

# **Design Example Report**

Title	<5 mW No-load Input Power, 2.1 W CV/CC Charger Using LinkZero <sup>TM</sup> -LP LNK574DG	
Specification	85 VAC – 265 VAC Input; 6 V, 0.35 A Output	
Application	inkZero-LP Reference Design	
Author	Applications Engineering Department	
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#### Summary and Features

- Ultra low no-load consumption, <5 mW at 230 VAC
- Primary side CV/CC controller eliminates secondary side control and optocoupler, provides low cost, low part count solution.
- EcoSmart<sup>™</sup> 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
- FEEDBACK pin reference voltage varies with output load to provide excellent cross regulation as well as cable drop compensation.
- Meets EN550022 and CISPR-22 Class B conducted EMI with 10 dB margin.

PATENT INFORMATION

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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.



# 1 Introduction

This report describes a universal input, 6 V, 350 mA flyback power supply using a LNK574DG device from the 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	Тур	Max	Units	Comment
Input						
Voltage	V <sub>IN</sub>	85		265	VAC	2 Wire – no P.E.
Frequency	f <sub>LINE</sub>	47	50/60	64	Hz	
No-load Input Power				5	mW	230 VAC
Output						
Output Voltage	V <sub>OUT</sub>		6		V	See V-I Curves, Figure 9, for limits
Output Ripple Voltage				200	mV	20 MHz bandwidth
Output Current	Ι <sub>ουτ</sub>		350		mA	
Total Output Power						
Continuous Output Power	Pout		2.1		W	
Efficiency						
Average efficiency	η	67	70		%	
Environmental						
Conducted EMI		Mee	ts CISPR2	22B / EN58	5015B	
Safety		Desigr	ned to mee Cla	et IEC950, ass II	UL1950	
	DM	0.5			kV	1.2/50 μs surge, IEC 1000-4-5, Series Impedance:
Surge	СМ	1			kV	Differential Mode: $2 \Omega$ Common Mode: $12 \Omega$
Ambient Temperature	T <sub>AMB</sub>	-5		40	°C	Free convection, sea level



# 3 Circuit Diagram



Figure 2 – Schematic.



# 4 Circuit Description

This flyback power supply was designed around the LNK574DG, U1 in Figure 2. The output voltage is sensed through the bias winding and fed back to U1 through resistor divider R3 and R4. That feedback is used by U1 to maintain Constant Voltage (CV) regulation of the output.

# 4.1 Input Rectification and Filtering

Diodes D1-D4 rectifies the AC input which is then filtered by capacitors C1 and C2. Inductor L1, C1 and C2 form a pi ( $\pi$ ) filter that attenuates differential mode conducted EMI. Resistor R1 provides high frequency damping. Shielding techniques (E-Shield<sup>TM</sup>) were used in the construction of T1 to reduce common mode EMI displacement currents. This filter arrangement, the proprietary E-Shield techniques together with the IC frequency jitter function provide excellent EMI performance even without a Y capacitor or clamp network on the primary side.

## 4.2 LinkZero-LP Primary

The power supply utilizes simplified bias winding voltage feedback, enabled by LNK574DG ON/OFF control. The voltage across C5 is determined by the FEEDBACK (FB) pin reference voltage and the resistor divider formed by R3 and R4. The FB pin reference voltage, which varies with load, is set to 1.36 V at no load and gradually increases to 1.70 V at full load to provide good output load regulation as well as cable drop compensation. In the CV region, U1 enables/disables switching cycles to maintain the FB pin reference voltage. Diode D6 and low cost ceramic capacitor C5 provide rectification and filtering of the primary feedback winding waveform. At increased loads, beyond the maximum power threshold, the IC transitions into the Constant Current (CC) region. In this region, the FB pin voltage begins to reduce as the power supply output voltage falls. In order to maintain a constant output current, the internal oscillator frequency is reduced in this region until it reaches typically 48% of the starting frequency. 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.

## 4.3 Design of External Bias for LinkZero-LP

Diode D5 and R2 form the external bias circuit and although this is not necessary for the operation of the LinkZero-LP family, its use can help to significantly improve the average efficiency of a power supply, especially at 230 VAC. During steady-state operation the external bias circuit supplies the IC bias current. Resistor R2 is chosen such that the bias winding supplies 200  $\mu$ A to 300  $\mu$ A into the BP pin.

## 4.4 Primary Clamp and Transformer Construction

A clampless primary circuit is achieved due to the very tight tolerance current limit trimming techniques used in manufacturing the LNK574DG, plus the transformer construction techniques used. Peak drain voltage is therefore limited to typically less than



550 V at 265 VAC – providing significant margin to the 700 V maximum drain voltage (BV<sub>DSS</sub>).

#### 4.5 Output Rectification

Output rectification is provided by diode D7 and filtering is provided by capacitor C7. Resistor R5 and capacitor C6 provide high frequency filtering for improved EMI.

#### 4.6 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 C3 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, U1 powers up again and resumes switching. The no-load power consumption can be reduced further with a higher value for BP pin capacitor C3. If the load increases such that fewer than 160 cycles were skipped, the IC resumes normal operation.

When U1 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 off-time also determines the ripple on the output voltage. The total energy stored in C5 and C3 determine the PD off-time (and also the output ripple in PD mode). The typical choice for C5 is between 100 nF and 330 nF and for C3 is between 47 nF and 470 nF.



# 5 PCB Layout



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



Item	Qty	Ref Des	Description	Manufacturer P/N	Manufacturer
1	2	C1 C2	3.3 µF, 400 V, Electrolytic, (8 x 11.5)	TAQ2G3R3MK0811MLL3	Taicon
2	1	C3	220 nF, 50 V, Ceramic, X7R, 0805	GRM21BR71H224KA01L	Murata
3	1	C4	1000 pF, 50 V, Ceramic, X7R, 0805	ECJ-2VB1H102K	Panasonic
4	1	C5	220 nF, 50 V, Ceramic, X7R, 1206	ECJ-3YB1H224K	Panasonic
5	1	C6	220 pF, 100 V, Ceramic, X7R, 0805	ECJ-2VB2A221K	Panasonic
6	1	C7	330 $\mu F,$ 16 V, Electrolytic, Very Low ESR, 72 M $\Omega,$ (8 x 11.5)	EKZE160ELL331MHB5D	Nippon Chemi-Con
7	4	D1 D2 D3 D4	1000 V, 1 A, Rectifier, DO-41	1N4007-E3/54	Vishay
8	1	D5	75 V, 300 mA, Fast Switching, DO-35	1N4148TR	Vishay
9	1	D6	200 V, 1 A, Rectifier, Glass Passivated, DO-213AA (MELF)	DL4003-13-F	Diodes Inc
10	1	D7	50 V, 1 A, Schottky, DO-214AC	SS15-TP	Micro commercial
11	1	J3	6 ft, 26 AWG, 2.1 mm connector (custom)	3PH323A0	Anam
12	1	L1	1 mH, 0.15 A, Ferrite Core	SBCP-47HY102B	Tokin
13	1	R1	4.7 kΩ, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ472V	Panasonic
14	1	R2	82 kΩ, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ823V	Panasonic
15	1	R3	113 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF1133V	Panasonic
16	1	R4	9.09 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF9091V	Panasonic
17	1	R5	5.1 Ω, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ5R1V	Panasonic
19	1	RF1	10 Ω, 2 W, Fusible/Flame Proof Wire Wound CRF253-4 10R V		Vitrohm
20	1	T1	Bobbin, EF16, Horizontal, 9 pins (5x4)	EF16HP09-QO	TDK
21	1	U1	LinkZero-LP, SO-8	LNK574DG	Power Integrations

# 6 Bill of Materials

Note - All parts are RoHS compliant



# 7 Transformer Specification

### 7.1 Electrical Diagram



Figure 4 – Transformer Electrical Diagram.

### 7.2 Electrical Specifications

Electrical Strength	1 second, 60 Hz, from pins 1-5 to pins 6-9.	3000 VAC
Primary Inductance	Pins 5-4, all other windings open, measured at 100 kHz, 0.4 V <sub>RMS</sub> .	2.75 mH, ±10%
Resonant Frequency	Pins 5-4, all other windings open.	520 kHz (Min.)
Primary Leakage Inductance	Pins 4-5, with pins 7-9 shorted, measured at 100 kHz, 0.4 $V_{RMS}$ .	50 μH (Max.)

### 7.3 Materials

Item	Description
[1]	Core: PC44 EF16-Z, TDK or equivalent gapped for AL of 235.8 nH/T <sup>2</sup>
[2]	Bobbin: EE16X16H, Horizontal 9 pin
[3]	Magnet Wire: #35 AWG
[4]	Magnet Wire: #29 AWG
[5]	Triple Insulated Wire: #28 AWG
[6]	Tape: 3M 1298 Polyester Film, 2.0 mils thick, 9.8 mm wide
[7]	Varnish



# 7.4 Transformer Build Diagram



Figure 5 – Transformer Build Diagram.

### 7.5 Transformer Construction

<b>Bobbin Preparation</b>	Primary pin side of the bobbin orients to the left hand side.	
WD#1	Start on pin 2, wind 27 bifilar turns of item [3] from left to right. Wind with tight	
Feedback	tension across entire bobbin evenly. Finish on pin 1.	
Insulation	1 layer of tape [6] for insulation	
WD#2 Primary	Start on pin 4, wind 54 turns of item [3] from left to right. After finishing the first layer, placing one layer of tape [6]. Continue to wind the wire from right to left with another 54 turns. Finish on pin 5.	
Insulation	1 layer of tape [6] for insulation.	
WD #3 Balance Shield	Start on any pin on the secondary temporarily. Wind 9 trifilar turns of item [4], wind from right to left with tight tension uniformly, and connect end of winding to pin 5. Cut out wire connected to secondary side and leave this end not connected	
Insulation	1 layer of tape [6] for insulation.	
WD #4	Start at pin 9, wind 9 bifilar turns of item [5] from right to left. Wind uniformly. After	
Secondary	finishing the 9 <sup>th</sup> turn, bring the wire back and finish it on pin 8.	
Insulation	3 layers of tape [6] for insulation.	
Grind Core	Grind the core to get 2.75 mH. Secure the core with tape.	
Secure and Varnish	Secure the core with tape. Dip varnish for 3 minutes.	



# 8 Transformer Design Spreadsheet

LinkZero-LP 052410;					
Rev.1.0; Copyright					
Power Integrations	INDUT	INFO		LINUT	LINKZERO-LP 052410_Kev1-0.XIS; LINKZERO-LP
			OUIPUI	UNIT	Flyback Transformer Design Spreadsneet
		5	[		
VACMIN	85			Volts	Minimum AC Input Voltage
VACMAX	265			Volts	Maximum AC Input Voltage
fL	50			Hertz	AC Mains Frequency
VO	6.00			Volts cable (For CV/CC designs enter typical CV tolera limit)	
Ю	0.32			Amps	Power Supply Output Current (For CV/CC designs enter typical CC tolerance limit)
PO			1.92	Watts	Output Power (VO x IO + dissipation in output cable)
Feedback Type	BIAS		Bias Winding		Choose 'BIAS' for Bias winding feedback and 'OPTO' for Optocoupler feedback from the 'Feedback Type' drop down box at the top of this spreadsheet
Clampless design	YES		Clamples s		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
Ν	0.70		0.7		Efficiency Estimate at output terminals. For CV only designs enter 0.7 if no better data available
Z	0.45		0.45		Loss Allocation Factor (Secondary side losses / Total losses)
tC	2.90			mSecond s	Bridge Rectifier Conduction Time Estimate
CIN	10.00			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-LP VA	RIABLES				
LinkZero-LP	Auto		LNK574		LinkZero-LP device.
Chosen Device		LNK57 4			
ILIMITMIN			0.126	Amps	Minimum Current Limit
ILIMITMAX			0.146	Amps	Maximum Current Limit
fSmin			93000	Hertz	Minimum Device Switching Frequency
I^2fMIN			1664.64	A^2Hz	I^2f Minimum value (product of current limit squared and frequency is trimmed for tighter tolerance)
I^2fTYP			1849.6	A^2Hz	I <sup>^</sup> 2f typical value (product of current limit squared and frequency is trimmed for tighter tolerance)
VOR	78.00		78	Volts	Reflected Output Voltage
VDS			10	Volts	LinkZero-LP on-state Drain to Source Voltage
VD			0.5	Volts	Output Winding Diode Forward Voltage Drop
KP			1.60		Ripple to Peak Current Ratio (0.9 <krp<1.0 :<br="">1.0<kdp<6.0)< td=""></kdp<6.0)<></krp<1.0>
ENTER TRANSFORMER	R CORE/C	ONSTRUC	TION VARIA	ABLES	
Core Type	EF16		EF16		User-Selected transformer core
Core		EF16	DODDIN	P/N:	PC40EF16-Z
BODDIN			RORRIN	P/N:	EF16_BUBBIN
AE			0.201	cm/2	Core Effective Cross Sectional Area
			3.70		Ungenned Core Effective Inductores
RW/			100	mm	Bobbin Physical Winding Width
M			0	mm	Safety Margin Width (Half the Primary to Secondary
1			2		Creepage Distance)
NS	٩		<u>ک</u> ۵		Number of Secondary Turns
NB	0		28		Number of Bias winding turns



VB   19.50   Voits   Bits Winding Voitage     R1   113.00   k-ohms   Upper Resistor divider component between bias winding and FB pin of LinkGro-LP     R2   8.87   k-ohms   Events     RBP   86.6   k-ohms   Events     CFB   680.00   pF   Pin resistor (and/exe-LP     CBD   220.00   nF   BP incapacitor     MAX   37   Mainum DC Input Voltage     VMN   033   Amp   Awarage Pinary Pinary Inductance     VMN   01280   Amps   Pinary Inductance.     IP   0.1280   Amps   Pinary Inductance.     IP   0.1280   Amps   Pinary Inductance.     IP   22724   uHenries   Typical Pinary Inductance.     IP   108						
R1   113.00   k-ohm   Upper Resistor in the resistor divider component between base winding and FB pin of LinkZeroL-P     R2   8.87   k-ohm   Ever Resistor in the resistor divider component between base winding and FB pin of LinkZeroL-P     RBP   8.6.6   k-ohms   Optional BP pin resistor (divider component between base winding and FB pin of LinkZeroL-P     CFB   686.000   pF   FB pin resistor (brinve noise sensitivity)     CBP   20.000   nF   FB pin resistor (brinve noise sensitivity)     CBP   20.000   nF   FB pin resistor (brinve noise sensitivity)     CBP   20.000   nF   FB pin resistor (brinve noise sensitivity)     CBP   20.000   nF   FB pin resistor (brinve noise sensitivity)     CBP   20.000   nF   FB pin resistor (brinve noise sensitivity)     CBP   20.1200   nF   PB pin resistor (brinve noise sensitivity)     CBR   0.03   Amps   Awarage Primary Current     CURENT WAVEPORM SHAPE PARAMETERS   Maximum Duty Cycle   Awarage Primary Current     IAVG   0.1260   Amps   Primary Rinde Current     IRMS   0.1260   Amps   Primary Rinde Current     IP   10.8   Primary Rinde Current   Primary Rinde Current     IP   10.8   Primary Rinde Current	VB			19.50	Volts	Bias Winding Voltage
R2       Image: Set of the set of the set of the set of the deside of the provided of the set of t	R1			113.00	k-ohms	Upper Resistor in the resistor divider component between bias wiinding and FB pin of LinkZero-LP
RBP       86.6       k-ohms       Optional PP in resistor (connected between BP pin and bias winding) to improve efficiency         CFB       680.00       pF       FB pin resistor (improve noise sensitivity)         CBP       620.00       nF       BP pin capacitor         Recommended Bias       11N4003       nF       BP pin capacitor         DC INPUT VOLTAGE PARAMETERS       103       Volts       Maximum DC Input Voltage         VMAX       0.37       Volts       Maximum DC uput Voltage         CURRENT WAVEFORM SHAPE PARAMETERS       Current       Maximum Duty Cycle         DMAX       0.37       Maximum DC input Voltage         IP       0.1280       Amps       Nermap Primary Ringe Current         IR       0.1280       Amps       Primary RMS Current         IRAS       0.05       Amps       Primary Wolds Network of Turns         ALG       2.234       nH/T*2       Gapped Core Effective Inductance         MP       108       Primary Wolds Network of Turns         ALG       2.34       nH/T*2       Gapped Core Effective Inductance         BM       1832       Gause       ACF ILV Density for Core Loss Curves (0.5 X Peak to Peak)	R2			8.87	k-ohms	Lower Resistor in the resistor divider component between bias wiinding and FB pin of LinkZero-LP
CFB       680.00       pF       FB pin resistor (Improve noise sensitivity)         CBP       220.00       nF       BP pin capacitor         Recommended Bias       1N4003       Place this diode on the return leg of the bias winding for optimal EMI.         DC INPUT VOLTAGE PARAMETERS       103       Volts       Maximum DC Input Voltage         VMAX       375       Volts       Maximum DC Input Voltage         CURRENT WAVEFORM SHAPE PARAMETERS       0.37       Maximum DU Cycle         DMAX       0.1280       Amps       Primary Ripe Current         IP       0.1280       Amps       Primary Ripe Current         IR       0.1280       Amps       Primary Inductance tolerance         IR       0.1280       Amps       Primary Inductance tolerance         IR       0.1280       Amps       Primary Inductance tolerance         IP       108       Primary Vinding Number of Turns       ALG         ALG       234       nH/TY2       Gapped Core Effective Inductance         IP       1832       Gauss       Pack/turno Interestive Mox Core         BAC       916       Gauss       ACF Fux Density for Core Lass Curves (0.5 X Peak to Peak to Peak) <t< td=""><td>RBP</td><td></td><td></td><td>86.6</td><td>k-ohms</td><td>Optional BP pin resistor (connected between BP pin and bias winidng) to improve efficiency</td></t<>	RBP			86.6	k-ohms	Optional BP pin resistor (connected between BP pin and bias winidng) to improve efficiency
CBP       220.00       nF       BP pin capacitor optimal EML         Recommended Bias Diode       1N4003       Piace this diode on the return leg of the bias winding for optimal EML         DC INPUT VOLTAGE PARAMETERS       103       Volts       Maximum DC Input Voltage         VMAX       375       Volts       Maximum DLity Cycle         DMAX       0.37       Maximum Duty Cycle         IAVG       0.03       Amps       Average Primary Current         IP       0.1260       Amps       Minimum Peak Primary Current         IRMS       0.1260       Amps       Primary Ripple Current         IP_TOLERANCE       108       Primary Ripple Current       Primary Ripple Current         ALG       234       nH/Tr2       Gause Maximum Quertaing Flux Density, BM-2000 is recommended         BAC       916       Gause       Age Three Density, BM-2000 is recommended         Ur       1637       Relative Permeability of Ungapped Core         LG	CFB			680.00	pF	FB pin resistor (Improve noise sensitivity)
Recommended Bias       IN4003       Place this diade on the return leg of the bias winding for optimal EMI.         DC INPUT VOLTAGE PARAMETERS       103       Volts       Maximum DC Input Voltage         VMAX       375       Volts       Maximum DC Input Voltage         CURRENT WAVEFORM SHAPE PARAMETERS       0.37       Maximum Duty Cycle         GURRENT WAVEFORM SHAPE PARAMETERS       0.33       Amps         DMAX       0.1260       Amps       Minimum Dealt Primary Current         IP       0.1260       Amps       Primary RMS Current         IRMS       0.1260       Amps       Primary RMS Current         TRANSFORMER PRIMARY DESIGN PARAMETERS       Typical Primary Inductance: 4/- 10%.         LP       2724       uHenries       Typical Primary Inductance: 4/- 10%.         LP       108       Primary Winding Number of Turns       ALG         ALG       1032       Gauss       Recentive Correctors (JS X Peak to Peak)         BAC       916       Gauss       Relative Permeability of Ungapped Corre         ILG       0.14       mm       Estimated Tatal Insulation Thickness (JS X Peak to Peak)         BWE       2.0       mm       Maximum Order and promase (JS X Peak to Peak) </td <td>CBP</td> <td></td> <td></td> <td>220.00</td> <td>nF</td> <td>BP pin capacitor</td>	CBP			220.00	nF	BP pin capacitor
DC INPUT VOLTAGE PÅRAMETERS       Optimiser         VMIN       103       Volts       Minimum DC Input Voltage         VMAX       375       Volts       Maximum DC Input Voltage         CURRENT WAVEFORM SHAPE PARAMETERS       Maximum Duty Cycle       Maximum Duty Cycle         DMAX       0.37       Amps       Maximum Pask Primary Current         IP       0.1260       Amps       Primary RDV Cycle         IRMS       0.05       Amps       Primary RMS Current         IRMS       0.06       Amps       Primary RMS Current         TRANSFORMER PRIMARY DESIGN PARAMETERS       Primary Inductance tolerance       Primary Inductance tolerance         LP       108       Primary inductance tolerance       Maximum Operating Flux Density, BM<2000 is recommended	Recommended Bias			1N4003		Place this diode on the return leg of the bias winding for optimal FMI
TMIN       Total       103       Volts       Minimum DC Input Voltage         CURRENT WAVEFORM SHAPE PARAMETERS       375       Volts       Maximum DL Input Voltage         DMAX       0.37       Maximum DLity Cycle         DMAX       0.37       Maximum Duty Cycle         IAVG       0.37       Amps         IP       0.1260       Amps         IR       0.1260       Amps         IR       0.1260       Amps         IR       0.1260       Amps         IP       DLP       DESIGA PARAMETERS         LP       TOLERANCE       108         P/TOLERANCE       108       Primary Rinductance         IP       108       Primary Winding Number of Turns         ALG       234       nH/T+2       Gapped Core Effective Inductance         BM       1832       Gauss       Maximum Operating Flux Density, BM-2000 is recommended         Gauss       4       6       Gauss       Maximum Operating Flux Density, BM-2000 is recommended         BAC       916       Gauss       Maximum Operating Flux Density, BM-2000 is recommended       Neakinum Acutering totage Core         Ur       1637 </td <td>DC INPUT VOLTAGE P</td> <td>ARAMETE</td> <td>RS</td> <td></td> <td></td> <td></td>	DC INPUT VOLTAGE P	ARAMETE	RS			
TMAX       375       Voits       Maximum DC Input Voitage         CURRENT WAVEFORM SHAPE PARAMETERS        Maximum Duty Cycle          DMAX       0.03       Amps       Average Primary Current          IAVG       0.03       Amps       Average Primary Current          IP       0.1260       Amps       Primary RMS Current          IR       0.1260       Amps       Primary RMS Current          TRANSFORMER PRIMARY DESIGN PARAMETERS       Typical Primary Inductance. +/- 10%           LP_TOLERANCE       10       %       Primary Inductance. +/- 10%          LP_TOLERANCE       10       %       Primary Inductance. +/- 10%          LP_TOLERANCE       10       %       Primary Minding Number of Turns          ALG       234       nH/TV2       Sagped Core Efficitive Inductance.          BM       1832       Gauss       Flax Density for Core Loss Curves (0.5 X Peak to Peak)         ur       1637       Relative Permeability of Ungapped Core          LG       0.10       mm       Marufacuting tolgeracing problems - please verify with mag	VMIN			103	Volts	Minimum DC Input Voltage
CURRENT WAVEFORM SHAPE PARAMETERS       Maximum Duty Cycle         DMAX       0.37       Amps       Average Primary Current         IP       0.1260       Amps       Minimum Duty Cycle         IRM       0.1260       Amps       Minimum Deak Primary Current         IRM       0.1260       Amps       Primary RMS Current         IRMS       0.05       Amps       Primary Inductance. +/- 10%         LP       CURRANCE       10       %       Primary Inductance Iolerance         LP, TOLERANCE       10       %       Primary Inductance Iolerance         NP       108       Primary Winding Number of Turns         ALG       234       nH/T^2       Gapped Core Effective Inductance         BM       1832       Gauss       Relative Permeability of Ungapped Core         ur       1637       Relative Permeability of Ungapped Core         ur       1635       mm       Maximum Primary Wire Diameter including insulation         DD       0.185       mm       Estimated Total Insulation Thickness (Lo 2 1 firm thickness)         IR       0.04       mm       Estimated Total Insulation Thickness (Lo 2 1 firm thickness)         DIA       0.145	VMAX			375	Volts	Maximum DC Input Voltage
DMAX       0.37       Maximum Duty Cycle         IAVG       0.03       Amps       Average Primary Current         IP       0.1260       Amps       Mininum Peak Primary Ripple Current         IRMS       0.1260       Amps       Primary Ripple Current         IRMS       0.05       Amps       Primary Ripple Current         TRANSFORMER PRIMARY DESIGN PARAMETERS       Typical Primary Inductance. 4/- 10%       Primary Inductance tolerance         UP       2724       UHenries       Typical Primary Inductance tolerance         NP       108       Primary Minding Number of Turns         ALG       234       nH/T^2       Gapped Core Eflective Inductance         BM       1832       Gauss       Maximum Operating Flux Density, BM-2000 is recommended         BAC       916       Gauss       AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)         Ur       1637       Relative Permeability of Ungapped Core         LG       0.10       mm       Maximum Turnary Wire Diameter including insulation         INS       0.04       mm       Effective Bobbin Widh magnetics vendor. Increase ILG > 0.1 mm         INS       0.04       mm       Bare conductor diameter <t< td=""><td>CURRENT WAVEFORM</td><td>SHAPE P</td><td>ARAMET</td><td>ERS</td><td></td><td></td></t<>	CURRENT WAVEFORM	SHAPE P	ARAMET	ERS		
IAVG   0.03   Amps   Average Primary Current     IP   0.1260   Amps   Primary Ripple Current     IRR   0.05   Amps   Primary RMS Current     IRMS   0.05   Amps   Primary RMS Current     IRMS   0.05   Amps   Primary RMS Current     IRMS   0.05   Amps   Primary MMS Current     IP   2724   utlenries   Typical Primary Inductance tolerance     IP   108   Primary Mundine tot Turns     ALG   234   nH/T*2   Gapped Core Effective Inductance     BM   1832   Gauss   Racimum Oragening Flux Density, BM<2000 is recommended	DMAX			0.37		Maximum Duty Cycle
IP   0.1260   Amps   Minimum Peak Primary Rupple Current     IR   0.1260   Amps   Primary Rupple Current     IRMS   0.05   Amps   Primary Rupple Current     IRMSSORMER PRIMARY DESIGN PARAMETERS   Typical Primary Inductance. +/- 10%     LP   2724   UHenries   Typical Primary Inductance to encompare the second sec	IAVG			0.03	Amps	Average Primary Current
IR       0.1260       Amps       Primary Ripple Current         IRMS       0.05       Amps       Primary RMS Current         TRANSFORMER PRIMARY DESIGN PARAMETERS       Typical Primary Inductance. 1/- 10%         LP_TOLERANCE       10       %         NP       108       Primary Minding Number of Turns         ALG       234       nH/T^2       Gapped Core Effective Inductance         BM       1832       Gauss       Maximum Operating Flux Density, BM-2000 is recommended         BAC       916       Gauss       AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)         ur       1637       Relative Permeability of Ungapped Core         LG       0.10       mm       magnetics vendor. Increase LG > 0.1 mm (increase NS, decrease VOR, bigger Core)         BWE       20       mm       Effective Bobion Width         OD       0.185       mm       Maximum Primary Wire Gauge (Rounded to next smaller standard AWG value)         DIA       0.04       mm       Bare conductor diameter         CM       32       Cmils       Bare conductor diameter         CMA       10/6       676       mp ser conductor diameter         DIA       0.145	IP			0.1260	Amps	Minimum Peak Primary Current
IRMS   0.05   Amps   Primary RMS Current     TRANSFORMER PRIMARY DESIGN PARAMETERS   10   %   Primary Inductance tolerance     LP_TOLERANCE   10   %   Primary Inductance tolerance     NP   108   Primary Inductance tolerance     ALG   234   nH/T^2   Gapped Core Effective Inductance     BM   1832   Gauss   Maximum Operating Flux Density, BM-2000 is recommended     BAC   916   Gauss   AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)     ur   1637   Relative Permeability of Ungapped Core     LG   0.10   mm   manufacturing tolerancing problems - please verify with magnetics vendor. Increase LG > 0.1 mm (increase NS, decrease VOR, bigger Core)     BWE   20   mm   Effective Bobbin Witch     OD   0.145   mm   Maximum Primary Wire Diameter including insulation     INS   0.145   mm   Bare conductor diameter     AWG   335   AWG   Primary Wire Gauge (Rounded to next smaller standard AWG alue)     CMA   Info   676   Cmils/A     CMA   0.53   Amps   Secondary Current     INS   0.62   Amps   Secondary Current     Gauss   1.51   Amps   Secondary Current     CMA <td< td=""><td>IR</td><td></td><td></td><td>0.1260</td><td>Amps</td><td>Primary Ripple Current</td></td<>	IR			0.1260	Amps	Primary Ripple Current
TRANSFORMER PRIMARY DESIGN PARAMETERS       LP_TOLERANCE     10     2724     ulterries     Typical Primary Inductance. +/- 10%       LP_TOLERANCE     108     Primary Inductance tolerance       NP     108     Primary Winding Number of Turns       ALG     234     nH/T^2     Gapped Core Effective Inductance       BM     1832     Gauss     Maximum Operating Flux Density, BM-2000 is recommended       BAC     916     Gauss     AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)       ur     1637     Relative Permeability of Ungapped Core       LG     0.10     mm     manufacturing tolerancing problems - please verify with magnetics vendor. Increase LG > 0.1 mm (increase NS, decrease VOR, bigger Core)       BWE     20     mm     Effective Bobin Width       OD     0.185     mm     Maximum Primary Wire Diameter including insulation       INS     0.04     mm     Effective Bobin Width       OD     0.145     mm     Bare conductor dimeter       AWG     35     AWG     AWG avalue)     CAN DeCREASE CMA < 500 (decrease Lprimary layers), increase NS, use smaller Core)	IRMS			0.05	Amps	Primary RMS Current
LP   2724   UHenrics   Typical Primary Inductance. +/- 10%     LP_TOLERANCE   10   %   Primary Inductance tolerance     NP   108   Primary Inductance tolerance     ALG   234   nH/T^2   Gapped Core Effective Inductance     BM   1832   Gauss   Maximum Operating Flux Density, BM<2000 is recommended	TRANSFORMER PRIMA	<b>RY DESIG</b>	SN PARAN	<b>IETERS</b>		
LP_TOLERANCE     10     %     Primary inductance tolerance       NP     108     108     Primary Winding Number of Turns       ALG     234     nH/Tr2     Gapea Core Effective Inductance       BM     1832     Gauss     Maximum Operating Flux Density, BM<2000 is recommended	LP			2724	uHenries	Typical Primary Inductance. +/- 10%
NP   Image: NP   Image: NP     ALG   234   nH/T^2   Gapped Core Effective Inductance     BM   1832   Gauss   Maximum Operating Flux Density, BM<2000 is recommended     BAC   916   Gauss   AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)     ur   1637   Relative Permeability of Ungapped Core     LG   0.10   mm   III Info. Gap sizes below 0.1 mm may cause manufacturing tolerancing problems - please verify with magnetics vendor. Increase LG > 0.1 mm (increase NS, decrease VOR, bigger Core)     BWE   20   mm   Effective Bobbin With     OD   0.185   mm   Maximum Primary Wire Diameter including insulation     INS   0.04   mm   Estimated Total Insulation Thickness (= 2 * film thickness)     DIA   0.145   mm   Bare conductor diameter     AWG   35   AWG   Primary Wire Gauge (Rounded to next smaller standard AWG and info     CMA   Info   676   Cmils/A     CMA   Info   676   Cmils/A     IRIPPLE   0.53   Amps     LIRPPLE   0.53   Amps     Secondary RMS current   Secondary RMS Ripple Current     ISRS   0.29   Amps     ODS   124   Cmils     Secondary Max numu Outside Diameter for	LP_TOLERANCE			10	%	Primary inductance tolerance
ALG   Capped Core Effective Inductance     BM   1832   Gauss   Gauss   Maximum Operating Flux Density, BM<2000 is recommended     BAC   916   Gauss   AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)     ur   1637   Relative Perneability of Ungapped Core     LG   0.10   manufacturing tolerancing problems - please verify with manufacturing tolerancing for problems - please verify with manufacturing tolerancing for planeter including insulation     NKE   0.145   mm   Harcine Stresse Core Maximum Planeter     GMA   10.145   mm   Bare conductor effective area in circular mils     CMA   1nfo   676   Cmils/A	NP			108		Primary Winding Number of Turns
BM   1832   Gauss   Maximum Operating Flux Density, BM<2000 is recommended     BAC   916   Gauss   AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)     ur   1637   Relative Permeability of Ungapped Core     LG   0.10   mm   Relative Permeability of Ungapped Core     BWE   20   mm   Effective Permeability of Ungapped Core)     BWE   20   mm   Effective Bobbin Width     OD   0.185   mm   Maximum Primary Wire Diameter including insulation     INS   0.04   mm   Estimated Total Insulation Thickness (= 2* film thickness)     DIA   0.145   mm   Bare conductor diameter     AWG   35   AWG   Primary Wire Gauge (Rounded to next smaller standard AWG value)     CMA   1nfo   676   Cmils   Bare conductor effective area in circular mils     CMA   1nfo   676   Cmils   AMD ECREASE CMA < 500 (decrease L(primary layers), increase NS, use smaller Core)     TRANSFORMER SECONDARY DESIGN PARAMETERS   151   Amps   Secondary RMS Current     IRIPPLE   0.52   Amps   Secondary RMS Current     ISRMS   0.62   Amps   Secondary RMS Current     IRIPPLE   0.53   Amps   Output Capacitor RMS Ripple Current     ODS <td>ALG</td> <td></td> <td></td> <td>234</td> <td>nH/T^2</td> <td>Gapped Core Effective Inductance</td>	ALG			234	nH/T^2	Gapped Core Effective Inductance
BAC   916   Gauss   AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)     ur   1637   Relative Permeability of Ungapped Core     LG   0.10   mm   Relative Permeability of Ungapped Core     LG   0.10   mm   III Info. Gays Sizes below 0.1 mm may cause manufacturing tolerancing problems - please verify with magnetics vendor. Increase LG > 0.1 mm (increase NS, decrease VOR, bigger Core)     BWE   20   mm   Effective Bobbin Width     OD   0.185   mm   Maximum Prinary Wire Diameter including insulation     INS   0.04   mm   Estimated Total Insulation Thickness (= 2 * film thickness)     DIA   0.145   mm   Bare conductor diameter     AWG   35   AWG   Primary Wire Gauge (Rounded to next smaller standard AWG value)     CMA   1nfo   676   Cmils/A   Bare conductor effective area in circular mils     CMA   1nfo   676   Cmils/A   CAN DECREASE CMA < 500 (decrease L(primary layers), increase Ns, use smaller Core)     TRANSFORMER SECONDARY DESIGN PARAMETERS   1.51   Amps   Secondary RMS Current     ISRMS   0.62   Amps   Secondary RMS Current     ISRMS   0.62   Amps   Secondary Current     CMS   1.24   Cmils   Secondary Mins Cauge (Rounded up to next larger standard AWG value)<	ВМ			1832	Gauss	Maximum Operating Flux Density, BM<2000 is recommended
ur   1637   Relative Permeability of Ungapped Core     LG   0.10   mm   Relative Permeability of Ungapped Core     LG   0.10   mm   manufacturing tolerancing problems - please verify with magnetics vendor. Increase LG > 0.1 mm (increase NS, decrease VOR, bigger Core)     BWE   20   mm   Effective Bobbin Width     OD   0.185   mm   Maximum Primary Wire Diameter including insulation     INS   0.04   mm   Estimated Total Insulation Thickness (= 2 * film thickness)     DIA   0.145   mm   Bare conductor diameter     AWG   35   AWG   Primary Wire Gauge (Rounded to next smaller standard AWG value)     CM   32   Cmils   Bare conductor diameter     Info   676   Cmils/A   CAN DECREASE CMA < 500 (decrease L(primary layers), increase NS, use smaller Core)	BAC			916	Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
LG   0.10   mm   !!! Info. Gap sizes below 0.1 mm may cause manufacturing tolerancing problems - please verify with magnetics vendor. Increase LG > 0.1 mm (increase NS, decrease VOR,bigger Core)     BWE   20   mm   Effective Bobbin With Maximum Primary Wire Diameter including insulation     DD   0.185   mm   Maximum Primary Wire Diameter including insulation     INS   0.04   mm   Estimated Total Insulation Thickness (= 2* film thickness)     DIA   0.145   mm   Bare conductor diameter     AWG   35   AWG   Primary Wire Gauge (Rounded to next smaller standard AWG value)     CM   32   Cmils   Bare conductor effective area in circular mils     CMA   Info   676   Cmils/A Cmils/A   CAN DECREASE CMA < 500 (decrease L(primary layers), increase NS, use smaller Core)     TRANSFORMER SECONDARY DESIGN PARAMETERS   Umped parameters   Ispendent     Lumped parameters   1.51   Amps   Peak Secondary Current     ISP   1.51   Amps   Secondary RMS Current     ISPNS   0.62   Amps   Secondary Current     ISP   1.51   Amps   Output Capacitor RMS Ripple Current     CMS   0.29   AWG   Secondary Minimum Bare Conductor Diameter     ODS   0.21   Mm   Secondary Minimum Bare Conductor Diameter  <	ur			1637		Relative Permeability of Ungapped Core
BWE   20   mm   Effective Bobin Width     OD   0.185   mm   Maximum Primary Wire Diameter including insulation     INS   0.04   mm   Estimated Total Insulation Thickness (= 2 * film thickness)     DIA   0.145   mm   Bare conductor diameter     AWG   35   AWG   Primary Wire Gauge (Rounded to next smaller standard AWG value)     CM   32   Cmils   Bare conductor effective area in circular mils     CMA   Info   676   Cmils/A   CAN DECREASE CMA < 500 (decrease L(primary layers), increase NS, use smaller Core)	LG			0.10	mm	III Info. Gap sizes below 0.1 mm may cause manufacturing tolerancing problems - please verify with magnetics vendor. Increase LG > 0.1 mm (increase NS, deprese VOR bigger Corp.)
DNL   20   Inim   Delicities Boold Within     OD   0.185   mm   Maximum Primary Wire Diameter including insulation     INS   0.04   mm   Estimated Total Insulation Thickness (= 2 * film thickness)     DIA   0.145   mm   Bare conductor diameter     AWG   35   AWG   Primary Wire Gauge (Rounded to next smaller standard AWG value)     CM   32   Cmils   Bare conductor effective area in circular mils     CMA   Info   676   Cmils/A mp   CAN DECREASE CMA < 500 (decrease L(primary layers), increase NS, use smaller Core)	BW/E			20	mm	Effective Robbin Width
INS     0.04     mm     Bakantain Tinday Ti				0.185	mm	Maximum Primary Wire Diameter including insulation
DIA     0.145     mm     Bare conductor diameter       AWG     35     AWG     Primary Wire Gauge (Rounded to next smaller standard AWG value)       CM     32     Cmils     Bare conductor effective area in circular mils       CMA     Info     676     Cmils/A     CAN DECREASE CMA < 500 (decrease L(primary layers), increase NS, use smaller Core)	INS			0.04	mm	Estimated Total Insulation Thickness (= 2 * film thickness)
AWG   35   AWG   Primary Wire Gauge (Rounded to next smaller standard AWG value)     CM   32   Cmils   Bare conductor effective area in circular mils     CMA   Info   676   Cmils/A   CAN DECREASE CMA < 500 (decrease L(primary layers), increase NS, use smaller Core)				0 145	mm	Bare conductor diameter
CM     32     Cmils     Bare conductor effective area in circular mils       CMA     Info     676     Cmils/A     CAN DECREASE CMA < 500 (decrease L(primary layers), increase NS, use smaller Core)	AWG			35	AWG	Primary Wire Gauge (Rounded to next smaller standard
CMAInfo32Cmils/A mpDate conductor enective area in circular milsCMAInfo676Cmils/A mpCAN DECREASE CMA < 500 (decrease L(primary layers),increase NS,use smaller Core)TRANSFORMER SECONDARY DESIGN PARAMETERSLumped parameters1.51AmpsPeak Secondary CurrentISP1.51AmpsSecondary RMS CurrentIRIPPLE0.53AmpsOutput Capacitor RMS Ripple CurrentCMS124CmilsSecondary Bare Conductor minimum circular milsAWGS29AWGSecondary Wire Gauge (Rounded up to next larger standard AWG value)DIAS0.29mmSecondary Maximum Outside Diameter for Triple Insulated WireINSS0.41mmMaximum Secondary Insulation Wall ThicknessVDRAIN-VoltsPeak 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.PIVS37VoltsOutput Rectifier Maximum Peak Inverse Voltage	CM			22	Cmila	Awg value)
CMAInfo676Cmms ACMA DECICACE CMARCOUCLASE Contracts of decrease Epinitially layers), increase NS, use smaller Core)TRANSFORMER SECONDARY DESIGN PARAMETERSLumped parametersISP1.51AmpsPeak Secondary CurrentISRMS0.62AmpsSecondary RMS CurrentIRIPPLE0.53AmpsOutput Capacitor RMS Ripple CurrentCMS124CmilsSecondary Bare Conductor minimum circular milsAWGS29AWGSecondary Wire Gauge (Rounded up to next larger standard AWG value)DIAS0.29mmSecondary Minimum Bare Conductor DiameterODS1.11mmSecondary Maximum Outside Diameter for Triple Insulated WireINSS0.41mmMaximum Secondary Insulation Wall ThicknessVDRAINVoltsPeak 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.PIVS37VoltsOutput Rectifier Maximum Peak Inverse Voltage	CIVI			32	Cmils/A	Bare conductor effective area in circular fills CAN DECREASE CMA $< 500$ (decrease L (primary)
TRANSFORMER SECONDARY DESIGN PARAMETERS       Lumped parameters     ISP     1.51     Amps     Peak Secondary Current       ISRMS     0.62     Amps     Secondary RMS Current       IRIPPLE     0.53     Amps     Output Capacitor RMS Ripple Current       CMS     124     Cmils     Secondary Bare Conductor minimum circular mils       AWGS     29     AWG     Secondary Wire Gauge (Rounded up to next larger standard AWG value)       DIAS     0.29     mm     Secondary Minimum Bare Conductor Diameter       ODS     1.11     mm     Secondary Maximum Outside Diameter for Triple Insulated Wire       INSS     0.41     mm     Maximum Secondary Insulation Wall Thickness       VDRAIN     -     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     37     Volts     Output Rectifier Maximum Peak Inverse Voltage	CMA		Info	676	mp	lavers).increase NS.use smaller Core)
Lumped parameters         ISP       1.51       Amps       Peak Secondary Current         ISRMS       0.62       Amps       Secondary RMS Current         IRIPPLE       0.53       Amps       Output Capacitor RMS Ripple Current         CMS       124       Cmils       Secondary Bare Conductor minimum circular mils         AWGS       29       AWG       Secondary Wire Gauge (Rounded up to next larger standard AWG value)         DIAS       0.29       mm       Secondary Minimum Bare Conductor Diameter         ODS       1.11       mm       Secondary Maximum Outside Diameter for Triple Insulated Wire         INSS       0.41       mm       Maximum Secondary Insulation Wall Thickness         VOLTAGE STRESS PARAMETERS       -       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       37       Volts       Output Rectifier Maximum Peak Inverse Voltage	TRANSFORMER SECO	NDARY DE	SIGN PA	RAMETERS		
ISP1.51AmpsPeak Secondary CurrentISRMS0.62AmpsSecondary RMS CurrentIRIPPLE0.53AmpsOutput Capacitor RMS Ripple CurrentCMS124CmilsSecondary Bare Conductor minimum circular milsAWGS29AWGSecondary Wire Gauge (Rounded up to next larger standard AWG value)DIAS0.29mmSecondary Minimum Bare Conductor DiameterODS1.11mmSecondary Maximum Outside Diameter for Triple Insulated WireINSS0.41mmMaximum Secondary Insulation Wall ThicknessVDRAIN-VoltsPeak 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.PIVS37VoltsOutput Rectifier Maximum Peak Inverse Voltage	Lumped parameters					
ISRMS     0.62     Amps     Secondary RMS Current       IRIPPLE     0.53     Amps     Output Capacitor RMS Ripple Current       CMS     124     Cmils     Secondary Bare Conductor minimum circular mils       AWGS     29     AWG     Secondary Wire Gauge (Rounded up to next larger standard AWG value)       DIAS     0.29     mm     Secondary Minimum Bare Conductor Diameter       ODS     1.11     mm     Secondary Maximum Outside Diameter for Triple Insulated Wire       INSS     0.41     mm     Maximum Secondary Insulation Wall Thickness       VOLTAGE STRESS PARAMETERS     -     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     37     Volts     Output Rectifier Maximum Peak Inverse Voltage	ISP			1.51	Amps	Peak Secondary Current
IRIPPLE     0.53     Amps     Output Capacitor RMS Ripple Current       CMS     124     Cmils     Secondary Bare Conductor minimum circular mils       AWGS     29     AWG     Secondary Wire Gauge (Rounded up to next larger standard AWG value)       DIAS     0.29     mm     Secondary Minimum Bare Conductor Diameter       ODS     1.11     mm     Secondary Maximum Outside Diameter for Triple Insulated Wire       INSS     0.41     mm     Maximum Secondary Insulation Wall Thickness       VOLTAGE STRESS PARAMETERS     -     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     37     Volts     Output Rectifier Maximum Peak Inverse Voltage	ISRMS			0.62	Amps	Secondary RMS Current
CMS     124     Cmils     Secondary Bare Conductor minimum circular mils       AWGS     29     AWG     Secondary Wire Gauge (Rounded up to next larger standard AWG value)       DIAS     0.29     mm     Secondary Minimum Bare Conductor Diameter       ODS     1.11     mm     Secondary Maximum Outside Diameter for Triple Insulated Wire       INSS     0.41     mm     Maximum Secondary Insulation Wall Thickness       VOLTAGE STRESS PARAMETERS     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     37     Volts     Output Rectifier Maximum Peak Inverse Voltage	IRIPPLE			0.53	Amps	Output Capacitor RMS Ripple Current
AWGS   29   AWG   Secondary Wire Gauge (Rounded up to next larger standard AWG value)     DIAS   0.29   mm   Secondary Minimum Bare Conductor Diameter     ODS   1.11   mm   Secondary Maximum Outside Diameter for Triple Insulated Wire     INSS   0.41   mm   Maximum Secondary Insulation Wall Thickness     VOLTAGE STRESS PARAMETERS   0.41   mm   Maximum Secondary Insulation Wall Thickness     VDRAIN   -   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   37   Volts   Output Rectifier Maximum Peak Inverse Voltage	CMS			124	Cmils	Secondary Bare Conductor minimum circular mils
DIAS     0.29     mm     Secondary Minimum Bare Conductor Diameter       ODS     1.11     mm     Secondary Maximum Outside Diameter for Triple Insulated Wire       INSS     0.41     mm     Maximum Secondary Insulation Wall Thickness       VOLTAGE STRESS PARAMETERS     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     37     Volts     Output Rectifier Maximum Peak Inverse Voltage	AWGS			29	AWG	Secondary Wire Gauge (Rounded up to next larger standard AWG value)
ODS   1.11   mm   Secondary Maximum Outside Diameter for Triple Insulated Wire     INSS   0.41   mm   Maximum Secondary Insulation Wall Thickness     VOLTAGE STRESS PARAMETERS   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   37   Volts   Output Rectifier Maximum Peak Inverse Voltage	DIAS			0.29	mm	Secondary Minimum Bare Conductor Diameter
INSS   0.41   mm   Maximum Secondary Insulation Wall Thickness     VOLTAGE STRESS PARAMETERS   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   37   Volts   Output Rectifier Maximum Peak Inverse Voltage	ODS			1.11	mm	Secondary Maximum Outside Diameter for Triple
VOLTAGE STRESS PARAMETERS       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       37       Volts       Output Rectifier Maximum Peak Inverse Voltage	INSS			0.41	mm	Maximum Secondary Insulation Wall Thickness
VDRAIN     -     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     37     Volts     Output Rectifier Maximum Peak Inverse Voltage	VOLTAGE STRESS PAR	RAMETER	S			
PIVS 37 Volts Output Rectifier Maximum Peak Inverse Voltage	VDRAIN			-	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			37	Volts	Output Rectifier Maximum Peak Inverse Voltage



# 9 Performance Data

The ON/OFF control scheme employed by LinkZero-LP helps to yield virtually constant efficiency across the 25% to 100% load range required for compliance with EPA, CEC, CECP and AGO energy efficiency standards for external power supplies (EPS). This performance is automatic with ON/OFF control. There are no special burst modes that require the designer to consider specific thresholds within the load range in order to achieve compliance with global energy efficiency standards.

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



# 9.1 Efficiency

Figure 6 – Efficiency vs. Output Current, Room Temperature, 60 Hz.



Percent of Full Load	Efficier	ncy (%)
	115 VAC	230 VAC
25	74.9	68.9
50	74.6	70.0
75	73.7	70.9
100	72.9	70.2
Average	74.0	70.0
US EISA (2007) requirement	5	7
ENERGY STAR 2.0 requirement	6	7

#### 9.2 Active Mode CEC Measurement Data

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/EP
SupplyEffic TestMethod 0804.pdf		

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

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



## 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 1<sup>st</sup>, 2008 must meet minimum active mode efficiency and no load input power limits.

#### Active Mode Efficiency Standard Models

Nameplate Output (Po)	Minimum Efficiency in Active Mode of Operation
< 1 W	$0.5 \times P_{O}$
$\geq$ 1 W to $\leq$ 51 W	$0.09 \times \ln (P_0) + 0.5$
> 51 W	0.85

In = natural logarithm

#### No-load Energy Consumption

Nameplate Output (Po)	Maximum Power for No-load AC-DC EPS		
All	$\leq$ 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 1<sup>st</sup>, 2008. Active Mode Efficiency Standard Models

Nameplate Output (Po) Minimum Efficiency in Active Mode of Oper		
≤ 1 W	$0.48 \times P_{O} + 0.14$	
$>$ 1 W to $\leq$ 49 W	0.0626 × In (P <sub>o</sub> ) + 0.622	
> 49 W	0.87	

In = natural logarithm

#### Active Mode Efficiency Low Voltage Models (V<sub>O</sub><6 V and $I_O \ge 550$ mA)

Nameplate Output (Po)	Minimum Efficiency in Active Mode of Operation
≤ 1 W	0.497 × P <sub>0</sub> + 0.067
$>$ 1 W to $\leq$ 49 W	0.075 × ln (P <sub>o</sub> ) + 0.561
> 49 W	0.86

In = natural logarithm

#### No-load Energy Consumption (both models)

Nameplate Output (Po)	Maximum Power for No-load AC-DC EPS	
0 to < 50 W	$\leq$ 0.3 W	
$\geq$ 50 W to $\leq$ 250 W	$\leq$ 0.5 W	



# 9.3 No-load Input Power



Figure 7 – No-load Input Power vs. Input Line Voltage, Room Temperature, 50 Hz.



### 9.4 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 8 – Available Output Power for 0.2 W, 0.5 W, 1 W and 2 W Input Power.



## 9.5 Line and Load Regulation



Figure 9 – Load and Line Regulation, Room Temperature.



# **10 Thermal Performance**

Temperature measurements of key components were taken using T-type thermocouples. The thermocouples were soldered directly to a SOURCE pin of the LNK574DG device and to the cathode of the output rectifier D7. The thermocouples were glued to the external core and winding surfaces of transformer T1.

ltom	Temperature °C		
item	85 VAC	265 VAC	
Ambient Inside Box*	51.0	51.0	
LNK574DG	72.0	90.0	
Transformer	70.0	73.0	
Output Diode	63.0	67.0	

\*To simulate operation inside sealed enclosure at 40 °C external ambient.

These results show that all the parts in the board have thermal margin to run at 50  $^{\rm o}{\rm C}$  ambient.



# 11 Waveforms



#### 11.1 Drain Voltage and Current, Normal Operation

### 11.2 Output Voltage Start-Up Profile

Start-up into full resistive load and no-load were both verified. An 18  $\Omega$  resistor was used for the load, to maintain a 0.35 A under steady-state conditions.







Figure 13 – Start-Up Profile, 230 VAC. Fast Trace is at No-load. Slower Trace is at Maximum Load. 1 V, 5 ms / div.





#### 11.3 Drain Voltage and Current Start-Up Profile



Figure 15 – 265 VAC Input and Maximum Load. Upper:  $V_{DRAIN}$ , 200 V / div. Lower: I<sub>DRAIN</sub>, 0.1 A, 1 ms / div.



# 11.4 Load Transient Response





	2010/07/22 11:39:17		NORM:100kS/s	100ms/div	
	Stopped	T.		(100ms/div)	
					CH1: OFF
					5V/div 10:1
		+ + +			DC 0.00V
				1	CH2: OFF
					200V/div 100:1
			. : <b>,∕™</b>		DC 0V
٩Ļ	Viet and the second second	N .	Contraction of the local division of the loc		CH3: ON
					200mV/div 10:1
				1	AC
	1 1				CH4: ON
				1	200mV/div 1:1
					DC 0.002V
		***			
					Record Length
					Main: 100K
					Zoom: 2K
				1	Filter
т		- jaaraan jaaraan ja	بشميدهم المراجع		Smoothing: ON
					BW: 20MHZ
					rigger
					Mode: NURMHL
4⊑					Type. EDGE
÷					Source. CH4 j
					]





Figure 17 – Transient Response, 230 VAC, 2 mA to 350 mA to 2 mA. Upper: V<sub>OUT</sub> 1 V / div. Lower: I<sub>OUT</sub> 0.2 A, 10 ms / div.



**Figure 19** – Transient Response, 230 VAC, 170 mA to 262 mA to 170 mA. Upper: V<sub>OUT</sub> 0.2 V / div. Lower: I<sub>OUT</sub> 0.2 A, 10 ms / div.



## 11.5 Output Ripple Measurements

### 11.5.1 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  $\mu$ F electrolytic, and a 0.1  $\mu$ F ceramic capacitor connected as shown.



Figure 20 – Oscilloscope Probe Prepared for Ripple Measurement (End Cap and Ground Lead Removed).



### 11.5.2 Measurement Results

The maximum voltage ripple at the output terminals of the power supply was measured as 80 mV, well below 200 mV specification limit.











Figure 22 – Ripple, 115 VAC, Full Load.  $20 \ \mu s$ , 50 mV / div.



**Figure 24** – Ripple, 265 VAC, Full Load. 100 μs, 50 mV / div.



# **12 Conducted EMI**

Conducted emissions tests were performed at 115 VAC and 230 VAC at maximum load. Measurements were taken with an Artificial Hand connected to a load resistor. EMI of line and neutral were scanned into one picture and the load resistance was adjusted for maximum power output.

Composite EN55022B / CISPR22B conducted limits are shown. In all cases there was excellent (~10 dB) margin.



Figure 25 – Conducted EMI at 115 VAC, Artificial Hand, 6.2 V, 0.362 A.





Figure 26 - Conducted EMI at 230 VAC, Artificial Hand, 6.05 V, 0.373 A.



# 13 Statistical Data for the Design

The following is some statistical data collected from 50 DER-258 design boards to demonstrate the repeatability and variation of certain measurements over a relatively large sample size, line voltage and temperature.





Figure 27 – Cold Temperature Regulation. CVCC Response Measured at -5 °C and 90 VAC.





Figure 29 – High Ambient Regulation. CVCC Response Measured at 40 °C and 90 VAC.





# 14 Revision History

Date	Author	Revision	<b>Description &amp; changes</b>	Reviewed
07-Dec-10	PL	1.2	Initial Release	Apps and Mktg
29-Apr-13	KM	1.3	Updated Board Photos	



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