

## **CS1601 120W, High-efficiency PFC + Fluorescent Lamp Driver Reference Design**

### **Features**

- ❑ Line Voltage Range: 108 to 305 VACrms
- ❑ Output Voltage ( $V_{link}$ ): 460V
- ❑ Rated Maximum  $P_{in}$ : 120W
- ❑ Spread Spectrum Switching Frequency
- ❑ Integrated Digital Feedback Control
- ❑ Low Component Count

### **General Description**

The CRD1601-120W board demonstrates the performance of the CS1601 digital PFC controller in an electronic ballast application. The CRD1601 uses a resonant second stage driver to power up to two T5 fluorescent lamps. The CRD1601 has been designed to fit into a slimline T5 fluorescent electronic ballast form-factor.

### **ORDERING INFORMATION**

CRD1601-120W-Z PFC Customer Reference Design



Actual Size:  
356 mm x 27 mm  
14.0 in x 1.07 in



## 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, heat sinks or metallic parts may be extremely hot to touch when electrically active.

**⚠ WARNING** Heatsinking is required for Q4 & Q5. The end product should use tar pitch or an equivalent compound for this purpose. For lab evaluation purposes, a fan is recommended to provide adequate cooling.

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### 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](http://www.cirrus.com)

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## 1. INTRODUCTION

The CS1601 is a high-performance Variable Frequency Discontinuous Conduction Mode (VF-DCM), active Power Factor Correction (PFC) controller, optimized to deliver the lowest PFC system cost for electronic ballast applications. The CS1601 uses a digital control algorithm that is optimized for high efficiency and near unity power factor over a wide input voltage range (108-305 VAC).

The CS1601 uses an adaptive digital control algorithm. Both the ON time and the switching frequency are varied on a cycle-by-cycle basis over the entire AC line to achieve close to unity power factor. The variation in switching frequency also provides a spread frequency spectrum, thus minimizing the conducted EMI filtering requirements.

The feedback loop is closed through an integrated digital control system within the IC. Protection features such as overvoltage, overcurrent, overpower, open circuit, overtemperature, and brownout help protect the device during abnormal transient conditions. Details of these features are provided in the CS1601 data sheet.

The CRD1601-120W board demonstrates the performance of the CS1601 over a wide input voltage range. This board has been designed to generate 460V from the PFC stage, which is then processed by the resonant driver, to power up to two T5 lamps connected in series, for a total output of 108W.

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

Terminal block J1 is used to connect the AC line. The lamp is connected to terminal J2 as shown in the schematic.



**Figure 1. Board Connections**

**DANGER**  
**High Voltage Hazard**

ONLY QUALIFIED PERSONNEL SHOULD HANDLE THE CRD1601-120W.



**Warning:**

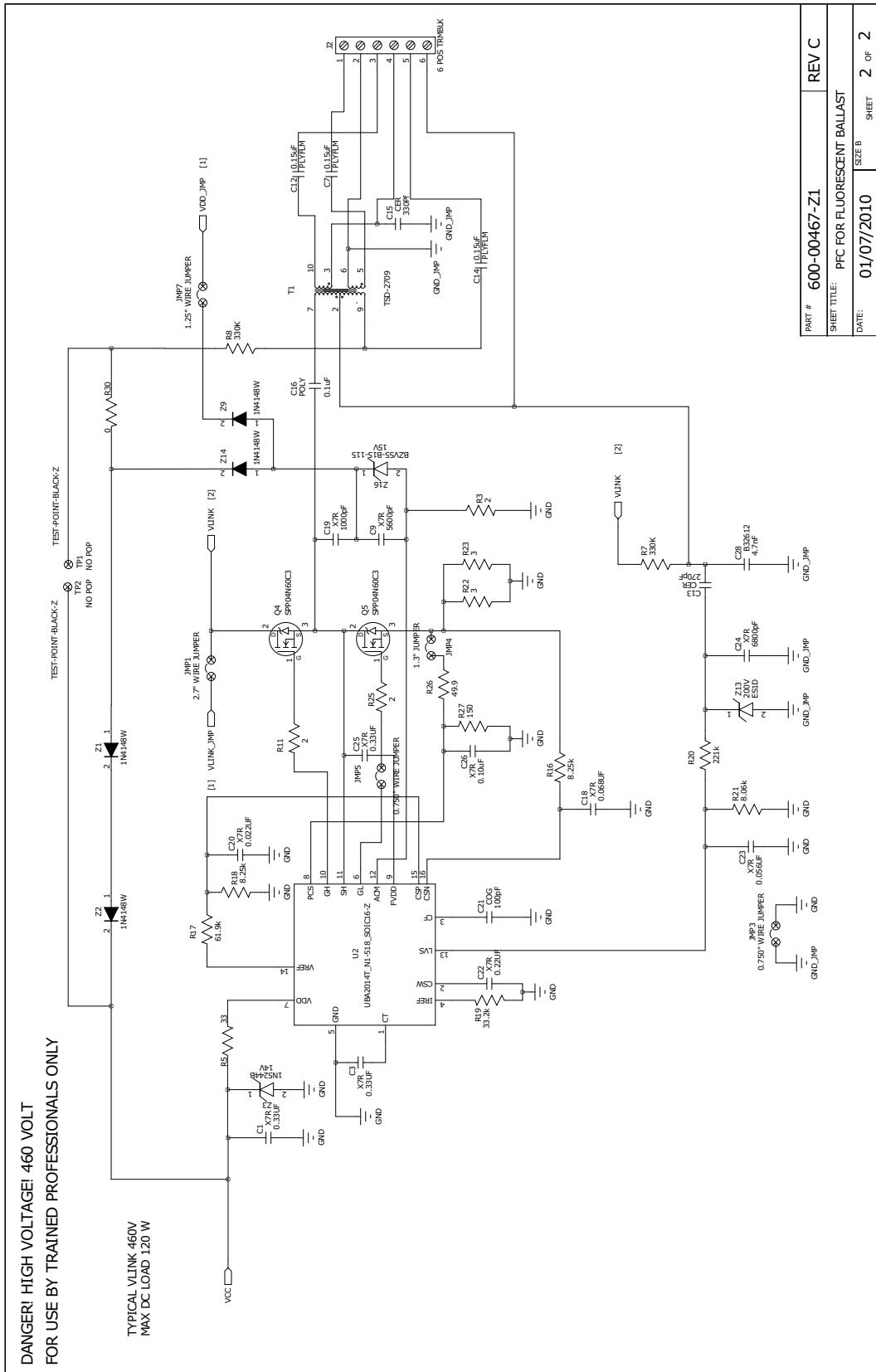
Heatsinking is required for Q4 & Q5.

The end product should use tar pitch or an equivalent compound for this purpose.  
For lab evaluation purposes, a fan is recommended to provide adequate cooling.





**DANGER! HIGH VOLTAGE! 460 VOLT  
FOR USE BY TRAINED PROFESSIONALS ONLY**



### 3. BILL OF MATERIALS

#### BILL OF MATERIAL (Page 1 of 2)

Item	Cirrus PIN	Rev	Description	Qty	Reference Designator	MFG	MFG PN	Notes
1	001-10235-21	A	CAP 0.33uF ±10% 50V X7R NPb 1206	3	C1 C3 C25	KEMET	C1206C334K3RAC	
2	001-06280-Z1	A	CAP 3.0pF ±5% 50V COG NPb 1206	1	C2	KEMET	C1206C305GAC	
3	001-06276-21	A	CAP 2200pF ±10% 50V X7R NPb 1206	2	C4 C11	KEMET	C1206C222K3RAC	
4	001-10233-21	A	CAP 4.7uF ±20% 25V X7R NPb 1206	1	C5	TDK	C3216X7R TE475M	
5	0120-186-Z1	A	CAP 0.15uF ±10% 250V ELEC NPb RAD	2	C6 C17	NICHICON	UZZE4710MFD	
6	013-00037-21	A	CAP 0.15uF ±10% 250V POLY NPb RAD	3	C7 C12 C14	EPOSOS	B32528C315K	
7	011-00064-Z1	A	CAP 0.22uF ±20% 330V PLY FLM NPb TH	1	C8	EPOSOS	B32912B3224M	
8	001-06166-21	A	CAP 5600pF ±10% 50V X7R NPb 1206	1	C9	KEMET	C1206C562K3RAC	
9	001-06136-Z1	A	CAP 1000pF ±10% 50V COG NPb 1206	1	C10	KEMET	C1206C1024K3GAC	
10	011-00048-Z1	A	CAP 270pF ±10% 1kV CER NPb RAD	1	C13	TDK	CK45-R3AD2711K-NR	EC00839
11	011-00046-Z1	A	CAP 330pF ±10% 2kV CER NPb RAD	1	C15	TDK	CK45-R3AD3311K-NR	
12	013-00027-Z1	A	CAP 1.1uF ±10% 630V POLY NPb RAD	1	C16	PANASONIC	EQQE6104KF	
13	001-06138-Z1	A	CAP 0.068uF ±10% 50V X7R NPb 1206	1	C18	KEMET	C1206C683K3RAC	
14	011-00045-Z1	A	CAP 1000pF ±10% 500V X7R NPb RAD	1	C19	VISHAY SPRAGUE	562R5TSD10	
15	001-06109-Z1	A	CAP 0.022uF ±5% 50V X7R NPb 1206	1	C20	KEMET	C1206C223J5RAC	
16	001-05542-Z1	A	CAP 1000pF ±5% 50V COG NPb 1206	1	C21	KEMET	C1206C10115GAC	
17	001-06194-Z1	A	CAP 0.22uF ±5% 50V X7R NPb 1206	1	C22	KEMET	C1206C224K3RAC	
18	001-06321-Z1	A	CAP 0.056uF ±10% 50V X7R NPb 1206	1	C23	KEMET	C1206C563K3RAC	
19	001-06148-Z1	A	CAP 6800pF ±10% 50V X7R NPb 1206	1	C24	MURATA	GRM188R71E104KA01D	
20	001-10225-Z1	A	CAP 0.10uF ±10% 25V X7R LESR NPb 0603	1	C26	VISHAY	YY1222M47YY5U1Q063V0	NO POP
21	011-00049-Z1	A	CAP 2200pF ±20% DISC 500V RAD NPO	0	C27 C29	EPICOIS	B32812A1472J008	
22	013-00026-Z1	A	CAP 0.77uF ±5% 1600V POLY NPb RAD	1	C28	VISHAY	YY1222M47YY5U1Q063V0	
23	011-00049-Z1	A	CAP 2200pF ±20% DISC 500V RAD NPO	2	C30 C33	PANASONIC	EQQE6334KF	
24	013-00034-Z1	A	CAP 0.33uF ±10% 630V POLY NPb RAD	1	C31	KEMET	C315C331J165CA	FORM LEADS TO MATCH LAYOUT
25	011-00059-Z1	A	CAP 330pF ±20% 100V COG C315 NPb TH	1	C32	DIODES INC	IN4006G-T	
26	070-00132-Z1	A	DIODE RECT 800V 1A 200mA NPb DO-41	1	D1	ON SEMI	MURS36013G	
27	070-00166-Z1	A	DIODE RECT 600V 4A ULT 400V SMC	1	D2	MICRO COMMERCIAL CO	GBU41-BP	
28	070-00157-Z1	A	DIODE RECT BRIDGE 600V 4A NPb GBU	1	D3	DIODES INC	L14148	
29	070-00011-Z1	A	DIODE SS 75V 500mW NPb SO80	1	D4	LITTLE FUSE	37213150411	
30	180-00022-Z1	A	FUSE 3.15A TLAG IEC NPb SHORT T1R5	1	F2	PHENIX CONTACT	1727092	
31	110-00021-Z1	A	CON TRN BLK 6X1 FLM RA GRN NPb TH	1	G1	WEIDMULLER	1716030000	
32	110-00010-Z1	A	CON 3POS TERM BLK 0.08mm SPR NPb RA	1	J6	ALPHA WIRE COMPANY	305011 BK005	SEE ASSY DWG FOR LENGTH
33	080-00013-Z1	A	WIRE 24 AWG SOLID PVC INS BLK NPb	10	J7	RENCO	RUCS-1005	
34	050-00050-Z1	A	XFMR 380uH 10% .2650 NPb TH	1	J8	Premier Magnetics	TS-D-2796	
35	050-00039-Z1	A	XFMR 5mH 1.1 1500Vrms 4Pin NPb TH	1	J9	RENCO	ZT24-V-RC	NO POP
36	040-0127-Z1	A	IND TH1-13 ±15% TOR VERT NPb TH	1	L5	RENCO	RL-440-2-4.00	
37	050-00047-Z1	A	XFMR COMMON MODE CHOKE 1.3 A TH NPb 0	1	L6	KEYSTONE	STB13NN60N	INSTALL RUBBER FEET SJ61A3
38	304-00001-Z1	A	SPCR STANDOFF 4-40 THR 875L AL NPb	0	Q1	ST MICROELECTRONICS	SPHP14N80C3	
39	071-00108-Z1	A	TRAN MOSFET nCH11A 600V NPb TO220-3	2	Q4 Q5	INFININEON	VISHAY	
40	071-00082-Z1	A	TRAN MOSFET nCH99W NPb TO220-3	2	Q6	INFININEON	VISHAY	
41	030-00101-Z1	A	RES 17.8K OHM 1/4W ±1% NPb 1206	1	R1	DALE	CFCW12061K00F36	
42	020-06310-Z1	A	RES 20K OHM 1/4W ±1% NPb 1206 FILM	1	R2	DALE	CFCW12061K15F4EA	
43	020-06347-Z1	A	RES 2.00 OHM 1/4W ±1% NPb 1206	3	R3 R11 R25	DALE	CFCW12061K78F4EA	
44	020-06337-Z1	A	RES 2.49 OHM 1/4W ±1% NPb 1206 FILM	1	R4	DALE	CFCW120624R9F4EA	
45	021-00054-Z1	A	RES 3.3 OHM 1/4W ±5% NPb 1206 FILM	1	R5	DALE	CFCW120635RQ1NEA	
46	031-00052-Z1	A	RES 330K OHM 1/4W ±5% CAREL NPb AXL	2	R7 R8	PANASONIC	ERD-S27J33AV	
47	020-06390-Z1	A	RES 17.8K OHM 1/4W ±1% NPb 1206	1	R10	DALE	CFCW12061K0BF4EA	
48	020-06365-Z1	A	RES 1.75M OHM 1/4W ±1% NPb 1206	6	R12 R33 R34 R35 R37	DALE	CFCW12061M15F4EA	
49	020-06391-Z1	A	RES 1.78K OHM 1/4W ±1% NPb 1206	1	R13	DALE	CFCW12061K78F4EA	
50	020-06324-Z1	A	RES 2.0 OHM 1/4W ±1% NPb 1206 FILM	1	R14	DALE	CFCW120620R0F4EA	
51	020-06343-Z1	A	RES 8.25K OHM 1/4W ±1% NPb 1206	2	R16 R18	DALE	CFCW1206825F4EA	
52	020-06345-Z1	A	RES 61.8K OHM 1/4W ±1% NPb 1206	1	R17	DALE	CFCW12061K0BF4EA	
53	020-06346-Z1	A	RES 33.2K OHM 1/4W ±1% NPb 1206	1	R19	DALE	CFCW12061K15F4EA	
54	020-06342-Z1	A	RES 221K OHM 1/4W ±1% NPb 1206 FILM	1	R20	DALE	CFCW120622R0F4EA	
55	020-06344-Z1	A	RES 8.06K OHM 1/4W ±1% NPb 1206	1	R21	DALE	CFCW1206806F4EA	
56	021-06199-Z1	A	RES 3 OHM 1/2W ±5% 400uA 1206 FILM	2	R22 R23	PANASONIC	ERJ473R0U	
57	020-02273-Z1	A	RES 0 OHM 1/4W NPb 206 FILM	2	R24 R30	DALE	CFCW1206000Z0EA	
58	020-02467-Z1	A	RES 49.9 OHM 1/4W ±1% NPb 1206 FILM	1	R26	DALE	CFCW120649R9F4EA	

Item	Cirrus P/N	Rev	Description	Qty	Reference & Designator	MFG	MFG P/N	Notes
59	020-0250-Z1	A	RES 150 OHM 14mV ±1% NpB 1206 FILM	1	R27	DALE	CRCW1206150RFKEA	
60	020-02498-Z1	A	RES 75 OHM 14mV ±1% NpB 1206 FILM	0	R28 R29	DALE	CRCW1206750RFKEA	NO POP
61	020-02581-Z1	A	RES 199 OHM 14mV ±1% NpB 1206 FILM	1	R32	DALE	CRCW1206199RFKEA	ECC00825
62	030-00091-Z1	A	RES 0.1 OHM 2mV ±1% WW NpB AXL	1	R38	VISHAY	G003R1000FET0780	
63	030-00091-Z1	A	RES 0.1 OHM 2mV ±1% WW NpB AXL	0	R39	VISHAY	G003R1000FET0780	NO POP
64	020-06372-Z1	A	RES 0.24 OHM 1mV ±1% NpB 2512	0	R40 R41	PANASONIC	ERJ1TRQR24U	NO POP
65	036-00015-Z1	A	VARISTOR 470V RMS 14MM NpB RAD	1	RV1	EPCOS	S14K300	
66	060-00042-Z1	A	XFMIR 1.3mH 200VAc 10PIN NpB TH	1	T1	PREMIER	TSD-2709	
67	110-00045-Z1	A	CON TEST PT. 1PC TIN PLAT NpB BLK	0	TP1 TP2	KEYSTONE	5001	NO POP
68	065-00331-Z3	A2	IC CIRUS LPWR FACTOR CORR NpB SOIC8	1	U1	CIRRUS LOGIC	CSU1601-FS27A/2	ECC00839
69	060-00477-Z1	A	IC CNTL BALLAST 600V NpB SOIC16	1	U2	NXP	UBA16017N1.518	SEE ASSEMBLY DRAWING
70	365-00005-Z1	A	FEET PROT ADH BACK .375x.25 BLK NpB	4	XMH1 XMH2 XMH3 XMH4	3M	S161A3	
71	070-00007-Z1	A	DIODE FAST 3mV 350mW NpB SOD123	4	Z1 Z2 Z9 Z14	DIODES INC	1N4148V-7-F	
72	070-00194-Z1	A	DIODE ZEN 14V 150HM 500mW NpB DO-35	1	Z3	FAIRCHILD SEMICONDUCTOR	1N5244B	
73	070-00196-Z1	A	DIODE RECT 200V 1A SMA NpB DO-214AC	1	Z13	TAIWAN SEMICONDUCTOR	ES1D	
74	070-00195-Z1	A	DIODE ZENER 500mW 15V 8.5mA MINIMLF	1	Z16	NXP	BZV55-B15.15	
75	603-00467-Z1	C	ASSY DWG CRD1601-1-20W-Z-NpB	REF		CIRRUS LOGIC	603-00467-Z1	
76	422-00013-01	C	LBL SUBASSY PRODUCT ID AND REV	1		CIRRUS LOGIC	422-00013-01	
77	240-00467-Z1	C	PCB CRD1601-1-20W-Z-NpB	REF		CIRRUS LOGIC	240-00467-Z1	
78	600-00467-Z1	C	SCHEM CRD1601-1-20W-Z-NpB	REF		CIRRUS LOGIC	600-00467-Z1	ECC00820/0825/0839

#### 4. BOARD LAYOUT

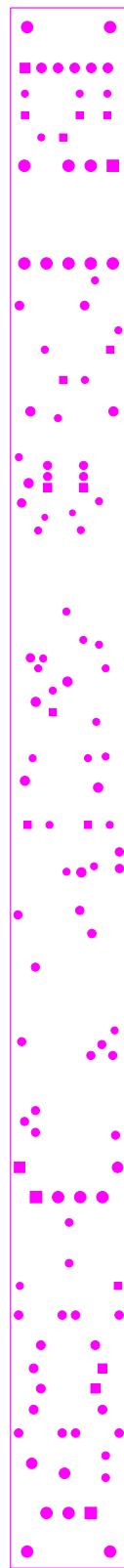


Figure 2. Solder Mask (Top)

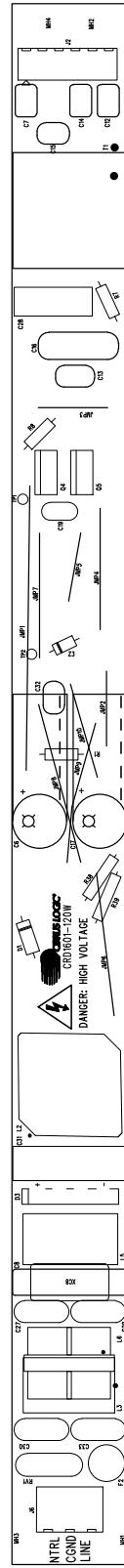
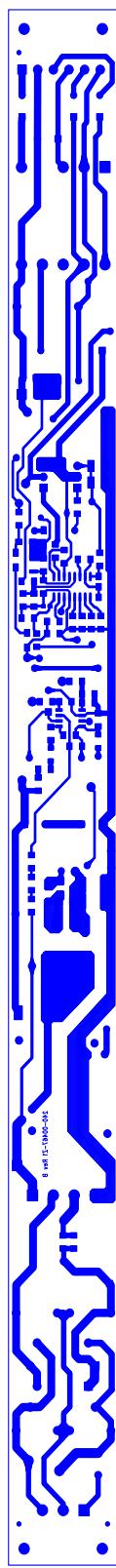
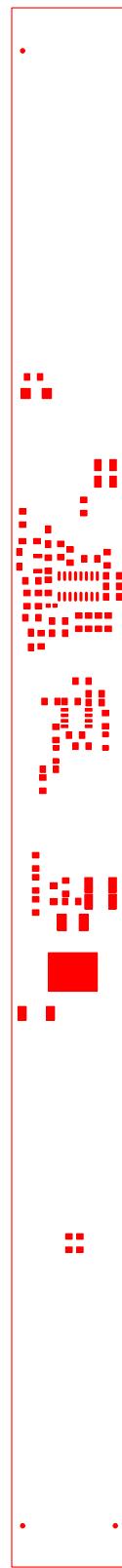


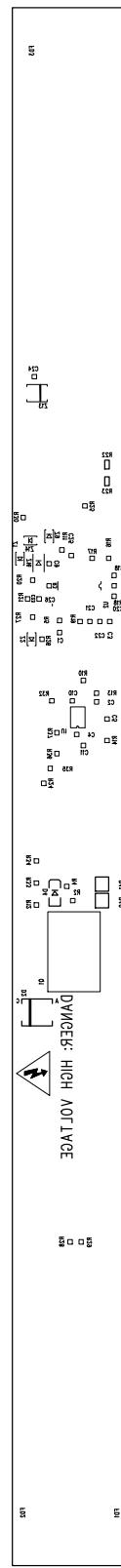
Figure 3. Silkscreen (Top)



**Figure 4. Circuit Routing (Bottom)**



**Figure 5. Solder Paste Mask (Bottom)**



**Figure 6. Silkscreen (Bottom)**



**Figure 7. Solder Mask (Bottom)**

## 5. PERFORMANCE PLOTS

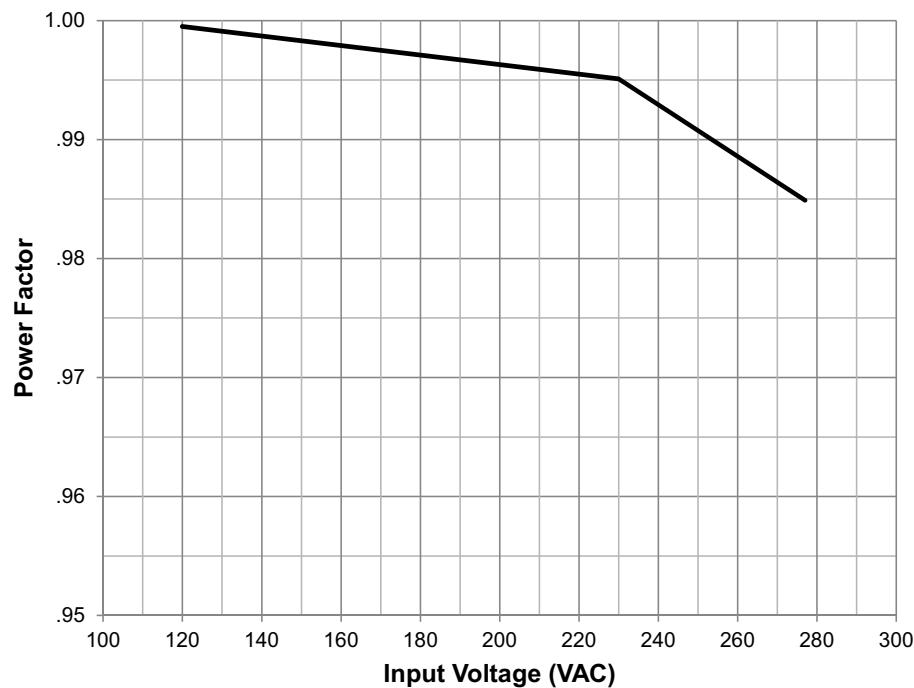


Figure 8. Power Factor vs. AC Input Voltage

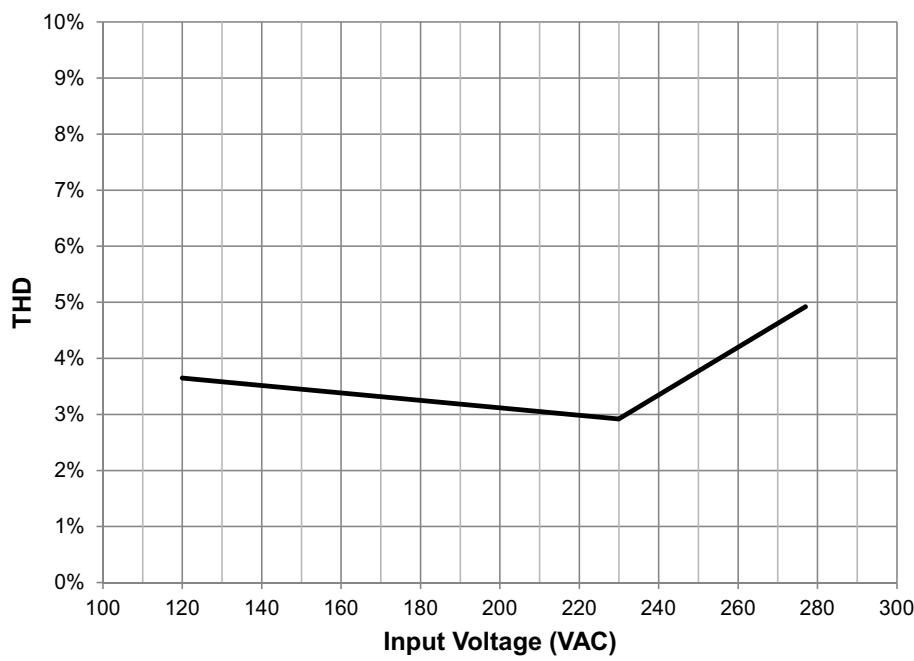
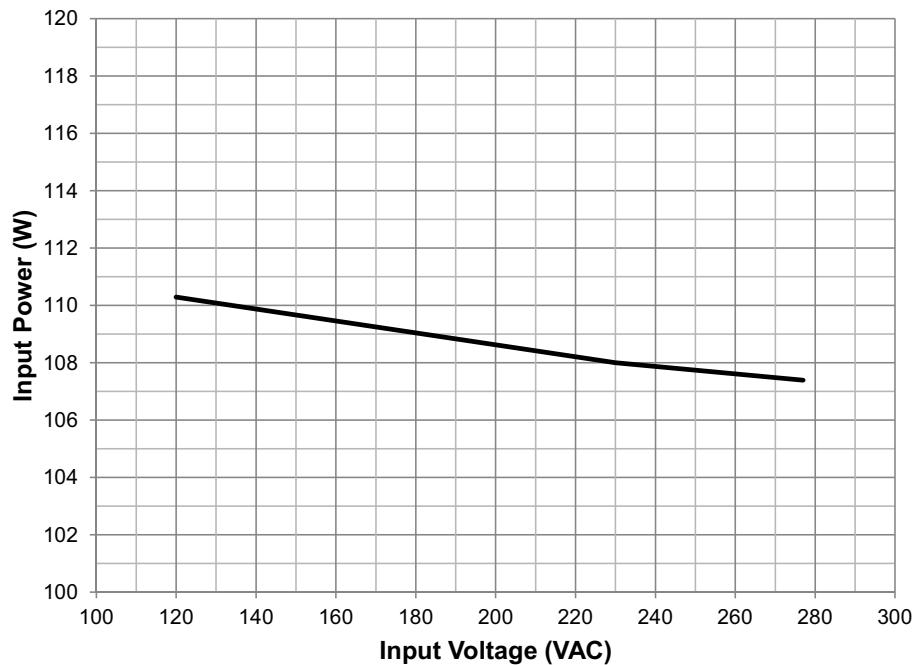


Figure 9. THD vs. AC Input Voltage



**Figure 10. Input Power vs. AC Input Voltage**

## 6. REVISION HISTORY

Revision	Date	Changes
RD1	FEB 2011	Initial Release.
RD2	FEB 2011	Minor BOM & schematic change to eliminate possible flicker.
RD3	MAR 2011	Updated BOM, Schematic, and layers to rev C (rev A2 Cirrus device).
RD4	OCT 2011	Revised part number to reflect lead free.