Design Example Report

Title	***3.8 W 2-Output Supply Using LNK623PG***
Specification	85 – 265 VAC Input; 5 V, 0.15 A & 12 V, 0.25 A Outputs
Application	General Purpose
Author	Applications Engineering Department
Document Number	DER-213
Date	May 1, 2009
Revision	1.0

Summary and Features

- Revolutionary control concept provides very low cost, low part-count solution
  - Primary-side control eliminates secondary-side control and optocoupler
  - Provides ±5% constant voltage (CV) accuracy
  - Over-temperature protection – tight tolerance (±5%) with hysteretic recovery for safe PCB temperatures under all conditions
  - Auto-restart output short circuit and open-loop protection
  - Extended pin creepage distance for reliable operation in humid environments – >3.2 mm at package
- EcoSmart® – Easily meets all current international energy efficiency standards – China (CECP) / CEC / ENERGY STAR EPS v2 / EU CoC
  - Design easily passes EN550022 and CISPR-22 Class B EMI testing with >10 dB margin

Power Integrations
5245 Hellyer Avenue, San Jose, CA 95138 USA.
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

Table of Contents

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.

1 Introduction

This document is an engineering report describing a power supply utilizing a LNK623. This power supply is intended as a general purpose evaluation platform for LinkSwitch-CV.

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

Figure 1 – Populated Circuit Board Photograph.

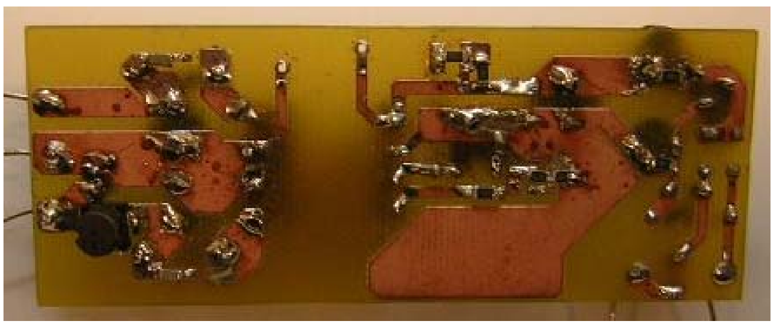


Figure 2 – Populated Circuit Board Photograph.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

2 Power Supply Specification

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	85		265	VAC	2 Wire – no P.E.
Frequency	f_{LINE}		50/60		Hz	
No-load Input Power (230 VAC)			0.18		W	
Output						
Output Voltage 1	V_{OUT1}		5		V	± 5%
Output Ripple Voltage 1	$V_{RIPPLE1}$				mV	20 MHz bandwidth
Output Current 1	I_{OUT1}		0.15		A	
Output Voltage 2	V_{OUT1}		12		V	± 10%
Output Ripple Voltage 2	$V_{RIPPLE1}$				mV	20 MHz bandwidth
Output Current 2	I_{OUT1}		0.25		A	
Total Output Power						
Continuous Output Power	P_{OUT}		3.8		W	
Efficiency						
Full Load	η				%	Measured at P_{OUT} 25 °C
Average active efficiency at 25, 50, 75 and 100 % of P_{OUT}	η_{CEC}				%	Per California Energy Commission (CEC) / ENERGY STAR EPS v2
Environmental						
Conducted EMI		Meets CISPR22B / EN55022B				
Safety		Designed to meet IEC950, UL1950 Class II				
Surge					kV	1.2/50 µs surge, IEC 1000-4-5, Series Impedance: Differential Mode: 2 Ω Common Mode: 12 Ω
Surge					kV	100 kHz ring wave, 500 A short circuit current, differential and common mode
Ambient Temperature	T_{AMB}	0		40	°C	Free convection, sea level

3 Schematic

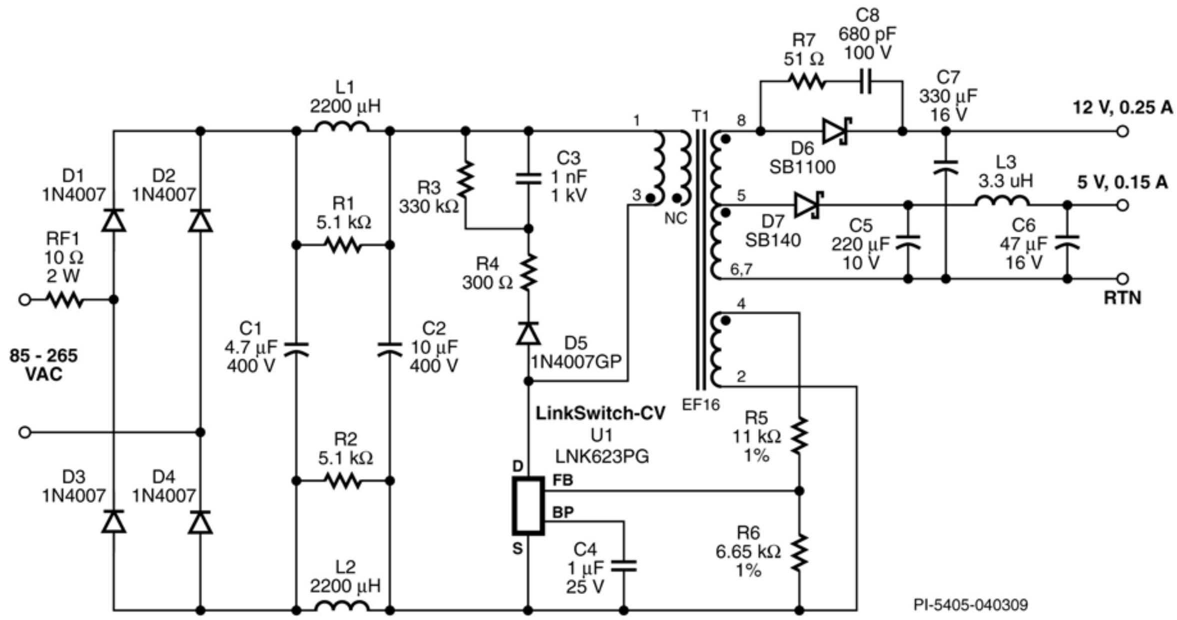


Figure 3 – Schematic.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

4 Circuit Description

The LNK623PG has an integrated 700 V switching MOSFET and ON/OFF control function which together deliver high efficiency under all load conditions and low no-load energy consumption. Both the operating efficiency and no-load performance exceed all current international energy efficiency standards.

The IC monolithically integrates the 700 V power MOSFET switch and controller. A unique ON/OFF control scheme provides CV regulation.

The controller consists of an oscillator, a feedback (sense and logic) circuit, a 5.8 V regulator, BYPASS pin programming functions, over-temperature protection, frequency jittering, a current-limit circuit, leading-edge blanking and an ON/OFF state machine for CV control.

The LNK623PG also provides a sophisticated range of protection features including auto-restart for control loop component open/short circuit faults and output short circuit conditions. Accurate hysteretic thermal shutdown ensures safe average PCB temperatures under all conditions.

The IC package provides extended creepage distance between high and low voltage pins (both at the package and PCB), which is required in highly humid environments to prevent arcing and to further improve reliability.

4.1 Input EMI Filtering

AC input power is rectified by diodes D1 through D4. The rectified DC is filtered by the bulk storage capacitors C1 and C2. Components L1, L2, C1 and C2 form a pi (π) filter, which attenuates conducted differential-mode EMI noise. Resistors R1 and R2 damp high frequency ringing and improve EMI.

4.2 LNK623 Primary

The device is powered from the BYPASS pin via the decoupling capacitor C4.

The rectified and filtered input voltage is applied to one end of the primary winding of T1. The other side of the transformer’s primary winding is driven by the integrated MOSFET in U1. The leakage inductance drain voltage spike is limited by an RCD-R clamp consisting of components D5, R3, R4, and C3.

4.3 Output Rectification

The +5 V secondary of the transformer is rectified by D7, a Schottky barrier type for higher efficiency, and C5. In this application, L3 and C16 are used to reduce voltage ripple.

The +12 V secondary is rectified by Schottky barrier D6 and C7.

4.4 Output Feedback

The LNK623 regulates the output using On/Off control in the constant voltage (CV) regulation region of the output characteristic. The output voltage is sensed by a feedback winding on the transformer. The feedback resistors (R5 and R6) were selected using standard 1% resistor values to center both the nominal output voltage threshold.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

5 PCB Layout

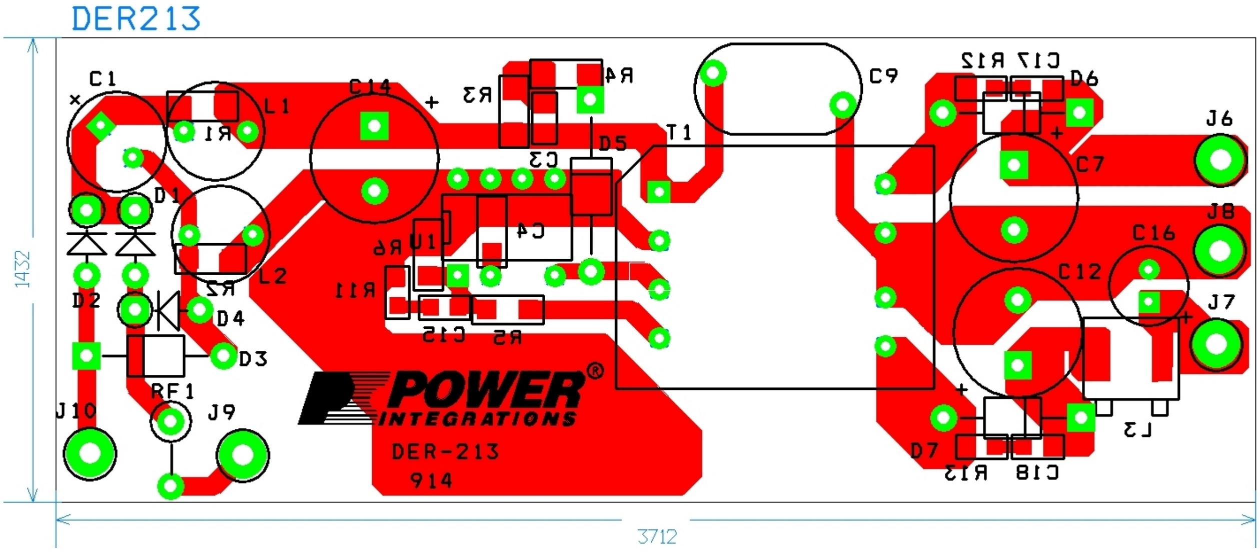


Figure 4 – Printed Circuit Layout.

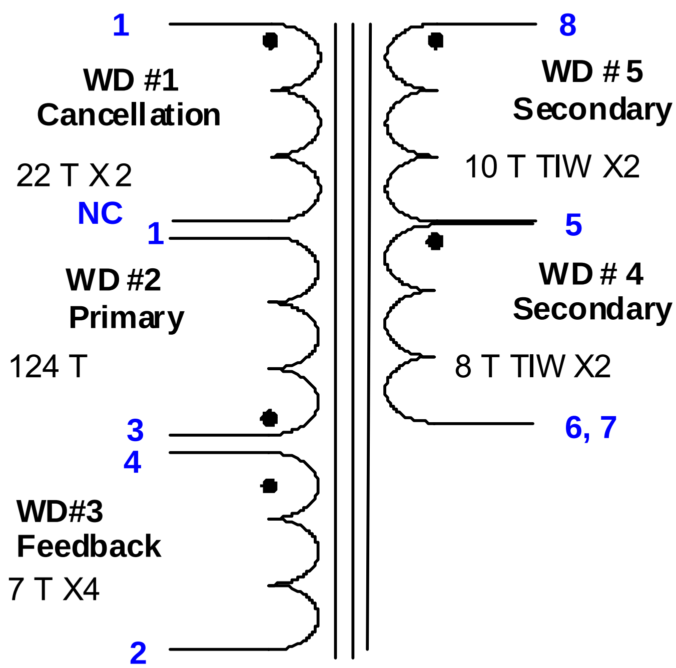
6 Bill of Materials

Item	Qty	Ref Des	Description	Mfg Part Number	Mfg
1	1	C1	4.7 μF, 400 V, Electrolytic, (8 x 11.5)	TAQ2G4R7MK0811MLL3	Taicon Corporation
2	1	C2	10 μF, 400 V, Electrolytic, Low ESR, 90 mA, (10 x 16)	SMQ400VB10RM10X16LL	Nippon Chemi-Con
3	1	C3	1 nF, 1000 V, Ceramic, X7R, 0805	C0805C102KDRACTU	Kemet
4	1	C4	1 μF, 25 V, Ceramic, X7R, 1206	ECJ-3YB1E105K	Panasonic
5	1	C5	220 μF, 10 V, Electrolytic, Very Low ESR, 130 mΩ, (6.3 x 11)	EKZE100ELL221MF11D	Nippon Chemi-Con
6	1	C6	47 μF, 16 V, Electrolytic, Low ESR, 500 mΩ, (5 x 11.5)	ELXZ160ELL470MEB5D	Nippon Chemi-Con
7	1	C7	330 uF, 16 V, Electrolytic, Very Low ESR, 72 mΩ, (8 x 11.5)	EKZE160ELL331MHB5D	Nippon Chemi-Con
8	1	C8	470 pF, 100 V, Ceramic, X7R, 0805	ECJ-2VB2A471K	Panasonic
9	5	D1 D2 D3 D4 D5	1000 V, 1 A, Rectifier, DO-41	1N4007-E3/54	Vishay
10	1	D6	100 V, 1 A, Schottky, DO-41	SB1100	Fairchild
11	1	D7	40 V, 1 A, Schottky, DO-41	SB140	Vishay
12	5	J6 J7 J8 J9 J10	Test Point, WHT,THRU-HOLE MOUNT	5012	Keystone
13	2	L1 L2	2200 μH, 0.21 A	SBC4-222-211	Tokin
14	1	L3	3.3 μH, 1.5 A	SSB64-3R3	Tokin
15	2	R1 R2	5.1 kΩ, 5%, 1/4 W, Metal Film, 1206	ERJ-8GEYJ512V	Panasonic
16	1	R3	330 kΩ, 5%, 1/4 W, Metal Film, 1206	ERJ-8GEYJ334V	Panasonic
17	1	R4	300 Ω, 5%, 1/4 W, Metal Film, 1206	ERJ-8GEYJ301V	Panasonic
18	1	R5	11 kΩ, 1%, 1/4 W, Metal Film	MFR-25FBF-11K0	Yageo
19	1	R6	6.65 kΩ, 1%, 1/4 W, Metal Film	MFR-25FBF-6K65	Yageo
20	1	R7	51 Ω, 5%, 1/4 W, Metal Film, 1206	ERJ-8GEYJ510V	Panasonic
21	1	RF1	10 Ω, 2 W, Fusible/Flame Proof Wire Wound	CRF253-4 10R	Vitrohm
22	1	T1	Bobbin, EF16, Horizontal, 8 pin	SP 1738 K	Kaschke
23	1	U1	LinkSwitch-CV	LNK623PG	Power Integrations

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

7 Transformer Specification

7.1 Electrical Diagram



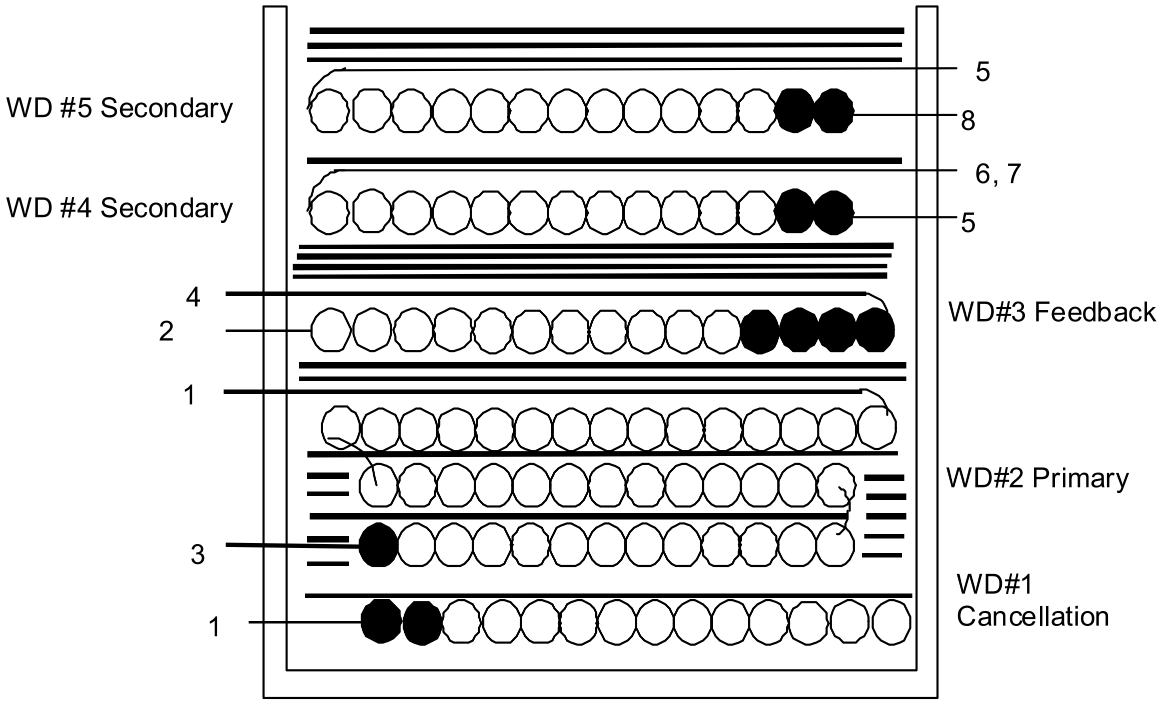
7.2 Electrical Specifications

Electrical Strength	1 second, 60 Hz, from primary to secondary	3000 VAC
Primary Inductance	Pins 1-2, all other windings open, measured at 66 kHz, 0.4 VRMS	2.800 mH, ±10%
Resonant Frequency	Pins 1-2, all other windings open	500 kHz (Min.)
Primary Leakage Inductance	Pins 1-2, with pins 10 and 9 shorted, measured at 66 kHz, 0.4 VRMS	75.0 μH

7.3 Materials

Item	Description
[1]	Core: PC44, gapped for A_L of 182 nH/t^2
[2]	Bobbin: Horizontal 8 pin, EF16 with extended creepage
[3]	Magnet Wire: 0.15 mm diameter (double insulation)
[4]	Magnet Wire: 0.20 mm diameter (double insulation)
[5]	Triple Insulated Wire: 0.2 mm diameter
[6]	Tape, 3M
[7]	Varnish

7.4 Transformer Build Diagram



7.5 Transformer Construction

WD1 Cancellation Winding	Primary pin side of the bobbin oriented to left hand side. Start at pin 1. Wind 22 bifilar turns of item [3] from left to right. Wind with tight tension across bobbin evenly. Cut at the end.
Insulation	1 Layer of tape [6] for basic insulation.
WD #2 Primary Winding	Apply 5 layers of 1mm tape on the right side (approximately) to match the height of the first two primary layers. Apply 2 layers of 1mm tape on the left side, to match the height of the first primary layer. Start at Pin 3. Wind 34 turns of item [3] from left to right. Apply one layer of tape [3]. Apply 2 layers of 1mm tape on the left side to match the height of the second layer. Then wind another 34 turns from right to left. Apply one layer of tape [3]. Check that height is uniform across the bobbin (important!). On the final layer wind 56 turns from left to right.
Insulation	2 layers of tape [6] for insulation.
WD #3 Feedback Winding	Temporarily hang the start end of the wires of item [4] on pin 5, wind 7 quad-filar turns from right to left uniformly, terminate the end of the wires at pin 2, bring the start end of the wires across the bobbin to the left side to terminate at pin 4.
Insulation	4 layers of tape [6] for insulation.
WD #4 Secondary Winding	Start at pin 5 wind 8 turns of item [5] from right to left. Spread turns evenly across bobbin. Finish on pin 6 or 7.
Insulation	1 layer of tape [6] for basic insulation.
WD #5 Secondary Winding	Start at pin 8 wind 10 turns of item [5] from right to left. Spread turns evenly across bobbin. Finish on pin 5.
Insulation	2 layers of tape [6] for basic insulation.
Core Assembly	Assemble and secure core halves.
Varnish	Dip varnish assembly with item [7].

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

8 Transformer Design Spreadsheet

ACDC_LNK-CV_100608; Rev.0.8; Copyright Power Integrations 2008	INPUT	INFO	OUTPUT	UNIT	ACDC_LNK-CV_100608_Rev0-8.xls; LinkSwitch-CV Continuous/Discontinuous Flyback Transformer Design Spreadsheet
ENTER APPLICATION VARIABLES					
VACMIN	85			Volts	Minimum AC Input Voltage
VACMAX	265			Volts	Maximum AC Input Voltage
fL	50			Hertz	AC Mains Frequency
VO	5			Volts	Output Voltage
PO	3,75			Watts	Output Power
n	0,72				Efficiency Estimate
Z			0,5		Loss Allocation Factor
tC			3	mSeconds	Bridge Rectifier Conduction Time Estimate
CIN	14,7			uFarads	Input Filter Capacitor
ENTER LinkSwitch-CV VARIABLES					
LinkSwitch-CV	LNK623P		LNK623P		Chosen LinkSwitch-CV device
ILIMITMIN			0,186	Amps	LinkSwitch-CV Minimum Current Limit
ILIMITMAX			0,214	Amps	LinkSwitch-CV Maximum Current Limit
fS			100000	Hertz	LinkSwitch-CV Switching Frequency
I2FMIN			3600	A^2Hz	LinkSwitch-CV Min I2F (power Co-efficienct)
I2FMAX			4680	A^2Hz	LinkSwitch-CV Max I2F (power Co-efficienct)
VOR	85		85	Volts	Reflected Output Voltage
VDS			10	Volts	LinkSwitch-CV on-state Drain to Source Voltage
VD			0,5	Volts	Output Winding Diode Forward Voltage Drop
DCON			5,599807	us	Output Diode conduction time
KP_TRANSIENT			0,966787		Worst case ripple to peak current ratio. Maintain KP_TRANSIENT below 0.25
ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES					
Core Type	EF16		EF16		
Core		EF16		P/N:	PC40EF16-Z
Bobbin		EF16 BOBBIN		P/N:	
AE			0,201	cm^2	Core Effective Cross Sectional Area
LE			3,76	cm	Core Effective Path Length
AL			1100	nH/T^2	Ungapped Core Effective Inductance
BW			10	mm	Bobbin Physical Winding Width
M			0	mm	Safety Margin Width (Half the Primary to Secondary Creepage Distance)
L			3		Number of Primary Layers
NS	8		8		Number of Secondary Turns
DC INPUT VOLTAGE PARAMETERS					
VMIN			97,415	Volts	Minimum DC Input Voltage
VMAX			374,7666	Volts	Maximum DC Input Voltage

FEEDBACK VARIABLES					
NFB			7		Feedback winding number of turns
VFLY			4,8125		Voltage on the Feedback winding when LinkSwitch-CV turns off
RUPPER			11,03082	k-ohms	Upper resistor of feedback network
RLOWER			7,844136	k-ohms	Lower resistor of feedback network
Bias Winding Parameters					
Add Bias winding	NO		NO		Enter 'Yes' if you want to add a Bias winding
VB			N/A		Bias Winding Voltage
NB			N/A		Number of Bias winding turns. Bias winding is assumed to be AC stacked on top of the Feedback winding
CURRENT WAVEFORM SHAPE PARAMETERS					
DMAX			0,492997		Maximum Duty Cycle
IAVG			0,053465	Amps	Average Primary Current
IP			0,186	Amps	Minimum Peak Primary Current
IR			0,1551	Amps	Primary Ripple Current
IRMS			0,082381	Amps	Primary RMS Current
TRANSFORMER **PRIMARY DESIGN PARAMETERS**					
LPMIN			2559,052	uHenries	Minimum Primary Inductance
LP_TOL			10		
NP			123,6364		Primary Winding Number of Turns
ALG			167,412	nH/T^2	Gapped Core Effective Inductance
BM			2265,476	Gauss	Maximum Flux Density, (BM<2500) Calculated at typical current limit and typical primary inductance
BP			2644,428	Gauss	Peak Flux Density, (BP<3000) Calculated at maximum current limit and maximum primary inductance
BAC			820,9717	Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
ur			1637,471		Relative Permeability of Ungapped Core
LG			0,127914	mm	Gap Length (Lg > 0.1 mm)
BWE			30	mm	Effective Bobbin Width
OD			0,242647	mm	Maximum Primary Wire Diameter including insulation
INS			0,046868	mm	Estimated Total Insulation Thickness (= 2 * film thickness)
DIA			0,19578	mm	Bare conductor diameter
AWG			33	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CM			50,79683	Cmils	Bare conductor effective area in circular mils
CMA		Info	616,6093	Cmils/Amp	CAN DECREASE CMA < 500 (decrease L(primary layers),increase NS,smaller Core)
TRANSFORMER SECONDARY DESIGN PARAMETERS					

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

Lumped parameters					
ISP			2,874545	Amps	Peak Secondary Current
ISRMS			1,291119	Amps	Secondary RMS Current
IO			0,75	Amps	Power Supply Output Current
IRIPPLE			1,050947	Amps	Output Capacitor RMS Ripple Current
CMS			258,2238	Cmils	Secondary Bare Conductor minimum circular mils
AWGS			25	AWG	Secondary Wire Gauge (Rounded up to next larger standard AWG value)
DIAS			0,456749	mm	Secondary Minimum Bare Conductor Diameter
ODS			1,25	mm	Secondary Maximum Outside Diameter for Triple Insulated Wire
INSS			0,396625	mm	Maximum Secondary Insulation Wall Thickness
VOLTAGE STRESS PARAMETERS					
VDRAIN			573,2666	Volts	Maximum Drain Voltage Estimate (Includes Effect of Leakage Inductance)
PIVB			N/A	Volts	Bias Diode Maximum Peak Inverse Voltage
PIVS			29,2496	Volts	Output Rectifier Maximum Peak Inverse Voltage
TRANSFORMER SECONDARY DESIGN PARAMETERS (MULTIPLE OUTPUTS)					
1st output					
VO1	5		5	Volts	Output Voltage (if unused, defaults to single output design)
IO1	0,15		0,15	Amps	Output DC Current
PO1			0,75	Watts	Output Power
VD1			0,5	Volts	Output Diode Forward Voltage Drop
NS1			8		Output Winding Number of Turns
ISRMS1			0,258224	Amps	Output Winding RMS Current
IRIPPLE1			0,210189	Amps	Output Capacitor RMS Ripple Current
PIVS1			29,2496	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS1			51,64477	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS1			32	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS1			0,203459	mm	Minimum Bare Conductor Diameter
ODS1			1,25	mm	Maximum Outside Diameter for Triple Insulated Wire
2nd output					
VO2	12			Volts	Output Voltage
IO2	0,25			Amps	Output DC Current
PO2			3	Watts	Output Power
VD2			0,7	Volts	Output Diode Forward Voltage Drop
NS2			18,47273		Output Winding Number of Turns
ISRMS2			0,430373	Amps	Output Winding RMS Current
IRIPPLE2			0,350316	Amps	Output Capacitor RMS Ripple Current
PIVS2			67,99454	Volts	Output Rectifier Maximum Peak Inverse Voltage

CMS2			86,07462	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS2			30	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS2			0,256342	mm	Minimum Bare Conductor Diameter
ODS2			0,541339	mm	Maximum Outside Diameter for Triple Insulated Wire
Total power			3,75	Watts	Total Output Power

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

9 Performance Data

All measurements performed at room temperature, 50 Hz input frequency.

9.1 Efficiency

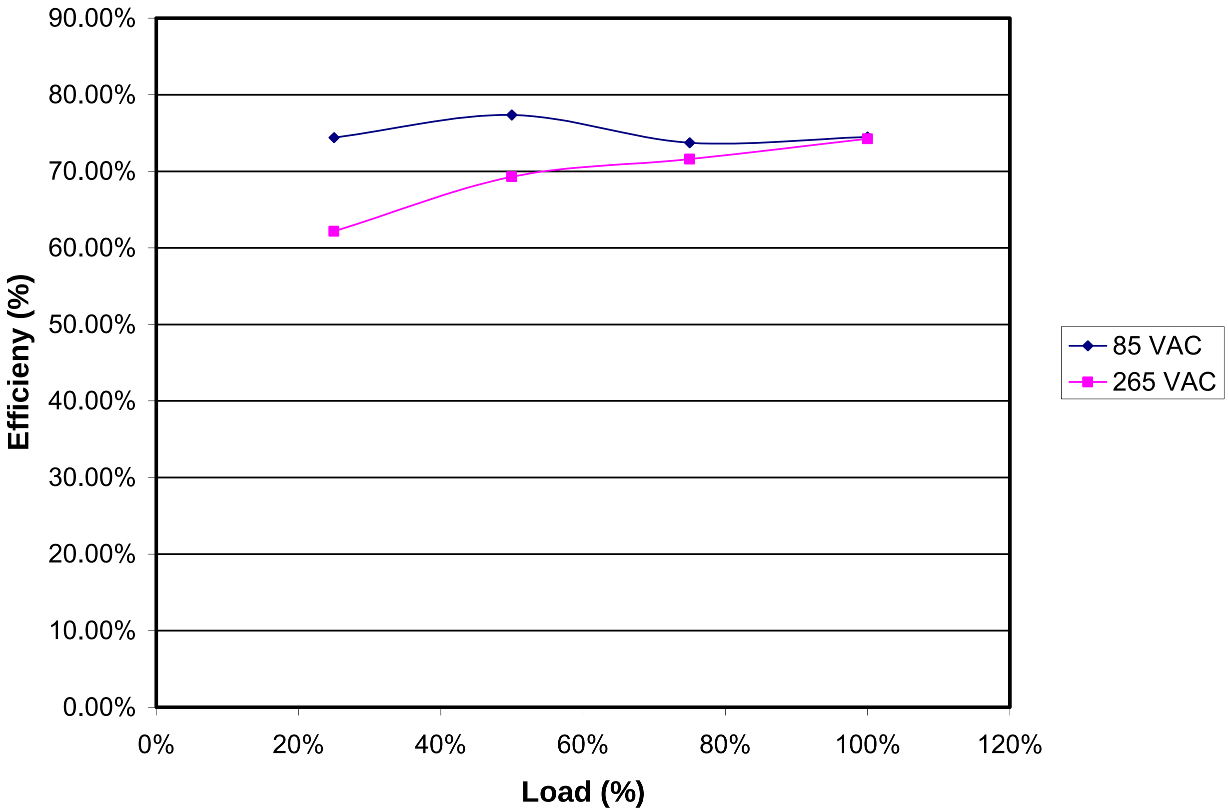


Figure 5 – Efficiency vs. Load, Room Temperature, 50 Hz.

9.1 Active Mode Efficiency

% of Full Load	% Efficiency at 115 VAC	% Efficiency at 230 VAC
25	72.4	62.2
50	77.1	69.3
75	74.9	71.6
100	75.8	74.3
Average Efficiency	**75.1%**	**69.3%**
CEC Requirement	**61.9%**	
NOTE: for this application (multiple output) this standard is not applicable, however the values can be used as reference		

9.2 Energy Efficiency Requirements

The external power supply requirements below all require meeting active mode efficiency and no-load input power limits. Minimum active mode efficiency is defined as the average efficiency of 25, 50, 75 and 100% of output current (based on the nameplate output current rating).

For adapters that are single input voltage only then the measurement is made at the rated single nominal input voltage (115 VAC or 230 VAC), for universal input adapters the measurement is made at both nominal input voltages (115 VAC and 230 VAC).

To meet the standard the measured average efficiency (or efficiencies for universal input supplies) must be greater than or equal to the efficiency specified by the standard.

The test method can be found here:

http://www.energystar.gov/ia/partners/prod_development/downloads/power_supplies/EPSupplyEffic_TestMethod_0804.pdf

For the latest up to date information please visit the PI Green Room:

http://www.powerint.com/greenroom/regulations.htm

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

9.2.1 USA Energy Independence and Security Act 2007

This legislation mandates all single output single output adapters, including those provided with products, manufactured on or after July 1st, 2008 must meet minimum active mode efficiency and no load input power limits.

Active Mode Efficiency Standard Models

Nameplate Output (P_O)	Minimum Efficiency in Active Mode of Operation
< 1 W	$0.5 \times P_O$
≥ 1 W to ≤ 51 W	$0.09 \times \ln(P_O) + 0.5$
> 51 W	0.85

ln = natural logarithm

No-load Energy Consumption

Nameplate Output (P_O)	Maximum Power for No-load AC-DC EPS
All	≤ 0.5 W

This requirement supersedes the legislation from individual US States (for example CEC in California).

9.2.2 ENERGY STAR EPS Version 2.0

This specification takes effect on November 1st, 2008.

Active Mode Efficiency Standard Models

Nameplate Output (P_O)	Minimum Efficiency in Active Mode of Operation
≤ 1 W	$0.48 \times P_O + 0.14$
> 1 W to ≤ 49 W	$0.0626 \times \ln(P_O) + 0.622$
> 49 W	0.87

ln = natural logarithm

Active Mode Efficiency Low Voltage Models (V_O<6 V and $I_O \geq$ 550 mA)

Nameplate Output (P_O)	Minimum Efficiency in Active Mode of Operation
≤ 1 W	$0.497 \times P_O + 0.067$
> 1 W to ≤ 49 W	$0.075 \times \ln(P_O) + 0.561$
> 49 W	0.86

ln = natural logarithm

No-load Energy Consumption (both models)

Nameplate Output (P_O)	Maximum Power for No-load AC-DC EPS
0 to < 50 W	≤ 0.3 W
≥ 50 W to ≤ 250 W	≤ 0.5 W

9.2 No-load Input Power

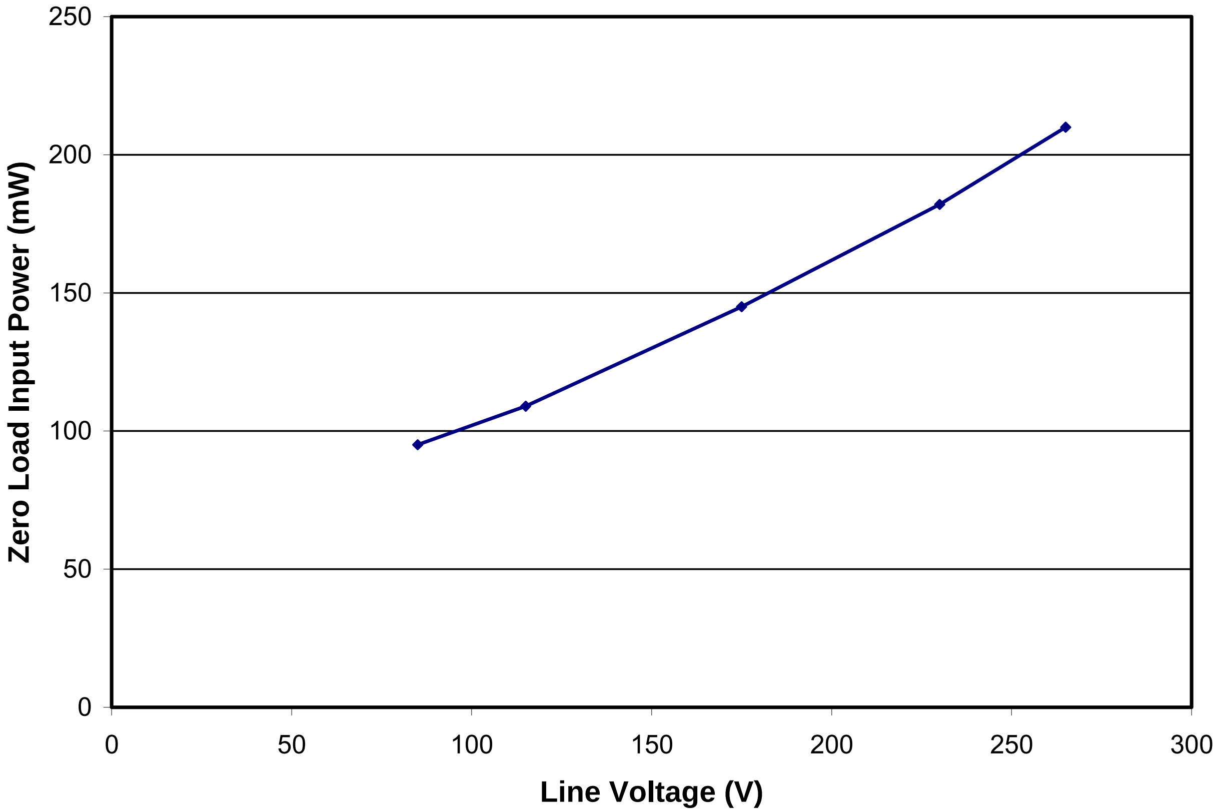


Figure 6 – Zero Load Input Power vs. Input Line Voltage, Room Temperature, 50 Hz.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

9.3 *Regulation*

Line Voltage	Rail (V)	Load (A)	Actual Voltage (V)	Line Voltage	Rail (V)	Load (A)	Actual Voltage (V)
85 VAC	5	0.15	5.137	230 VAC	5	0.15	5.115
	12	0.25	11.76		12	0.25	11.71
	5	0.1	5.18		5	0.1	5.15
	12	0.25	11.75		12	0.25	11.68
	5	0.05	4.93		5	0.05	4.85
	12	0.005	11.99		12	0.005	11.9
	5	0.1	5.14		5	0.1	5.11
	12	0.15	11.78		12	0.15	11.71
	5	0.15	4.94		5	0.15	4.87
	12	0.02	11.96		12	0.02	11.88
	5	0.15	5.12		5	0.15	5.08
	12	0.1	11.77		12	0.1	11.7
	5	0.15	5.07		5	0.15	5.04
	12	0.2	11.8		12	0.2	11.76
115 VAC	5	0.15	5.14	265 VAC	5	0.15	5.107
	12	0.25	11.77		12	0.25	11.7
	5	0.1	5.18		5	0.1	5.14
	12	0.25	11.76		12	0.25	11.67
	5	0.05	4.91		5	0.05	4.84
	12	0.005	11.97		12	0.005	11.9
	5	0.1	5.14		5	0.1	5.1
	12	0.15	11.78		12	0.15	11.7
	5	0.15	4.92		5	0.15	4.86
	12	0.02	11.94		12	0.02	11.87
	5	0.15	5.12		5	0.15	5.08
	12	0.1	11.78		12	0.1	11.69
	5	0.15	5.07		5	0.15	5.02
	12	0.2	11.8		12	0.2	11.73

Worst case deviation:
5 V Rail: +3.6% / -2.8%
12 V Rail: -0.1% / -2.8%

10 Thermal Performance

Item	Temperature in °C	
	85 VAC	265 VAC
Ambient	23	23
LNK623PG (U1)	50.5	55.8

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

11 Waveforms

11.1 Drain Voltage and Current, Normal Operation

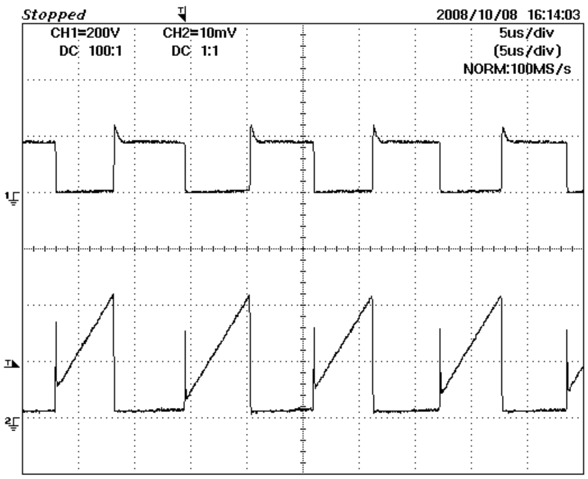


Figure 7 – 85 VAC, Full Load.
Upper: V_{DRAIN}, 200 V / div.
Lower: I_{DRAIN}, 0.1 A, 5 μs / div.

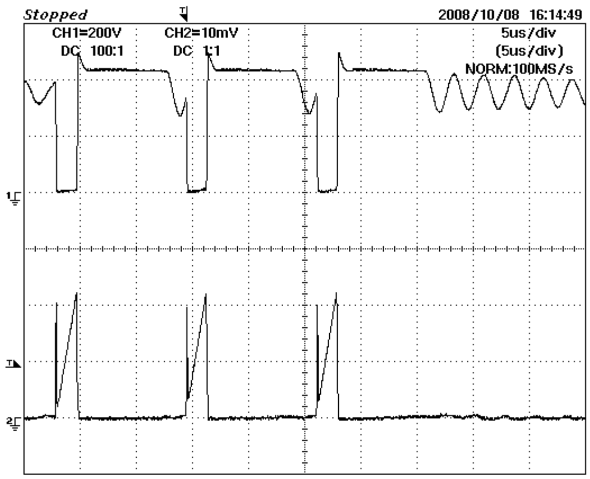


Figure 8 – 265 VAC, Full Load.
Upper: V_{DRAIN}, 200 V / div.
Lower: I_{DRAIN}, 0.1 A, 5 μs / div.

11.2 Output Voltage Start-up Profile

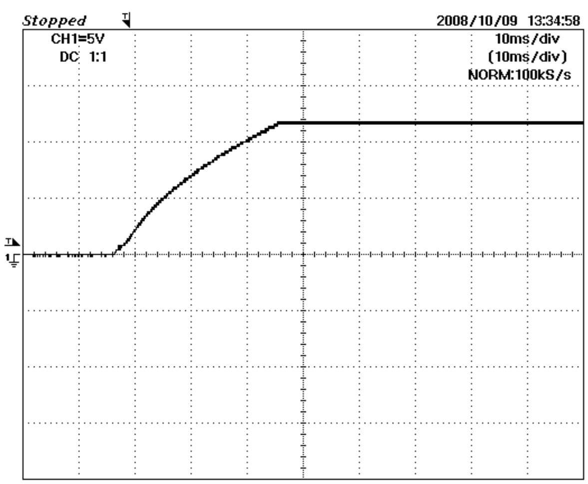


Figure 9 – Start-up Profile, 85 VAC
12 V, 5 V / div, 10 ms / div.

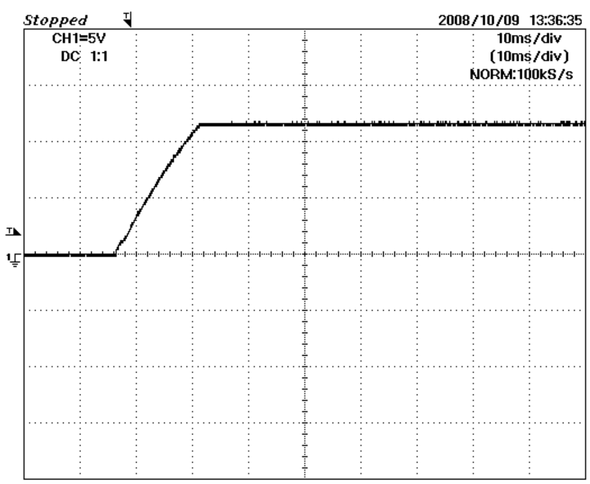


Figure 10 – Start-up Profile, 265 VAC
12 V, 5 V / div, 10 ms / div.

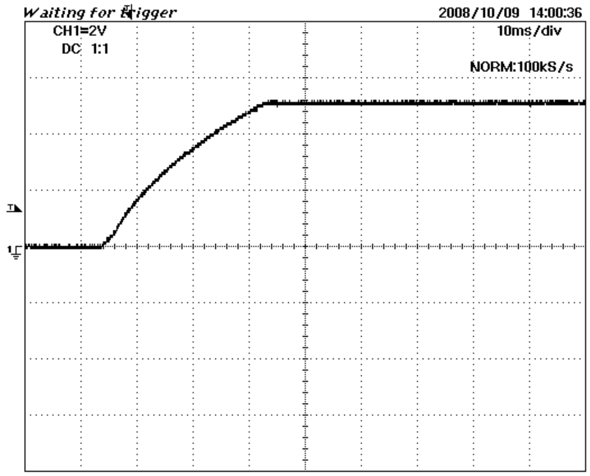


Figure 11 – Start-up Profile, 85 VAC
5 V, 2 V / div, 10 ms / div.

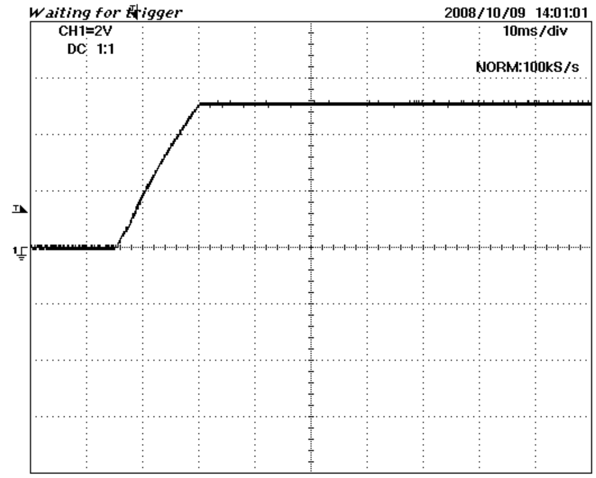


Figure 12 – Start-up Profile, 265 VAC
5 V, 2 V / div, 10 ms / div.

11.3 Drain Voltage and Current Start-up Profile

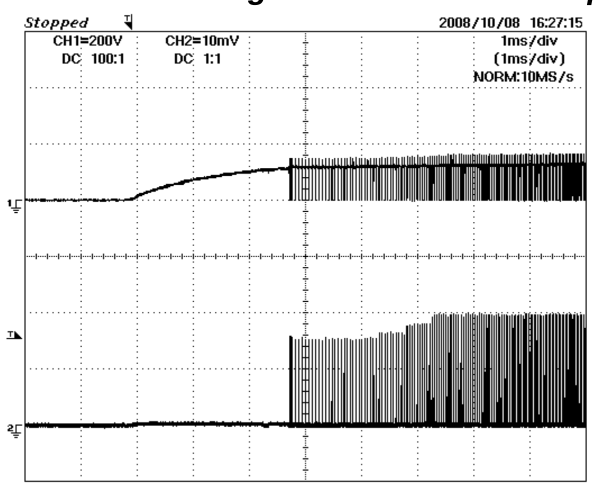


Figure 13 – 85 VAC Input and Maximum Load.
Upper: V_{DRAIN}, 200 V / div.
Lower: I_{DRAIN}, 0.1 A, 1 ms / div.

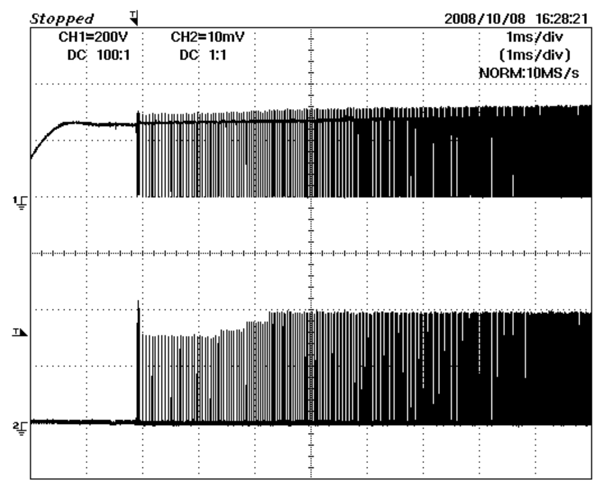


Figure 14 – 265 VAC Input and Maximum Load.
Upper: V_{DRAIN}, 200 V / div.
Lower: I_{DRAIN}, 0.1 A, 1 ms / div.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

11.4 Load Transient Response

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.

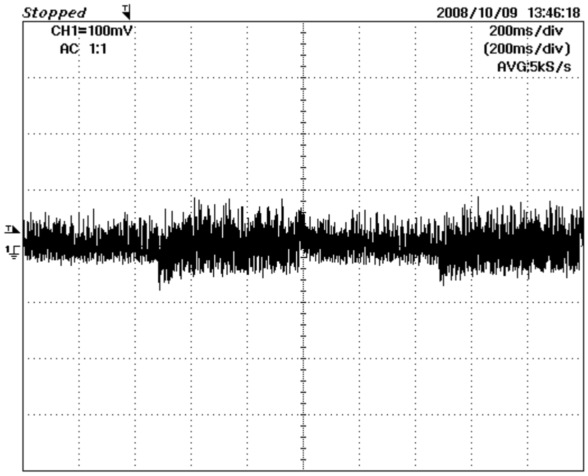


Figure 15 – Transient Response, 115 VAC, 50-100-50% 12 V Load Step.
12 V Output Voltage.
100 ms / div.

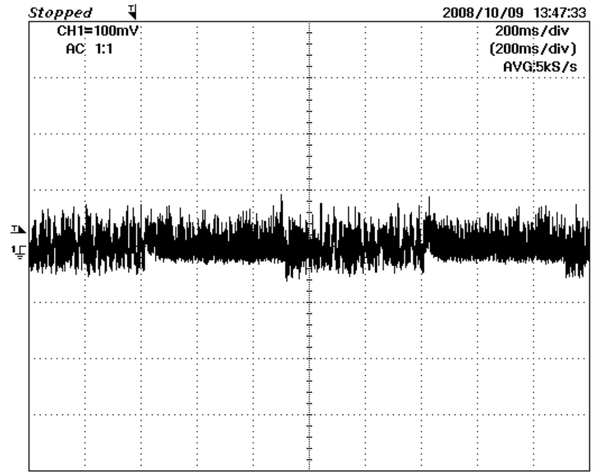


Figure 16 – Transient Response, 230 VAC, 50-100-50% 12 V Load Step.
12 V Output Voltage.
100 ms / div.

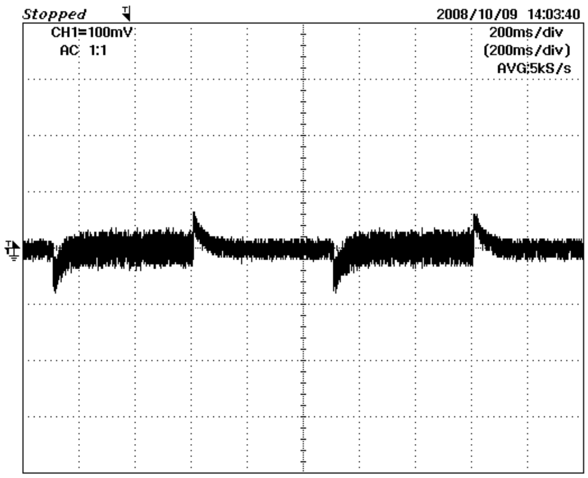


Figure 17 – Transient Response, 115 VAC, 50-100-50% 12 V Load Step.
5 V Output Voltage.
100 ms / div.

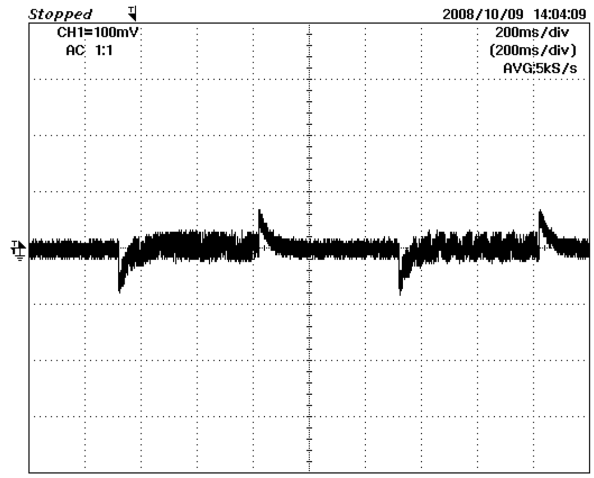


Figure 18 – Transient Response, 230 VAC, 50-100-50% 12 V Load Step.
5 V Output Voltage.
100 ms / div.

11.5 Output Ripple Measurements

11.5.1 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 Figure 19 and Figure 20.

The 5125BA probe adapter is affixed with two capacitors tied in parallel across the probe tip. The capacitors include one (1) 0.1 μF/50 V ceramic type and one (1) 1.0 μF/50 V aluminum electrolytic. ***The aluminum electrolytic type capacitor is polarized, so proper polarity across DC outputs must be maintained (see below).***

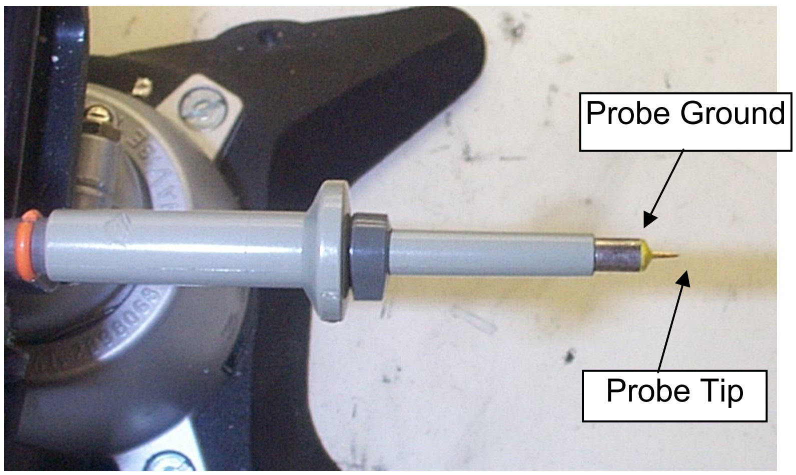


Figure 19 – Oscilloscope Probe Prepared for Ripple Measurement. (End Cap and Ground Lead Removed)

Figure 20 – Oscilloscope Probe with Probe Master 5125BA BNC Adapter. (Modified with wires for probe ground for ripple measurement, and two parallel decoupling capacitors added)

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

11.5.2 Measurement Results

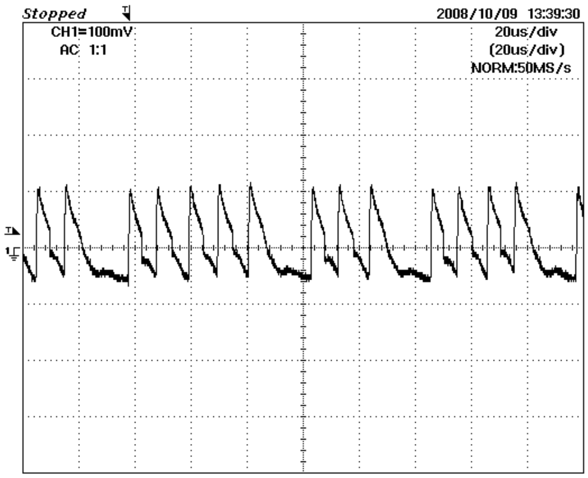


Figure 21 – 12 V Output Ripple, 85 VAC, Full Load. 20 µs, 100 mV / div.

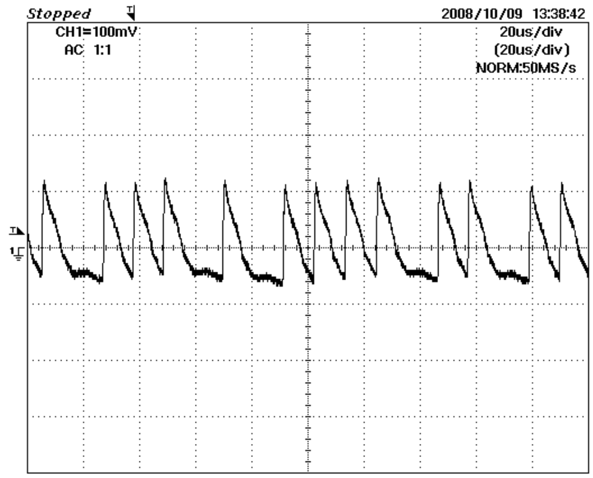


Figure 22 – 12 V Output Ripple, 265 VAC, Full Load. 20 µs, 100 mV / div.

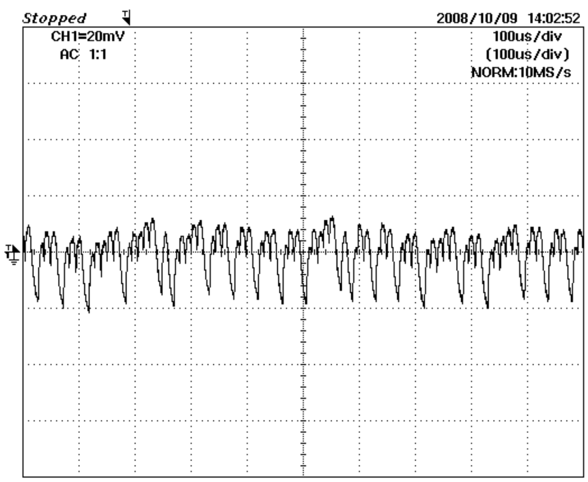


Figure 23 – 5 V Output Ripple, 85 VAC, Full Load. 100 µs, 20 mV / div.

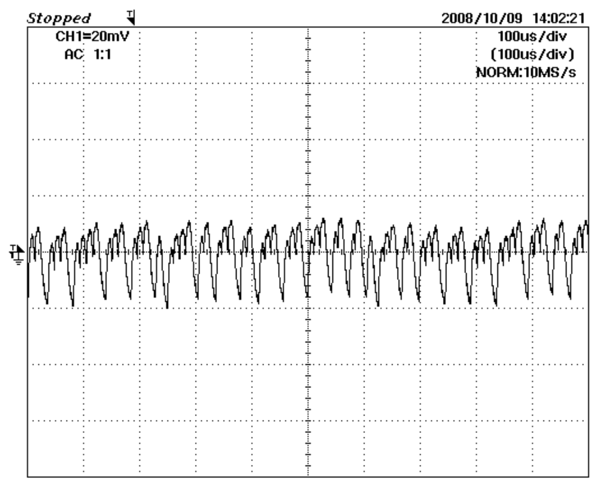


Figure 24 – 5 V Output Ripple, 265 VAC, Full Load. 100 µs, 20 mV / div.

12 Conducted EMI

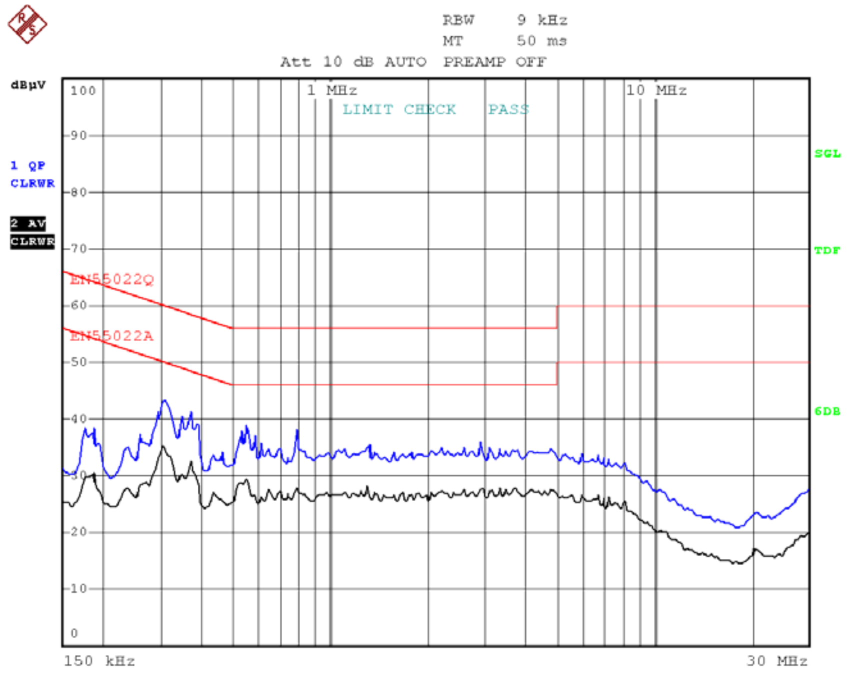


Figure 25 – Conducted EMI, Maximum Steady State Load, 115 VAC, 50 Hz, and EN55022 B Limits, L-Line, Secondary Ground connected to Artificial Hand.

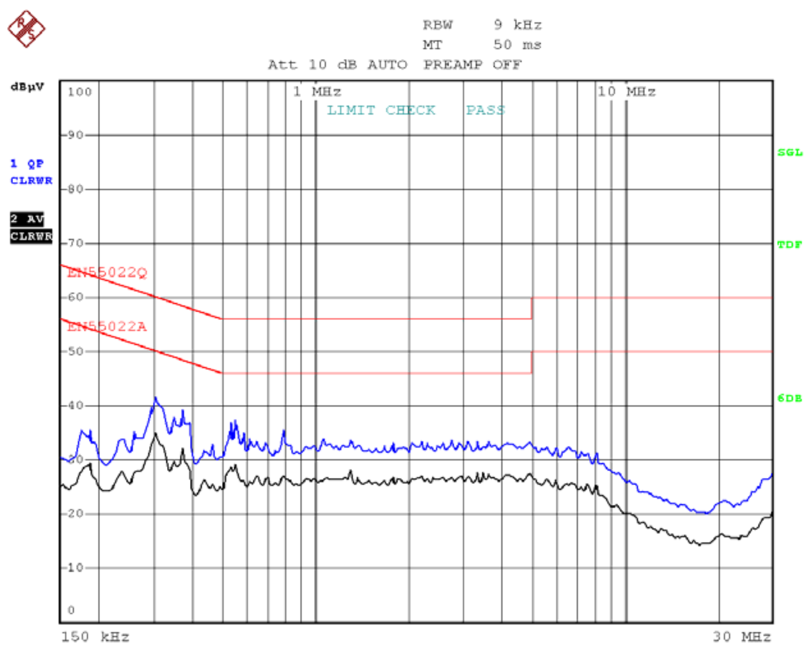


Figure 26 – Conducted EMI, Maximum Steady State Load, 115 VAC, 50 Hz, and EN55022 B Limits, N-Line, Secondary Ground connected to Artificial Hand.

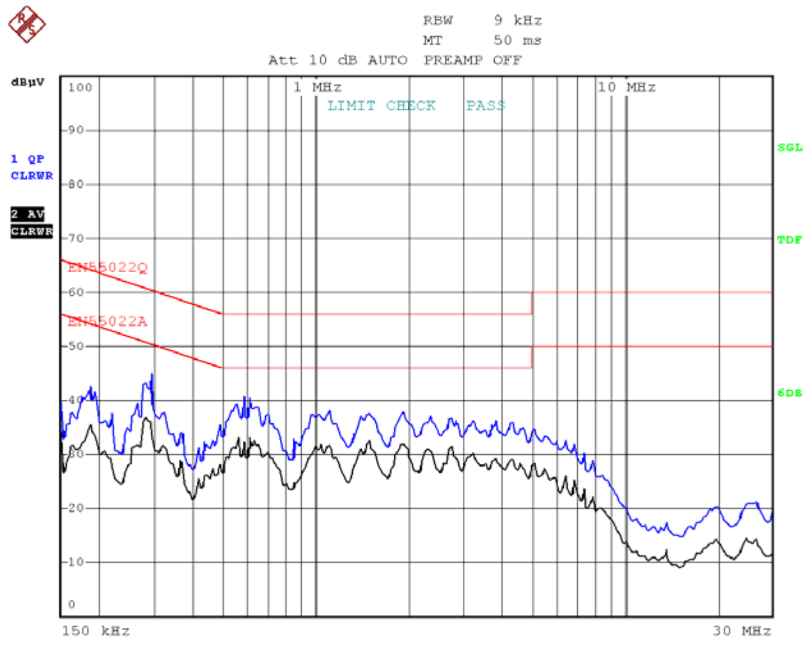


Figure 27 – Conducted EMI, Maximum Steady State Load, 230 VAC, 50 Hz, and EN55022 B Limits, L-Line, Secondary Ground connected to Artificial Hand.

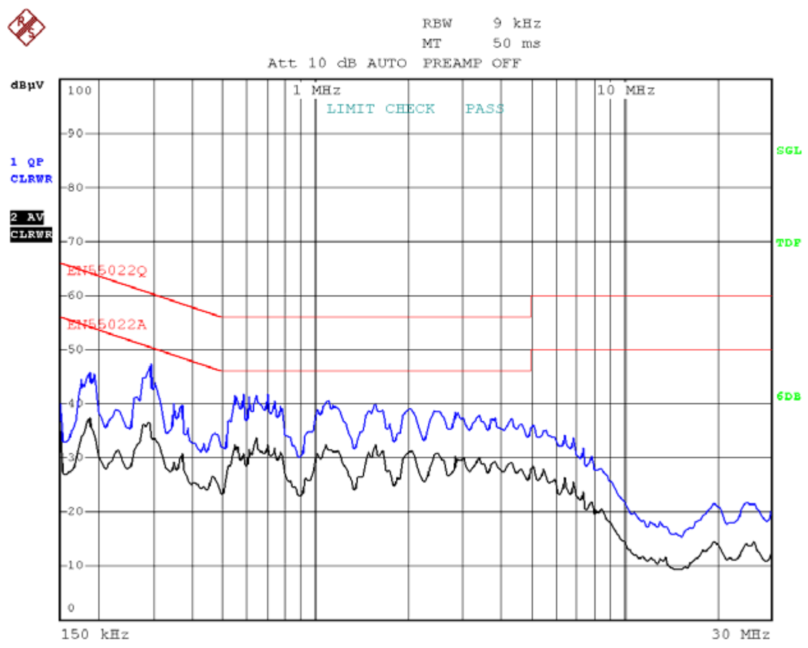


Figure 28 – Conducted EMI, Maximum Steady State Load, 230 VAC, 50 Hz, and EN55022 B Limits, N-Line, Secondary Ground connected to Artificial Hand.

13 Revision History

Date	Author	Revision	Description & changes	Reviewed
01-May-09	RP	1.0	Initial Release	Mktg & Apps

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

For the latest updates, visit our website: *www.powerint.com*

PATENT INFORMATION

The products and applications illustrated herein (including transformer construction and circuits external to the products) may be covered by one or more U.S. and foreign patents, or potentially by pending U.S. and foreign patent applications assigned to Power Integrations. A complete list of Power Integrations' patents may be found at www.powerint.com. Power Integrations grants its customers a license under certain patent rights as set forth at http://www.powerint.com/ip.htm.

Power Integrations Worldwide Sales Support Locations

WORLD HEADQUARTERS
5245 Hellyer Avenue
San Jose, CA 95138, USA.
Main: +1-408-414-9200
Customer Service:
Phone: +1-408-414-9665
Fax: +1-408-414-9765
e-mail: usasales@powerint.com

GERMANY
Rueckertstrasse 3
D-80336, Munich
Germany
Phone: +49-89-5527-3911
Fax: +49-89-5527-3920
e-mail: eurosales@powerint.com

JAPAN
Kosei Dai-3 Bldg.,
2-12-11, Shin-Yokohama,
Kohoku-ku, Yokohama-shi,
Kanagawa 222-0033
Phone: +81-45-471-1021
Fax: +81-45-471-3717
e-mail: japansales@powerint.com

TAIWAN
5F, No. 318, Nei Hu Rd., Sec. 1
Nei Hu Dist.
Taipei, Taiwan 114, R.O.C.
Phone: +886-2-2659-4570
Fax: +886-2-2659-4550
e-mail: taiwansales@powerint.com

CHINA (SHANGHAI)
Rm 1601/1610, Tower 1,
Kerry Everbright City
No. 218 Tianmu Road West,
Shanghai, P.R.C. 200070
Phone: +86-21-6354-6323
Fax: +86-21-6354-6325
e-mail: chinasales@powerint.com

INDIA
#1, 14th Main Road
Vasanthanagar
Bangalore-560052 India
Phone: +91-80-41138020
Fax: +91-80-41138023
e-mail: indiasales@powerint.com

KOREA
RM 602, 6FL
Korea City Air Terminal B/D, 159-6
Samsung-Dong, Kangnam-Gu,
Seoul, 135-728, Korea
Phone: +82-2-2016-6610
Fax: +82-2-2016-6630
e-mail: koreasales@powerint.com

UNITED KINGDOM
1st Floor, St. James's House
East Street, Farnham
Surrey, GU9 7TJ
United Kingdom
Phone: +44 (0) 1252-730-141
Fax: +44 (0) 1252-727-689
e-mail: eurosales@powerint.com

CHINA (SHENZHEN)
Rm A, B & C 4th Floor, Block C,
Electronics Science and Technology Building, 2070
Shennan Zhong Rd,
Shenzhen, Guangdong,
China, 518031
Phone: +86-755-8379-3243
Fax: +86-755-8379-5828
e-mail: chinasales@powerint.com

ITALY
Via De Amicis 2
20091 Bresso MI – Italy
Phone: +39-028-928-6000
Fax: +39-028-928-6009
e-mail: eurosales@powerint.com

SINGAPORE
51 Newton Road,
#15-08/10 Goldhill Plaza,
Singapore, 308900
Phone: +65-6358-2160
Fax: +65-6358-2015
e-mail: singaporesales@powerint.com

APPLICATIONS HOTLINE
World Wide +1-408-414-9660

APPLICATIONS FAX
World Wide +1-408-414-9760