Design Example Report

Title	***<5 mW (Including 1 mw Pre-Load) No-Load Input Power, 8 W Standby Power Supply Using LinkZero™-LP LNK576DG***
Specification	85 VAC – 265 VAC Input; 5 V, 1.6 A Output
Application	Standby Power Supply For TV
Author	Applications Engineering Department
Document Number	DER-417
Date	February 28, 2014
Revision	0.2

Summary and Features

- Ultra low no-load consumption, <4 mW at 230 VAC with 1mW preload
- EcoSmart™ – 70% average efficiency, exceeds standards requirement of 67%, and thus meets all existing and proposed harmonized energy efficiency standards including: CECP (China), CEC, EPA, AGO, European Commission

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5245 Hellyer Avenue, San Jose, CA 95138 USA.
Tel: +1 408 414 9200   Fax: +1 408 414 9201
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Important Note:
Although this board was designed to satisfy safety isolation requirements, it has not been agency approved. Therefore, all testing should be performed using an isolation transformer to provide the AC input to the power supply.

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1 Introduction

This report describes a universal input, 5 V, 1600 mA flyback power supply using a LinkZero-LP family of ICs. It contains the complete specification of the power supply, a detailed circuit diagram, the entire bill of materials required to build the supply, extensive documentation of the power transformer along with test data and oscillographs of important electrical waveforms.

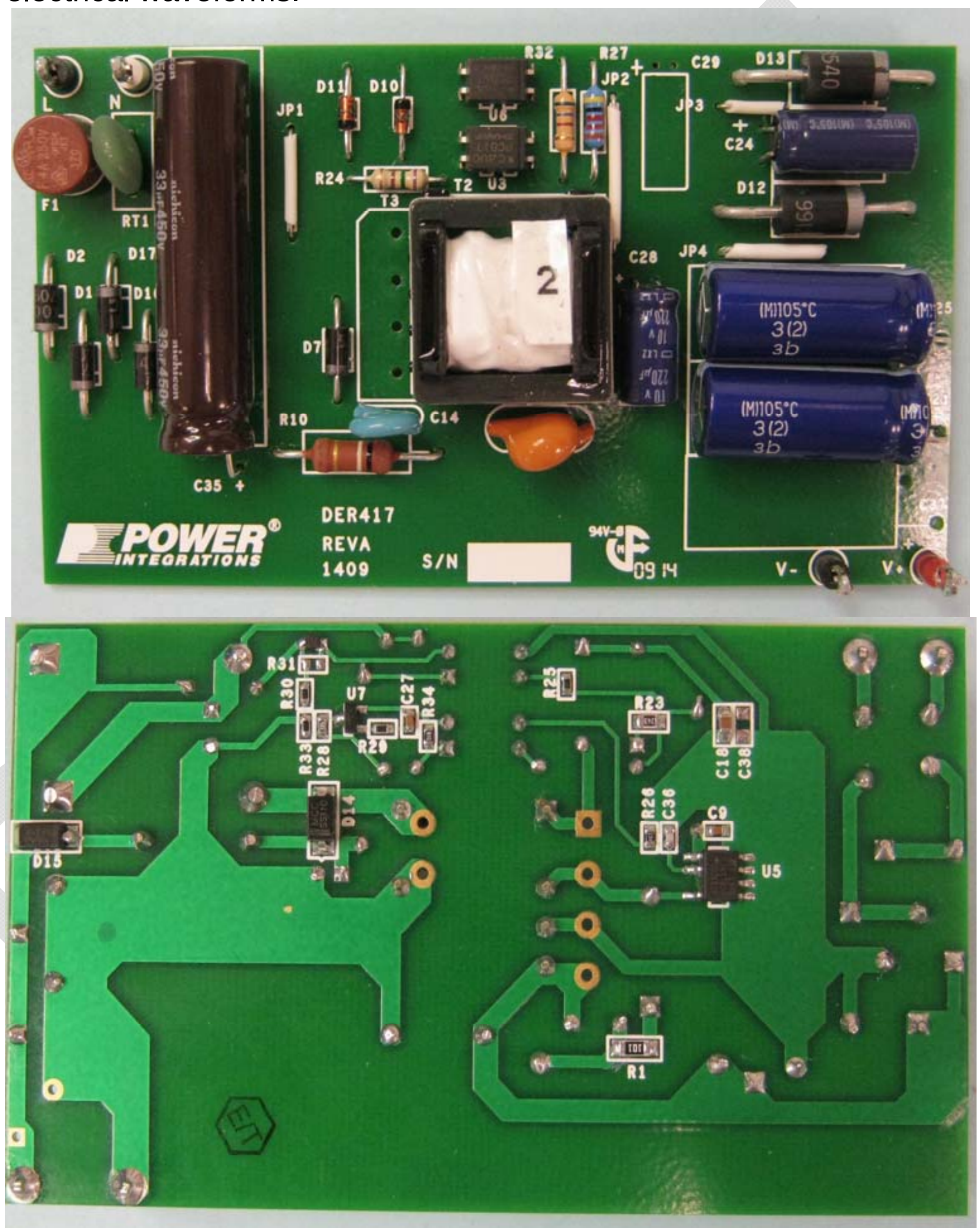

Figure 1 – Populated Circuit Board Photographs.

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}	85		265	VAC	2 Wire – no P.E.
Frequency	f_{LINE}	47	50/60	64	Hz	
No-load Input Power				4	mW	230 VAC
Output						
Output Voltage	V_{OUT}		5		V	See V-I Curves, Figure 9, for limits
Output Ripple Voltage	V_{RIPPLE}			120	mV	20 MHz bandwidth
Output Current	I_{OUT}		1600		mA	
Total Output Power						
Continuous Output Power	P_{OUT}			8	W	
Ambient Temperature	T_{AMB}	-5		65	^{o}C	Free convection, sea level

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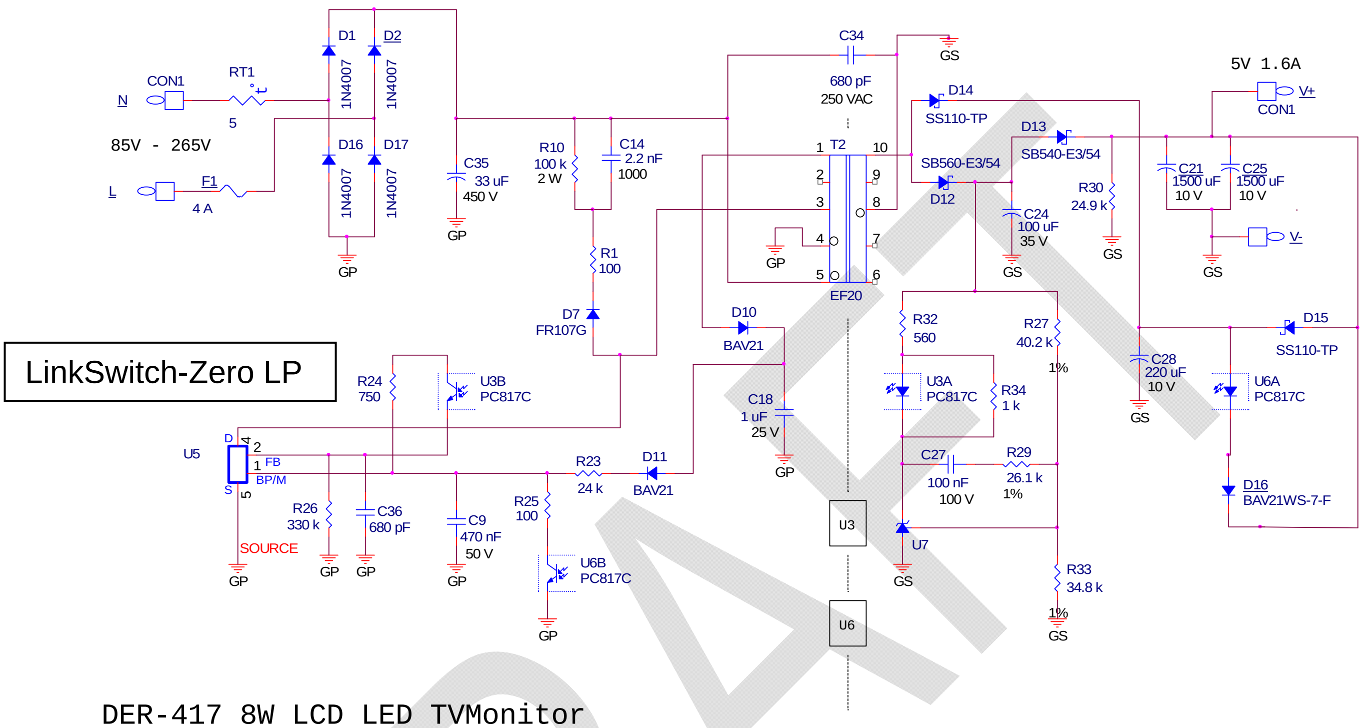
3 Circuit Diagram

For LinkSwitch-Zero LP part number please contact local PI sales office.



DER-417 8W LCD LED TVMonitor
standby LNKZero LP TV Board

Figure 2 – Schematic.

4 Circuit Description

4.1 Input Rectification

Diodes D1-D4 rectifies the AC input which is then filtered by capacitor C35. In some applications, additional reduction in no-load or light load input power can be achieved by disconnecting capacitor C35 using a relay. When the capacitor is disconnected from the circuit, reduction in input power is achieved due to elimination of capacitor leakage current which contributes to the loss. If this reduction of loss is not required and capacitor C35 is kept in the circuit at all times.

4.2 LinkZero-Lp Primary:

The LinkZero-LP device (U5) integrates an oscillator, an ON/OFF controller, start-up and protection circuitry and a power MOSFET all on one monolithic IC.

One side of the power transformer primary is connected to the positive leg of C35 and the other side is connected to the DRAIN (D) pin of U5. At the start of a switching cycle, the controller turns the MOSFET ON, and current ramps up in the primary winding, which stores energy in the core of the transformer. When that current reaches the limit threshold, the controller turns the MOSFET OFF. Due to the phasing of the transformer windings and the orientation of the output diode, the stored energy then induces a voltage across the secondary winding, which forward biases the output diode, and the stored energy is delivered to the output capacitor.

4.3 Primary Clamp

The clamp network formed by C14, R10, R1, and D7 limits the drain voltage (preventing spikes at MOSFET turn off) and dissipates transformer leakage inductance energy.

4.4 Output Rectification

Output rectification is provided by diode D12 and filtering is provided by capacitor C24.

4.5 Ultra-low No-load Input Power

The LinkZero-LP has a built in “power-down” (PD) mode wherein when 160 consecutive switching cycles have been skipped, the chip goes into the PD mode and inhibits switching and in addition, dramatically reduces its internal power consumption. The PD mode occurs when the output load has reduced to about 0.3% of full load. During PD mode the internal circuitry of the device completely shuts down and thus the capacitor connected to BYPASS (BP) pin C9 is discharged from 5.8 V. The controller wakes up to check output load conditions at a frequency determined by the user through the choice of the BP pin capacitor value. Once the BP pin voltage reaches 3 V, U5 powers up again and resumes switching. If the load increases such that fewer than 160 cycles were skipped, the IC resumes normal operation.

When U5 is in PD mode, the time taken for the BP pin voltage to discharge to VBPPDRESET (~3 V) determines the duration of the PD off-time. The duration of the PD

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off-time also determines the ripple on the output voltage. The total energy stored in C18 and C9 determine the PD off-time (and also the output ripple in PD mode).

4.6 Feedback

The output voltage is sensed through resistor divider R27 and R33 and fed back to U5 through TL431 and optocoupler. Switching cycles are skipped if the FB pin disable threshold voltage (1.7 V) is exceeded. When the sensed voltage at the FB pin falls below the disable threshold, switching cycles are re-enabled. By adjusting the ratio of enabled to disable switching cycles, output regulation is maintained.

At increased loads, beyond the output power limiting point, the FB pin voltage begins to reduce as the power supply output voltage falls. As the FB pin voltage falls, the switching frequency reduces to provide some output current limiting. When the FB pin voltage drops below the auto-restart threshold (typically 0.9 V on the FB pin), the power supply enters the auto-restart mode. In this mode, the power supply will turn off for 1.2 s and then turn back on for 170 ms. The auto-restart function reduces the average output current during an output short-circuit condition.

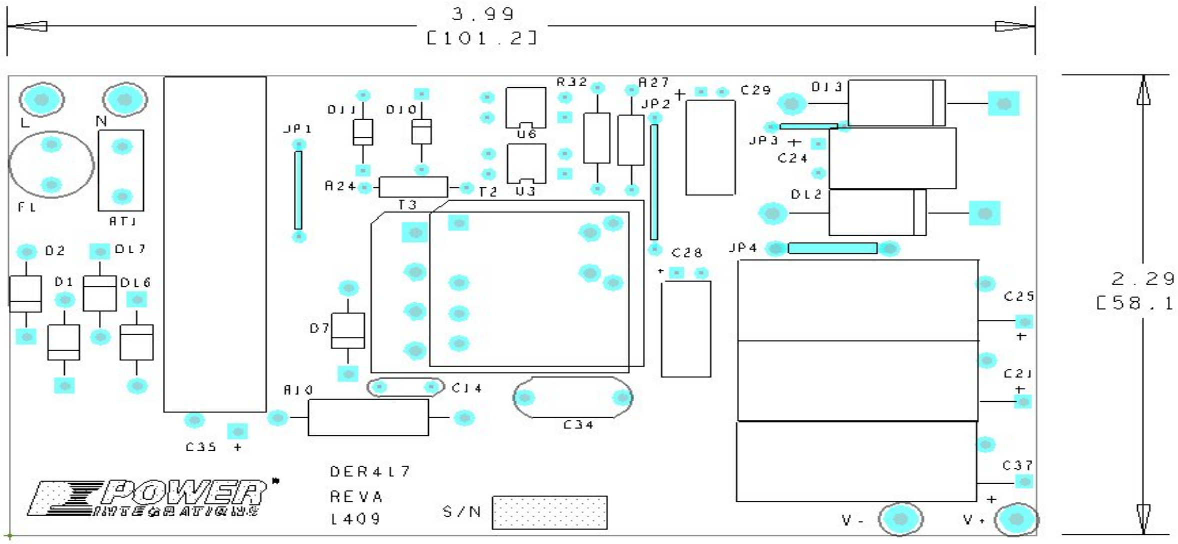
4.7 Output Switch-Capacitor for Light Load Performance Improvement

This design uses a special arrangement of components consisting of D13, C21 and C25 on the secondary side to achieve very low no load input power. Diode D12 and capacitor C24 is the main output rectifier filter. Output voltage of the power supply is sensed across C24. Capacitor C24 has a low capacitance. The additional rectifier filter comprising of diode D13 and capacitors C21 and C25, isolates the capacitors C21 and C25 from the rest of the circuit. Capacitors C25 and C21 are with a value large enough to provide low ripple output voltage. During normal operation, loss in diode D13 can result in loss of efficiency and also drop in output voltage due to diode losses.

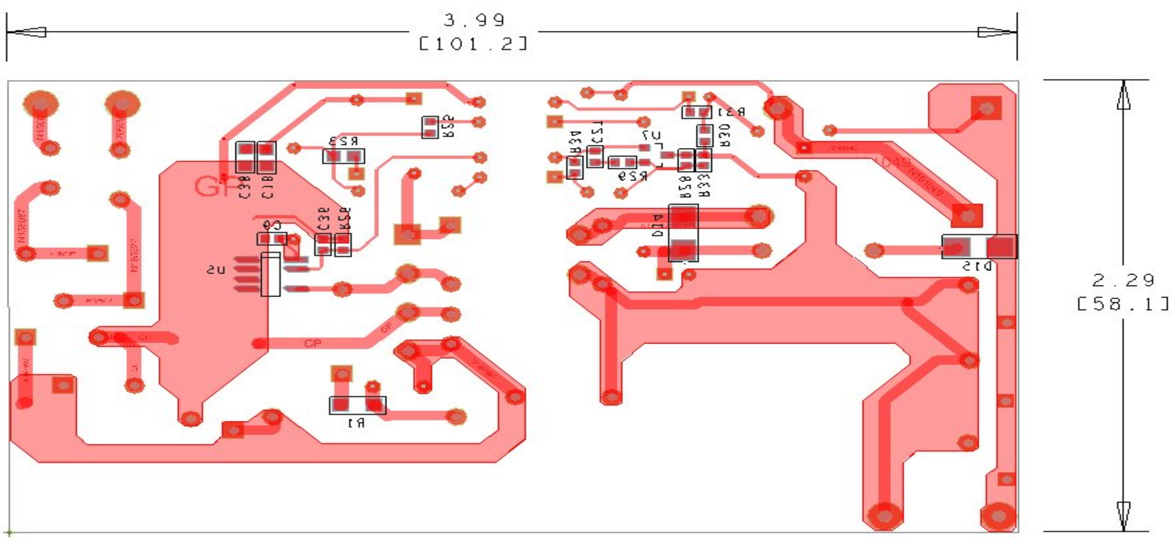
This design also uses special circuit formed by components D14, D15, D16, C28 and U6 to wake up the IC to normal load when the power supply is in PD mode.

During PD mode C28 is charged through D14 and D1, the potential difference across the U6A and D16 is negligible ,as soon as load is connected to the power supply, the voltage at the output drops and the potential difference across the U6A and D16 becomes large enough to pull the opto low which pulls the BP pin of U5 to low to wake up from PD mode to avoid the undershoot in the output voltage.

5 PCB Layout:



Top View.



Bottom View

Figure 3 – Printed Circuit Board Layout (Dimensions in Inches).

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6 Bill of Materials

Item	Qty	Ref Des	Description	Mfg Part Number	Mfg
1	1	C9	470 nF, 50 V, Ceramic, X7R, 0603	UMK107B7474KA-TR	Taiyo Yuden
2	1	C14	2.2 nF, 1KV, Ceramic, SL, 0.2" L.S.	DEBB33A222KA2B	Murata
3	1	C18	1 μF, 25 V, Ceramic, X5R, 0805	C2012X5R1E105K	TDK
4	2	C21 C25	1500 μF, 10 V, Electrolytic, Low ESR, 45 mΩ, (10 x 25)	ELXZ100ELL152MJ25S	Nippon Chemi-Con
5	1	C24	100 μF, 35 V, Electrolytic, Low ESR, 180 mΩ, (6.3 x 15)	ELXZ350ELL101MF15D	Nippon Chemi-Con
6	1	C27	100 nF 100 V, Ceramic, X7R, 0603	GRM188R72A104KA35D	Murata
7	1	C28	220 μF, 10 V, Electrolytic, Low ESR, 250 mΩ, (6.3 x 11.5)	ELXZ100ELL221MFB5D	Nippon Chemi-Con
8	1	C34	680 pF, Ceramic, Y1	440LT68-R	Vishay
9	1	C35	33 μF, 450 V, Electrolytic ,(10 x 42)	UPZ2W330MND9	Nichicon
10	1	C36	680 pF 100 V, Ceramic, NPO, 0603	CGA3E2C0G2A681J	TDK
11	4	D1 D2 D16 D17	1000 V, 1 A, Rectifier, DO-41	1N4007-E3/54	Vishay
12	1	D7	1000 V, 1 A, Fast Recovery Diode,GP DO-41	FR107G-B	Rectron
13	2	D10 D11	250 V, 250 mA, Fast Switching, DO-35	BAV21	Vishay
14	1	D12	60 V, 5 A, Schottky, DO-201AD	SB560-E3/54	Vishay
15	1	D13	40 V, 5 A, Schottky, DO-201AD	SB540-E3/54	Vishay
16	2	D14 D15	100 V, 1 A, Schottky, DO-214AC (SMA)	SS110-TP	Micro Commercial
17	1	D16	250 V, 0.2 A, Fast Switching, 50 ns, SOD-323	BAV21WS-7-F	Diode Inc.
18	1	F1	4 A, 250 V, Fast, TR5	37014000410	Wickman
19	1	JP1	Wire Jumper, Insulated, 24 AWG, 0.5 in	C2003A-12-02	Gen Cable
20	1	JP2	Wire Jumper, Insulated, 24 AWG, 0.7 in	C2003A-12-02	Gen Cable
21	1	JP3	Wire Jumper, Insulated, 24 AWG, 0.4 in	C2003A-12-02	Gen Cable
22	1	JP4	Wire Jumper, Insulated, TFE, 18AWG, 0.5 in	C2052A-12-02	Alpha
23	2	L V-	Test Point, BLK, THRU-HOLE MOUNT	5011	Keystone
24	1	N	Test Point, WHT, THRU-HOLE MOUNT	5012	Keystone
25	1	R1	100 Ω, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ101V	Panasonic
26	1	R10	100 kΩ, 5%, 2 W, Metal Oxide	RSF200JB-100K	Yageo
27	1	R23	24 kΩ, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ243V	Panasonic
28	1	R24	750 Ω, 5%, 1/4 W, Carbon Film	CFR-25JB-750R	Yageo
29	1	R25	100 Ω, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF1000V	Panasonic
30	1	R26	330 kΩ, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ334V	Panasonic
31	1	R27	40.2 kΩ, 1%, 1/4 W, Metal Film	MFR-25FBF-40K2	Yageo
32	1	R29	26.1 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF2612V	Panasonic
33	1	R30	24.9 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF2492V	Panasonic
34	1	R32	560 Ω, 5%, 1/4 W, Carbon Film	CFR-25JB-560R	Yageo
35	1	R33	34.8 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF3482V	Panasonic
36	1	R34	1 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF1001V	Panasonic
37	1	RT1	TKS Thermistor, 5 Ohms, 3 A	SCK08053MSY	Thinking Elect.
38	1	T2	Bobbin, EF20, Horizontal, 10 pins		
39	2	U3 U6	Optocoupler, 35 V, CTR 200-300%, 4-DIP	PC817C	Sharp
40	1	U5	LinkSwitchZero-LP, LNK576DG, SO-8-DN	LNK576DG	Power Integrations
41	1	U7	2.4 V Shunt Regulator IC, 1%, 0 to 70C, SOT-23-3	NCP431ACSNT1G	ON Semi
42	1	V+	Test Point, RED, THRU-HOLE MOUNT	5010	Keystone

Note – All parts are RoHS compliant

7 Transformer Specification

7.1 Electrical Diagram

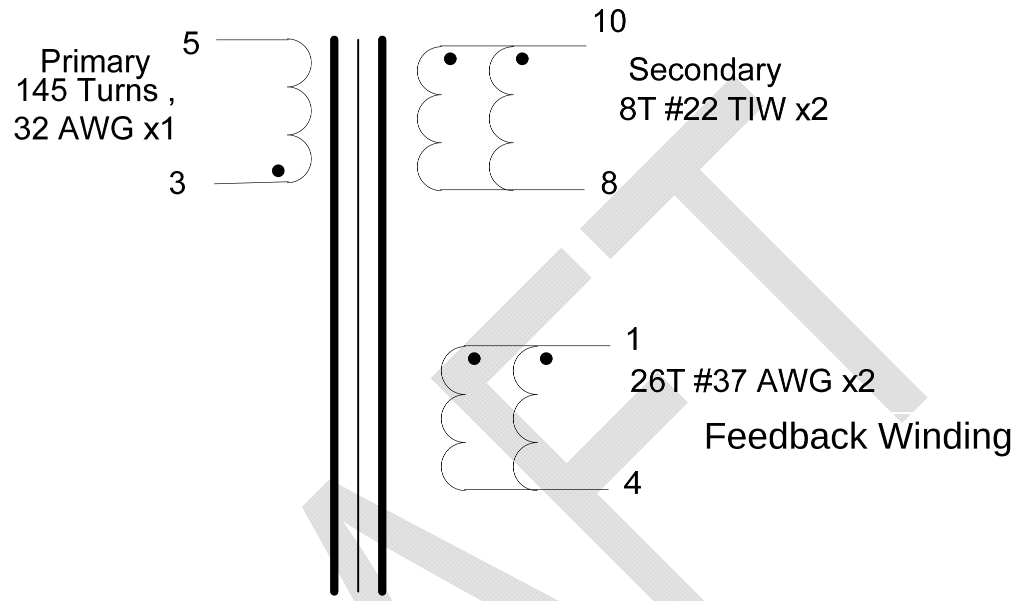

Figure 4 – Transformer Electrical Diagram.

7.2 Electrical Specifications

Electrical Strength	60 Hz 1 second, from pins 1, 2, 3, 4 to pins 5, 6.	3000 VAC
Nominal Primary Inductance	Measured at 1 V pk-pk, typical switching frequency, between pin 1 to pin 2, with all other windings open.	2375 μH
Tolerance	Tolerance of primary inductance.	±%5
Maximum Primary Leakage	Measured between pin 1 to pin 2, with all other windings shorted.	95 μH

7.3 Materials

Item	Description
[1]	Core: EF20, PC40EF20-Z ,gapped for ALG of 112 nH/T²
[2]	Bobbin EF20.
[3]	Barrier Tape: Polyester film [1 mil (25 μm) base thickness], 10.00 mm wide.
[4]	Varnish.
[5]	Magnet Wire: #32 AWG and #37 AWG, Solderable Double Coated.
[6]	Triple Insulated Wire: #22 AWG.

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7.4 Transformer Build Diagram

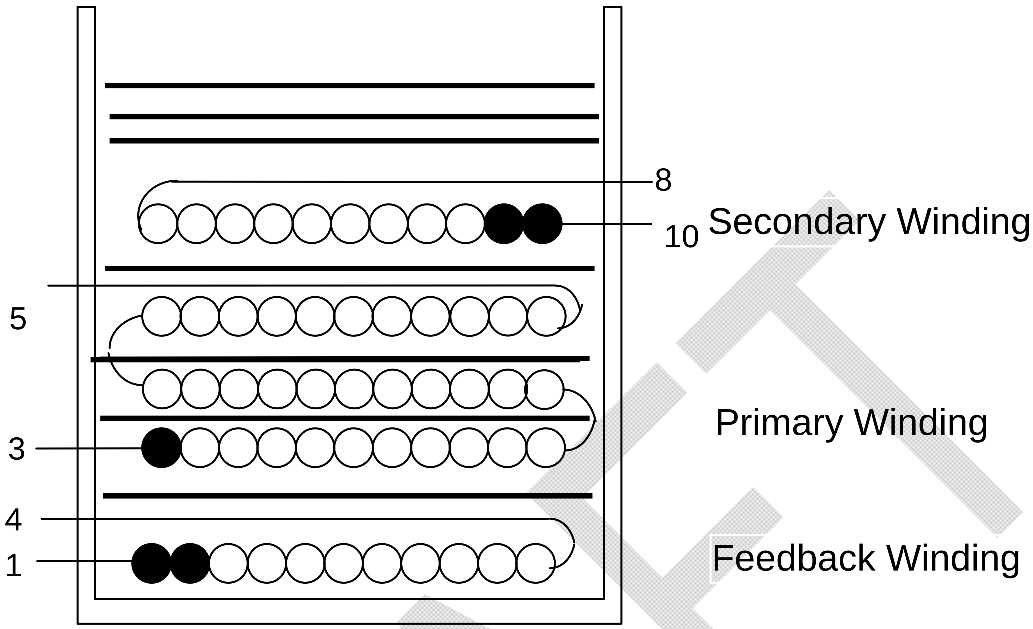

Figure 5 – Transformer Build Diagram.

7.5 Transformer Construction

Bias Winding	Start on pin(s) 1 and wind 26 turns (x 2 filar) of item [5]. Wind in same rotational direction as primary winding. Spread the winding evenly across entire bobbin. Finish this winding on pin(s) 4. Add 1 layer of tape, item [3], for insulation.
Primary Winding	Start on pin(s) 3 and wind 145 turns (x 1 filar) of item [5] in 3 layer(s) from left to right. At the end of 1st layer, continue to wind the next layer from right to left. At the end of 2nd layer, continue to wind the next layer from left to right. On the final layer, spread the winding evenly across entire bobbin. Finish this winding on pin(s) 5. Add 1 layer of tape, item [3], for insulation.
Secondary Winding	Start on pin(s) 10 and wind 8 turns (x 2 filar) of item [6]. Spread the winding evenly across entire bobbin. Wind in same rotational direction as primary winding. Finish this winding on pin(s) 8. Add 2 layers of tape, item [3], for insulation.
Core Assembly	Assemble and secure core halves. Item [1].
Varnish	Dip varnish uniformly in item [4]. Do not vacuum impregnate.

8 Transformer Design Spreadsheet

Note: *This design is made using a LinkZero-LP part that is currently made especially for this application hence a dedicated spreadsheet is not yet available. This design was made by modifying an existing spreadsheet.*

ACDC_LinkZero-AX_021914; Rev.1.4; Copyright Power Integrations 2014	**INPUT**	**INFO**	**OUTPUT**	**UNIT**	**ACDC_LinkZero-AX_021914_Rev1-4.xls; LinkZero-AX 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	5.50			Volts	Output Voltage (main) measured at the end of output cable (For CV/CC designs enter typical CV tolerance limit)
IO	1.60			Amps	Power Supply Output Current (For CV/CC designs enter typical CC tolerance limit)
PO			8.80	Watts	!!! For UNIVERSAL INPUT : REDUCE PO<5W (use larger LinkZero-AX, or reduce input voltage range)
Feedback Type	**Opto**		**Opto**		Choose 'Bias' for Bias winding feedback, 'Direct' for direct sensing of output and 'Opto' for Optocoupler feedback from the 'Feedback Type' drop down box at the top of this spreadsheet
Clampless Design	**No**		**External Clamp**		Choose 'YES' from the 'Clampless Design' drop down box at the top of this spreadsheet for a clampless design. Choose 'NO' to add an external clamp circuit. Clampless design lowers the total cost of the power supply
n	0.74		0.74		Efficiency Estimate at output terminals. For CV only designs enter 0.7 if no better data available
Z			0.5		Loss Allocation Factor (Secondary side losses / Total losses)
tC	2.90			mSeconds	Bridge Rectifier Conduction Time Estimate
CIN	33.00			uFarads	Input Capacitance
Input Rectification Type	**F**		**F**		Choose H for Half Wave Rectifier and F for Full Wave Rectification from the 'Rectification' drop down box at the top of this spreadsheet
ENTER LinkZero-AX VARIABLES					
LinkZero-AX	**LNK586DG**		**LNK586DG**		LinkZero-AX device.
ILIMITMIN			0.326	Amps	Minimum Current Limit
ILIMITMAX			0.375	Amps	Maximum Current Limit
fSmin			93000	Hertz	Minimum Device Switching Frequency. May be lowwer than 93 kHz for high line (230 VAC) designs
I^2fMIN			11025	A^2Hz	I^2f Minimum value (product of current limit squared and frequency is trimmed for tighter tolerance)
I^2fTYP			12250	A^2Hz	I^2f typical value (product of current limit squared and frequency is trimmed for tighter tolerance)
VOR	109.00		109	Volts	Reflected Output Voltage

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VDS	10.00		10	Volts	LinkZero-AX on-state Drain to Source Voltage
VD			0.5	Volts	Output Winding Diode Forward Voltage Drop
KP		***Info***	0.62		!!! Info. INCREASE KP > 0.9 (Increase VOR, Larger input capacitor)
Core Type	**EF20**		**EF20**		User-Selected transformer core
Core		EF20		P/N:	PC40EF20-Z
Bobbin		EF20_BOBBIN		P/N:	EF20_BOBBIN
AE			0.335	cm^2	Core Effective Cross Sectional Area
LE			4.49	cm	Core Effective Path Length
AL			1570	nH/T^2	Ungapped Core Effective Inductance
BW			12.2	mm	Bobbin Physical Winding Width
M			0	mm	Safety Margin Width (Half the Primary to Secondary Creepage Distance)
L	3.00		3		Number of primary layers
NS	8.00		8		Number of Secondary Turns
NB			24		Number of Bias winding turns
VB	18.00		18.00	Volts	Bias Winding Voltage
R1			N/A	k-ohms	Calculated standard value (1%) of Upper Resistor in the resistor divider component between bias wiinding and FB pin of LinkZero-AX
R2			N/A	k-ohms	Calculated standard value (1%) of Lower Resistor in the resistor divider component between bias wiinding and FB pin of LinkZero-AX
RBP			46.00	k-ohms	Optional BP pin resistor (connected between BP pin and bias winidng) to improve efficiency. Calculated standard 5% value is displayed
CBIAS (or COUT)			1.00	uF	Maximum value of output capacitor. Larger value may result in issues during startup. Lower value of CBIAS can be used
CFB			680.00	pF	FB pin resistor (Improve noise sensitivity)
CBP			220.00	nF	BP pin capacitor
Recommended Bias Diode			1N4003		Place this diode on the return leg of the bias winding for optimal EMI.
DC INPUT VOLTAGE PARAMETERS					
VMIN			97	Volts	Minimum DC Input Voltage
VMAX			375	Volts	Maximum DC Input Voltage
CURRENT WAVEFORM SHAPE PARAMETERS					
DMAX			0.60		Maximum Duty Cycle
IAVG			0.14	Amps	Average Primary Current
IP			0.33	Amps	Minimum Peak Primary Current
IR			0.22	Amps	Primary Ripple Current
IRMS			0.17	Amps	Primary RMS Current
TRANSFORMER PRIMARY DESIGN PARAMETERS					
LP			2351	uHenries	Typical Primary Inductance. +/- 7%
LP_TOLERANCE	7.00		7	%	Primary inductance tolerance
NP			145		Primary Winding Number of Turns
ALG			111	nH/T^2	Gapped Core Effective Inductance
BM			1808	Gauss	Maximum Operating Flux Density, BM<2000 is recommended
BAC			490	Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
ur			1675		Relative Permeability of Ungapped Core
LG			0.38	mm	Gap Length (Lg > 0.08 mm)
BWE			36.6	mm	Effective Bobbin Width

OD			0.25	mm	Maximum Primary Wire Diameter including insulation
INS			0.05	mm	Estimated Total Insulation Thickness (= 2 * film thickness)
DIA			0.20	mm	Bare conductor diameter
AWG			32	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CM			64	Cmils	Bare conductor effective area in circular mils
CMA			370	Cmils/Amp	Primary Winding Current Capacity (150 < CMA < 500)
Lumped parameters					
ISP			5.91	Amps	Peak Secondary Current
ISRMS			2.80	Amps	Secondary RMS Current
IRIPPLE			2.30	Amps	Output Capacitor RMS Ripple Current
CMS			560	Cmils	Secondary Bare Conductor minimum circular mils
AWGS			22	AWG	Secondary Wire Gauge (Rounded up to next larger standard AWG value)
DIAS			0.65	mm	Secondary Minimum Bare Conductor Diameter
ODS			1.53	mm	Secondary Maximum Outside Diameter for Triple Insulated Wire
INSS			0.44	mm	Maximum Secondary Insulation Wall Thickness
VOLTAGE STRESS PARAMETERS					
VDRAIN			591	Volts	Peak Drain Voltage is highly dependent on Transformer capacitance and leakage inductance. Please verify this on the bench and ensure that it is below 650 V to allow 50 V margin for transformer variation.
PIVS			26	Volts	Output Rectifier Maximum Peak Inverse Voltage
1st output					
VO1			5	Volts	Main Output Voltage (if unused, defaults to single output design)
IO1			1.750	Amps	Output DC Current
PO1			8.75	Watts	Output Power
VD1			0.5	Volts	Output Diode Forward Voltage Drop
NS1			7.33		Output Winding Number of Turns
ISRMS1			3.061	Amps	Output Winding RMS Current
IRIPPLE1			2.51	Amps	Output Capacitor RMS Ripple Current
PIVS1			24	Volts	Output Rectifier Maximum Peak Inverse Voltage
Pre-Load Resistor			2	k-Ohms	Recommended value of pre-load resistor
CMS1			612	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS1			22	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS1			0.65	mm	Minimum Bare Conductor Diameter
ODS1			1.66	mm	Maximum Outside Diameter for Triple Insulated Wire
2nd output					
VO2				Volts	Output Voltage
IO2				Amps	Output DC Current
PO2			0.00	Watts	Output Power
VD2			0.7	Volts	Output Diode Forward Voltage Drop
NS2			0.93		Output Winding Number of Turns
ISRMS2			0.000	Amps	Output Winding RMS Current
IRIPPLE2			0.00	Amps	Output Capacitor RMS Ripple Current

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PIVS2			2	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS2			0	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS2				AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS2				mm	Minimum Bare Conductor Diameter
ODS2				mm	Maximum Outside Diameter for Triple Insulated Wire
3rd output					
VO3				Volts	Output Voltage
IO3				Amps	Output DC Current
PO3			0.00	Watts	Output Power
VD3			0.7	Volts	Output Diode Forward Voltage Drop
NS3			0.93		Output Winding Number of Turns
ISRMS3			0.000	Amps	Output Winding RMS Current
IRIPPLE3			0.00	Amps	Output Capacitor RMS Ripple Current
PIVS3			2	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS3			0	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS3				AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS3				mm	Minimum Bare Conductor Diameter
ODS3				mm	Maximum Outside Diameter for Triple Insulated Wire
Total power			8.75	Watts	Total Output Power
Negative Output	N/A		N/A		If negative output exists enter Output number; eg: If VO2 is negative output, enter 2

Performance Data

All measurements performed at room temperature.

8.1 Efficiency(Full Load)

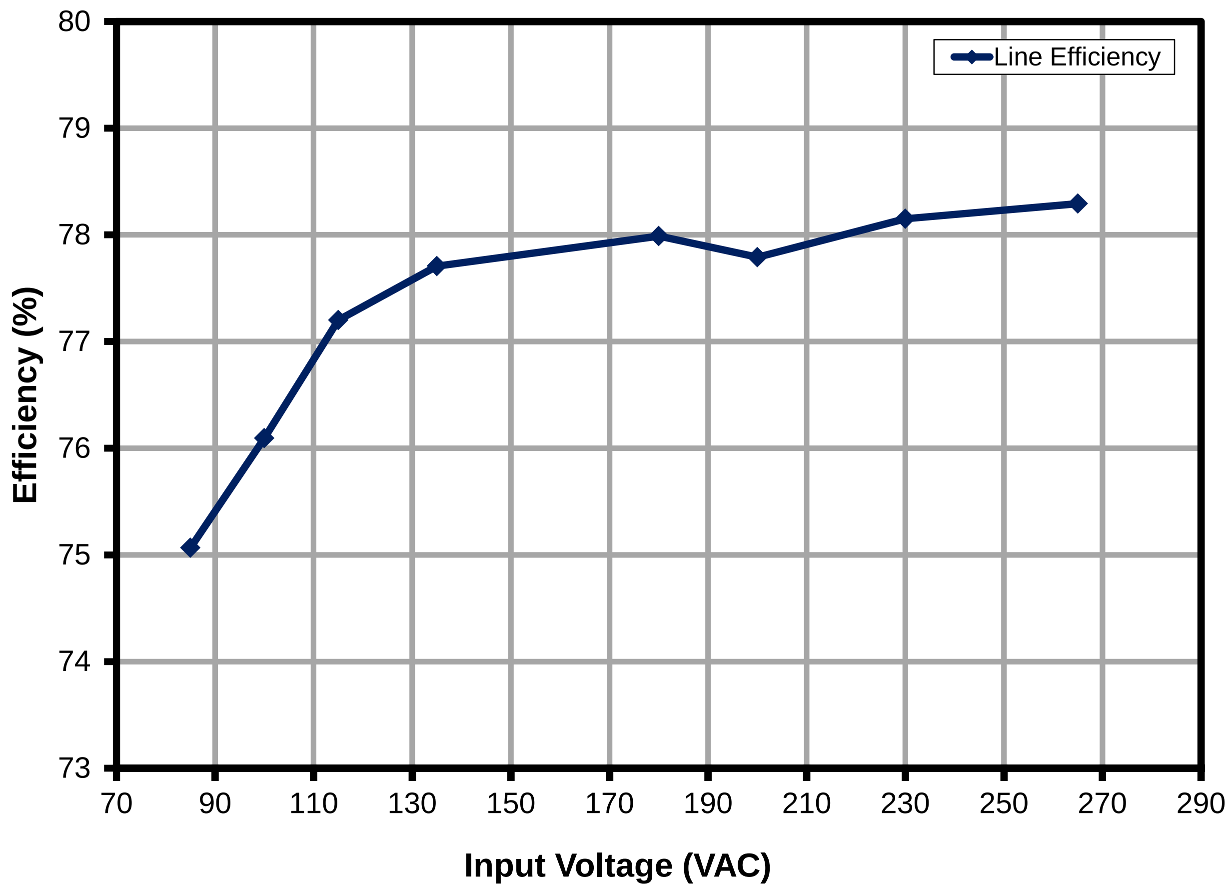

Figure 6 – Efficiency vs. Input Voltage, Room Temperature.

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8.1.1 Average Efficiency

8.1.2 8 W Output

Percent of Full Load	Efficiency (%)	
	115 VAC	230 VAC
25	77.1997	78.151
50	77.517	77.7017
75	77.9959	76.6223
100	75.8987	74.2714
Average	**77.152**	**76.6866**

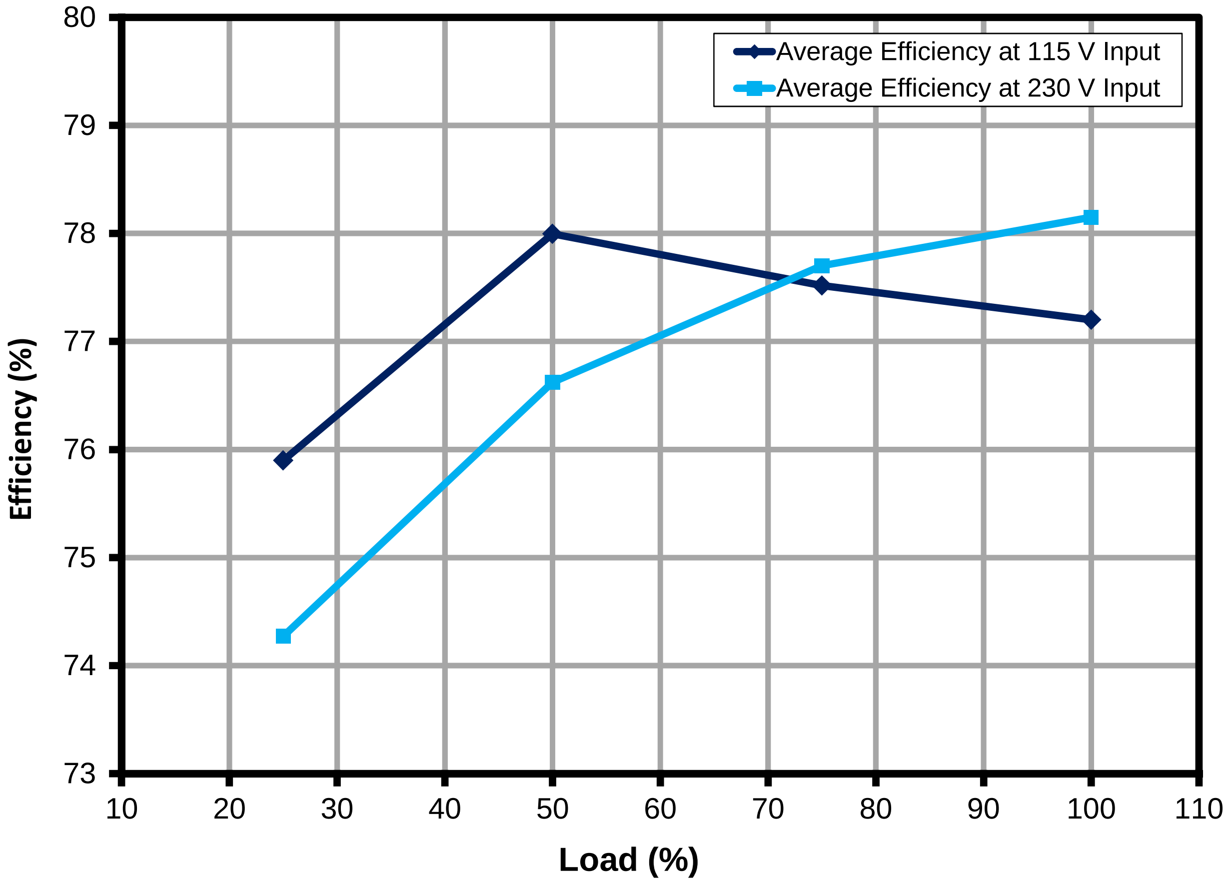

Figure 7 – Average Efficiency vs. Input Voltage, Room Temperature.

8.1.3 Input Power with 1 mW Load

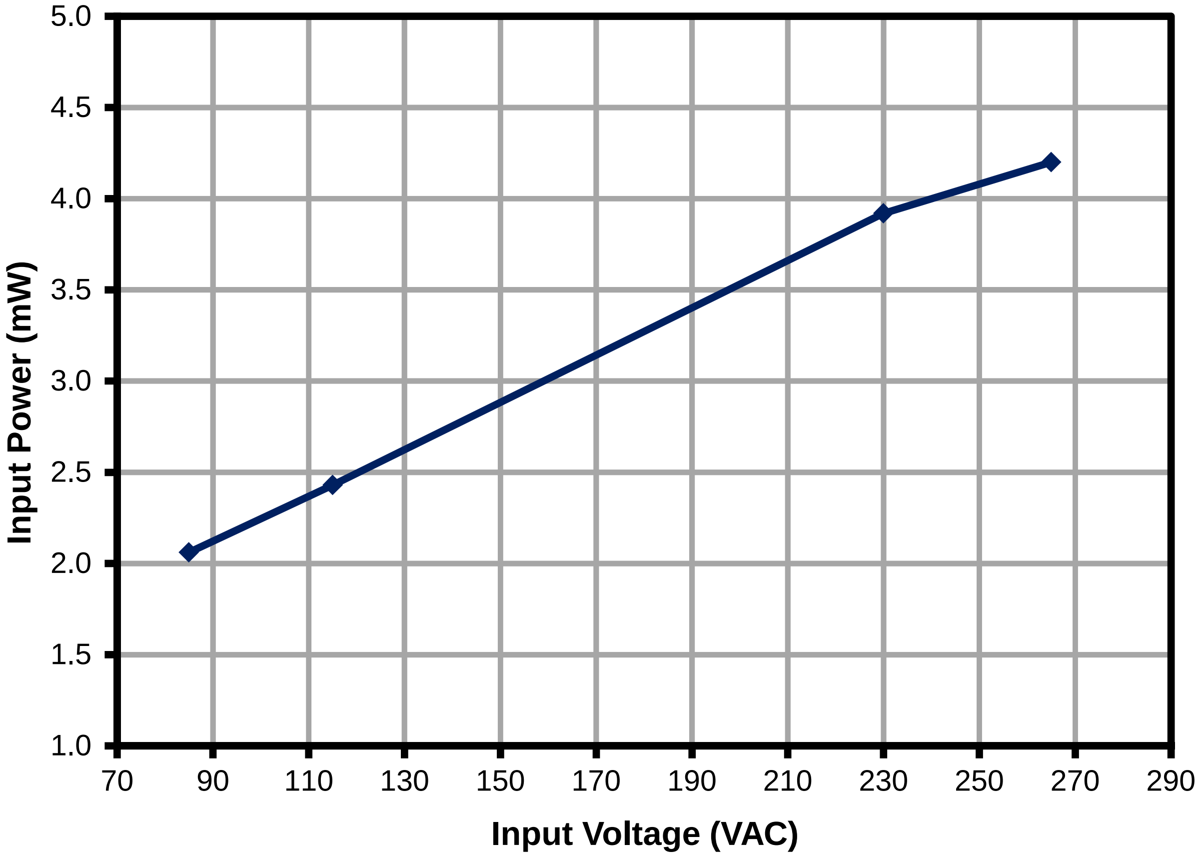

Figure 8 – No-load Input Power vs. Input Line Voltage, Room Temperature,

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8.2 Available Standby Output Power

The chart below shows the available output power vs. line voltage for an input power of 0.3 W, 0.5 W, 1 W and 2 W.

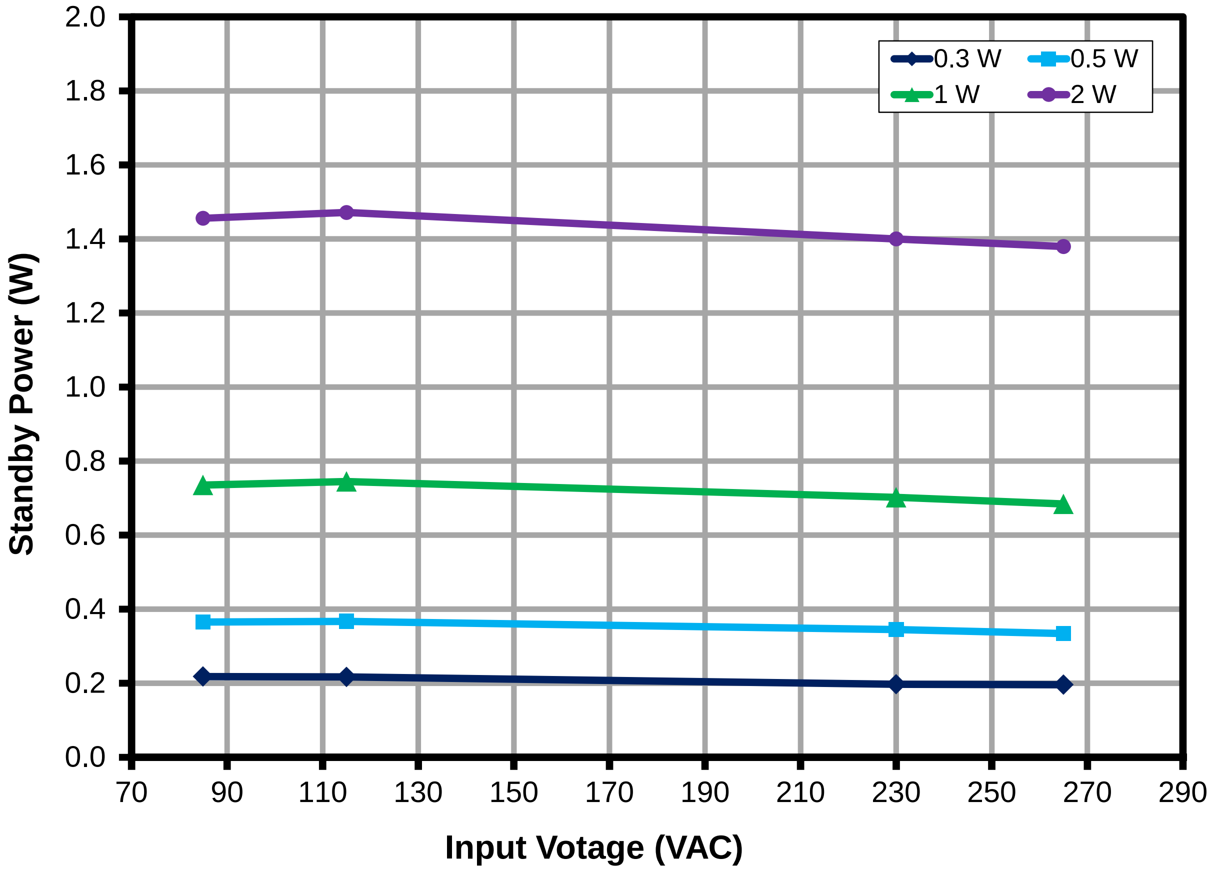

Figure 9 – Available Output Power for 0.2 W, 0.5 W, 1 W and 2 W Input Power.

8.3 *Line and Load Regulation*

Line and Load Regulation:

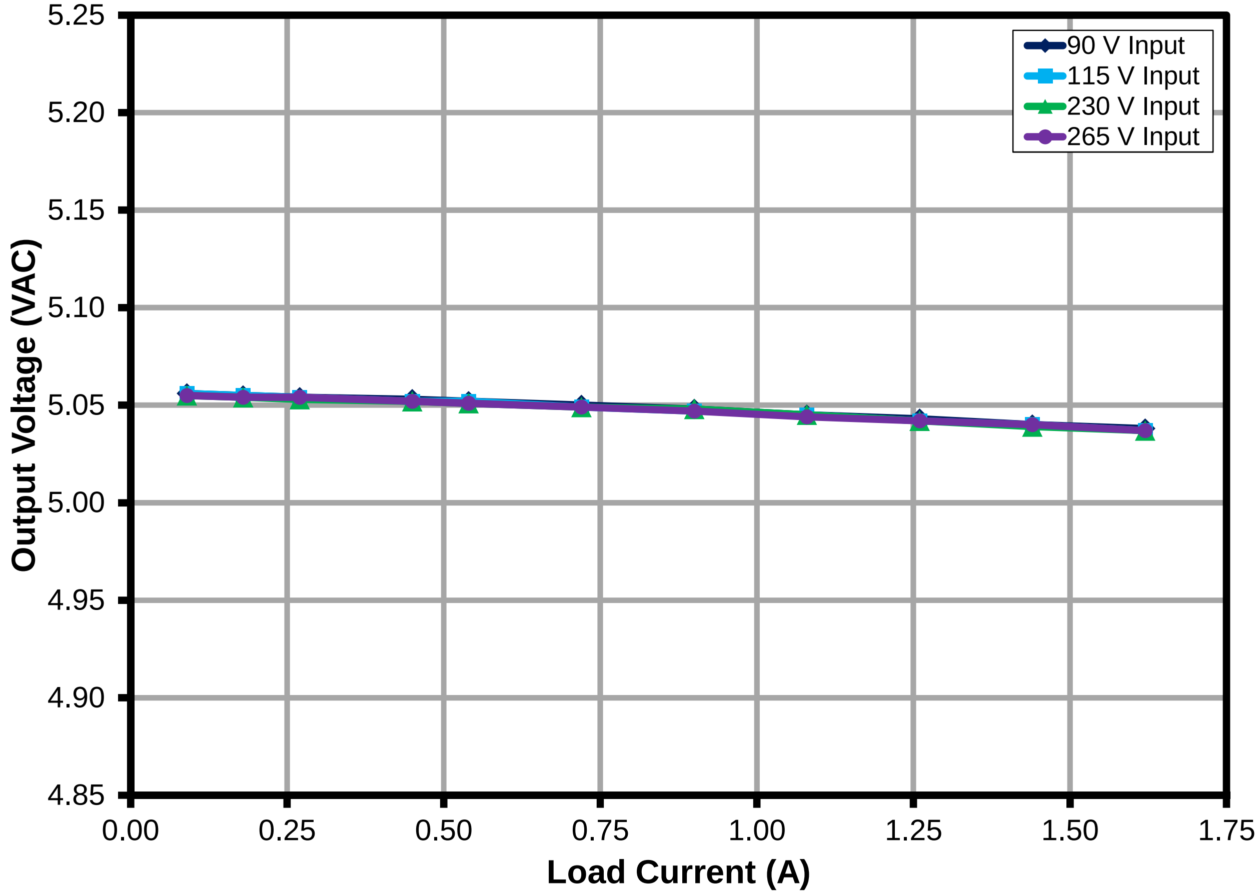

Figure 10 – Load and Line Regulation, Room Temperature.

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9 Thermal Performance

These results show that the IC has an acceptable rise in temperature.

9.1.1 8 W Output at 85 V_{IN}

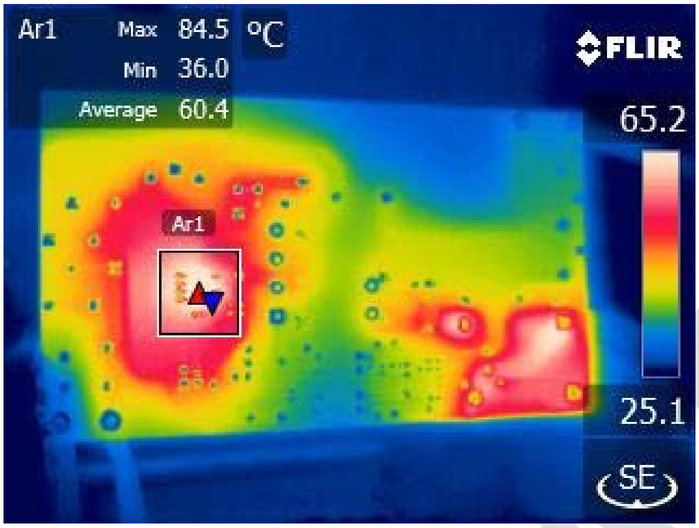

Figure 11 – 90 VAC, Full Load.
T (Ambient) = 26 ºC.
T (LNK586DG) = 84.5 ºC.

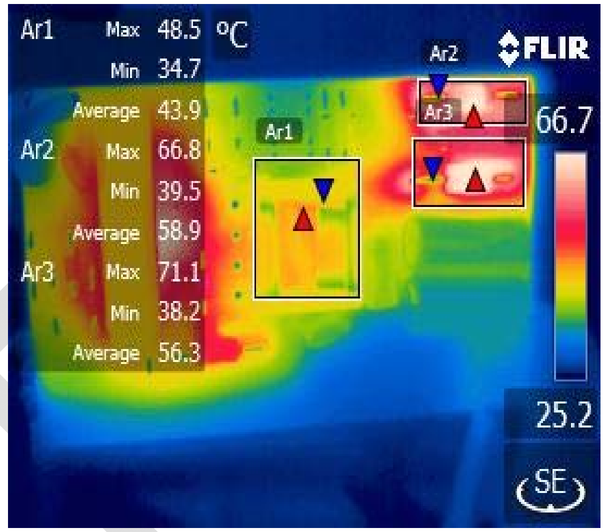

Figure 12 – 265 VAC, Full Load.
T (Ambient) = 26.2 ºC.
Transformer = 48.5 ºC.
T (Rectifier Diode) = 71.1 ºC.

9.1.2 8 W Output at 265 V_{IN}

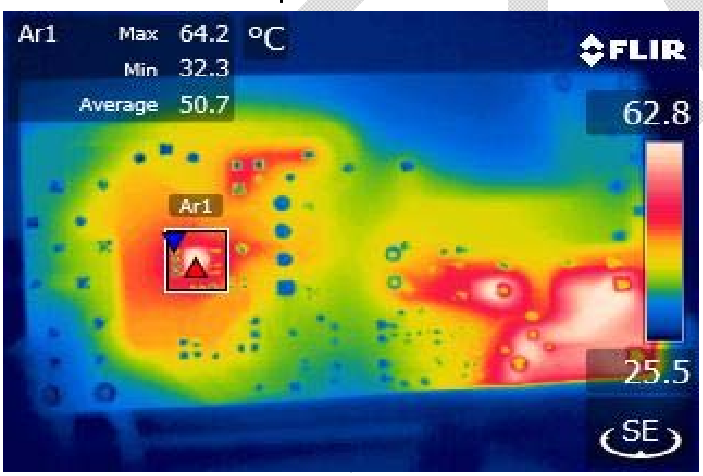

Figure 13 – 265 VAC, Full Load.
T (Ambient) = 26 ºC.
T (LNK586DG) = 64.2 ºC.

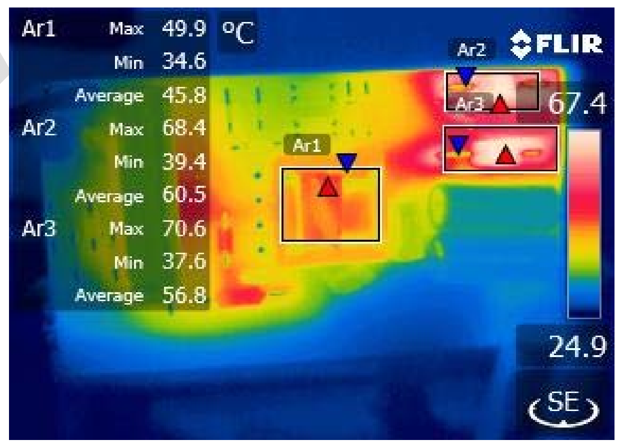

Figure 14 – 265 VAC, Full Load.
T (Ambient) = 26.2 ºC.
Transformer = 49.9 ºC.
T (Rectifier Diode) = 70.6 ºC.

10 Waveforms

10.1 Drain Voltage, Normal Operation

Figure 15 – 85 VAC, Full Load.
V_{DRAIN}, 100 V / div.
10 μs / div.

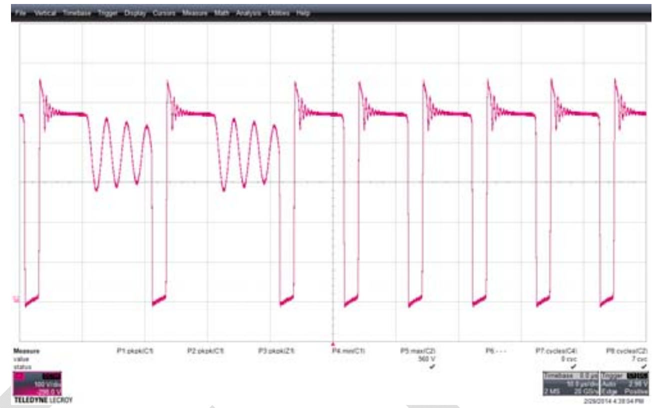

Figure 16 – 265 VAC, Full Load.
Upper: V_{DRAIN}, 200 V / div. (Max Drain Voltage = 500 V).

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10.2 Output Voltage Start-Up Profile

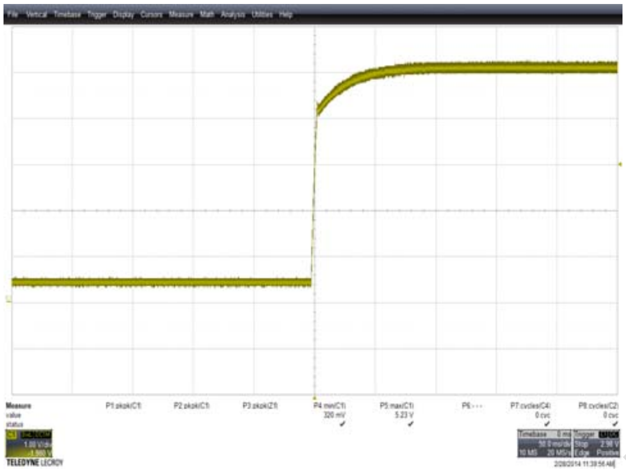

Figure 17 – Start-Up Profile, 85 VAC. Full Load.
1 V, 50 ms. / div.

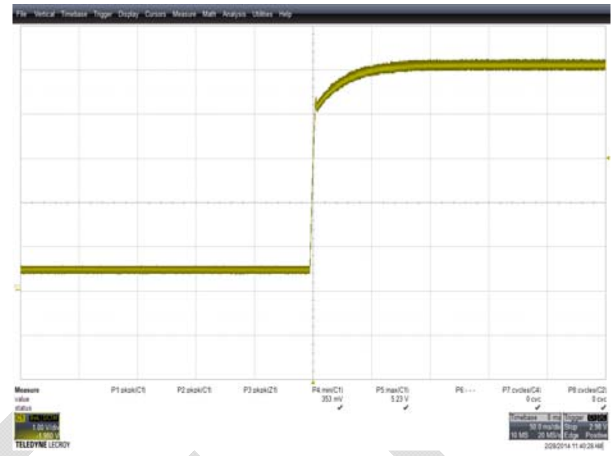

Figure 18 – Start-Up Profile, 115 VAC. Full Load.
1 V, 50 ms. / div.

Figure 19 – Start-Up Profile 230 VAC. Full Load.
1 V, 50 ms. / div.

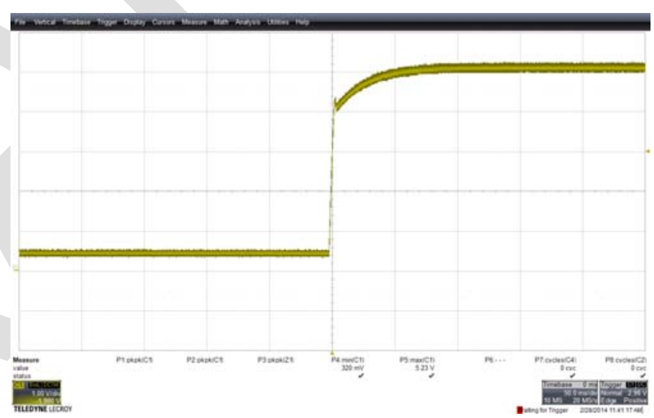

Figure 20 – Start-Up Profile, 265 VAC. Full Load.
1 V, 50 ms. / div.

10.3 Load Transient Response

10.3.1 50% Load to Full Load

Figure 21 – Transient Response, 90 VAC,
800 mA to 1600 mA.
Upper: V_{OUT} 1 V / div.
Lower: I_{OUT} 2 A, 200 ms / div.

Figure 22 – Transient Response, 115 VAC,
800 mA to 1600 mA.
Upper: V_{OUT} 1 V / div.
Lower: I_{OUT} 2 A, 200 ms / div.

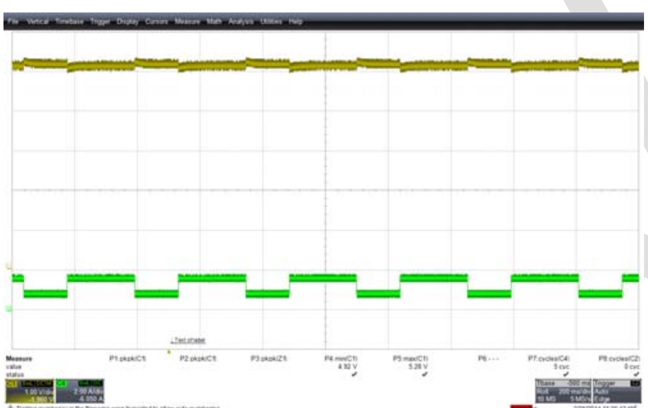

Figure 23 – Transient Response, 230 VAC,
800 mA to 1600 mA.
Upper: V_{OUT} 1 V / div.
Lower: I_{OUT} 2 A, 200 ms / div.

Figure 24 – Transient Response, 265 VAC,
800 mA to 1600 mA.
Upper: V_{OUT} 1 V / div.
Lower: I_{OUT} 2 A, 200 ms / div.

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10.3.2 Load Transient Response from 20 mA to Full Load

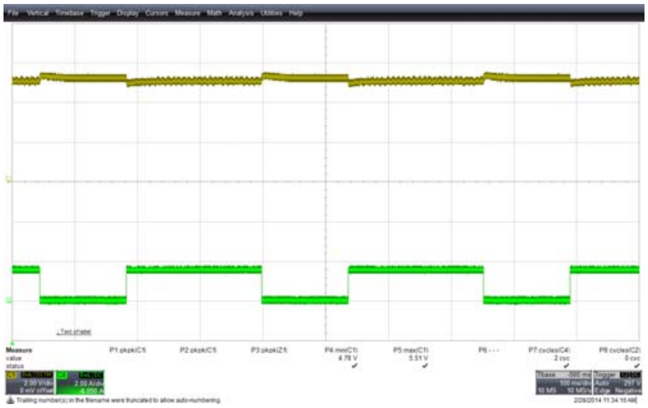

Figure 25 – Transient Response, 90 VAC,
20 mA to 1600 mA.
Upper: V_{OUT} 1 V / div.
Lower: I_{OUT} 2 A, 100 ms / div.

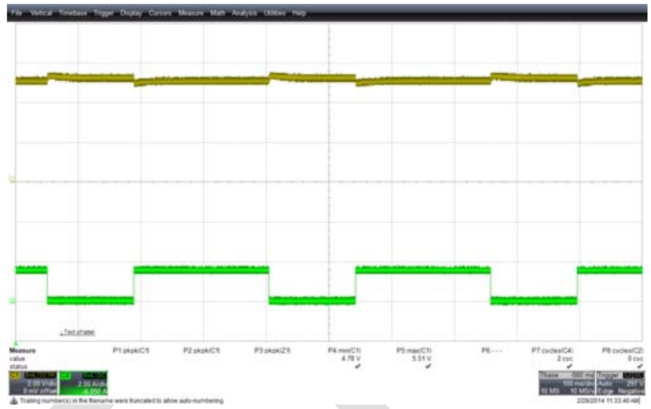

Figure 26 – Transient Response, 115 VAC,
20 mA to 1600 mA.
Upper: V_{OUT} 1 V / div.
Lower: I_{OUT} 2 A, 100 ms / div.

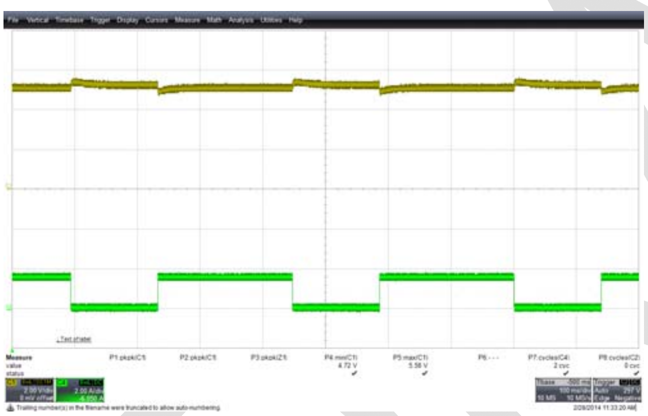

Figure 27 – Transient Response, 230 VAC,
20 mA to 1600 mA.
Upper: V_{OUT} 1 V / div.
Lower: I_{OUT} 2 A, 100 ms / div.

Figure 28 – Transient Response, 265 VAC,
20 mA to 1600 mA.
Upper: V_{OUT} 1 V / div.
Lower: I_{OUT} 2 A, 100 ms / div.

10.4 Output Ripple Measurements

11.4.1 Ripple Measurement Technique

A modified oscilloscope test probe was used to take output ripple measurements, in order to reduce the pickup of spurious signals. Using the probe adapter pictured below, the output ripple was measured with a 1 μF electrolytic, and a 0.1 μF ceramic capacitor connected as shown.

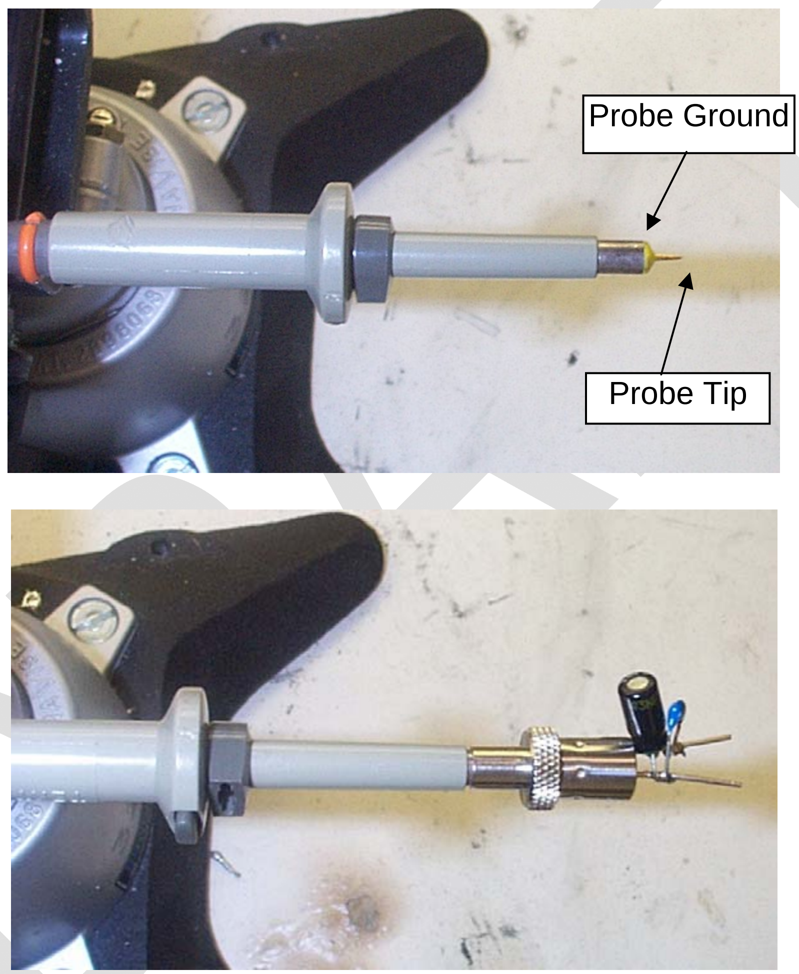

Figure 29 – Oscilloscope Probe Prepared for Ripple Measurement (End Cap and Ground Lead Removed).

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10.4.1 Measurement Results

10.4.2 8 W Output Ripple Measurement

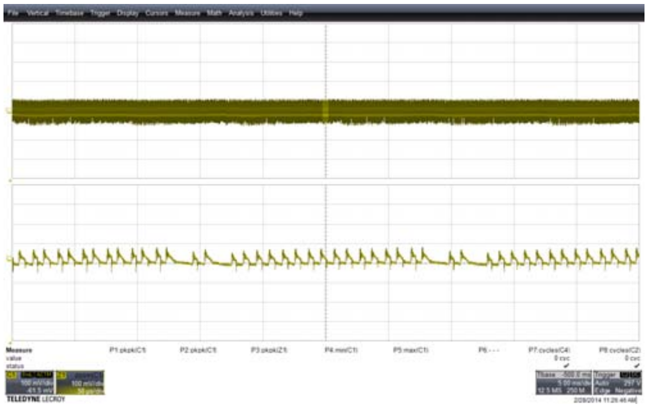

Figure 30 – Ripple, 85 VAC, Full Load.
Upper :5 ms, 100 mV / div.
Lower: 50 µs, 100 mV / div.

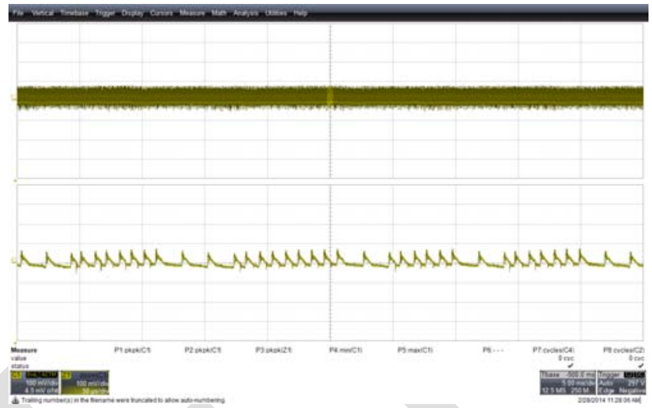

Figure 31 – Ripple, 115 VAC, Full Load.
Upper :5 ms, 100 mV / div.
Lower: 50 µs, 100 mV / div.

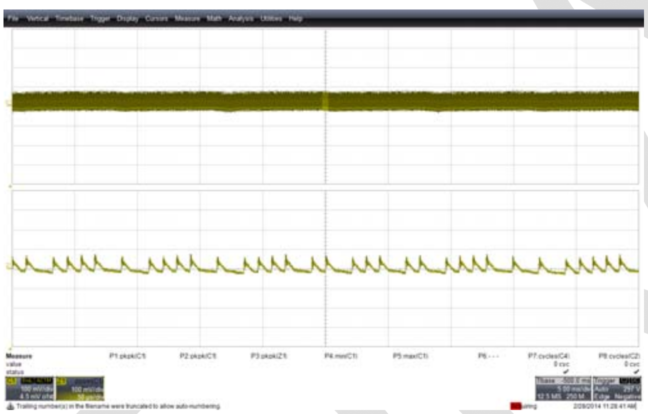

Figure 32 – Ripple, 230 VAC, Full Load.
Upper :5 ms, 100 mV / div.
Lower: 50 µs, 100 mV / div.

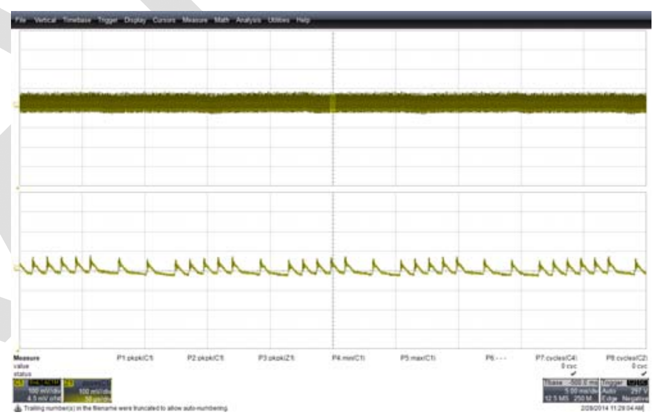

Figure 33 – Ripple, 265 VAC, Full Load.
Upper :5 ms, 100 mV / div.
Lower: 50 µs, 100 mV / div.

11.5 Output Voltage Ripple with 1 mW Load at 230 V_{IN}

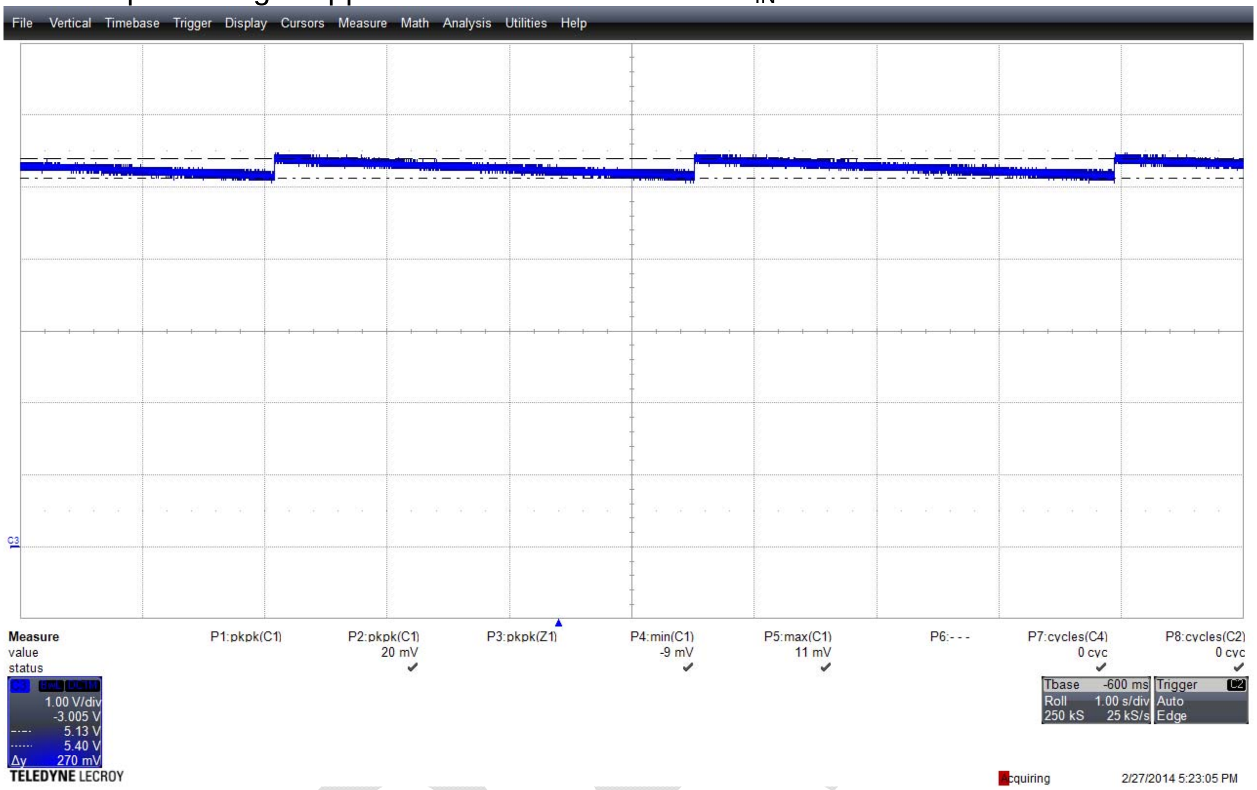

Figure 34 – Time: 1 s / div. Voltage: 1 V / div.

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11 Revision History

Date	Author	Revision	Description & changes	Reviewed
28-Feb-14	SK	1.0	Initial Release	Apps & Mktg

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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
Lindwurmstrasse 114
80337, Munich
Germany
Phone: +49-895-527-39110
Fax: +49-895-527-39200
e-mail: eurosales@powerint.com

JAPAN
Kosei Dai-3 Building
2-12-11, Shin-Yokohama,
Kohoku-ku, Yokohama-shi,
Kanagawa 222-0033
Japan
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 District
Taipei 11493, Taiwan R.O.C.
Phone: +886-2-2659-4570
Fax: +886-2-2659-4550
e-mail: taiwansales@powerint.com

CHINA (SHANGHAI)
Rm 2410, Charity Plaza, No. 88,
North Caoxi Road,
Shanghai, PRC 200030
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: +91-80-4113-8020
Fax: +91-80-4113-8023
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

EUROPE HQ
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)
3rd Floor, Block A,
Zhongtou International Business
Center, No. 1061, Xiang Mei Rd,
FuTian District, ShenZhen,
China, 518040
Phone: +86-755-8379-3243
Fax: +86-755-8379-5828
e-mail: chinasales@powerint.com

ITALY
Via Milanese 20, 3rd. Fl.
20099 Sesto San Giovanni
(MI) Italy
Phone: +39-024-550-8701
Fax: +39-028-928-6009
e-mail: eurosales@powerint.com

SINGAPORE
51 Newton Road,
#19-01/05 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