CRD1615A-8W
8 Watt Reference Design

Features

- Supports Cirrus Logic CS1615A
- Reduced BOM Cost Compared to CS1615
- Isolated Flyback Topology with Constant-current Output
- Flicker-free Dimming
- <1% Minimum Dimming Across a Broad Range of Dimmers
- Line Voltage 108VAC - 132VAC
- Rated Output Power: 7.5W
- Efficiency: ~82% at 250mA for 10×LEDs in Series
- Power Factor >0.99

General Description

The CRD1615A-8W reference design demonstrates the performance of the CS1615A single stage dimmable AC/DC LED driver IC with a 250mA output driving 10×LEDs in series. The CS1615A is designed to support a reduced off-chip BOM compared to the CS1615. It offers best-in-class dimmer compatibility and minimum dimming performance with leading-edge, trailing-edge, and digital dimmers. The form factor is targeted to fit into many LED bulb applications (GU10, A19-type, PAR, BR).

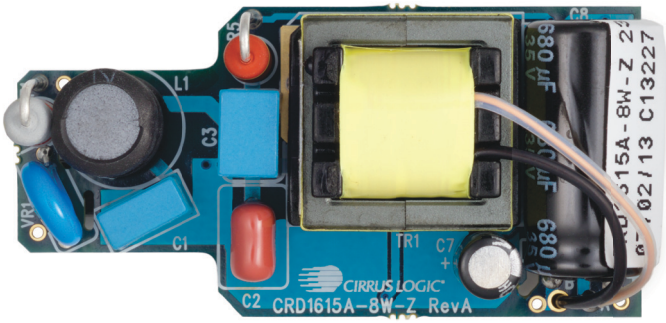
DIMENSIONS (OVERALL)

Length	Width	Height
2.028″(51.5*mm*)	× 1.004″(25.5*mm*)	× 0.65″(16.5*mm*)

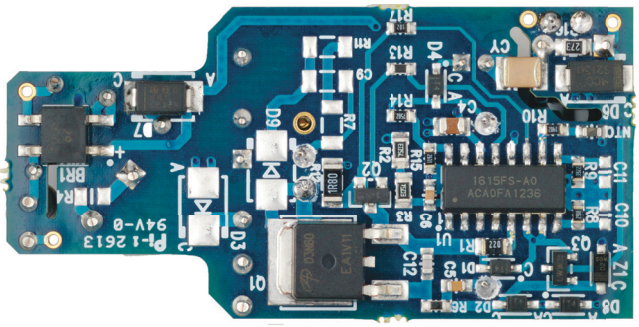
For more information, see Figure 3 on page 6.

ORDERING INFORMATION

CRD1615A-8W-Z	8 Watt Reference Design Supports CS1615A



Top



Bottom

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 CS1615A is a 120VAC quasi-resonant flyback mode dimmable LED controller IC. The CS1615A uses a digital control algorithm that is optimized for high efficiency and >0.99 power factor over an input voltage range (108VAC to 132VAC). The CS1615A integrates a dimmer compatibility circuit with a constant output current, quasi-resonant flyback stage. An adaptive dimmer compatibility algorithm controls the dimmer compatibility operation mode to enable flicker-free operation from 0% to 100% output current with leading-edge, trailing-edge, and digital dimmers.

The CRD1615A-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. Protection algorithms such as output open/short, current-sense resistor open/short, and overtemperature thermistors protect the system during abnormal conditions. When using the CS1615A for a design that does not require active clamp circuitry, the CLAMP pin should be left floating. Details of these features are provided in the CS1615A/16A data sheet DS1033 *Single Stage Dimmable Controller for LED Lamps*.

The CRD1615A-8W board demonstrates the performance of the CS1615A. This reference board has been designed for an output load of 10×LEDs in series at 250mA (~30.0V typical).

This data sheet provides the schematic and PCB layout for the reference design board. The performance graphs demonstrate the performance of the CS1615A dimmable-controller reference design in terms of Efficiency vs. Line Voltage, Power Factor vs. Line Voltage, THD vs. Line Voltage, Output Current vs. Line Voltage, and Output Current vs. Dim Angle.

Extreme caution needs to be exercised while handling this board. This board is to be used by trained professionals only.

2. SCHEMATIC

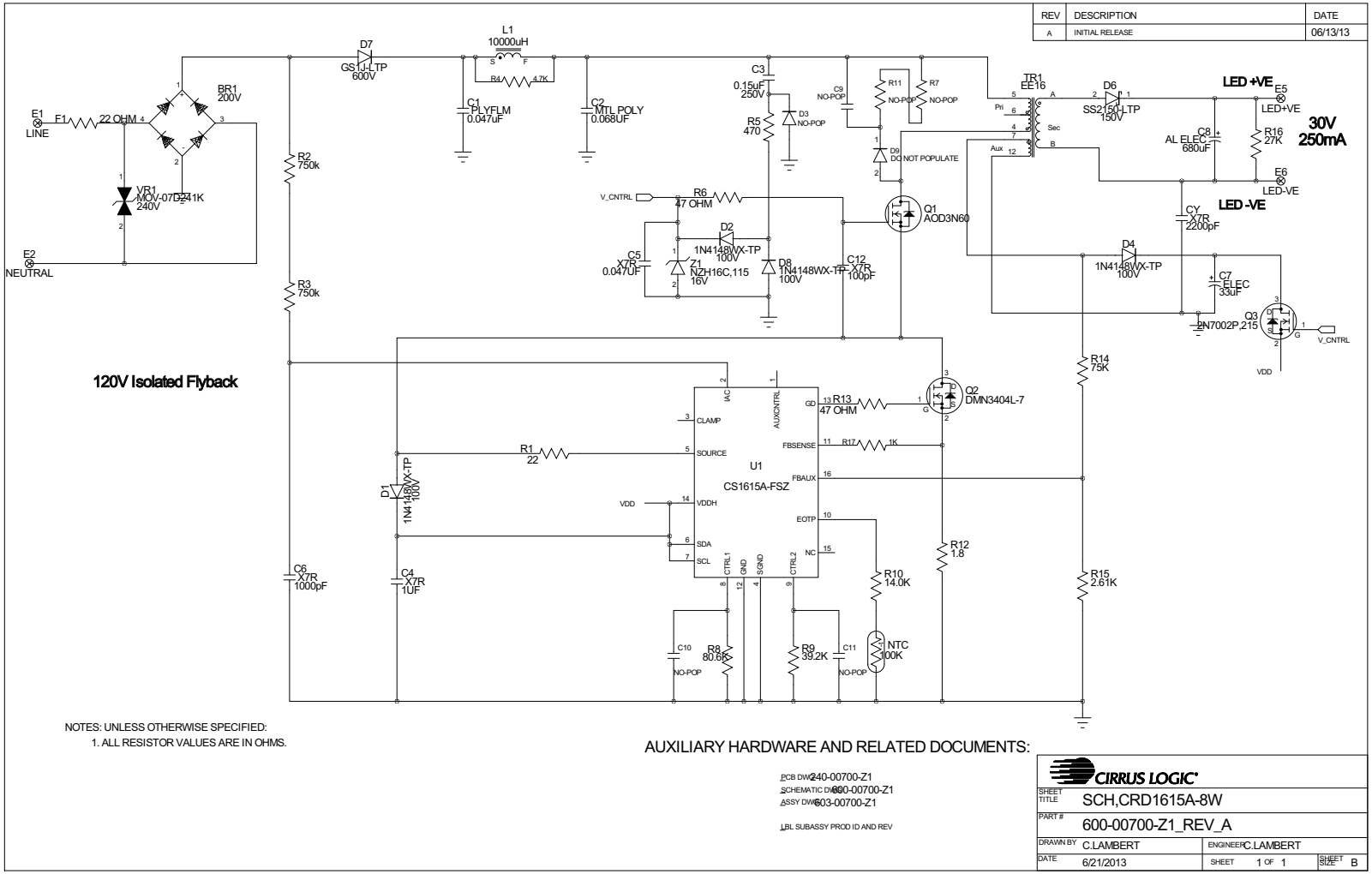


Figure 1. Schematic

3. BILL OF MATERIALS

Item	Rev	Description	Qty	Reference Designator	MFG	MFG P/N
1		DIODE RECT 200V 0.8A NPB MINIDIP	1	BR1	DIODES INC	HD02-T
2		CAP 0.047uF ±5% 250V POLY NPb RAD	1	C1	EPCOS	B32529C3473J
3		CAP 0.068uF ±10% 250V MPOLY NPb RAD	1	C2	PANASONIC	ECQE2683KB
4		CAP 0.15uF ±10% 250V POLY NPb RAD	1	C3	EPCOS	B32529C3154K
5		CAP 1uF ±10% 25V X7R NPb 0805	1	C4	TDK	C2012X7R1E105K125AB
6	A	CAP 0.047uF ±10% 25V X7R NPb 0603	1	C5	KEMET	C0603C473K3RAC
7	A	CAP 1000pF ±10% 50V X7R 0603	1	C6	KEMET	C0603C102K5RAC
8		CAP 33uF ±20% 35V ALUM ELEC NPb RAD	1	C7	PANASONIC	ECA1VHG330
9		CAP 680uF ±20% 35V AL ELEC NPb RAD	1	C8	PANASONIC	EEUFR1V681
10		CAP 220pF ±10% 600V X7R NPb1206	0	C9	AVX	1206CC221KAT1A
11		CAP 56pF ±5% 50V C0G NPb 0603	0	C10 C11	KEMET	C0603C560J5GAC
12		CAP 100pF ±10% 50V X7R CER NPb 0603	1	C12	TDK	C1608X7R1H101K
13		CAP 2200pf ±10% 2KV X7R NPb 1210	1	CY	JOHANSON DIELECTRICS	202S41W222KV4E
14		DIODE HS SWT 100V 150mA NPb SOD323	4	D1 D2 D4 D8	MICRO COMMERCIAL	1N4148WX-TP
15		DIODE 600V 1A NPb SMA DO-214AC	1	D3 D7	MCC	GS1J-LTP
16		DIODE SKY RECT 150V 2A NPb DO-214AC	1	D6	MCC	SS2150-LTP
17		DIODE ULT FAST 600V 1A NPb SMA	0	D9	ST MICROELECTRONICS	STTH1L06A
18		RES 22 OHM 2W ±10% MTLFLM NPb AXIAL	1	F1	TT ELECTRONICS	EMC2-22RKI
19		IND 10000uH 0.053A MINI-DRUM NPb TH	1	L1	RENCO	RL-5480-3-10000
20		THERM 100K OHM ±5% 0.10mA NPb 0603	1	NTC	MURATA	NCP18WF104J03RB
21		TRAN MOSFET nCH 2.5A 600V NPb DPAK	1	Q1	ALPHA & OMEGA	AOD3N60
22		TRAN MOSFET nCH 30V 5.8A NPb SOT23	1	Q2	DIODES INC	DMN3404L-7
23		TRAN MSFET nCH 60V 360mA NPb SOT-23	1	Q3	NXP	2N7002P,215
24		RES 22 OHM 1/8W ±5% NPb 0805 FILM	1	R1	DALE	CRCW080522R0JNEA
25		RES 750k OHM 1/8W ±1% NPb 0805 FILM	2	R2 R3	PANASONIC	ERJ6ENF7503V
26		RES 4.7k OHM 1/8W ±5% NPb 0805 FILM	0	R4	DALE	CRCW08054K70JNEA
27		RES 470 OHM 2W ±5% MTL FLM NPb AXL	1	R5	VISHAY	PR02000204700JR500
28		RES 47 OHM 1/10W ±1% NPb 0603	2	R6 R13	PANASONIC	ERJ3EKF47R0V
29		RES 10k OHM 1/4W ±1% NPb 1206 FILM	0	R7 R11	DALE	CRCW120610K0FKEA
30		RES 80.6k OHM 1/10W ±1% 0603 FILM	1	R8	DALE	CRCW060380K6FKEA
31		RES 39.2k OHM 1/10W ±1% NPb 0603	1	R9	DALE	CRCW060339K2FKEA
32		RES 14k OHM 1/10W ±1% NPB 0603 FILM	1	R10	DALE	CRCW060314K0FKEA
33		RES 1.8 OHM 1/4W ±1% NPb 1206 FILM	1	R12	DALE	CRCW12061R80FKEA
34		RES 75k OHM 1/10W ±1% NPb 0603 FILM	1	R14	DALE	CRCW060375K0FKEA
35		RES 2.61k OHM 1/10W ±1% NPb 0603	1	R15	DALE	CRCW06032K61FKEA
36		RES 27K OHM 1/8W ±0.1% NPb 0805	1	R16	PANASONIC	ERA-6YEB273V
37		RES 1k OHM 1/10W ±5% NPb 0603 FILM	1	R17	DALE	CRCW06031K00JNEA
38		XFMR 0.9mH ±10% 10KHz NPb TH	1	TR1	KUNSHAN EAGERNESS	EF16-CL011M
39	B1	IC CRUS TRIAC DIM PFC 120V NPb SO16	1	U1	CIRRUS LOGIC	CS1615A-FSZ/B1
40		VARISTOR 240V 210pF 15J 7mm NPb RAD	1	VR1	BOURNS	MOV-07D241K
41		DIODE ZENER 500mW 16V NPb SOD123F	1	Z1	NXP	NZH16C,115

Figure 2. Bill of Materials

4. BOARD LAYOUT

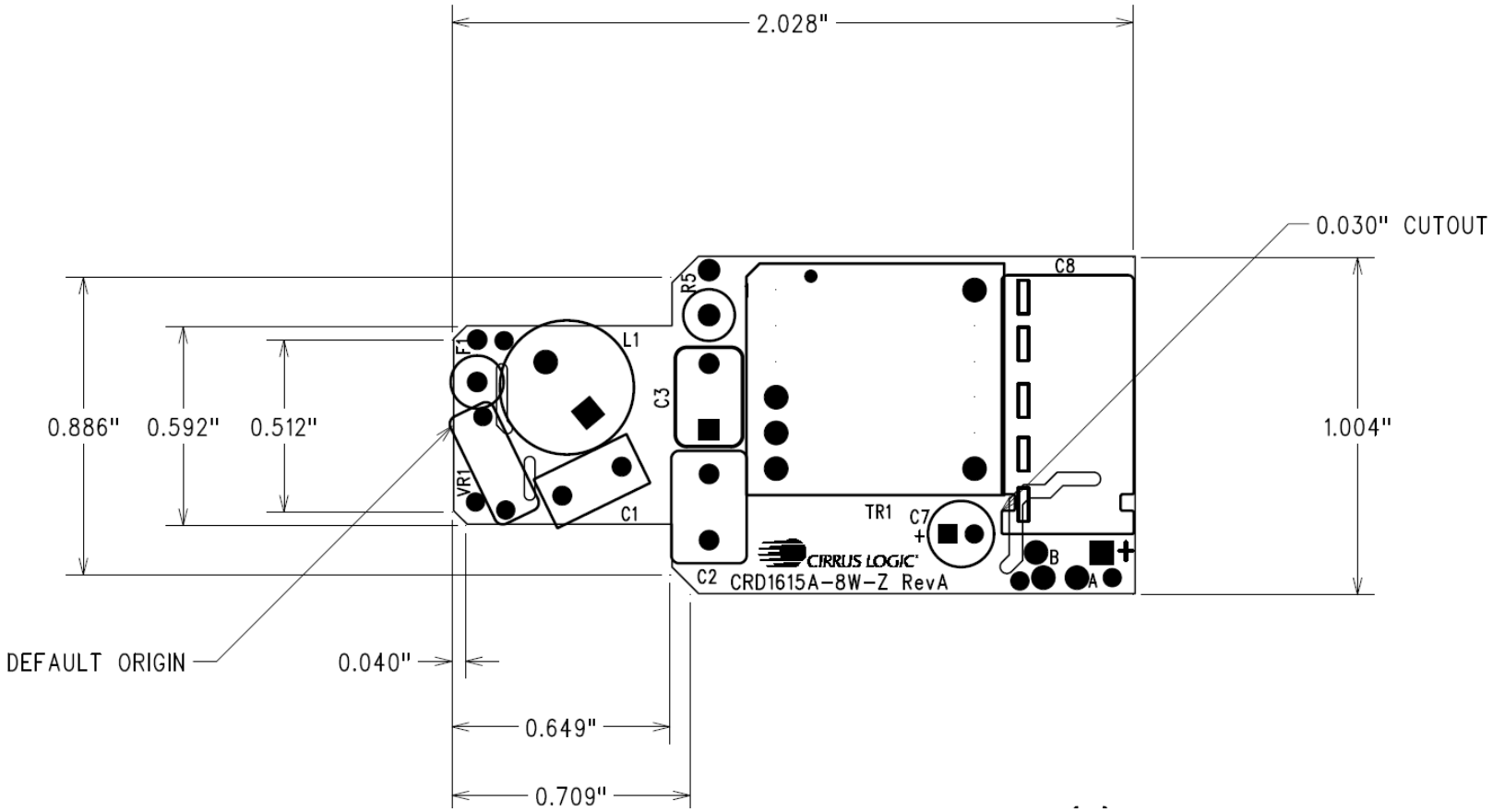


Figure 3. PCB Dimensions

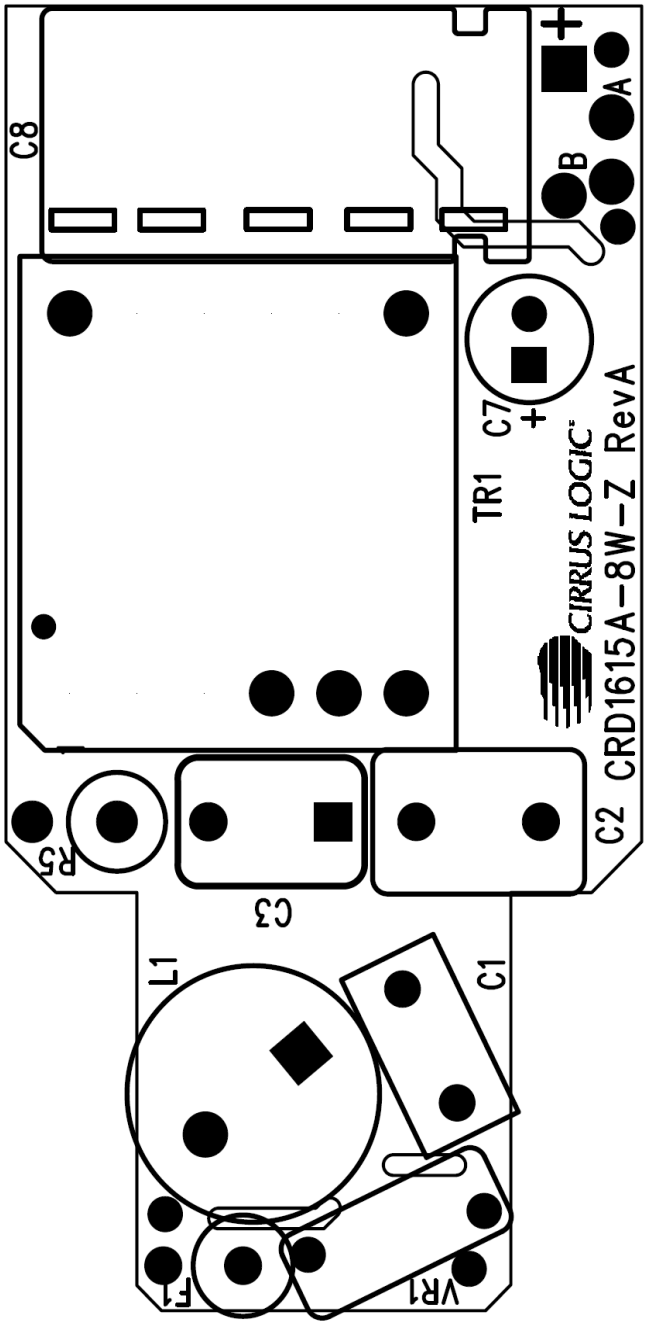


Figure 4. Top Silkscreen

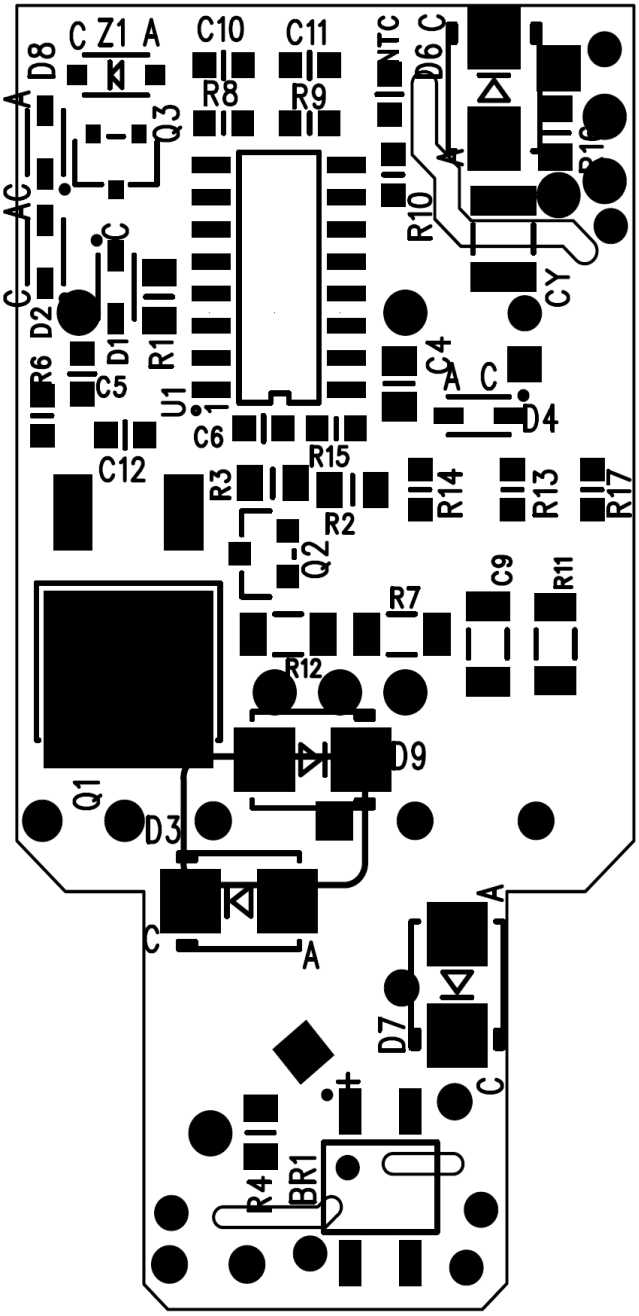


Figure 5. Bottom Silkscreen

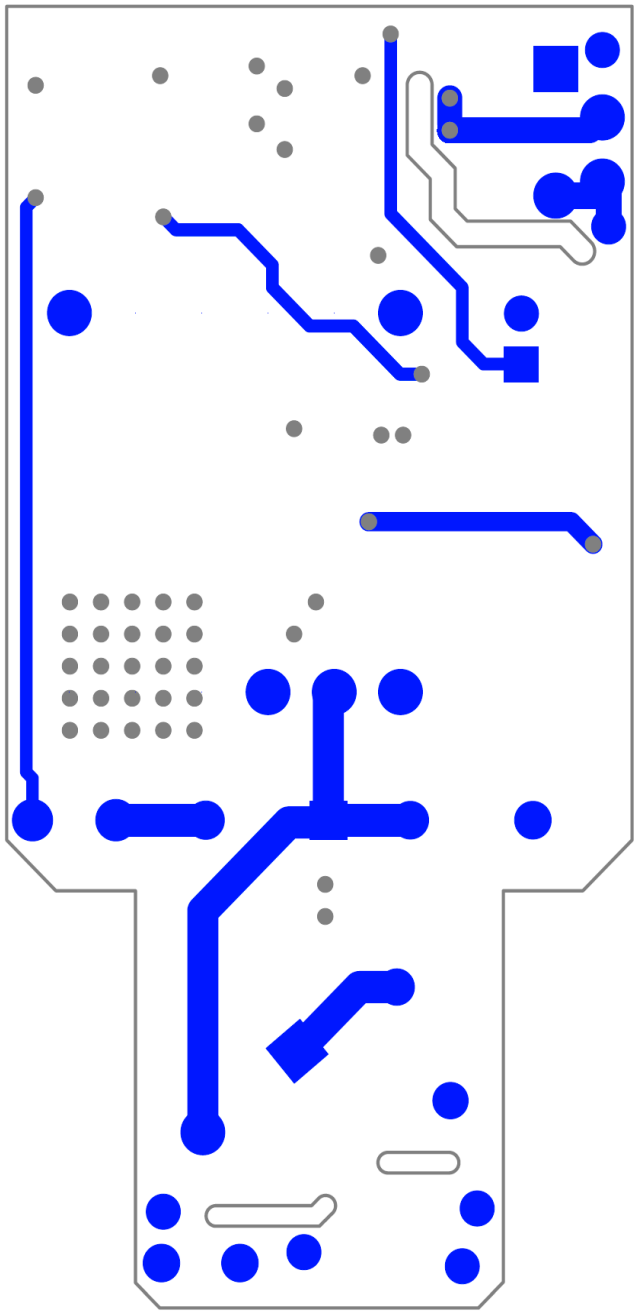


Figure 6. Top Routing

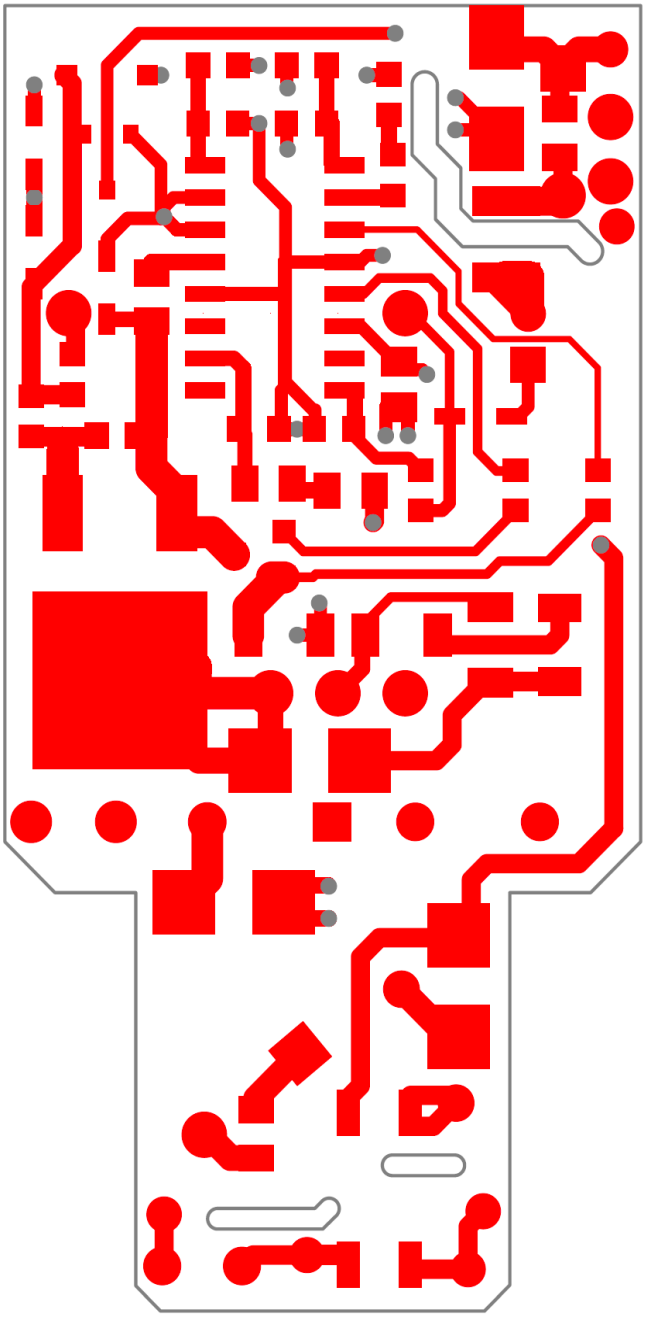


Figure 7. Bottom Routing

5. THERMAL IMAGING

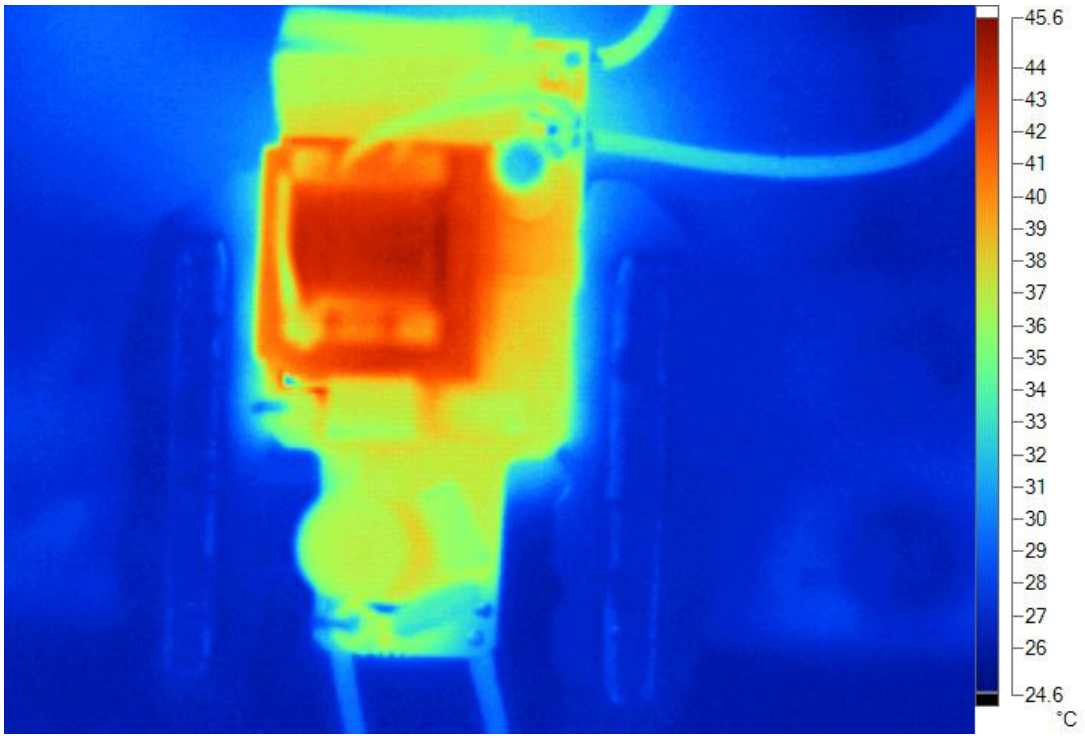


Figure 8. Top Thermal

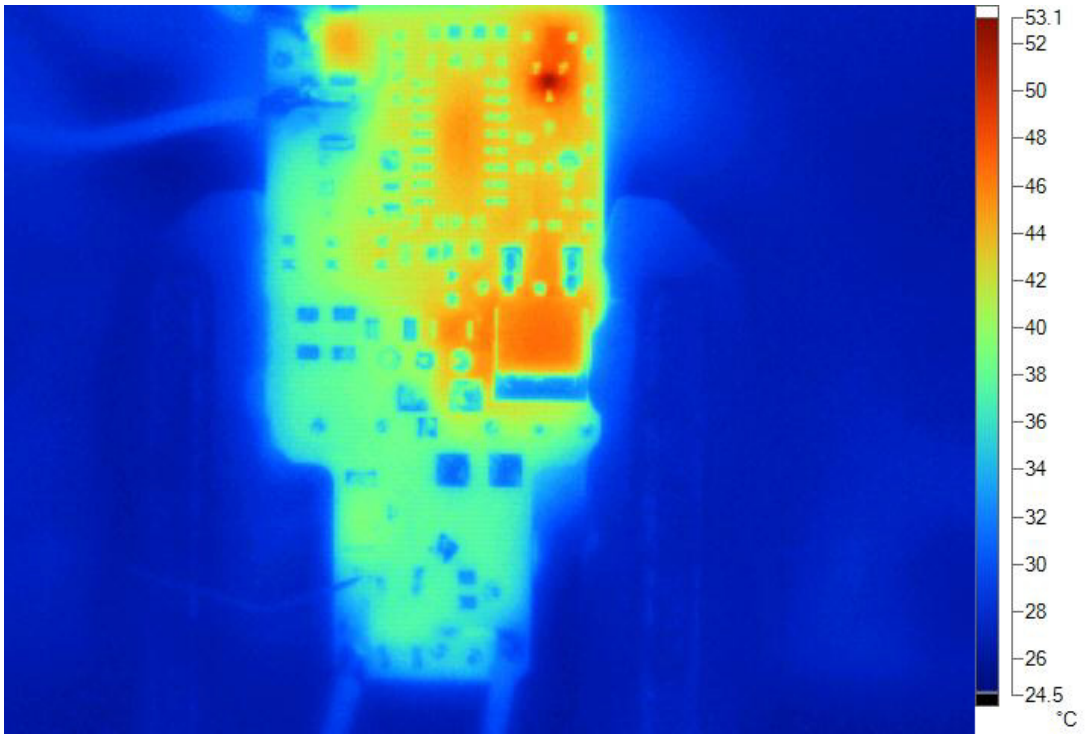


Figure 9. Bottom Thermal

6. DIMMER COMPATIBILITY

A19 Lamp with a CS1615A (120V/60Hz)			
Date	8/12/2013	**Power Factor[1,4]**	0.994
Vendor	Cirrus Logic	**EN55015 Compliant (Y/N)**	Y
Input Voltage	120V/60Hz	**Nominal Input Power (W)[1,4]**	9.0
Form Factor	A19	**Maximum Input Power (W)[1,4]**	9.0
Model #	CRD1615A-8W	**Output Voltage (V)[1,2]**	29.9
IC	CS1615A	**Output Current (mA)[1,2]**	247
Topology	Flyback	**Output Current Ripple ≤ 120Hz (mA)[1,3]**	200
Isolation (Y/N)	Y	**Output Power (W)[1,4]**	7.385
Efficiency (%)	81.7		

Dimmer[5]		**Flicker Free Steady-State**			**Monotonic Dimming**			**Max I_{out} (%)**			**Min I_{out} (%)**		
Manufacture	**Type**	**# of lamps**			**# of lamps**			**# of lamps**			**# of lamps**		
		1	**5**	**10**	**1**	**5**	**10**	**1**	**5**	**10**	**1**	**5**	**10**
Cooper 6001	Leading Edge	Y	Y	Y	Y	Y	Y	100.0	100.0	98.8	0.4	0.4	0.4
Cooper 9530	Leading Edge	Y	Y	Y	Y	Y	Y	100.4	100.4	99.6	0.4	0.4	0.4
Cooper DI06P	Leading Edge	Y	Y	Y	Y	Y	Y	100.0	100.0	98.8	0.4	0.4	0.4
GE 52136	Leading Edge	N	Y	Y	Y	Y	Y	100.0	100.0	98.8	0.4	0.4	0.4
GE IRIS 45639	Leading Edge	Y	Y	Y	Y	Y	Y	100.0	99.6	98.8	0.4	0.4	0.4
Legrand ADPD703HW4	Leading Edge	Y	Y	Y	Y	Y	Y	100.0	100.0	98.8	0.4	0.4	0.4
Legrand ADTP703UM4	Leading Edge	Y	Y	Y	Y	Y	Y	100.4	100.4	99.2	0.4	0.4	0.4
Leviton 6161	Leading Edge	N	Y	N	Y	Y	Y	99.2	98.8	98.8	0.4	0.8	0.4
Leviton 6613	Leading Edge	Y	Y	Y	Y	Y	Y	100.0	100.0	98.8	0.4	0.4	0.4
Leviton 6615	Trailing Edge	Y	Y	Y	Y	Y	Y	99.6	99.2	98.0	0.4	0.4	0.4
Leviton 6627	Leading Edge	Y	Y	Y	Y	Y	Y	89.9	89.9	91.5	3.2	2.4	2.4
Leviton 6631	Leading Edge	Y	Y	Y	Y	Y	Y	100.0	100.0	98.8	0.4	0.4	0.4
Leviton 6641	Leading Edge	Y	Y	Y	Y	Y	Y	99.6	98.0	98.4	0.4	0.4	0.4
Leviton 6683	Leading Edge	Y	Y	Y	Y	Y	Y	100.0	100.0	98.8	0.4	0.4	0.4
Leviton 6684	Leading Edge	Y	Y	Y	Y	Y	Y	100.0	100.0	98.8	0.4	0.4	0.4
Leviton 700	Leading Edge	Y	Y	Y	Y	Y	Y	100.0	100.0	98.8	0.4	0.4	0.4
Leviton ACE04	Trailing Edge	Y	Y	Y	Y	Y	N	99.6	99.6	98.4	0.4	0.4	0.4
Leviton ACM06	Leading Edge	Y	Y	Y	Y	Y	Y	99.6	99.6	98.8	0.4	0.4	0.4
Leviton ACX10	Leading Edge	Y	N	Y	Y	Y	N	99.6	14.6	10.1	4.5	0.8	0.4
Leviton HCM06	Leading Edge	Y	Y	Y	Y	Y	Y	100.0	100.0	99.2	0.4	0.4	0.4
Leviton IPI06-1L	Leading Edge	Y	Y	Y	Y	Y	Y	100.0	100.0	98.8	0.4	0.4	0.4
Leviton VZM06	Leading Edge	Y	Y	Y	Y	Y	Y	99.6	99.6	98.8	0.8	0.4	0.4
Lutron AB-600M	Leading Edge	Y	Y	Y	Y	Y	Y	93.9	94.3	95.1	0.4	0.4	0.4

Dimmer[5]		Flicker Free Steady-State			Monotonic Dimming			Max I_{out} (%)			Min I_{out} (%)		
Manufacture	Type	# of lamps			# of lamps			# of lamps			# of lamps		
		1	5	10	1	5	10	1	5	10	1	5	10
Lutron AY-600P	Leading Edge	Y	Y	Y	Y	Y	Y	98.8	97.2	98.8	0.4	0.4	0.4
Lutron CT-600P	Leading Edge	Y	N	Y	Y	Y	Y	97.6	97.2	98.4	0.4	0.4	0.4
Lutron CT-603PG	Leading Edge	N	Y	Y	Y	Y	Y	81.0	83.0	79.8	0.4	0.4	0.4
Lutron CTCL-153P	Leading Edge	Y	Y	Y	Y	Y	Y	95.5	94.7	95.5	0.4	0.4	0.4
Lutron DV-600P	Leading Edge	Y	Y	Y	Y	Y	Y	98.4	98.4	98.4	0.4	0.4	0.4
Lutron DVCL-153P	Leading Edge	Y	Y	Y	Y	Y	Y	95.5	96.0	96.8	0.4	0.4	0.4
Lutron DVELV-300P	Trailing Edge	Y	Y	Y	N	N	N	88.3	85.8	86.6	0.4	0.4	0.4
Lutron DVW-603PG	Leading Edge	Y	Y	Y	Y	Y	Y	80.6	82.6	79.8	0.4	0.4	0.4
Lutron GL-600P	Leading Edge	Y	Y	Y	Y	Y	Y	96.8	96.8	97.6	0.4	0.4	0.4
Lutron LG-103P	Leading Edge	Y	Y	Y	Y	Y	Y	98.0	97.6	98.4	0.4	0.4	0.4
Lutron MACL-153M	Leading Edge	Y	Y	Y	Y	Y	Y	91.1	90.7	91.1	0.4	0.4	0.4
Lutron MAW-600	Leading Edge	Y	Y	Y	Y	Y	Y	97.2	97.2	98.4	0.4	0.4	0.4
Lutron MIR-600	Leading Edge	Y	Y	Y	Y	Y	Y	96.8	97.2	98.0	0.4	0.4	0.4
Lutron NT2000	Leading Edge	Y	Y	Y	Y	Y	Y	94.7	94.3	96.0	0.4	0.4	0.4
Lutron NTELV-600	Trailing Edge	Y	Y	Y	N	N	N	92.7	92.3	92.7	0.4	0.4	0.4
Lutron NTLV-600	Leading Edge	Y	Y	Y	Y	Y	Y	100.0	100.0	98.8	0.4	0.4	0.4
Lutron Q-603P	Leading Edge	Y	Y	Y	Y	Y	Y	98.4	98.4	98.4	0.4	0.4	0.4
Lutron S-103P	Leading Edge	Y	Y	Y	Y	Y	Y	98.4	97.6	98.4	0.4	0.4	0.4
Lutron S-600P	Leading Edge	Y	N	Y	Y	Y	Y	98.0	97.6	98.4	0.4	0.4	0.4
Lutron SELV-303P	Trailing Edge	Y	Y	Y	N	N	N	89.5	86.6	87.9	0.4	0.4	0.4
Lutron SLV-600P	Leading Edge	N	N	Y	Y	Y	Y	98.8	98.8	98.8	0.4	0.4	0.4
Lutron SLV-603P	Leading Edge	Y	Y	Y	Y	Y	Y	99.2	98.8	98.8	0.4	0.4	0.4
Lutron SPS-600	Leading Edge	Y	Y	Y	Y	Y	Y	98.8	98.8	98.8	0.4	0.4	0.4
Lutron SPSLV-1000	Leading Edge	Y	Y	Y	Y	Y	Y	99.6	99.2	98.8	0.4	0.4	0.4
Lutron TG-600P	Leading Edge	Y	Y	Y	Y	Y	Y	99.6	100.0	98.8	0.4	0.4	0.4
Lutron TG-603PG	Leading Edge	Y	N	Y	Y	Y	Y	83.8	83.8	85.4	0.4	0.4	0.4
Lutron TGCL-153P	Leading Edge	Y	Y	Y	Y	Y	Y	98.0	97.2	98.0	0.4	0.4	0.4
Smarthome 2486D	Leading Edge	Y	Y	Y	Y	Y	Y	100.0	99.6	98.8	0.4	0.4	0.4

1. Tested at nominal input voltage, nominal input frequency and without a dimmer after soaking for 15 minutes
2. Average
3. Peak-to-peak
4. Measured with Chroma 66202 Power Analyze
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7. TRANSFORMER CONSTRUCTION

The CRD1615A-8W provides power factor correction and dimmer compatibility with a constant output current, quasi-resonant flyback stage. The following sections describe the flyback transformer installed on the CRD1615A-8W.

7.1 Flyback Transformer

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

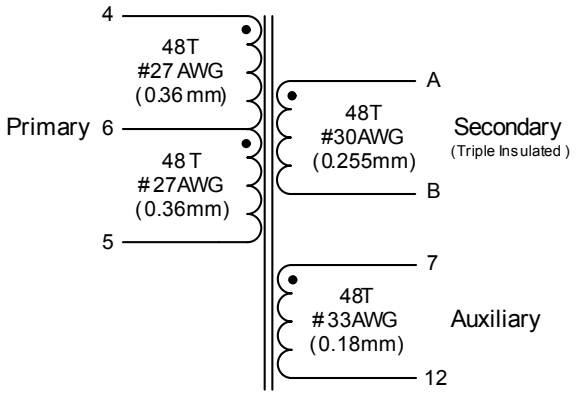

Figure 10. Flyback Transformer Schematic

7.1.1 Electrical Specifications

Characteristics conditions:

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

Parameter	Condition	Symbol	Min	Typ	Max	Unit
Flyback Transformer						
Electrical Strength (Note 1)	$f_{operate}$=50/60Hz		-	3.75	-	kV_{RMS}
Primary Inductance (Note 2)	$f_{resonant}$=10kHz, 0.3V at 20°C	L_P	0.8	0.9	1.0	mH
Primary Leakage Inductance(Note 2)	$f_{resonant}$=10kHz, 0.3V at 20°C	L_K	-	-	20	µH
Primary DC Resistance (Note 2)	t_{DCR}=20°C		1.9	2.2	2.5	Ω
Secondary DC Resistance (Note 3)	t_{DCR}=20°C		0.8	1.0	1.2	mΩ
Auxiliary DC Resistance (Note 4)	t_{DCR}=20°C		3.0	3.5	4.0	mΩ

Notes:
1. Time = 2sec.
2. Measured across pins 4 and 5
3. Measured across pins B and A
4. Measured across pins 12 and 7

8. PERFORMANCE PLOTS

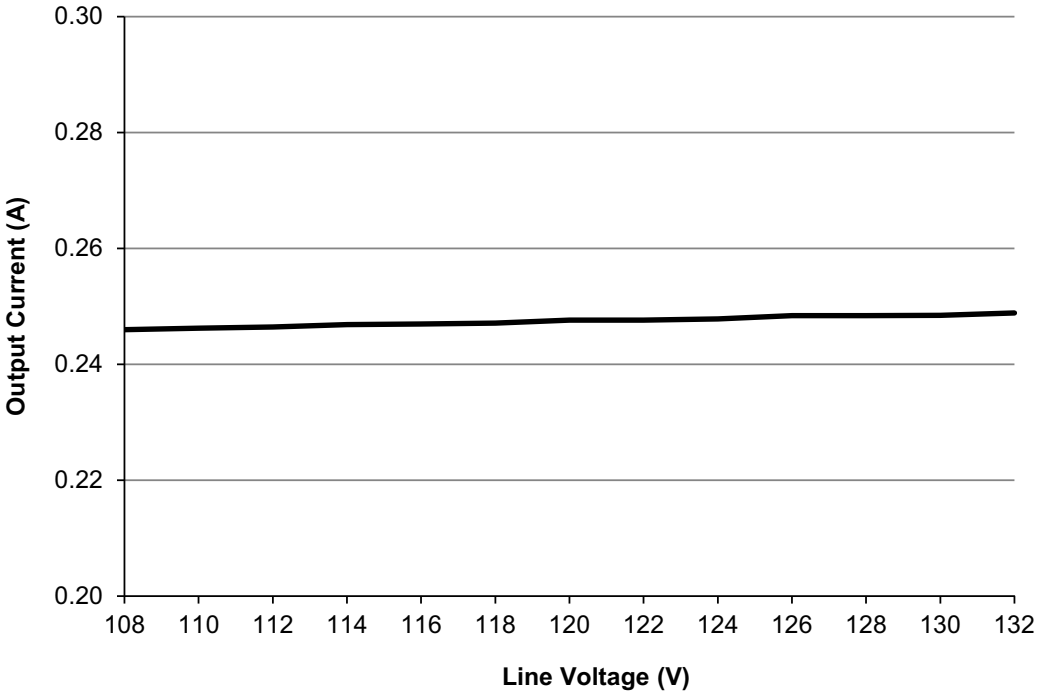

Figure 11. Output Current vs. Line Voltage

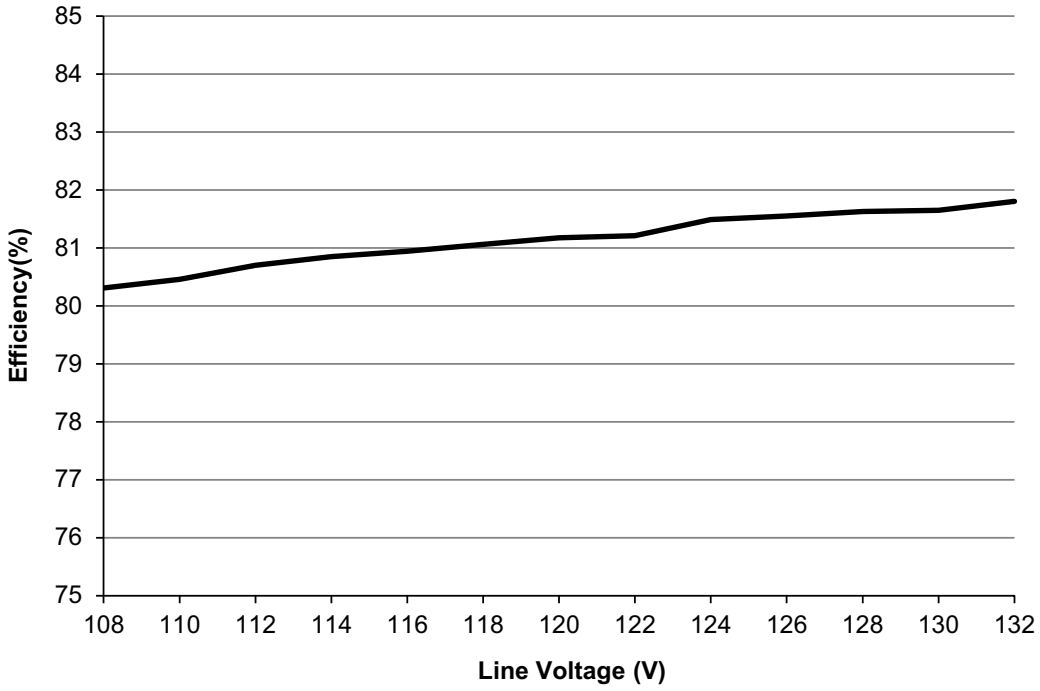

Figure 12. Typical Efficiency vs. Line Voltage

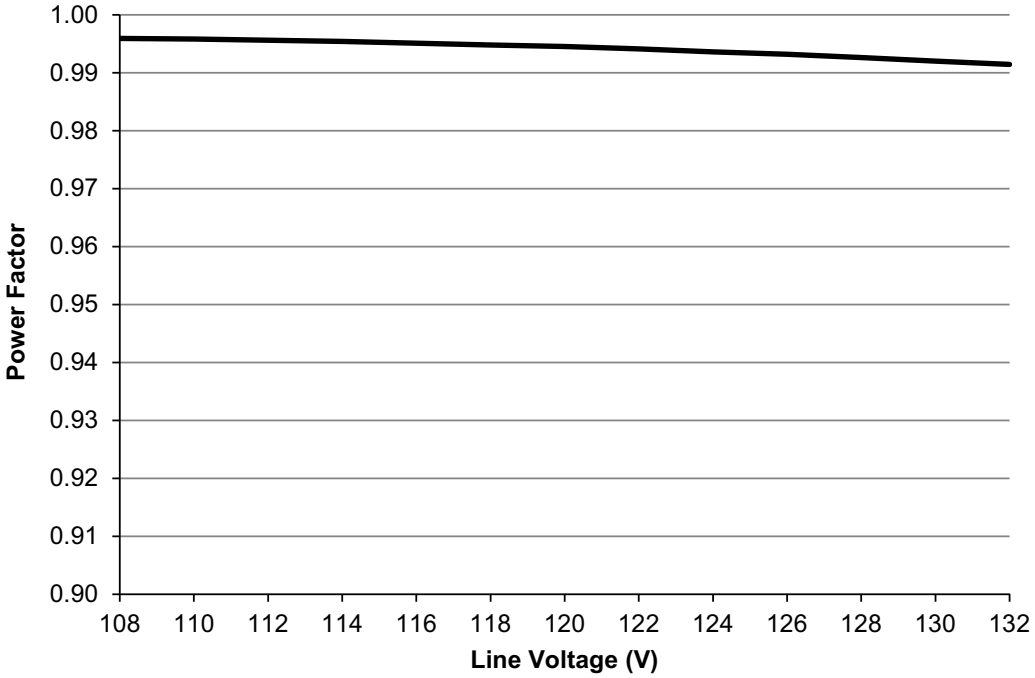

Figure 13. Power Factor vs. Line Voltage

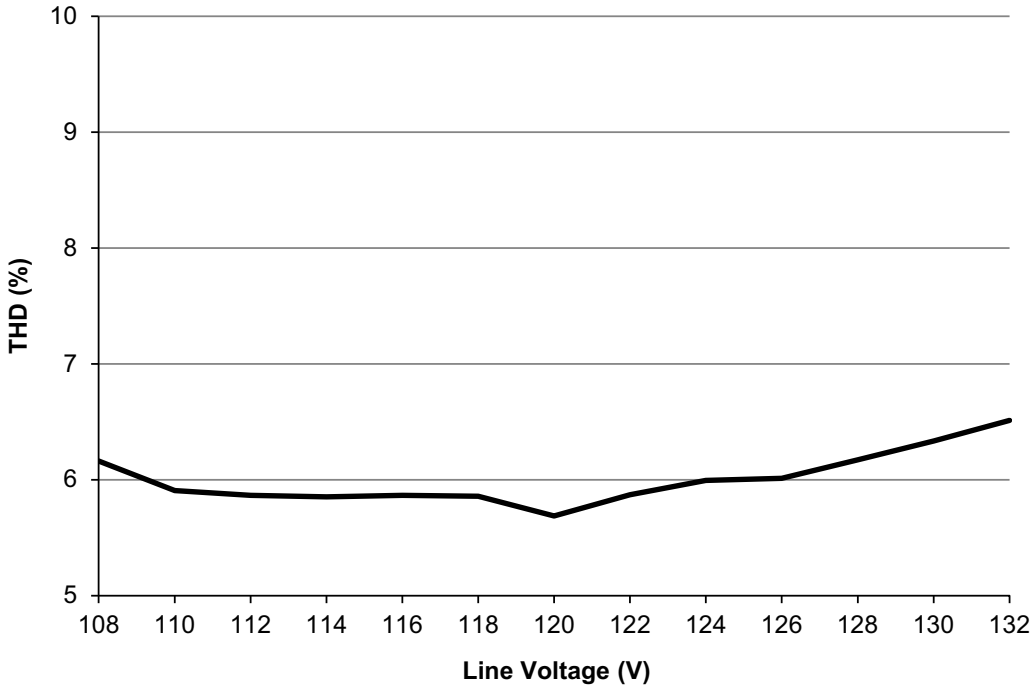

Figure 14. THD vs Line Voltage

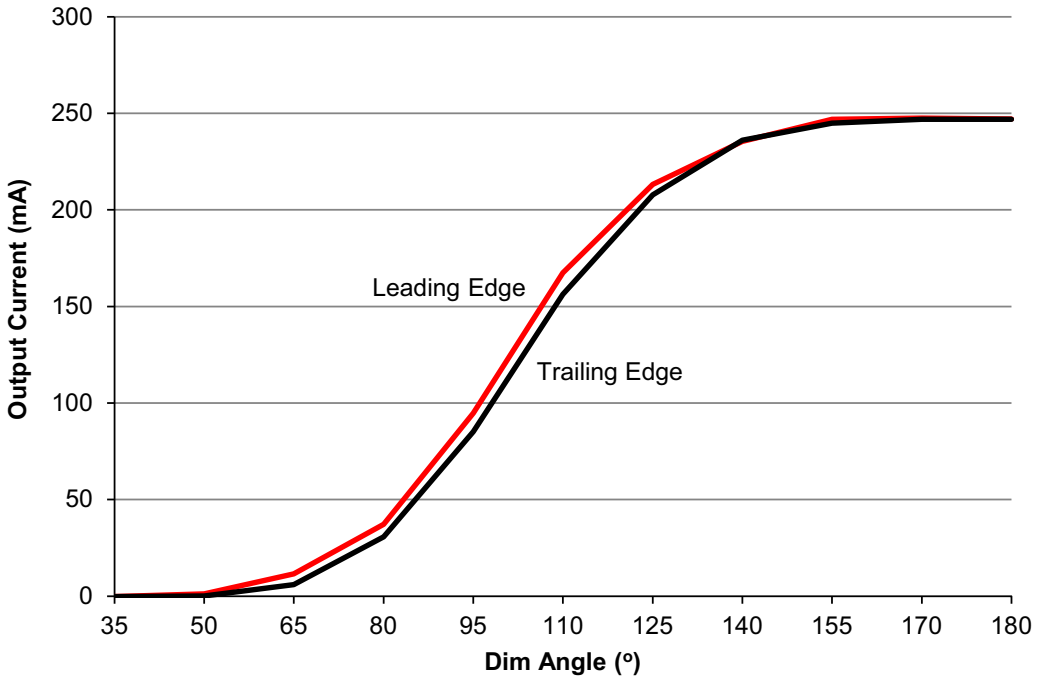

Figure 15. Typical Output Current vs Dim Angle

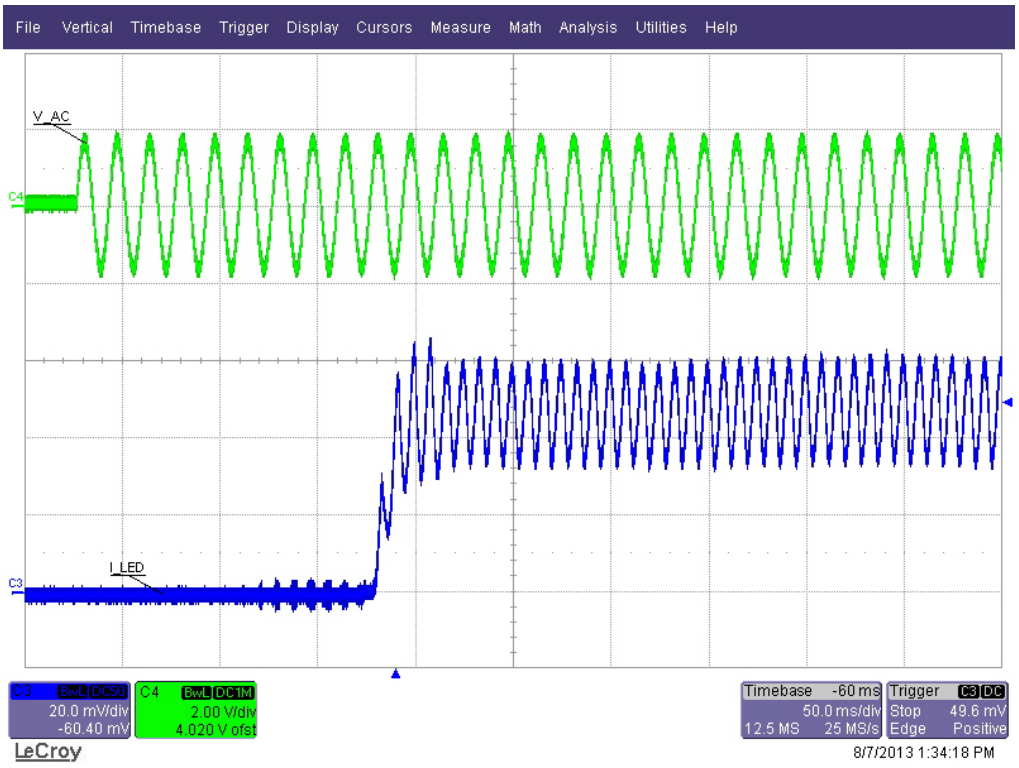

Figure 16. No-dimmer Mode, Startup, 120 VAC

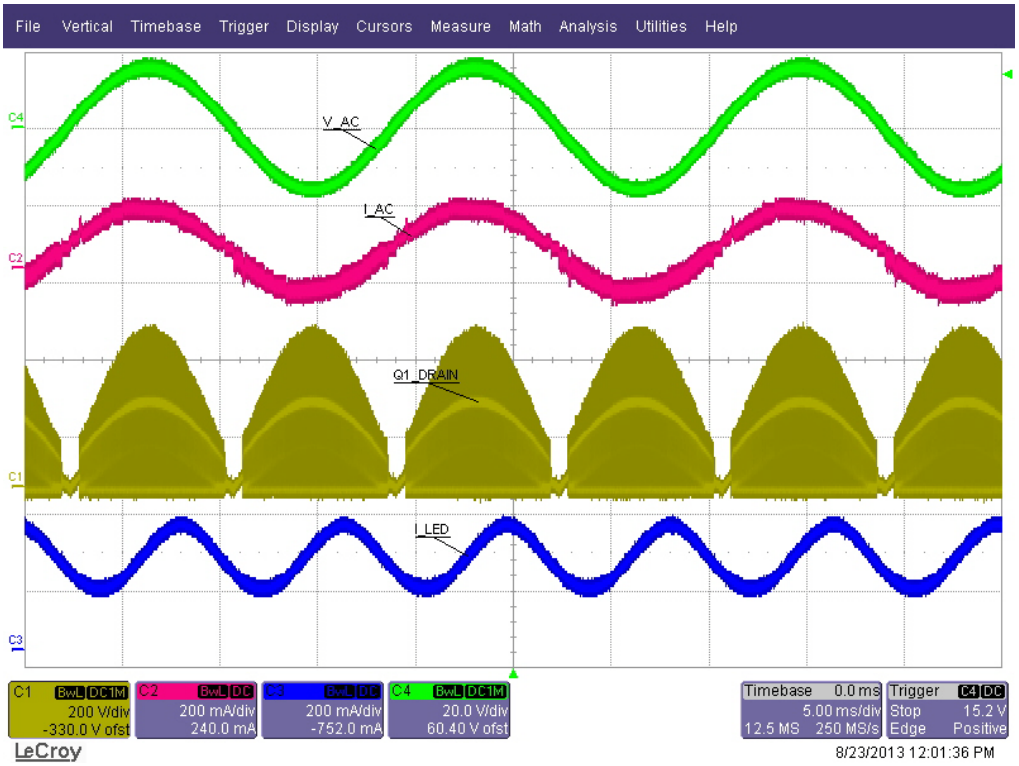

Figure 17. No-dimmer Mode, Steady-state, 120 VAC

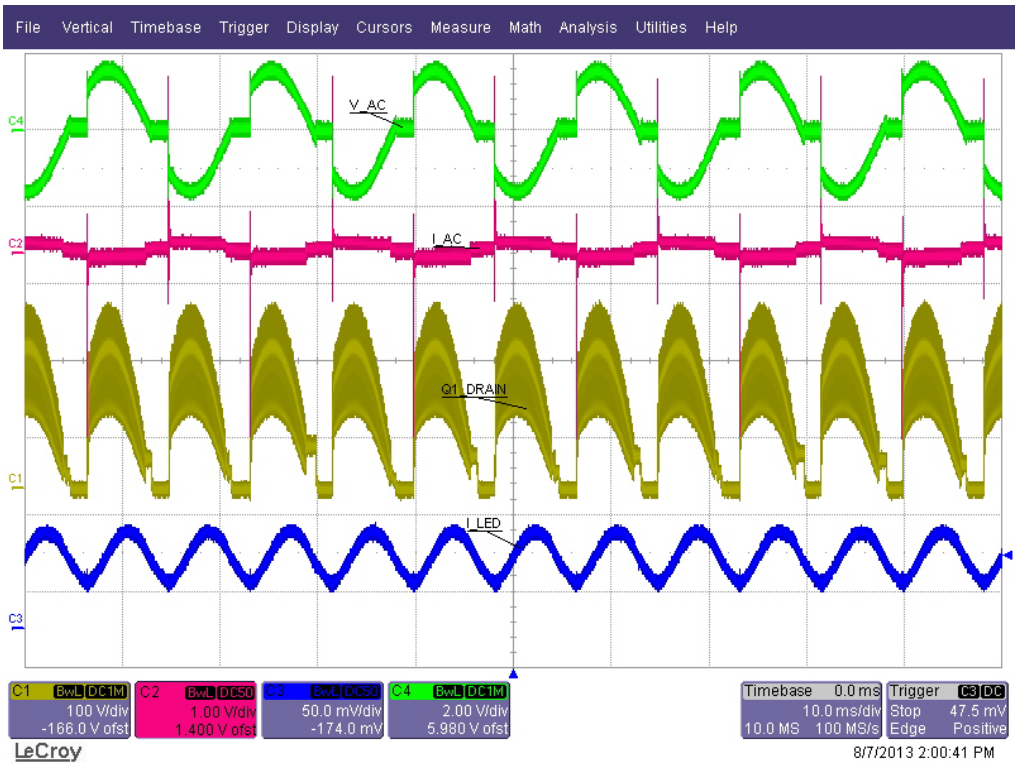

Figure 18. Leading-edge Dimmer Mode, Steady-state, 120VAC

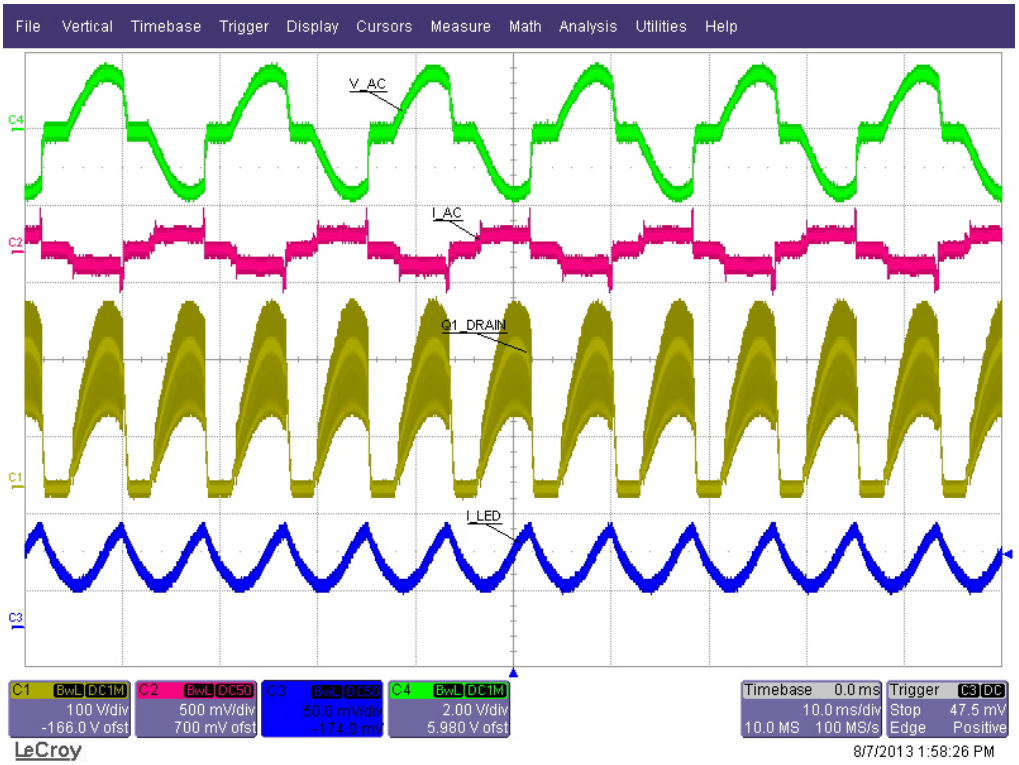

Figure 19. Trailing-edge Dimmer Mode, Steady-state, 120VAC

9. CONDUCTED EMI

Device Under Test: CRD1615A-8W-Z **Operating Conditions:** NOMINAL

Test Specification: EN55022:2010 **Operator Name:** CAL

Scan Settings (1 Range)

Frequencies			Receiver Settings			
Start	***Stop***	***Step***	***Res BW***	***M-Time***	***Atten***	***Preamp***
150 kHz	30 MHz	4.5 kHz	9 kHz (6dB)	50 ms	Auto	Off

Final Measurement

Detectors: QP, AV **Peaks:** 10 **Meas Time:** See scan settings **Acc. Margin:** 12 dB

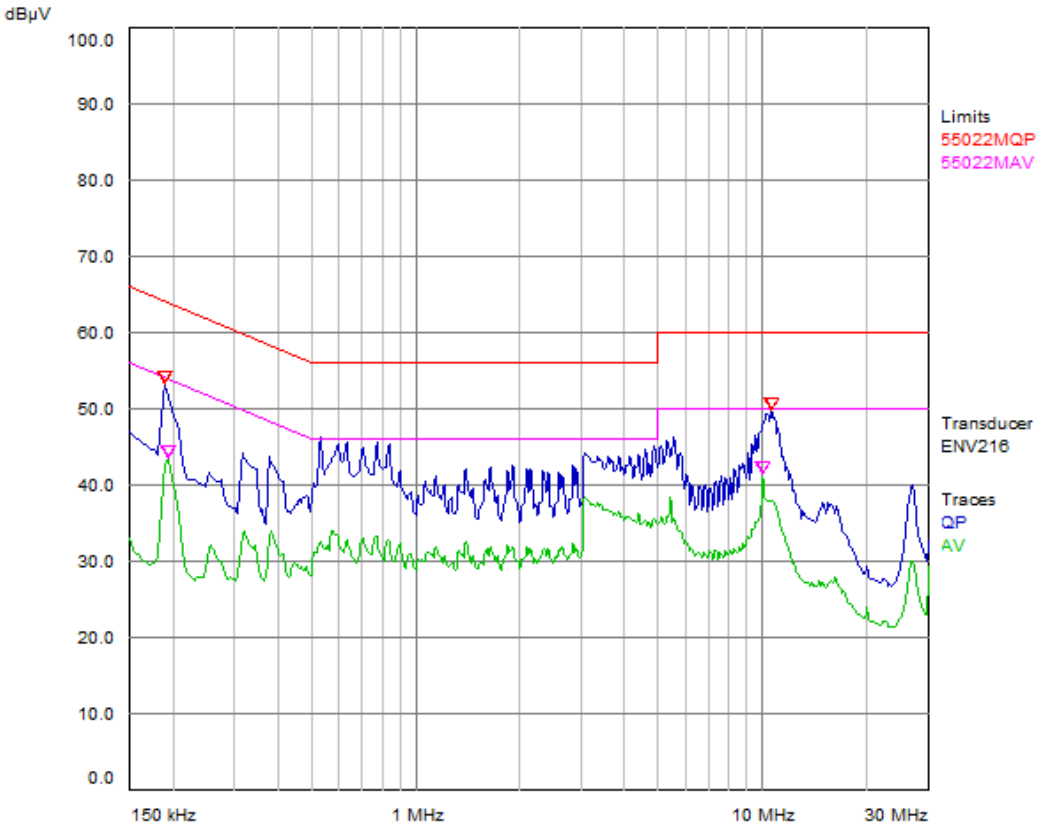

Figure 20. Conducted EMI

Final Measurement Results

Trace	Frequency (MHz)	Level (dBµV)	Limit (dBµV)	Delta Limit (dB)	Delta Ref (dB)	Comment
1 QP	0.19	53.18	64.01	-10.83		N/on
2 AV	10.0005	41.29	50.00	-8.71		N/on

*** = Limit Exceeded**

10. REVISION HISTORY

Revision	Date	Changes
RD1	JUL 2013	**Preliminary release**
RD2	AUG 2013	**Content clarification**