

## **CS1601 120W, High-efficiency PFC Demonstration Board**

### **Features**

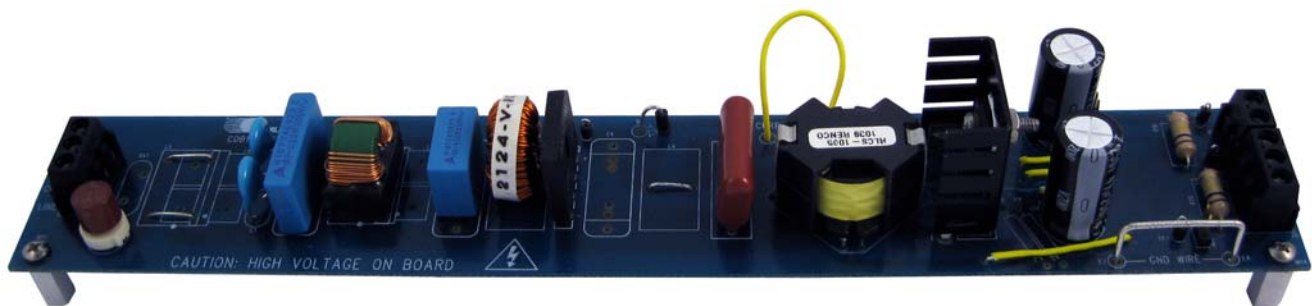
- ❑ Line Voltage Range: 108 to 305 VACrms
- ❑ Output Voltage ( $V_{LINK}$ ): 460V
- ❑ Rated  $P_{out}$  : 115W
- ❑ Efficiency: 95% @ 115W
- ❑ Spread Spectrum Switching Frequency
- ❑ Integrated Digital Feedback Control
- ❑ Low Component Count

### **General Description**

The CDB1601-120W board demonstrates the performance of the CS1601 digital PFC controller as a stand-alone unit. This board is 95% efficient at full load, and has been tailored for use with a resonant second stage to power up to two T5 fluorescent lamps for a maximum output power of 108W. A resonant second stage driver efficiency of 94% is assumed for this application.

### **ORDERING INFORMATION**

CDB1601-120W Customer Demonstration Board



Actual Size:  
258 mm x 43 mm  
8.16 in x 1.7 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. 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 CDB1601-120W board demonstrates the performance of the CS1601 over a wide input voltage range of 108 to 305 VAC, typically seen in universal input ballast applications. This board has been designed for a 460 V, 115 W full load output application.

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

Prior to applying AC power to the CDB1601-120W board, the CS1601 needs to be biased using an external 13 VDC power supply, applied across pins 1 and 3 of terminal block J5. Terminal block J6 is used to connect the AC line. The load is connected to J7. As a safety measure, jumper J1 is provided as a means to apply a small resistive load (200 k $\Omega$  minimum) to rapidly discharge the output capacitors. Other jumpers and test points are provided to evaluate the behavior of the IC and the various sections of the design.



**Figure 1. Board Connections**



**DANGER**  
**High Voltage Hazard**  
 ONLY QUALIFIED PERSONNEL SHOULD HANDLE THE CDB1601-120W.



**WARNING:**

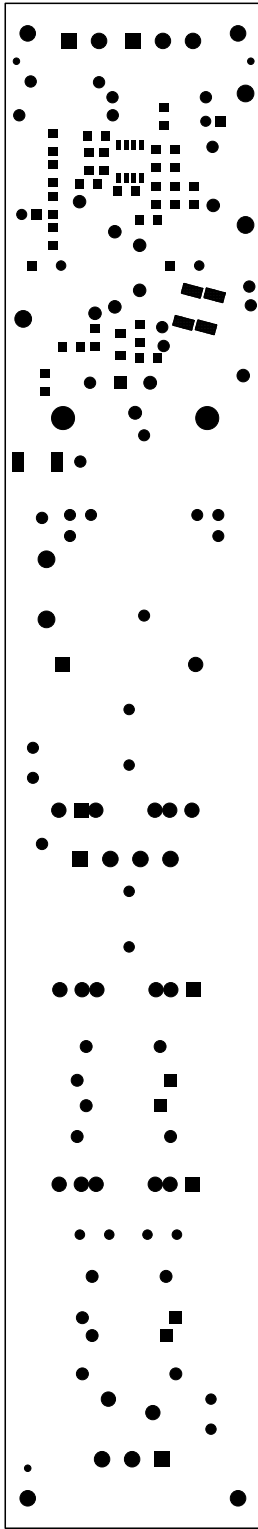
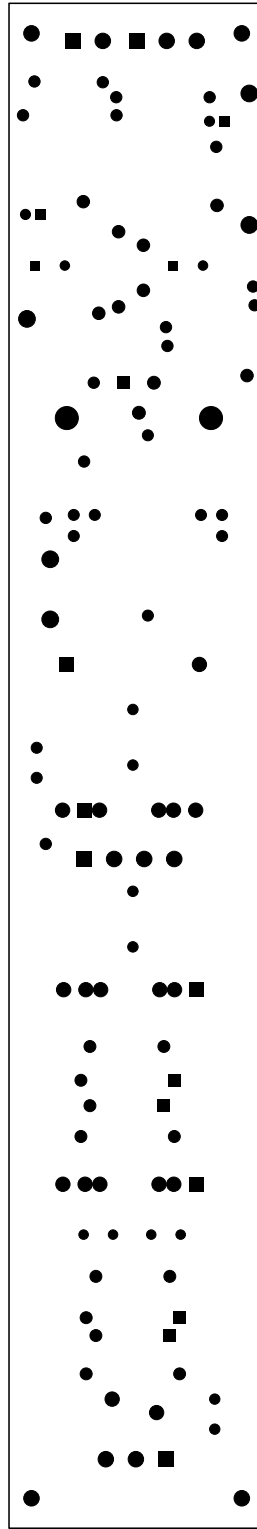
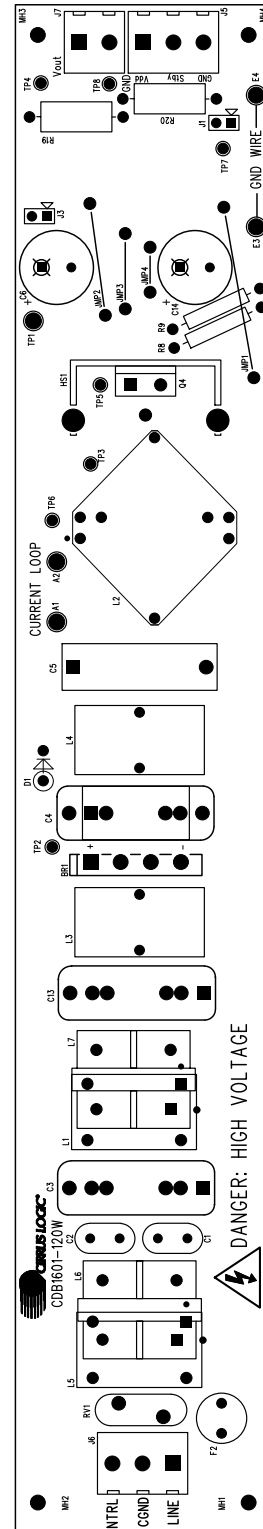
Heatsinking is required for Q4.

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.

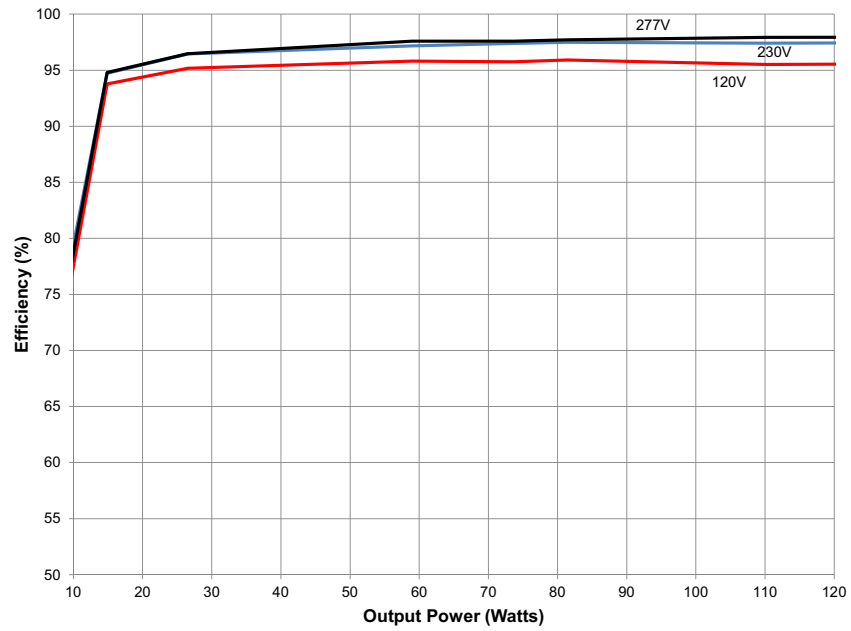
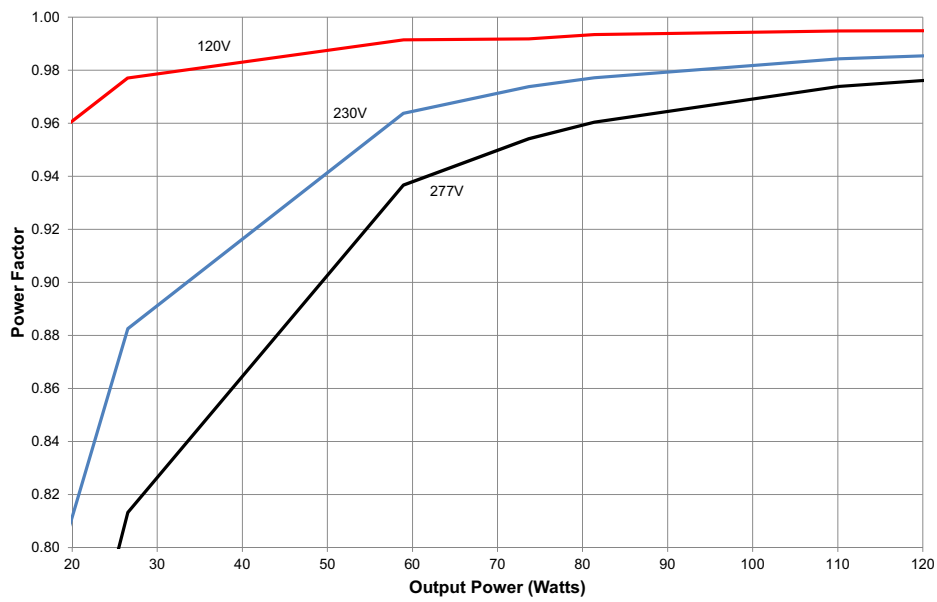


**3. BILL OF MATERIALS**
**BILL OF MATERIAL (Page 1 of 1)**
**CIRRUS LOGIC  
CDB1601-120W\_Rev\_C**

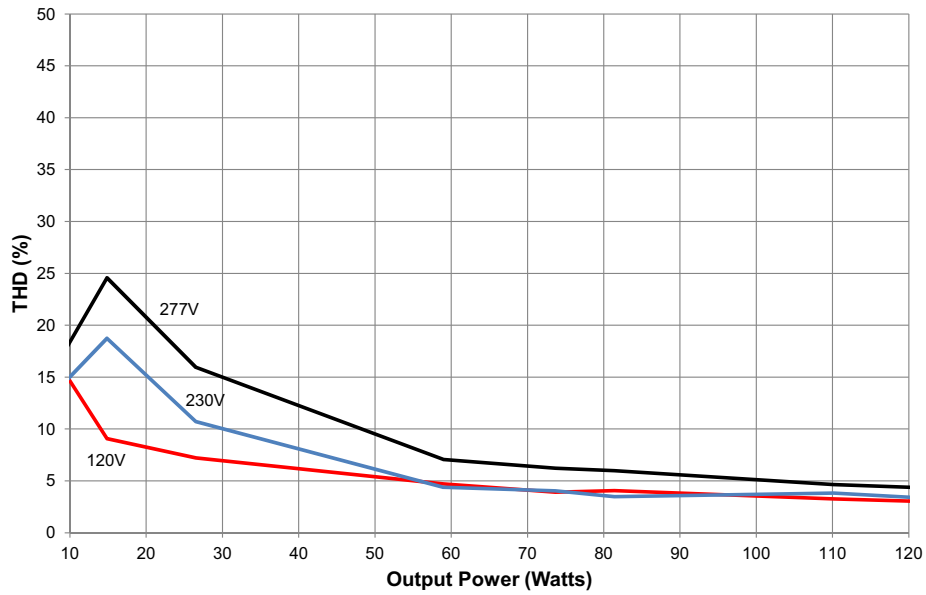
Item	Cirrus PN	Rev	Description	Qty	Reference Designator	MFG	MFG PIN	Notes
1	070-00197-Z1	A	DIODE RECT BRIDGE 600V 4A NPB GBU	1	BRT1	MICRO COMMERCIAL CO		
2	011-00042-Z1	A	CAP 2200PF ±10% 2000V CER NPB RAD	2	C1 C2	MURATA	DEB6330222KA2B	
3	011-00055-Z1	A	CAP 0.22UF ±20% 305V PLY FILM NPB TH	0	C3	EPCCOS	B32923C324M	NO POP
4	011-00040-Z1	A	CAP 0.47UF ±20% 305V PLY FILM NPB TH	0	C4	EPCCOS	B32923C347M	NO POP
5	013-00034-Z1	A	CAP 0.33UF ±10% 630V POLY NPB RAD	1	C5	PANASONIC	EOE6E8334M	
6	012-00186-Z1	A	CAP 47UF ±20% 250V ELEC NPB RAD	2	C6 C14	NICHICON	UVZ2E70MH	
7	001-05280-Z1	A	CAP 33PF ±5% 50V COG NPB 1206	1	C7	KEYMET	C1206C330J5GAC	
8	001-05783-Z1	A	CAP 330PF ±10% 50V COG NPB 1206	0	C8	KEYMET	C1206C331K5GAC	NO POP
9	001-10233-Z1	A	CAP 4.7UF ±20% 25V XTR NPB 1206	1	C9	TDK	C3216X7R1E475M	
10	001-05542-Z1	A	CAP 100PF ±5% 50V COG NPB 1206	1	C10	KEYMET	C1206C101J5GAC	
11	001-06276-Z1	A	CAP 0.22UF ±20% 330V PLY FILM NPB TH	0	C11 C12	KEYMET	C1206C222K5RAC	NO POP
12	011-00064-Z1	A	DIODE RECT 800V 1A 200mA NPB DO-41	1	C13	EPCCOS	B32912B3224M	ECO840
13	070-00132-Z1	A	DIODE RECT 600V 4A 200mA NPB TH	1	D1	DIODES INC	1N4006G-T	
14	070-00012-Z1	A	DIODE RECT 600V 4A ULT FST NPB SMC	1	D2	ON SEMICONDUCTOR	MURS360T3G	
15	070-00001-Z1	A	DIODE SS 75V 500mA NPB SOD80	1	F2	DIODES INC	LL4148	
16	180-00022-Z1	A	FUSE 3.15A TLAG IEC NPB SHORT TR5	1	F4	LITTLE FUSE	37213150411	REQUIRES 1 SCREW, 300-00025-Z1, 1 WASHER, 301-00013-Z1, 1 NUT, 302-00007-Z1 OR MOUNTING KIT
17	311-00019-Z1	A	HTSNK W LOCK TAB .5" TO220 NPB	1	HS1	AAVID THERMALLOY	6021PRG	4880G AAVID
18	115-00014-Z1	A	HDR 2X1 ML .1" 0628D ST GLD NPB TH	2	J1 J3	SAMTEC	TSW-102-07-G-S	
19	110-03001-Z1	A	CON 3POS TERM BLK 5.08mm SPR NPB RA	1	J5 J6	WEIDMULLER	1716030000	
20	110-03002-Z1	A	CON 2POS TERM BLK 5.08mm SPR NPB RA	1	J7	WEIDMULLER	1716020000	
21	060-00013-Z1	A	WIRE 24 AWG SOLID PVC INS BLK NPB	6,000	JMP1 JMP2 JMP3 JMP4 W2	ALPHA WIRE COMPANY	30501 BK005	SEE ASSY DWG FOR LENGTH
22	050-00039-Z1	A	XFMR 5mh 1:1 1500V rms 4RN NPB TH	1	L1	PREMIER MAGNETICS	TSD-2796	
23	050-00059-Z1	A	XFMR 380UH 10% 2850V NPB TH	1	L2	RENCO	RCLS-1005	
24	040-00127-Z1	A	IND 1mH 1.5A ±15% TOR VERT NPB TH	1	L3	BOURNS	2724-VRC	NO POP
25	040-00127-Z1	A	IND 1mH 1.5A ±15% TOR VERT NPB TH	0	L4	BOURNS	2724-VRC	NO POP
26	050-00039-Z1	A	XFMR 5mh 1:1 1500V rms 4PN NPB TH	0	L5	PREMIER MAGNETICS	TSD-2796	NO POP
27	050-00047-Z1	A	XFMR COMMON MODE CHOKE T3 A TH NPB	0	L6 L7	RENCO	RL-4400-2-4.00	NO POP
28	304-00004-Z1	A	SPCR STANDOFF 4-40 THR .500" L NPB	4	MH1 MH2 MH3 MH4	KEYSTONE	Z203	REQUIRES SCREW 4-40X5X16" PH STEEL 300-00025-Z1
29	071-00107-Z1	A	TRAN MOSFT nCH 11A 600V NPB TO220FP	1	Q4	ST MICROELECTRONICS	STF13NM60N	
30	020-06337-Z1	A	RES 24.9 OHM 1/4W ±1% NPB 1206 FILM	1	R1	DALE	CRCW206249R9FKEA	
31	020-02502-Z1	A	RES 100 OHM 1/4W ±1% NPB 1206 FILM	0	R2	DALE	CRCW206100R9FKEA	
32	020-02616-Z1	A	RES 1K OHM 1/4W ±1% NPB 1206 FILM	1	R3	DALE	CRCW2061K00R9FKEA	NO POP
33	020-02273-Z1	A	RES 0 OHM 1/4W NPB 1206 FILM	2	R4 R6	DALE	CRCW206000020EA	
34	020-06390-Z1	A	RES 17.8K OHM 1/4W ±1% NPB 1206	1	R5	DALE	CRCW20617K8R9FKEA	
35	020-06310-Z1	A	RES 20K OHM 1/4W ±1% NPB 1206 FILM	1	R7	DALE	CRCW20620K0R9FKEA	
36	030-00091-Z1	A	RES 0.1 OHM 2W ±1% WW NPB AXL	0	R8	VISHAY	G003R1000FE7080	NO POP
37	030-00091-Z1	A	RES 0.1 OHM 2W ±1% WW NPB AXL	1	R9	VISHAY	G003R1000FE7080	
38	020-06356-Z1	A	RES 1.15M OHM 1/4W ±1% NPB 1206	6	R10 R11 R12 R13 R15 R16	DALE	CRCW2061M15R9FKEA	
39	020-06391-Z1	A	RES 1K OHM 1/4W ±1% NPB 1206 FILM	1	R14	DALE	CRCW2061K00R9FKEA	
40	020-06391-Z1	A	RES 1.78K OHM 1/4W ±1% NPB 1206	1	R17	DALE	CRCW2061K78R9FKEA	
41	020-06372-Z1	A	RES 0.24 OHM 1W ±1% NPB 2512	0	R18 R22	PANASONIC	ERJ1TR0FR24U	
42	030-00080-Z1	A	RES 10K 1W ±5% MTL FLN NPB AXL	2	R19 R20	XICON	204-100K-RC	
43	036-00015-Z1	A	VARISTOR 470V/6A5 14MM NPB RAD	0	RV1	EPCCOS	S14K-300	NO POP
44	110-00045-Z1	A	CON TEST PT 1 CTR TIN PLAT NPB BLK	7	TP2 TP3 TP4 TP5 TP6 TP7 TP8	KEYSTONE	301	
45	050-00313-Z1	A	IC CRUS LPWR FACTOR CORR NPB SOLC8	1	U1	CIRRUS LOGIC	CS1801-F5ZA2	ECO840
46	050-00002-01	A	WIRE 28T AVG. KYMAR MOD. 500FT	2,000	W1	SQUIRES	L1500 UL1422 28T BLU	ADD LENGTH TO BOM QUANTITY IN INCHES
47	050-00040-Z1	A	WIRE 16AWG SOLID PVC INS BLK NPB	4,000	W3	ALPHA WIRE COMPANY	30571 BK005	ADD LENGTH TO BOM QUANTITY IN INCHES
48	311-00025-Z1	A	HTSNK TO220 MOUNTING KIT NPB	1	XHST	AAVID THERMALLOY	4880G	INCLUDES ALL MOUNTING HARDWARE
49	300-00025-Z1	A	SCREW 4-40X5/16" PH MACH SS NPB	4	XMH1 XMH2 XMH3 XMH4	BUILDING FASTENERS	PMSSS 440 0031 PH	SCREWS FOR STANDOFFS
50	240-00466-Z1	C	PCB DWG CDB 1601-120W-Z NPB	1	REF	CIRRUS LOGIC	240-00466-Z1	ECO805/826/840
51	603-00466-Z1	C	ASSY DWG CDB 1601-120W-Z NPB	1	REF	CIRRUS LOGIC	603-00466-Z1	ECO805/826/840
52	600-00466-Z1	C	SCHEM CDB1601-120W-Z NPB	1	REF	CIRRUS LOGIC	600-00466-Z1	ECO805/826/840
53	422-00013-01	C	LBL SUBASSY PRODUCT ID AND REV	1	REF	CIRRUS LOGIC	422-00013-01	

**4. BOARD LAYOUT**

**Figure 3. Solder Mask (Bottom)**

**Figure 4. Solder Mask (Top)**

**Figure 5. Silkscreen (Top)**

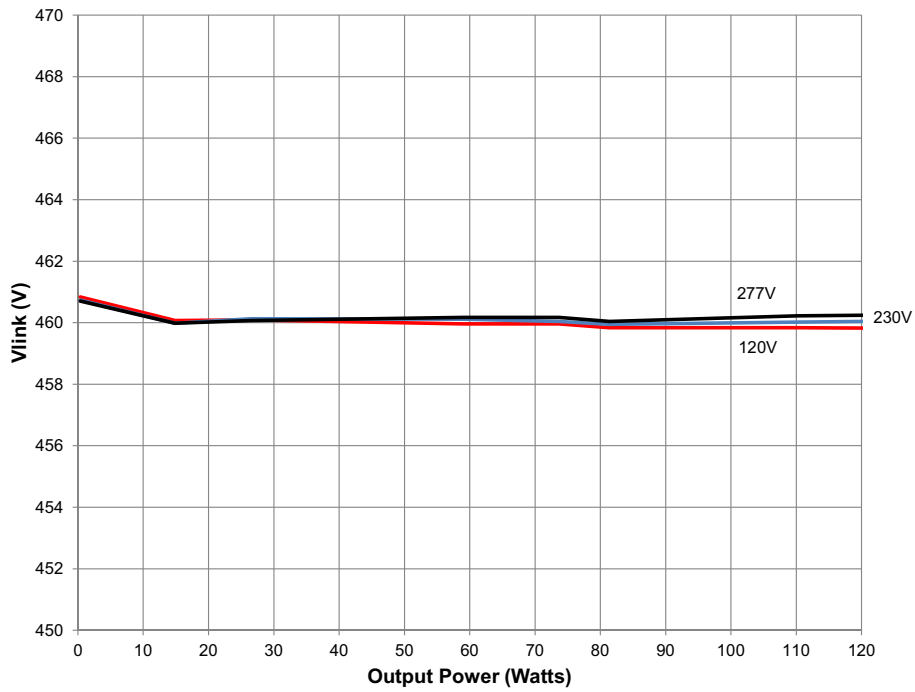


**5. TYPICAL PERFORMANCE PLOTS**

**Figure 9. Efficiency vs. Output Power**

**Figure 10. Power Factor vs. Output Power**

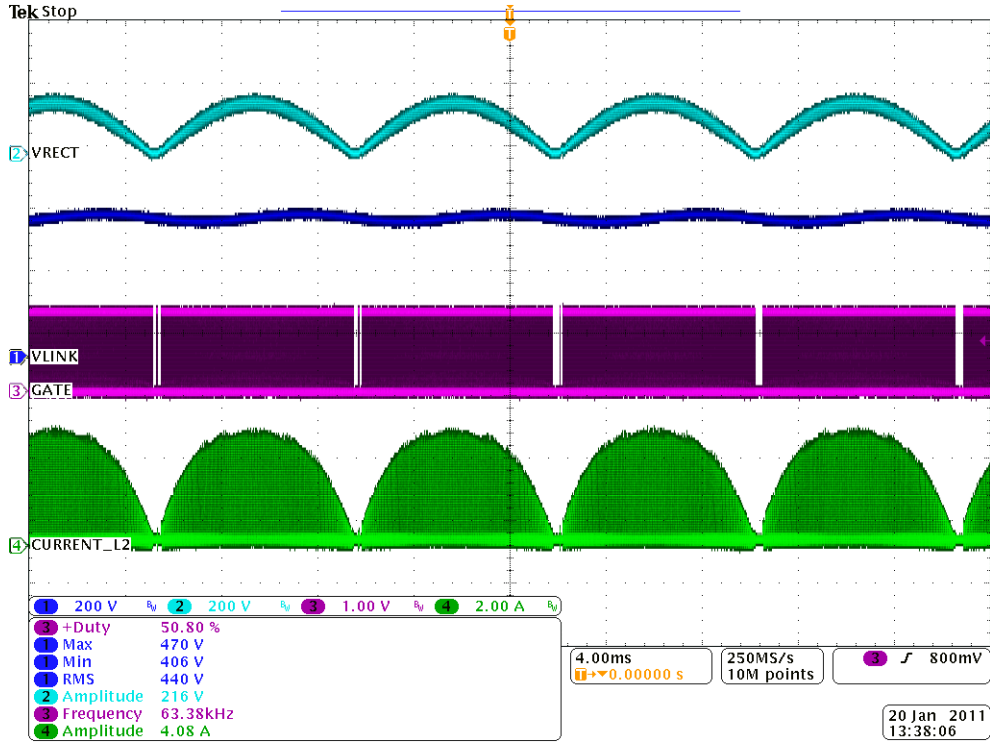
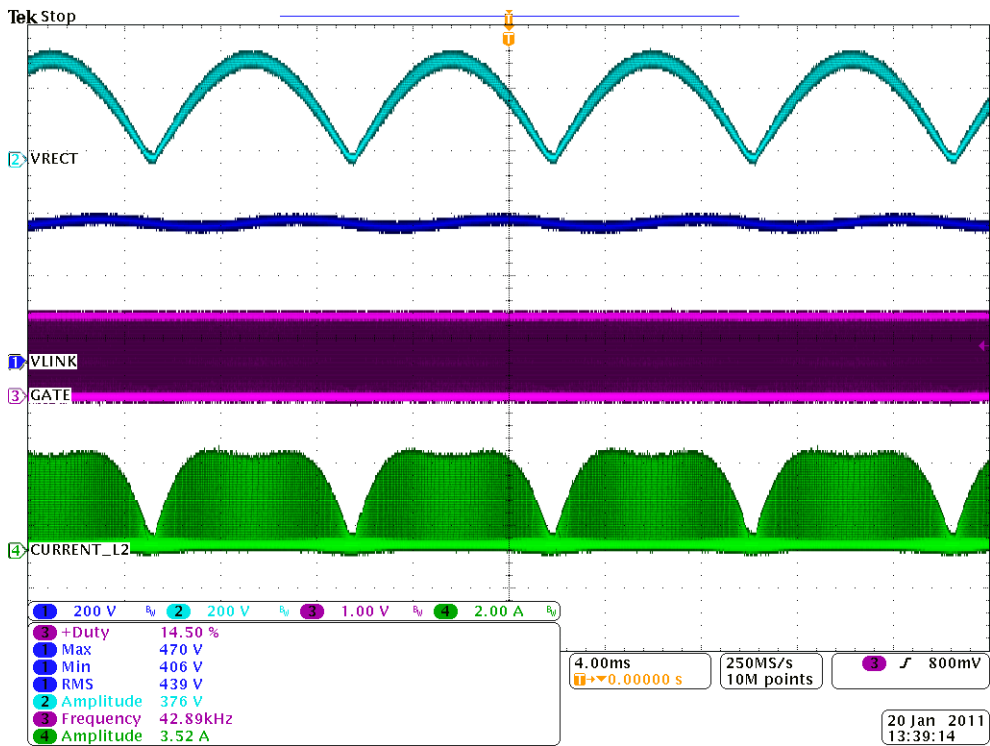


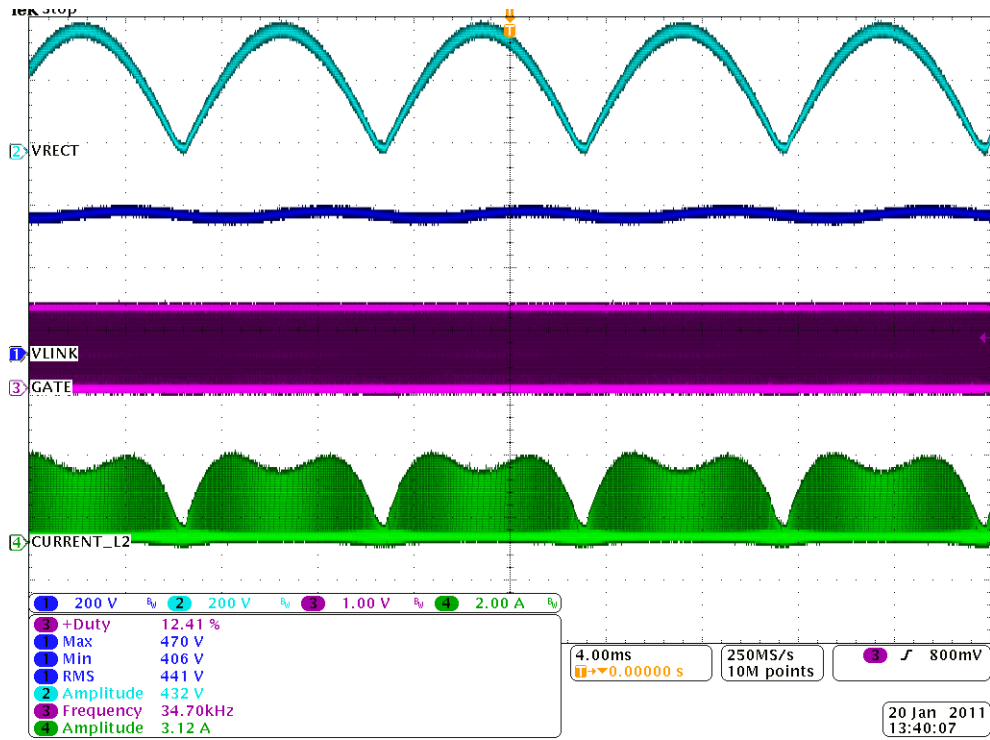


**Figure 11. THD vs. Output Power**



**Figure 12. V<sub>Link</sub> Voltage vs. Output Power**


**Figure 13. Steady State Waveforms — 120 VAC**

**Figure 14. Steady State Waveforms — 230 VAC**



**Figure 15. Steady State Waveforms — 277 VAC**

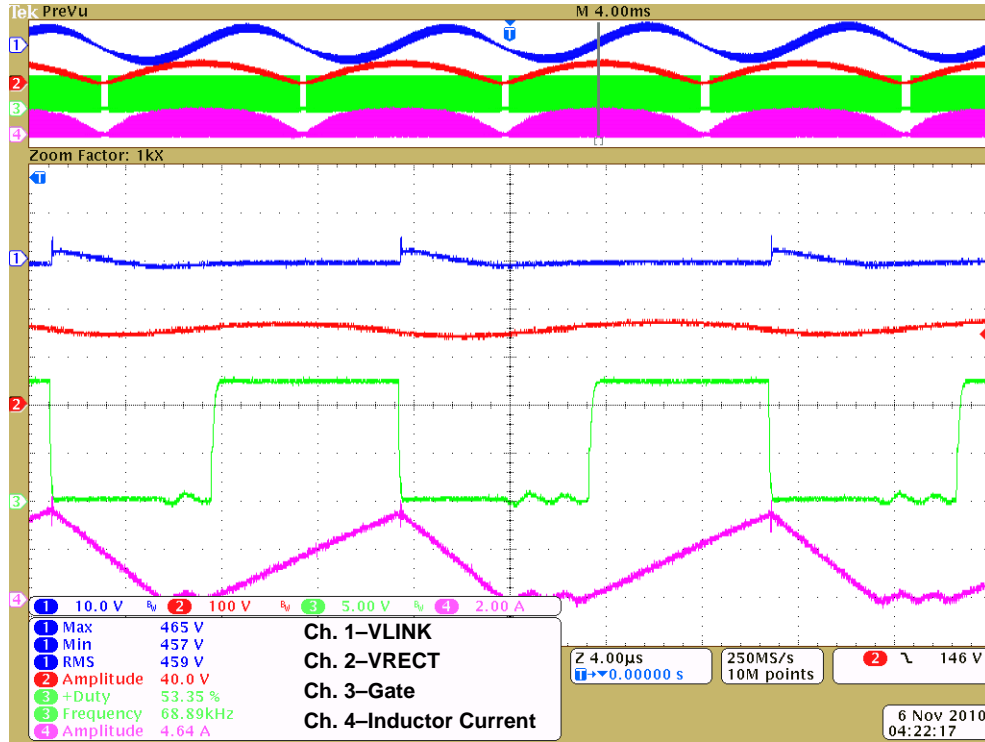


Figure 16. Switching Frequency Profile at Peak of AC Line Voltage — 120 VAC

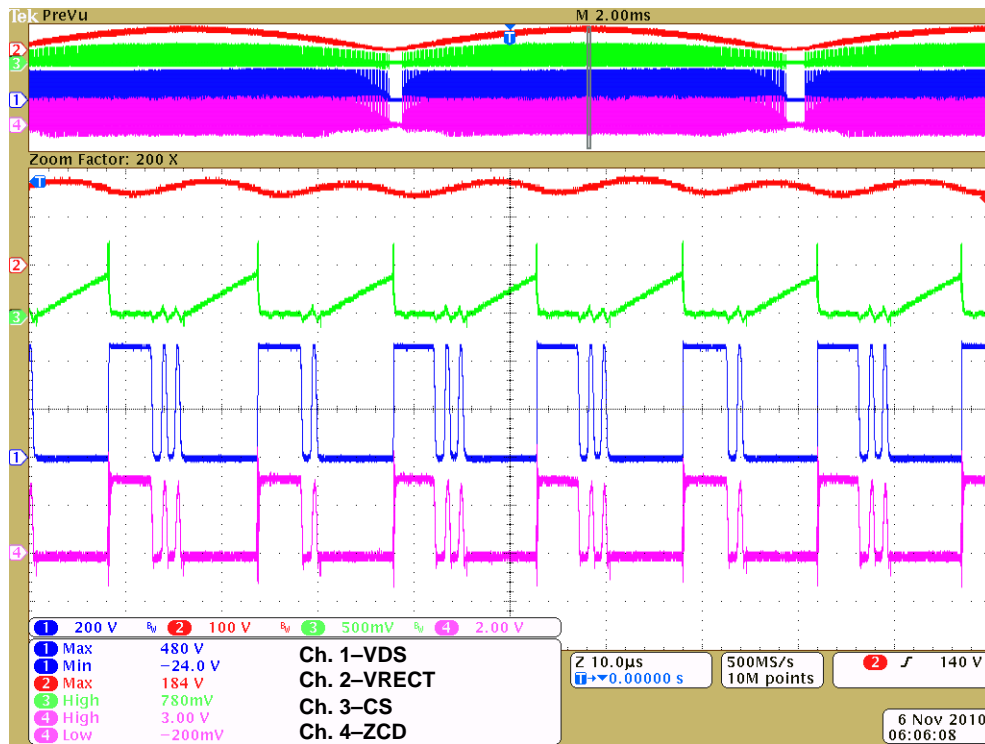


Figure 17. Switching Frequency Profile at Peak of AC Line Voltage — 120 VAC (cont.)

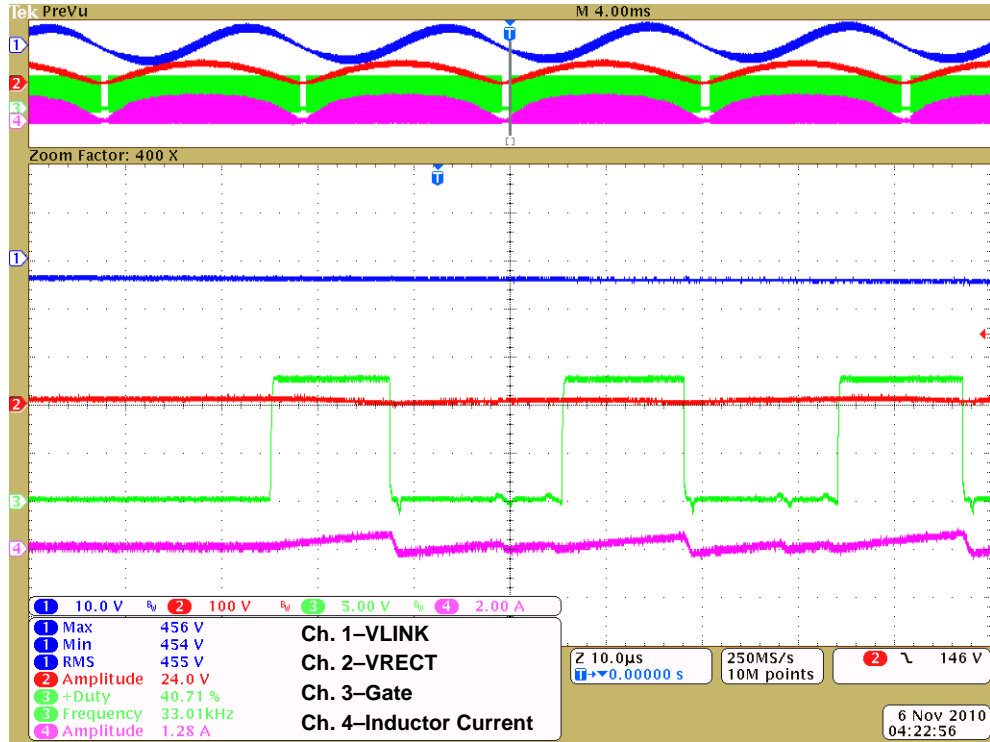


Figure 18. Switching Frequency Profile at Trough of AC Line Voltage —120 VAC

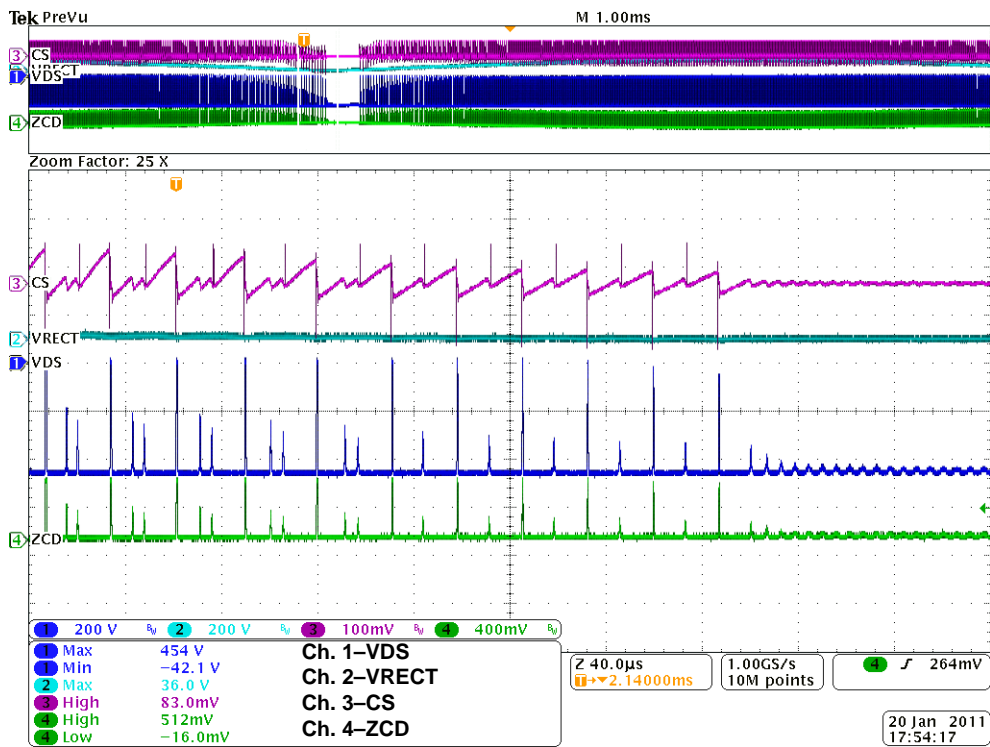


Figure 19. Switching Frequency Profile at Trough of AC Line Voltage — 120 VAC (cont.)

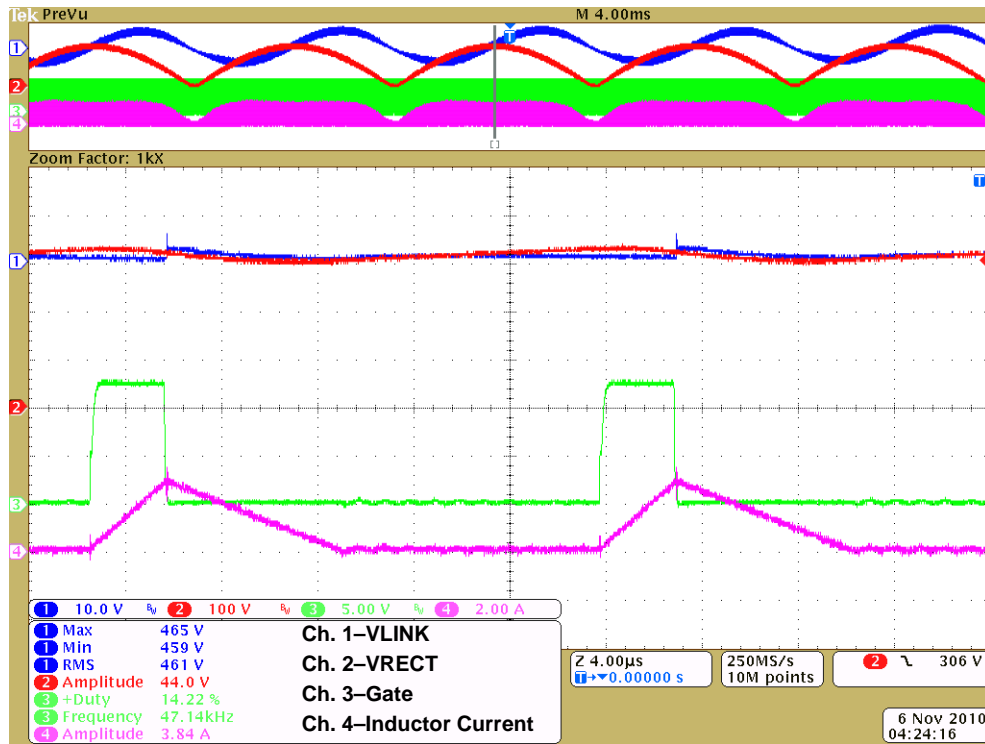


Figure 20. Switching Frequency Profile at Peak of AC Line Voltage — 230 VAC

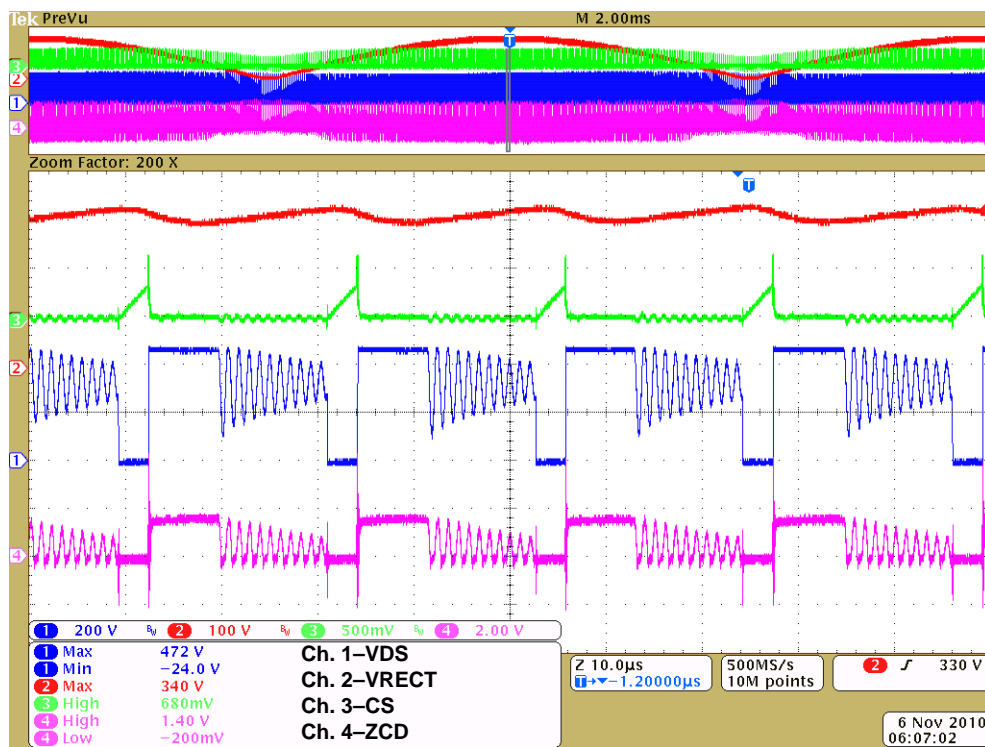


Figure 21. Switching Frequency Profile at Peak of AC Line Voltage — 230 VAC (cont.)

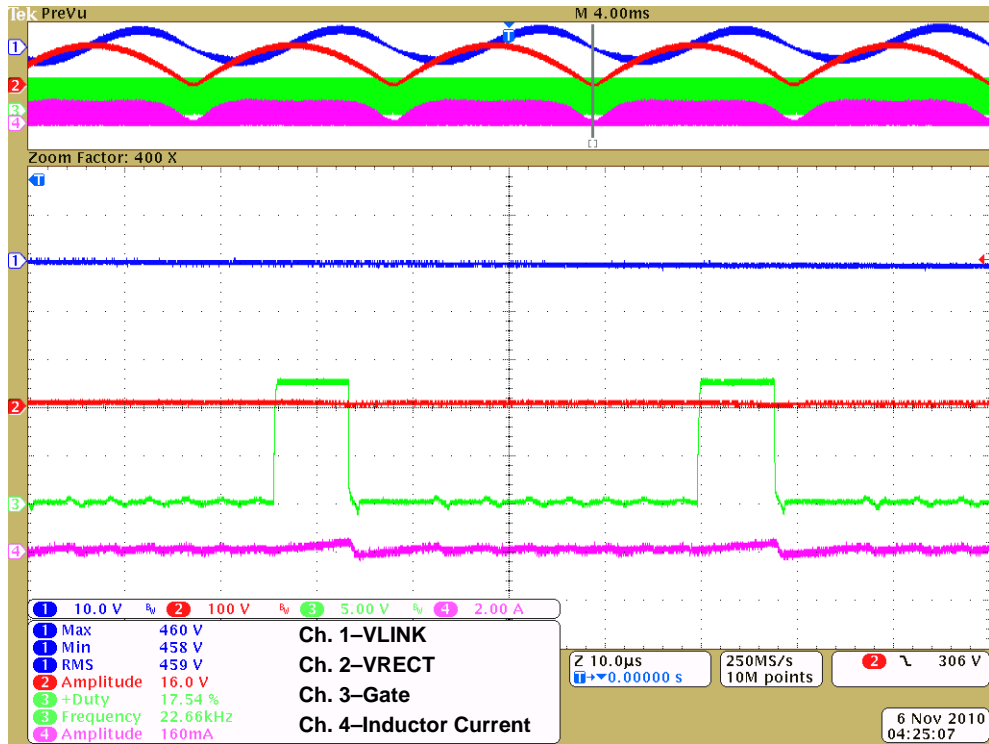


Figure 22. Switching Frequency Profile at Trough of AC Line Voltage — 230 VAC

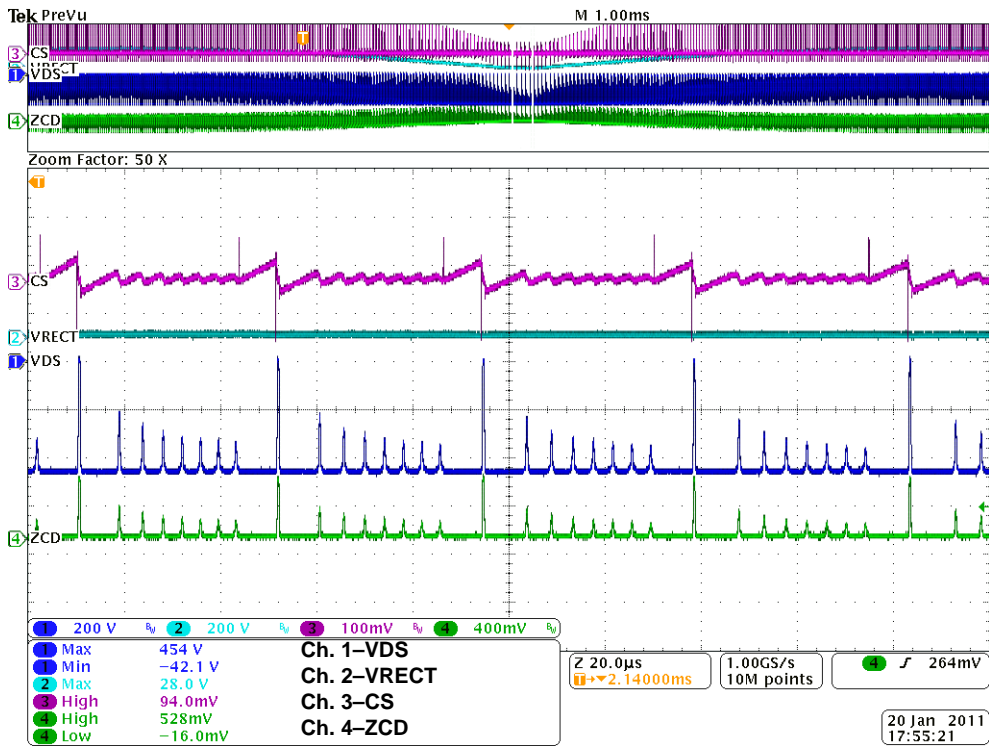
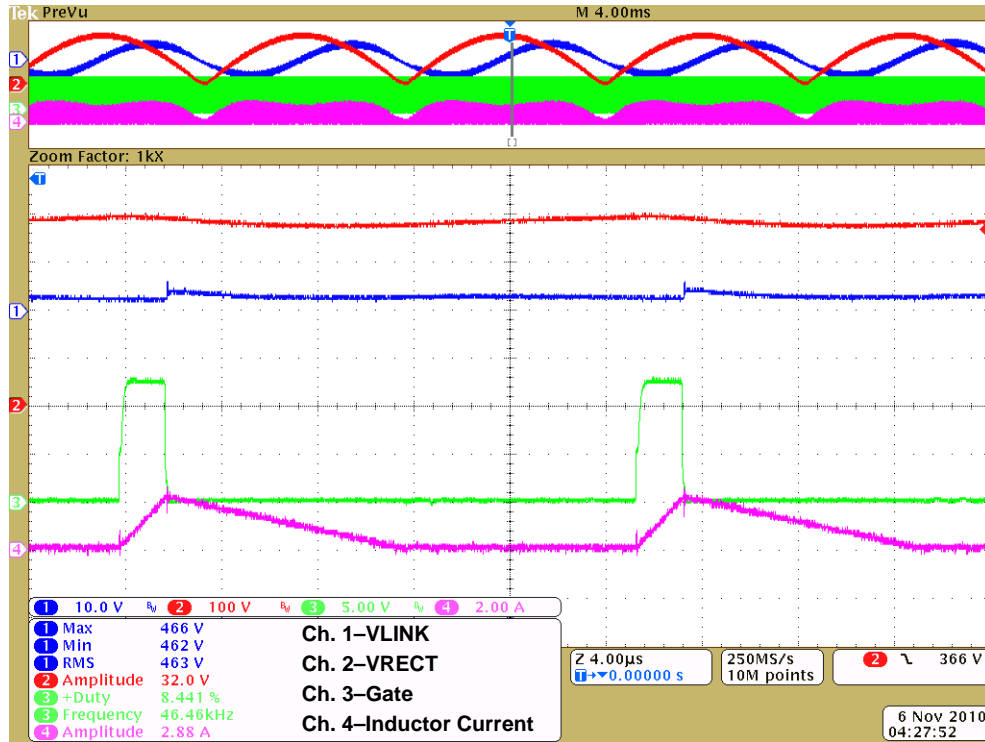
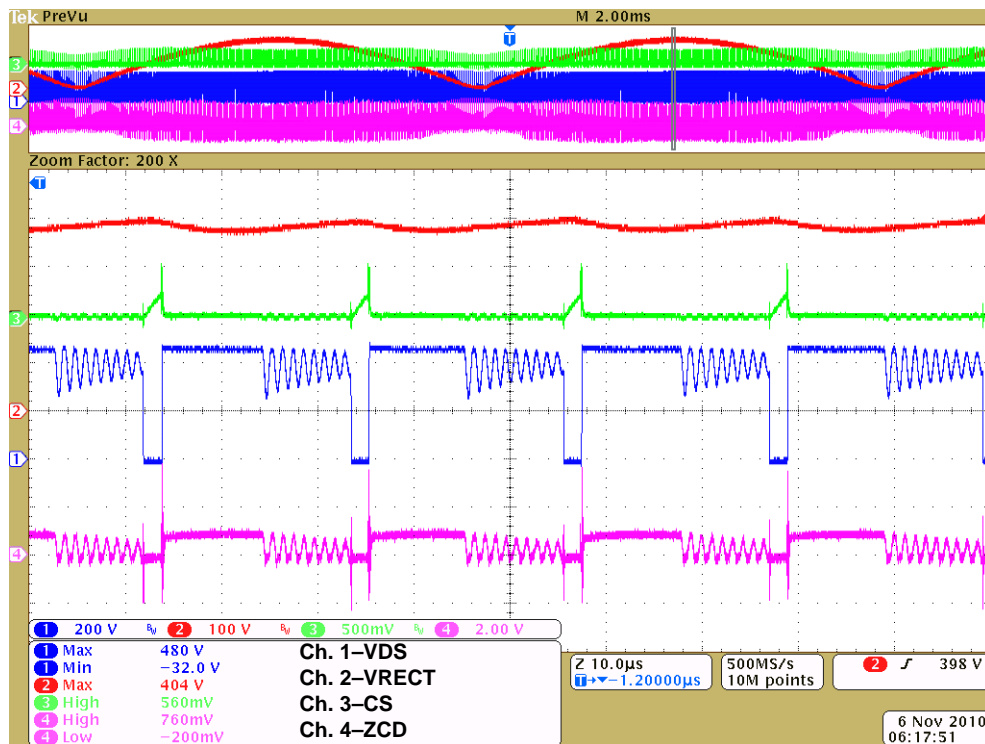


Figure 23. Switching Frequency Profile at Trough of AC Line Voltage — 230 VAC (cont.)

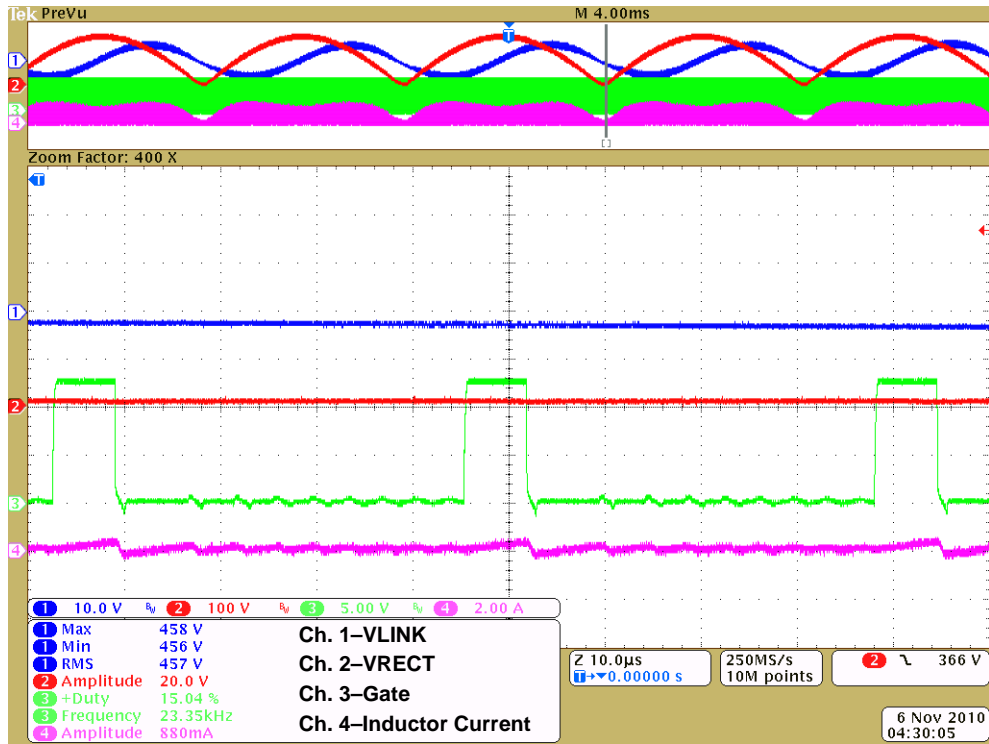
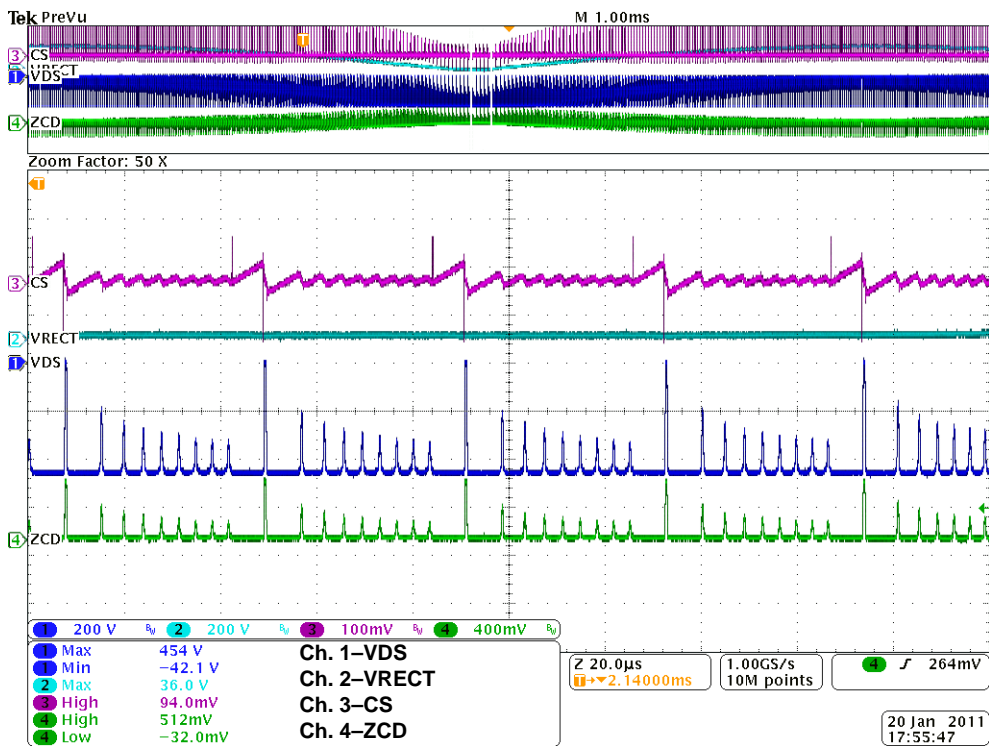


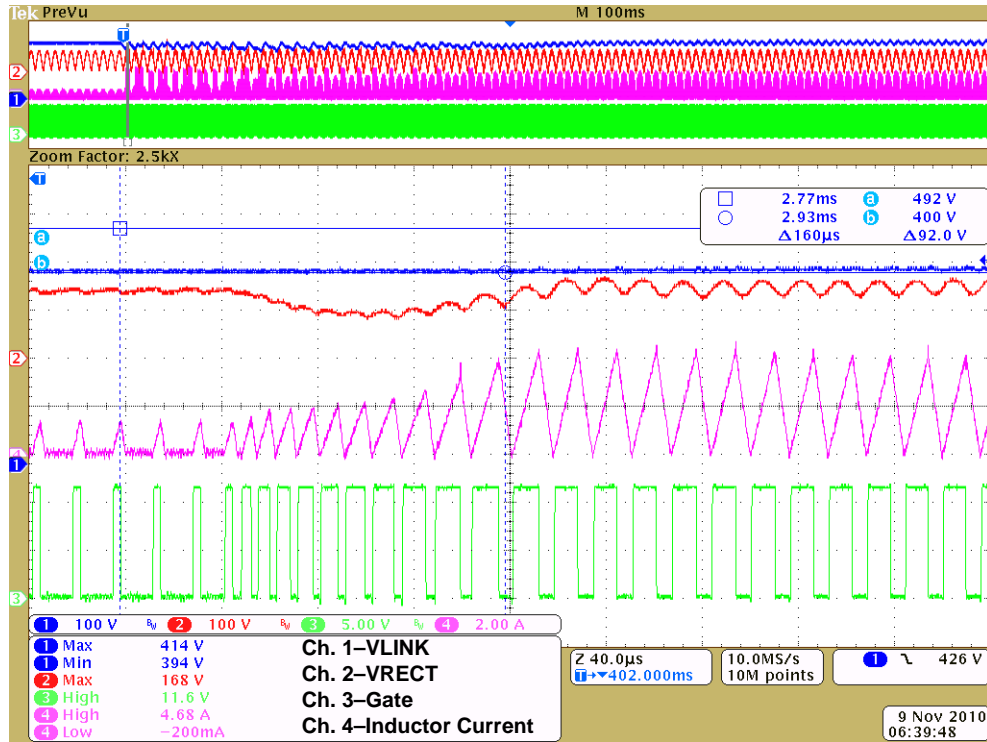
**Figure 24. Switching Frequency Profile at Peak of AC Line Voltage — 277 VAC**



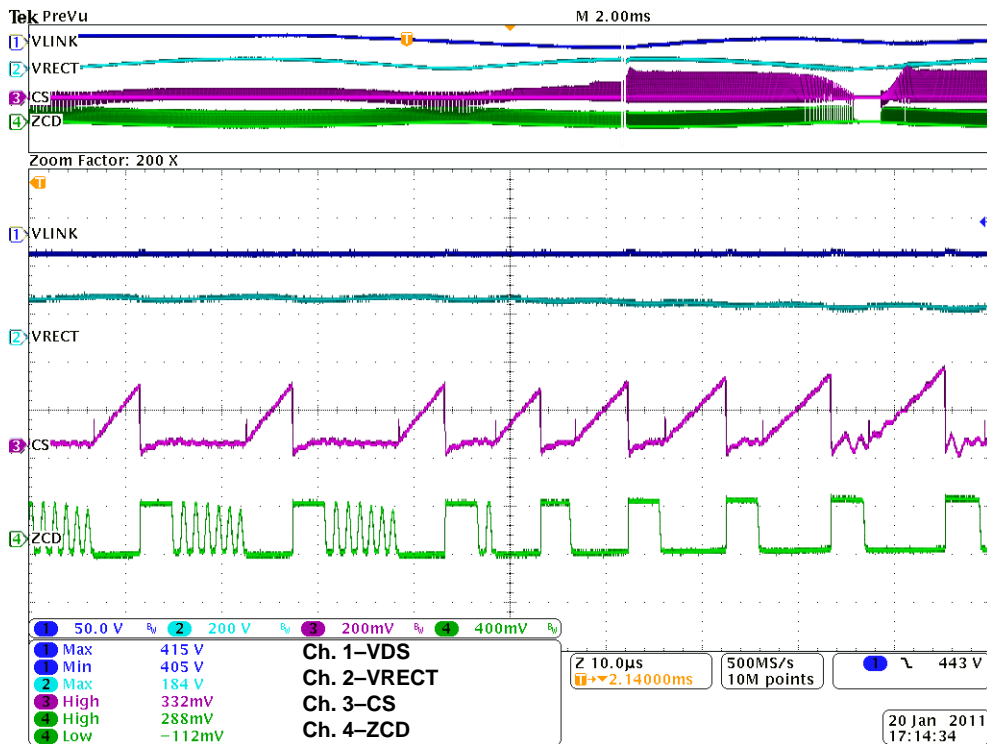
**Figure 25. Switching Frequency Profile at Peak of AC Line Voltage — 277 VAC (cont.)**




**Figure 26. Switching Frequency Profile at Trough of AC Line Voltage — 277 VAC**

**Figure 27. Switching Frequency Profile at Trough of AC Line Voltage — 277 VAC (cont.)**



**Figure 28. Transient — 15W to 115W Load at 10W/μs, Vin = 120VAC**



**Figure 29. Transient — 15W to 115W Load at 10W/μs, Vin = 120VAC (cont.)**

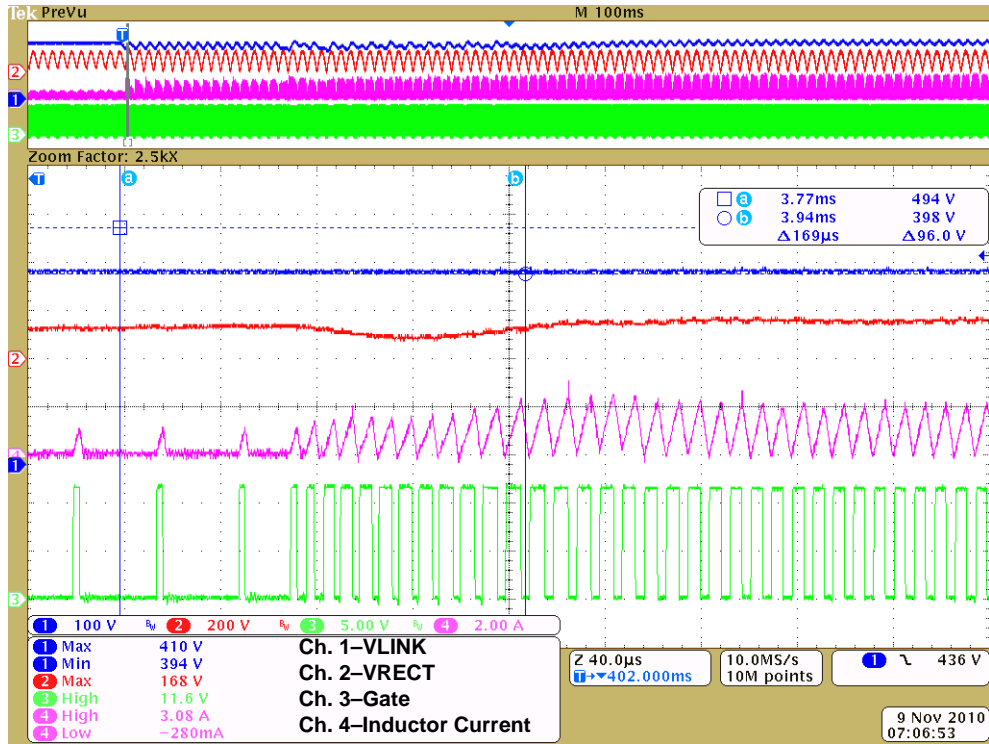


Figure 30. Transient — 15W to 115W Load at 10W/μs, Vin = 230VAC

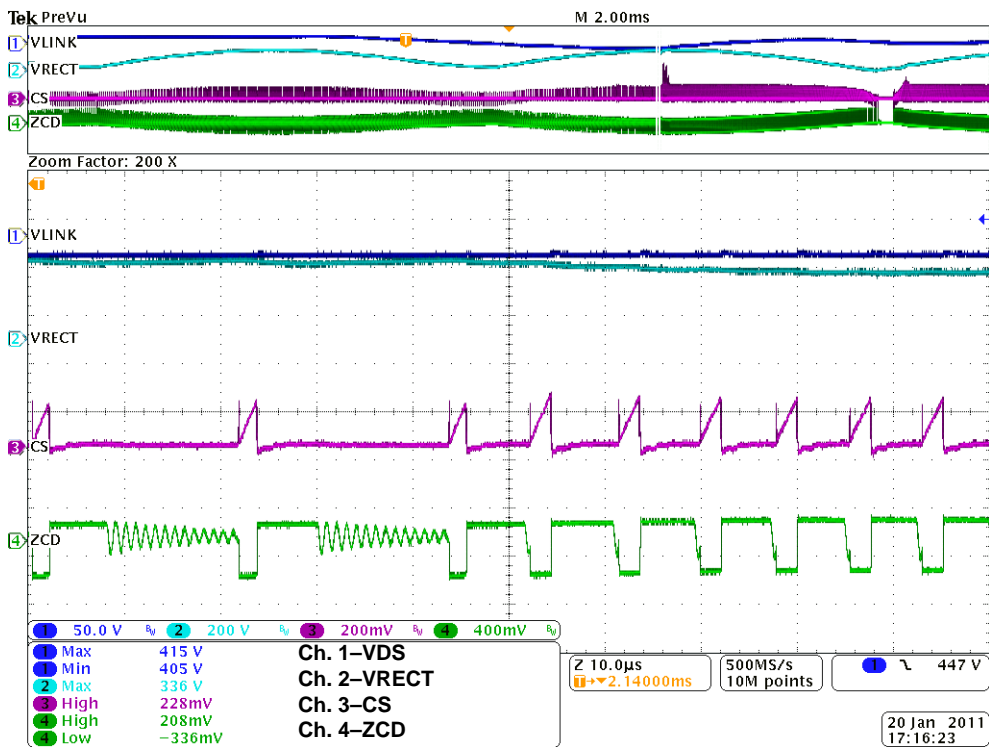


Figure 31. Transient — 15W to 115W Load at 10W/μs, Vin = 230VAC (cont.)

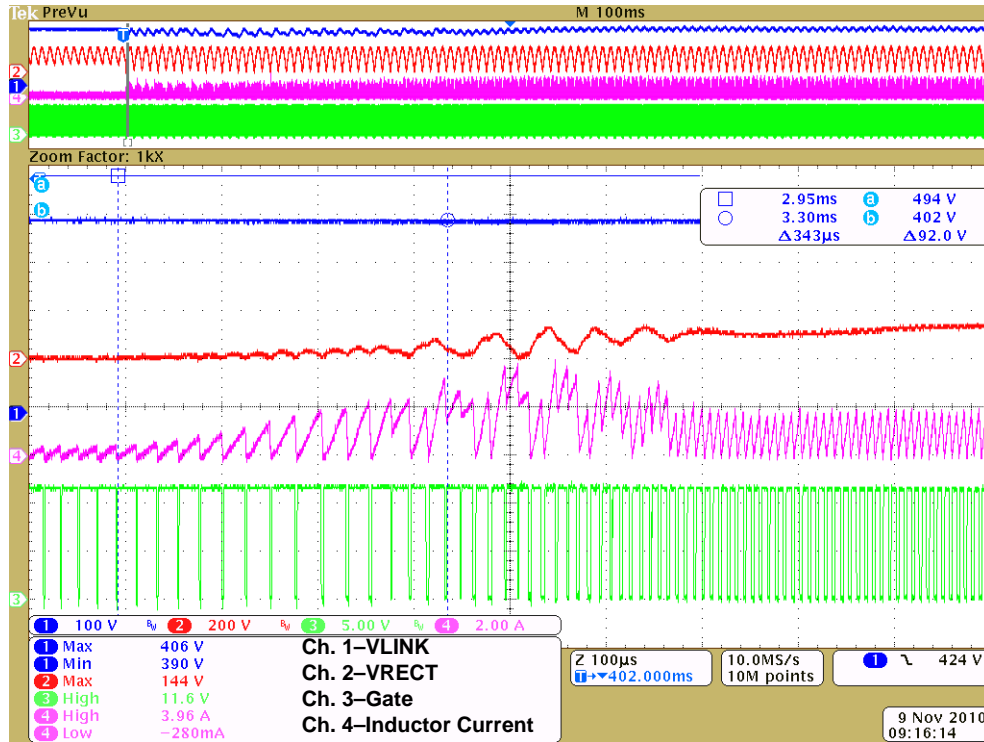


Figure 32. Transient — 15W to 115W Load at 10W/µs, Vin = 277VAC

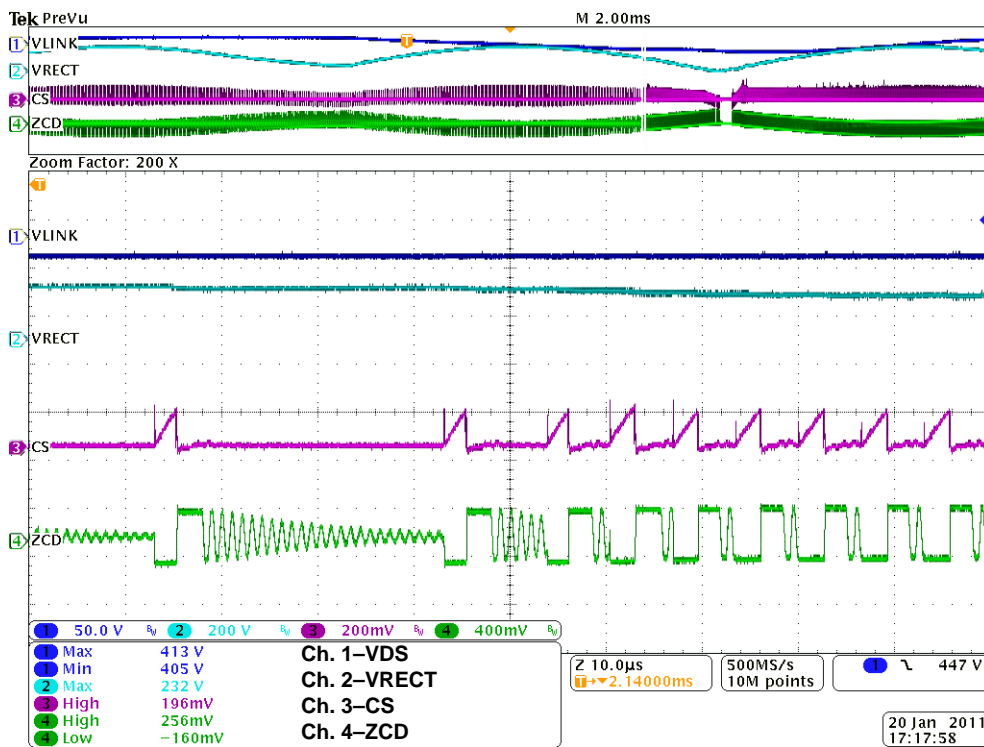


Figure 33. Transient — 15W to 115W Load at 10W/µs, Vin = 277VAC (cont.)

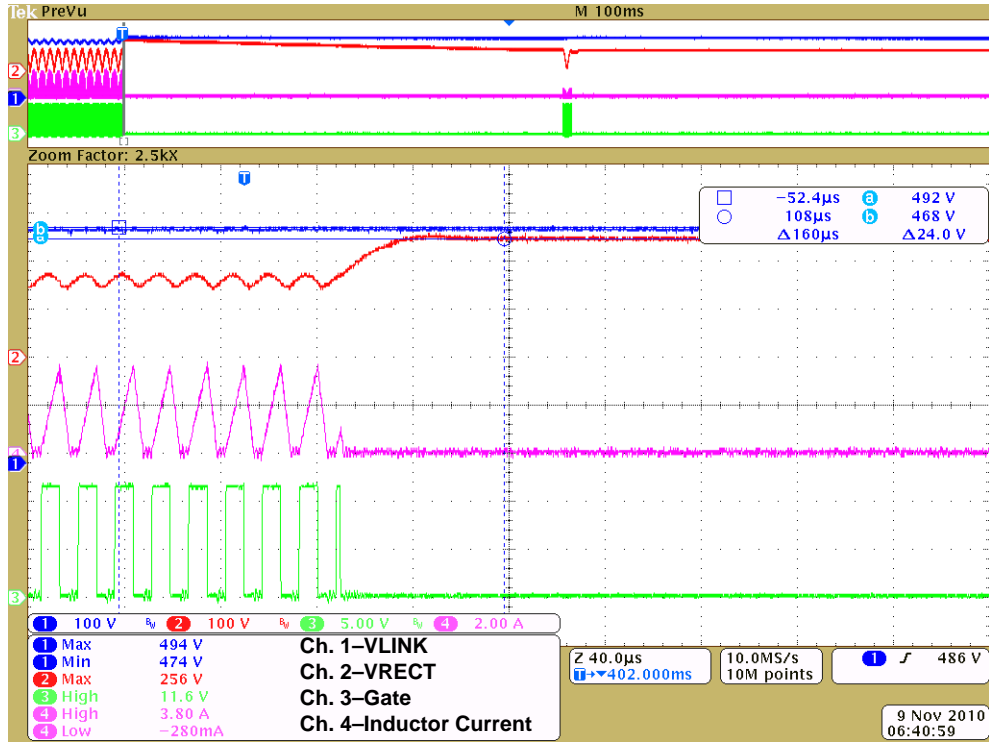


Figure 34. Transient — 115W to Zero Load at 10W/µs, Vin = 120VAC

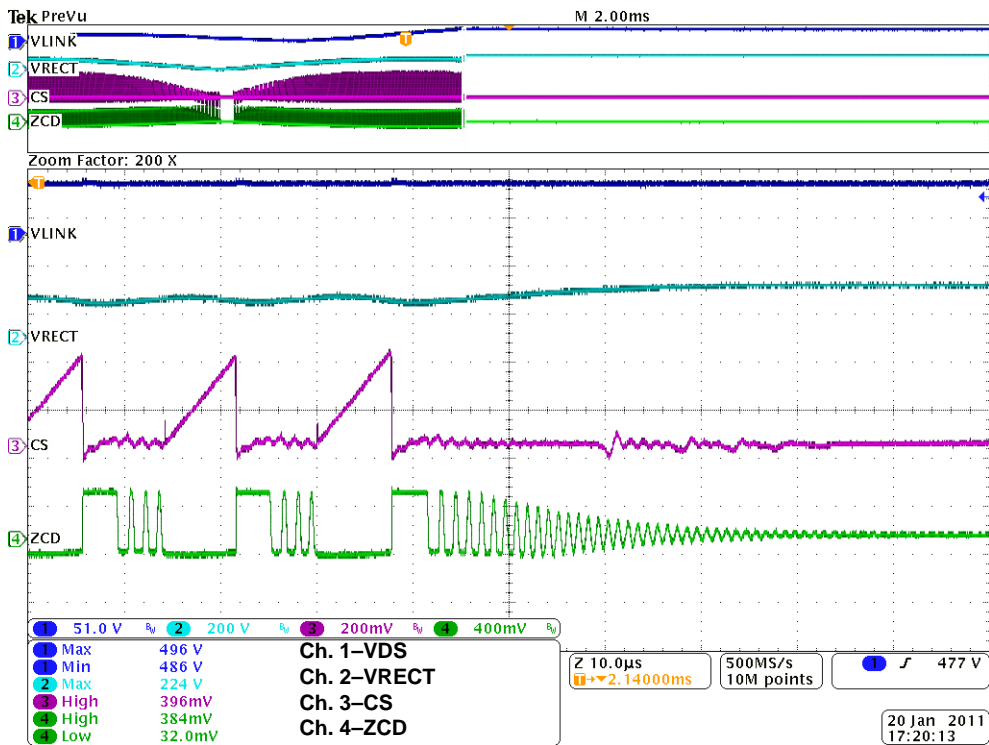
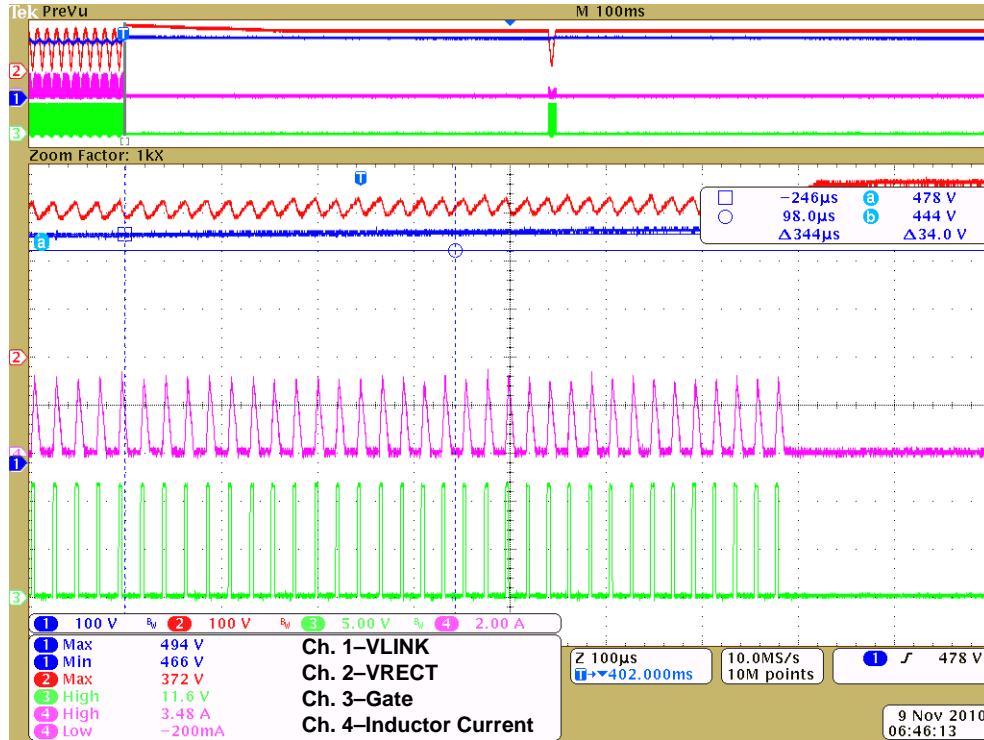
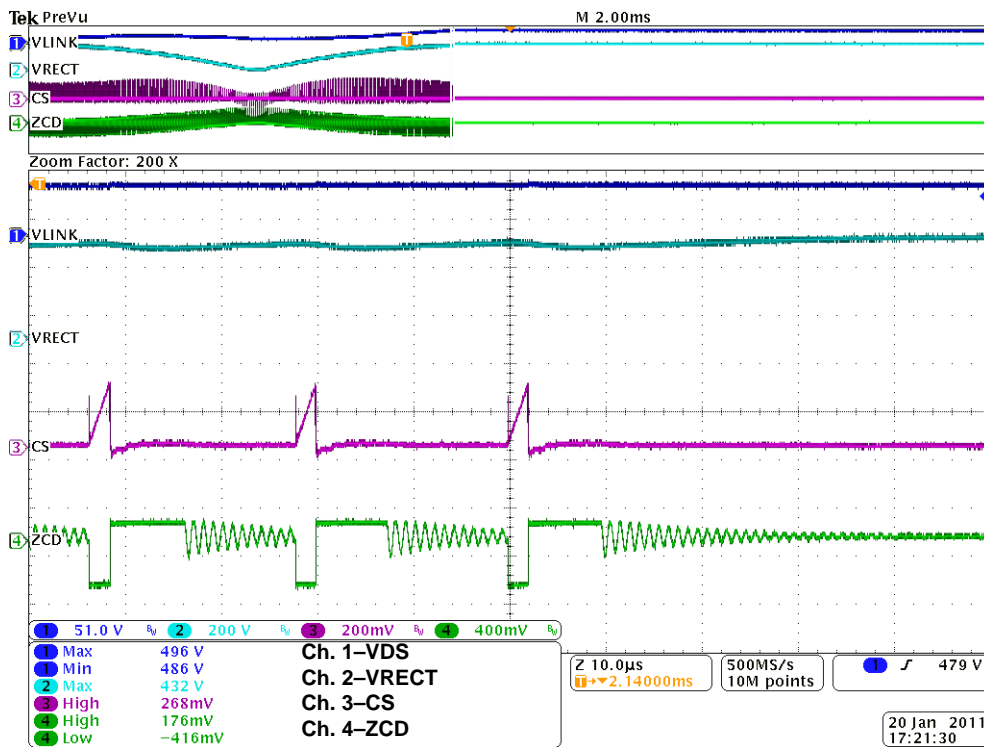
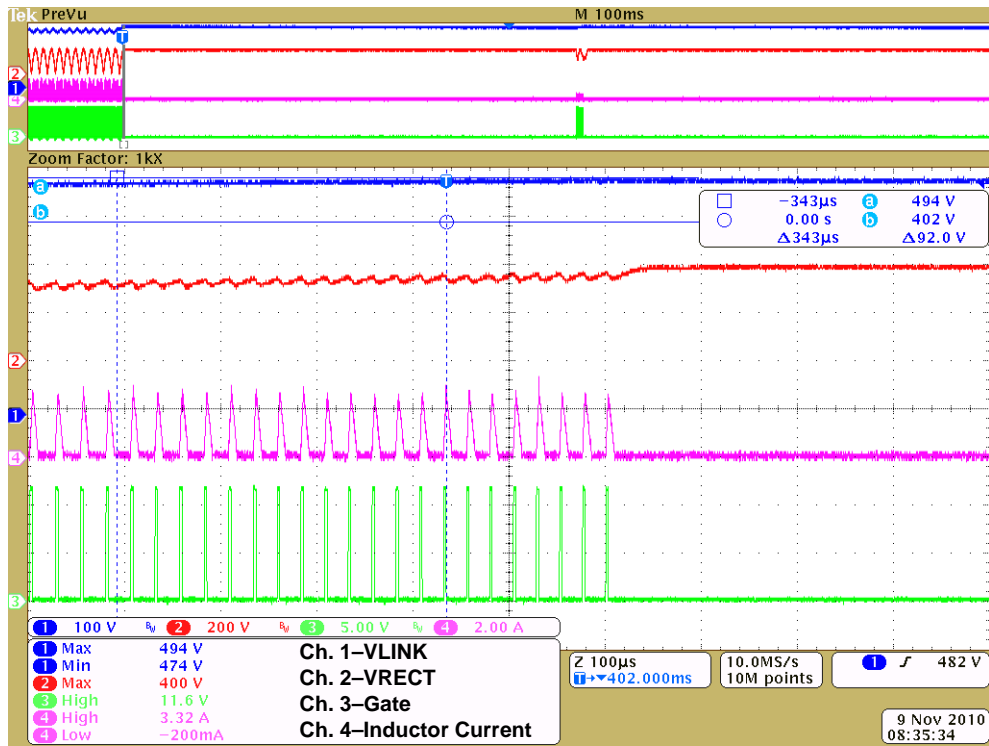
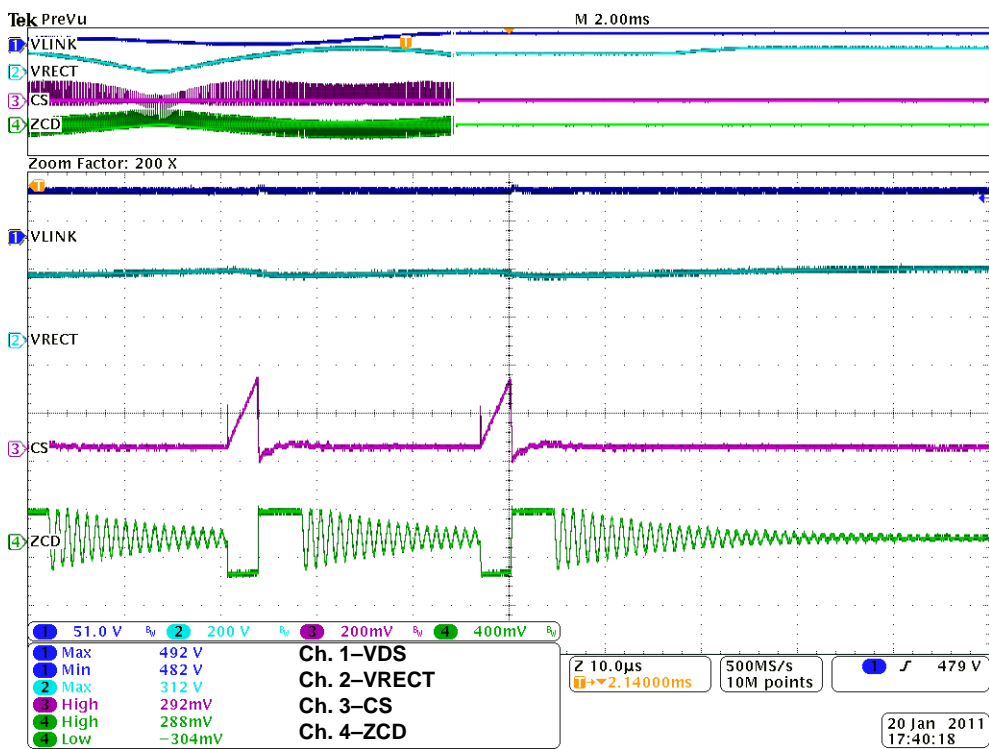


Figure 35. Transient — 115W to Zero Load at 10W/µs, Vin = 120VAC (cont.)


**Figure 36. Transient — 115W to Zero Load at 10W/μs, Vin = 230VAC**

**Figure 37. Transient — 115W to Zero Load at 10W/μs, Vin = 230VAC (cont.)**



**Figure 38. Transient — 115W to Zero Load at 10W/µs, Vin = 277VAC**



**Figure 39. Transient — 115W to Zero Load at 10W/µs, Vin = 277VAC (cont.)**

**6. REVISION HISTORY**

<b>Revision</b>	<b>Date</b>	<b>Changes</b>
DB1	FEB 2011	Initial Release.
DB2	FEB 2011	Minor BOM change.
DB3	MAR 2011	Updated BOM & Layers to rev C.