Design Example Report

Title	***9W power supply using TNY267P***
Specification	Input: 85 – 265 VAC Output: 5V/0.56A, 3.3V/0.48A, 12V/100mA, -12V/15mA, -22V/100mA, Floating 4V/100mA
Application	DVD Player
Author	Power Integrations Applications Department
Document Number	DER-8
Date	February 4, 2004
Revision	1.0

Summary and Features

- Low cost
- No Y-cap
- No common-mode choke
- Low EMI even with output grounded
- Good output cross-regulation even with no TL431
- Low consumption during standby

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Table Of Contents

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 an 9W (11W peak) multiple output power supply utilizing a TNY267P for a DVD player supply.

This design is low cost and meets EMI with no common-mode choke, no X-cap, and no Y-cap. Cross-regulation is tight in spite of having a simple low-cost zener regulation scheme.

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

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2 Photograph

Note the following:

- Uses little board space
- Uses small transformer: EE25L
- Uses small output capacitors
- Uses small output diodes
- Does not use TL431
- Uses small primary snubber
- Does not use linear regulator at 12V.

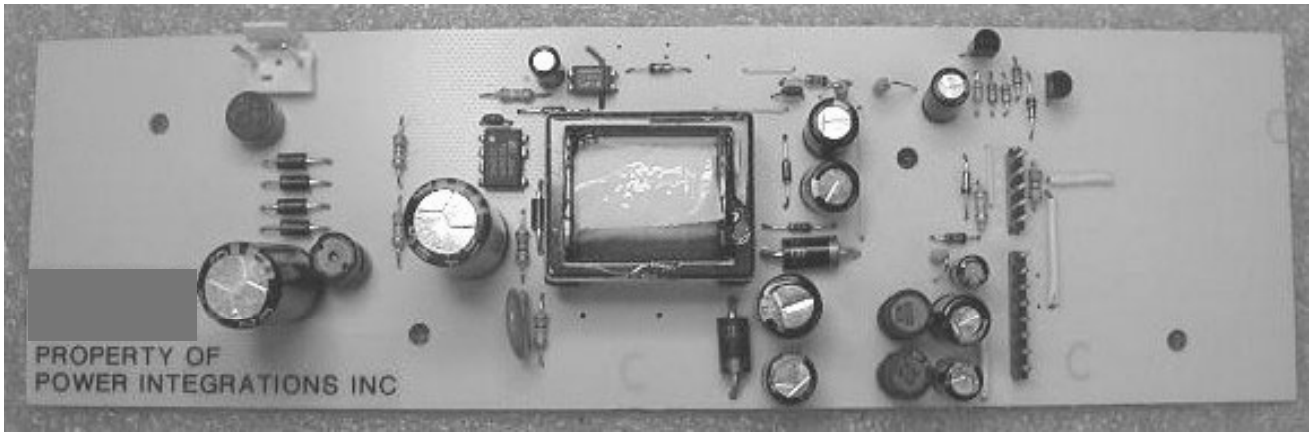

Figure 1 – Power Integrations PSU unit.

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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 1	V_{OUT1}		3.3		V	
Output Ripple Voltage 1	$V_{RIPPLE1}$			50	mV	20 MHz Bandwidth
Output Current 1	I_{OUT1}		0.48	0.6	A	
Output Voltage 2	V_{OUT2}		5.0		V	± 5%
Output Ripple Voltage 2	$V_{RIPPLE2}$			50	mV	20 MHz Bandwidth
Output Current 2	I_{OUT2}		0.58	0.85	A	
Output Voltage 3	V_{OUT3}		12		V	
Output Ripple Voltage 3	$V_{RIPPLE3}$			80	mV	20 MHz Bandwidth
Output Current 3	I_{OUT3}		0.40	0.1	A	
Output Voltage 4	V_{OUT4}		-12		V	zener regulated
Output Ripple Voltage 4	$V_{RIPPLE4}$			80	mV	20 MHz Bandwidth
Output Current 4	I_{OUT4}		0.015		A	
Output Voltage 5	V_{OUT5}		-23		V	
Output Ripple Voltage 5	$V_{RIPPLE5}$			400	mV	20 MHz Bandwidth
Output Current 5	I_{OUT5}		0.01	0.1	A	
Output Voltage 6	V_{OUT6}		4.0		V	floating output for display
Output Ripple Voltage 6	$V_{RIPPLE6}$					20 MHz Bandwidth
Output Current 6	I_{OUT6}		0.1		A	
Total Output Power						
Continuous Output Power	P_{OUT}		9.0		W	
Peak Output Power	P_{OUT_PEAK}			11	W	
Efficiency	η		72		%	Measured at full load, 25 °C
Environmental						
Conducted EMI		Meets CISPR22B / EN55022B				
Ambient Temperature	T_{AMB}	0		40	°C	Free convection, sea level

Note 1: *Above peak current specs are based on actual DVD board measurements. Actual power supply peak current capability is greater.*

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4 Schematic

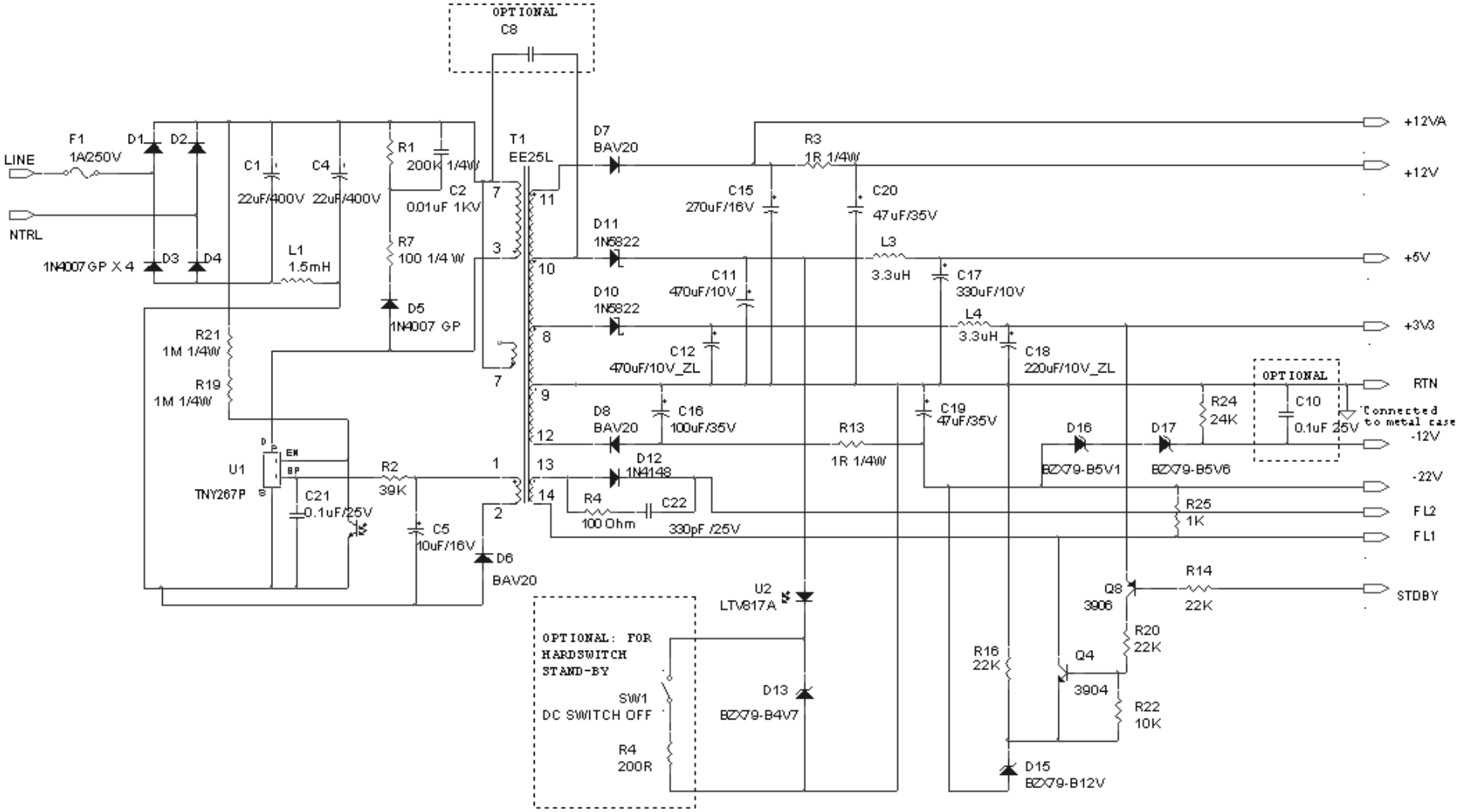

Figure 2 – Schematic.

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5 Circuit Description

This circuit is configured as a flyback using the TNY267P.

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 C4. Inductor L1, C1 and C4 form a pi (π) filter, which attenuates conducted differential-mode EMI noise.

5.2 Auxiliary Bias Supply

The auxiliary bias supply circuit is made up of the primary-side transformer bias winding, diode D6, capacitor C5 and resistor R2. The bias voltage was given just enough current to disable the internal current source during “DC Switch” operation. In this case, the standby power consumption is minimized.

5.3 Output Voltage Sensing, Feedback and DC switch

The combined voltage drops of Zener diode D13 and optocoupler U2 set the main output voltage. TinySwitch-II feedback current is independent of load allowing tight output voltage tolerance with this simple Zener circuit. The operation of the TNYSwitch allows the use of a “DC switch” (SW1) to put the power supply in a standby condition, with very low consumption. The DC switch does not need to be safety-rated, and thus is much lower cost than an equivalent AC switch. During DC Switch operation, the 5V output is regulated at 1V, and all other outputs are at $1/5^{th}$ of normal output voltage. The DVD system draws very little current during this output voltage condition. The net result is that the input power is ~200 mW at 230 Vac input.

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6 PCB Layout

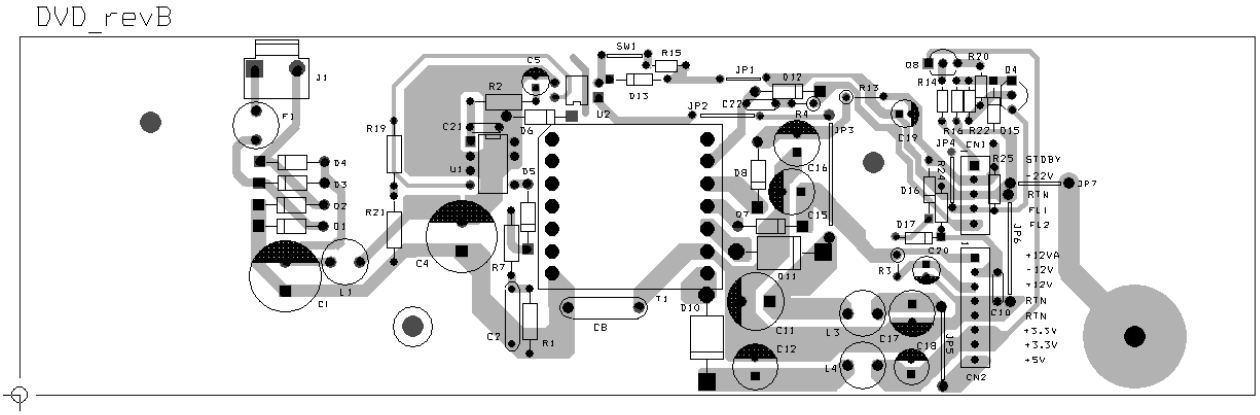

Figure 3 – Printed Circuit Layout.

Note: The assembled unit has some component locations not stuffed.

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7 Bill Of Materials

Item	Quantity	Reference	Part
1	2	C4	22uF/400V
		C1	22uF/400V
2	1	C2	0.01uF 1KV
3	1	C5	10uF/35V
4	1	C8	2.2nF FY1
5	1	C10	0.1uF 50V
6	1	C11	470uF/10V
7	1	C12	470uF/10V_ZL
8	1	C15	270uF/16V
9	1	C16	100uF/35V
10	1	C17	330uF/10V
11	1	C18	220uF/10V_ZL
12	2	C19	47uF/35V
		C20	47uF/35V
13	1	C21	0.1uF/50V
14	1	C22	330pF /50V
15	4	D1	1N4007GP
		D2	1N4007GP
		D3	1N4007GP
		D4	1N4007GP
16	1	D5	1N4007 GP
17	3	D6	BAV20
		D7	BAV20
		D8	BAV20
18	2	D11	1N5822
		D10	1N5822
19	1	D12	1N4148
20	1	D13	BZX79-B4V7
21	1	D15	BZX79-B12V
22	1	D16	BZX79-B5V1
23	1	D17	BZX79-B5V6
24	1	F1	1A/250V
25	2	U2	LTV817A
26	1	L1	1.5mH
27	2	L3	3.3uH
		L4	3.3uH
28	1	Q4	3904
29	1	Q8	3906
30	1	R1	200K 1/4W
31	1	R2	39K
32	2	R13	1R 1/4W
		R3	1R 1/4W
33	1	R4	optional
34	1	R4	100 Ohm
35	1	R7	100 1/4 W
36	3	R14	22K
		R16	22K
		R20	22K
37	2	R19	1M 1/4W
		R21	1M 1/4W
38	1	R22	10K
39	1	R24	24K
40	1	R25	1K

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41	1	SW1	DC SWITCH OFF
42	1	T1	EE25L
43	1	U1	TNY267P

Note: All resistors are 1/8W unless otherwise specified.

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8 Transformer Specification

8.1 Electrical Diagram

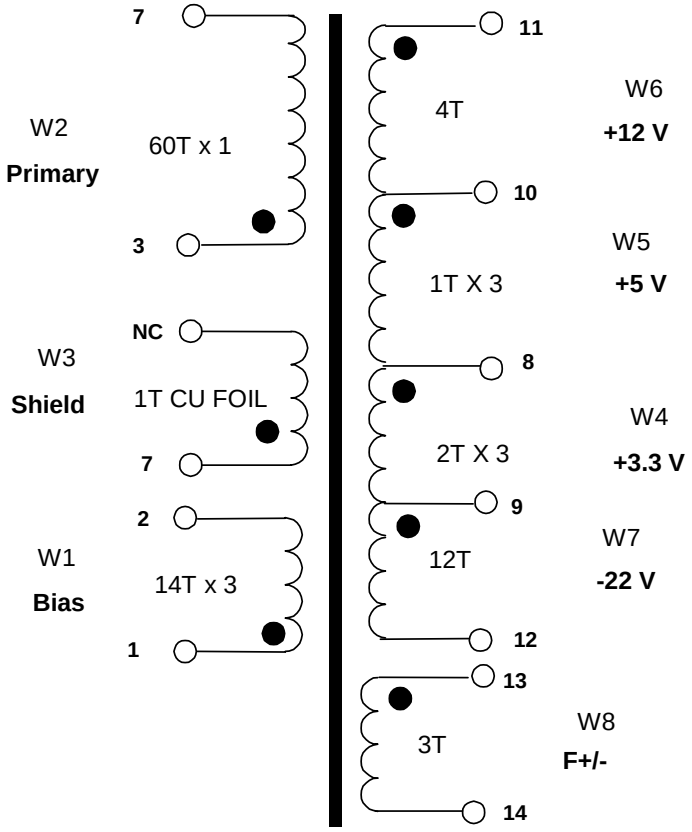

Figure 4 –Transformer Electrical Diagram.

8.2 Electrical Specifications

Electrical Strength	1 second, 60 Hz, from pins 1-7 to pins 8-14	3000 VAC
Primary Inductance	Pins 3-7, all other windings open. Measured at 132 kHz, 1 VRMS	1.43 mH +15%
Resonant Frequency	Pin 3-7, all other windings open	300 kHz (Min.)
Primary Leakage Inductance	Pins 3-7, with pins 8-14 shorted. Measured at 132 kHz, 1 VRMS	30 µH (Max.)

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8.3 Materials

Item	Description
[1]	Core: EEL25, TDK Gapped for AL of 392 nH/T^2
[2]	Bobbin: EEL25 Horizontal 14 pins
[3]	Magnet Wire: # 25 AWG
[4]	Magnet Wire: #28 AWG
[5]	Magnet Wire: #26 AWG
[6]	Copper Foil 2.0 mils thick, 16 mm wide.
[7]	Tape: 3M 1298 Polyester Film, 16 mm wide
[8]	Tape: 3M 1298 Polyester Film, 22 mm wide
[9]	Margin tape: 3M # 44 Polyester web. 3.0 mm wide
[10]	Teflon
[11]	Varnish

8.4 Transformer Build Diagram

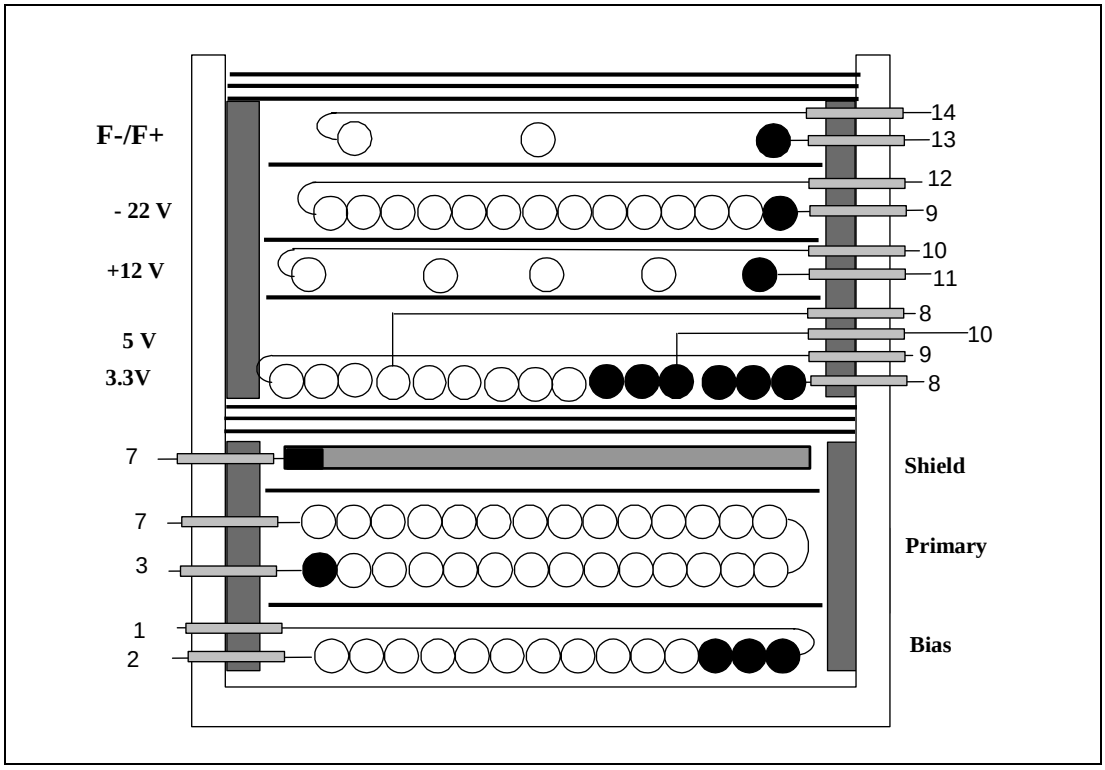

Figure 5 – Transformer Build Diagram. REV B

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8.5 Copper Foil Preparation

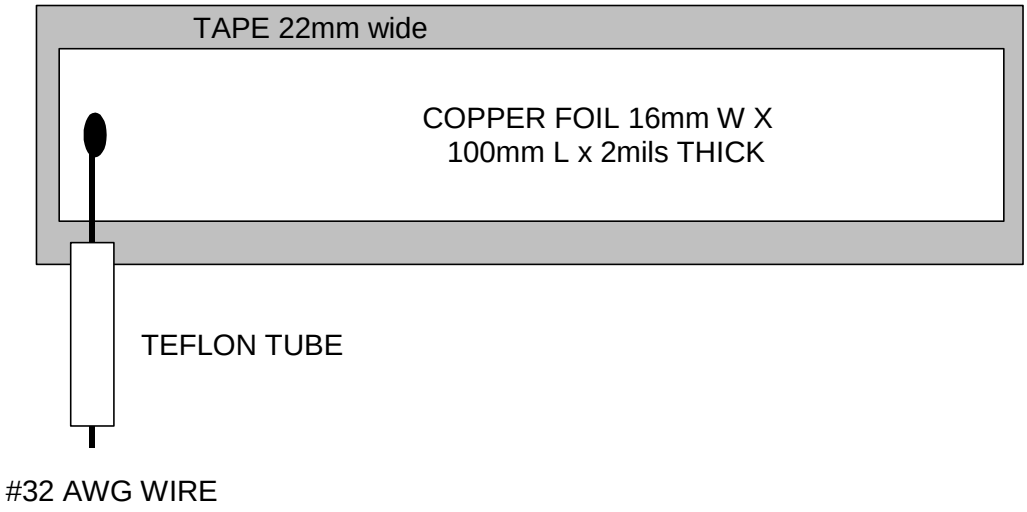

Figure 6 – Foil Winding Preparation Diagram.

8.6 Winding Instructions

Bobbin Set Up Orientation	Set up the bobbin with its pin1 to pin7 oriented to the left hand side.
Margin Tape	Apply 3.0 mm margin at each side of bobbin using item [9]. Match combined height of primary, shield and bias windings.
W1 Bias Winding	Start at pin 10 temporally. Wind 14 trifilar turns of item [4] from right to left. Wind tightly and uniformly across entire width of bobbin. Finish at pin 2 using item [10] at the finish leads. Flip the starting lead over to pin 1 using item [10] at the finish lead.
Basic Insulation	Apply 1 layers of tape item [7]
W2 Two Layers Primary Winding	Start on pin 3 using item [10] at the start leads. Wind 30 turns of item [3] from left to right. Wind another 30 turns from right to left in second layer. Finish on pin 7 using item [10] at the finish leads.
Basic Insulation	Apply 1 layers of tape item [7]
W3 Copper Shield	Start on pin 7 using item [10] at the start leads. Wind 1 turns of copper shield shown in figure 7. Apply next step tape item [8] first before close this winding to avoid copper shortage.
Basic Insulation	Apply 3 layers of tape item [8]
Margin Tape	Apply 3.0 mm margin at each side of bobbin using item [9]. Match combines height of secondary windings.
W4 3.3 V Winding.	Start at pin 8 using item [10] at the start leads. Wind 2 trifilar turns of item [5]. The wires should be tightly and uniformly wound spread across the bobbin width. Finish on pin 9 using item [10] at the finish leads.

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W5 +5V Winding	Start on pin 10 using item [10] at the start leads. Wind 1 trifilar turn of item [5]. Wind the wire between 3.3V windings. Finish on pin 8 using item [10] at the finish leads.
Basic Insulation	Apply one layer of tape item [7]
W6 +12 Winding	Start at pin 11 using item [10] at the start leads. Wind 4 turns of item [4]. Wind uniformly spread across the bobbin. Finish at pin 10 using item [10] at the finish leads.
Basic Insulation	Apply one layer of tape item [7]
W7 -22 V Winding	Start at pin 9 using item [10] at the start leads. Wind 12 turns of item [4]. Wind from right to left in a uniform and tightly wound spread across the bobbin width. Finish on pin 12 using item [10] at the finish leads.
W8 F- / F+ Winding	Start at pin 13 using item [10] at the start leads. Wind 3 turns of item [4]. Finish at pin 14 using item [10] at the finish leads.
Outer Insulation	3 Layers of tape [8] for insulation.
Core Assembly	Assemble and secure core halves. Item [1]
Final Varnish	Dip varnish uniformly in item [11]

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9 Performance Data

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

9.1 Efficiency

Units were loaded as follows: 0.6A@5V; 0.6A@3.3V; 0.1A@12V; 10mA@-12V; 0.1A@-22V.

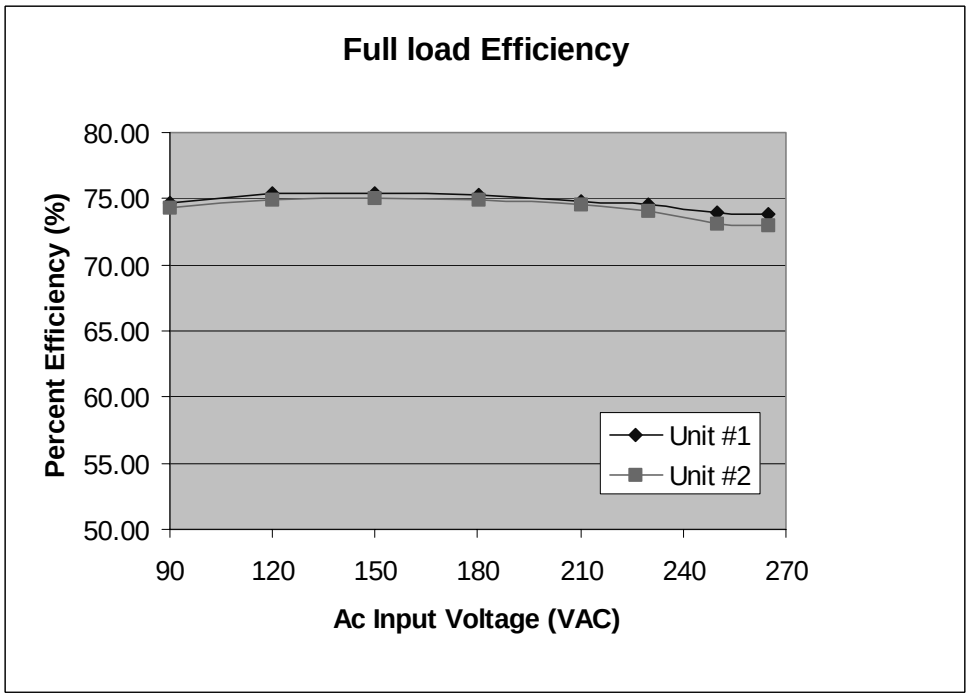

Figure 7- Efficiency vs. Input Voltage, Room Temperature, 60 Hz.

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9.2 Standby Input Power at 2W load.

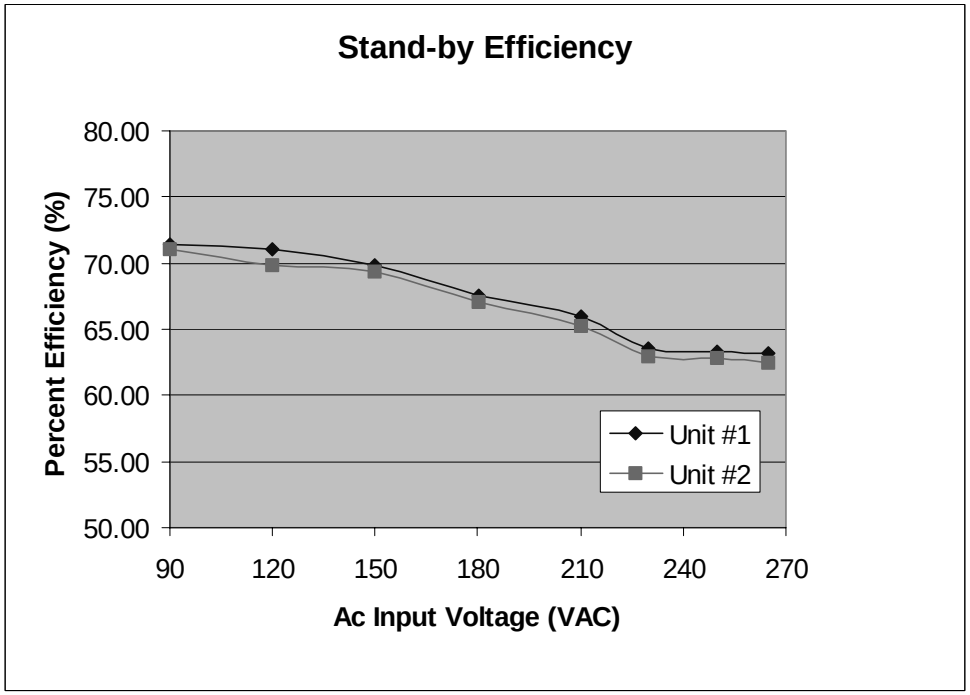

Figure 8- Standby Input Power vs. Input Line Voltage

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9.3 Cross Regulation

The tests were done at room temperature at minimum and maximum input voltage.

9.3.1 Play Mode

Load Combination 1: 0.56A@5V; 0.48A@3.3V; 40mA@12V; 15mA@-12V; 10mA@22V

Output	Vin@90V		Vin@265V	
	UNIT #1	UNIT #2	UNIT #1	UNIT #2
3.3 V	3.35	3.29	3.34	3.36
5 V	5.17	5.08	5.28	5.18
+12 V	12.65	12.48	12.99	12.83
-12 V	-12.16	-12.0	-12.78	-12.66
-23 V	-22.87	-22.8	-23.49	-23.46

Load Combination 2: 0.85A@5V; 0.48A@3.3V; 40mA@12V; 15mA@-12V; 10mA@22V

Output	Vin@90V		Vin@265V	
	UNIT #1	UNIT #2	UNIT #1	UNIT #2
3.3 V	3.4	3.33	3.47	3.42
5 V	5.15	5.05	5.24	5.16
+12 V	12.81	12.64	13.11	13.0
-12 V	-12.6	-12.48	-13.12	-13.13
-23 V	-23.31	-23.28	-23.83	-23.94

Load Combination 3: 0.85A@5V; 0.48A@3.3V; 100mA@12V; 15mA@-12V; 100mA@22V

Output	Vin@90V		Vin@265V	
	UNIT #1	UNIT #2	UNIT #1	UNIT #2
3.3 V	3.37	3.32	3.46	3.4
5 V	5.14	5.06	5.27	5.18
+12 V	12.26	12.06	12.55	12.33
-12 V	-11.15	-11.0	-11.63	-11.27
-23 V	-21.86	-21.61	-22.34	-22.06

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9.3.2 Stand-by Mode

Load Combination 4: 110mA@5V; 50mA@3.3V; 15mA@12V; 15mA@-12V; 1mA@22V

Output	**Vin@90V**		**Vin@265V**	
	UNIT #1	**UNIT #2**	**UNIT #1**	**UNIT #2**
3.3 V	3.44	3.37	3.5	3.44
5 V	5.23	5.14	5.31	5.23
+12 V	12.4	12.15	12.66	12.40
-12 V	-11.1	-10.73	-11.55	-11.18
-23 V	-21.82	-21.53	-22.26	-21.98

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10 Conducted EMI

EMI was tested at room temperature, 230 VAC input, at Load Combination 2: 0.85A@5V; 0.48A@3.3V; 100mA@12V; 15mA@-12V; 100mA@-22V.

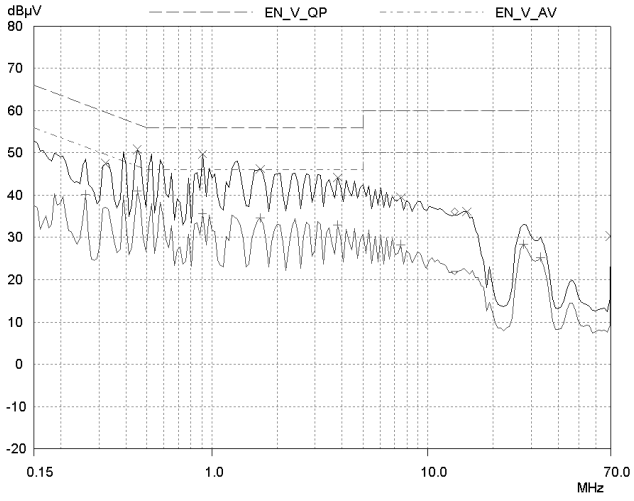

Figure 9 – LINE, Secondary Ground Connected to Earth. Unit#2

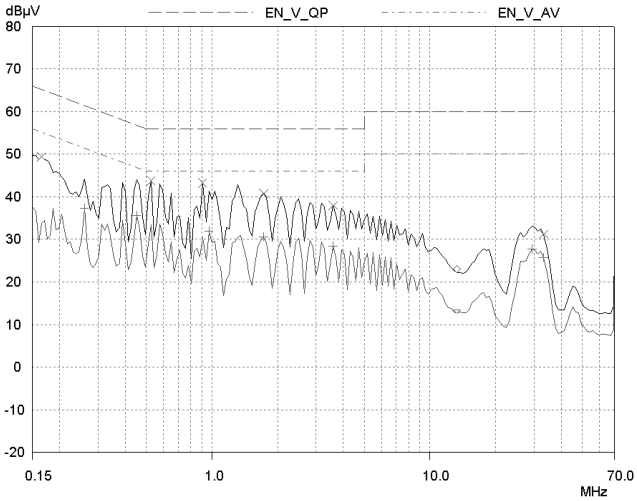

Figure 10 - LINE, Secondary Ground NOT Connected to Earth. UNIT#2

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11 Revision History

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

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