Design Example Report

Title	***2.4W Charger using LNK500P***
Specification	Input: 85 – 265 VAC Output: 5.9V / 400 mA.
Application	Cell Phone Charger
Author	Power Integrations Applications Department
Document Number	DER-1
Date	February 4, 2004
Revision	1.0

Summary and Features

- Accurate CVCC characteristic
- Low cost solution for CV/CC charger
- No Y-cap needed for EMI
- Very low AC leakage
- No load power consumption <300 mW

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

Design Reports contain a power supply design specification, schematic, bill of materials, and transformer documentation. Performance data and typical operation characteristics are included. Typically only a single prototype has been built.

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1 Introduction

This document is an engineering report describing a 5.9 VDC, 400 mA CV/CC charger utilizing a LNK500P.

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

2 Photograph

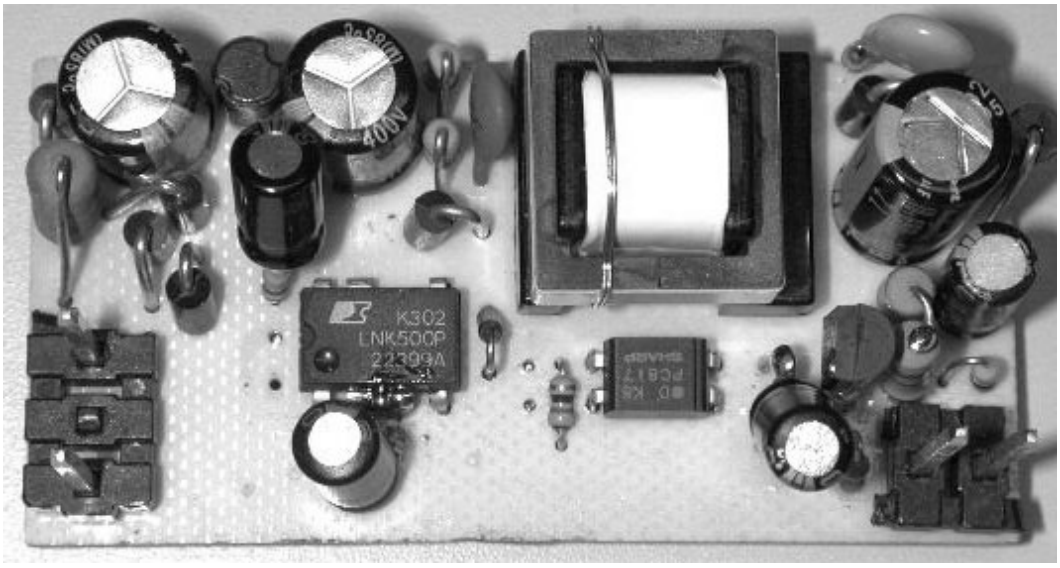

Figure 1 PSU

3 Power Supply Specification

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	85		265	VAC	2 Wire – no P.E.
Frequency	f_{LINE}	47	50/60	64	Hz	
No-load Input Power (230 VAC)				0.3	W	
Output						
Output Voltage	V_{OUT}		5.9		V	
Output Ripple Voltage	V_{RIPPLE}			60	mV	20 MHz Bandwidth
Output Current 1	I_{OUT}		0.4		A	
Total Output Power						
Continuous Output Power	P_{OUT}		2.36		W	
Efficiency	η		62		%	Measured at full load, 25 °C
Environmental						
Conducted EMI		Meets CISPR22B / EN55022B				
Ambient Temperature	T_{AMB}	0		40	°C	Free convection, sea level

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4 Schematic

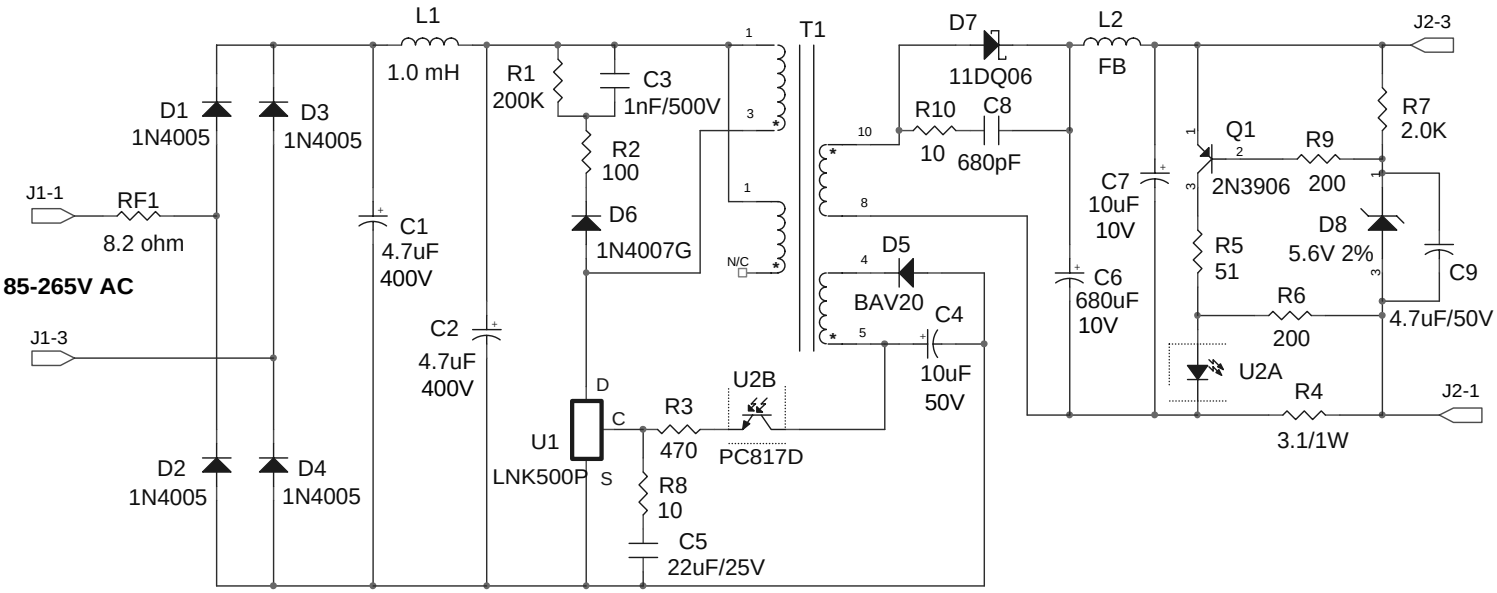

Figure 2 – Schematic.

5 Circuit Description

This circuit is configured as a flyback using the LNK500P.

5.1 Input Rectification

AC input power is rectified by a full bridge, consisting of D1 through D4. The rectified DC is then filtered by the bulk storage capacitors C1 and C2. Inductor L1, C1 and C2 form a pi (π) filter, which attenuates conducted differential-mode EMI noise.

5.2 Output Voltage Sensing, Feedback

Before the output current reaches about 400 mA, the output voltage is set by Zener diode D8 and bias voltage of Q1. When output current reaches about 400 mA the current loop, which combined by U2, R4 and R6 takes over the regulation. So the output is in constant current mode. The value of R4 and R6 determines the output current.

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6 PCB Layout

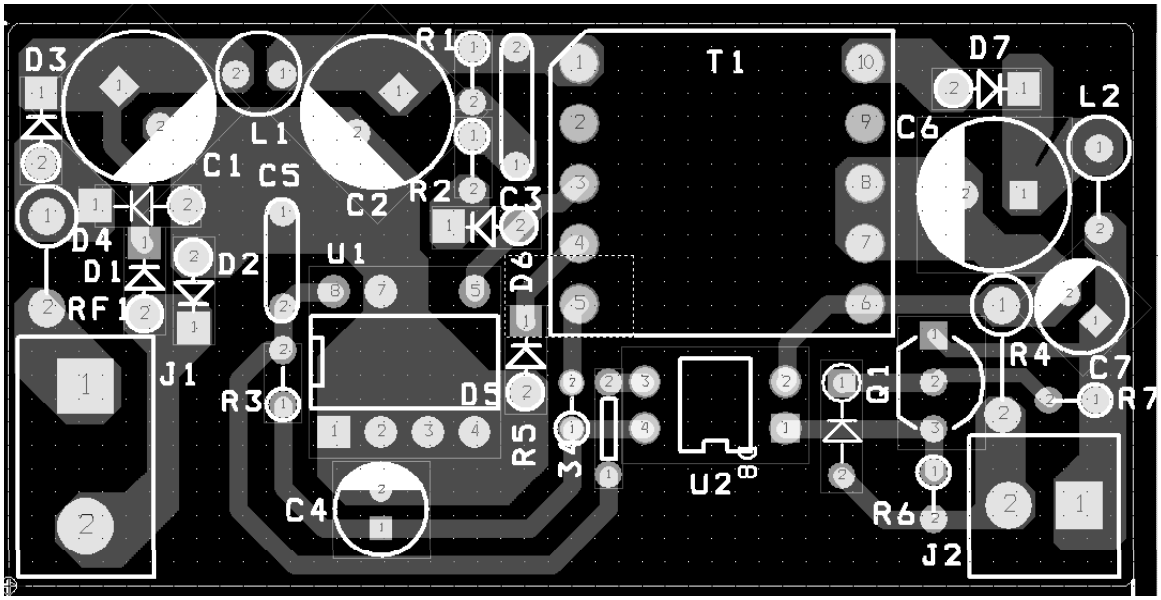

Figure 3 – Printed Circuit Layout.

Notes:
There are a few modification of this layout. Please refer to schematic.

- C5 has R8 added in series
- RC snubber added onto D7
- C9 added in parallel with D8

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7 Bill of Materials

Item	Qty	Ref	Description	P/N	Mfg
1	2	C1, C2	4.7uF/400V, Electrolytic cap		Any
2	1	C3	1.0nF/500V, ceramic disk		Any
3	1	C4	10uF/50V, electrolytic cap, low esr		Any
4	1	C5	22uF/25V, electrolytic cap		Any
5	1	C6	680uF/10V, electrolytic cap low esr		Any
6	1	C7	100uF/10V, electrolytic cap low esr		Any
7	1	C8	680pF/500V, ceramic disk		Any
8	1	C9	4.7uF/50V, electrolytic cap		Any
9	4	D1-D4	1A/600V, general diode	1N4005	Diode
10	1	D5	0.25A/200V, general diode	BAV20	Philips
11	1	D6	1A//1000V, glass passive	1N4007G	Vishay
12	1	D7	1.1A/60V, schottky diode	11DQ06	IR
13	1	D8	5.6V 2% zener diode	BZX79B5V6	Any
14	1	L1	1.0 mH	47HY102	Tokin
15	1	L2	Ferrite bead		Any
16	1	R1	200k, 1/4W		Any
17	1	R2	100, 1/8W		Any
18	1	R3	470, 1/8W		Any
19	1	R4	3.1, 1W		Any
20	1	R5	51, 1/8W		Any
21	1	R6	200, 1/8W		Any
22	1	R7	2K, 1/8W		Any
23	1	R9	5.1, 1/8W		Any
24	2	R8, R10	10, 1/8W		Any
25	1	RF1	8.2, 1W, fusible		Any
26	1	T1	EE16 customized transformer		
27	1	U1	LNK500P		PI
28	1	U2	Opto-coupler	PC817D	Sharp
29	1	Q1	small signal transistor	2N3906	Any

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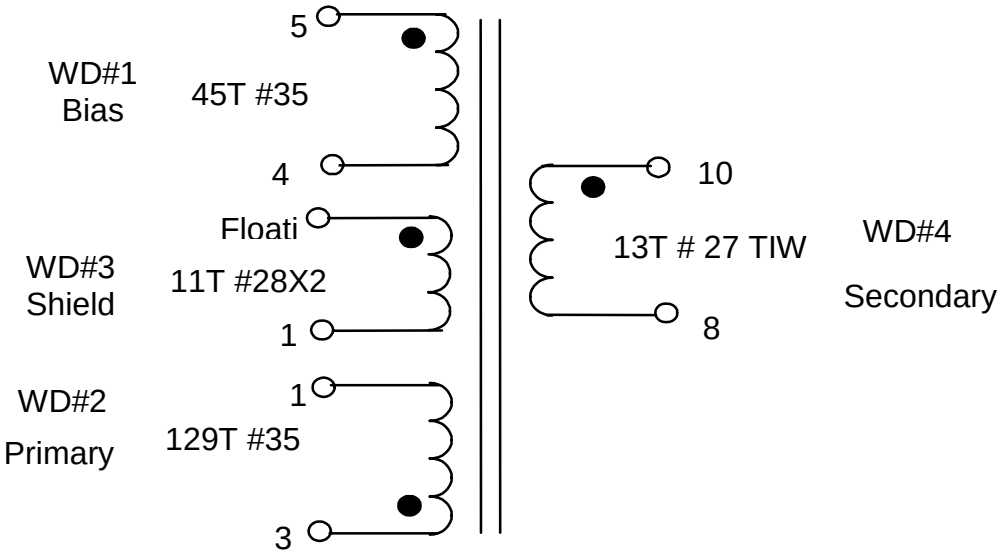
8 Transformer

8.1 Transformer Diagram



8.2 Electrical Specifications

Electrical Strength	60Hz 1minute, from Pins 1-5 to Pins 6-10	3000 V ac
Primary Inductance (Pin 1 to Pin 3)	All windings open	3.55 mH +/- 7% at 42KHz
Resonant Frequency. (Pin 1 to Pin 3)	All windings open	350 kHz (Min.)
Primary Leakage Inductance. (Pin 1 to Pin 3)	Pins 8-10 shorted	80 uH Max.

8.3 Materials

Item	Description
[1]	Core: PC40EF16-Z, TDK or equivalent Gapped for AL of 213.3 nH/T^2
[2]	Bobbin: Horizontal 10 pin
[3]	Magnet Wire: #35 AWG
[4]	Magnet Wire: #28 AWG
[5]	Triple Insulated Wire: #27 AWG.
[6]	Tape: 3M 1298 Polyester Film, 2.0 mils thick, 8.4 mm wide
[7]	Tinned bus wire 32 AWG
[8]	Varnish

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8.4 Transformer Construction

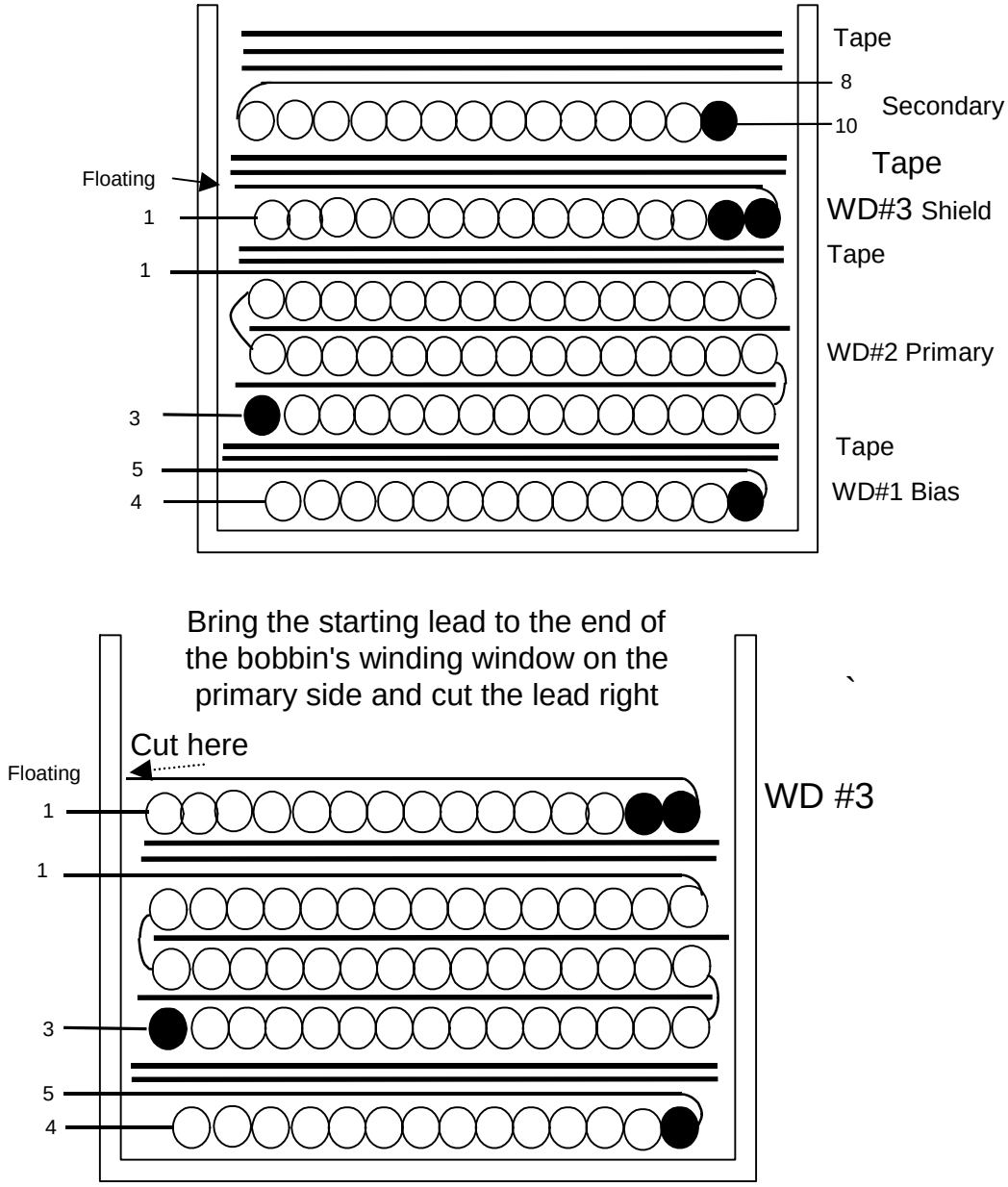

Figure 4 Transformer winding details

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8.5 Winding Instructions

WD1 Bias Winding	Primary pin side of the bobbin oriented to left hand side. Start at Pin 8 temporarily. Wind 45 turns of item [3] from right to left. Wind with tight tension across entire bobbin evenly. Finish on Pin 4.
WD1	Change the start pin from pin 8 to pin 5.
Insulation	2 Layers of tape [6] for insulation.
WD#2 Primary winding	Start at pin 3 wind 44 turns of item [3] from left to right, apply one layer of type [6]. Then wind another 44 turns next layer from right to left, apply one layer of type [6]. Wind 41 turns in third layer from left to right. Wind with tight tension across entire bobbin evenly Finish at pin 1
Insulation	2 Layers of tape [6] for insulation.
WD #3 Shield Winding	Start at Pin 8 temporarily, wind 11 bifilar turns of item [4]. Wind from right to left with tight tension. Wind uniformly, in a single layer across entire width of bobbin. Finish on Pin 1.
WD #3	Flip the starting end to left hand side. Cut the lead of the starting end as in shown in figure 4.
Insulation	2 Layers of tape [6] for insulation.
WD #4 Secondary Winding	Start at pin 10, wind 13 turns of item [5] from right to left. Wind uniformly, in a single layer across entire bobbin evenly. Finish on pin 8.
Outer Insulation	3 Layers of tape [6] for insulation.
Core Assembly	Assemble and secure core halves.
Core Grounding	Start at pin 1, wind 2 turns of item [7] around the core close to primary side. Finish at pin1. Wind it tight making good contact with core.
Varnish	Varnish

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9 Performance Data

All measurements performed at room temperature, 60 Hz input frequency.

9.1 Efficiency

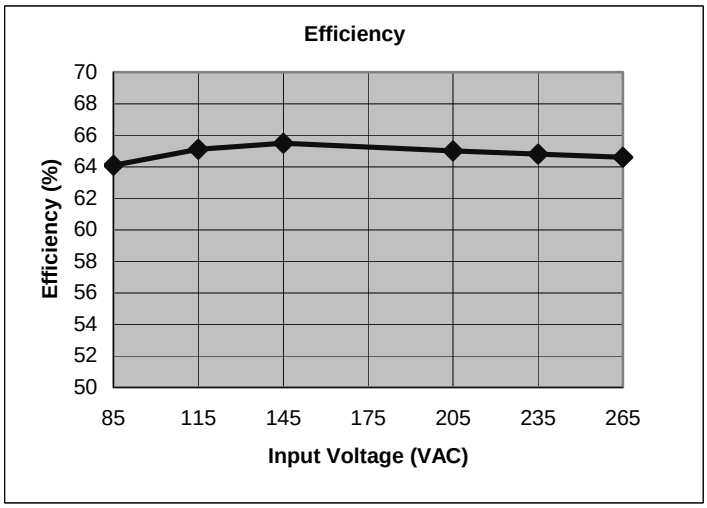

Figure 5 Efficiency vs input voltage at full load

9.2 No-load power consumption

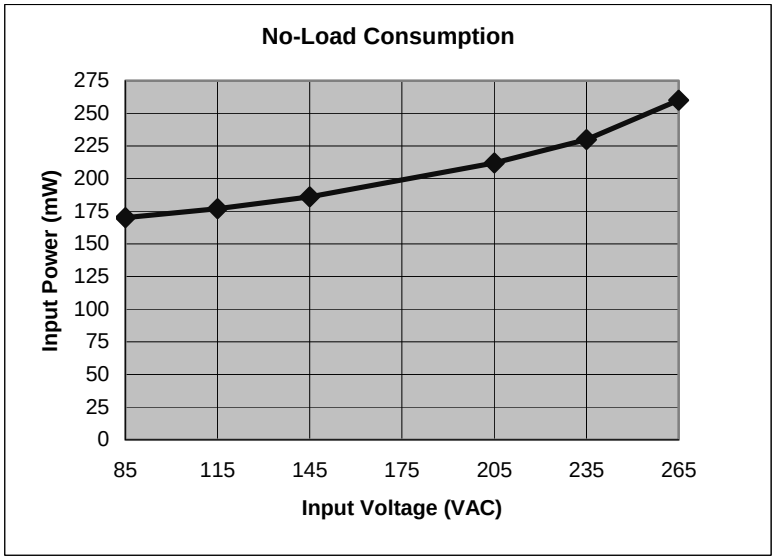

Figure 6- Standby Input Power vs. Input Line Voltage

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9.2.1 Output Characteristic

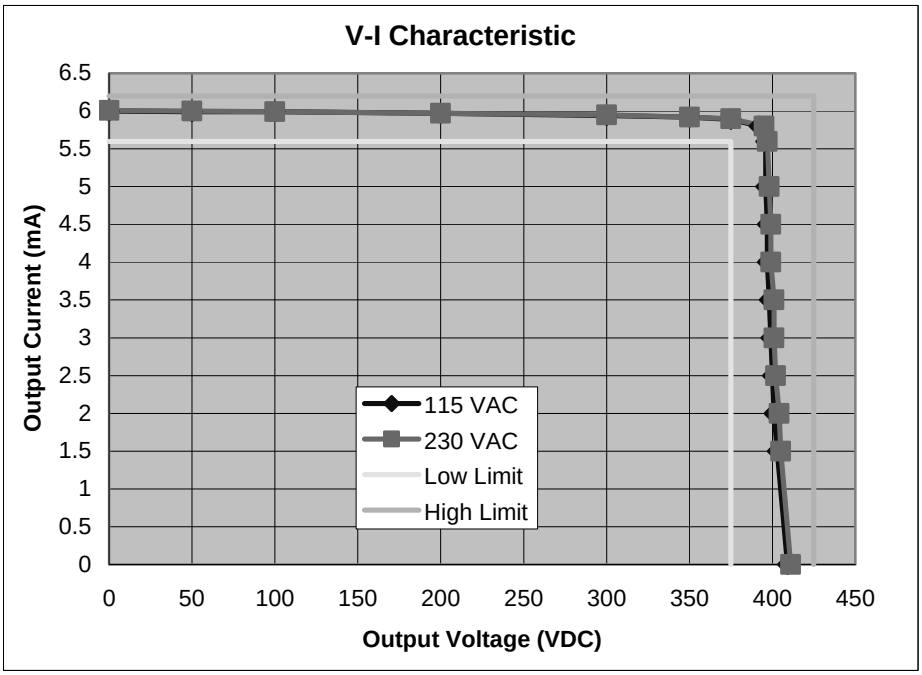

Figure 7 Output V-I characteristic

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9.3 Output Ripple & Noise

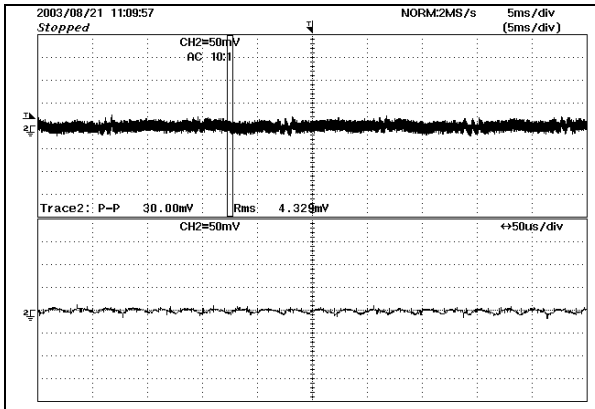

Figure 8 Output ripple & noise at 115 VAC

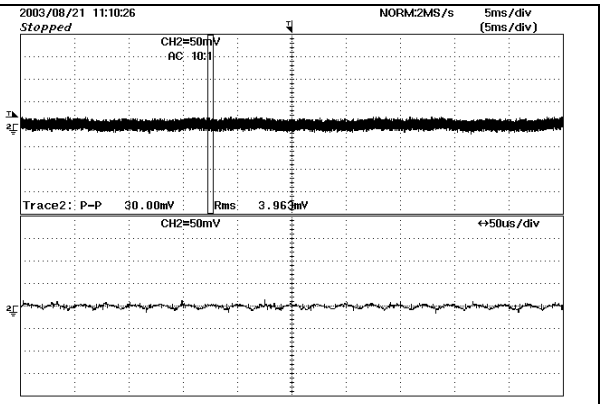

Figure 9 Output ripple & noise at 230 VAC

9.4 Output Start up

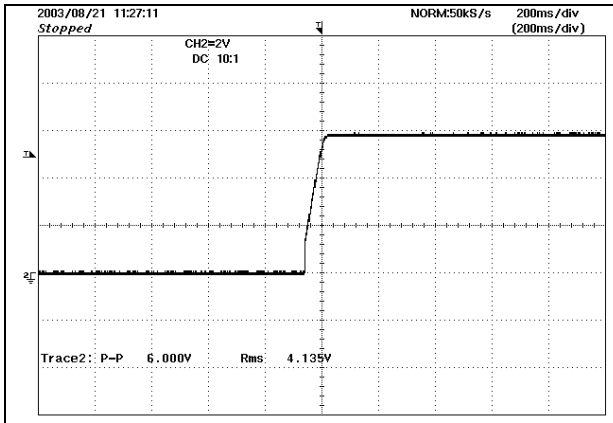

Figure 10 Output start up at 115 VAC, full load

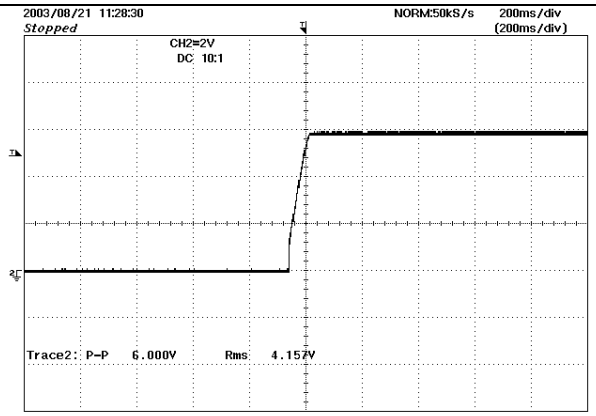

Figure 11 Output start up at 230 VAC, full load

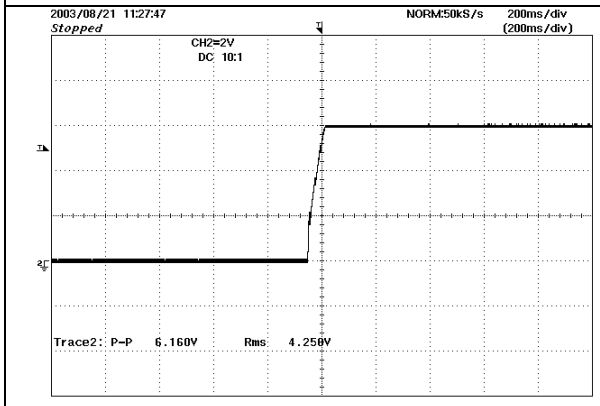

Figure 12 Output start up at 115 VAC, no load

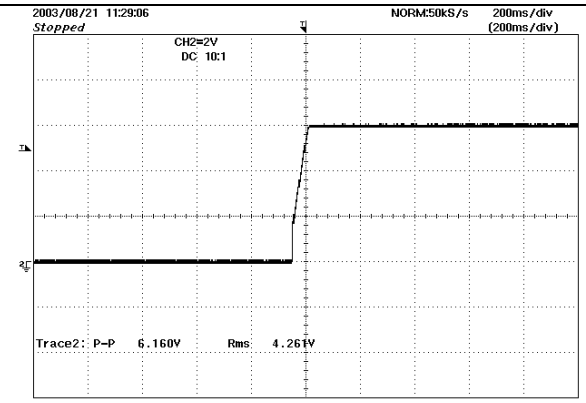

Figure 13 Output start up at 230 VAC, no load

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9.5 Drain voltage during start up

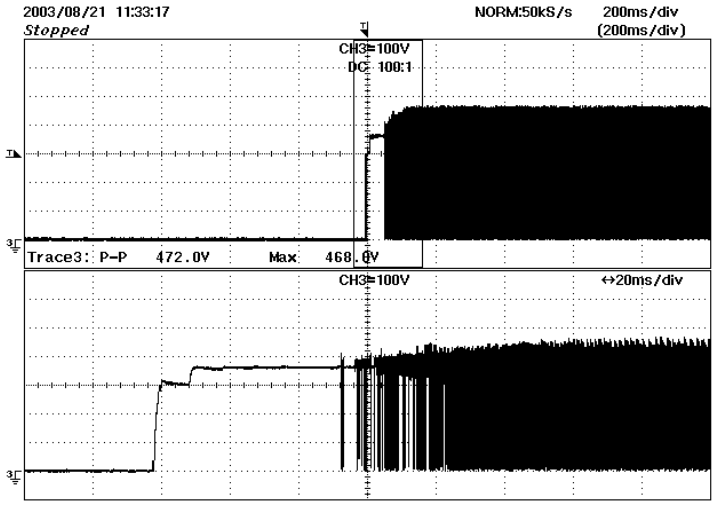

Figure 14 Drain voltage during start up at 265 VAC, full load

9.6 Operation

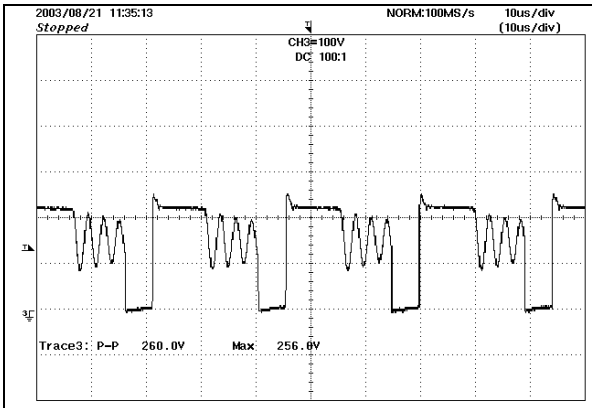

Figure 15 Drain waveform, normal operation 115 VAC

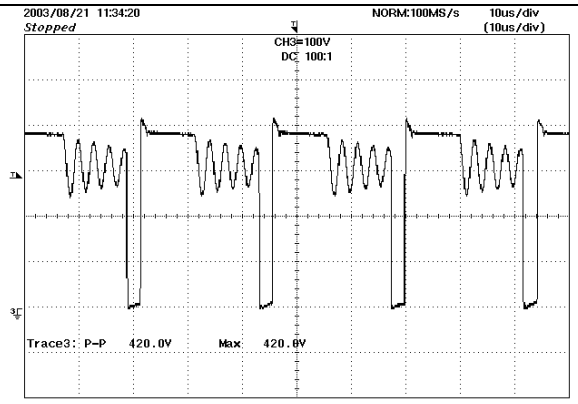

Figure 16 Drain waveform, normal operation at 230 VAC

10 Thermal Performance

Temperature of LinkSwitch during normal operation, open air

Item	85 VAC	265 VAC
Ambient	25 °C	25 °C
LNK500P	42°C	43°C

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11 Conducted EMI

EMI was tested at room temperature, 230 VAC input, during normal operation

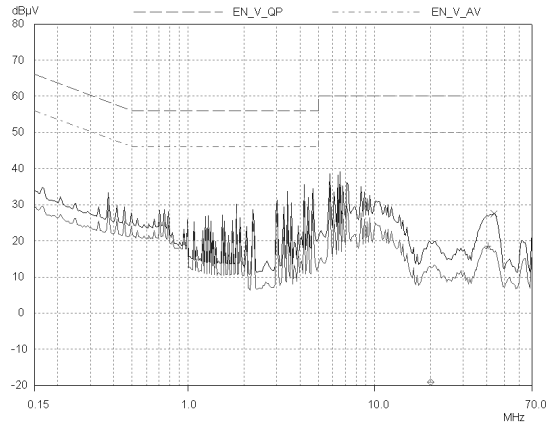

Figure 17 Line, floating

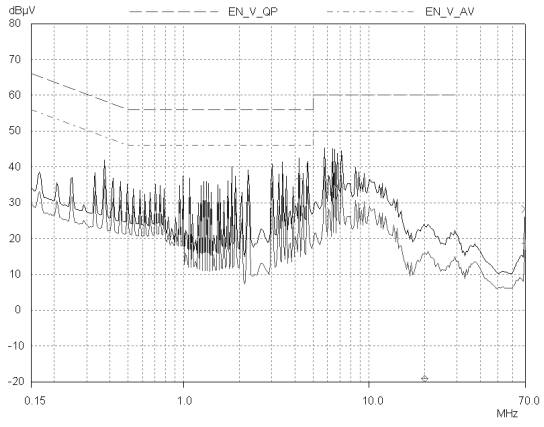

Figure 18 Line, artificial hand

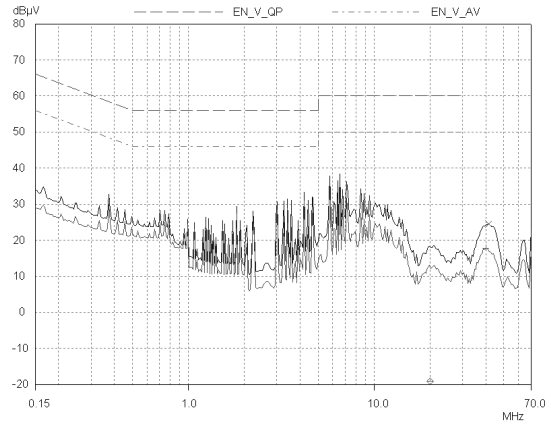

Figure 19 Neutral, floating

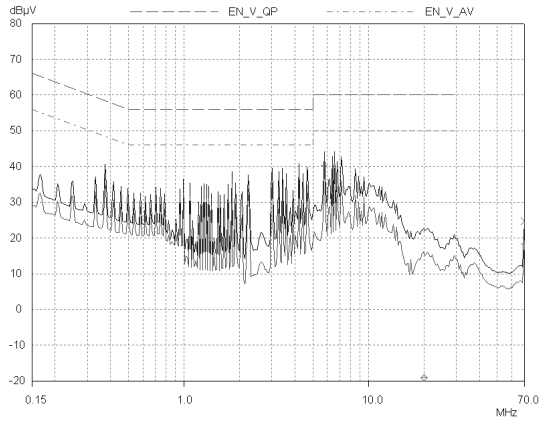

Figure 20 Neutral, artificial hand

12 Revision History

Date	Author	Revision	Description & changes	Reviewed
February 4, 2004	YG	1.0	First Release	AM/VC

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