Design Example Report

Title	***2.2W Charger using LNK501P***
Specification	Input: 198 – 253 VAC Output: 3.6V / 0.6 A
Application	Cell Phone Charger
Author	Power Integrations Applications Department
Document Number	DER-15
Date	February 4, 2004
Revision	1.0

Summary and Features

This report details the design of an isolated Flyback converter for a cell phone charger.

- Uses LinkSwitch LNK501
- European input voltage
- Typical Efficiency > 65 %
- Meets EN550022 Class B EMI tests with No Y1 capacitor
- Very low earth leakage current
- Uses only 20 components

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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 giving performance characteristics of an isolated Flyback converter with European input voltage and 3.6V 0.6A output. This design uses LinkSwitch – an integrated IC comprising a high voltage MOSFET, PWM controller. The controller provides an I^2f type characteristic to provide a constant current output current without secondary side current sensing.

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

2 Power Supply Specification

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	198	220	253	Vac	
Output						
Output Voltage 1	V_{OUT1}	2.88	3.6	4.14	V	at 220Vac
		1.7			V	at 198 Vac
				5.1	V	at 253 Vac
Open circuit voltage	V_{OCV}	5.62		6.48	V	at 220Vac
Output Ripple Voltage 1	$V_{RIPPLE1}$			1.2	V	20 MHz Bandwidth
Output Current 1	I_{OUT1}	498	600	684	mA	
Total Output Power						
Continuous Output Power	P_{OUT}		2.16		W	
Conducted EMI Margin						EN550022 B, FCC B
Efficiency	η		65		%	At full load
Ambient Temperature	T_{AMB}	0		40	^{o}C	Free convection, Sea level

Table 1 – Power Supply Specification

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3 Schematic

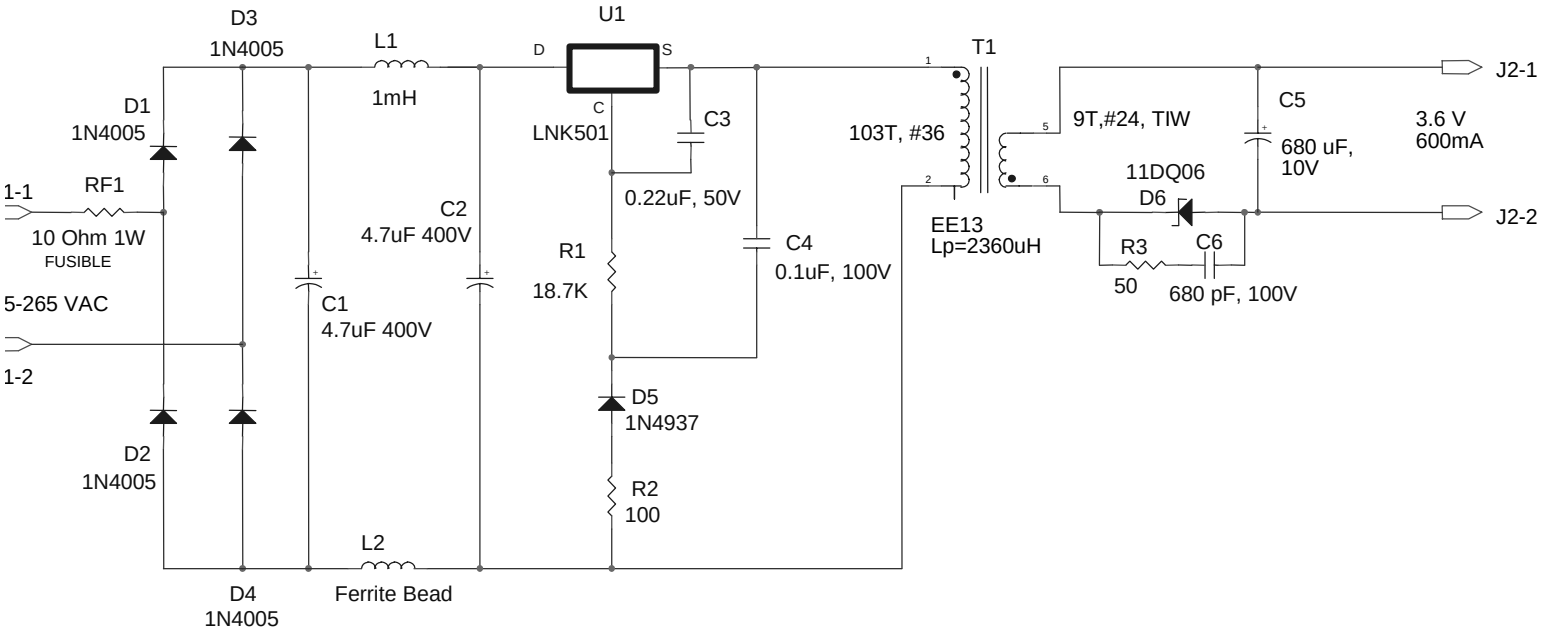

Figure 1 – Flyback Converter – 2.2W 3.6V 0.6A.

4 PCB Layout

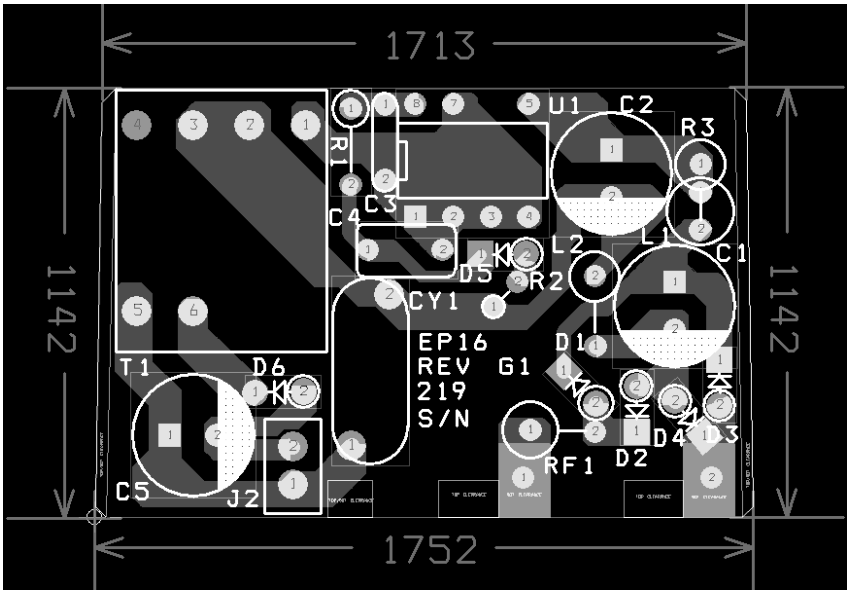

Figure 2 – PCB Layout

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5 Bill Of Materials

Item	Quantity	Reference	Part Description
1	2	C1, C2	4.7uF 400V, Electrolytic D=8.5mm, L=12mm
2	1	C3	0.22uF, 50V, Ceramic
3	1	C4	0.1uF, 100V, Metal Film
4	1	C5	680uF, 10V, AL
5	1	C6	680 pF, 100V, ceramic
6	4	D1, D2, D3, D4	1N4005, 1A, 600V
7	1	D5	1N4937, 1A, 600V, Fast Rectifier.
8	1	D6	11DQ06, 1A, 60V, Schottky
9	1	L1	1mH, Inductor Tokin SBCP-47HY102B
10	1	L2	Ferrite Bead
11	1	RF1	10 Ohm 1W, Fusible
12	1	R1	18.7K 1%, 1/8W
13	1	R2	100, 5%, 1/8W
14	1	R3	50 Ohm, 5%, 1/8W
15	1	T1	Custom EE13
16	1	U1	LNK501

Table 2 – Bill of Materials

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6 Transformer

6.1 Transformer Winding

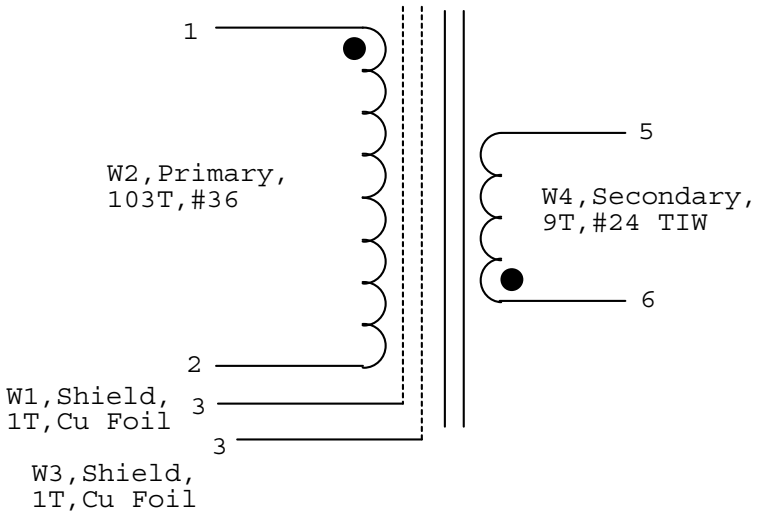

Figure 3 – Transformer Winding

6.2 Electrical Specifications

Electrical Strength	60Hz 1minute, from Pins 1-3 to Pins 5-6	3 kV for 1 minute
Primary Inductance (Pin 1 to Pin 2)	All windings open	2200 µH – 2530 µH
Resonant Frequency	All windings open	300 kHz min.
Primary Leakage Inductance	L_{13} with pins 5-6 shorted	100 µH max.

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6.3 Transformer Construction

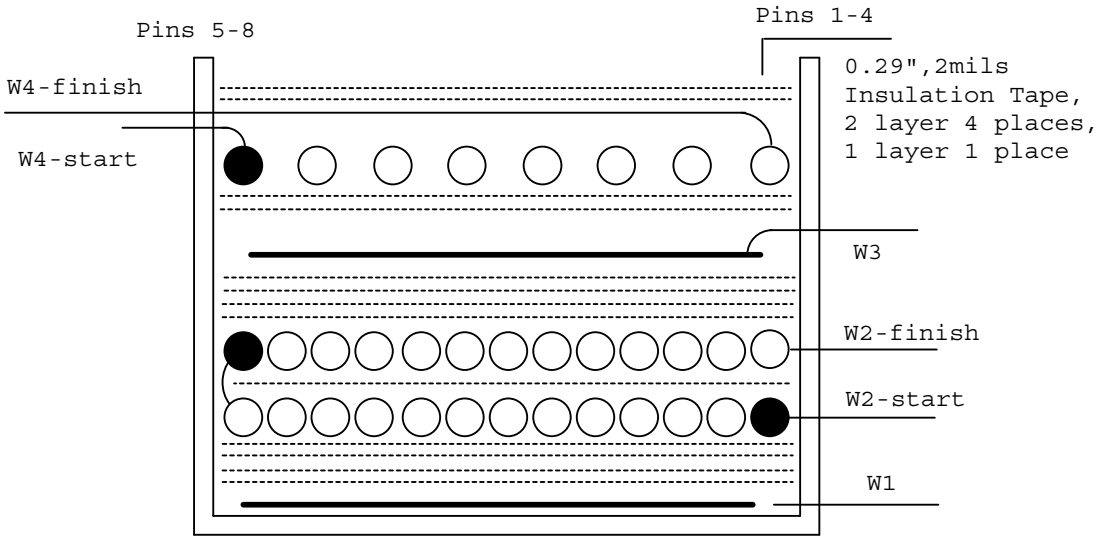

Figure 4 – Transformer construction

6.4 Winding Instructions

Place the bobbin on the winding machine with pins 1-4 on the right side and pins 5-8 on the left side.

W1 (Shield)	Wind 1 turn with 0.25” x 2 mils copper foil, *with start and finish ends insulated from each other with tape*. Solder a piece of #34 wire to the copper foil and terminate it at pin 3 (primary return). Make sure start and finish ends do not short.
Basic Insulation	4 layers of tape for insulation.
W2 (Primary Winding)	Wind 103 turns in 2-3 layers with # 36 AWG magnet wire – first layer 50T from right to left starting from pin 1 – one layer of insulation tape – second layer 50T from left to right – 3T in the third layer (do not spread), and finish at pin 2.
Basic Insulation	4 layers of tape for insulation.
W3 (Shield)	Wind 1 turn with 0.25” x 2 mils copper foil, *with start and finish ends insulated from each other with tape*. Solder a piece of #34 wire to the copper foil and terminate it at pin 3 (primary return). Make sure start and finish ends do not short.
Basic Insulation	2 layers of tape for insulation.
W4 (Secondary Winding)	Wind 9 turns with #24 triple insulated wire from left to right starting from 6 and finishing at 5.
Outer Insulation	2 layers of tape for insulation.
Core Assembly	Assemble and secure core halves.
Final Assembly	Impregnate transformer uniformly with varnish.

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6.5 Materials

Item	Description
[1]	Core: EE13, PC40EE13, TDK Gapped for A_L = 225 nH/T^2
[2]	Bobbin: Horizontal 8 pins
[3]	Magnet Wire: #36 AWG
[4]	Triple Insulated wire: # 24 AWG
[5]	Copper foil: 0.25” x 2 mils
[6]	Tape: 3M 1298 Polyester Film (white) 0.29” x 2 mils
[7]	Varnish

Table 3 – Transformer BOM

6.6 Design Notes:

Power Integrations Device	LNK501
Frequency of Operation	42 KHz
Mode	Discontinuous
Peak Current	0.25 A
Reflected Voltage (Secondary to Primary)	49 V
Maximum AC Input Voltage	253 V
Minimum AC Input Voltage	198 V

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7 Performance Data

All measurements are performed at room temperature unless otherwise specified. The output voltages are measured at the end of the output cable.

7.1 Efficiency

The measurements are made for various load and line conditions. The efficiencies are calculated and shown in Figure 5 and Figure 6.

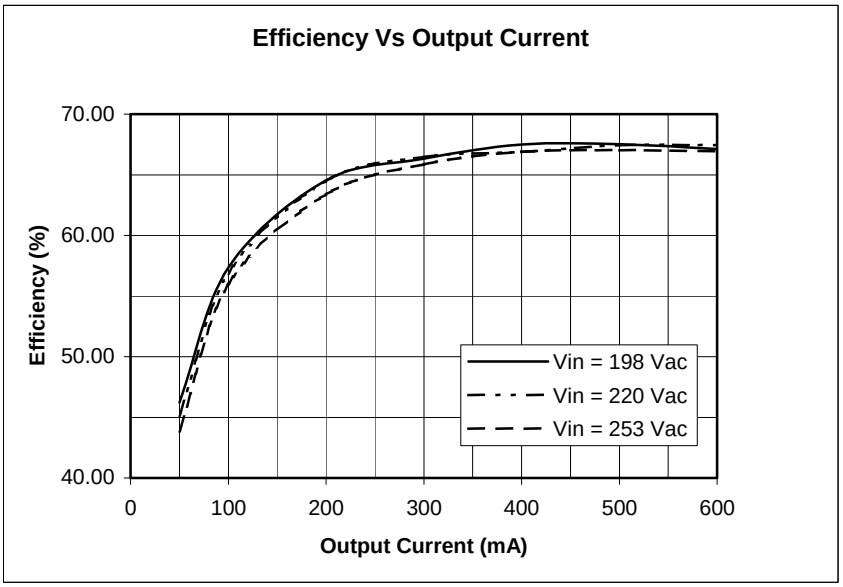

Figure 5 – Efficiency Vs Output Current

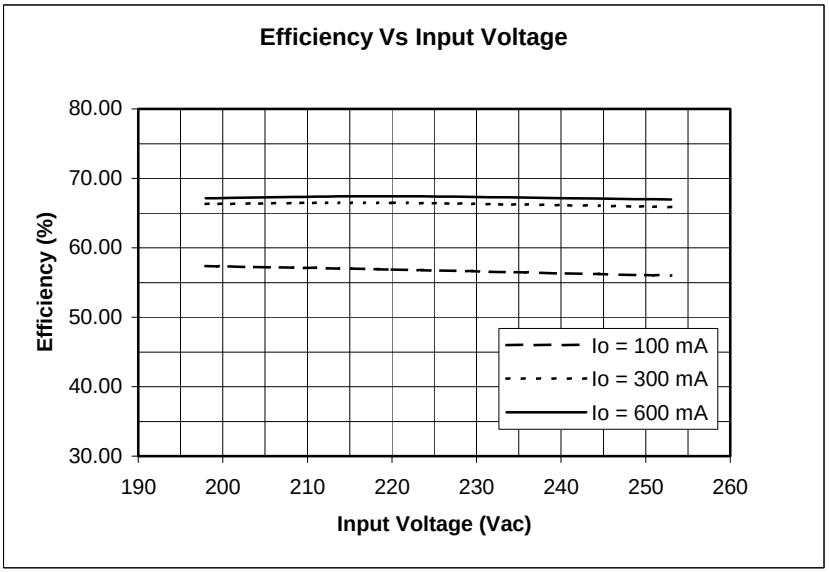

Figure 6 – Efficiency Vs Input Voltage

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7.2 Regulation

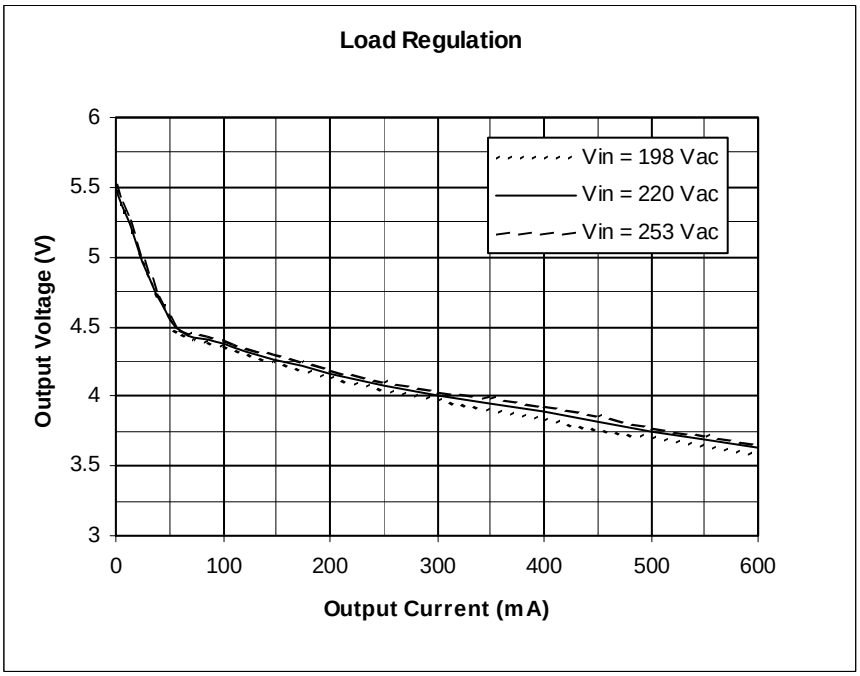

Figure 7 – Load Regulation

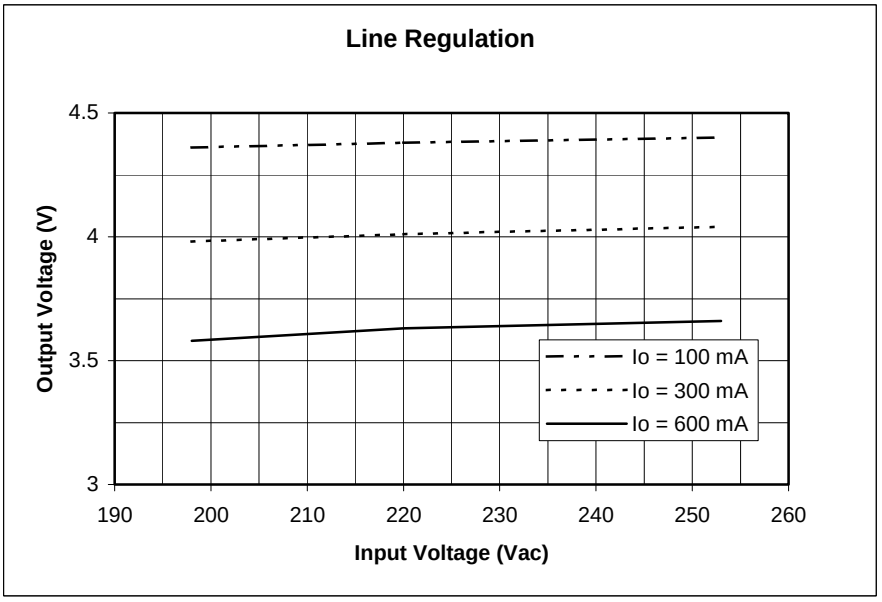

Figure 8 – Line Regulation

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7.3 No Load Input Power

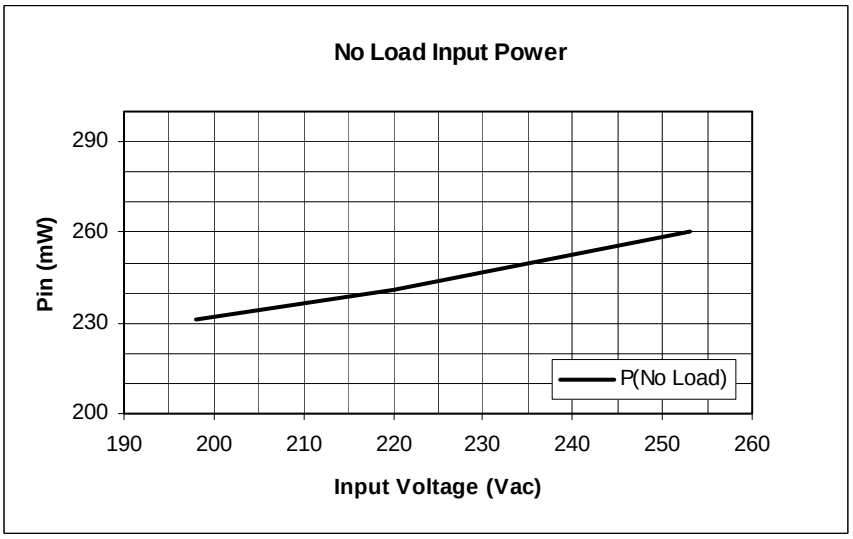

Figure 9 – No Load Input Power

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7.4 Output Ripple Measurements

7.4.1 Ripple Measurement Technique

For DC output ripple measurements, a modified oscilloscope test probe must be utilized in order to reduce spurious signals due to pickup. Details of the probe modification are provided in Figure 10 and Figure 11.

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

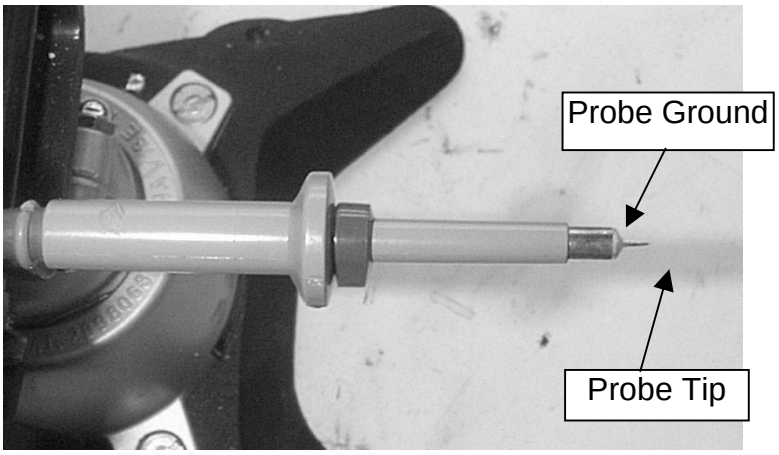

Figure 10 – Oscilloscope Probe Prepared for Ripple Measurement.

(End Cap and Ground Lead Removed)

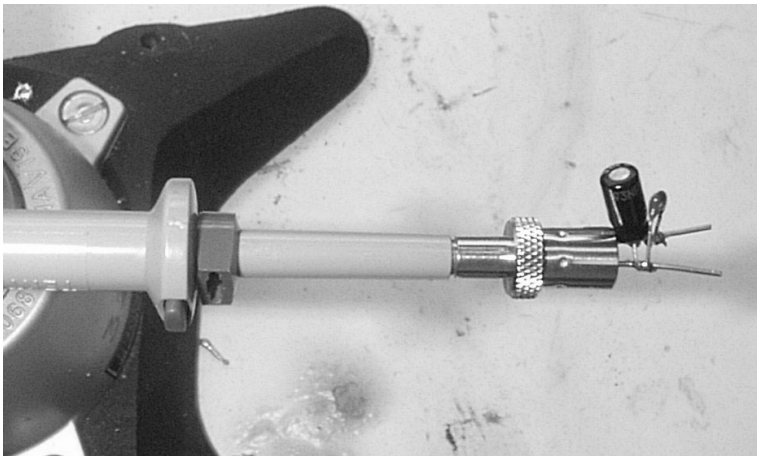

Figure 11 – Oscilloscope Probe with Probe Master 5125BA BNC Adapter

(Modified with wires for probe ground for ripple measurement, and two parallel decoupling capacitors added).

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7.4.2 Output Voltage Ripple

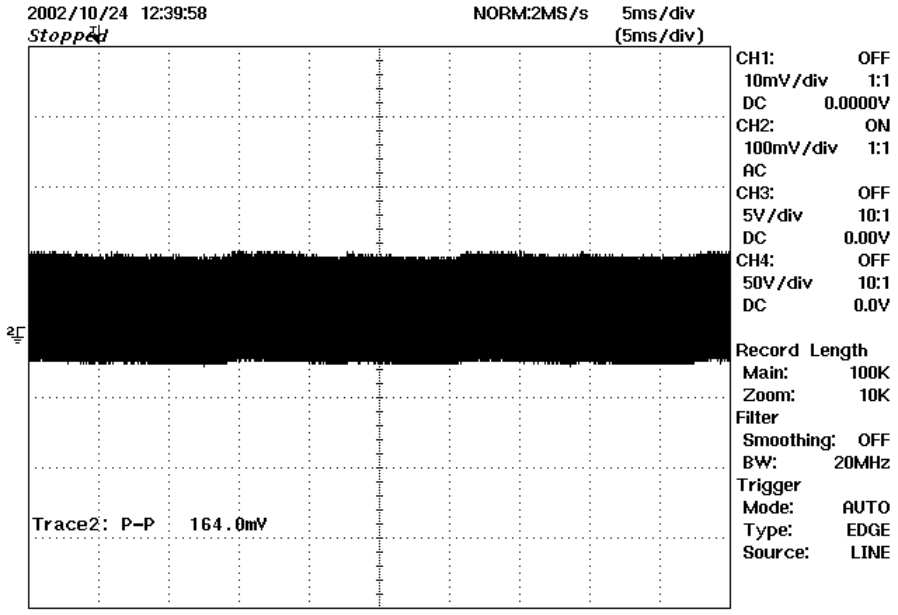

Figure 12 – Output Voltage Ripple at Vin = 220 Vac, Vo = 3.6 V, Io = 600 mA

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8 EMI Tests

The EMI tests are done at 220 Vac input and 6 Ω (600 mA) load.

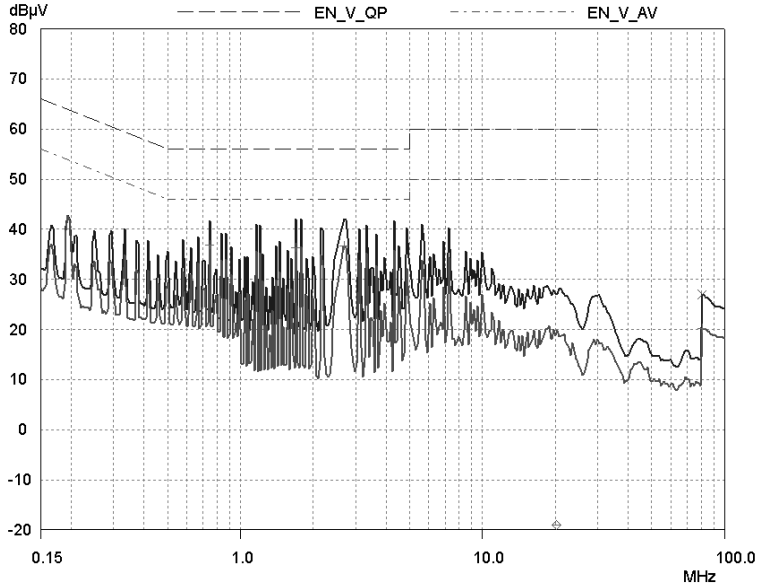

Figure 13 – EN55022 Class B, Line, artificial hand connected to output return

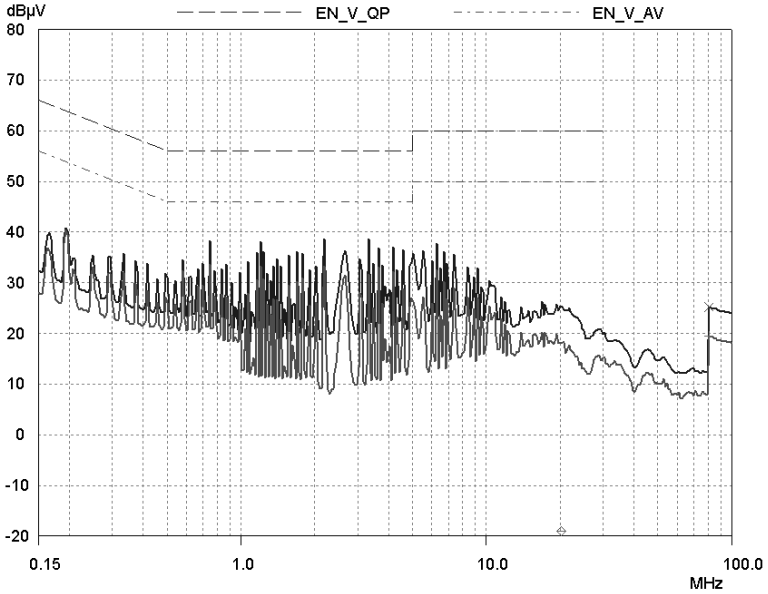

Figure 14 – EN55022 Class B, Neutral, artificial hand connected to output return

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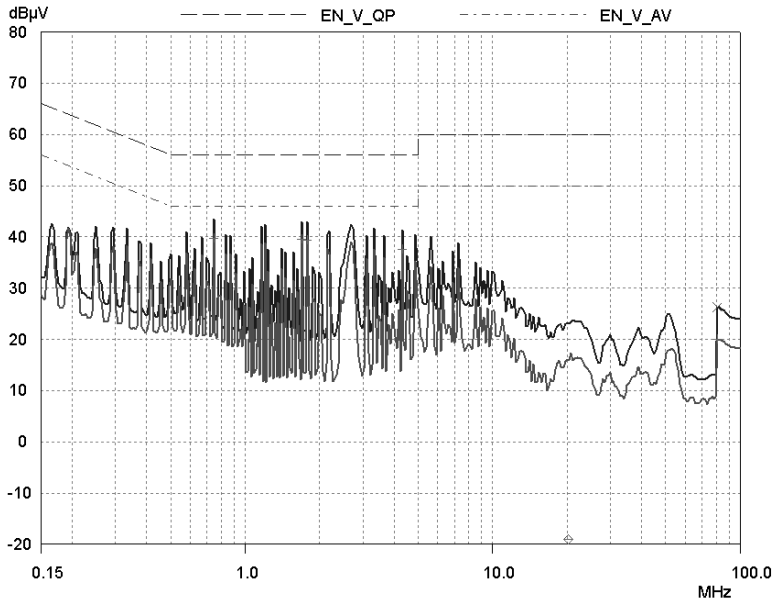

Figure 15 – EN55022 Class B, Line, with out artificial hand connected to output return

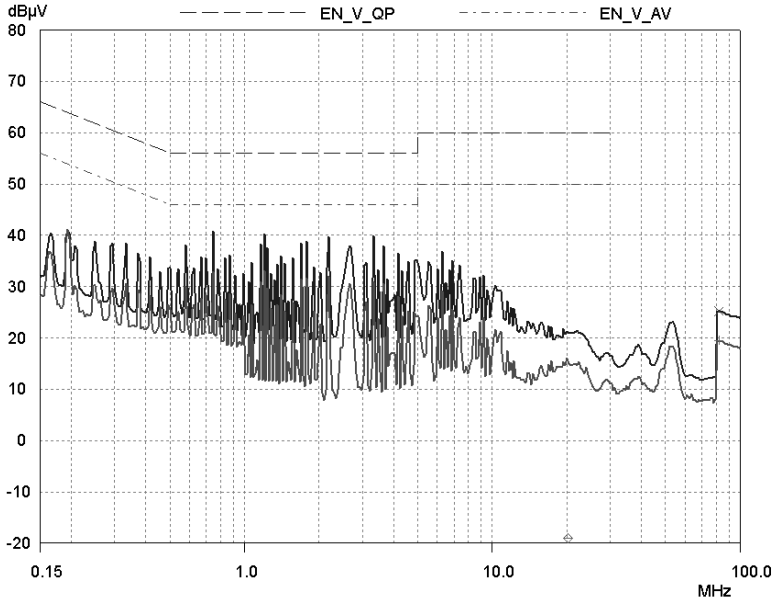

Figure 16 – EN55022 Class B, Neutral, with out artificial hand connected to output return

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9 Revision History

Date	Author	Revision	Description & changes	Reviewed
February 4, 2004	MJ	1.0	Initial release	AM/VC

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Notes

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