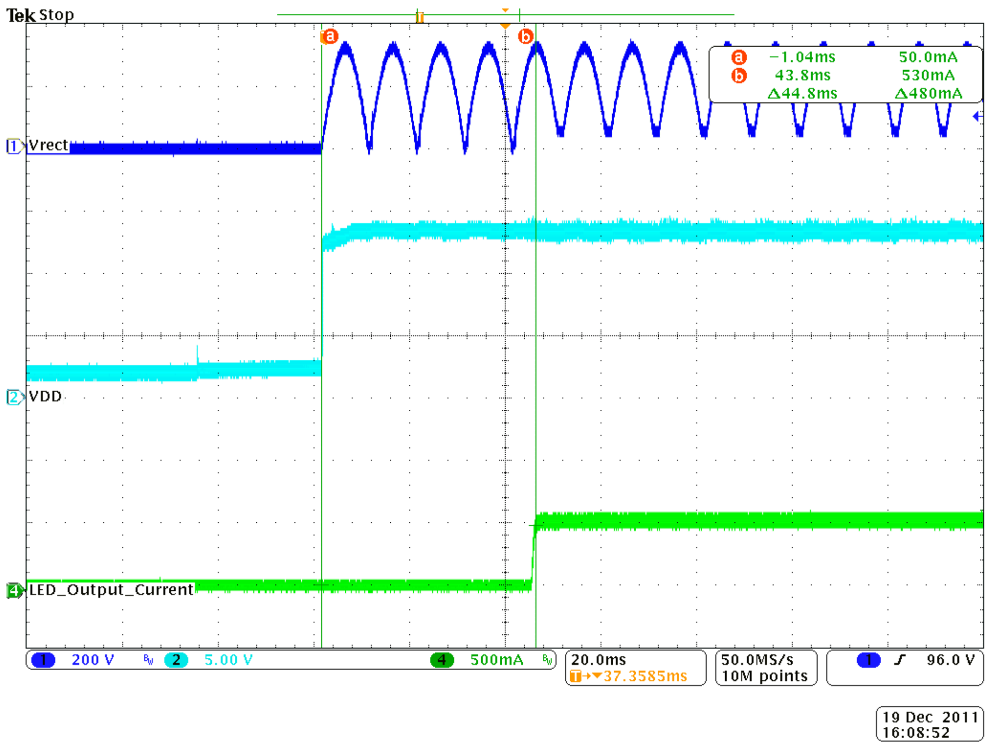


Figure 14. No-dimmer Mode, Startup 120 VAC

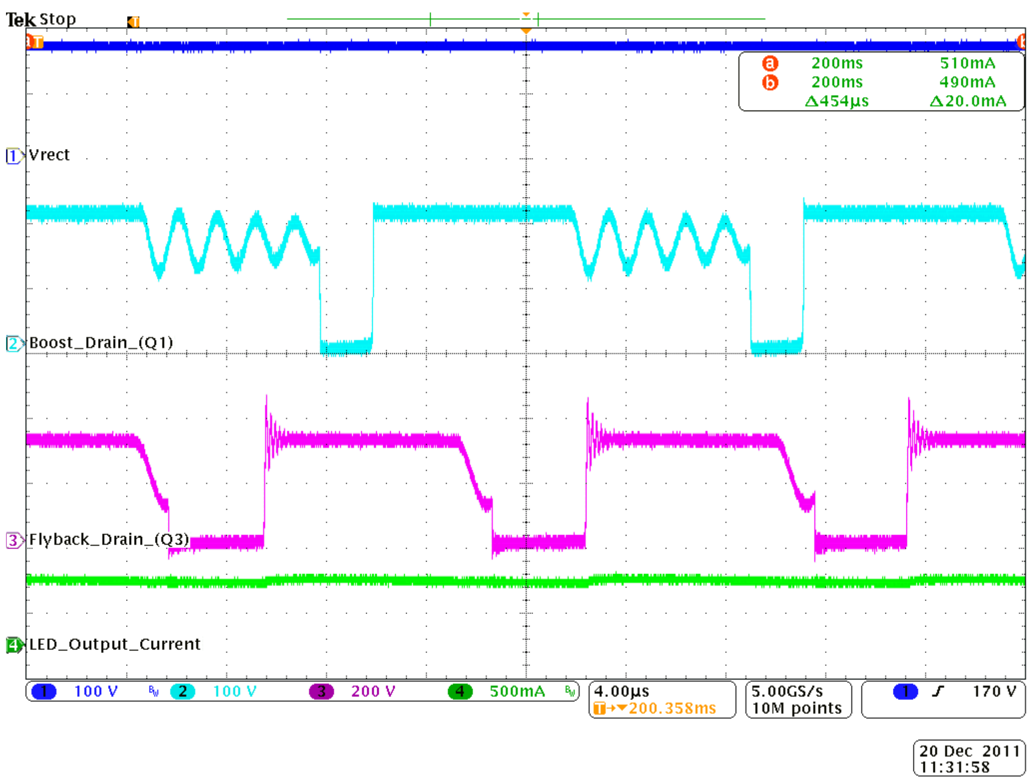


Figure 15. No-dimmer Mode, Steady-state, 120VAC

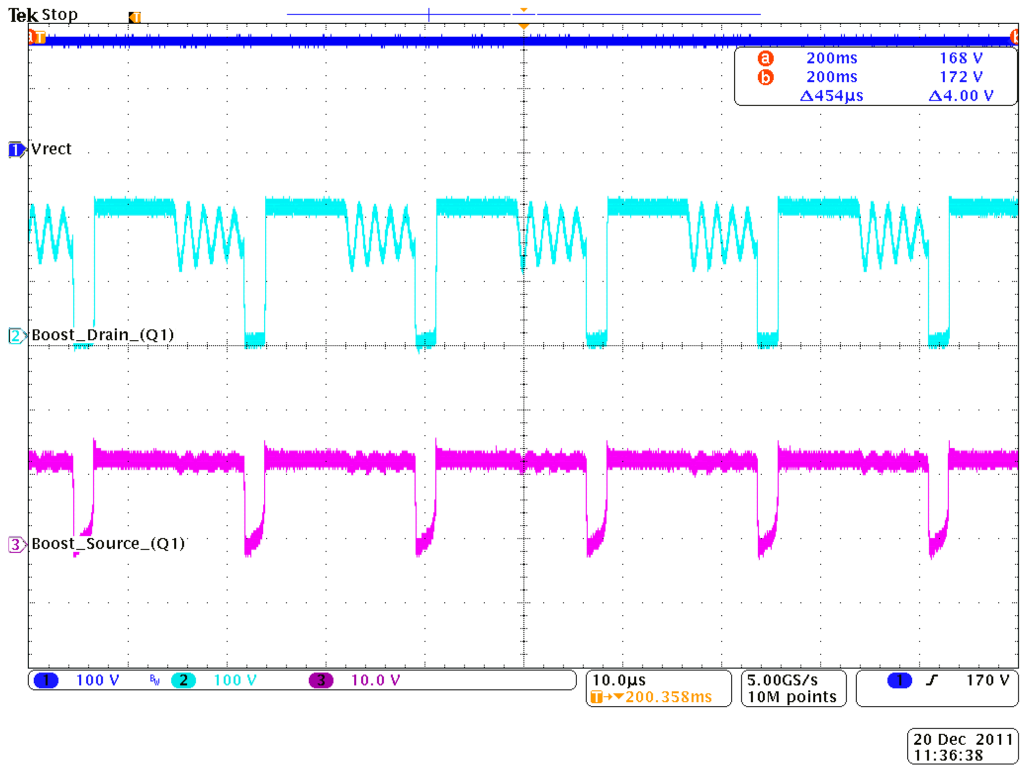


Figure 16. Boost FET, Q1, Waveform

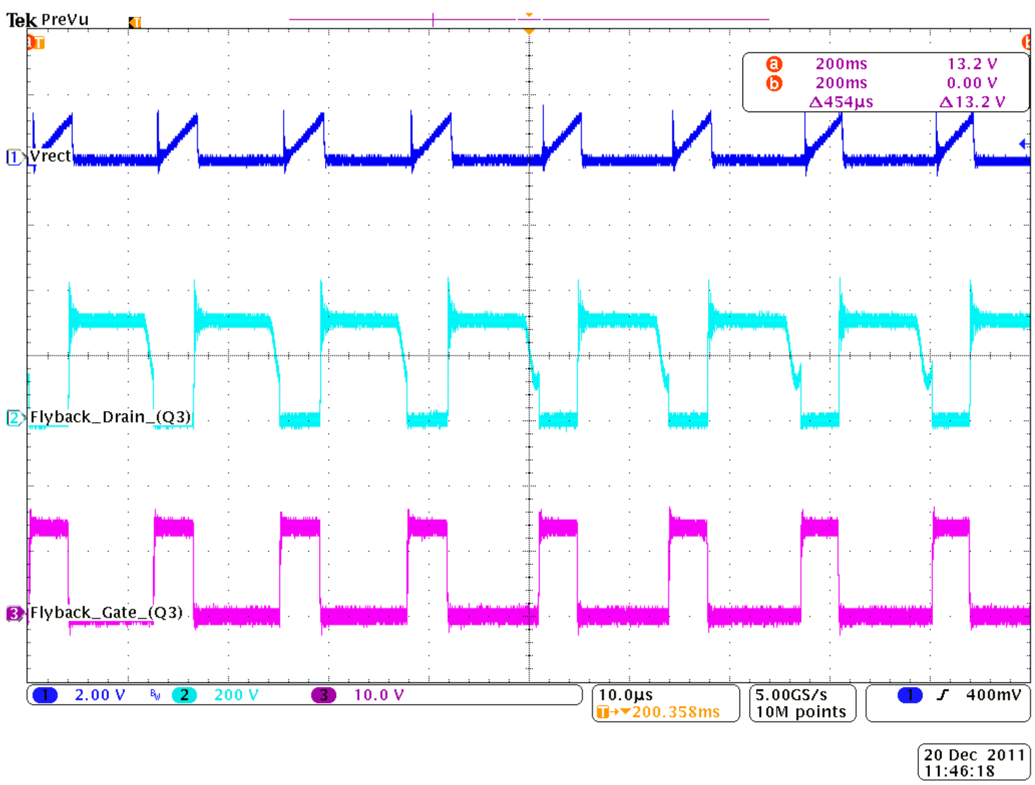


Figure 17. Flyback FET, Q3, Waveform

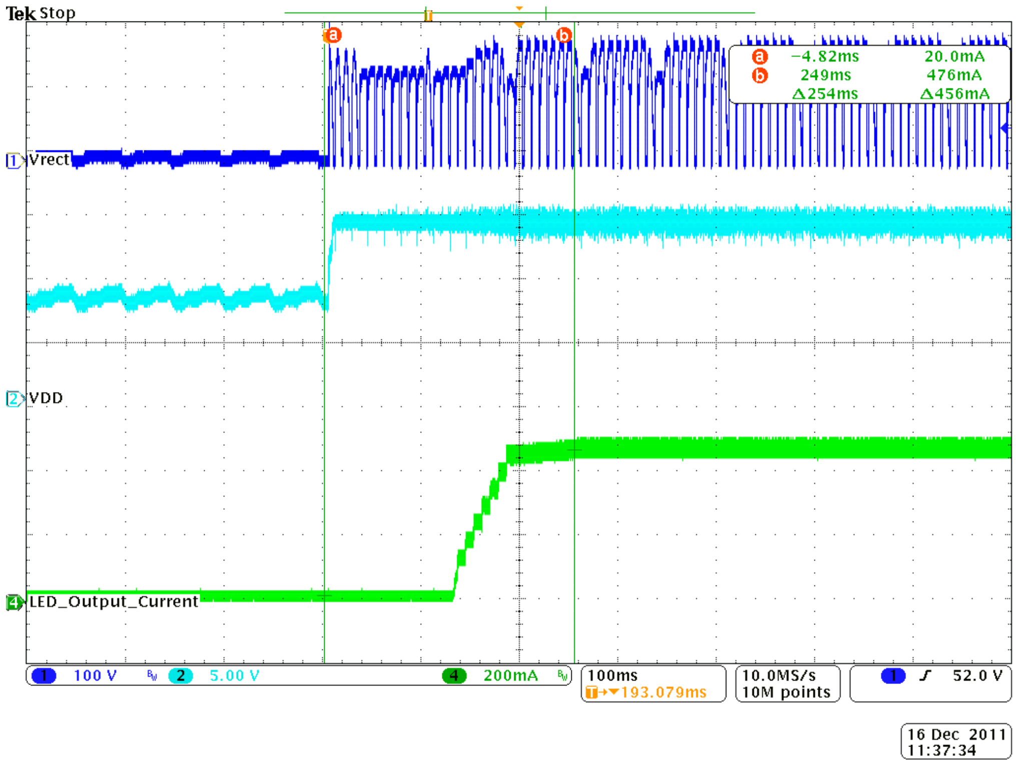


Figure 18. ILED at Maximum Dim Angle, Turn-on Waveforms

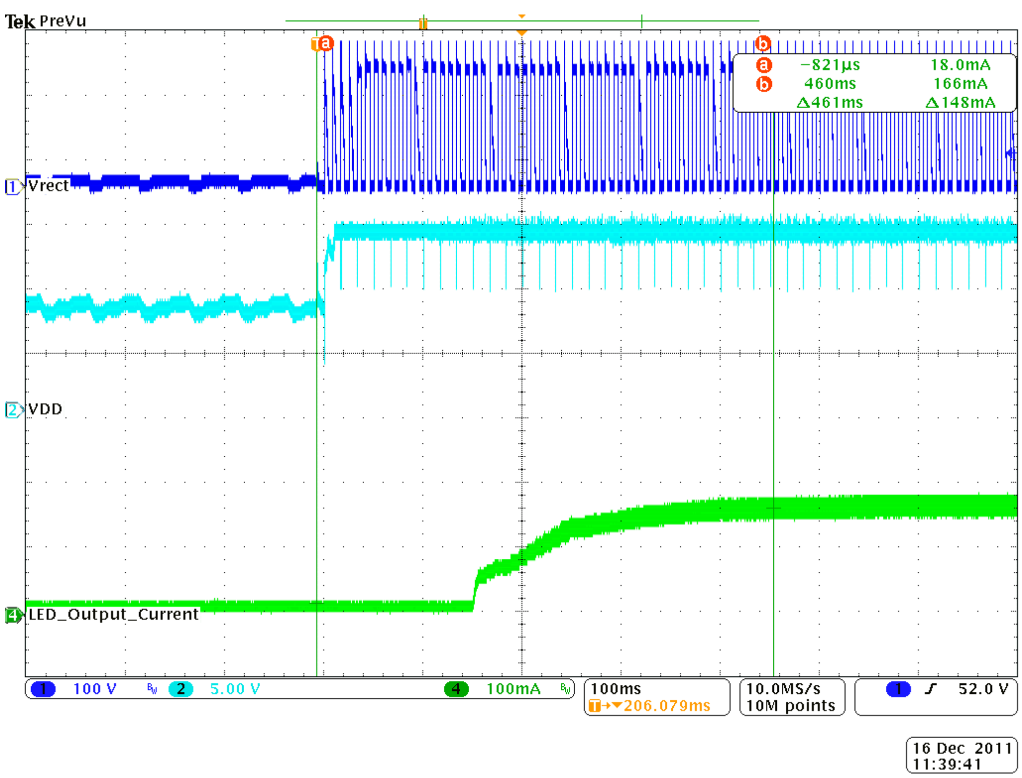


Figure 19. ILED at Medium Dim Angle, Turn-on Waveforms

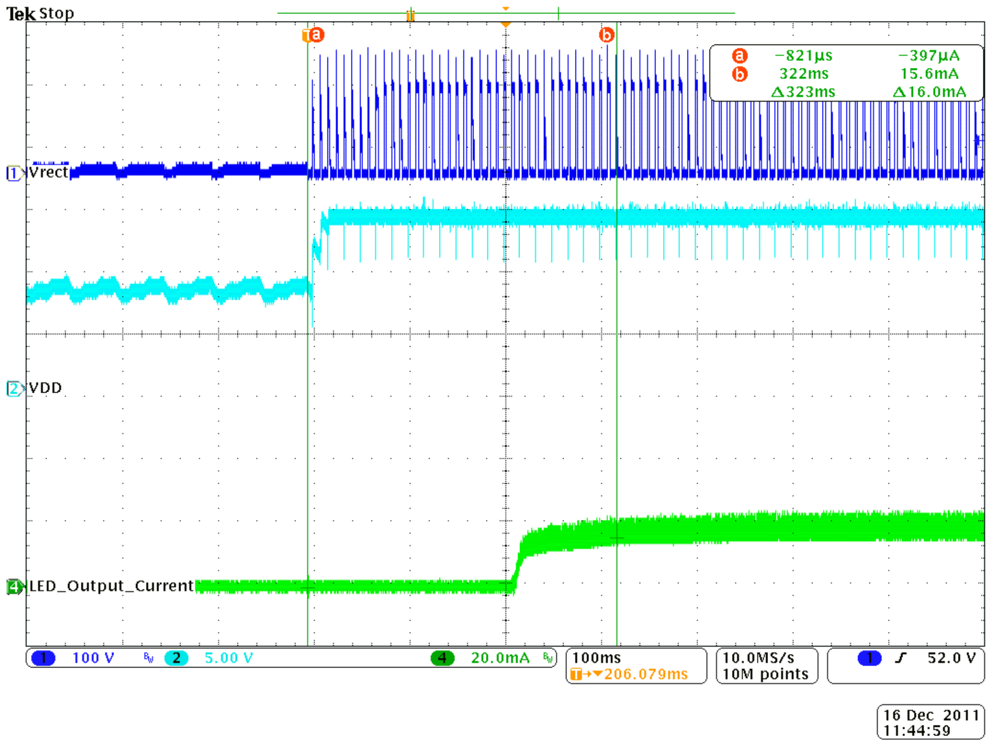


Figure 21. ILED at Minimum Dim Angle, Turn-on Waveforms

8. REVISION HISTORY

Revision	Date	Changes
DB1	FEB 2012	Initial Release.
DB2	FEB 2012	Change to schematic and BOM.
DB3	AUG 2012	Updated schematic.
DB4	FEB 2013	Corrected typographical errors.