Design Example Report

Title	***11W (24W peak) Power Supply using TOP245P***
Specification	Input: 90 – 265 VAC Output: 3.4V_{DVD}/0.24A, 12V_{DVD}/0.03A/0.22$A_{pk,}$ 5V_{DVD}/0.7A/1A_{pk}, 5V_{VCR}/0.14A, 6V_{VCR}/0.6A/ 0.85A_{pk} 14V_{VCR} / 0.14A/ 0.5$A_{pk,}$ 40V_{VCR} / 0.007A
Application	DVD+VCR Player
Author	Power Integrations Applications Department
Document Number	DER-21
Date	March 30, 2004
Revision	1.0

Summary and Features

This report describes a design for a multiple output power supply, such as required for a DVD / VCR player, featuring the following:

- No heatsinks
- No Y-cap
- No X-cap
- No linear regulators
- small 11 mH common mode choke
- EMI has 11 dB margin
- good cross regulation
- good peak power capability (can deliver peak load at 70 Vac)

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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

A production DVD/VCR player was bought on the open market, evaluated and the PSU output specification was derived from actual measurements. A new PSU with TOP245P was designed to reduce the cost while meeting the specification to compare the relative complexity and cost of a supply using a TOPSwitch implementation.

This document is an engineering report describing the PSU design using TOP245P. The new design reduces the magnetic core size from EERL28 to EEL22, eliminates X-caps, Y caps, linear regulators, and the heatsink. It meets EMI with good margin, peak power with good margin, and uses a low cost DIP TOP245P.

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

2 Photograph

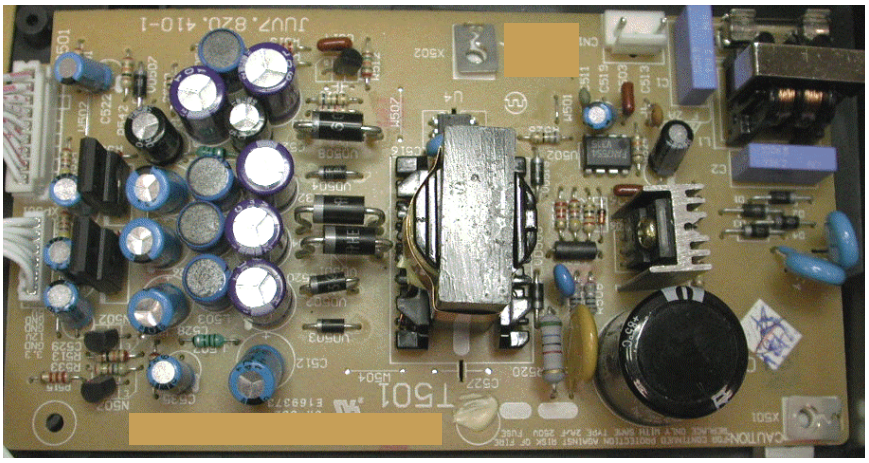

Figure 1 – Original Production PS Circuit Board Photograph.

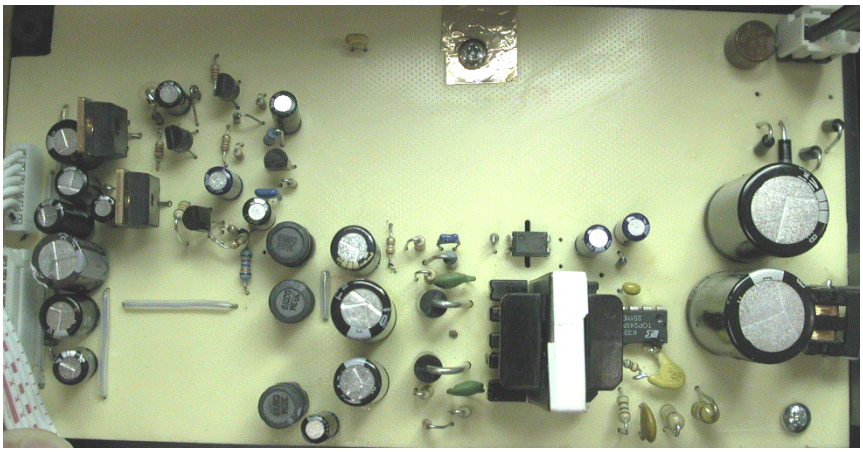

Figure 2 – TOPSwitch Prototype Circuit Board Photograph.

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3 Power Supply Specification

The load currents below are actual measurements of the DVD/VCR unit. The capability of the PSU design is higher.

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	85		265	VAC	
Frequency	f_{LINE}	47	50/60	64	Hz	
DVD Output (O/P1~3)						
Output Voltage 1	V_{OUT1}	3.3	3.4	3.5	V	20 MHz Bandwidth for all the outputs
Output Ripple Voltage 1	$V_{RIPPLE1}$				mV	
Output Current 1	I_{OUT1}		0.24		A	
Output Voltage 2	V_{OUT2}	4.85	5.0	5.25	V	
Output Ripple Voltage 2	$V_{RIPPLE2}$				mV	
Output Current 2	I_{OUT2}		0.7	1	A	
Output Voltage 3	V_{OUT3}	10.5	12	13.5	V	
Output Ripple Voltage 3	$V_{RIPPLE3}$				mV	
Output Current 3	I_{OUT3}		0.03	0.22	A	
VCR Output (O/P4~7)						
Output Voltage 4	V_{OUT4}	4.85	5.0	5.25	V	
Output Ripple Voltage 4	$V_{RIPPLE4}$				mV	
Output Current 4	I_{OUT4}		0.14		A	
Output Voltage 5	V_{OUT5}	5.5	6.0	6.5	V	
Output Ripple Voltage 5	$V_{RIPPLE5}$				mV	
Output Current 5	I_{OUT5}		0.6	0.85	A	
Output Voltage 6	V_{OUT6}	12	14	16	V	
Output Ripple Voltage 6	$V_{RIPPLE6}$				mV	
Output Current 6	I_{OUT6}		0.14	0.5	A	
Output Voltage 7	V_{OUT7}	35	40	45	V	
Output Ripple Voltage 7	$V_{RIPPLE7}$				mV	
Output Current 7	I_{OUT7}		0.007		A	
Total Output Power						
Continuous Output Power	P_{OUT}		11		W	
Peak Output Power	P_{OUT_PEAK}			22	W	actual load measruement
Efficiency	η		63		%	Measured at P_{OUT} (11 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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4 Schematic

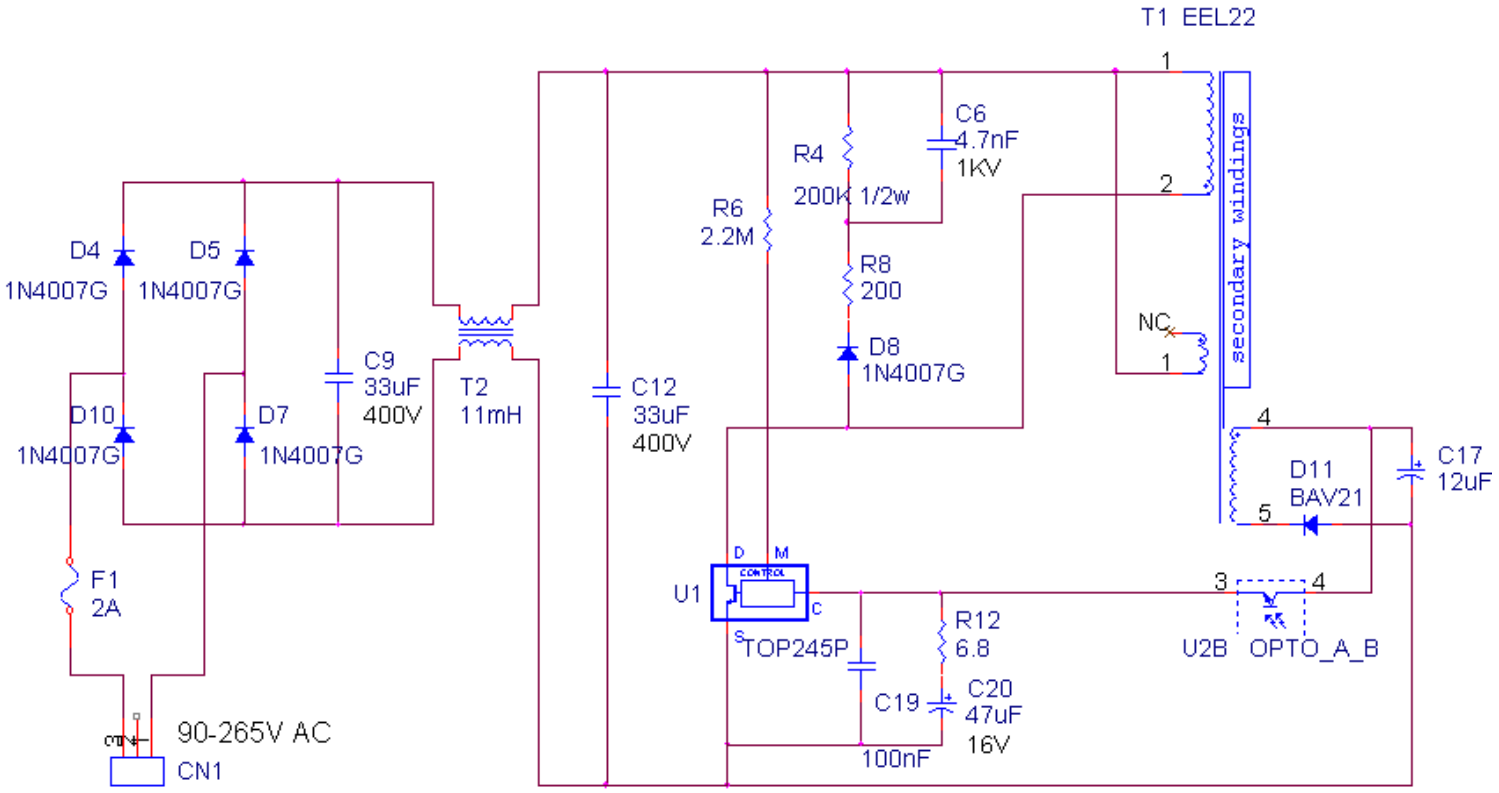

Figure 3 –Schematic (Primary side).

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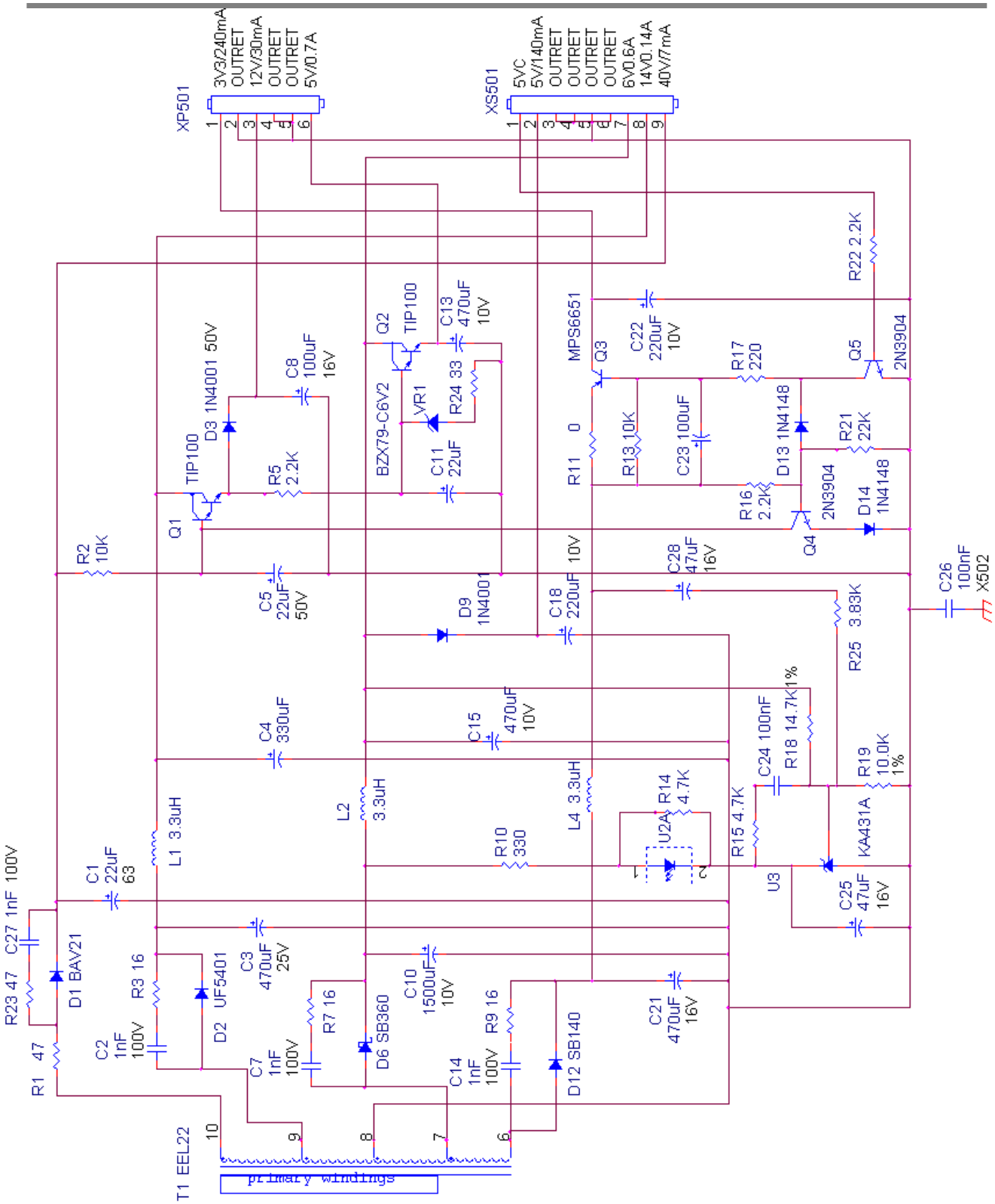

Figure 4 –Schematic (Secondary side)

NOTE: R23, C27, R24, R25, C28 were added onto the prototype PCB, and are not included in the PCB design

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5 PCB Layout

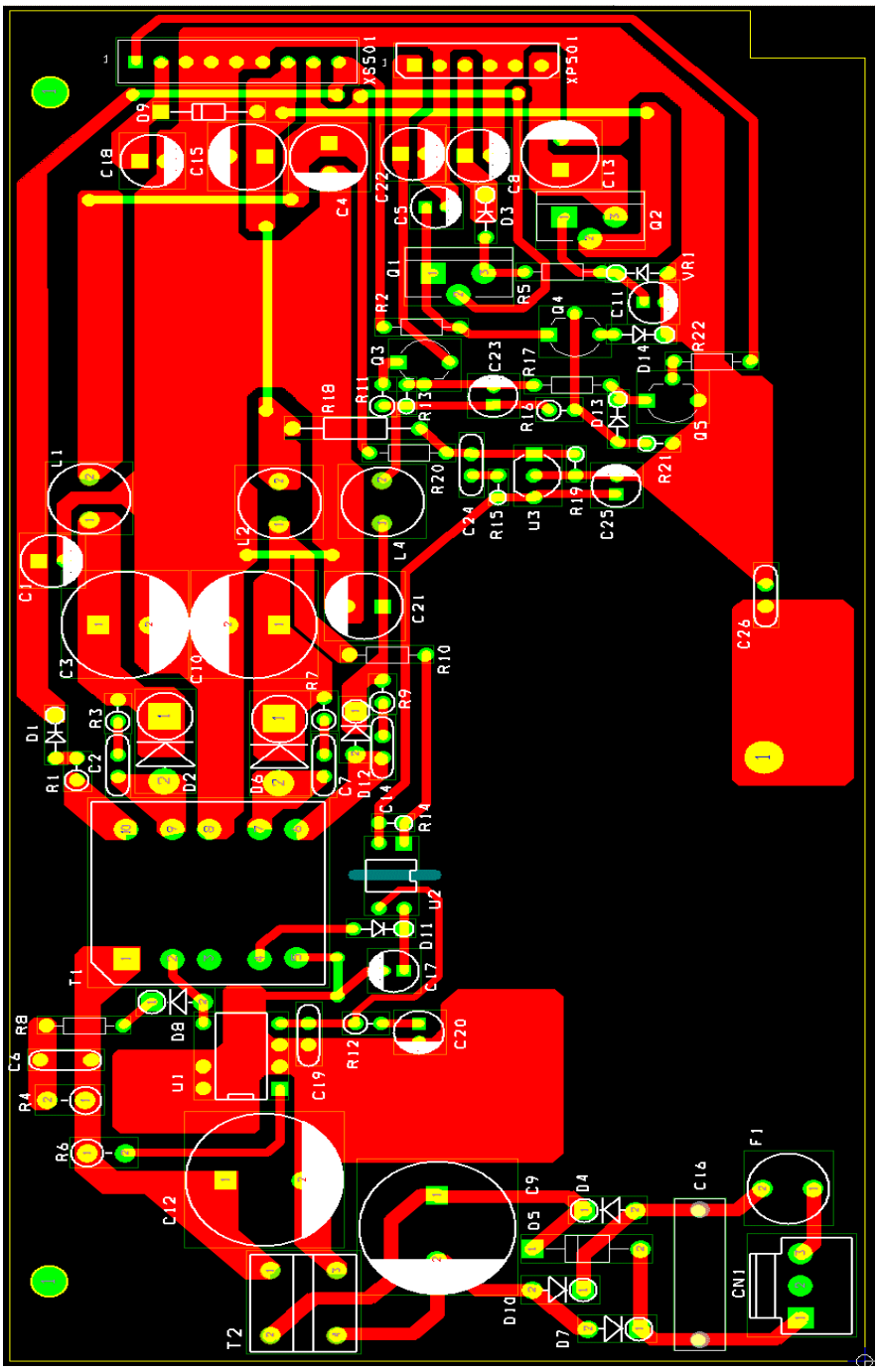

Figure 5 – Printed Circuit Layout.

Note: C16, R20 are not fitted.
R23, C27, R24, R25, C28 were added onto the copper side of the prototype

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6 Bill Of Materials

Item	Quan	Part Reference	Value	Description
1	1	C1	22uF	Cap,Al Elect,22uF,50V,6.3mmX11.5mm,LXZ Series,NIPPON CHEMI-CON
2	4	C2 C7 C14 C27	1nF	Cap,Cer,1000 pF, 100V, X7R, 10%
3	1	C3	470uF	Cap,Al Elect,470uF,25V, KZE Series,NIPPON CHEMI-CON
4	1	C4	330uF	Cap,Al Elect,330uF,16V,8mmX12mm,LXZ Series,NIPPON CHEMI-CON
5	2	C5 C11	22uF	Cap,Al Elect,22uF,50V,5mmX11.5mm,LXZ Series,NIPPON CHEMI-CON
6	1	C6	4.7nF	Cap,Cer,4.7nF, 1000V, 10%
7	2	C8 C23	100uF	Cap,Al Elect,100uF,16V,6.3mmX11.5mm,LXZ Series,NIPPON CHEMI-CON
8	2	C9 C12	33uF	Cap,Al Elect, 33UF 400V,16mmX25mm, EB RADIAL
9	1	C10	1500uF	Cap,Al Elect,1500uF,10V,LXZ Series,NIPPON CHEMI-CON
10	2	C13 C15	470uF	Cap,Al Elect,470uF,10V,8mmX12mm,LXZ Series,NIPPON CHEMI-CON
11	1	C16	DNP	Do Not Populate
12	1	C17	12uF	Cap,Al Elect,12uF,50V,5mmX11.5mm,LXZ Series,NIPPON CHEMI-CON
13	2	C18 C22	220uF	Cap,Al Elect,220uF,10V,6.3mmX11.5mm,LXZ Series,NIPPON CHEMI-CON
14	3	C19 C24 C26	100nF	Cap,Cer, 0.10 uF, 50V, Z5U, 20%
15	3	C20 C25 C28	47uF	Cap,Al Elect,47uF,16V,5mmX11.5mm,LXZ Series,NIPPON CHEMI-CON
16	1	C21	470uF	Cap,Al Elect,470uF,16V,8mmX15mm,KZE Series,NIPPON CHEMI-CON
17	1	CN1	3POS(1 X 3) .156 VERT TIN	CONN HEADER 3POS(1 X 3) .156 VERT TIN
18	2	D1 D11	BAV21	Diode Fast Switch 250V 500MW DO35
19	1	D2	UF5401	Rectifier Ultrafast 100V, 3A, D0-201AD
20	2	D3 D9	1N4001	Rectifier GPP 1A 50V DO-41
21	5	D4 D5 D7 D8 D10	1N4007G	Rectifier GPP 1000V 1A DO-41
22	1	D12	SB140	Rectifier Schottky 1A 40V
23	1	D6	SB360	Rectifier Schottky 3A 60V DO-201AD
24	2	D13 D14	1N4148	Diode SGL JUNC 100V 4.0NS DO-35
25	1	F1	2A	FUSE T-LAG 2A,250V Slo-Blo IEC SHORT TR5
26	3	L1 L2 L4	3.3uH	Inductor,3.3uH,2.66A
27	2	Q1 Q2	TIP100	
28	1	Q3	MPS6651	TRANS,MPSA42,AMP NPN 300V HV TO-92
29	2	Q4 Q5	2N3904	TRANS,2N3904,NPN SS GP 200MA TO-92
30	2	R1 R23	47	Res, 47, 1/4W, 5%, Carbon Film
31	1	R24	33	Res, 33, 1/4W, 5%, Carbon Film
32	2	R2 R13	10K	Res, 10K, 1/8W, 5%, Carbon Film
33	3	R3 R7 R9	16	Res, 16, 1/4W, 5%, Carbon Film
34	1	R25	3.83K	Res, 3.83K, 1/4W, 5%, Carbon Film

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35	1	R4	200K 1/2w	Res, 200K, 1/2W, 5%, Carbon Film
36	1	R5	2.2K	Res, 2.2K, 1/8W, 5%, Carbon Film
37	1	R6	2.2M	Res, 2.2M, 1/2W, 5%, Carbon Film
38	1	R8	200	Res, 200, 1/8W, 5%, Carbon Film
39	1	R10	330	Res, 330, 1/8W, 5%, Carbon Film
40	1	R11	0	Res, 0, 1/4W, 5%, Carbon Film, use is as a jumper
41	1	R12	6.8	Res, 6.8, 1/4W, 5%, Carbon Film
42	2	R14 R15	4.7K	Res, 4.7K, 1/8W, 5%, Carbon Film
43	2	R16 R22	2.2K	Res, 2.2K, 1/4W, 5%, Carbon Film
44	1	R17	220	Res, 220, 1/8W, 5%, Carbon Film
45	1	R18	14.7K	Res,14.7K, 1/4W, 1%, M-FILM
46	1	R19	10.0K	Res,10.0K, 1/4W, 1% M-FILM
47	1	R20	DNP	Do Not Populate
48	1	R21	22K	Res, 22K, 1/8W, 5%, Carbon Film
49	1	T1	EEL22	
50	1	T2	11mH	CHOKE,11mH,0.3A,SU9V-03050,TOKIN
51	1	U1	TOP245P	IC,TOP245P,INT. OFF-LINE SWITCHER,DIP-8B
52	1	U2	OPTO_A_B	IC,PC817X1,PHOTOCOUPLER TRAN OUT CTR 80-160% 4-DIP
53	1	U3	KA431A	IC,TL431CLP, ADJ SHUNT REG TO-92
54	1	VR1	BZX79-C6V2	Diode, Zener, 6.2V, 1/2W, 5%, DO-35
55	1	XP501	1X6, HEADER	CONN,1X6, HEADER 6POS .100 VERT TIN
56	1	XS501	1X9, HEADER	CONN,1X9, HEADER 6POS .100 VERT TIN

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7 Transformer Specification

7.1 Electrical Diagram

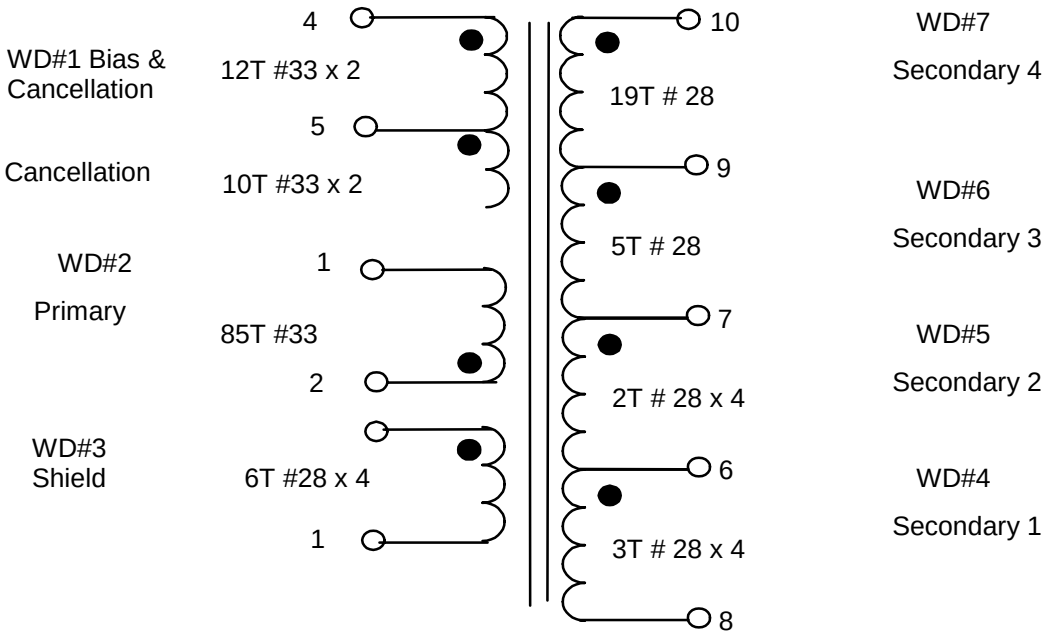

Figure 6 –Transformer Electrical Diagram

7.2 Electrical Specifications

Electrical Strength	1 second, 60 Hz, from Pins 1 - 5 to Pins 6 -10	3000 VAC
Primary Inductance	Pins 1-2, all other windings open, measured at 132 kHz, 0.4 VRMS	880 uH, -10/+10%
Resonant Frequency	Pins 1-2, all other windings open	1M kHz (Min.)
Primary Leakage Inductance	Pins 1-2, with Pins 6-10 shorted, measured at 132 kHz, 0.4 VRMS	26 µH (Max.)

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7.3 Materials

Item	Description
[1]	Core: PC40EEL22, TDK or equivalent Gapped for AL of 123 nH/T^2
[2]	Bobbin: EEL22, Vertical 10 pins
[3]	Magnet Wire: #28 AWG
[4]	Magnet Wire: #33 AWG
[5]	Tape: Margin 6 mm
[6]	Tape: Margin 3 mm
[7]	Tape: 3M 1298 Polyester Film, 9.8mm wide
[8]	Tape: 3M 1298 Polyester Film, 19.4mm wide

7.4 Transformer Build Diagram

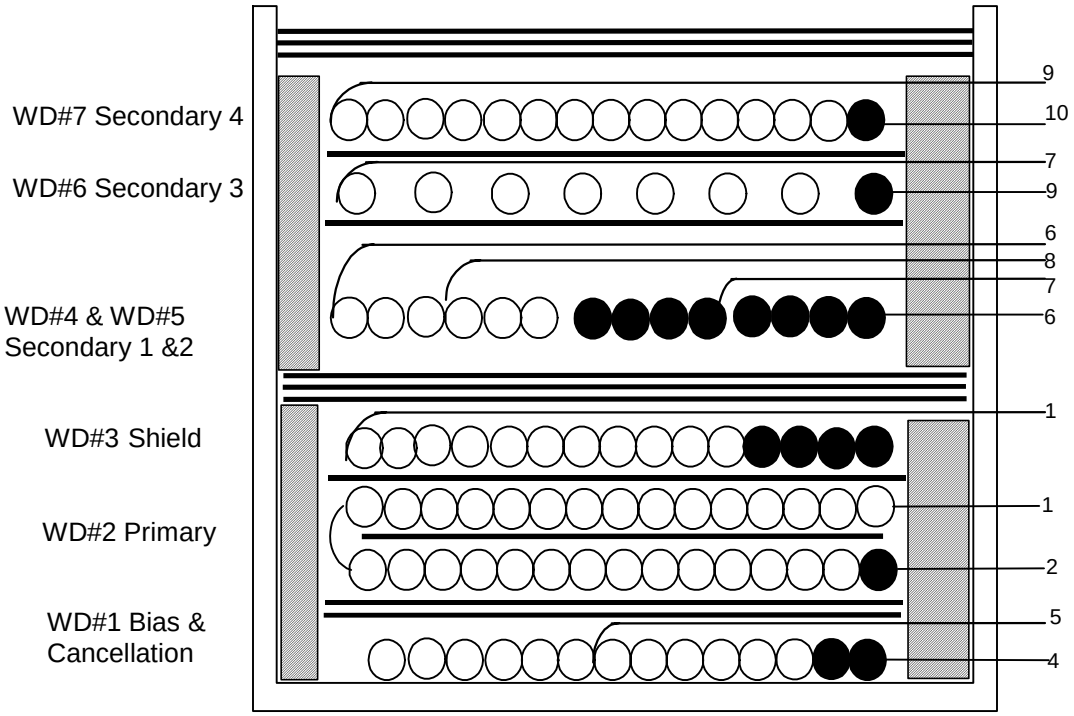

Figure 7 – Transformer Build Diagram.

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7.5 Transformer Construction

Bobbin Preparation	Pin side of the bobbin orients to the right hand side.
Margin Tape	Wind item [5] at the pin side of the bobbin to match the height of the primary windings. Wind item [6] on the top side of the bobbin to match the height as the opposite side
WD#1 Cancellation	Start on Pin 4, wind 12 turns bifilar of item [4] from right to left. Wind with tight tension across bobbin evenly. After finishing 12th turn, bring the wire back and finish it on Pin 5. Start from the Pin 5, rout the same wires to the ending position of the previous winding, continuous to wind another 10 turns, cut the wires after finishing 10th turns. Overall, total 22 turns winding should be well fit the entire length of the bobbin.
Insulation	2 Layers of tape [7] for insulation
WD#2 Primary	Start on pin 2, wind 43 turns of item [4] from right to left. After finishing the first layer, apply one layer tape of item [7], then continue to wind another 42 turns from left to right and finish the wire on pin 1.
Insulation	1 Layers of tape [7] for insulation.
WD #3 Shield	Start at Pin 2 temporarily, wind 6 quadfilar turns of item [3]. Wind from right to left with tight tension. Wind uniformly, in a single layer across entire width of bobbin. Bring the wires back and finish on Pin 1. Cut the starting lead.
Insulation	3 Layers of tape [8] for insulation.
Margin Tape	Wind item [5] at the pin side of the bobbin to match the height of the secondary windings. Wind item [6] on the top side of the bobbin to match the height as the opposite side
WD #4 & WD #5	Start at pin 6, wind 3 quadfilar turns of item [3] from right to left. Wind uniformly, in a single layer across entire bobbin evenly. Leave even space between turns. Bring the wire back and finish on pin 8. In the same layer, start at pin 7, wind 2 quadfilar turns of item [3] from right to left in the open space between the previous winding. Wind uniformly, in a single layer across entire bobbin evenly. Bring the wire back and finish on pin 6.
Insulation	1 Layers of tape [7] for insulation.
WD #6	Start at pin 9, wind 5 turns of item [3] from right to left. Wind uniformly, in a single layer across entire bobbin evenly. Bring the wire back and finish on pin 7
Insulation	1 Layers of tape [7] for insulation.
WD #7	Start at pin 10, wind 19 turns of item [3] from right to left. Wind uniformly, in a single layer across entire bobbin evenly. Bring the wire back and finish on pin 9
Insulation	3 Layers of tape [8] for insulation.
Finish	Grind the core to get 880uH. Secure the core with tape.

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8 Transformer Spreadsheet

TOP_GX_FX_082203.xls:	INPUT	INFO	OUTPUT	UNIT	
ENTER APPLICATION VARIABLES					**Customer**
VACMIN	90			Volts	Minimum AC Input Voltage
VACMAX	265			Volts	Maximum AC Input Voltage
fL	50			Hertz	AC Mains Frequency
VO	6			Volts	Output Voltage
PO	24	*Warning*		Watts	!!!!!!!!! For Universal Input reduce Continuous Output Power PO_CONT below 22W (or use larger TOPSwitch-GX/FX)
n	0.69				Efficiency Estimate
Z	0.5				Loss Allocation Factor
VB	15			Volts	Bias Voltage
tC	3			mSeconds	Bridge Rectifier Conduction Time Estimate
CIN	66			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*	Hertz	TOPSwitch-GX Switching Frequency: Choose between 132 kHz and 66 kHz
fSmin			*124000*	Hertz	TOPSwitch-GX Minimum Switching Frequency
fSmax		Warning	*140000*	Hertz	!!!!!!!!! Warning : fs > fsmax)
VOR	110			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	**0.48**				Ripple to Peak Current Ratio (0.4 < KRP < 1.0 : 1.0< KDP<6.0)
ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES					
Core Type	**eel22**				
Core		*EEL22*		*P/N:*	PC40EE22/29/6-Z
Bobbin		*EEL22_BOBBIN*		*P/N:*	*
AE			0.358	cm^2	Core Effective Cross Sectional Area
LE			6.32	cm	Core Effective Path Length
AL			1400	nH/T^2	Ungapped Core Effective Inductance
BW			18	mm	Bobbin Physical Winding Width
M	3			mm	Safety Margin Width (Half the Primary to Secondary Creepage Distance)
L	**2**				Number of Primary Layers
NS	**5**				Number of Secondary Turns
DC INPUT VOLTAGE PARAMETERS					
VMIN			94	Volts	Minimum DC Input Voltage

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VMAX			375	Volts	Maximum DC Input Voltage
CURRENT WAVEFORM SHAPE PARAMETERS					
DMAX			0.57		Maximum Duty Cycle
IAVG			0.37	Amps	Average Primary Current
IP			0.86	Amps	Peak Primary Current
IR			0.41	Amps	Primary Ripple Current
IRMS			0.50	Amps	Primary RMS Current
TRANSFORMER PRIMARY DESIGN PARAMETERS					
LP			880	uHenries	Primary Inductance
NP			85		Primary Winding Number of Turns
NB			12		Bias Winding Number of Turns
ALG			123	nH/T^2	Gapped Core Effective Inductance
BM			**2497**	Gauss	Maximum Flux Density at PO, VMIN (BM<3000)
BP			**3421**	Gauss	Peak Flux Density (BP<4200)
BAC			599	Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
ur			1967		Relative Permeability of Ungapped Core
LG			**0.33**	mm	Gap Length (Lg > 0.1 mm)
BWE			24	mm	Effective Bobbin Width
OD			0.28	mm	Maximum Primary Wire Diameter including insulation
INS			0.05	mm	Estimated Total Insulation Thickness (= 2 * film thickness)
DIA			0.23	mm	Bare conductor diameter
AWG			31	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CM			81	Cmils	Bare conductor effective area in circular mils
CMA		Warning	**161**	Cmils/Amp	!!!!!!!!! INCREASE CMA>200 (increase L(primary layers),decrease NS,larger Core)
TRANSFORMER SECONDARY DESIGN PARAMETERS (SINGLE OUTPUT / SINGLE OUTPUT EQUIVALENT)					
Lumped parameters					
ISP			14.54	Amps	Peak Secondary Current
ISRMS			7.39	Amps	Secondary RMS Current
IO			4.00	Amps	Power Supply Output Current
IRIPPLE			6.21	Amps	Output Capacitor RMS Ripple Current
CMS			1478	Cmils	Secondary Bare Conductor minimum circular mils
AWGS			18	AWG	Secondary Wire Gauge (Rounded up to next larger standard AWG value)
DIAS			1.03	mm	Secondary Minimum Bare Conductor Diameter
ODS			2.40	mm	Secondary Maximum Outside Diameter for Triple Insulated Wire
INSS			0.69	mm	Maximum Secondary Insulation Wall Thickness
VOLTAGE STRESS PARAMETERS					
VDRAIN			626	Volts	Maximum Drain Voltage Estimate (Includes Effect of Leakage Inductance)
PIVS			28	Volts	Output Rectifier Maximum Peak Inverse Voltage
PIVB			68	Volts	Bias Rectifier Maximum Peak Inverse Voltage
TRANSFORMER SECONDARY DESIGN PARAMETERS (MULTIPLE OUTPUTS)					
1st output					

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VO1	40.0			Volts	Output Voltage
IO1	0.007			Amps	Output DC Current
PO1			0.28	Watts	Output Power
VD1	0.7			Volts	Output Diode Forward Voltage Drop
NS1			31.31		Output Winding Number of Turns
ISRMS1			0.013	Amps	Output Winding RMS Current
IRIPPLE1			0.01	Amps	Output Capacitor RMS Ripple Current
PIVS1			179	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS1			3	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS1			45	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS1			0.05	mm	Minimum Bare Conductor Diameter
ODS1			0.38	mm	Maximum Outside Diameter for Triple Insulated Wire
2nd output					
VO2	3.4			Volts	Output Voltage
IO2	1.000			Amps	Output DC Current
PO2			3.40	Watts	Output Power
VD2	0.5			Volts	Output Diode Forward Voltage Drop
NS2			3.00		Output Winding Number of Turns
ISRMS2			1.847	Amps	Output Winding RMS Current
IRIPPLE2			1.55	Amps	Output Capacitor RMS Ripple Current
PIVS2			17	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS2			369	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS2			24	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS2			0.51	mm	Minimum Bare Conductor Diameter
ODS2			4.00	mm	Maximum Outside Diameter for Triple Insulated Wire
3rd output					
VO3	13.6			Volts	Output Voltage
IO3	0.500			Amps	Output DC Current
PO3			6.80	Watts	Output Power
VD3	0.7			Volts	Output Diode Forward Voltage Drop
NS3			11.00		Output Winding Number of Turns
ISRMS3			0.924	Amps	Output Winding RMS Current
IRIPPLE3			0.78	Amps	Output Capacitor RMS Ripple Current
PIVS3			62	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS3			185	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS3			27	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS3			0.36	mm	Minimum Bare Conductor Diameter
ODS3			1.09	mm	Maximum Outside Diameter for Triple Insulated Wire

Note in some instances, PIExpert may give warnings concerning the high power: this is due to the fact that the transformer was designed for maximum peak power capability to handle transient loads caused by disk spin-up. In practice, lower continuous power is used.

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9 Performance Data

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

9.1 Efficiency

Load Condition:

DVD	
3.3V	0.24A
5V	0.7A
12V	0.03A
VCR	
5V	0.14A
6V	0.6A
14V	0.14A
40V	0.007A

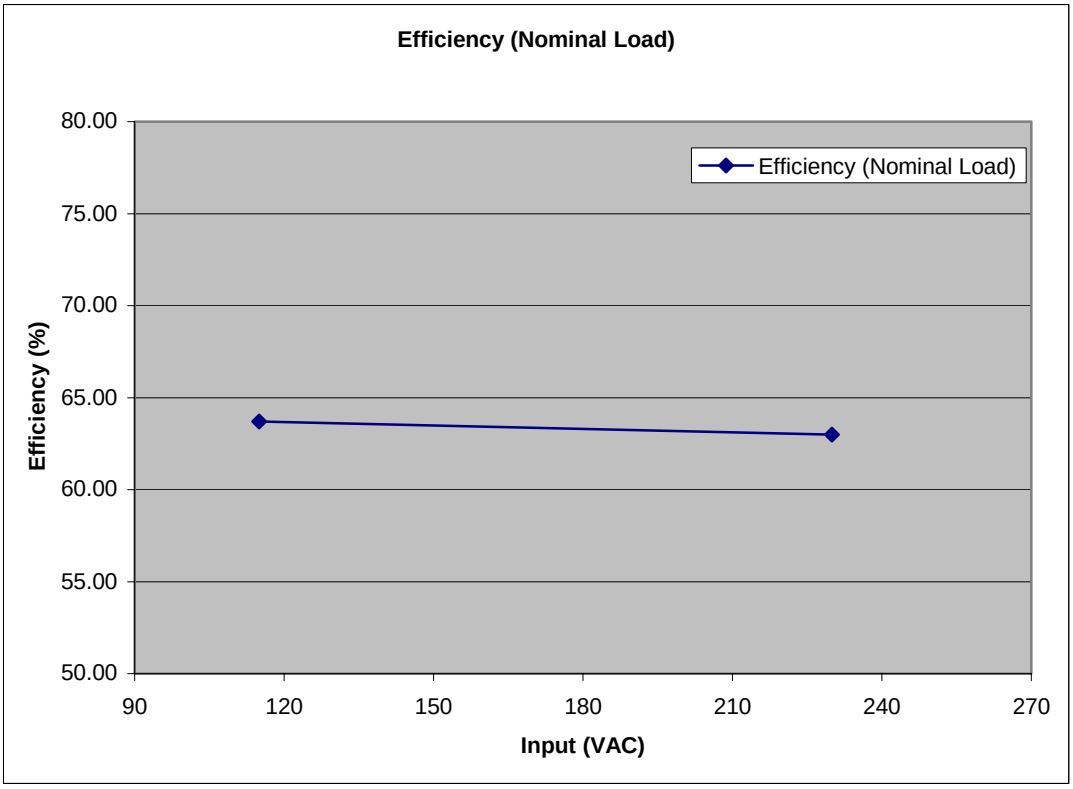

Figure 8 - Efficiency vs. Input Voltage, Room Temperature, 60 Hz.

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9.2 Regulation

9.2.1 Line Regulation

Load Condition: The load combination is the same as stated in paragraph 9.1

Vout (VDC)	@115V	@230V
DVD	V	V
3.3V	3.29	3.29
5V	4.99	4.99
12V	11.56	11.48
VCR		
5V	5.11	5.11
6V	5.89	5.89
14V	13.0	12.9
40V	37.2	37.1

9.2.2 Voltage regulation in the unit

Minimum and Maximum output voltages were recorded for each output using a Fluke 87 DVM with min/max function, while various operations were tried (start/stop, pause/run, chapter jump, fast forward/rewind, simultaneous eject and load for both VCR and DVD tray). The test was done at room temperature, and at both 90 and 265 Vac input. The min and max for all conditions is recorded.

Output	Minimum	Maximum
DVD	V	V
3.3V	3.28	3.36
5V	4.96	5.08
12V	10.92	11.96
VCR		
5V	5.08	5.28
6V	5.88	5.92
14V	12.3	13.3
40V	36.8	37.8

NOTE: 14V and 12V both drive motors and do not require tight regulation. However, if the centering for the 14V output is desired to be higher, one turn in the transformer can be added for 14V, and a zener placed on the 12V transistor's base. This will also tighten the voltage regulation of the 12V output.

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9.2.3 Peak Load Margin

A flyback power supply has lowest peak power capability at minimum AC voltage. The DVD+VCR unit has a very fluctuating power requirement, which is difficult to characterize. It draws maximum power when loading a VCR tape and a DVD at the same time. A good test for peak power margin is to see the minimum AC voltage that the unit can operate normally. The unit was powered up at normal AC voltage, then reduced down to 70 Vac. Then a tape and a DVD are pushed in at the same time.

Input voltage	Result
70 Vac	**PASS**

70 Vac is a very good result and implies there is plenty of margin for peak power capability.

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10 Thermal Performance

Test Condition: Open chassis measurement. Unit is recording from DVD to VCR (highest continuous load). Input voltage is 90 Vac (worst case).

Temperature (°C)	
Item	**(°C)**
Ambient (Deg.C)	25
TOP245P (U1)	78

This result suggests that it can operate up to 55 ^{o}C internal ambient or more. If a higher internal ambient temperature capability is desired, more PCB copper area can be added underneath the TOP245P.

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11 Conducted EMI

11.1 Original PSU EMI

EMI was tested at room temperature, 230 VAC input using the original production PSU. The VCR was set to record from DVD, which is the maximum continuous load. If the case of the unit is connected to the LISN ground, the production unit fails conducted EMI, both Quasi-Peak and Average!

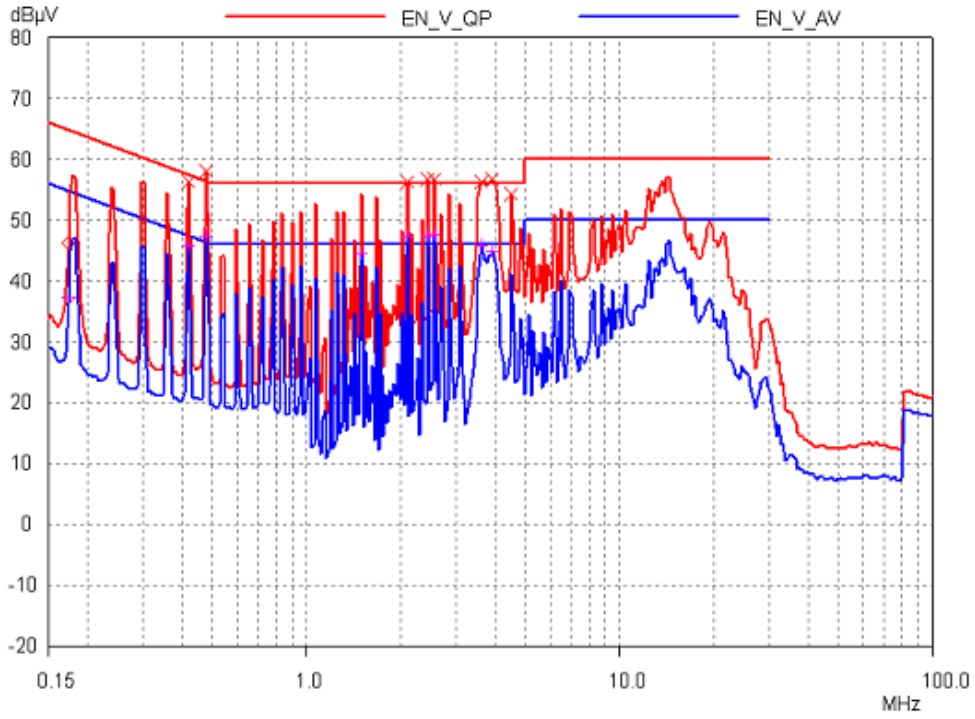

Figure 9 Original PSU, Neutral, Secondary Grounded

11.2 PI PSU EMI

EMI was retested at room temperature, 230 VAC input with the TOP245P PSU installed in the system. The VCR was recording from DVD, which is the maximum continuous load. Neutral measurement was the worst case and the results are shown. Results are shown with chassis connected to LISN ground plug using a piece of wire (worst case), connected to LISN “Artificial Hand”, and with no connection. Results with and without optional 100 pF Y-cap also shown. Red line is QP, Blue line is AVG. EMI is low using low-cost EMI filter because of TOP245P built-in frequency jittering.

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11.3 The DVD/VCR

Chassis floating (not connected to LISN), 8 dB margin was achieved.

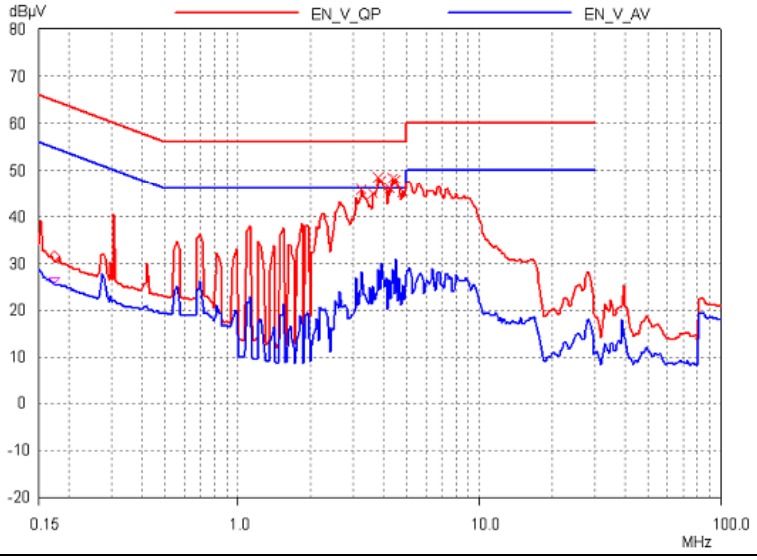

Figure 10 Neutral, Stand Alone

11.4 The DVD/VCR With Artificial Hand Connection

Chassis connected to LISN “Artificial Hand”, 6 dB margin was achieved.

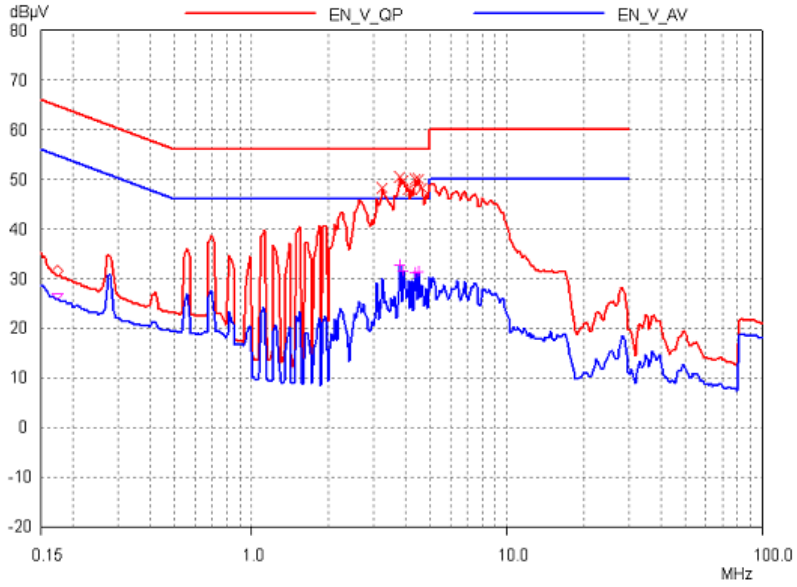

Figure 11 Neutral, Artificial Hand

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11.5 The DVD/VCR with Chassis connected to LISN Ground

The metal case of the unit is grounded to LISN, 4 dB margin was achieved.

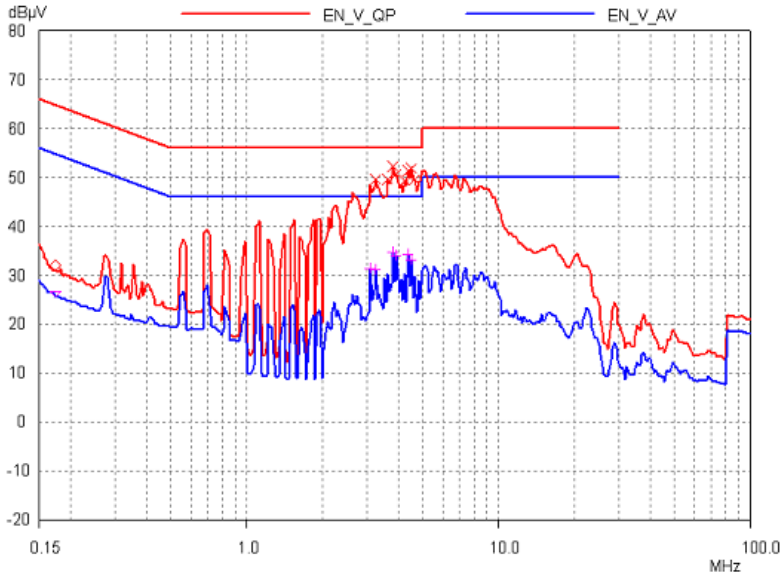

Figure 12 Neutral, Secondary Grounded

11.6 With Optional 100pF Y-cap and chassis connection to LISN Ground

With metal case of the unit grounded to LISN, if more margin is desired, 100pF Y-cap could be added to achieve 12 dB margin (see Figure 14)

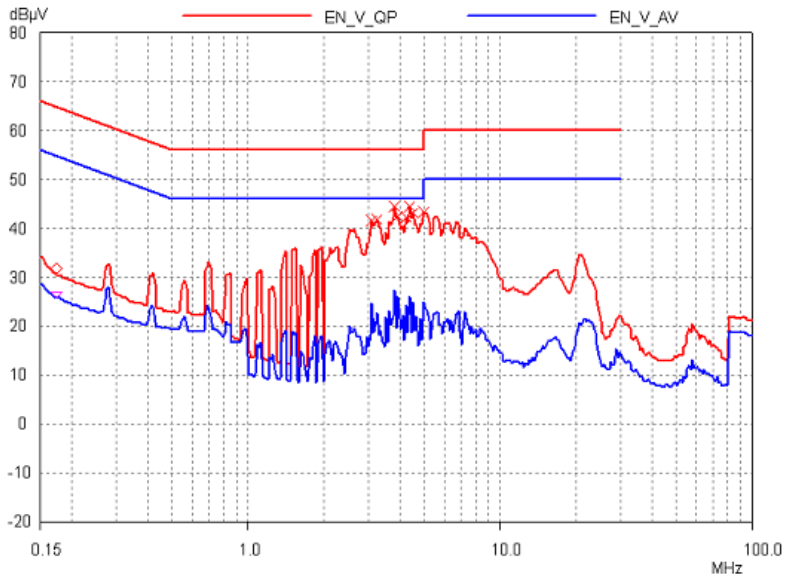

Figure 13 Neutral, Secondary Grounded

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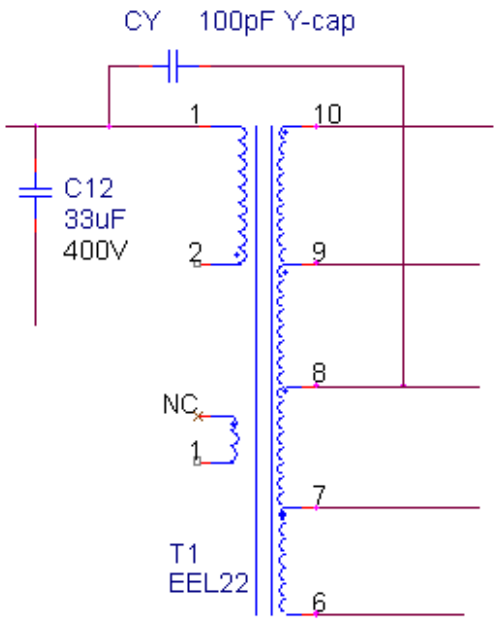

Figure 14 Schematic for optional Y cap connection

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12 Revision History

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

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