Design Example Report

Title	***17W (25W peak) DVD Recorder Power Supply using TOP245P***
Specification	Input: 90 – 265 VAC Output: 3.4V/2.55A, 5.1V/1.5A, 5.1Vsb/0.85A, 12V/2.8A, 12Vsb/0.4A, -5.3V/0.3A, -5.3Vsb/20mA, -22Vsb/10mA, +33Vsb/2mA, 3.5V VFD/165mA
Application	DVD Recorder
Author	Power Integrations Applications Department
Document Number	DER-18
Date	March 30, 2004
Revision	1.0

Summary and Features

This report describes a design for a DVD power supply, featuring the following:

- No heatsinks
- Switched Outputs for Low Standby consumption
- Low cost/ Low parts count
- No Y-cap
- No X-cap
- Meets EMI requirements

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Important Note:
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 prototype multiple output power supply utilizing a TOP245P. This power supply is designed for a DVD Recorder or similar application.

This design is low cost and meets EMI with no X-cap, and no Y-cap. It meets thermal requirements with no heatsink in either primary or secondary side.

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

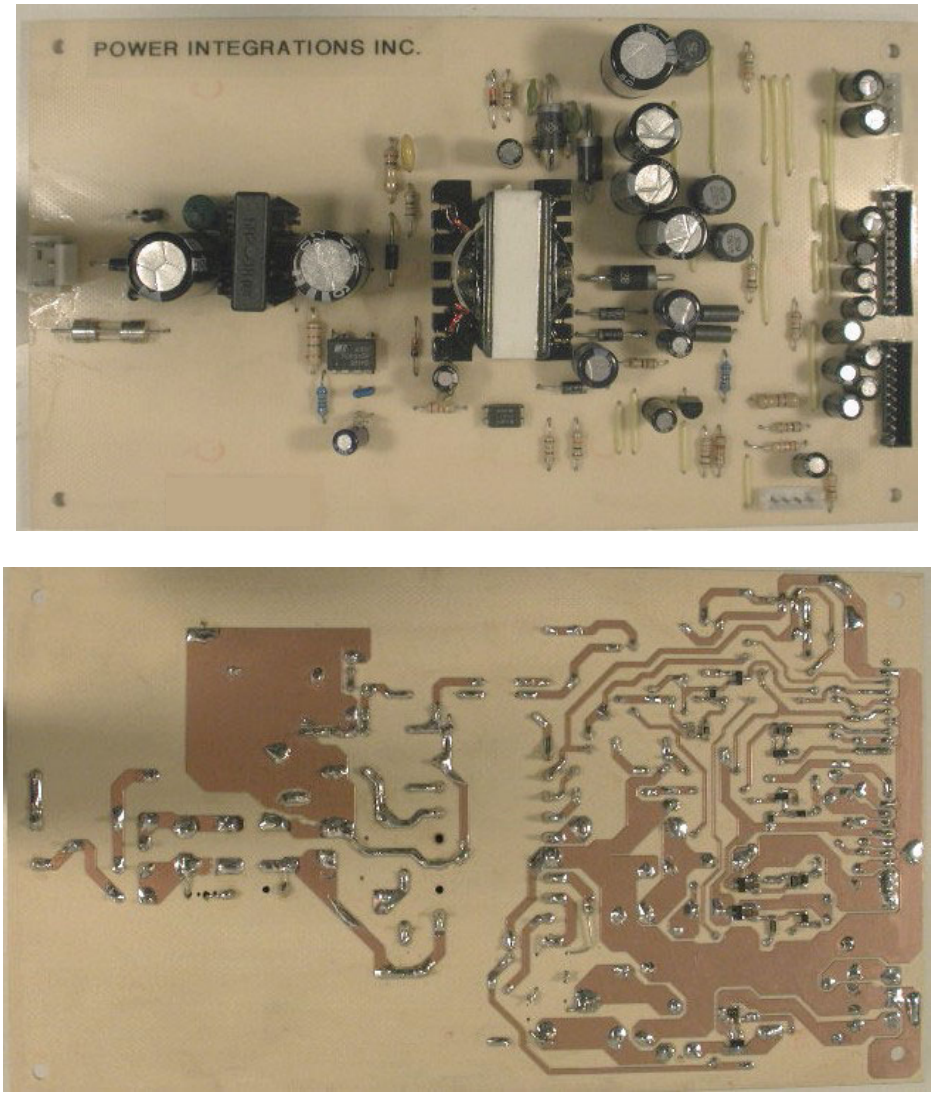

Figure 1 – Populated Circuit Board Photograph. Component side (Top) and Solder side (Bottom).

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2 Power Supply Specification

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	85		280	VAC	
Frequency	f_{LINE}	47	50/60	64	Hz	
No-load Input Power (230 VAC)				N/A	W	
Output						
Output Voltage 1	V_{OUT1}	3.3	3.4	3.5	V	
Output Ripple Voltage 1	$V_{RIPPLE1}$			50	mV	20 MHz Bandwidth
Output Current 1	I_{OUT1}			2.55	A	
Output Voltage 2	V_{OUT2}	4.85	5.1	5.25	V	
Output Ripple Voltage 2	$V_{RIPPLE2}$			50	mV	20 MHz Bandwidth
Output Current 2	I_{OUT2}			1.5	A	
Output Voltage 3	V_{OUT3}	4.94	5.1	5.46	V	Standby Output
Output Ripple Voltage 3	$V_{RIPPLE3}$			100	mV	20 MHz Bandwidth
Output Current 3	I_{OUT3}	.08		0.85	A	
Output Voltage 4	V_{OUT4}	10.8	12.0	12.8	V	
Output Ripple Voltage 4	$V_{RIPPLE4}$			100	mV	20 MHz Bandwidth
Output Current 4	I_{OUT4}	0		2.8	A	
Output Voltage 5	V_{OUT5}	11.4	12.0	12.8	V	Standby Output
Output Ripple Voltage 5	$V_{RIPPLE5}$			100	mV	20 MHz Bandwidth
Output Current 5	I_{OUT5}	0.14		0.4	A	
Output Voltage 6	V_{OUT6}	-5.5	-5.3	-5.0	V	
Output Ripple Voltage 6	$V_{RIPPLE6}$			50	mV	20 MHz Bandwidth
Output Current 6	I_{OUT6}	0		0.3	A	
Output Voltage 7	V_{OUT7}	-5.5	-5.3	-5.0	V	Standby Output
Output Ripple Voltage 7	$V_{RIPPLE7}$			200	mV	20 MHz Bandwidth
Output Current 7	I_{OUT7}	0		0.02	A	
Output Voltage 8	V_{OUT8}	30	33	35	V	Standby Output
Output Ripple Voltage 8	$V_{RIPPLE8}$			50	mV	20 MHz Bandwidth
Output Current 8	I_{OUT8}	0.001		0.002	A	
Output Voltage 8	V_{OUT8}	-28	-22	-18	V	Standby Output
Output Ripple Voltage 8	$V_{RIPPLE8}$			50	mV	20 MHz Bandwidth
Output Current 8	I_{OUT8}			0.010	A	
Output Voltage 8	V_{OUT8}	3.15	3.5	3.85	V	Filament Power Floating Winding
Output Ripple Voltage 8	$V_{RIPPLE8}$			50	mV	20 MHz Bandwidth
Output Current 8	I_{OUT8}			0.165	A	
Total Output Power						
Continuous Output Power	P_{OUT}		17		W	
Peak Output Power	P_{OUT_PEAK}		25		W	
Efficiency	η	74			%	Measured at P_{OUT} (17 W), 25 °C
Environmental						
Conducted EMI		Meets CISPR22B / EN55022B				
Safety		Designed to meet IEC950, UL1950 Class II				
Ambient Temperature	T_{AMB}		25		°C	Free convection, sea level

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3 Schematic

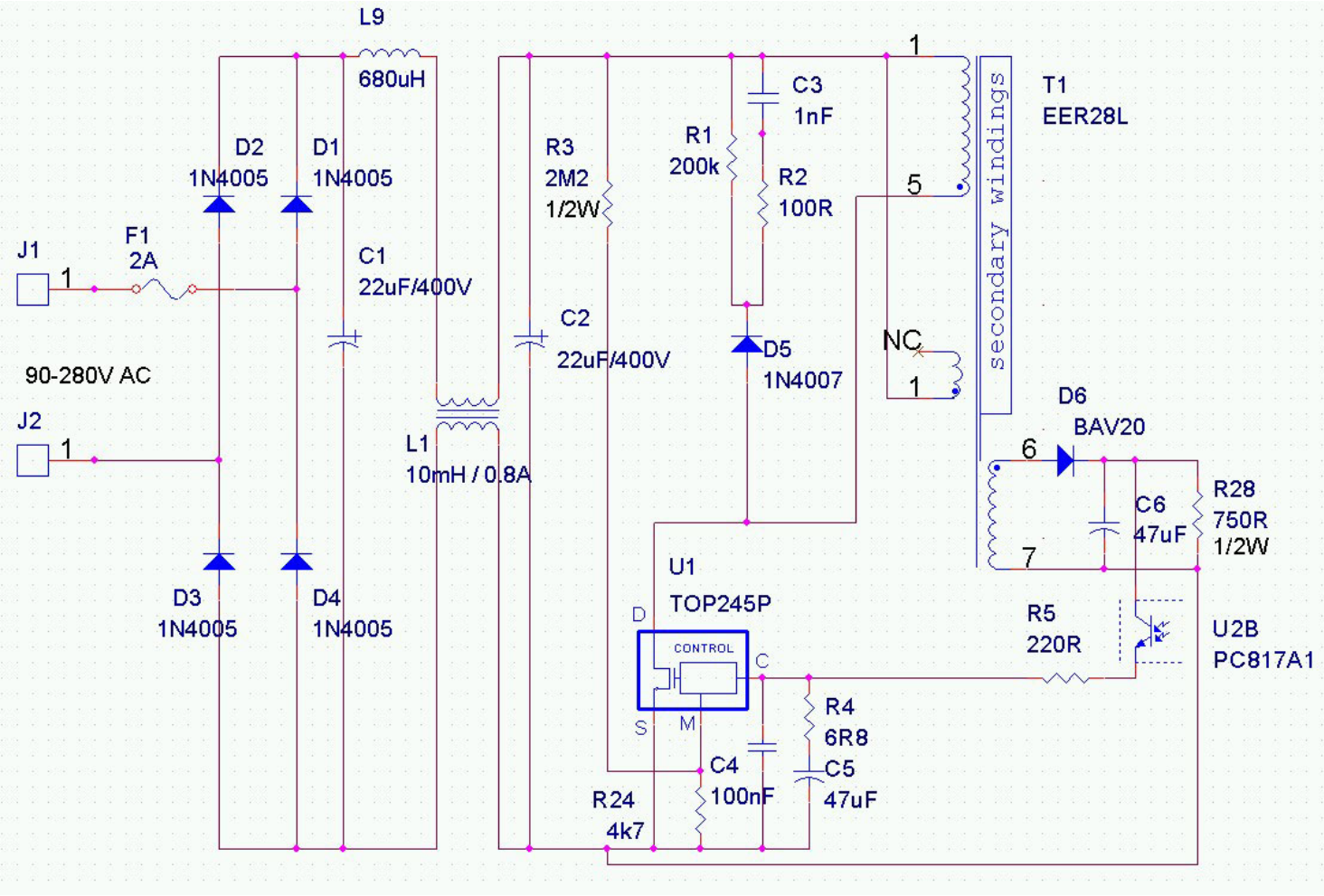

Figure 2 – Schematic (Primary Side)

Note: 1 – L9 was inserted on the actual board, it was not included in the original layout.

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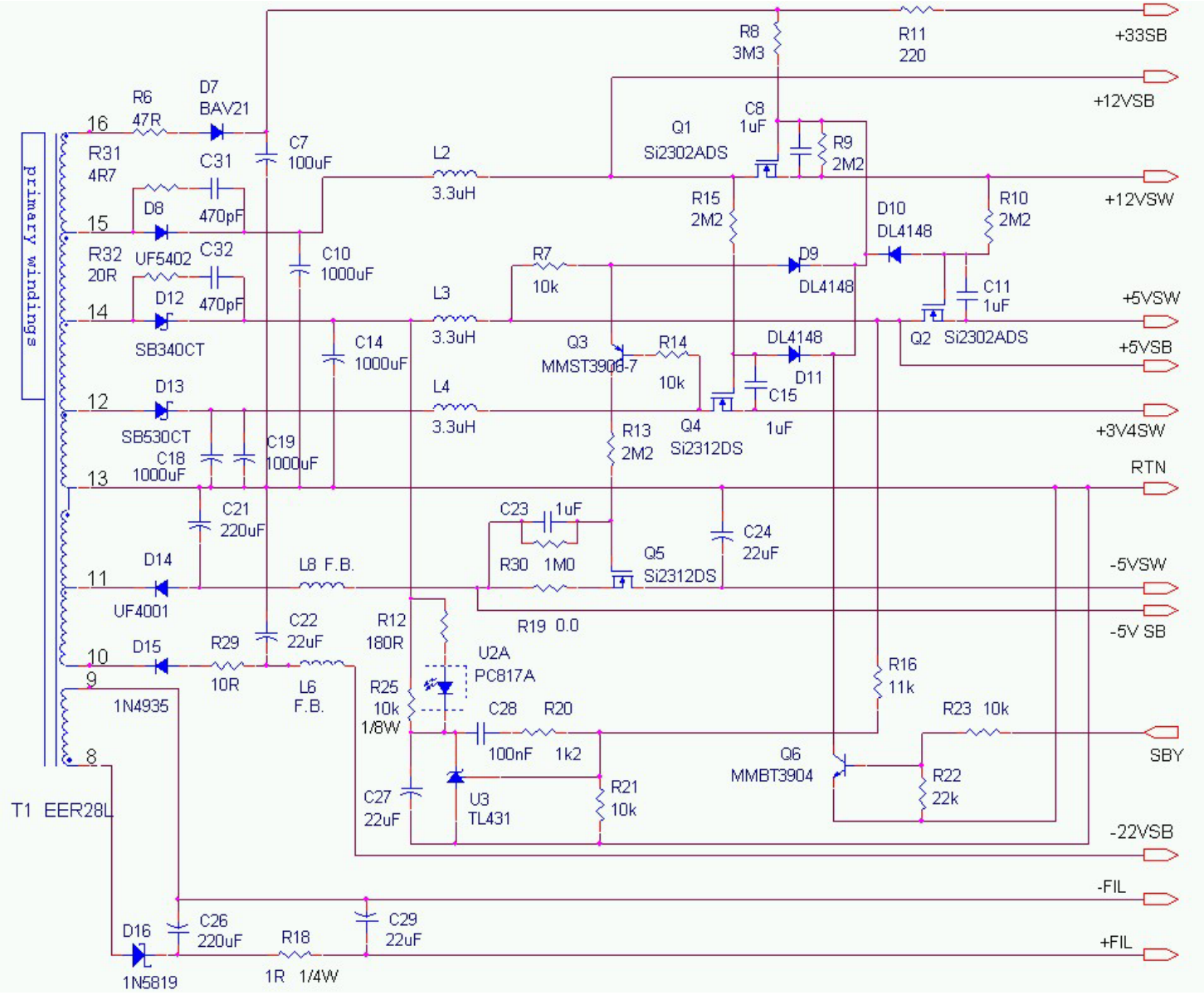

Figure 3 – **Schematic (Secondary Side)**

Note: 1- R30 was fitted in parallel with C23, it was not included in the original layout.
2- Snubber networks R31, R32, C31, & C32 were fitted in parallel with D8 and D12, and were not included in the original layout

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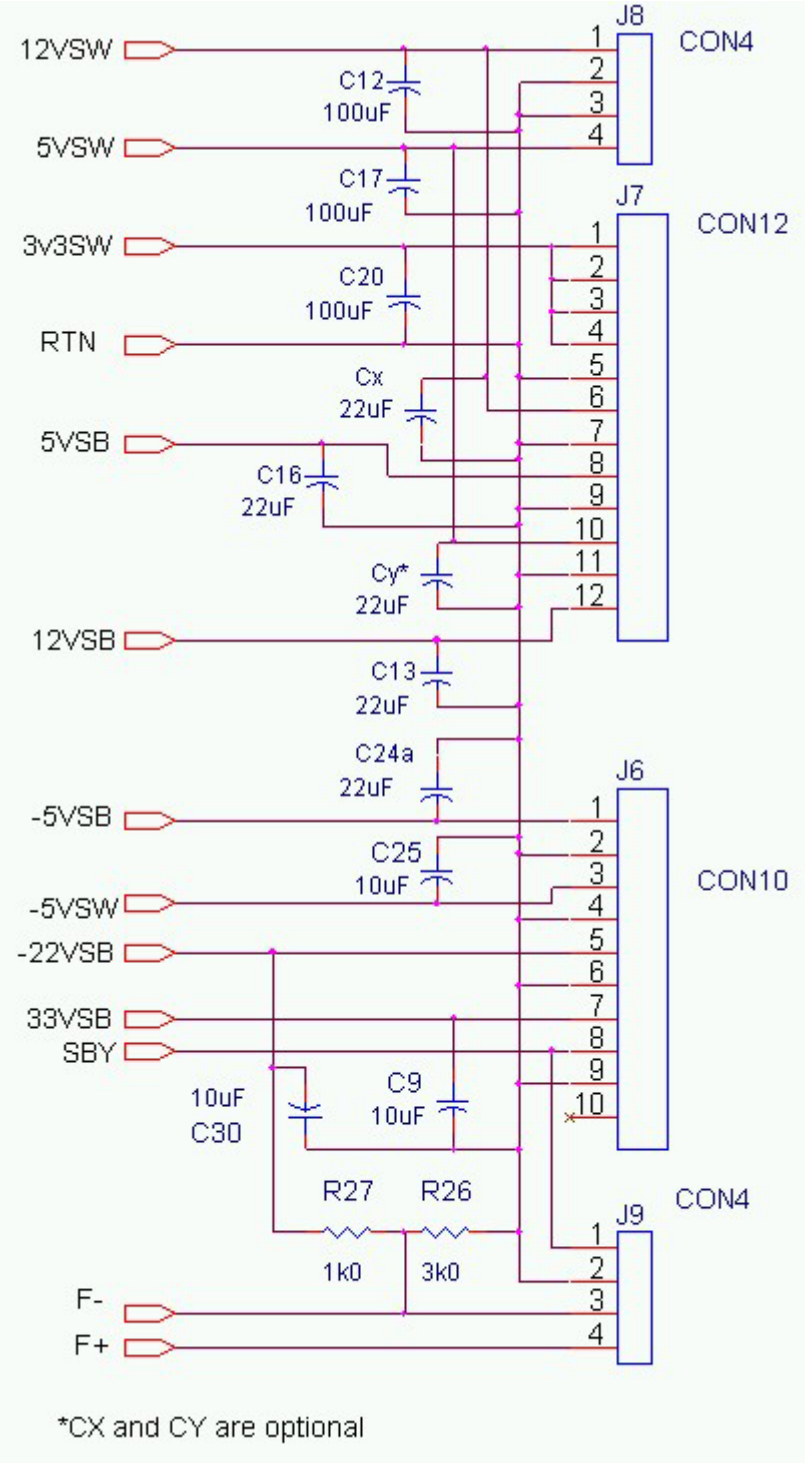

Figure 4 – **Schematic (Connector Side)**

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4 Bill Of Materials

Item Number	Qty.	Part Reference	Value	Description
1	1	C1	22uF/400V	
2	1	C2	22uF/400V	
3	1	C3	1nF/1KV	
4	1	C4	100nF	Cap,Cer, 0.10 uF, 50V, Z5U, 20%
5	1	C5	47uF	Cap,Al Elect,47uF,16V,5mmX11.5mm,LXZ Series,NIPPON CHEMI-CON
6	1	C6	47uF	Cap,Al Elect,47uF,16V,5mmX11.5mm,LXZ Series,NIPPON CHEMI-CON
7	1	C7	100uF	Cap,Al Elect,100uF,50V,8mmX12mm,LXZ Series,NIPPON CHEMI-CON
8	4	C8 C11 C15 C23	1uF	CAP 1uF 25V CERM CHIP X7R 0805 SMD
9	3	C9 C25 C30	10uF	Cap,Al Elect,12uF,50V,5mmX11.5mm,LXZ Series,NIPPON CHEMI-CON
10	4	C10 C14 C18 C19	1000uF	Cap,Al Elect,1000uF,16V,10mmX20mm,LXZ Series,NIPPON CHEMI-CON
11	3	C12 C17 C20	100uF	Cap,Al Elect,100uF,50V,8mmX11.5mm,KZE Series,NIPPON CHEMI-CON
12	8	C13 C16 C22 C24 C24a C27 CX CY*	22uF	Cap,Al Elect,22uF,50V,5mmX11mm,KZE Series,NIPPON CHEMI-CON
13	1	C21	220uF	Cap,Al Elect,220uF,16V,6.3mmX11mm,LXZ Series,NIPPON CHEMI-CON
14	1	C26	220uF	Cap,Al Elect,220uF,10V,6.3mmX11mm,KZE Series,NIPPON CHEMI-CON
15	1	C28	100nF	CAP 0.1uF 50V CERM CHIP X7R 0805 SMD
16	1	C29	22uF	Cap,Al Elect,22uF,50V,5mmX11.5mm,LXZ Series,NIPPON CHEMI-CON
16a	2	C31, C32	470pf	Cap,Cer, 470pF, 1kV, Z5U, 20%
17	4	D1 D2 D3 D4	1N4005	Rectifier GPP 600V 1A DO-41
18	1	D5	1N4007GP	Rectifier GPP 1000V 1A DO-41
19	1	D6	BAV20	
20	1	D7	BAV21	Diode Fast Switch 250V 500MW DO35
21	1	D8	UF5402	Rectifier Ultrafast 200V, 1A, D0-201AD
22	3	D9 D10 D11	DL4148	RECT,DL4148, PASSIVATED 500mW SMD MELF
23	1	D12	SB340CT	Rectifier Schottky 3A 40V DO-201AD
23a	1	D13	SB530CT	Rectifier Schottky 5A 30V DO-201AD
24	1	D14	UF4001	Rectifier Ultrafast 50V, 1A, D0-41
25	1	D15	1N4935	Rectifier Fast Rec 200V 1A DO-41
26	1	D16	1N5819	Rectifier Schottky 1A 40V DO-41
27	1	F1	2A	FUSE T-LAG 2A,250V Slo-Blo IEC SHORT TR5
28	2	J1 J2	TERM_1Pin	Terminal,1Pin,18AWG
29	1	J6	CON10	

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30	1	J7	CON12	
31	1	J8	CON4	
32	1	J9	CON4	
33	1	L1	10mH / 0.8A	
34	3	L2 L3 L4	3.3uH	Inductor,3.3uH,2.66A
35	2	L6 L8	F.B.	Bead,Ferrite,2.0 uH,Axial
36	1	L9	680uH	COIL 680.uH MOLDED SHIELDED
37	1	Q1	Si2302ADS	
38	1	Q2	Si2302ADS	
39	1	Q3	MMST3906-7	TRANSISTOR,2N3906, PNP 40V SOT-323
40	1	Q4	Si2312DS	
41	1	Q5	Si2312DS	
42	1	Q6	MMBT3904	
43	1	R1	200k	Res, 200K, 1/4W, 5%, Carbon Film
44	1	R2	100R	Res, 100, 1/4W, 5%, Carbon Film
45	1	R3	2M2	Res, 2.2M, 1/2W, 5%, Carbon Film
46	1	R4	6R8	Res, 6.8, 1/4W, 5%, Carbon Film
47	1	R5	220R	Res, 220, 1/4W, 5%, Carbon Film
48	1	R6	47R	Res, 47, 1/4W, 5%, Carbon Film
49	2	R7 R21	10k	Res,10K 1/10W 1% 0805 SMD
50	1	R8	3M3	Res, 3.3M, 1/4W, 5%, Carbon Film
51	3	R9 R10 R15	2M2	Res,2.2M 1/8W 5% 1206 SMD
52	1	R11	220	Res, 220R, 1/4W, 5%, Carbon Film
53	1	R12	180R	Res, 180, 1/4W, 5%, Carbon Film
54	1	R13	2M2	Res, 2.2M, 1/4W, 5%, Carbon Film
55	2	R14 R23	10k	Res, 10K, 1/4W, 5%, Carbon Film
56	1	R16	11k	Res, 11K, 1/4W, 5%, Carbon Film
57	1	R18	1R	Res, 1 ,1/4W, 5%, Metal Film
58	1	R19	0	Res,XXX 1/10W 1% 0805 SMD
59	1	R20	1k2	Res,1.2K 1/10W 5% 0805 SMD
60	1	R22	22k	Res, 22K, 1/4W, 5%, Carbon Film
61	1	R24	4k7	Res, 4.7K, 1/4W, 5%, Carbon Film
62	1	R25	10k	Res, 10K, 1/8W, 5%, Carbon Film
63	1	R26	3k0	Res, 3.0K, 1/4W, 5%, Carbon Film
63a		R27	1K0	Res, 1.0K, 1/4W, 5%, Carbon Film
64	1	R28	750R	Res, 750, 1/2W, 5%, Carbon Film
65	1	R29	10R	Res, 10, 1/4W, 5%, Carbon Film
66	1	R30	1M0	Res,1.0M 1/10W 5% 0805 SMD
66a	1	R31	4R7	Res, 4R7, 1/8W, 5%, Carbon Film
66b	1	R32	20R	Res, 20R, 1/8W, 5%, Carbon Film
67	1	T1	EER28L	Custom (See Spec)
68	1	U1	TOP245P	TOPSwitch
69	1	U2	PC817X1	IC,PC817A1,PHOTOCOUPLER TRAN OUT CTR 80-160% 4-DIP
70	1	U3	TL431	Shunt regulator 1%

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5 Layout

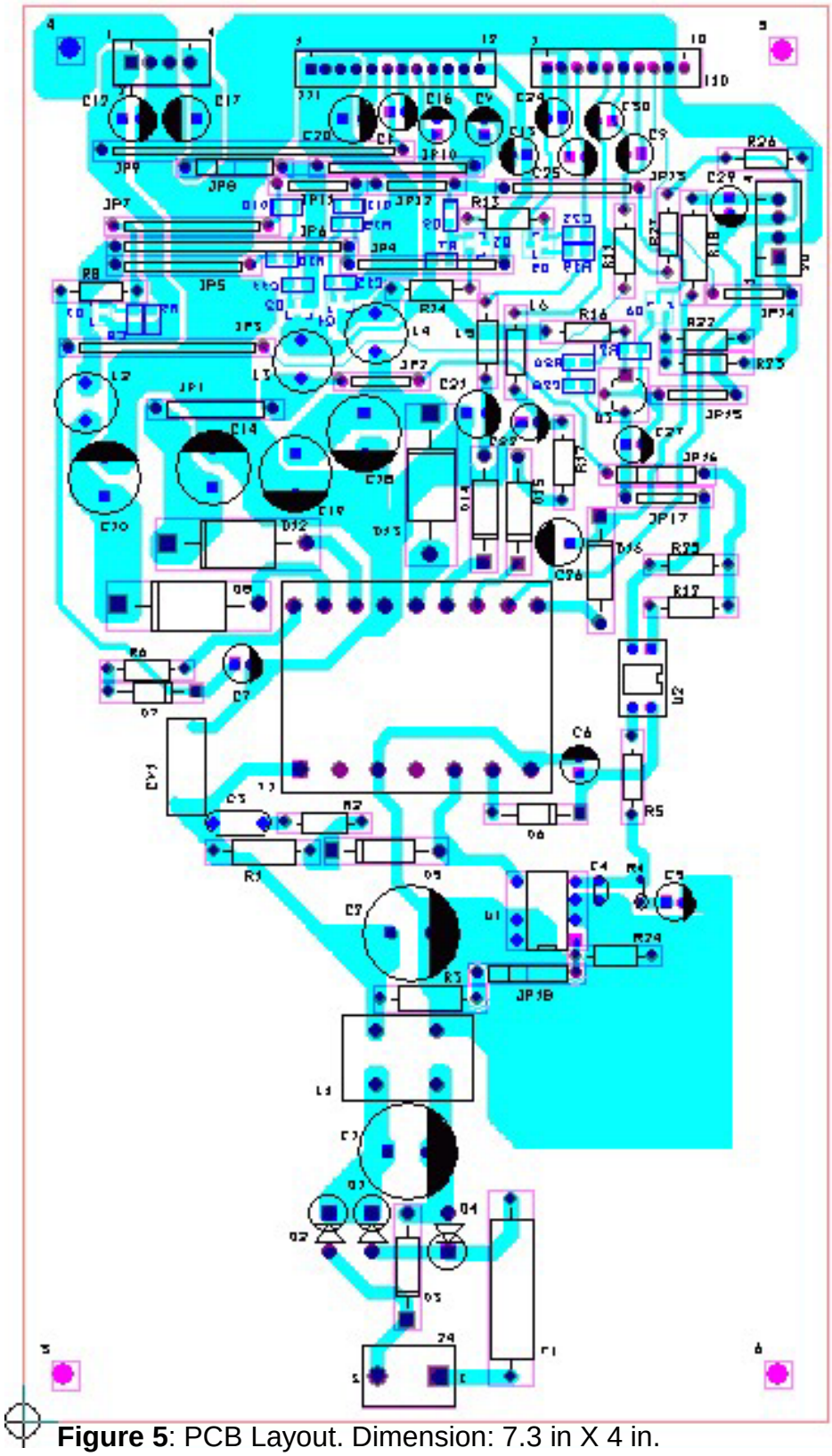

Figure 5: PCB Layout. Dimension: 7.3 in X 4 in.

Note: Some components were added and are not shown above (see schematic note).

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6 Transformer Specification

6.1 Electrical Diagram

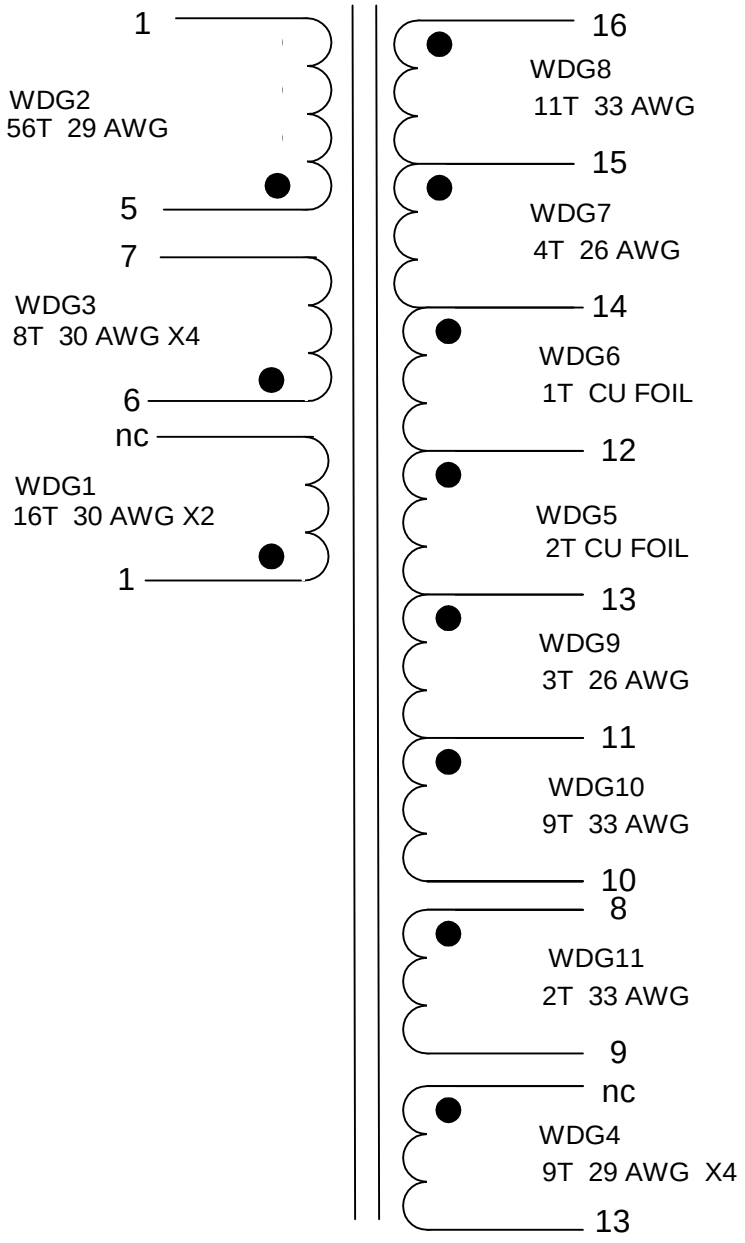

Figure 6 –Transformer Electrical Diagram

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6.2 Electrical Specifications

Electrical Strength	1 second, 60 Hz, from Pins 1-7 to Pins 8-16	3000 VAC
Primary Inductance	Pins 1-5, all other windings open, measured at 100 kHz, 0.4 VRMS	550 µH, +10%
Resonant Frequency	Pins 1-5, all other windings open	750 kHz (Min.)
Primary Leakage Inductance	Pins 1-5, with Pins 8-16 shorted, measured at 100 kHz, 0.4 VRMS	40 µH (Max.)

6.3 Materials

Item	Description
[1]	Core: EER28L
[2]	Bobbin: BEER28L, VERTICAL 16-PINS
[3]	Magnet Wire: 30 AWG
[4]	Magnet Wire: 29 AWG
[5]	Magnet Wire: 33 AWG
[6]	Magnet Wire: 26 AWG
[7]	Tape: Margin 6 mm
[8]	Tape, Tape: 3M 1298 Polyester Film, 10.5mm wide
[9]	Tape, Tape: 3M 1298 Polyester Film, 22mm wide
[10]	Tape, Tape: 3M 1298 Polyester Film, 14mm wide
[11]	Copper Foil: 1mil x 9.5mm wide x 190 mm long
[12]	Varnish

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6.4 Transformer Build Diagram

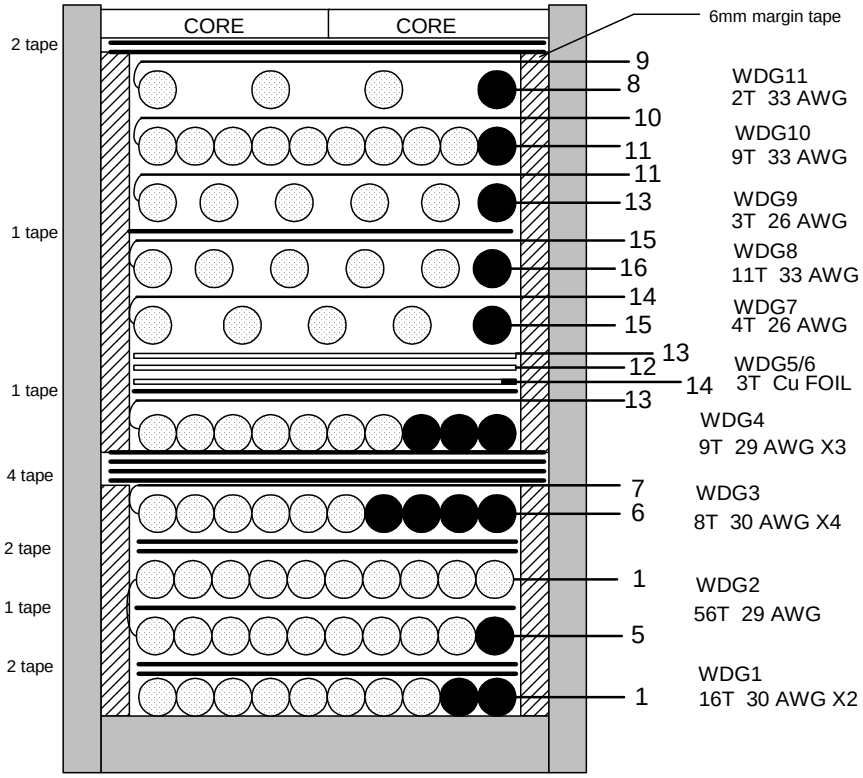

Figure 7 – Transformer Build Diagram.

6.4.1 WDG5/6 Copper Foil build diagram:

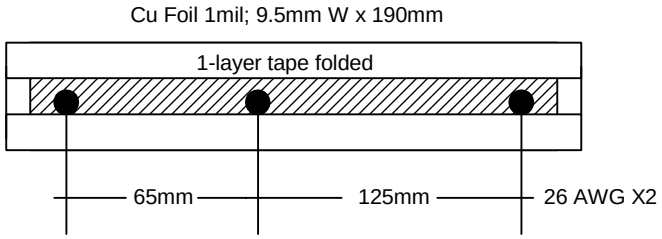

Figure 8 – Copper Foil Build Diagram.

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6.5 Transformer Construction

Bobbin Preparation	Pull Pins 2, 3 & 4 on bobbin to provide polarization. Place the bobbin with pins oriented on the right hand side.
Margin	Apply 6 mm wide margin tape on both sides of the bobbin. Match height of primary windings.
WGD1: Shield	Start at Pin 1. Wind 16 bifilar turns of 30 AWG wire in 1 layer. Cut end leads floating.
Basic Insulation	Use two layers of 10.5 mm tape for basic insulation.
WGD2: Primary (1st -layer)	Start at Pin 5. Wind 30 turns of 29 AWG wire for the 1st layer.
Basic Insulation	Put one layer of 10.5 mm tape for basic insulation
WGD2: Primary (2nd -layer)	Continue winding 26 turns for the 2nd layer. Finish on Pin 1.
Basic Insulation	Put two layers of 10.5 mm tape for basic insulation
WGD3: Bias	Start at Pin 6. Wind 8 quadfilar turns of 30 AWG wire in 1 layer. Finish on Pin 7.
Reinforced Insulation	Put 4 layers of 22 mm tape for reinforced insulation
Margin	Apply 6 mm wide margin tape on both sides of the bobbin. Match height of secondary windings.
WGD4: Bias	Start at Pin 16 temporarily. Wind 9 quadfilar turns of 29 AWG wire in 1 layer. Finish on Pin 13. Cut start-leads floating.
Basic Insulation	Put one layer of 10.5mm tape for basic insulation
WGD5/6: 3V/5V	Use prepared cu foil shown in Figure 7. Start at pin 14, wind 1 turn, terminate at pin 12,continue to wind two turns. Finish at pin 13. Secure end with 10.5 mm tape.
WGD7: 12V	Start at Pin 15. Wind 4 turns of 26 AWG wire in 1 layer. Spread evenly across the bobbin. Finish on Pin 14.
WGD8: 33V	Start at Pin 16. Wind 11 turns of 33 AWG wire in 1 layer. Spread evenly across the bobbin. Finish on Pin 15.
Basic Insulation	Put one layer of 10.5 mm tape for basic insulation
WGD9: - 5V	Start at Pin 13. Wind 3 turns of 26 AWG wire in 1 layer. Spread evenly across the bobbin. Finish on Pin 11.
WGD10: - 22V	Start at Pin 11. Wind 9 turns of 33 AWG wire in 1 layer. Spread evenly across the bobbin. Finish on Pin 10.
WGD11: 3V VFD	Start at Pin 8. Wind 2 turns of 33 AWG wire in 1 layer. Spread evenly across the bobbin. Finish on Pin 9.
Outer Wrap	Wrap windings with 2 layers of 22 mm tape
Core Preparation	Glue core halves together.
Final Assembly	Varnish impregnate

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7 Transformer Spreadsheets

ACDC_TOPGX_Rev1.5_081203 Copyright Power Integrations Inc. 2003	INPUT	INFO	OUTPUT	UNIT	TOP_GX_081203.xls: TOPSwitch-GX Continuous/Discontinuous Flyback Transformer Design Spreadsheet
ENTER APPLICATION VARIABLES					Customer
VACMIN	90			Volts	Minimum AC Input Voltage
VACMAX	280			Volts	Maximum AC Input Voltage
fL	50			Hertz	AC Mains Frequency
VO	5			Volts	Output Voltage
PO	25			Watts	
n	0.75				Efficiency Estimate
Z	0.75				Loss Allocation Factor
VB	15			Volts	Bias Voltage
tC	3			mSeconds	Bridge Rectifier Conduction Time Estimate
CIN	44			uFarads	Input Filter Capacitor
ENTER TOPSWITCH-GX VARIABLES					
TOP-GX	TOP245P			Universal	115 Doubled/230V
Chosen Device		TOP245P	Power Out	22W	30W
KI	1				External Ilimit reduction factor (KI=1.0 for default ILIMIT, KI <1.0 for lower ILIMIT)
ILIMITMIN			1.023	Amps	Use 1% resistor in setting external ILIMIT
ILIMITMAX			1.177	Amps	Use 1% resistor in setting external ILIMIT
Frequency - (F)=132kHz, (H)=66kHz	F				Full (F) frequency option - 132kHz
fS	132000		132000	Hertz	TOPSwitch-GX Switching Frequency: Choose between 132 kHz and 66 kHz
fSmin			124000	Hertz	TOPSwitch-GX Minimum Switching Frequency
fSmax			140000	Hertz	TOPSwitch-GX Maximum Switching Frequency
VOR	103			Volts	Reflected Output Voltage
VDS	10			Volts	TOPSwitch on-state Drain to Source Voltage
VD	0.5			Volts	Output Winding Diode Forward Voltage Drop
VDB	0.7			Volts	Bias Winding Diode Forward Voltage Drop
KP	0.50				Ripple to Peak Current Ratio (0.4 < KRP < 1.0 : 1.0< KDP<6.0)

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ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES				
Core Type	EER28L			
Core		EER28L	P/N:	PC40EER28L-Z
Bobbin		EER28L_BOBBIN	P/N:	BEER-28L-1112CPH
AE			0.814 cm^2	Core Effective Cross Sectional Area
LE			7.55 cm	Core Effective Path Length
AL			2520 nH/T^2	Ungapped Core Effective Inductance
BW	21.5		21.5 mm	Bobbin Physical Winding Width
M	6		mm	Safety Margin Width (Half the Primary to Secondary Creepage Distance)
L	2.1			Number of Primary Layers
NS	3			Number of Secondary Turns
DC INPUT VOLTAGE PARAMETERS				
VMIN			75 Volts	Minimum DC Input Voltage
VMAX			396 Volts	Maximum DC Input Voltage
CURRENT WAVEFORM SHAPE PARAMETERS				
DMAX			0.61	Maximum Duty Cycle
IAVG			0.45 Amps	Average Primary Current
IP			0.97 Amps	Peak Primary Current
IR			0.48 Amps	Primary Ripple Current
IRMS			0.58 Amps	Primary RMS Current
TRANSFORMER PRIMARY DESIGN PARAMETERS				
LP			717 uHenries	Primary Inductance
NP			56	Primary Winding Number of Turns
NB			9	Bias Winding Number of Turns
ALG			227 nH/T^2	Gapped Core Effective Inductance
BM			1518 Gauss	Maximum Flux Density at PO, VMIN (BM<3000)
BP			1846 Gauss	Peak Flux Density (BP<4200)
BAC			380 Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
ur			1860	Relative Permeability of Ungapped Core
LG			0.41 mm	Gap Length (Lg > 0.1 mm)
BWE			19.95 mm	Effective Bobbin Width
OD			0.36 mm	Maximum Primary Wire Diameter including insulation
INS			0.06 mm	Estimated Total Insulation Thickness (= 2 * film thickness)
DIA			0.30 mm	Bare conductor diameter

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AWG	29	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CM	128	Cmils	Bare conductor effective area in circular mils
CMA	221	Cmils/ Amp	Primary Winding Current Capacity (200 < CMA < 500)
TRANSFORMER SECONDARY DESIGN PARAMETERS (SINGLE OUTPUT / SINGLE OUTPUT EQUIVALENT)			
Lumped parameters			
ISP	18.13	Amps	Peak Secondary Current
ISRMS	8.60	Amps	Secondary RMS Current
IO	5.00	Amps	Power Supply Output Current
IRIPPLE	7.00	Amps	Output Capacitor RMS Ripple Current
CMS	1721	Cmils	Secondary Bare Conductor minimum circular mils
AWGS	17	AWG	Secondary Wire Gauge (Rounded up to next larger standard AWG value)
DIAS	1.15	mm	Secondary Minimum Bare Conductor Diameter
ODS	3.17	mm	Secondary Maximum Outside Diameter for Triple Insulated Wire
INSS	1.01	mm	Maximum Secondary Insulation Wall Thickness
VOLTAGE STRESS PARAMETERS			
VDRAIN	632	Volts	Maximum Drain Voltage Estimate (Includes Effect of Leakage Inductance)
PIVS	26	Volts	Output Rectifier Maximum Peak Inverse Voltage
PIVB	75	Volts	Bias Rectifier Maximum Peak Inverse Voltage

TRANSFORMER SECONDARY DESIGN PARAMETERS (MULTIPLE OUTPUTS)			
1st output			
VO1	3.4	Volts	Output Voltage
IO1	2.550	Amps	Output DC Current
PO1	8.67	Watts	Output Power
VD1	0.5	Volts	Output Diode Forward Voltage Drop
NS1	2.13		Output Winding Number of Turns
ISRMS1	4.388	Amps	Output Winding RMS Current
IRIPPLE1	3.57	Amps	Output Capacitor RMS Ripple Current
PIVS1	18	Volts	Output Rectifier Maximum Peak Inverse

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				Voltage
CMS1		878	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS1		20	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS1		0.81	mm	Minimum Bare Conductor Diameter
ODS1		4.47	mm	Maximum Outside Diameter for Triple Insulated Wire
2nd output				
VO2	12.2		Volts	Output Voltage
IO2	0.850		Amps	Output DC Current
PO2		10.37	Watts	Output Power
VD2	1.2		Volts	Output Diode Forward Voltage Drop
NS2		7.31		Output Winding Number of Turns
ISRMS2		1.463	Amps	Output Winding RMS Current
IRIPPLE2		1.19	Amps	Output Capacitor RMS Ripple Current
PIVS2		64	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS2		293	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS2		25	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS2		0.46	mm	Minimum Bare Conductor Diameter
ODS2		1.30	mm	Maximum Outside Diameter for Triple Insulated Wire
3rd output				
VO3	33.0		Volts	Output Voltage
IO3	0.002		Amps	Output DC Current
PO3		0.07	Watts	Output Power
VD3	1.0		Volts	Output Diode Forward Voltage Drop
NS3		18.55		Output Winding Number of Turns
ISRMS3		0.003	Amps	Output Winding RMS Current
IRIPPLE3		0.00	Amps	Output Capacitor RMS Ripple Current
PIVS3		164	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS3		1	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS3		51	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS3		0.02	mm	Minimum Bare Conductor Diameter
ODS3		0.51	mm	Maximum Outside Diameter for Triple Insulated Wire
Total power		19.10 6	Watts	!!!!!!!!!! Warning: total output power not equal to PO (PO= 25 W)

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8 Performance Data

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

8.1 Efficiency

Load Condition: 3.3Vsb/2A; 5Vsw/0.4A; 5Vsb/0.4A; 12Vsw/0.3A, 12Vsb/0.1A; -5Vsw/01.A; -5Vsb/240 ohms, -22Vsb/11K; +33Vsb/16Kohms; 3.3V VFD/20 ohms

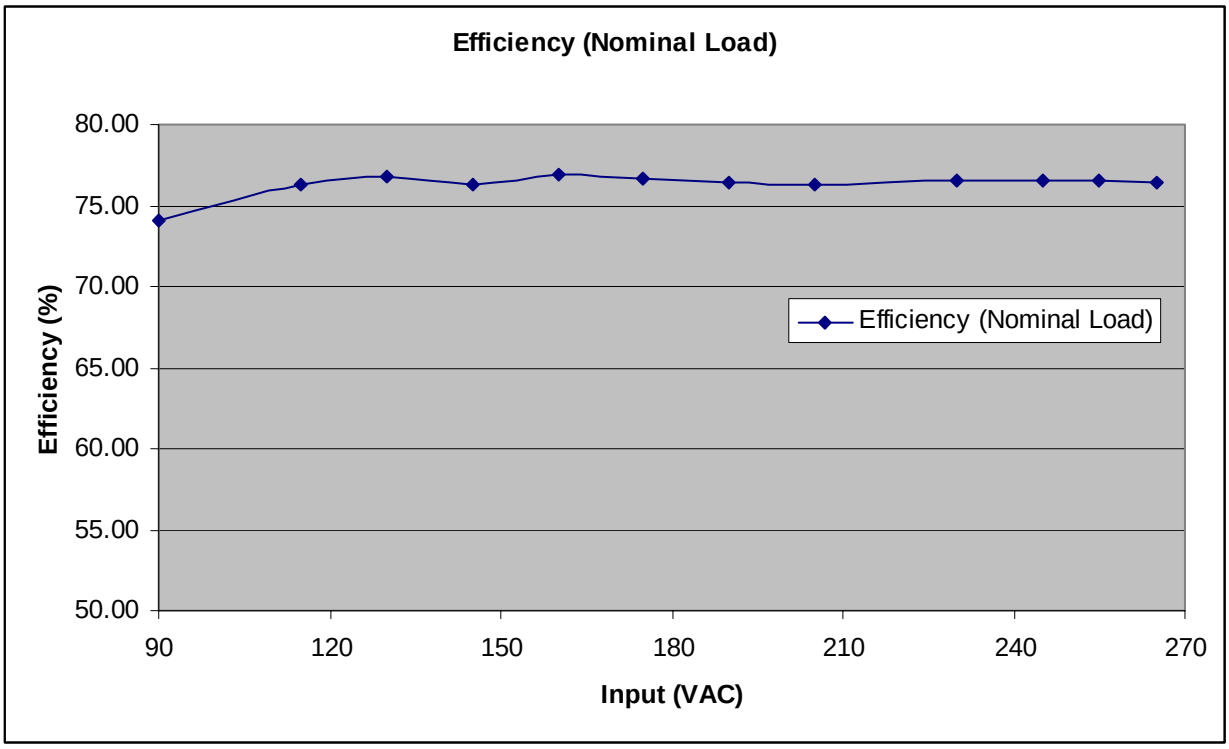

Figure 9- Efficiency vs. Input Voltage, Room Temperature, 60 Hz. Efficiency at 115Vac and 230Vac are 76.3% and 76.5% respectively.

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8.2 Cross Regulation

8.2.1 Nominal load

Load Condition: 3.3Vsb/2A; 5Vsw/0.4A; 5Vsb/0.4A; 12Vsw/0.3A, 12Vsb/0.1A; -5Vsw/0.08A; -5Vsb/240 ohms, -22Vsb/11K; +33Vsb/16Kohms; 3.3V VFD/20 ohms

Vout (VDC)	Load (A)	@115V	@230V
3.3Vsb	2A	3.25 V	3.25
5Vsw/	0.4A	5.27	5.27
5Vsb/	0.4A	5.28	5.28
12Vsw	0.3A	12.50	12.46
12Vsb	0.1A	12.51	12.47
-5Vsw	0.08A	-5.08	-5.15
-5Vsb	240 ohms	-5.17	-5.15
-22Vsb	11K	-22.81	-22.71
+33Vsb	16Kohms	33.07	32.94
3.3V VFD	20 ohms	3.24	3.24

Figure 9 –Nominal load at Room Temperature.

8.2.2 Peak Load (One output at a time)

At 115V

Vout	Iout	Vout (measured)	Iout	Vout (measured)	Iout	Vout (measured)	Iout	Vout (measured)
3.3Vsb	***2.51Apk***	***3.15 V***	2A	3.27 V	2A	3.23 V	2A	3.21 V
5Vsw/	0.4A	5.27	***1.2Apk***	***5.22***	0.4A	5.27	0.4A	5.27
5Vsb/	0.4A	5.28	0.4A	5.28	***0.55Apk***	***5.28***	0.4A	5.28
12Vsw	0.3A	12.5	0.3A	12.71	0.3A	12.52	***1.2Apk***	***12.2***
12Vsb	0.1A	12.51	0.1A	12.72	0.1A	12.53	0.1A	12.26
-5Vsw	0.08A	-5.22	0.08A	-5.37	0.08A	-5.21	0.08A	-5.41
-5Vsb	240 Ω	-5.22	240 Ω	-5.37	240 Ω	-5.21	240 Ω	-5.41
-22Vsb	11K Ω	-22.92	11K Ω	-23.5	11K Ω	-22.89	11K Ω	-23.58
+33Vsb	16K Ω	33.26	16K Ω	34.05	16K Ω	33.23	16K Ω	34.05
3.3V VFD	20 Ω	3.25	20 Ω	3.31	20 Ω	3.26	20 Ω	3.26

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Continuation (115V)

Vout	Iout	Vout (measured)	Iout	Vout (measured)
3.3Vsb	2A	3.22 V	2A	3.22 V
5Vsw/	0.4A	5.27	0.4A	5.29
5Vsb/	0.4A	5.28	0.4A	5.28
12Vsw	0.3A	12.38	0.3A	12.46
12Vsb	***0.4Apk***	***12.51 V***	0.1A	12.47
-5Vsw	0.08A	-5.23	***0.12Apk***	***-5.0 V***
-5Vsb	240 Ω	-5.24	240 Ω	-5.0
-22Vsb	11K Ω	-22.96	11K Ω	-22.61
+33Vsb	16K Ω	33.29	16K Ω	33.0
3.3V VFD	20 Ω	3.25	20 Ω	3.24

At 230V

Vout	Iout	Vout (measured)	Iout	Vout (measured)	Iout	Vout (measured)	Iout	Vout (measured)
3.3Vsb	***2.51Apk***	***3.19 V***	2A	3.29 V	2A	3.25 V	2A	3.24 V
5Vsw/	0.4A	5.27	***1.2Apk***	***5.22***	0.4A	5.27	0.4A	5.27
5Vsb/	0.4A	5.28	0.4A	5.28	***0.55Apk***	***5.28***	0.4A	5.28
12Vsw	0.3A	12.48	0.3A	12.64	0.3A	12.49	***1.2Apk***	***12.22***
12Vsb	0.1A	12.49	0.1A	12.66	0.1A	12.5	0.1A	12.29
-5Vsw	0.08A	-5.18	0.08A	-5.29	0.08A	-5.17	0.08A	-5.3
-5Vsb	240 Ω	-5.18	240 Ω	-5.29	240 Ω	-5.17	240 Ω	-5.3
-22Vsb	11K Ω	-22.81	11K Ω	-23.22	11K Ω	-22.77	11K Ω	-23.2
+33Vsb	16K Ω	33.08	16K Ω	33.67	16K Ω	33.05	16K Ω	33.55
3.3V VFD	20 Ω	3.31	20 Ω	3.30	20 Ω	3.26	20 Ω	3.25

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Continuation (230V)

Vout	Iout	Vout (measured)	Iout	Vout (measured)
3.3Vsb	2A	3.25 V	2A	3.25
5Vsw/	0.4A	5.27	0.4A	5.27
5Vsb/	0.4A	5.28	0.4A	5.28
12Vsw	0.3A	12.36	0.3A	12.44
12Vsb	***0.4Apk***	***12.37***	0.1A	12.45
-5Vsw	0.08A	-5.18	***0.12Apk***	***-4.99***
-5Vsb	240 Ω	-5.18	240 Ω	-4.99
-22Vsb	11K Ω	-22.78	11K Ω	-22.53
+33Vsb	16K Ω	33.04	16K Ω	32.86
3.3V VFD	20 Ω	3.25	20 Ω	3.25

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9 Thermal Performance

Open chassis measurement. The temperature stabilized after 1 hour of continuous nominal load operation without airflow.

Load Condition: 3.3Vsb/2A; 5Vsw/0.4A; 5Vsb/0.4A; 12Vsw/0.3A, 12Vsb/0.1A; -5Vsw/0.08A; -5Vsb/240 ohms, -22Vsb/11K; +33Vsb/16Kohms; 3.3V VFD/20 ohms

Temperature (°C)		
Item	**90VAC**	**265 VAC**
Ambient	25	25
TOP245P (U1)	61	68
Transformer (T1)	43	41
3V Rectifier (D13)	71	70
5V Rectifier (D12)	58	59
12V Rectifier (D8)	54	58

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10 Waveforms

10.1 Drain Voltage and Current, Normal Operation

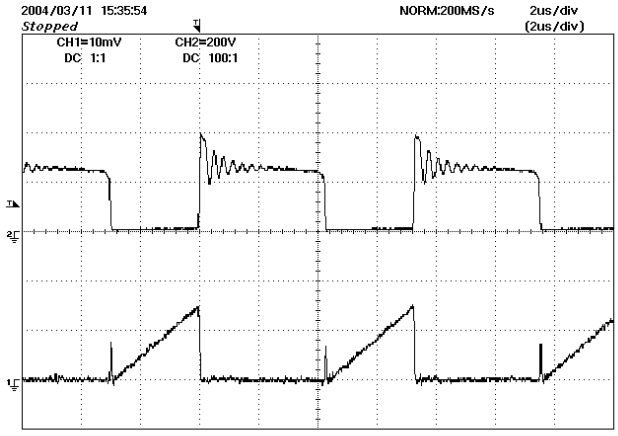

Figure 10 - 115 VAC, Nominal Load.
Upper: V_{DRAIN}, 200 V, 2 µs / div
Lower: I_{DRAIN}, 0.5 A / div

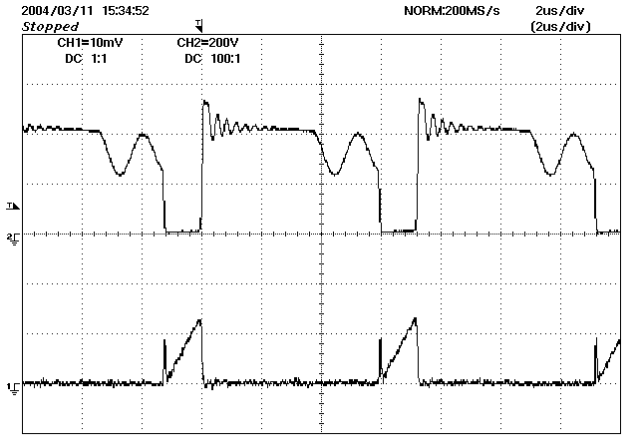

Figure 10a - 230 VAC, Nominal Load
Upper: V_{DRAIN}, 200 V / div,2 µs / div
Lower: I_{DRAIN}, 0.5 A / div

10.2 Drain Voltage and Current Start-up Profile

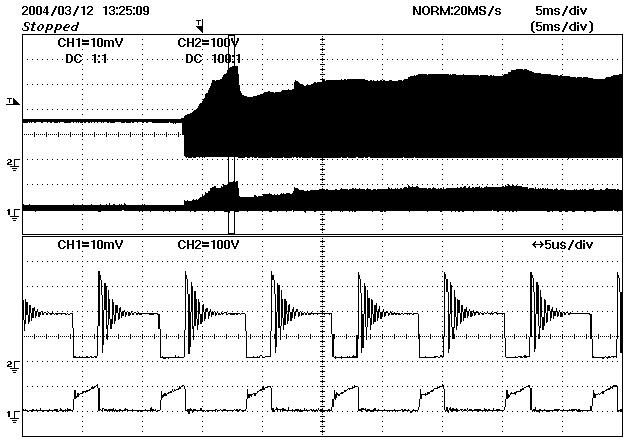

Figure 11 - 90 VAC Input and Maximum Load. Upper: I_{DRAIN}, V_{DRAIN}, 100 V & 5 ms / div.
Lower: 1A / div.

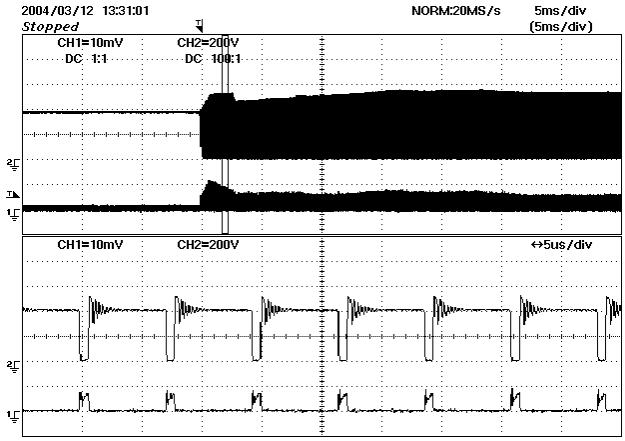

Figure 12 - 265 VAC Input and Maximum Load.
Upper: V_{DRAIN}, 200 V & 5 ms / div.
Lower: I_{DRAIN}, 1 A / div.

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10.3 Output Start-up Profile

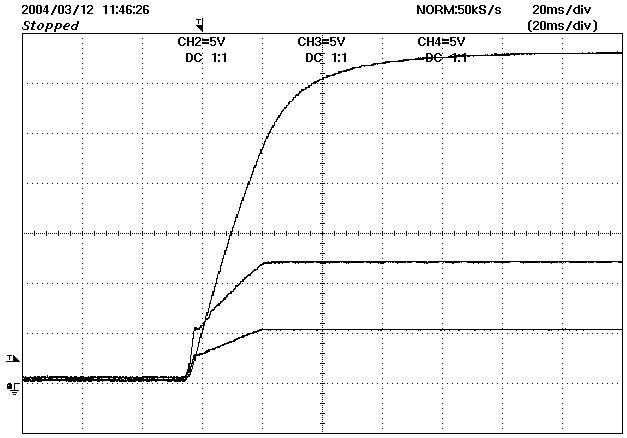

Figure 13 - 115 VAC Input and Nominal Load.
5Vsb/12Vsb/33Vsb, 5 V & 20 ms / div.

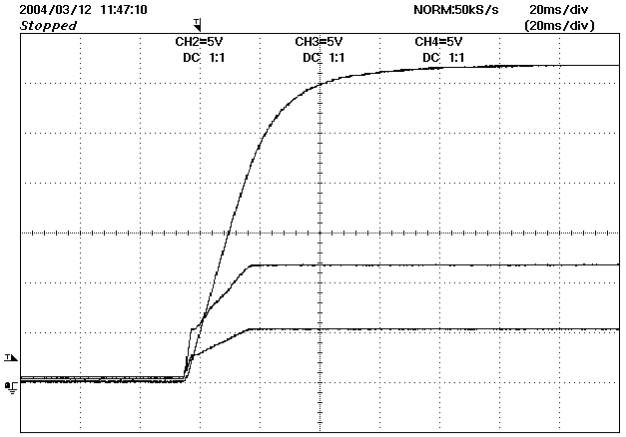

Figure 14 - 230 VAC Input and Nominal Load.
5Vsb/12Vsb/33Vsb, 5 V & 20 ms / div.

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10.4 Load Transient Response (Load Step)

In the figures shown below, signal averaging was used to enable better viewing of the load transient response. The oscilloscope was triggered using the load current step as a trigger source. Since the output switching and line frequency occur essentially at random with respect to the load transient, contributions to the output ripple from these sources will average out, leaving the contribution only from the load step response.

At 5Vsb output

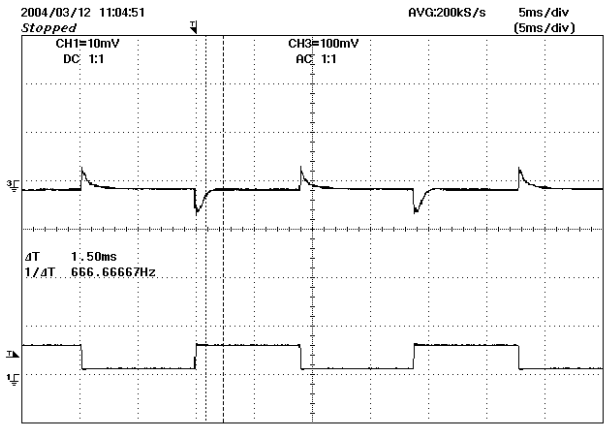

Figure 15 – Transient Response, 90 VAC, 1.2A-1.7A Load Step.
Top: Output Voltage
1V, 1 ms / div
Bottom: Load Current 2 A/div

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11 Output Ripple Measurements

11.1.1 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 16 and Figure 17.

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).***

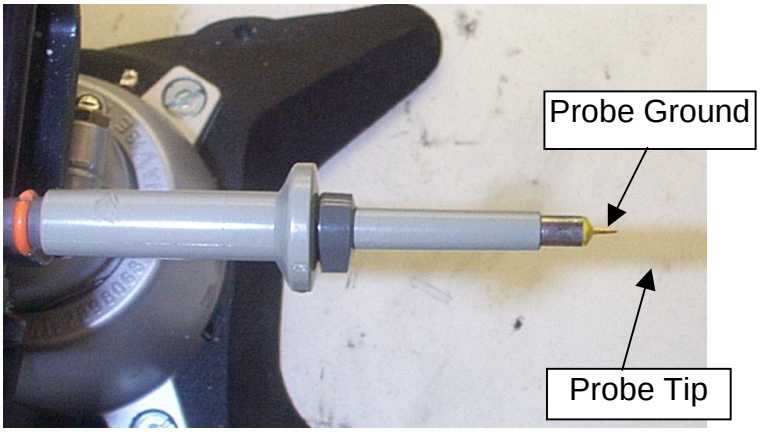

Figure 16 - Oscilloscope Probe Prepared for Ripple Measurement. (End Cap and Ground Lead Removed)

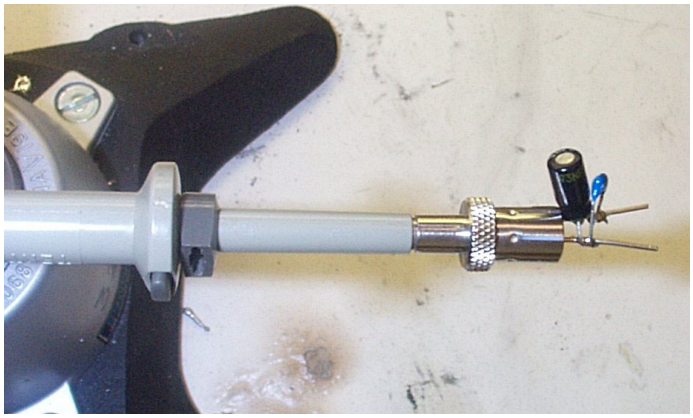

Figure 17 - Oscilloscope Probe with Probe Master 5125BA BNC Adapter. (Modified with wires for probe ground for ripple measurement, and two parallel decoupling capacitors added)

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11.1.2 Measurement Results

Peak Load (One output at a time)

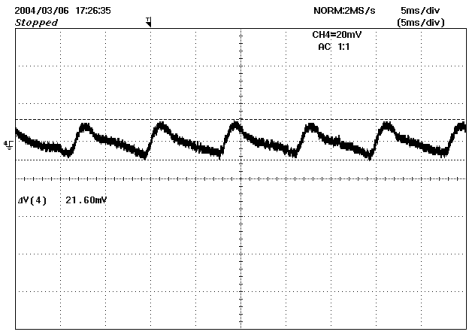

Figure 18 – 3.3Vsw Ripple, 115 VAC, Peak Load.
5 ms, 20 mV / div

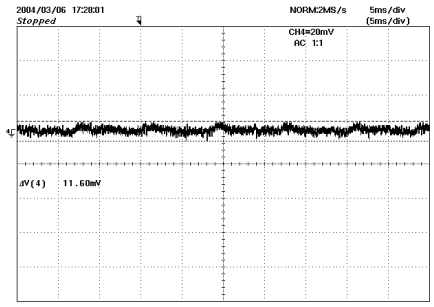

Figure 19 – 3.3 Vsw Ripple, 230 VAC, Peak Load.
5 ms, 20 mV / div

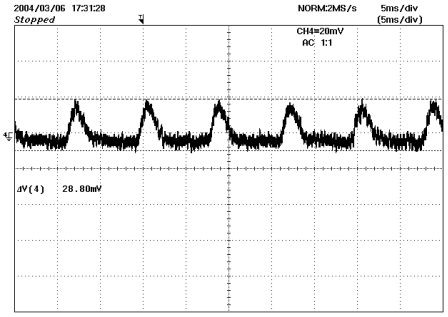

Figure 20 – 5Vsw Ripple, 115 VAC, Peak Load.
5 ms, 20 mV /div

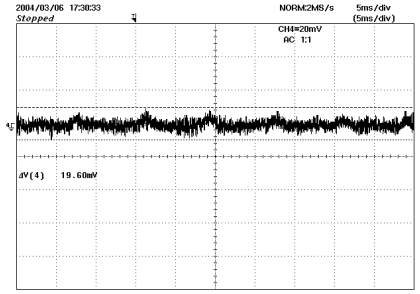

Figure 21 – 5Vsw Ripple, 230 VAC, Peak Load.
5 ms, 20 mV /div

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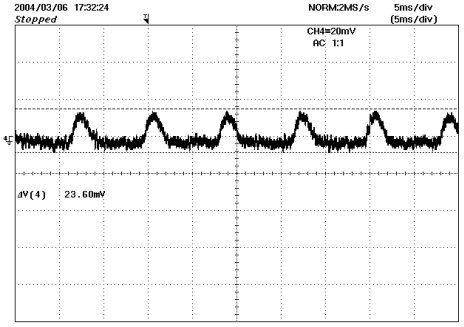

Figure 22 – 5Vsb Ripple, 115 VAC, Peak Load.
5 ms, 20 mV / div

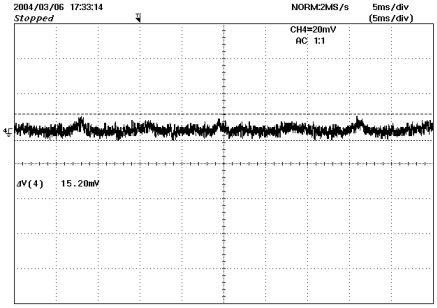

Figure 23 – 5 Vsb Ripple, 230 VAC, Full Load.
5 ms, 20 mV / div

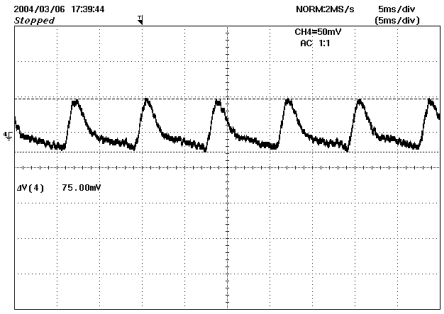

Figure 24 – 12Vsw Ripple, 115 VAC, Peak Load.
5 ms, 50 mV /div

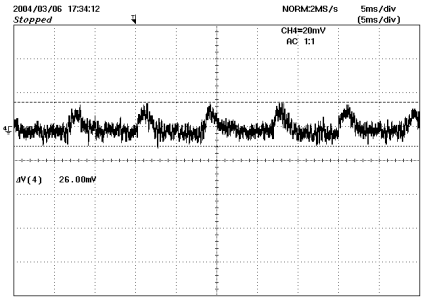

Figure 25 – 12Vsw Ripple, 230 VAC, Peak Load.
5 ms, 50 mV /div

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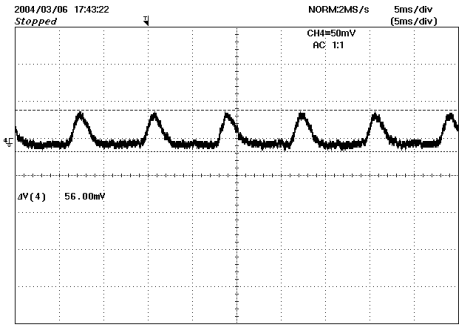

Figure 26 – 12Vsb Ripple, 115 VAC, Peak Load.
5 ms, 50 mV / div

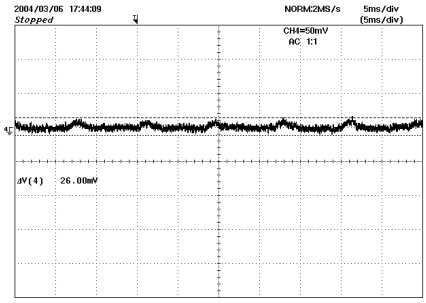

Figure 27 – 12 Vsb Ripple, 230 VAC, Peak Load.
5 ms, 50 mV / div

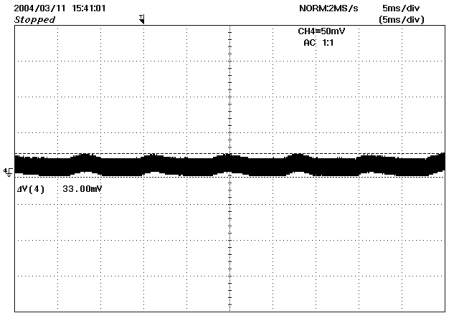

Figure 28 – -5Vsw Ripple, 115 VAC, Peak Load.
5 ms, 20 mV /div

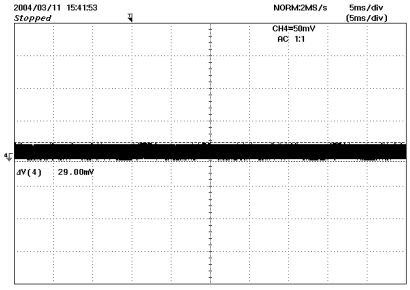

Figure 29 – -5Vsw Ripple, 230 VAC, Peak Load.
5 ms, 20 mV /div

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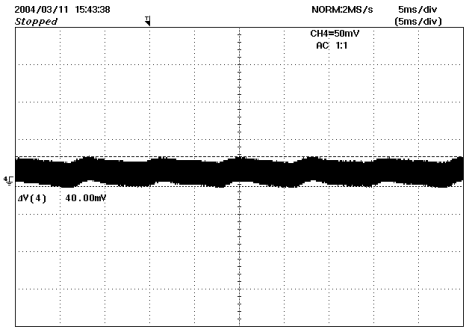

Figure 30 – -5Vsb Ripple, 115 VAC, Peak Load.
5 ms, 50 mV / div

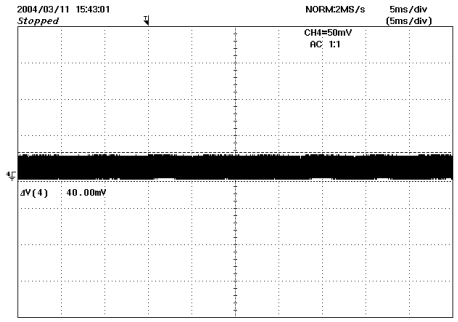

Figure 31 – -5 Vsb Ripple, 230 VAC, Peak Load.
5 ms, 50 mV / div

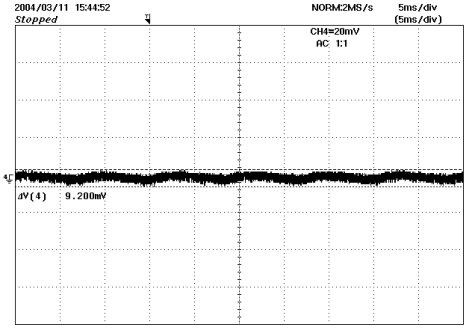

Figure 32 – -22Vsb Ripple, 115 VAC, Peak Load.
5 ms, 20 mV /div

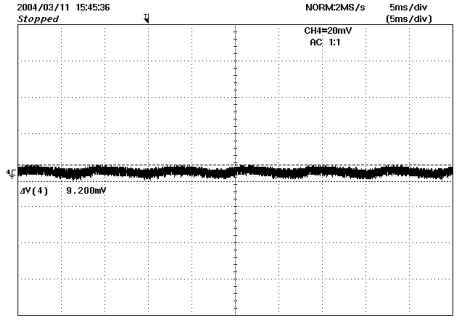

Figure 33 – -22Vsb Ripple, 230 VAC, Peak Load.
5 ms, 20 mV /div

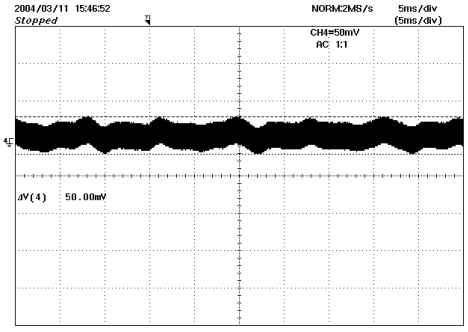

Figure 34 – 33Vsb Ripple, 115 VAC, Peak Load.
5 ms, 50 mV / div

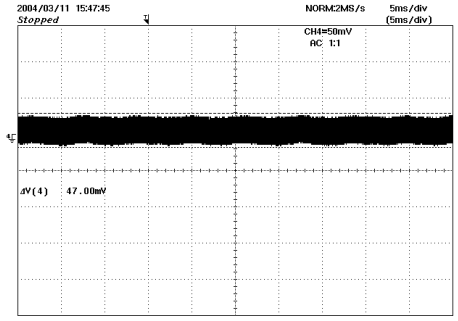

Figure 35 – 33 Vsb Ripple, 230 VAC, Peak Load.
5 ms, 50 mV / div

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12 Conducted EMI

EMI was tested at room temperature, at 115 VAC & 230 VAC input, with a resistor load on each output as follows; 3.3V / 1.6 ohms; 5V / 7 ohms; 12V / 31 ohms; -5V / 240 ohms; -22V / 11K ohms; 33V / 16K ohms; VFD / 20 ohms. All plots are **shown with output common connected to the ground of the LISN**, to show worst case results.

12.1 EMI@230V

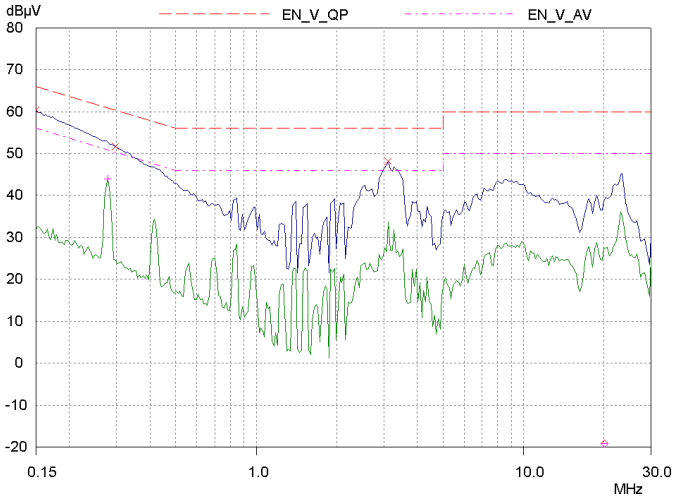

Figure 36 - Conducted EMI, Maximum Steady State Load, LINE: 230 VAC, 60 Hz, and EN55022 B Limits, with output grounded to LISTN

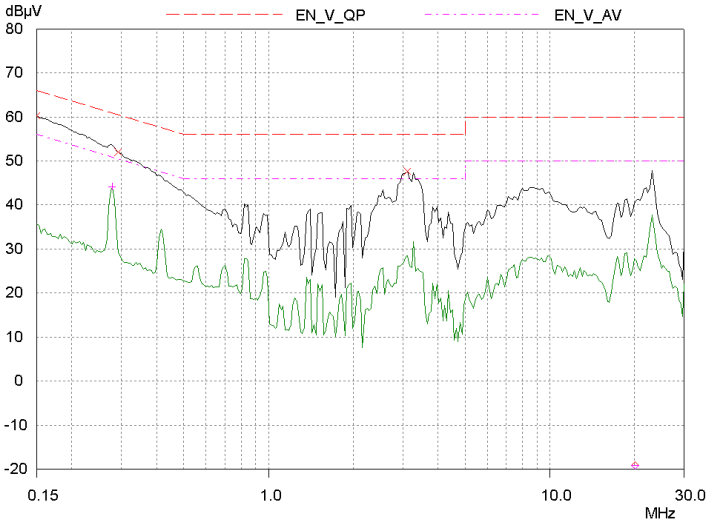

Figure 37 - Conducted EMI, Maximum Steady State Load, NEUTRAL 230 VAC, 60 Hz, and EN55022 B Limits**,** with output grounded to LISTN

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12.2 EMI@115V

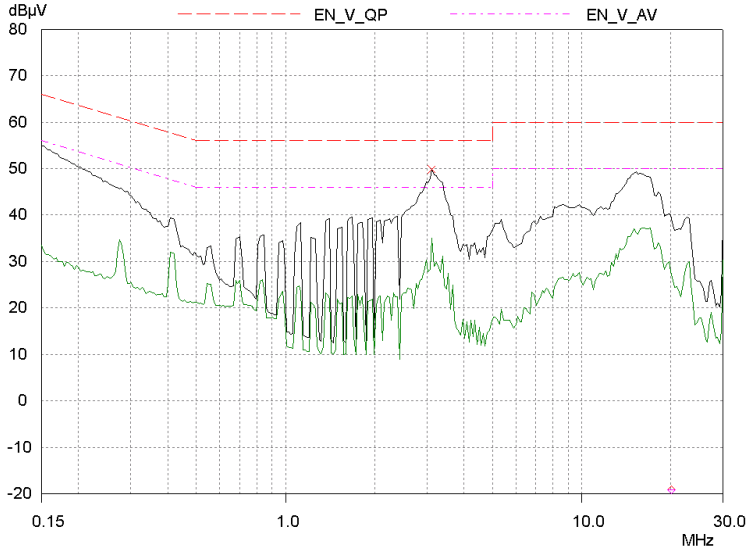

Figure 38 - Conducted EMI, Maximum Steady State Load, LINE: 115 VAC, 60 Hz, and EN55022 B Limits, , with output grounded to LISTN

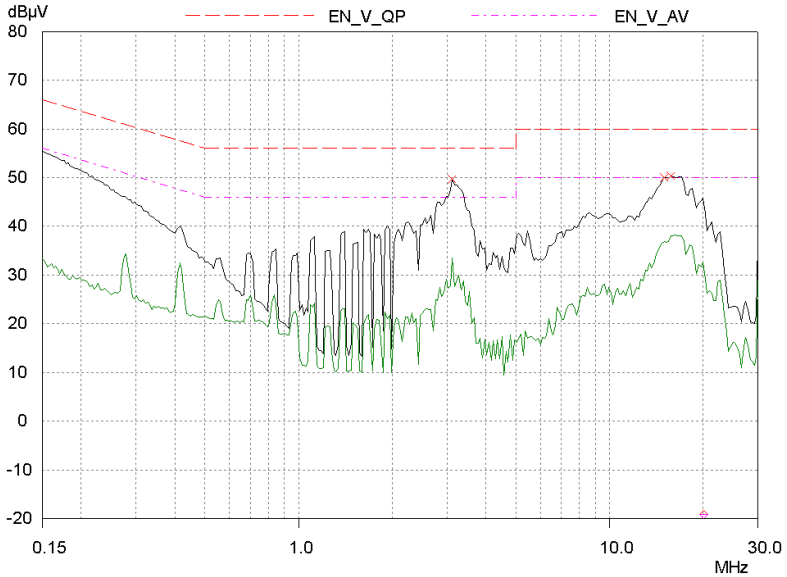

Figure 39 - Conducted EMI, Maximum Steady State Load, NEUTRAL 115 VAC, 60 Hz, and EN55022 B Limits, , with output grounded to LISTN

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13 Revision History

Date	Author	Revision	Description & changes	Reviewed
March 30, 2004	ME	1.0	First Release	VC /AM

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