Design Example Report

Title	***High Performance, Low Profile 100 W PFC Stage Using HiperPFS™ PFS704EG***
Specification	90 VAC – 264 VAC Input; 380 VDC Output
Application	PFC Front End Stage
Author	Applications Engineering Department
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Revision	1.0

Summary and Features

- Low component count, high performance PFC
- EN61000-3-2 Class D compliance
- High PFC efficiency enables 80 Plus PC Main design
- Frequency sliding maintains high efficiency across load range
- Feed forward line sense gain - maintains relatively constant loop gain over entire operating voltage range
- Excellent transient load response
- Power Integration eSIP™ low-profile, low thermal resistance package
- Low profile, <15 mm above PCB

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Important Note:
Although this board is designed to satisfy safety isolation requirements, the engineering prototype has not been agency approved. Therefore, all testing should be performed using an isolation transformer to provide the AC input to the prototype board.

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1 Introduction

This document is an engineering report describing a PFC power supply utilizing a HiperPFS PFS704EG integrated PFC controller. This power supply is intended as a general purpose evaluation platform that operates from universal input and provides a regulated 380 VDC output voltage and a continuous output power of 100 W.

This power supply can deliver the rated power at 110 VAC or higher at a room temperature of 25 ºC. For operation at higher temperatures or lower input voltages, use of forced air cooling is recommended.

The document contains the power supply specification, schematic, bill of materials, inductor documentation, printed circuit layout, and performance data.

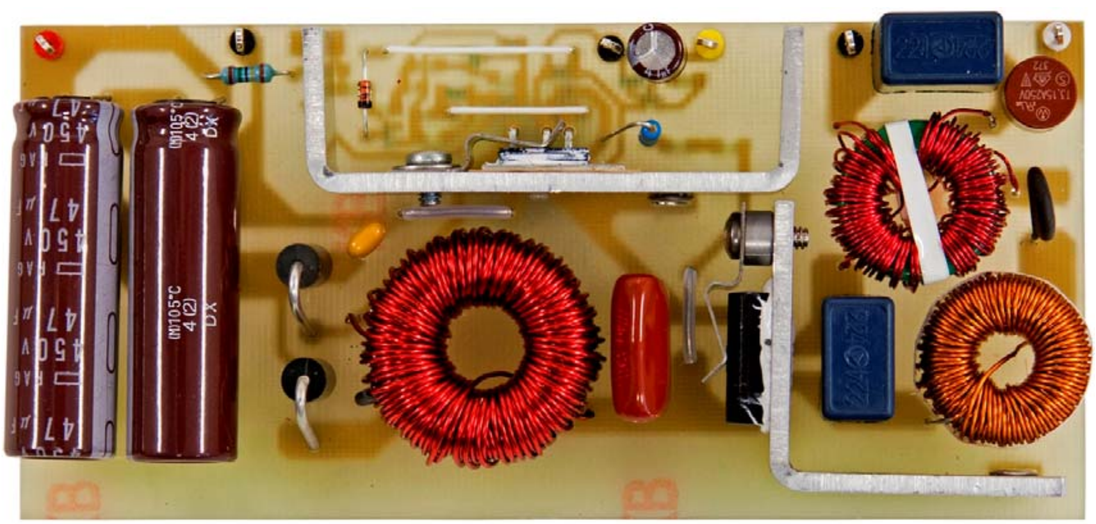

Figure 1 – Top Side of the Populated Circuit Board Photograph.

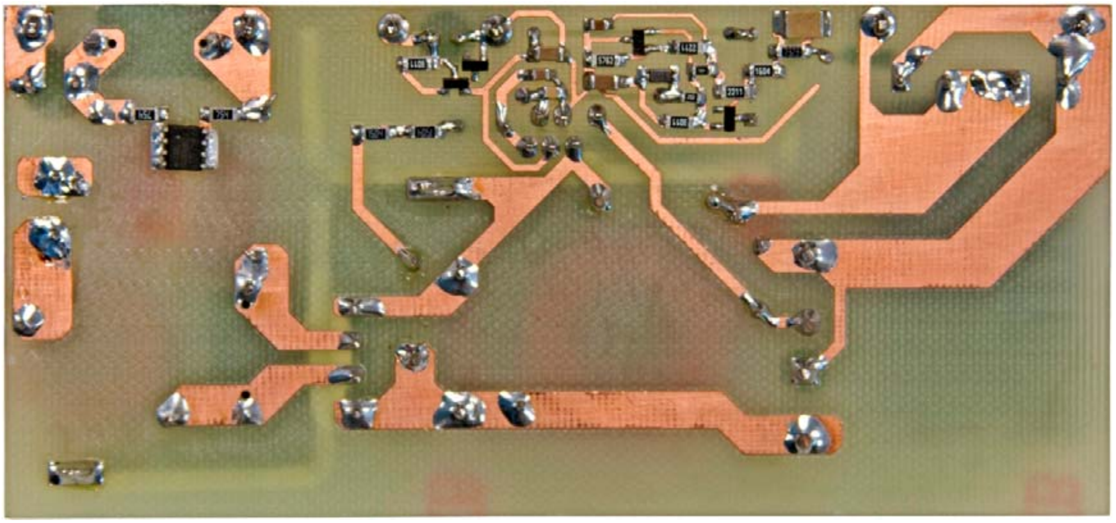

Figure 2 – Bottom Side of the Populated Circuit Board Photograph.

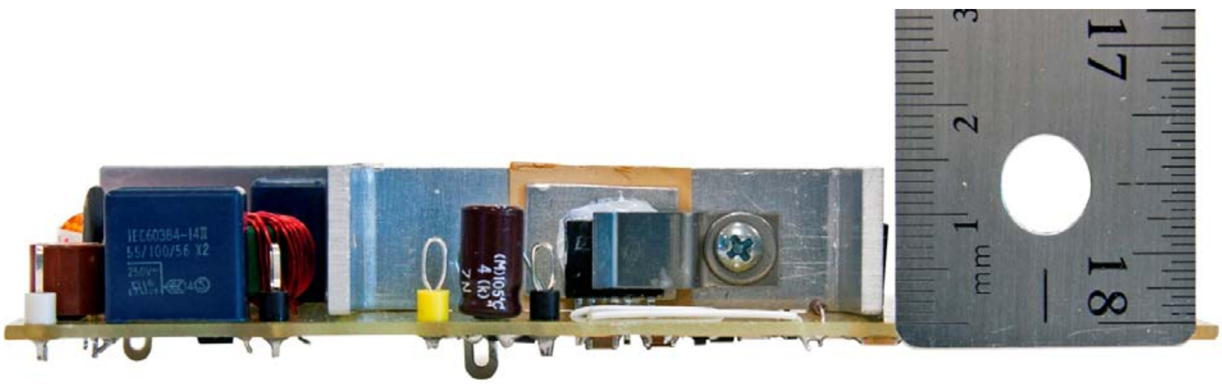

Figure 3 – Side of the Populated Circuit Board Photograph.

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2 Power Supply Specification

The table below represents the minimum acceptable performance of the design. Actual performance is listed in the results section.

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	90		264	VAC	3 Wire
Frequency	f_{LINE}	47	50/60	64	Hz	
Output						
Output Voltage	V_{OUT}	370	380	390	V	
Output Ripple Voltage p-p	V_{RIPPLE}			20	V	20 MHz bandwidth
Output Current	I_{OUT}		0.262		A	
Total Output Power						
Continuous Output Power	P_{OUT}		100		W	
Efficiency						
Full Load	η		94		%	Measured at P_{OUT} 25 °C
Minimum efficiency at 20, 50 and 100 % of P_{OUT}	η_{80+}		94		%	Measured at 115 VAC Input
Environmental						
Line Surge Differential Mode (L1-L2)			1		kV	1.2/50 µs surge, IEC 1000-4-5, Series Impedance: Differential Mode: 2 Ω
Ambient Temperature	T_{AMB}	0		40	°C	Forced convection required at T_{AMB} >25 ºC and/or V_{IN} <115 V, sea level
Auxiliary Supply Input						
Auxiliary Supply	V_{AUX}	15		24	V	DC Supply

3 Schematic

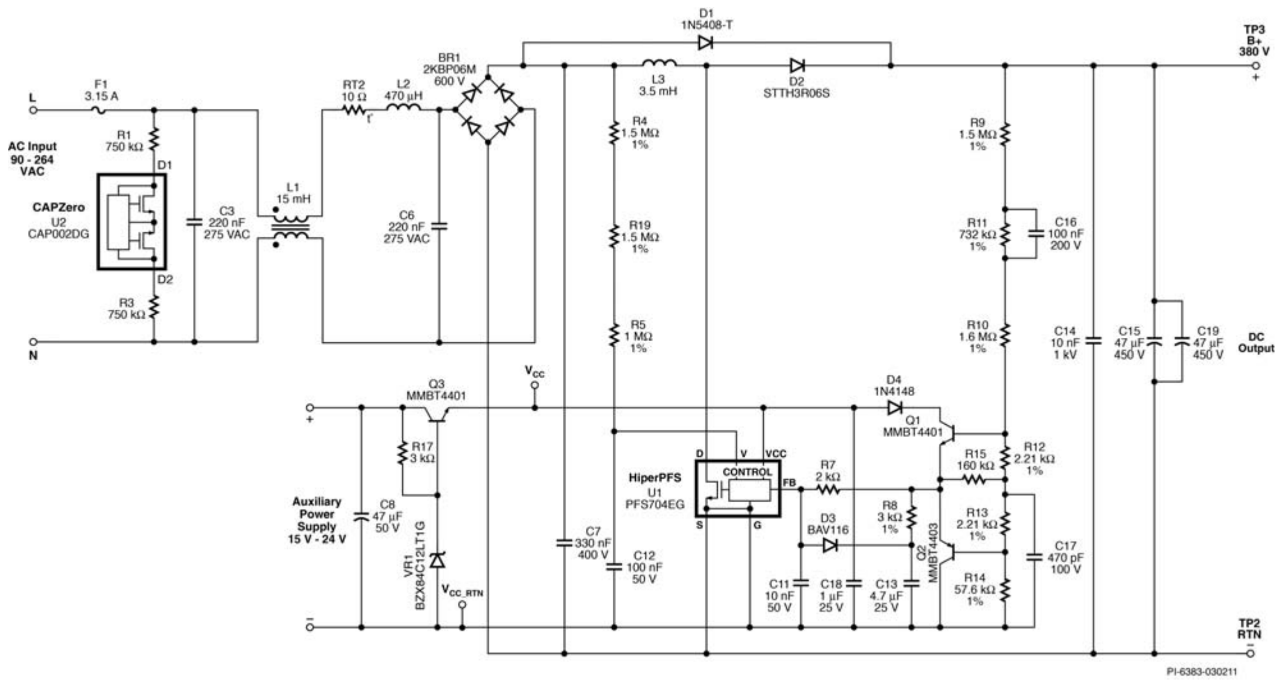

Figure 4 – Schematic.

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4 Circuit Description

This PFC circuit is designed using PFS704EG Power Integrations integrated PFC controller. This design is rated for a continuous output power of 100 W and provides a regulated output voltage of 380 VDC nominal maintaining a high input power factor and overall efficiency from light load to full load.

4.1 Input EMI Filter and Rectifier

Fuse F1 provides protection to the circuit and isolates it from the AC supply in case of a fault. Diode Bridge BR1 rectifies the AC input. Capacitors C3, C6 and C7 together with inductors L1 and L2 form the EMI filter reducing the common mode and differential mode noise. Resistors R1, R3 and CAPZero, IC U2 are required to discharge the EMI filter capacitors once the AC is disconnected. The use of CAPZero IC U2 eliminates the static loss of R1 and R3, reducing standby and no-load input power. Thermistor RT2 limits the inrush current when AC is first applied.

4.2 PFS704EG Boost Converter

The boost converter stage consists of inductor L3, diode rectifier D2, filter capacitors C15 and C19 and the PFS704EG IC U1. This converter stage controls the input current of the power supply while simultaneously regulating the output DC voltage. Diode D1 prevents a resonant build up of output voltage at start-up by bypassing inductor L5 (preventing saturation) while simultaneously charging output capacitors C15 and C19. Capacitor C14 is used for reducing the loop length and area of the output circuit to reduce EMI and overshoot of voltage across the drain and source of the MOSFET inside U1 at each switching instant.

4.3 Bias Supply Regulator

The PFS704EG IC requires a regulated supply of 12 V for operation and the supply voltage must remain below 13.4 V to avoid IC damage. Resistor R17, Zener diode VR1, and transistor Q3 form a shunt regulator that prevents the supply voltage to IC U1 from exceeding 13 V. Capacitors C8 and C18 filter the supply voltage to ensure reliable operation of IC U1. The minimum value of C18 (including tolerance and temperature) should be ≥0.47 μF for correct IC operation, thus limiting VCC pin noise to ≤200 mV.

4.4 Input Feed Forward Sense Circuit

The input voltage of the power supply is sensed by the IC U1 using resistors R4, R5 and R19. The capacitor C12 filters any noise on this signal.

4.5 Output Feedback

Divider network comprising of resistors R9, R10, R11, R12, R13 and R14 are used to scale the output voltage and provide feedback to the IC U1. The circuit comprising of diode D4, transistor Q1, Q2 and the resistors R12 and R13 form a non-linear feedback circuit which help in improving the transient response by decreasing the response time of the PFC circuit to large output voltage changes.

Resistors R7, R8, R15 and capacitors C13 and C17 are required for shaping the loop response of the feedback circuit. The combination of resistor R8 and capacitor C13 provide a low frequency zero.

Diode D3 protects the circuit during a single fault condition in which capacitor C13 is accidentally shorted. If capacitor C13 is shorted, diode D3 ensures that the voltage at the FB pin of IC U1 is below the FB_{OFF} threshold preventing any switching of the MOSFET inside U1.

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5 PCB Layout

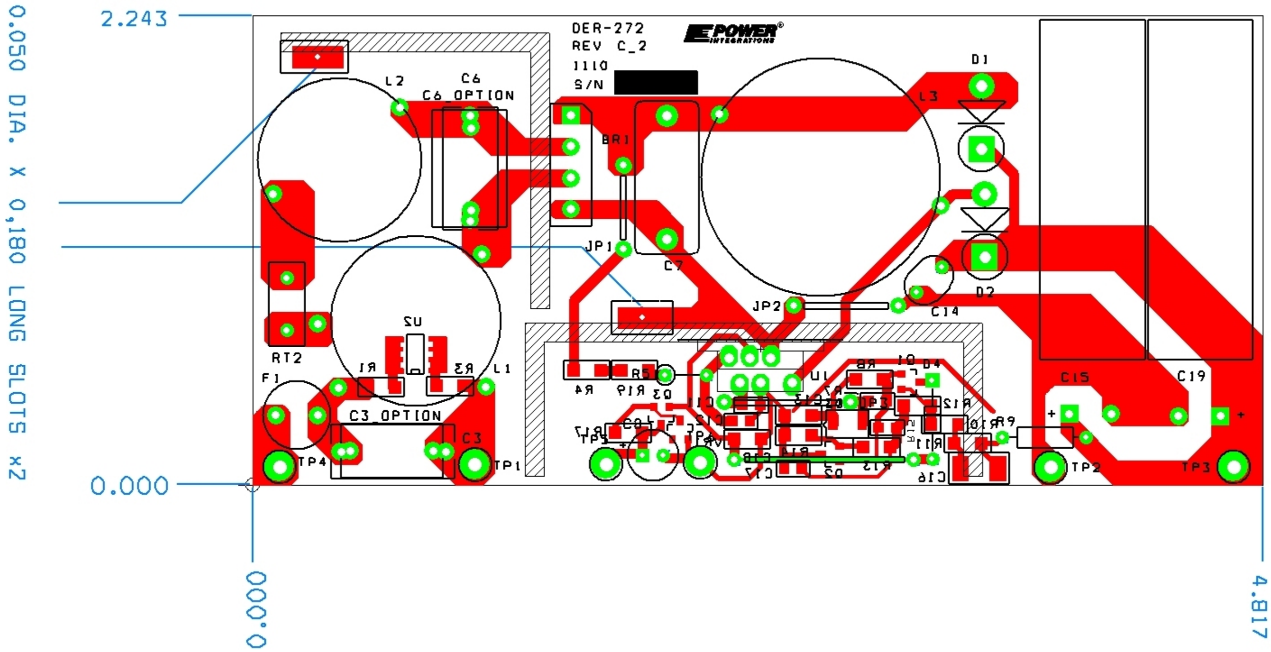

Figure 5 – Printed Circuit Layout, 4.81” (122.2 mm) x 2.24” (56.9 mm).

6 Bill of Materials

Item	Qty	Ref Des	Description	Mfg Part Number	Mfg
1	1	BR1	600 V, 2 A, Bridge Rectifier, Glass Passivated	2KBP06M-E4/51	Vishay
2	2	C3 C6	220 nF, 275VAC, Film, X2	LE224-M	OKAYA ELECT
3	1	C7	330 nF, 400 V, Film	DME4P33K-F	Cornell Dubilier
4	1	C8	47 μF, 50 V, Electrolytic, Gen. Purpose, (6.3 x 11)	EKMG500ELL470MF11D	Nippon Chemi-Con
5	1	C11	10 nF, 50 V, Ceramic, X7R, 0805	ECJ-2VB1H103K	Panasonic
6	1	C12	100 nF, 50 V, Ceramic, X7R, 0805	C2012X7R1H104K	TDK
7	1	C13	4.7 μF, 25 V, Ceramic, X7R, 1206	ECJ-3YB1E475M	Panasonic
8	1	C14	10 nF, 1 kV, Disc Ceramic, X7R	SV01AC103KAR	AVX
9	2	C15 C19	47 μF, 450 V, Electrolytic, Low ESR, (12.5 x 40)	EPAG451ELL470MK40S	Nippon Chemi-Con
10	1	C16	100 nF, 200 V, Ceramic, X7R, 1812	18122C104KAT2A	AVX
11	1	C17	470 pF, 100 V, Ceramic, X7R, 0805	08051C471KAT2A	AVX
12	1	C18	1 μF, 25 V, Ceramic, X7R, 1206	C3216X7R1E105K	TDK Corp
13	1	D1	1000 V, 3 A, Recitifier, DO-201AD	1N5408-T	Diodes, Inc.
14	1	D2	600 V, 3 A, SMC, DO-201AD	STTH3R06	ST Micro
15	1	D3	130 V, 5%, 250 mW, SOD-123	BAV116W-7-F	Diodes, Inc.
16	1	D4	75 V, 300 mA, Fast Switching, DO-35	1N4148TR	Vishay
17	2	ESIPCLIP M4 METAL1 ESIPCLIP M4 METAL2	Heat sink Hardware, Edge Clip, 20.76 mm L x 8 mm W x 0.015 mm Thk	NP975864	Aavid Thermalloy
18	1	F1	3.15 A, 250V, Slow, TR5	37213150411	Wickman
19	2	GREASE1	Thermal Grease, Silicone, 5 oz Tube	CT40-5	ITW Chemtronics
20	1	HS-HIPERPFS-100W-BRIDGE1	Heat sink, Bridge, Al 3003, 0.090 Thk, Custom		Custom
21	1	HS-HIPERPFS-100W-ESIP2	Heat sink, eSIP, Al 3003, 0.090 Thk, Custom		Custom
22	1	HTSSPRDRR1	HEATSPREADER, Al, 1100, 0.032 Thk x 0.750" (19 mm) L x 0.590" (15mm) W		Custom
23	1	JP1	Wire Jumper, Insulated, TFE, 22 AWG, 0.4”	C2004-12-02	Alpha
24	2	JP2 JP3	Wire Jumper, Insulated, TFE, 22 AWG, 0.3”	C2004-12-02	Alpha
25	1	L1	10 mH, 1 A, Common Mode Choke	744822110	Wurth Elect
26	1	L2	470 μH, 1.6A, Vertical Toroidal	2120-V-RC	Bourns
27	1	L3	1000 μH, 0.18 A, 7 x 10.5 mm	SBC2-102-181	Tokin
28	2	Q1 Q3	NPN, Small Signal BJT, GP SS, 40 V, 0.6 A, SOT-23	MMBT4401T-7-F	Diodes, Inc.
29	1	Q2	PNP, Small Signal BJT, 40 V, 0.6 A, SOT-23	MMBT4403-7-F	Diodes, Inc.
30	2	R1 R3	750 kΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ754V	Panasonic

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31	2	R4 R19	1.50 MΩ, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF1504V	Panasonic
32	1	R5	1 MΩ, 1%, 1/4 W, Metal Film	MFR-25FBF-1M00	Yageo
33	1	R7	2 kΩ, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ202V	Panasonic
34	2	R8 R17	3.01 kΩ, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF3011V	Panasonic
35	1	R9	1.5 MΩ, 1%, 1/4 W, Metal Film	RNF14FTD1M50	Stackpole
36	1	R10	1.60 MΩ, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF1604V	Panasonic
37	1	R11	732 kΩ, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF7323V	Panasonic
38	2	R12 R13	2.21 kΩ, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF2211V	Panasonic
39	1	R14	57.6 kΩ, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF5762V	Panasonic
40	1	R15	160 kΩ, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ164V	Panasonic
41	1	RT2	NTC Thermistor, 10 Ohms, 1.7 A	CL-120	Thermometrics
42	1	SCREW1	SCREW MACHINE PHIL 4-40X 3/16 SS	67413609	MSC Industrial Supply
43		SCREW2	SCREW MACHINE PHIL 4-40 X 5/16 SS	PMSSS 440 0031 PH	Building Fasteners
44	1	STANDOFF RND1	SPACER RND 0.140" DIA x 0.125" L, Aluminum	3403	Keystone
45	2	TERMINAL EYELET1 TERMINAL EYELET2	Terminal, Eyelet, Tin Plated Brass, Zierick PN 190	190	Zierick
46	1	TO-220 PAD1	HEATPAD TO-247 .006" K10	K10-104	Bergquist
47	3	TP1 TP2 TP6	Test Point, BLK,THRU-HOLE MOUNT	5011	Keystone
48	1	TP3	Test Point, RED,THRU-HOLE MOUNT	5010	Keystone
49	1	TP4	Test Point, WHT,THRU-HOLE MOUNT	5012	Keystone
50	1	TP5	Test Point, YEL,THRU-HOLE MOUNT	5014	Keystone
51	1	U1	HiperPFS, eSIP7/6-TH	PFS704EG	Power Integrations
52	1	U2	CAPZero, SO-8C	CAP002DG	Power Integrations
53	1	VR1	12 V, 5%, 225 mW, SOT23	BZX84C12LT1G	On-Semi
54	2	WASHER1 WASHER2	WASHER FLAT #4 SS	FWSS 004	Building Fasteners

7 Inductor Design Spreadsheet

ACDC_PFS_101210; Rev.1.0; Copyright Power Integrations 2010	INPUT	INFO	OUTPUT	UNITS	ACDC_HiperPFS_101210_Rev1-0.xls; Continuous Mode Boost Converter Design Spreadsheet
Enter Applications Variables					
Input Voltage Range	**Universal**		**Universal**		Select Universal or High_Line option
VACMIN			90	V	Minimum AC input voltage
VACMAX			265	V	Maximum AC input voltage
VBROWNIN			77.76		Expected Minimum Brown-in Voltage
VBROWNOUT			70.40	V	Specify brownout voltage.
VO	385			V	Nominal Output voltage
PO	100			W	Nominal Output power
fL			50	Hz	Line frequency
TA Max			40	deg C	Maximum ambient temperature
n			0.93		Enter the efficiency estimate for the boost converter at VACMIN
KP	0.600		0.6		Ripple to peak inductor current ratio at the peak of VACMIN
VO_MIN			365.75	V	Minimum Output voltage
VO_RIPPLE_MAX			20	V	Maximum Output voltage ripple
tHOLDUP			20	ms	Holdup time
VHOLDUP_MIN			310	V	Minimum Voltage Output can drop to during holdup
I_INRUSH			40	A	Maximum allowable inrush current
Forced Air Cooling	**No**		**No**		Enter "Yes" for Forced air cooling. Otherwise enter "No"
PFS Parameters					
PFS Part Number	**Auto**		**PFS704**		Selected PFS device
IOCP min			3.80	A	Minimum Current limit
IOCP typ			4.20	A	Typical current limit
IOCP max			4.60	A	Maximum current limit
RDSON			1.10	ohms	Typical RDSon at 100 'C
RV			4.00	Mohms	Line sense resistor
C_VCC			1.00	uF	Supply decoupling capacitor
C_V			100.00	nF	V pin decoupling capacitor
C_FB			10.00	nF	Feedback pin decoupling capacitor
FS_PK			79.61	kHz	Estimated peak frequency of operation
FS_AVG			64.71	kHz	Estimated average frequency of operation
IP			2.41	A	MOSFET peak current
PFS_IRMS			1.15	A	PFS MOSFET RMS current
PCOND_LOSS_PFS			1.45	W	Estimated PFS conduction losses
PSW_LOSS_PFS			0.77	W	Estimated PFS switching losses
PFS_TOTAL			2.23	W	Total Estimated PFS losses
TJ Max			100	deg C	Maximum steady-state junction temperature
Rth-JS			3.00	degC/W	Maximum thermal resistance (Junction to heat sink)
HEATSINK Theta-CA			23.96	degC/W	Maximum thermal resistance of heat sink
Basic Inductor Calculation					
LPFC			665.10	uH	Value of PFC inductor at peak of VACMIN and Full Load
LPFC (0 Bias)			3471.18	uH	Value of PFC inductor at No load. This is the value measured with LCR meter
LPFC_RMS			1.36	A	Inductor RMS current (calculated at VACMIN and Full Load)
Inductor Construction Parameters					
Core Type	**Sendust**		**Sendust**		Enter "Sendust", "Pow Iron" or "Ferrite"
Core Material	**125u**		**125u**		Select from 60u, 75u, 90u or 125 u for Sendust cores. Fixed at PC44 or equivalent for Ferrite cores. Fixed at 52 material for Pow Iron cores.

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Core Geometry	**TOROID**		**TOROID**		Select from Toroid or EE for Sendust cores and from EE, or PQ for Ferrite cores
Core	**77350(OD=24.3)**		**77350(OD=24.3)**		Core part number
AE			38.8	mm^2	Core cross sectional area
LE			58.8	mm	Core mean path length
AL			104	nH/t^2	Core AL value
VE			2280	mm^3	Core volume
HT			9.65	mm	Core height/Height of window
MLT			33.4	cm	Mean length per turn
BW			N/A	mm	Bobbin width
NL			183		Inductor turns
LG			N/A	mm	Gap length (Ferrite cores only)
ILRMS			1.36	A	Inductor RMS current
Wire type	**Regular**				Select between "Litz" or "Regular" for double coated magnet wire
AWG	23	*Info*	23	AWG	!!! Info. Selected wire gauge is too thick and may cause increased proximity losses. Selecta thinner wire gauge
Filar	1		1		Inductor wire number of parallel strands
OD			0.574	mm	Outer diameter of single strand of wire
AC Resistance Ratio			5.54		Ratio of AC resistance to the DC resistance (using Dowell curves)
J			5.27	A/mm^2	Estimated current density of wires. It is recommended that 4 < J < 6
BM_TARGET			N/A	Gauss	Target flux density at VACMIN (Ferrite cores only)
BM			2580	Gauss	Maximum operating flux density
BP			5323	Gauss	Peak Flux density (Estimated at VBROWNOUT)
LPFC_CORE_LOSS			0.96	W	Estimated Inductor core Loss
LPFC_COPPER_LOSS			1.88	W	Estimated Inductor copper losses
LPFC_TOTAL LOSS			2.84	W	Total estimated Inductor Losses
Critical Parameters					
IRMS			1.19	A	AC input RMS current
IO_AVG			0.26	A	Output average current
Output Diode					
Part Number	**Auto**		**STTH2R06**		PFC Diode Part Number
Type			ULTRAFAST		Diode Type - Special - Diodes specially catered for PFC applications, SiC - Silicon Carbide type, UF - Ultrafast recovery type
Manufacturer			ST		Diode Manufacturer
VRRM			600	V	Diode rated reverse voltage
IF			2	A	Diode rated forward current
TRR			75	ns	Diode Reverse recovery time
VF			1.1	V	Diode rated forward voltage drop
PCOND_DIODE			0.29	W	Estimated Diode conduction losses
PSW_DIODE			1.39	W	Estimated Diode switching losses
P_DIODE			1.67	W	Total estimated Diode losses
TJ Max			125	deg C	Maximum Operating temperature
Rth-JS			35.00	degC/W	Maximum thermal resistance (Junction to heat sink)
HEATSINK Theta-CA			15.34	degC/W	Maximum thermal resistance of heat sink
Output Capacitor					
CO	**Auto**		**100.00**	uF	Minimum value of Output capacitance
VO_RIPPLE_EXPECTED			8.9	V	Expected ripple voltage on Output with selected Output capacitor
T_HOLDUP_EXPECTED			23.6	ms	Expected holdup time with selected Output capacitor
ESR_LF			1.66	ohms	
ESR_HF			0.663	ohms	
IC_RMS_LF			0.18	A	Low Frequency Capacitor RMS current
IC_RMS_HF			0.53	A	High Frequency Capacitor RMS current
CO_LF_LOSS			0.06	W	Estimated Low Frequency ESR loss in

					Output capacitor
CO_HF_LOSS			0.18	W	Estimated High frequency ESR loss in Output capacitor
Total CO LOSS			0.24	W	Total estimated losses in Output Capacitor
Input Bridge and Fuse					
I^2t Rating			7.02	A^2s	Minimum I^2t rating for fuse
Fuse Current rating			1.82	A	Minimum Current rating of fuse
VF			0.90	V	Input bridge Diode forward Diode drop
IAVG			1.13	A	Input average current at 70 VAC.
PIV_INPUT BRIDGE			375	V	Peak inverse voltage of input bridge
PCOND_LOSS_BRIDGE			1.94	W	Estimated Bridge Diode conduction loss
CIN			0.33	uF	Input capacitor. Use metallized polypropylene or film foil type with high ripple current rating
RT			8.84	ohms	Input Thermistor value
D_Precharge			1N5407		Recommended precharge Diode
Feedback Components					
R2			1.54	Mohms	Feedback network, first high voltage divider resistor
R3			1.54	Mohms	Feedback network, second high voltage divider resistor
R4			698.00	kohms	Feedback network, third high voltage divider resistor
C2			100.00	nF	Feedback network, loop speedup capacitor
R5			2.20	kohms	Feedback component, NPN transistor bias resistor
R6			2.20	kohms	Feedback component, PNP transistor bias resistor
R7			57.60	kohms	Feedback network, lower divider resistor
C3			470.00	pF	Feedback component- noise suppression capacitor
R8			160.00	kohms	Feedback network - pole setting resistor
R9			2.94	kohms	Feedback network - zero setting resistor
R10			10.00	kohms	Feedback pin filter resistor
C4			10.00	uF	Feedback network - compensation capacitor
D3			1N4148		Feedback network reverse blocking Diode
D4			1N4001		Feedback network - capacitor failure detection Diode
Q1			2N4401		Feedback network - speedup circuit NPN transistor
Q2			2N4403		Feedback network - speedup circuit PNP transistor
Loss Budget (Estimated at VACMIN)					
PFS Losses			2.23	W	Total estimated losses in PFS
Boost diode Losses			1.67	W	Total estimated losses in Output Diode
Input Bridge losses			1.94	W	Total estimated losses in input bridge module
Inductor losses			2.84	W	Total estimated losses in PFC choke
Output Capacitor Loss			0.24	W	Total estimated losses in Output capacitor
Total losses			8.91	W	Overall loss estimate
Efficiency			0.92		Estimated efficiency at VACMIN. Verify efficiency at other line voltages

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8 Main Inductor Specifications

8.1 Electrical Diagram

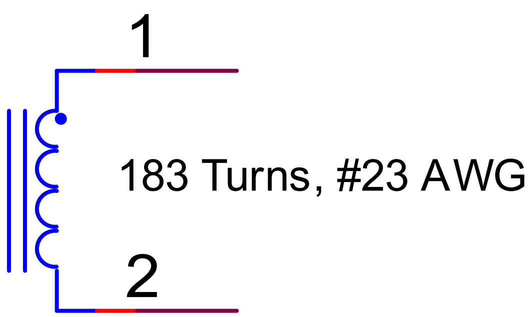


Figure 6 – Main Inductor Electrical Diagram.

8.2 Electrical Specifications

Primary Inductance	Pins 1-2 measured at 10 kHz, 0.4 V RMS	15 mH, ±30%

8.3 Materials

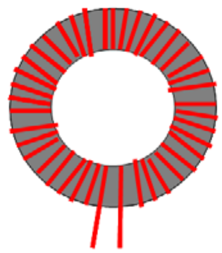
Item	Description
[1]	Core: Magnetics Inc, Mfg: 77350-A7
[2]	Single strange wire: #23 AWG

8.4 Winding Instructions

1. Wind turns in one direction to fill up the surface of layer #1 (65 ~ 68 turns).

2. Continue winding to fill up layer #2 (58 ~ 62 turns).

3. Continue winding on layer #3 for the remaining turns.



9 Common-mode Inductor Specifications

9.1 *Electrical Diagram*

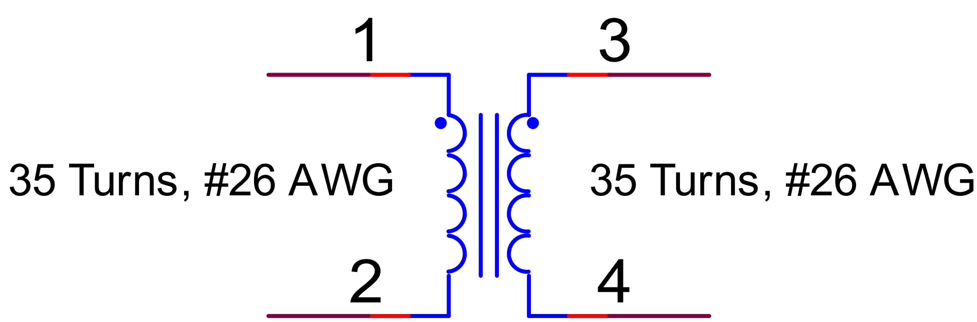


Figure 7 – Common-Mode Inductor Electrical Diagram.

9.2 *Electrical Specifications*

Primary Inductance	Pins 1-2, 3-4 measured at 10 kHz	15 mH, ±30%

9.3 *Materials*

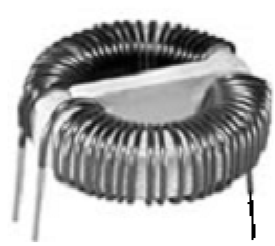
Item	Description
[1]	Material: TS10 TDG. Core type T18*10*8. Manufacturer: Zhejiang Tiantong, China
[2]	Magnet Wire: #26 AWG

9.4 *Winding Instructions*

1. Insert a divider (tape or plastic wrap) in the core to divide into 2 sections equally.

2. Start winding on one section with 28 turns or completely fill up the section for the 1st layer, then equally spread the remaining turns for the 2nd layer.

3. Repeat step 2 for the other section winding.



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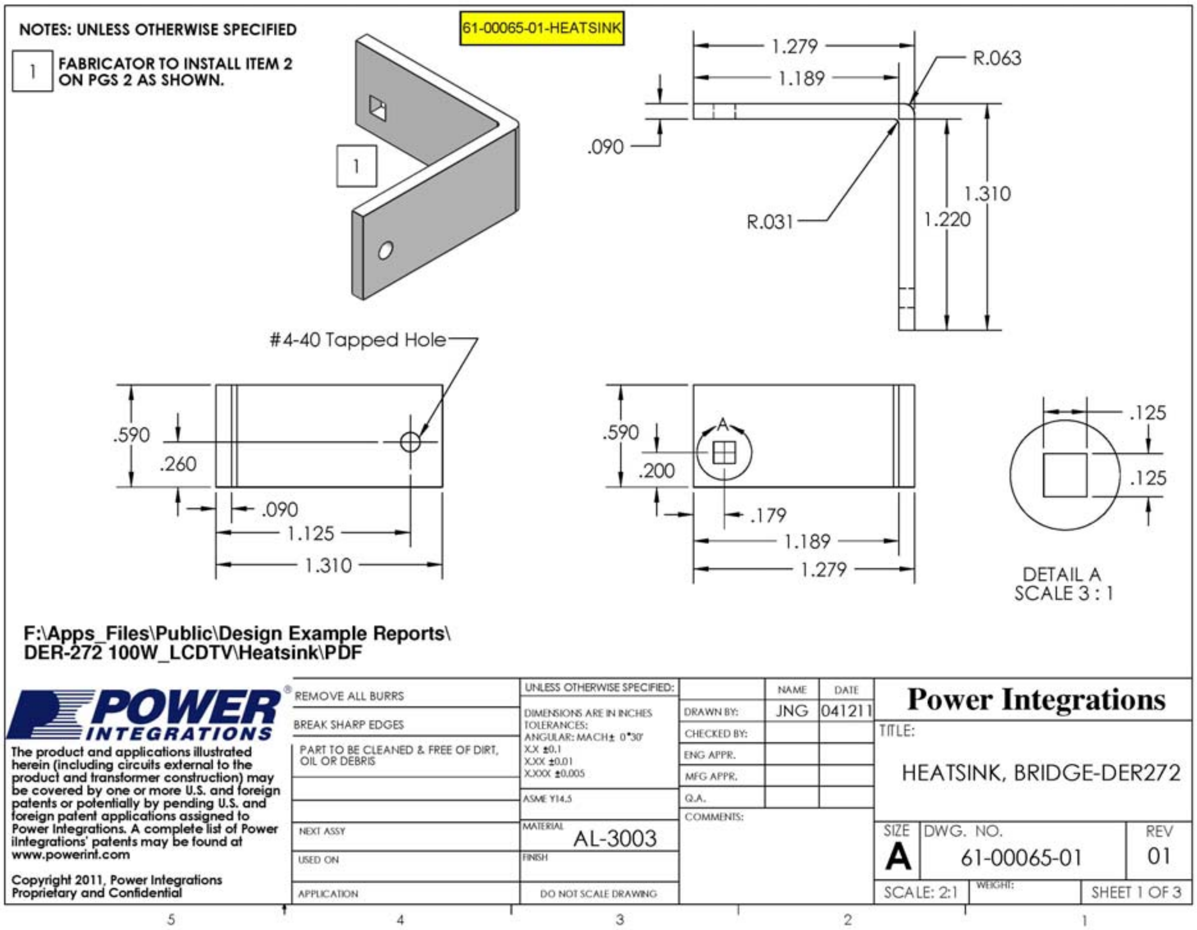
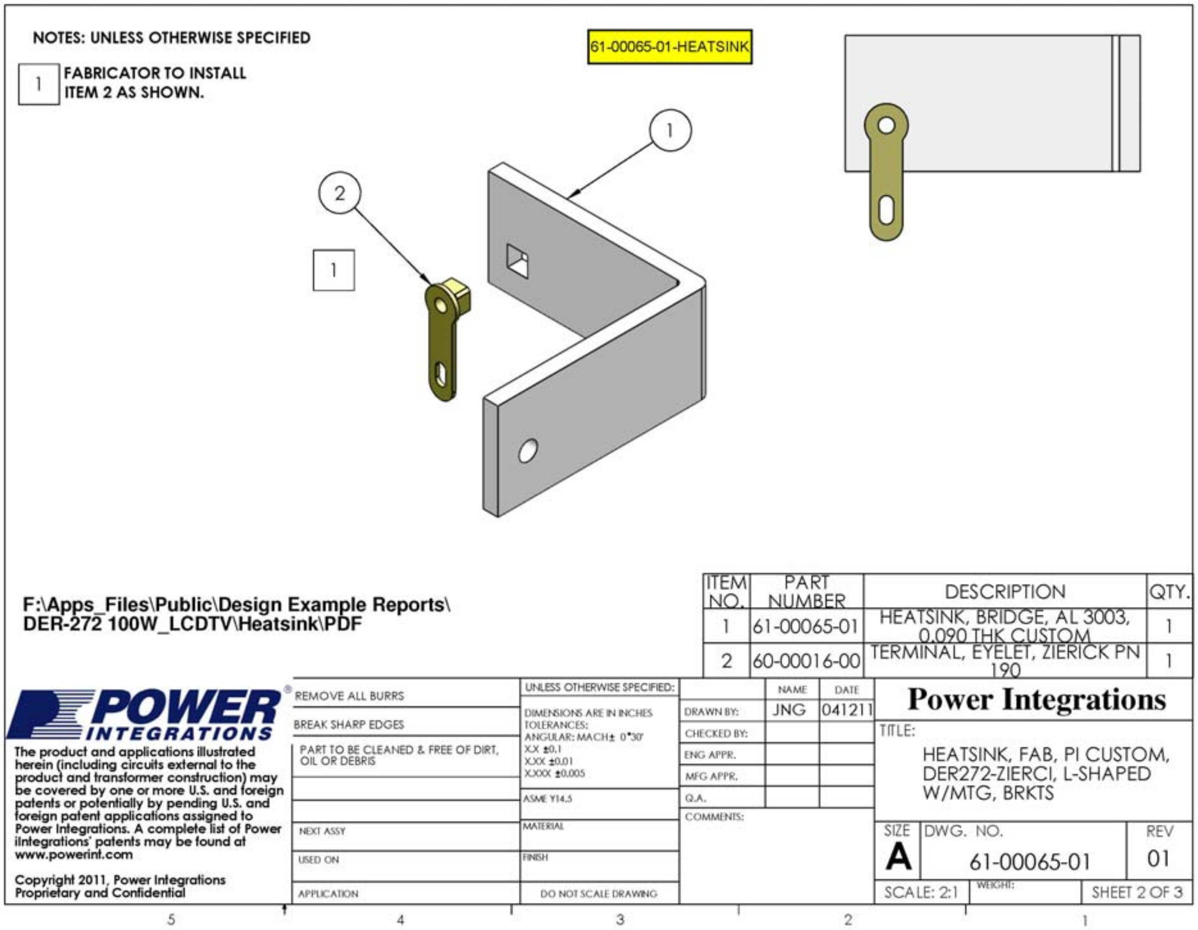
10 Heat Sink Specifications

10.1 Diode Bridge Heat Sink Assembly





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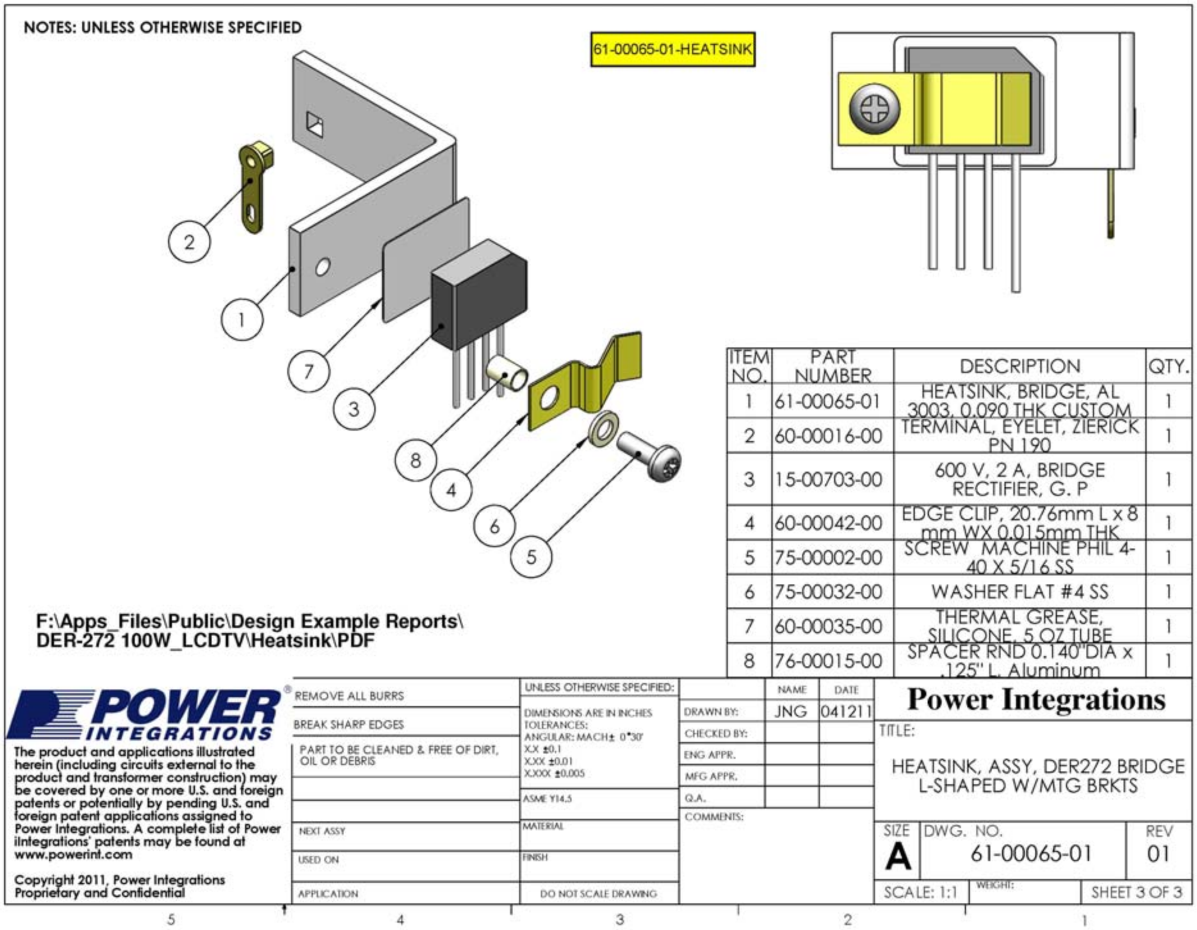
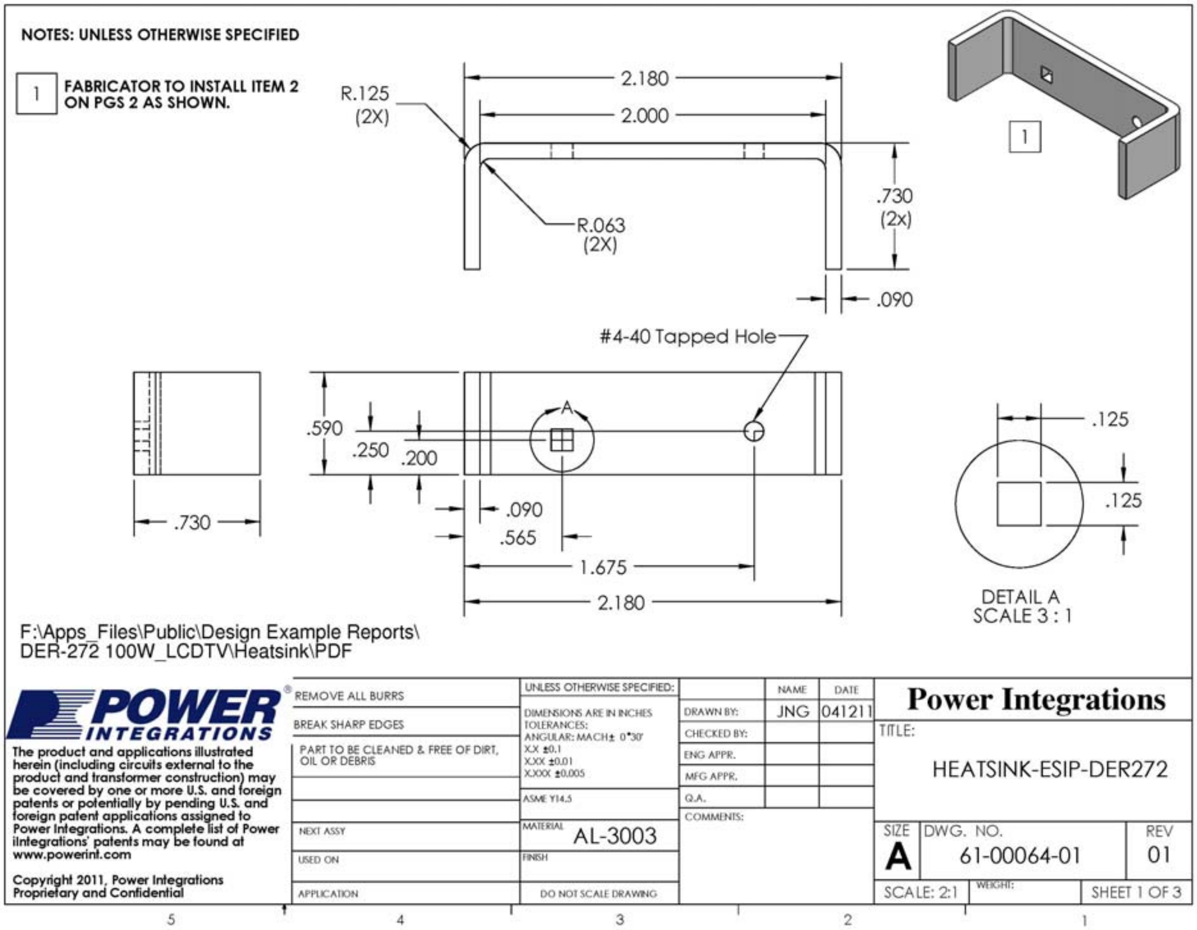


ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	61-00065-01	HEATSINK, BRIDGE, AL 3003, 0.090 THK CUSTOM	1
2	60-00016-00	TERMINAL, EYELET, ZIERICK PN 190	1
3	15-00703-00	600 V, 2 A, BRIDGE RECTIFIER, G. P	1
4	60-00042-00	EDGE CLIP, 20.76mm L x 8 mm WX 0.015mm THK	1
5	75-00002-00	SCREW MACHINE PHIL 4-40 X 5/16 SS	1
6	75-00032-00	WASHER FLAT #4 SS	1
7	60-00035-00	THERMAL GREASE, SILICONE, 5 OZ TUBE	1
8	76-00015-00	SPACER RND 0.140"DIA x .125" L, Aluminum	1

10.2 eSIP Heat Sink Assembly



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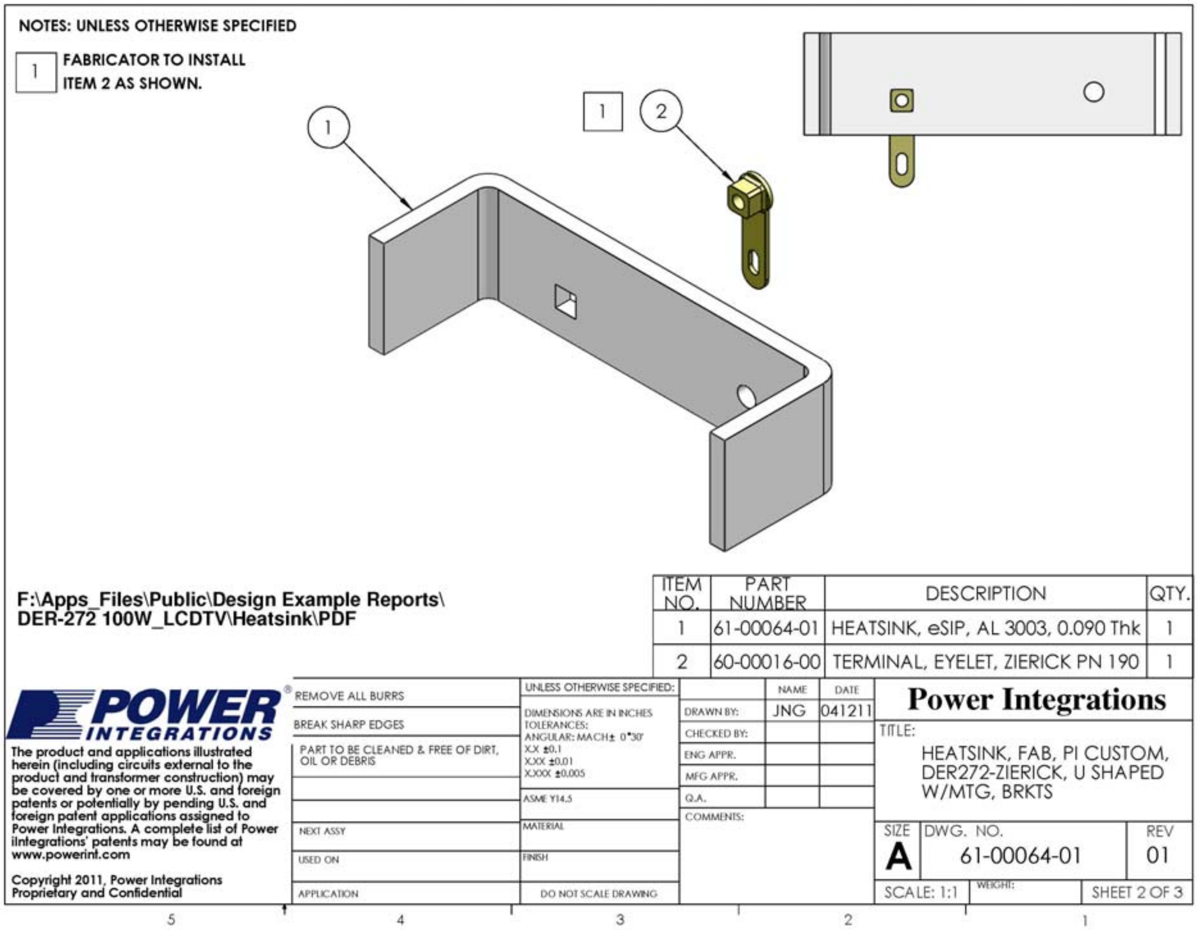
NOTES: UNLESS OTHERWISE SPECIFIED
1 FABRICATOR TO INSTALL ITEM 2 AS SHOWN.
1
2
1
F:\Apps_Files\Public\Design Example Reports\ DER-272 100W_LCDTV\Heatsink\PDF
ITEM NO. | PART NUMBER | DESCRIPTION | QTY.
1 | 61-00064-01 | HEATSINK, eSIP, AL 3003, 0.090 Thk | 1
2 | 60-00016-00 | TERMINAL, EYELET, ZIERICK PN 190 | 1
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PART TO BE CLEANED & FREE OF DIRT, OIL OR DEBRIS
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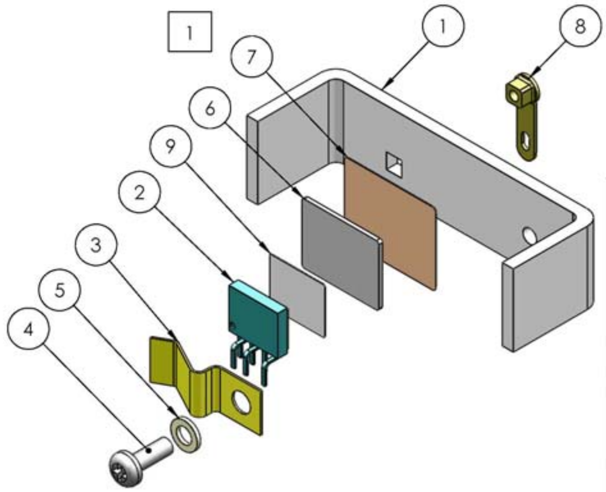
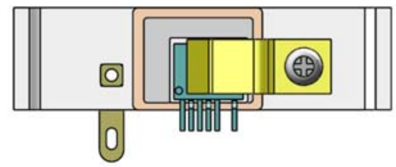
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGULAR: MACH± 0°30'
X.X ±0.1
X.XX ±0.01
X.XXX ±0.005
ASME Y14.5
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN BY: JNG 041211
CHECKED BY:
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
Power Integrations
TITLE:
HEATSINK, FAB, PI CUSTOM, DER272-ZIERICK, U SHAPED W/MTG, BRKTS
SIZE A
DWG. NO. 61-00064-01
REV 01
SCALE: 1:1
WEIGHT:
SHEET 2 OF 3
5
4
3
2
1

NOTES: UNLESS OTHERWISE SPECIFIED

1 TRIM ITEM #7 .750" LONG (BER20-ND)





ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	61-00064-01	HEATSINK, eSIP, AL 3003, 0.090 Thk	1
2	10-00313-00	HiperPFS, PFS704EG, eSIP7/6-TH	1
3	60-00042-00	EDGE CLIP, 20.76mm L x 8 mm WX 0.015mm THK	1
4	75-00089-00	SCREW MACHINE PHIL 4-40 X 3/16 SS	1
5	75-00032-00	WASHER FLAT #4 SS	1
6	61-00066-00	HEATSPREADER, AL, 1100, 0.032 THK x 16.0mm x 12.5mm	1
7	66-00083-00	HEATPAD TO-247 .006" K10	1
8	60-00016-00	TERMINAL, EYELET, ZIERICK PN 190	1
9	66-00035-00	THERMAL GREASE SILICONE, 5OZ TUBE	1

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DER-272 100W_LCDTV\Heatsink\PDF

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APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGULAR: MACH± 0°30'
X.X ±0.1
X.XX ±0.01
X.XXX ±0.005
ASME Y14.5
MATERIAL
FINISH
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN BY:	JNG	041211
CHECKED BY:		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

Power Integrations

TITLE: HEATSINK, ASSY, DER272 ESIP U SHAPED W/MTG BRKTS

SIZE A | DWG. NO. 61-00064-01 | REV 01

SCALE: 1:1 | WEIGHT: | SHEET 3 OF 3

5 4 3 2 1

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11 Performance Data

All measurements performed at room temperature, 60 Hz input frequency for voltages below 150 VAC and input frequency of 50 Hz for 150 VAC and higher.

11.1 Efficiency (w/ thermistor in-circuit, no forced air cooling)

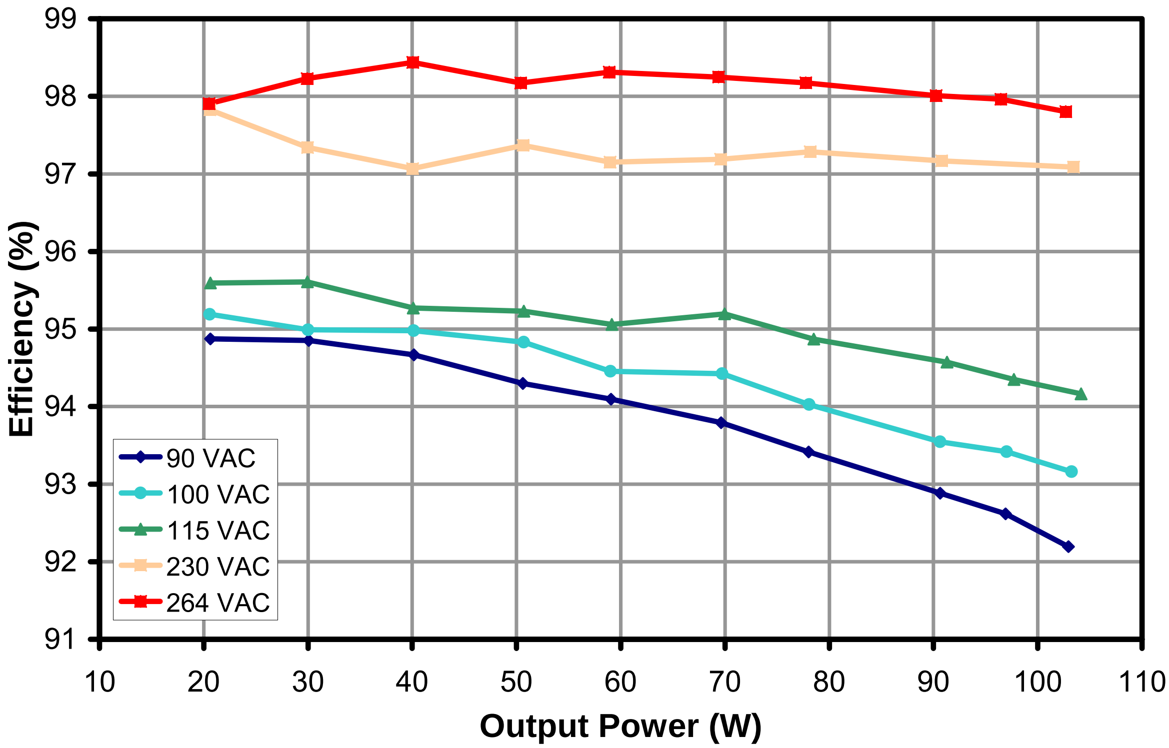

Figure 8 – Efficiency vs. Output Power.

11.2 Input Power Factor

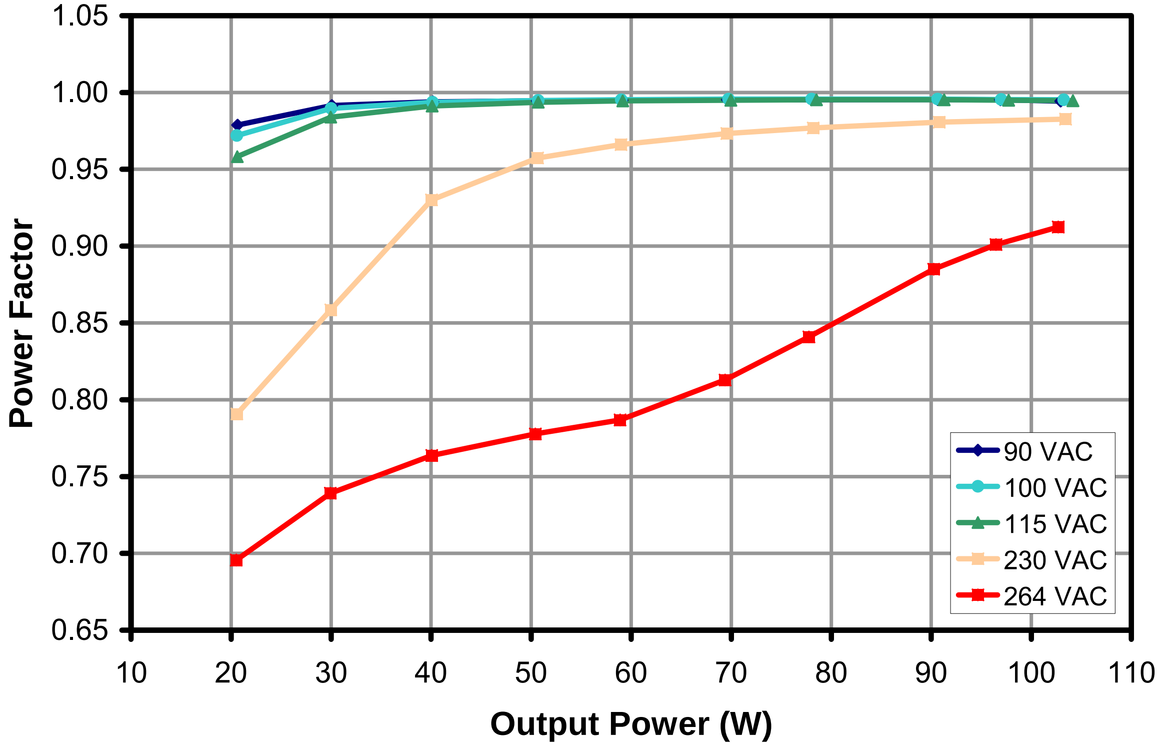

Figure 9 – Input Power Factor vs. Output Power.

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11.3 Regulation

11.3.1 Load

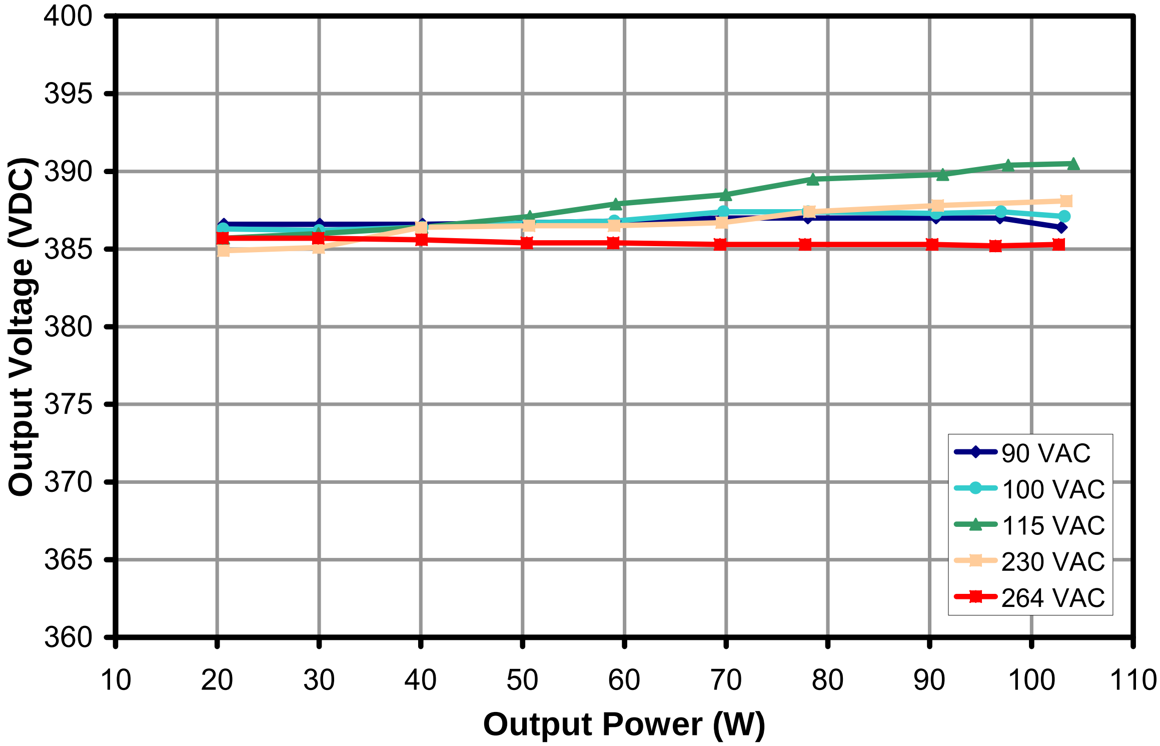

Figure 10 – Load Regulation.

11.3.2 Line

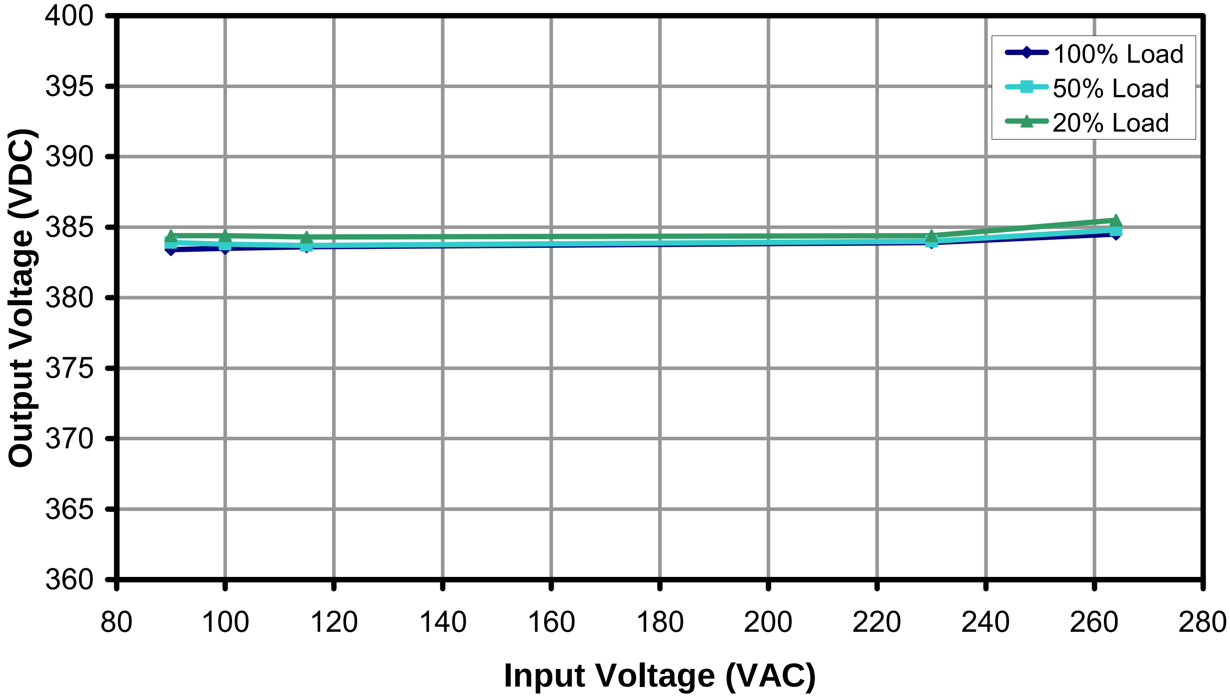

Figure 11 – Line Regulation.

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11.4 Input Current Harmonic Distortion (IEC 61000-3-2 Class D)

Measured at 230 VAC Input 50 Hz

11.4.1 50% Load at Output

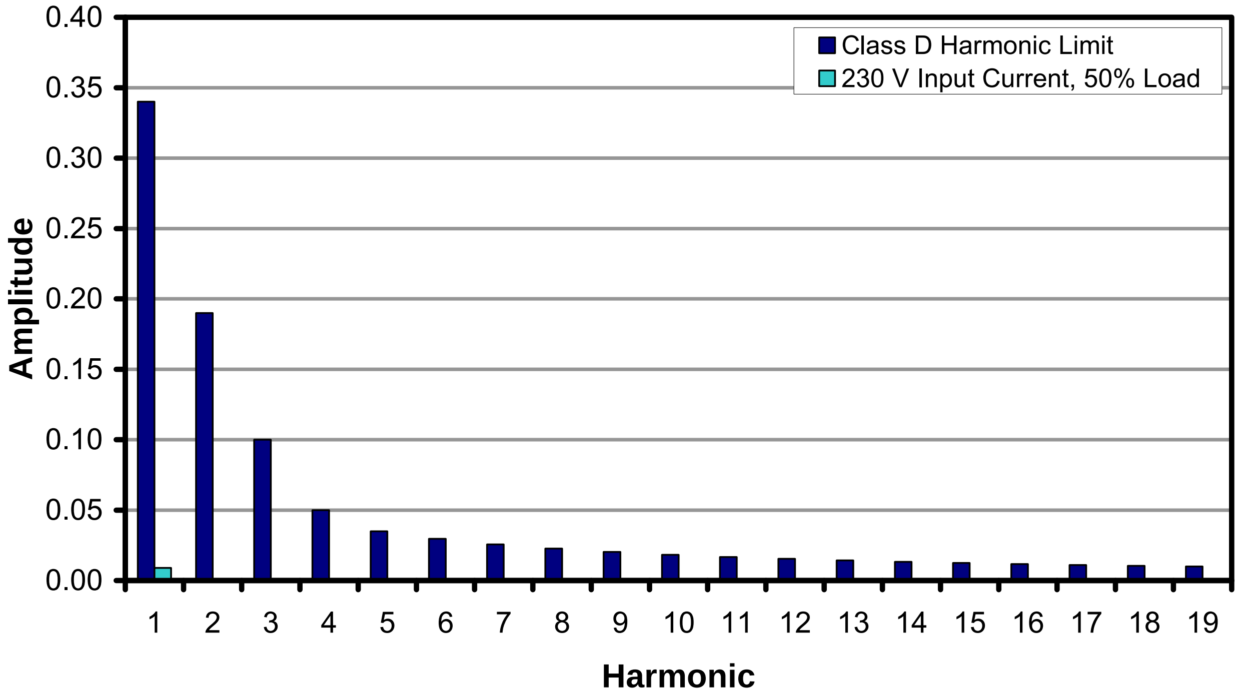

Figure 12 – Amplitude of Input Current Harmonics for 50% Load at 230 VAC Input.

11.4.2 100% Load at Output

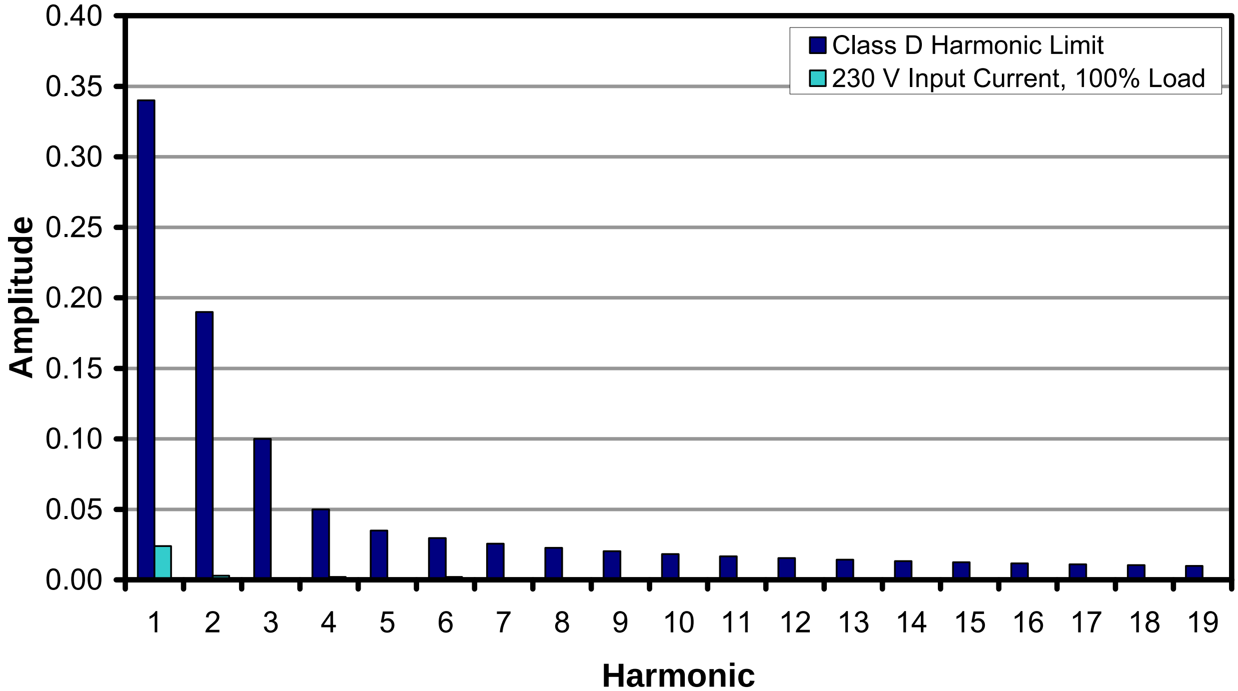

Figure 13 – Amplitude of Input Current Harmonics for 100% Load at 230 VAC Input.

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12 Thermal Performance

The unit was allowed to reach thermal equilibrium prior to the measurement. Table 1 shows full load temperature of key components at equilibrium, room temperature and without any forced air cooling.

Component	Temperature (ºC)
CM Inductor, L1	58.4
Differential Inductor, L2	63
Bridge Rectifier, BR1	82
Bridge Rectifier Capacitor, C7	58.5
Boost Inductor, L3	72
Output Diode	66
Output Capacitor	39.2
PFS704, U1	88.8
Ambient	44

Table 1 – Thermal Performance of Key Components at Full Load, 115 VAC.

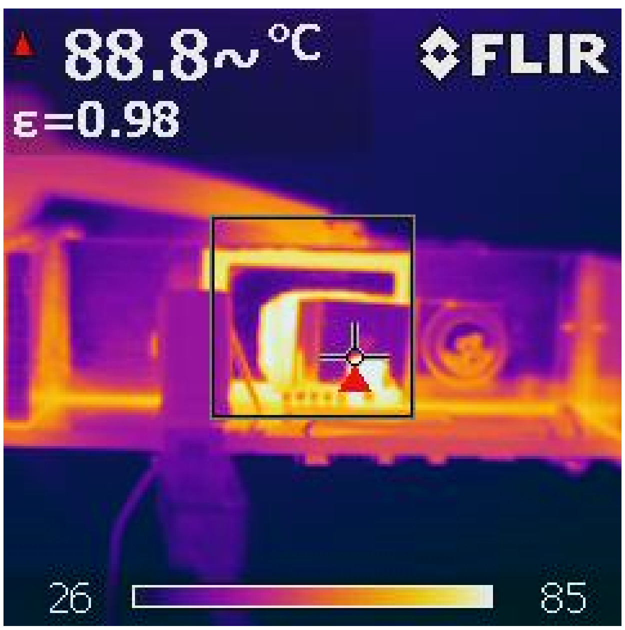

Figure 14 – Infrared Image of U1 IC, PFS704EG and Side of the Board at Thermal Equilibrium. 115 VAC, Full Load, No Forced-Air Flow, 44ºC Ambient.

13 Waveforms

13.1 Input Current at 115 VAC and 60 Hz

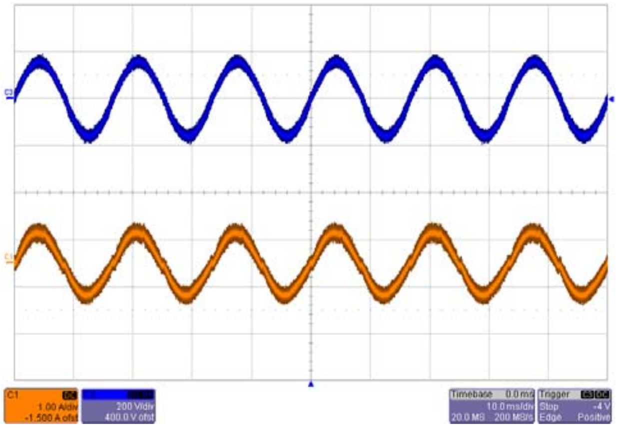

Figure 15 – 115 VAC, 50% Load.
Top: V_{IN}, 200 V / div.
Bottom: I_{IN}, 1 A, 10 ms / div.

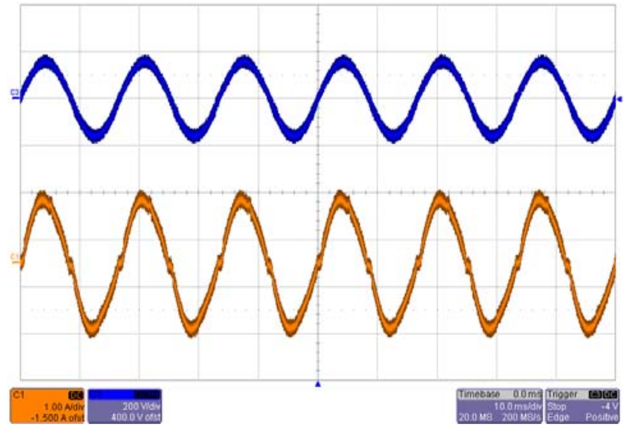

Figure 16 – 115 VAC, 100% Load.
Top: V_{IN}, 200 V / div.
Bottom: I_{IN}, 1 A, 10 ms / div.

13.2 Input Current at 230 VAC and 50 Hz

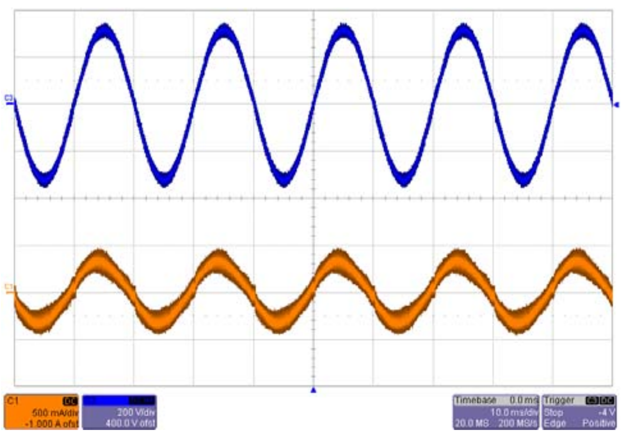

Figure 17 – 230 VAC, 50% Load.
Top: V_{IN}, 200 V / div.
Bottom: I_{IN}, 500 mA, 10 ms / div.

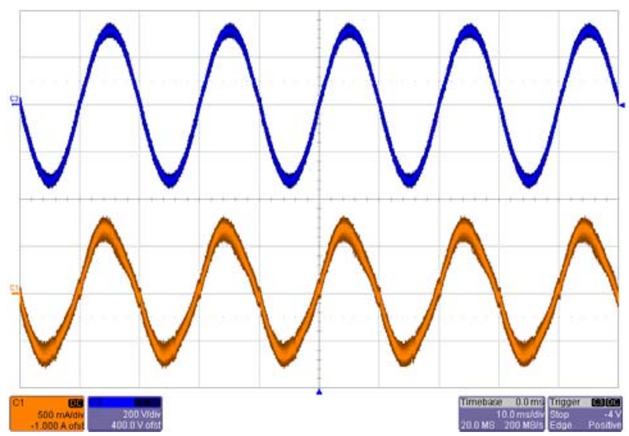

Figure 18 – 230 VAC, 100% Load.
Top: V_{IN}, 200 V / div.
Bottom: I_{IN}, 500 mA, 10 ms / div.

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13.3 Start-up at 90 VAC and 60 Hz

Load in CC mode during turn-on of PFC.

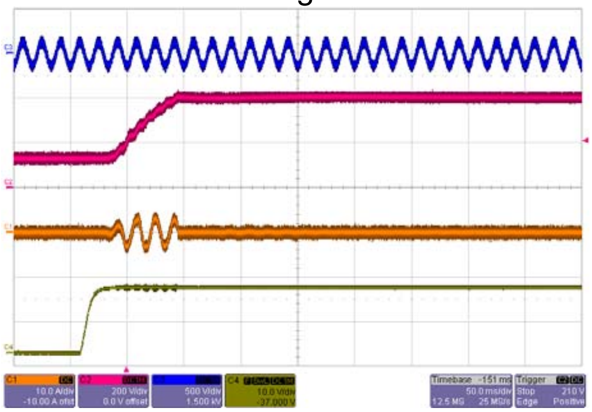

Figure 19 – 90 VAC, No Load.
Top: V_{IN}, 500 V / div.
Second: V_O, 200 V / div.
Third: I_{IN}, 10 A / div.
Bottom: V_{CC}, 10 V / div., 50 ms / div.

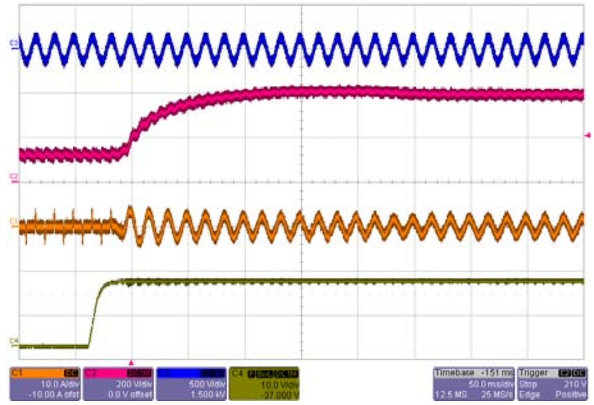

Figure 20 – 90 VAC, Full Load.
Top: V_{IN}, 500 V / div.
Second: V_O, 200 V / div.
Third: I_{IN}, 10 A / div.
Bottom: V_{CC}, 10 V / div., 50 ms / div.

13.4 Start-up at 115 VAC and 60 Hz

Load in CC mode during turn-on of PFC.

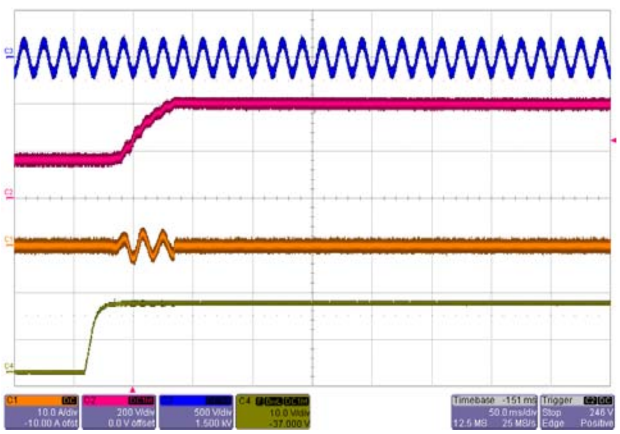

Figure 21 – 115 VAC, No Load.
Top: V_{IN}, 500 V / div.
Second: V_O, 200 V / div.
Third: I_{IN}, 10 A / div.
Bottom: V_{CC}, 10 V / div., 50 ms / div.

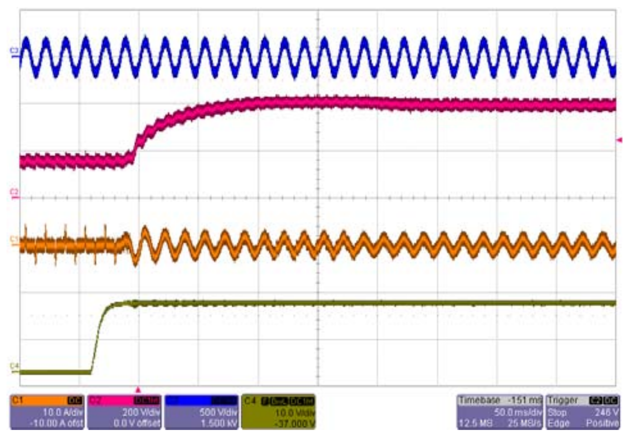

Figure 22 – 115 VAC, Full Load.
Top: V_{IN}, 500 V / div.
Second: V_O, 200 V / div.
Third: I_{IN}, 10 A / div.
Bottom: V_{CC}, 10 V / div., 50 ms / div.

13.5 Start-up at 230 VAC and 50 Hz

Load in CC mode during turn-on of PFC.

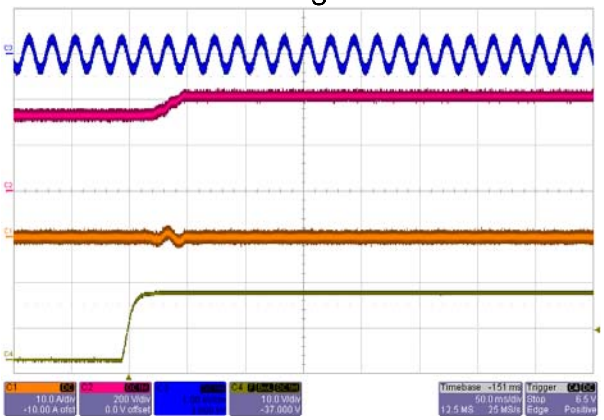

Figure 23 – 230 VAC, No-load.
Top: V_{IN}, 1 kV / div.
Second: V_O, 200 V / div.
Third: I_{IN}, 10 A / div.
Bottom: V_{CC}, 10 V, 50 ms / div.

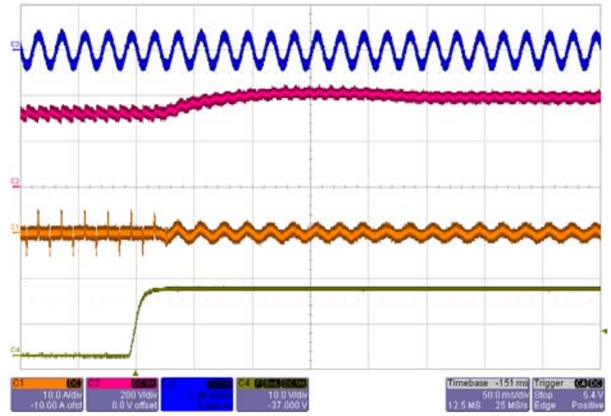

Figure 24 – 230 VAC, Full Load.
Top: V_{IN}, 1 kV / div.
Second: V_O, 200 V / div.
Third: I_{IN}, 10 A / div.
Bottom: V_{CC}, 10 V, 50 ms / div.

13.6 Start-up at 264 VAC and 50 Hz

Load in CC mode during turn-on of PFC.

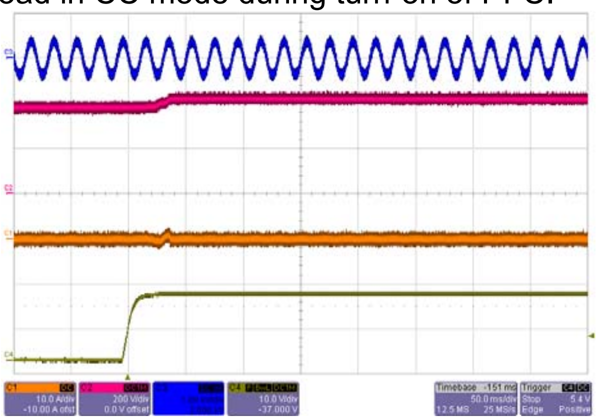

Figure 25 – 264 VAC, No-load.
Top: V_{IN}, 1 kV / div.
Second: V_O, 200 V / div.
Third: I_{IN}, 10 A / div.
Bottom: V_{CC}, 10 V, 50 ms / div.

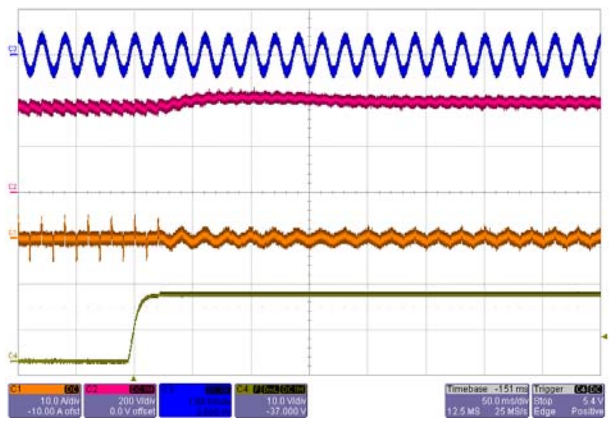

Figure 26 – 264 VAC, Full Load.
Top: V_{IN}, 1 kV / div.
Second: V_O, 200 V / div.
Third: I_{IN}, 10 A / div
Bottom: V_{CC}, 10 V, 50 ms / div.

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13.7 Load Transient Response (90 VAC / 60 Hz)

In the figures shown below, signal averaging was used to better enable viewing the load transient response. The oscilloscope was triggered using the load current step as a trigger source. Since the output switching and line frequency occur essentially at random with respect to the load transient, contributions to the output ripple from these sources will average out, leaving the contribution only from the load step response.

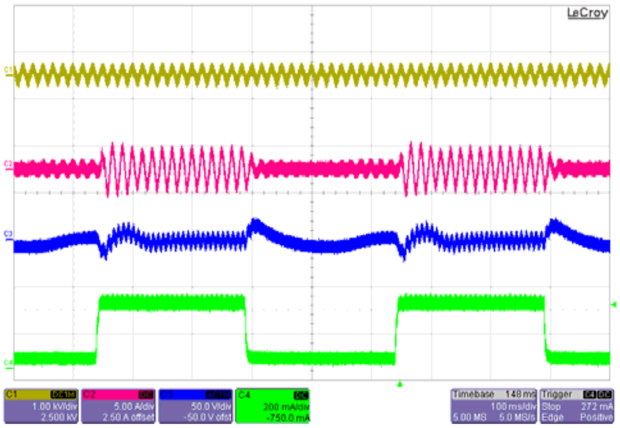

Figure 27 – Transient Response, 90 VAC, 10–100–10% Load Step.
Top: V_{IN}, 1 kV / div.
Second: I_{IN}, 5 A /div.
Third: V_O (AC Coupled), 50 V / div.
Bottom: I_{LOAD} 200 mA, 100 ms / div.

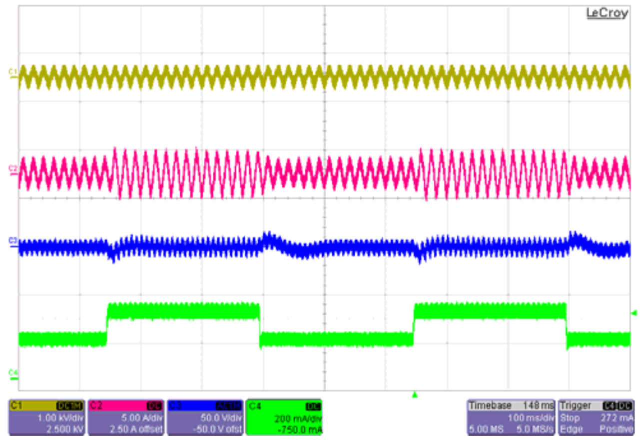

Figure 28 – Transient Response, 90 VAC, 50–100–50% Load Step.
Top: V_{IN}, 1 kV / div.
Second: I_{IN}, 5 A / div.
Third: V_O (AC Coupled), 50 V / div.
Bottom: I_{LOAD} 200 mA, 100 ms / div.

13.8 Load Transient Response (115 VA / 60 Hz)

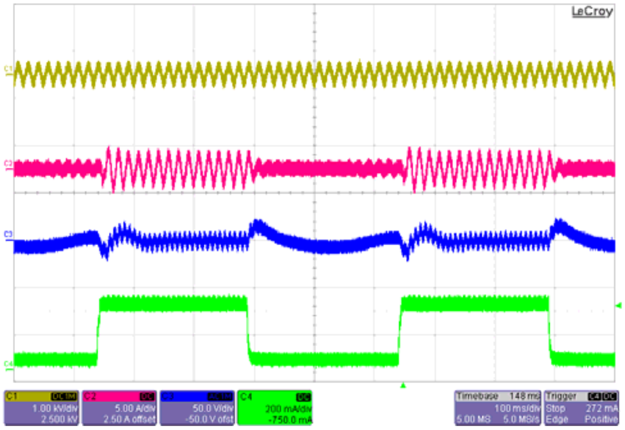

Figure 29 – Transient Response, 115 VAC,
10–100–10% Load Step.
Top: V_{IN}, 1 kV / div.
Second: I_{IN}, 5 A /div.
Third: V_O (AC Coupled), 50 V / div.
Bottom: I_{LOAD} 200 mA, 100 ms / div.

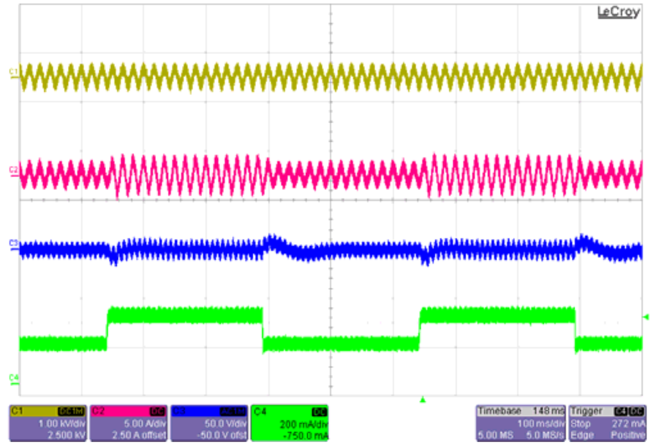

Figure 30 – Transient Response, 115 VAC,
50–100–50% Load Step.
Top: V_{IN}, 1 kV / div.
Second: I_{IN}, 5 A /div.
Third: V_O (AC Coupled), 50 V / div.
Bottom: I_{LOAD} 200 mA, 100 ms / div.

13.9 Load Transient Response (230 VAC / 50 Hz)

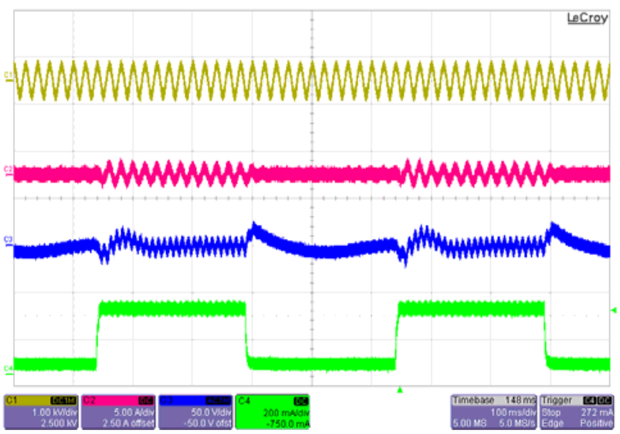

Figure 31 – Transient Response, 230 VAC,
10–100–10% Load Step.
Top: V_{IN}, 1 kV / div.
Second: I_{IN}, 5 A / div.
Third: V_O (AC Coupled),50 V / div.
Bottom: I_{LOAD} 200 mA, 100 ms / div.

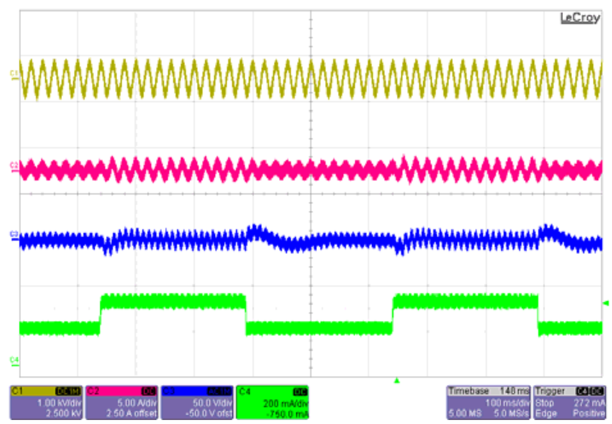

Figure 32 – Transient Response, 230 VAC,
50–100–50% Load Step.
Top: V_{IN}, 1 kV / div.
Second: I_{IN}, 5 A / div.
Third: V_O (AC Coupled), 50 V / div.
Bottom: I_{LOAD} 200 mA, 100 ms / div

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13.10 Load Transient Response (264 VAC / 50 Hz)

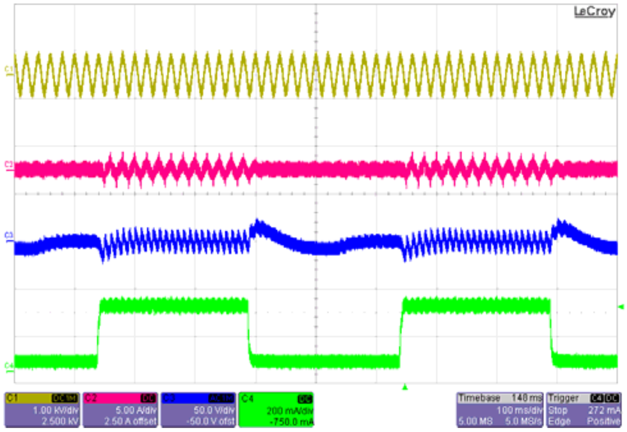

Figure 33 – Transient Response, 264 VAC,
10–100–10% Load Step.
Top: V_{IN}, 1 kV / div.
Second: I_{IN}, 5 A / div.
Third: V_O (AC Coupled), 50 V / div.
Bottom: I_{LOAD} 200 mA, 100 ms / div.

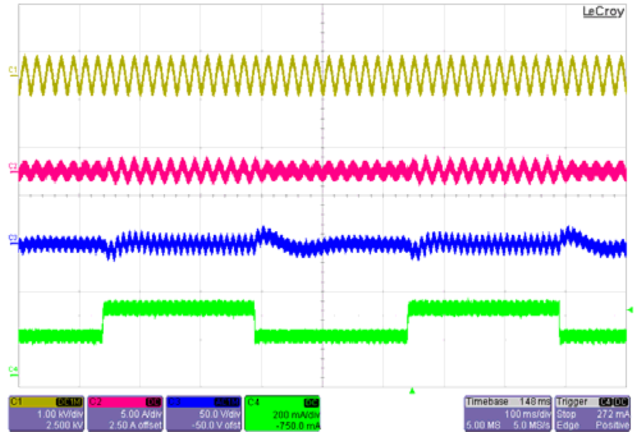

Figure 34 – Transient Response, 264 VAC,
50–100–50% Load Step.
Top: V_{IN}, 1 kV / div.
Second: I_{IN}, 5 A / div.
Third: V_O (AC Coupled), 50 V / div.
Bottom: I_{LOAD} 200 mA, 100 ms / div.

13.11 1000 ms Line Dropout (115 VC / 60 Hz and 230 VAC / 50 Hz)

13.11.1 50% Load at Output

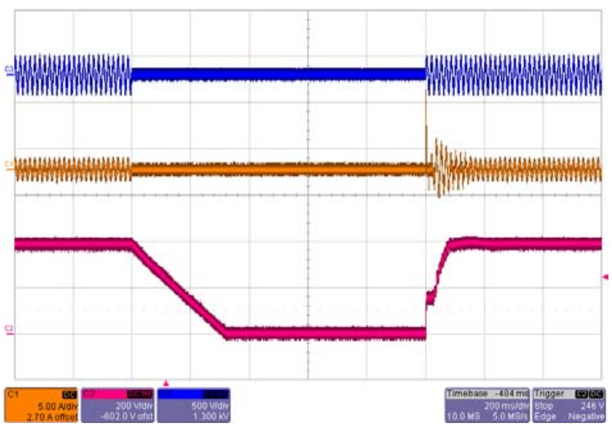

Figure 35 – Line Dropout 115 VAC, 1000 ms.
Top: V_{IN}, 500 V / div.
Middle: I_{IN}, 5 A / div.
Bottom: V_O, 200 V, 200 ms / div.

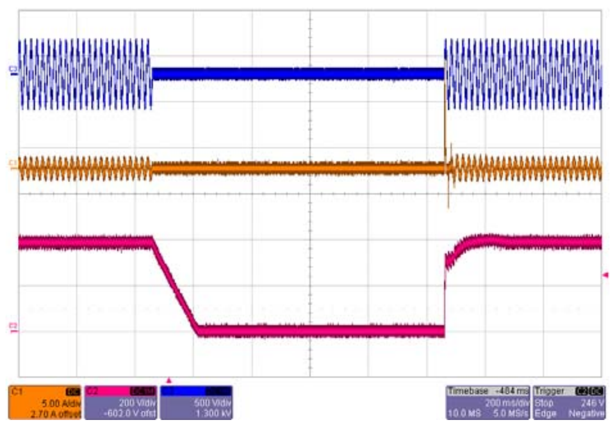

Figure 36 – Line Dropout 230 VAC, 1000 ms.
Top: V_{IN}, 500 V / div.
Middle: I_{IN}, 5 A / div.
Bottom: V_O, 200 V, 200 ms / div.

13.11.2 Full Load at Output

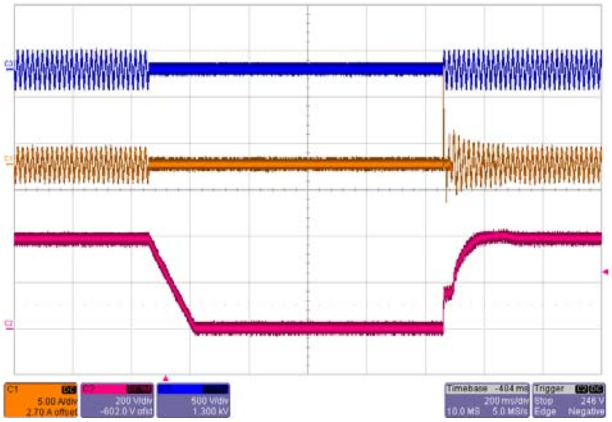

Figure 37 – Line Dropout 115 VAC, 1000 ms.
Top: V_{IN}, 500 V / div.
Middle: I_{IN}, 5 A / div.
Bottom: V_O, 200 V, 200 ms / div.

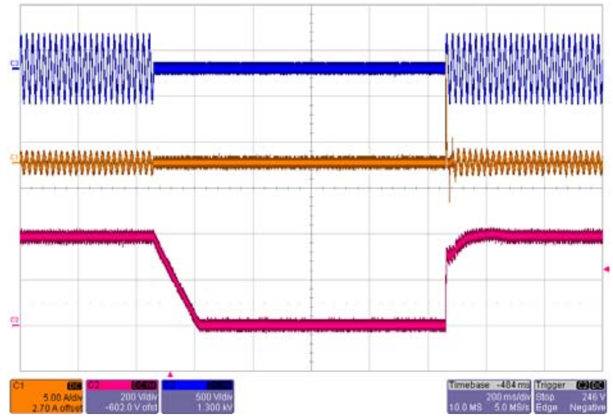

Figure 38 – Line Dropout 230 VAC, 1000 ms.
Top: V_{IN}, 500 V / div.
Middle: I_{IN}, 5 A / div.
Bottom: V_O, 200 V, 200 ms / div.

13.12 One Cycle Line Dropout (115 VAC / 60 Hz and 230 VAC / 50 Hz)

13.12.1 Full Load at Output

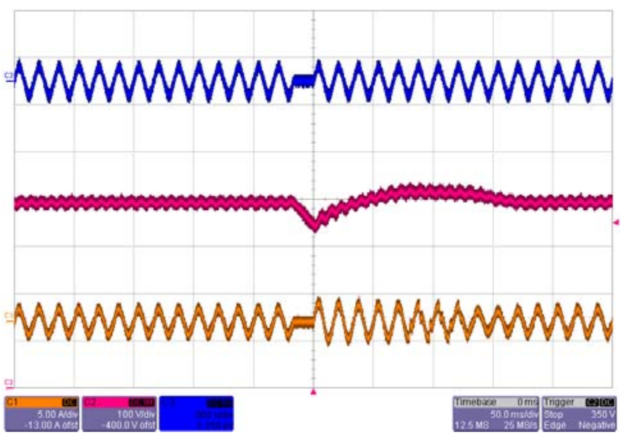

Figure 39 – Line Dropout 115 VAC, 60 Hz.
Top: V_{IN}, 500 V / div.
Middle: V_O, 100 V /div.
Bottom: I_{IN}, 5 A, 50 ms / div.

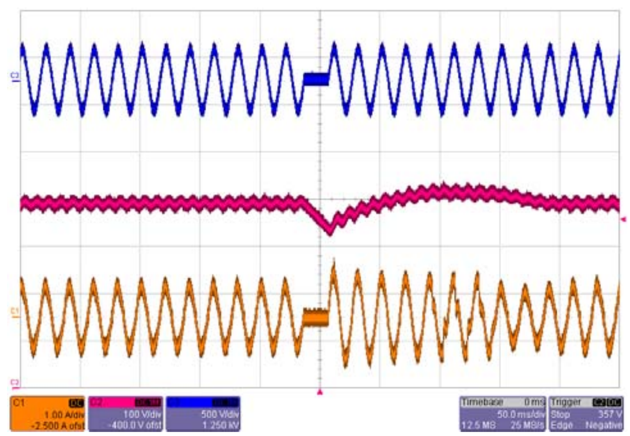

Figure 40 – Line Dropout 230 VAC, 50 Hz.
Top: V_{IN}, 500 V / div.
Middle: V_O, 100 V / div.
Bottom: I_{IN}, 5 A, 50 ms /div.

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13.13 Line Sag (115 VAC – 85 VAC – 115 VAC, 60 Hz)

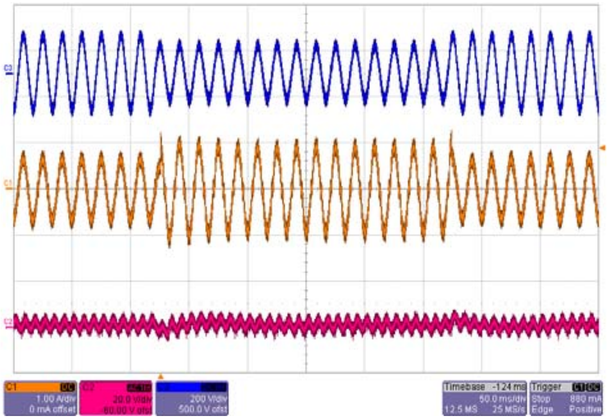

Figure 41 – Line Sag 115 VAC, 50% Load.
Top: V_{IN}, 200 V / div.
Middle: I_{IN}, 1 A, 50 ms / div.
Bottom: V_O (AC Coupled), 20 V / div.

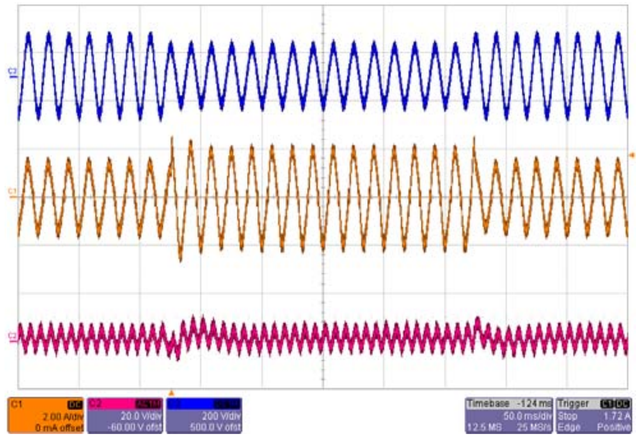

Figure 42 – Line Sag 115 VAC, 100% Load.
Top: V_{IN}, 200 V / div.
Middle: I_{IN}, 2 A, 50 ms / div.
Bottom: V_O (AC Coupled), 20 V / div.

13.14 Line Surge (132 VAC – 147 VAC – 132 VAC, 60 Hz)

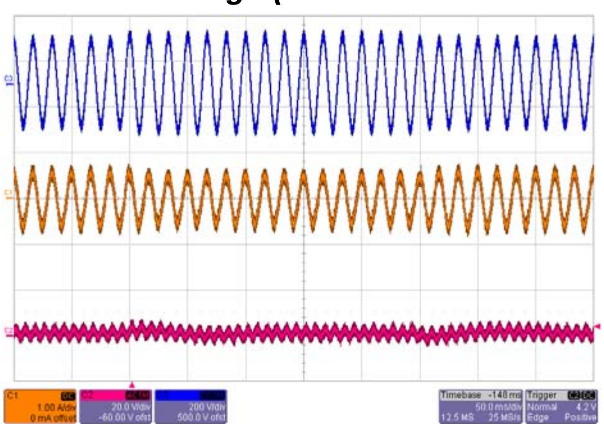

Figure 43 – Line Surge 132 VAC, 50% Load.
Top: V_{IN}, 200 V / div.
Middle: I_{IN}, 1 A, 50 ms / div.
Bottom: V_O (AC Coupled), 20 V / div.

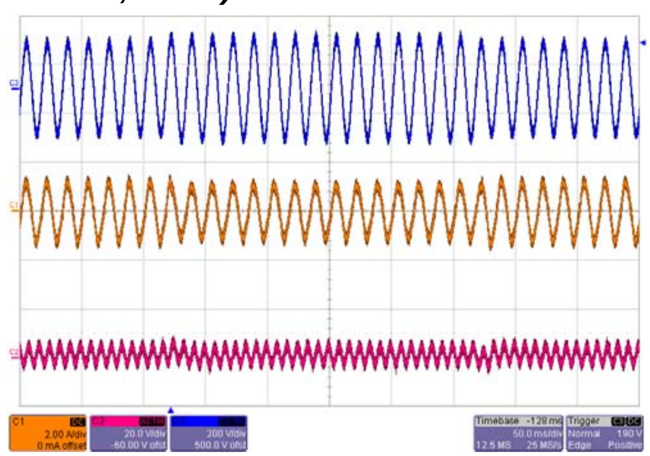

Figure 44 – Line Surge 132 VAC, 100% Load.
Top: V_{IN}, 200 V / div.
Middle: I_{IN}, 2 A, 50 ms / div.
Bottom: V_O (AC Coupled), 20 V / div.

13.15 Line Sag (230 VAC – 170 VAC – 230 VAC, 50 Hz)

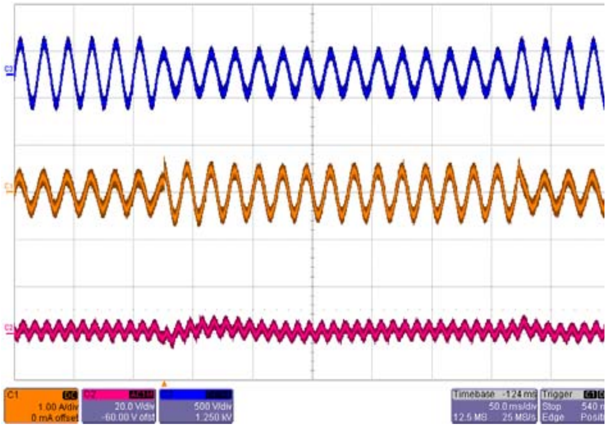

Figure 45 – Line Sag 230 VAC, 50% Load.
Top: V_{IN}, 500 V / div.
Middle: I_{IN}, 1 A, 50 ms / div.
Bottom: V_O (AC Coupled), 20 V / div.

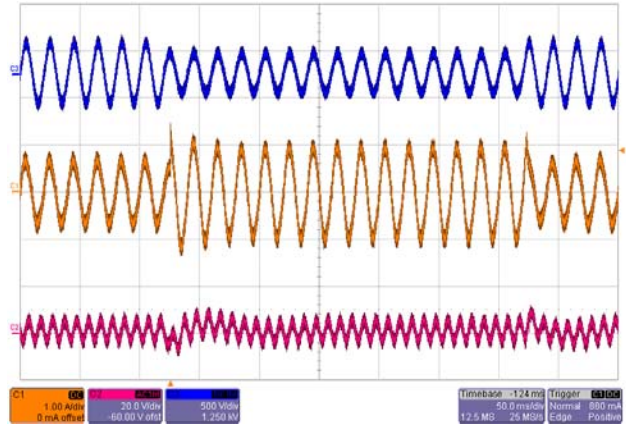

Figure 46 – Line Sag 230 VAC, 100% Load.
Top: V_{IN}, 500 V / div.
Middle: I_{IN}, 1 A, 50 ms / div.
Bottom: V_O (AC Coupled), 20 V / div.

13.16 Line Surge (264 VAC – 293 VAC – 264 VAC, 50 Hz)

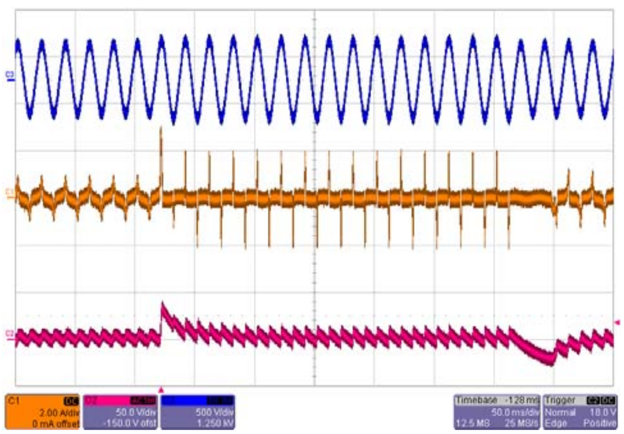

Figure 47 – Line Surge 264 VAC, 50% Load.
Top: V_{IN}, 500 V / div.
Middle: I_{IN}, 2 A, 50 ms / div.
Bottom: V_O (AC Coupled), 50 V / div.

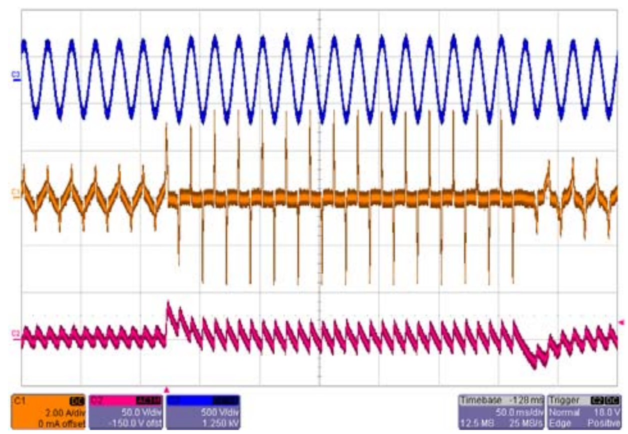

Figure 48 – Line Surge 264 VAC, 100% Load.
Top: V_{IN}, 500 V / div.
Middle: I_{IN}, 2 A, 50 ms / div
Bottom: V_O (AC Coupled), 50 V / div.

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13.17 Brown-In and Brown-Out at Full Load

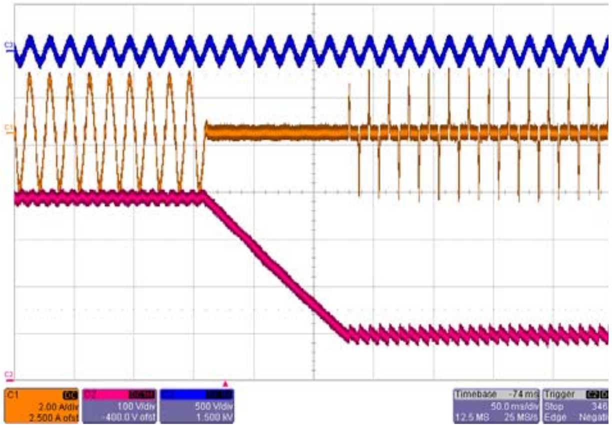

Figure 49 – Brown-out.
Top: V_{IN}, 500 V / div.
Middle: I_{IN}, 2 A, 50 ms / div.
Bottom: V_O, 100 V / div.

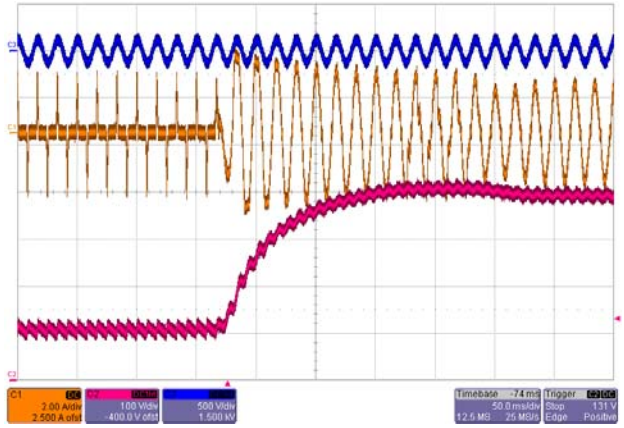

Figure 50 – Brown-in.
Top: V_{IN}, 500 V / div.
Middle: I_{IN}, 2 A, 50 ms / div
Bottom: V_O, 100 V / div.

Measured Brown-out Voltage: 71 VAC
Measured Brown-in Voltage: 82 VAC

13.18 Output Ripple Measurements

13.18.1 Ripple Measurement Technique

For DC output ripple measurements, a modified oscilloscope test probe must be utilized in order to reduce spurious signals due to pickup. Details of the probe modification are provided in the figures below.

The 4987BA probe adapter is affixed with one capacitor 0.02 μF/1 kV ceramic disc type tied in parallel across the probe tip.

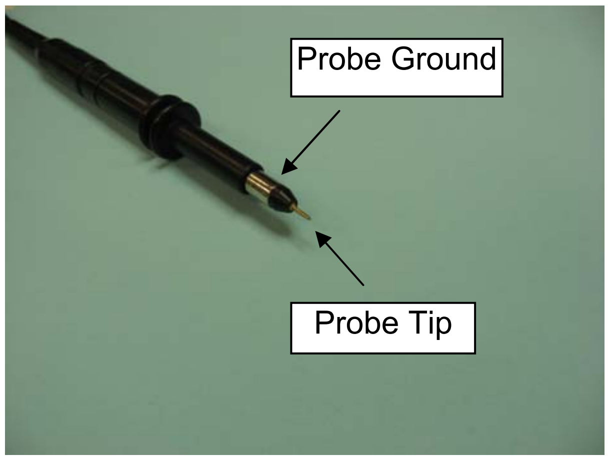

Figure 51 – Oscilloscope Probe Prepared for Ripple Measurement (End Cap and Ground Lead Removed).

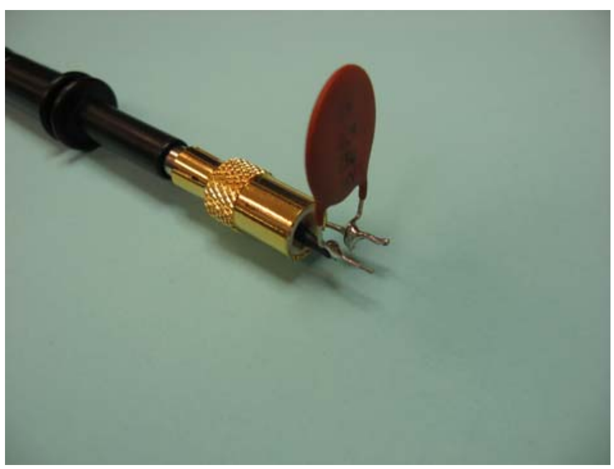

Figure 52 – Oscilloscope Probe with Probe Master (www.probemaster.com) 4987A BNC Adapter. Modified with wires for ripple measurement, and one parallel decoupling capacitor added.)

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13.18.2 Measurement Results

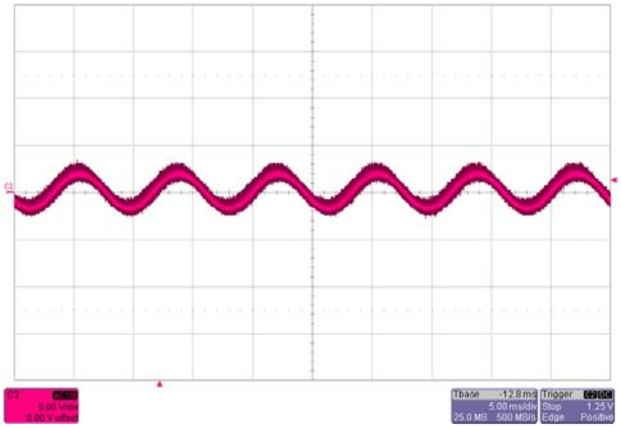

Figure 53 – Ripple, 90 VAC, 50% Load.
5 ms, 5 V / div.

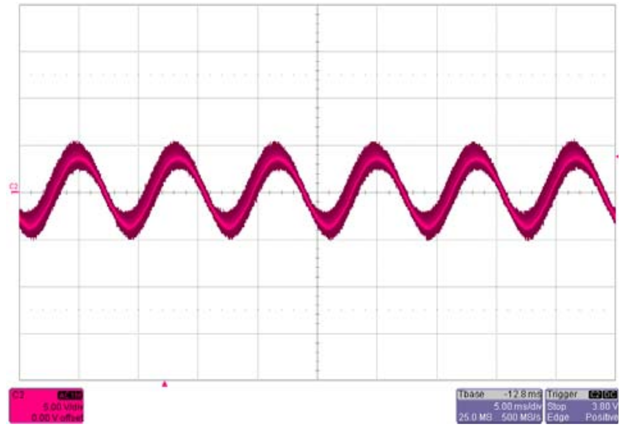

Figure 54 – Ripple, 90 VAC, 100% Load.
5 ms, 5 V / div.

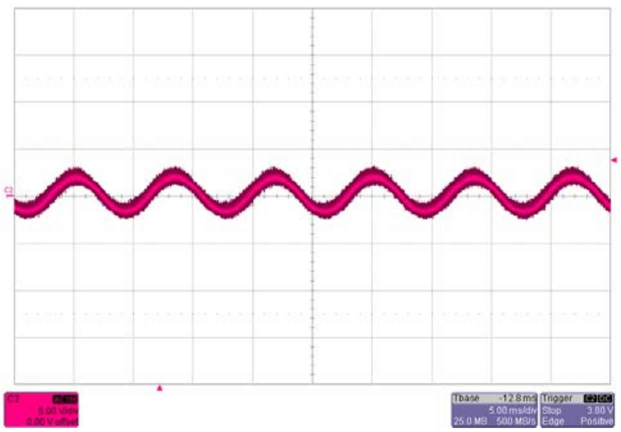

Figure 55 – Ripple, 115 VAC, 50% Load.
5 ms, 5 V / div.

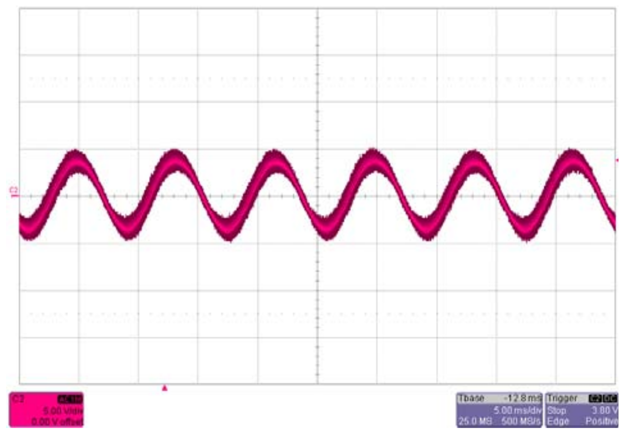

Figure 56 – Ripple, 115 VAC, 100% Load.
5 ms, 5 V / div.

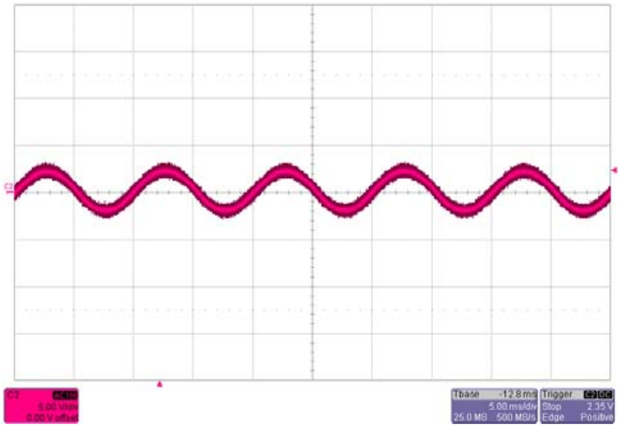

Figure 57 – Ripple, 230 VAC, 50% Load.
5 ms, 5 V / div.

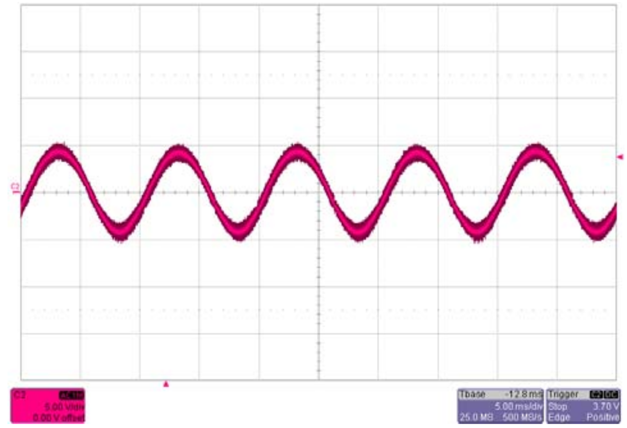

Figure 58 – Ripple, 230 VAC, 100% Load.
5 ms, 5 V / div.

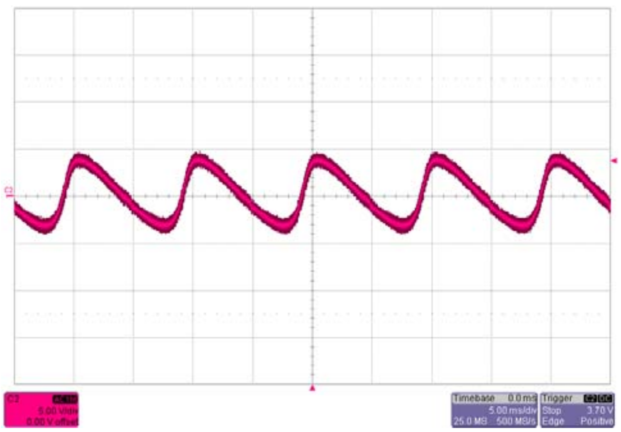

Figure 59 – Ripple, 264 VAC, 50% Load.
5 ms, 5 V / div.

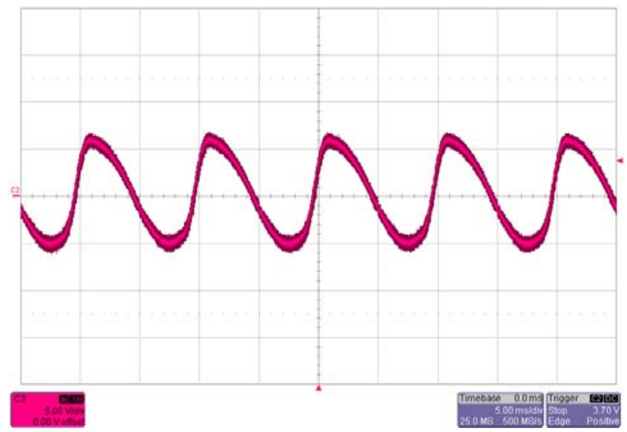

Figure 60 – Ripple, 264 VAC, 100% Load.
5 ms, 5 V / div.

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14 Line Surge Test

Differential surge test results to IEC6100-4-5.

Surge Level (V)	Input Voltage (VAC)	Injection Location (2 Ω source)	Injection Phase (º)	Test Results (Pass/Fail # Strikes)
+500	230	L1 to L2	90	Pass
-500	230	L1 to L2	270	Pass
+1000	230	L1 to L2	90	Pass
-1000	230	L1 to L2	270	Pass

15 EMI Scans at Full Load

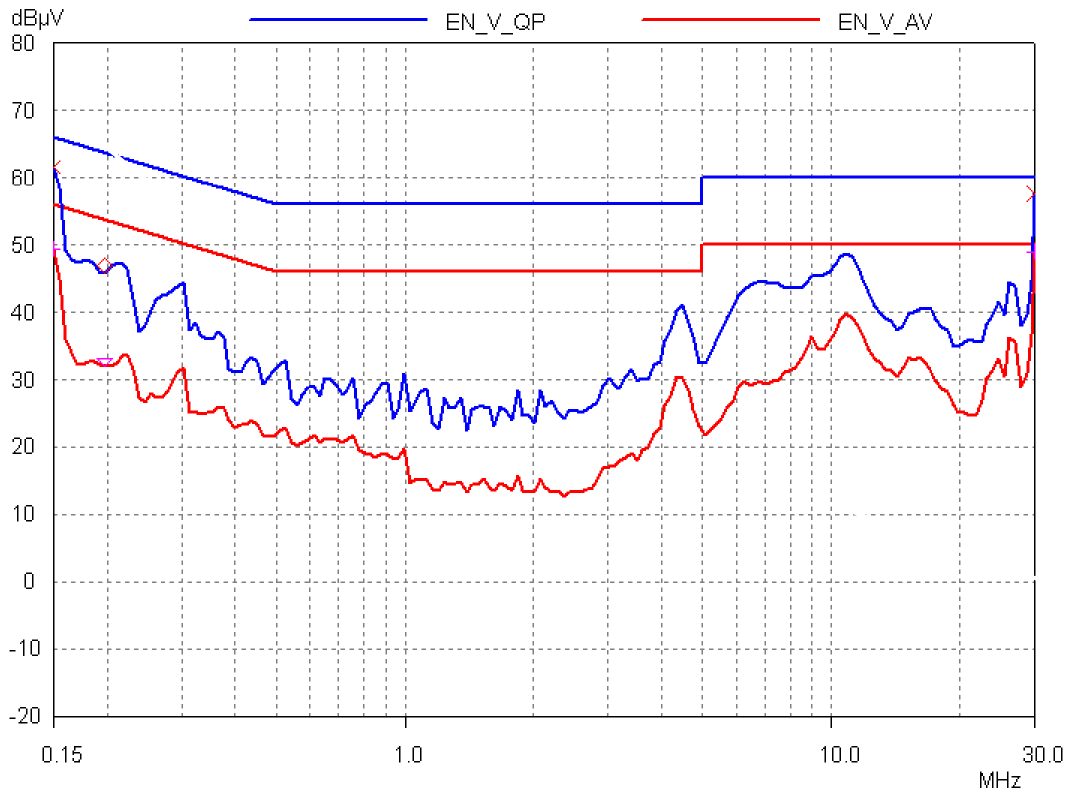

Figure 61 – 115 VAC, Line.

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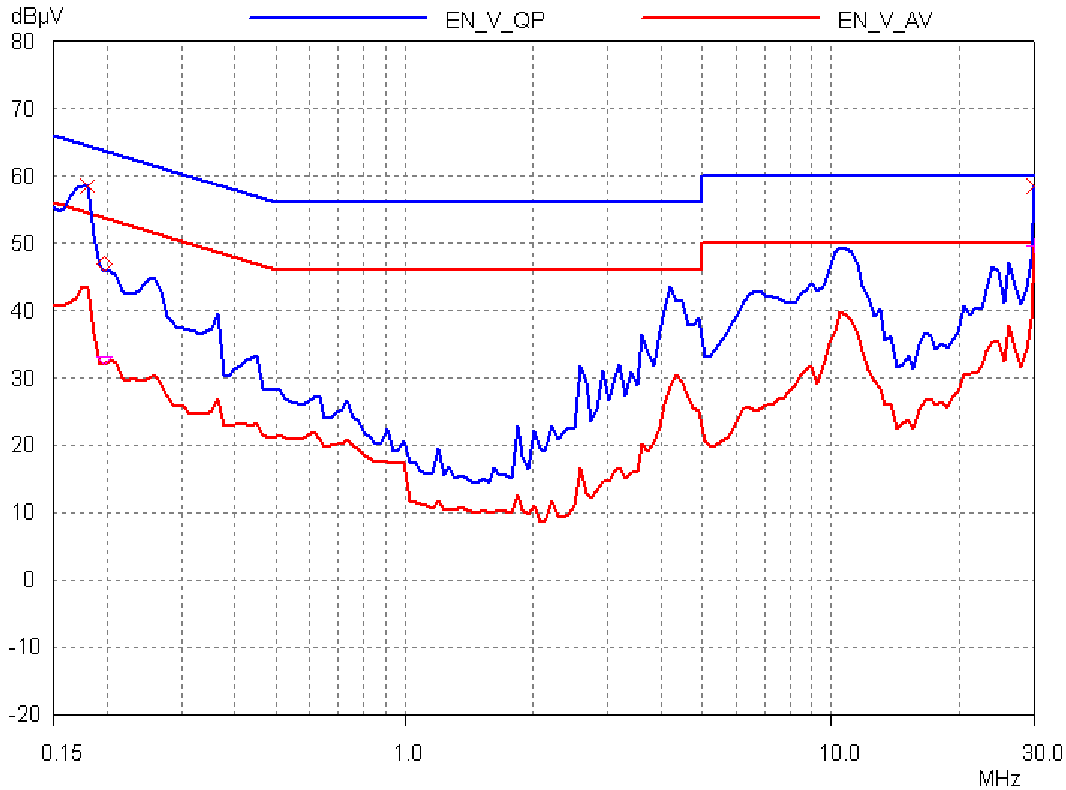

Figure 62 – 115 VAC, Neutral.

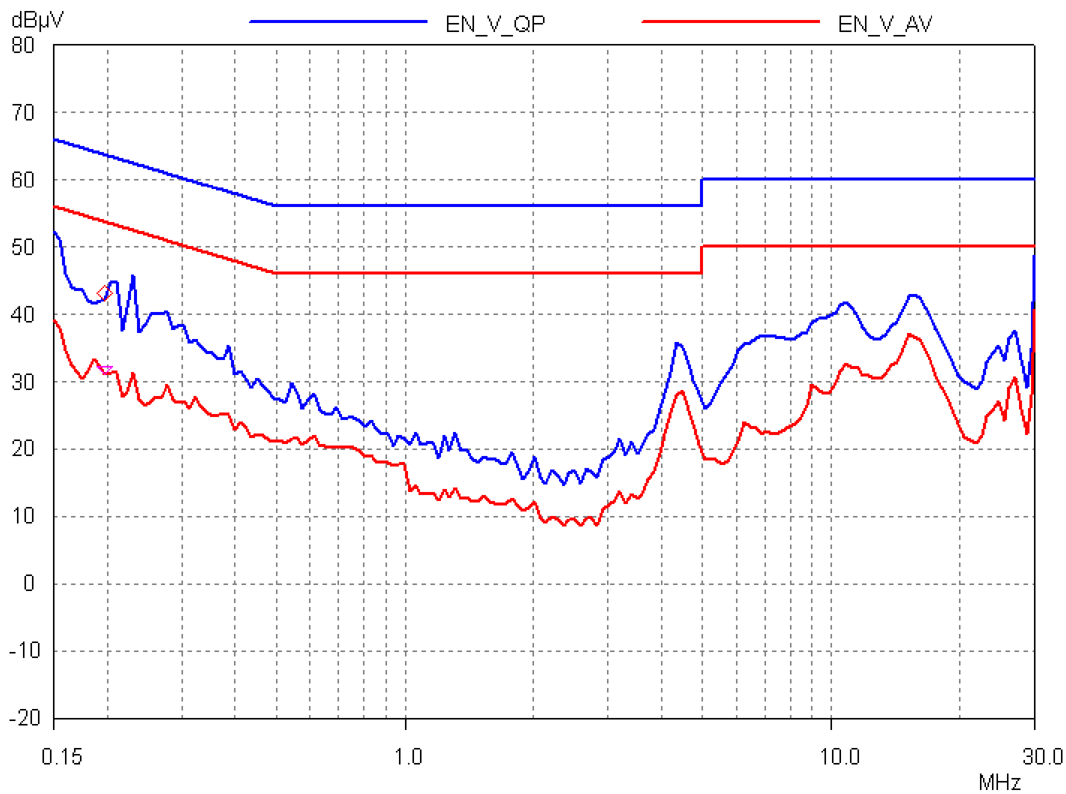

Figure 63 – 230 VAC, Line.

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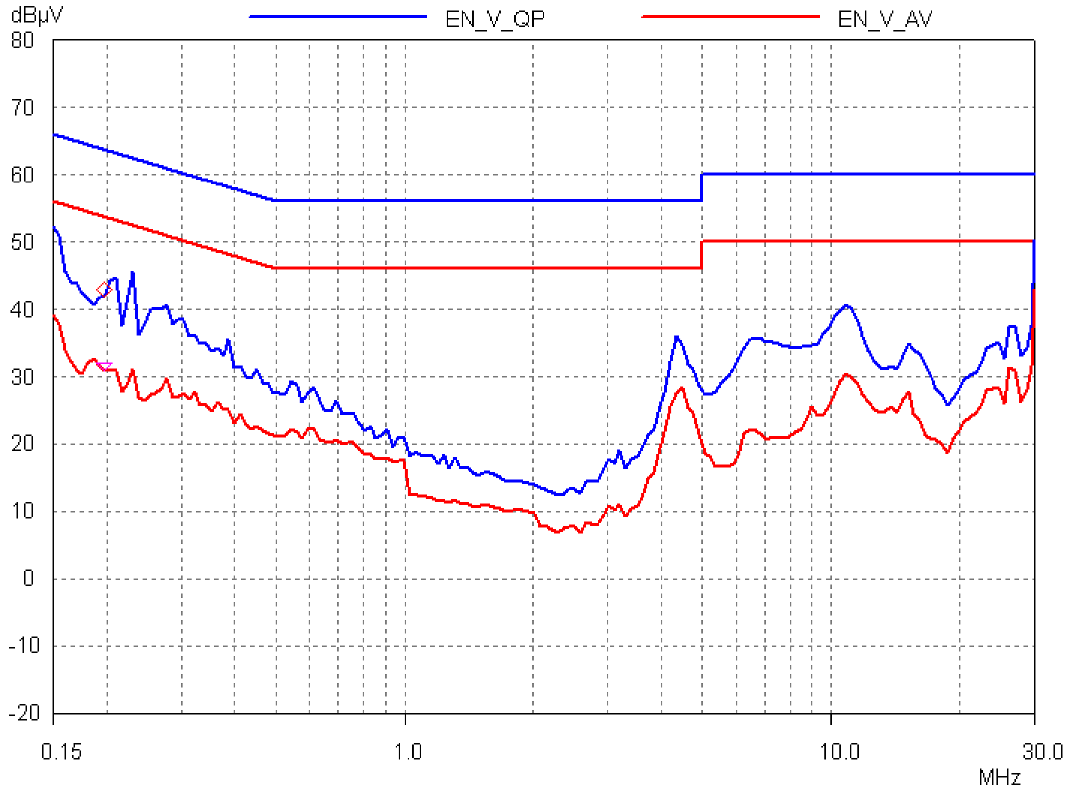

Figure 64 – 230 VAC, Neutral.

16 Revision History

Date	Author	Revision	Description and changes	Reviewed
25-Feb-11	EJ	1.0	Initial Release	Apps & Mktg

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