

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 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.

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

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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.

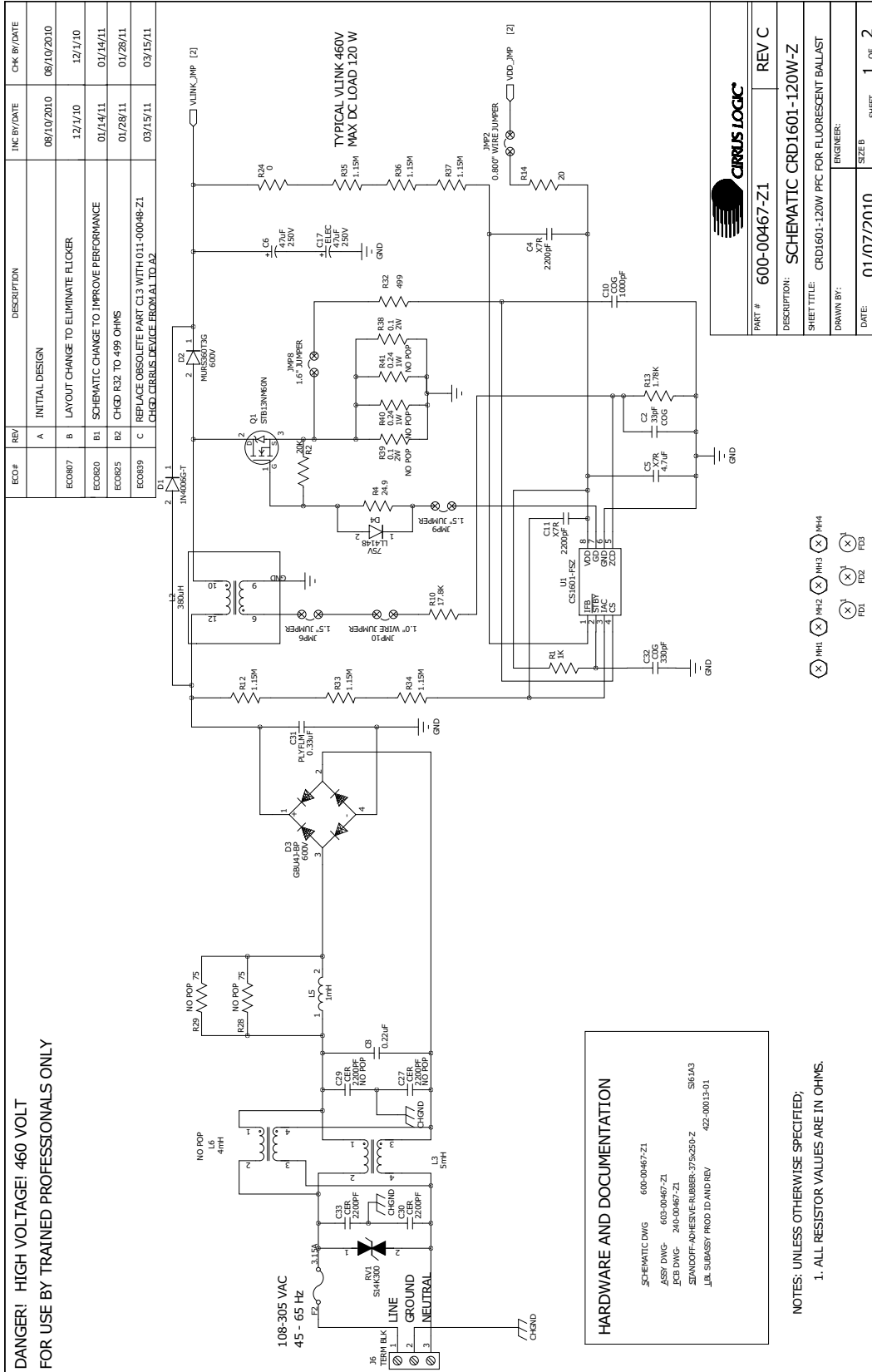


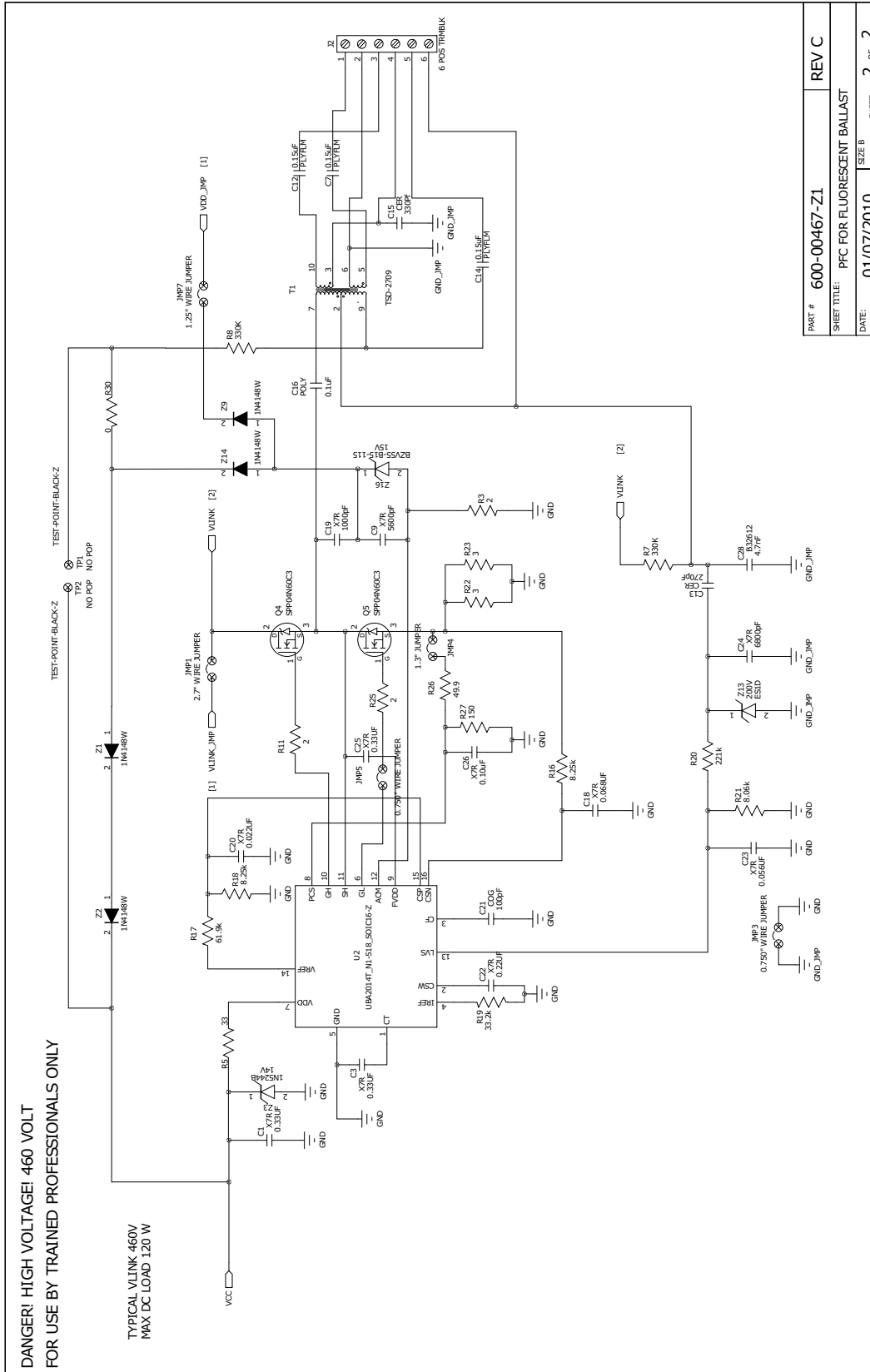
Warning:

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.

2. SCHEMATIC





3. BILL OF MATERIALS

BILL OF MATERIAL (Page 1 of 2)

 CIRRUS LOGIC
 CRD1601-120W_REV_C

| Item | Cirrus P/N | Rev | Description | Qty | Reference Designator | MFG | MFG P/N | Notes |
|------|--------------|-----|--------------------------------------|-----|---|---------------------|--------------------|----------------------------|
| 1 | 001-10235-Z1 | A | CAP 0.33uF ±10% 50V XTR NPB 1206 | 3 | C1 C3 C25 | KEMET | C1206C334K5RAC | |
| 2 | 001-05280-Z1 | A | CAP 33pF ±5% 50V COG NPB 1206 | 1 | C2 | KEMET | C1206C330J5GAC | |
| 3 | 001-06276-Z1 | A | CAP 2200pF ±10% 50V XTR NPB 1206 | 2 | C4 C11 | KEMET | C1206C222K5RAC | |
| 4 | 001-10233-Z1 | A | CAP 4.7uF ±20% 25V XTR NPB 1206 | 1 | C5 | TDK | C3216X7R1E475M | |
| 5 | 012-00186-Z1 | A | CAP 47uF ±20% 250V ELEC NPB RAD | 2 | C6 C17 | NICHICON | UVZ2E470MHD | |
| 6 | 013-00037-Z1 | A | CAP 0.15uF ±10% 250V POLY NPB RAD | 3 | C7 C12 C14 | EPCOS | B32529C3154K | |
| 7 | 011-00064-Z1 | A | CAP 0.22uF ±20% 330V PLY FILM NPB TH | 1 | C8 | EPCCOS | B32912B3224M | ECO0839 |
| 8 | 001-06516-Z1 | A | CAP 5600pF ±10% 50V XTR NPB 1206 | 1 | C9 | KEMET | C1206C562K5RAC | |
| 9 | 001-06036-Z1 | A | CAP 1000pF ±10% 50V COG NPB 1206 | 1 | C10 | KEMET | C1206C102K5GAC | |
| 10 | 011-00048-Z1 | A | CAP 270pF ±10% 1kV CER NPB RAD | 1 | C13 | TDK | CK45-R3AD271K-NR | ECO0839 |
| 11 | 011-00046-Z1 | A | CAP 330pF ±10% 2kV CER NPB RAD | 1 | C15 | TDK | CK45-R3D331K-NR | |
| 12 | 013-00027-Z1 | A | CAP 0.1uF ±10% 630V POLY NPB RAD | 1 | C16 | PANASONIC | ECO6104KF | |
| 13 | 001-06838-Z1 | A | CAP 0.088uF ±10% 50V XTR NPB 1206 | 1 | C18 | KEMET | C1206C883K5RAC | |
| 14 | 011-00045-Z1 | A | CAP 1000pF ±10% 500V XTR NPB RAD | 1 | C19 | VISHAY/SPRAGUE | 562R5TSD10 | |
| 15 | 001-06709-Z1 | A | CAP 0.022uF ±5% 50V XTR NPB 1206 | 1 | C20 | KEMET | C1206C223J5RAC | |
| 16 | 001-06542-Z1 | A | CAP 100pF ±5% 50V COG NPB 1206 | 1 | C21 | KEMET | C1206C101J5GAC | |
| 17 | 001-06948-Z1 | A | CAP 0.22uF ±10% 50V XTR NPB 1206 | 1 | C22 | KEMET | C1206C224K5RAC | |
| 18 | 001-06821-Z1 | A | CAP 0.066uF ±10% 50V XTR NPB 1206 | 1 | C23 | KEMET | C1206C663K5RAC | |
| 19 | 001-06548-Z1 | A | CAP 6800pF ±10% 50V XTR NPB 1206 | 1 | C24 | KEMET | C1206C682K5RAC | |
| 20 | 001-10225-Z1 | A | CAP 0.10uF 10% 25V XTRLESR NPB 0603 | 1 | C26 | MURATA | GRM188R71E104KA01D | NO POP |
| 21 | 011-00049-Z1 | A | CAP 2200pF ±20% DISC 500V RAD NPB | 0 | C27 C29 | VISHAY | YY1222M475UJ063V0 | |
| 22 | 013-00026-Z1 | A | CAP 4.7nF ±5% 1600V POLY NPB RAD | 1 | C28 | EPCOS | B32612A1472J008 | |
| 23 | 011-00049-Z1 | A | CAP 2200pF ±20% DISC 500V RAD NPB | 2 | C30 C33 | VISHAY | YY1222M475UJ063V0 | |
| 24 | 013-00034-Z1 | A | CAP 0.33uF ±10% 630V POLY NPB RAD | 1 | C31 | PANASONIC | ECO6334KF | |
| 25 | 011-00059-Z1 | A | CAP 330pF ±5% 100V COG C315 NPB TH | 1 | C32 | KEMET | C315C331J1G5CA | FORM LEADS TO MATCH LAYOUT |
| 26 | 070-00132-Z1 | A | DIODE RECT 800V 1A 20mA NPB DO-41 | 1 | D1 | DIODES INC | IN4006G-T | |
| 27 | 070-00166-Z1 | A | DIODE RECT 600V 4A ULT FST NPB SMC | 1 | D2 | ON SEMICONDUCTOR | MURS360T3G | |
| 28 | 070-00157-Z1 | A | DIODE RECT BRIDGE 600V 4A NPB GBU | 1 | D3 | MICRO COMMERCIAL CO | GBU4J-BP | |
| 29 | 070-00001-Z1 | A | DIODE SS 75V 500mA NPB SOD80 | 1 | D4 | DIODES INC | LL4148 | |
| 30 | 180-00022-Z1 | A | FUSE 3.15A TLAG IEC NPB SHORT TRS | 1 | F2 | LITTLE FUSE | 37213150411 | |
| 31 | 110-00321-Z1 | A | CON TERM BLK 6X7 FML RA GRN NPB TH | 1 | J2 | PHOENIX CONTACT | 1727052 | |
| 32 | 110-00301-Z1 | A | CON 3POS TERM BLK 5.08mm SPR NPB RA | 1 | J6 | WEIDMULLER | 1716030000 | |
| 33 | 080-00013-Z1 | A | WIRE 24 AWG SOLID PVC INS BLK NPB | 10 | JMP1 JMP2 JMP3 JMP4 JMP5 JMP6 JMP7 JMP8 JMP9 JMP 10 | ALPHA WIRE COMPANY | 3050V1 BK005 | SEE ASSY DWG FOR LENGTH |
| 34 | 050-00050-Z1 | A | XFMR 380uH 10% .2650 NPB TH | 1 | L2 | RENCO | RLCS-1005 | |
| 35 | 050-00039-Z1 | A | XFMR 5mH 1:1 1500Vrms 4PIN NPB TH | 1 | L3 | PREMIER MAGNETICS | TSD-2796 | |
| 36 | 040-00127-Z1 | A | IND 1mH 1.3A ±15% TOR VERT NPB TH | 1 | L5 | BOURNS | 2124-V-RC | |
| 37 | 050-00047-Z1 | A | XFMR COMMON MODE CHOKE 1.3 A TH NPB | 0 | L6 | RENCO | RL-4400-2-4.00 | NO POP |
| 38 | 304-00001-Z1 | A | SPCR STANDOFF 4-40 THR .875L AL NPB | 0 | MH1 MH2 MH3 MH4 | KEYSTONE | 1809 | INSTALL RUBBER FEET SJ61A3 |
| 39 | 071-00108-Z1 | A | TRAN MOSFET nCH 11A 600V NPB D2PAK | 1 | Q1 | ST MICROELECTRONICS | STB13NM60N | |
| 40 | 071-00092-Z1 | A | TRAN MOSFET nCH 69W NPB TO220-3 | 2 | Q4 Q5 | INFINEON | SPP04N60C3 | |
| 41 | 030-00010-Z1 | A | RES 1K 1/4W ±1% METAL FILM NPB AXL | 1 | R1 | VISHAY | CCF551K00FKE36 | |
| 42 | 020-06310-Z1 | A | RES 20K OHM 1/4W ±1% NPB 1206 FILM | 1 | R2 | DALE | CRCW120620K0FKEA | |
| 43 | 020-06347-Z1 | A | RES 2.00 OHM 1/4W ±1% NPB 1206 | 3 | R3 R11 R25 | DALE | CRCW12062R00FKEA | |
| 44 | 020-06337-Z1 | A | RES 24.9 OHM 1/4W ±1% NPB 1206 FILM | 1 | R4 | DALE | CRCW120624R9FKEA | |
| 45 | 021-00544-Z1 | A | RES 33 OHM 1/4W ±5% NPB 1206 FILM | 1 | R5 | DALE | CRCW120633R0JNEA | |
| 46 | 031-00052-Z1 | A | RES 330K OHM 1/4W ±5% CARB NPB AXL | 2 | R7 R8 | PANASONIC | ERD-52TJ334V | |
| 47 | 020-06390-Z1 | A | RES 17.8K OHM 1/4W ±1% NPB 1206 | 1 | R10 | DALE | CRCW120617K8FKEA | |
| 48 | 020-06356-Z1 | A | RES 1.15M OHM 1/4W ±1% NPB 1206 | 6 | R12 R33 R34 R35 R36 R37 | DALE | CRCW12061M15FKEA | |
| 49 | 020-06391-Z1 | A | RES 1.78K OHM 1/4W ±1% NPB 1206 | 1 | R13 | DALE | CRCW12061K78FKEA | |
| 50 | 020-06324-Z1 | A | RES 20 OHM 1/4W ±1% NPB 1206 FILM | 1 | R14 | DALE | CRCW120620R0FKEA | |
| 51 | 020-06343-Z1 | A | RES 8.25K OHM 1/4W ±1% NPB 1206 | 2 | R16 R18 | DALE | CRCW12068K25FKEA | |
| 52 | 020-06345-Z1 | A | RES 61.9K OHM 1/4W ±1% NPB 1206 | 1 | R17 | DALE | CRCW120661K9FKEA | |
| 53 | 020-06346-Z1 | A | RES 33.2K OHM 1/4W ±1% NPB 1206 | 1 | R19 | DALE | CRCW120633K2FKEA | |
| 54 | 020-06342-Z1 | A | RES 221K OHM 1/4W ±1% NPB 1206 FILM | 1 | R20 | DALE | CRCW1206221K FKEA | |
| 55 | 020-06344-Z1 | A | RES 8.06K OHM 1/4W ±1% NPB 1206 | 1 | R21 | DALE | CRCW12068K06FKEA | |
| 56 | 021-06319-Z1 | A | RES 3 OHM 1/2W ±5% NPB 1210 FILM | 2 | R22 R23 | PANASONIC | ERJ14YJ3R00 | |
| 57 | 020-02273-Z1 | A | RES 0 OHM 1/4W NPB 1206 FILM | 2 | R24 R30 | DALE | CRCW12060000Z0EA | |
| 58 | 020-02467-Z1 | A | RES 48.9 OHM 1/4W ±1% NPB 1206 FILM | 1 | R26 | DALE | CRCW120648R9FKEA | |

BILL OF MATERIAL (Page 2 of 2)
**CIRRUS LOGIC
CRD1601-120W_REV_C**

| Item | Cirrus P/N | Rev | Description | Qty | Reference Designator | MFG | MFG P/N | Notes |
|------|--------------|-----|--------------------------------------|-----|----------------------|-------------------------|-------------------|----------------------|
| 59 | 020-02520-Z1 | A | RES 150 OHM 1/4W ±1% NPb 1206 FILM | 1 | R27 | DALE | CRCW1206150RFFKEA | |
| 60 | 020-02488-Z1 | A | RES 75 OHM 1/4W ±1% NPb 1206 FILM | 0 | R28 R29 | DALE | CRCW120675R0FKEA | NO POP |
| 61 | 020-02581-Z1 | A | RES 499 OHM 1/4W ±1% NPb 1206 FILM | 1 | R32 | DALE | CRCW1206499RFFKEA | ECO0825 |
| 62 | 030-00081-Z1 | A | RES 0.1 OHM 2W ±1% WW NPb AXL | 1 | R38 | VISHAY | G003R1000FE7080 | |
| 63 | 030-00091-Z1 | A | RES 0.1 OHM 2W ±1% WW NPb AXL | 0 | R39 | VISHAY | G003R1000FE7080 | NO POP |
| 64 | 020-06372-Z1 | A | RES 0.24 OHM 1W ±1% NPb 2512 | 0 | R40 R41 | PANASONIC | ERJ1TRQFR24U | NO POP |
| 65 | 036-00015-Z1 | A | VARIABLE 470V RMS 14MM NPb RAD | 1 | RV1 | EPCOS | S14K300 | |
| 66 | 060-00042-Z1 | A | XFMR 1.3mH 200DVac 10PIN NPb TH | 1 | T1 | PREMEIR | TSD-2709 | |
| 67 | 110-00045-Z1 | A | CON TEST PT .1"CTR TIN PLAT NPb BLK | 0 | TP1 TP2 | KEYSTONE | 5001 | NO POP |
| 68 | 065-00331-Z3 | A2 | IC CRUS LPWR FACTOR CORR NPb SOIC8 | 1 | U1 | CIRRUS LOGIC | CS1601-FSZ/A2 | ECO0839 |
| 69 | 060-00477-Z1 | A | IC CNTL BALLAST 600V NPb SOIC16 | 1 | U2 | NXP | UBA2014T/N1,518 | |
| 70 | 305-00005-Z1 | A | FEET PROT ADH BACK .375x.25 BLK NPb | 4 | XMH1 XMH2 XMH3 XMH4 | 3M | SJ61A3 | SEE ASSEMBLY DRAWING |
| 71 | 070-00007-Z1 | A | DIODE FAST SW 75V 350mA NPb SOD123 | 4 | Z1 Z2 Z9 Z14 | DIODES INC | 1N4148W-7-F | |
| 72 | 070-00194-Z1 | A | DIODE ZEN 14V 150HM 500mA 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 MINIMILF | 1 | Z16 | NXP | BZV55-B15,115 | |
| 75 | 603-00467-Z1 | C | ASSY DWG CRD1601-120W-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 CRD1601-120W-Z-NPb | REF | | CIRRUS LOGIC | 240-00467-Z1 | |
| 78 | 600-00467-Z1 | C | SCHEM CRD1601-120W-Z-NPb | REF | | CIRRUS LOGIC | 600-00467-Z1 | ECO0820/0825/0839 |

4. BOARD LAYOUT

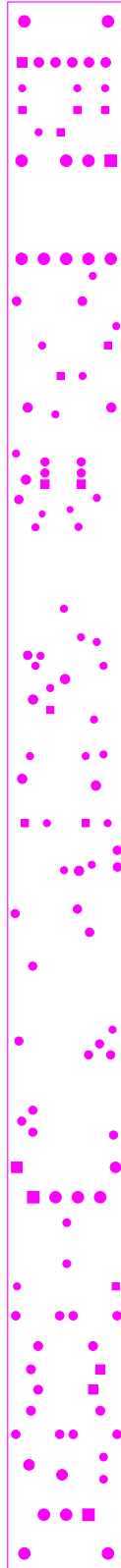


Figure 2. Solder Mask (Top)

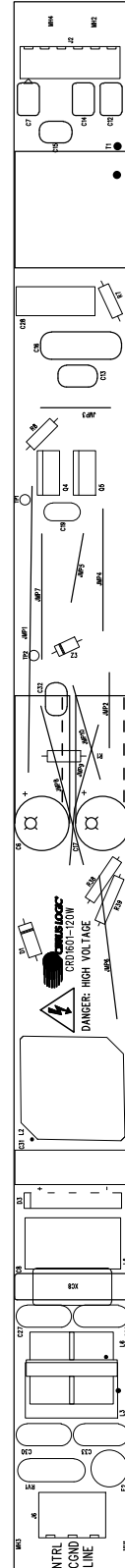


Figure 3. Silkscreen (Top)

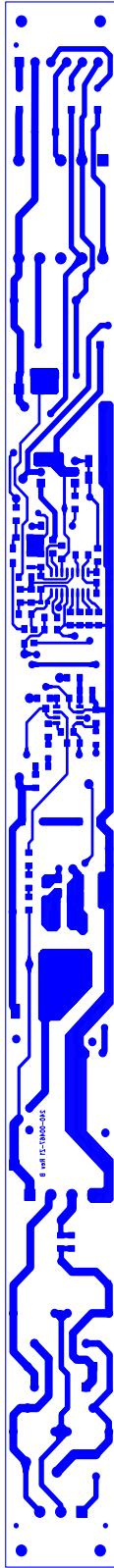


Figure 4. Circuit Routing (Bottom)



Figure 5. Solder Paste Mask (Bottom)

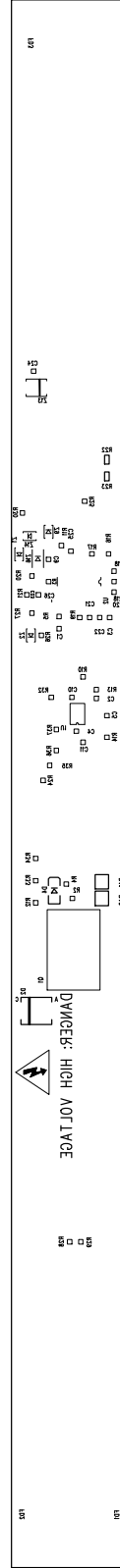


Figure 6. Silkscreen (Bottom)



Figure 7. Solder Mask (Bottom)

5. PERFORMANCE PLOTS

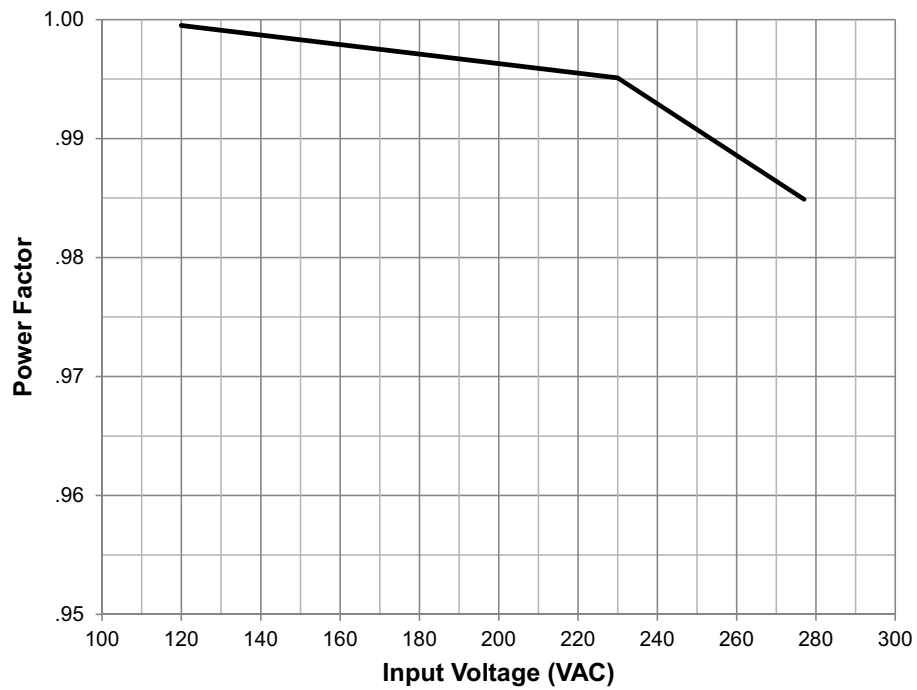


Figure 8. Power Factor vs. AC Input Voltage

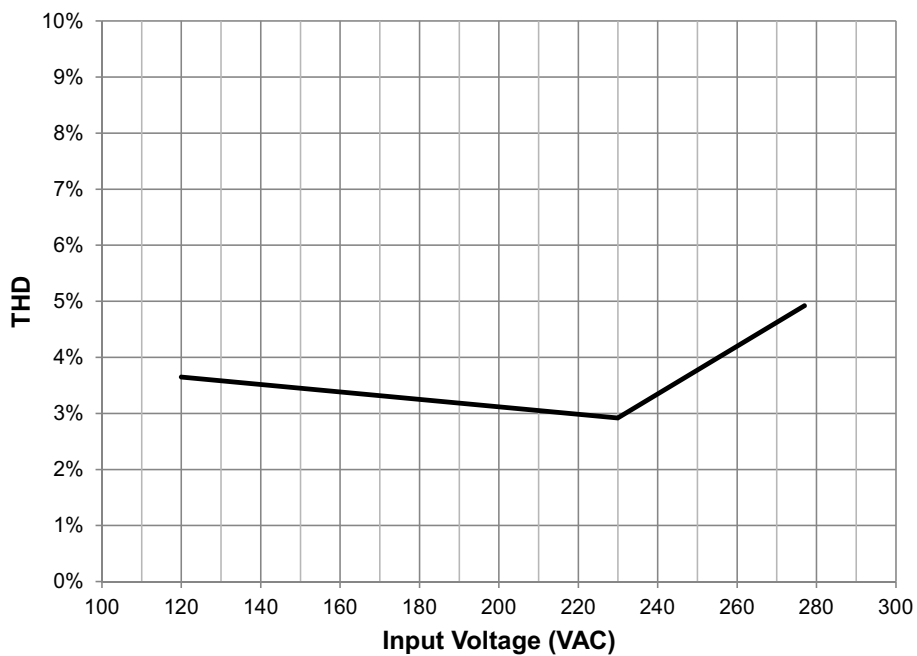


Figure 9. THD vs. AC Input Voltage

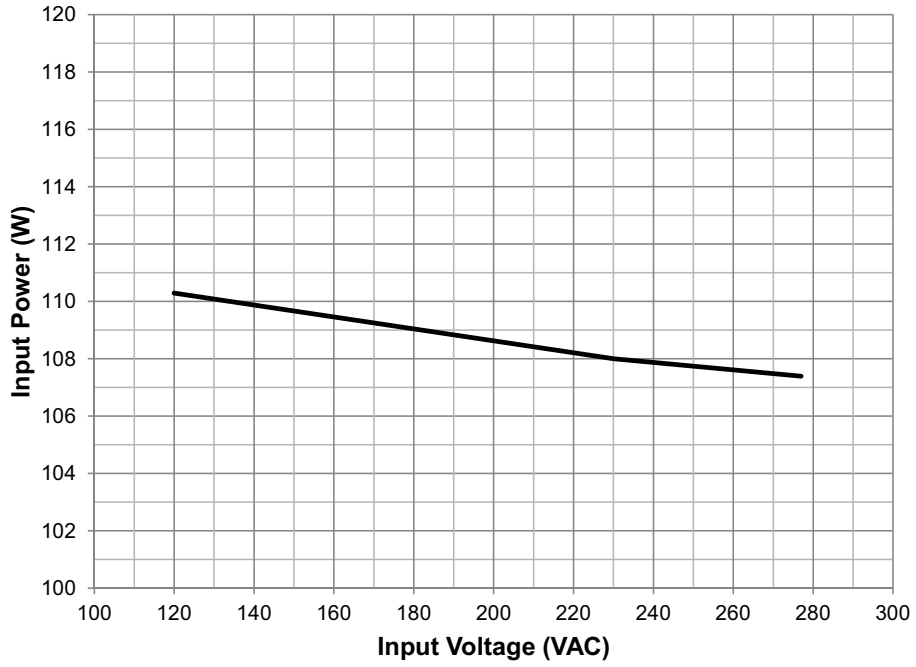


Figure 10. Input Power vs. AC Input Voltage

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). |