Design Example Report

Title	***42W, 4 Output Supply using TOP245Y***
Specification	Input: 230 VAC Outputs: 5V/4A, 6.8V/1.8A, 12V/0.8A, -10V/0.1A
Application	Set Top Box w/Hard Drive
Author	Power Integrations Applications Department
Document Number	DER-36
Date	April 27, 2004
Revision	1.0

Summary and Features

- High Efficiency (81% min)
- Low Parts Count
- Low Output Ripple
- Meets Conducted CISPR22B EMI with Margin
- Small Transformer (EER35)

Power Integrations
5245 Hellyer Avenue, San Jose, CA 95138 USA.
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

Table Of Contents

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.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

1 Introduction

This document is an engineering report describing a 230VAC input, 4 output supply power supply utilizing a TOP245Y. This power supply is intended for use in a set top box.

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

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

2 Power Supply Specification

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	180		265	VAC	2 Wire – no P.E.
Frequency	f_{LINE}	47	50		Hz	
No-load Input Power (230 VAC)				0.3	W	
Output						
Output Voltage 1	V_{OUT1}	4.75	5.00	5.25	V	± 5%
Output Ripple Voltage 1	$V_{RIPPLE1}$			50	mV	20 MHz Bandwidth
Output Current 1	I_{OUT1}	1	2.5	4	A	
Output Voltage 2	V_{OUT2}	6.12	6.80	7.48	V	± 10%
Output Ripple Voltage 2	$V_{RIPPLE2}$			50	mV	20 MHz Bandwidth
Output Current 2	I_{OUT2}	1.2	1.5	1.8	A	
Output Voltage 3	V_{OUT3}	10.8	12.0	13.2	V	± 10%
Output Ripple Voltage 3	$V_{RIPPLE3}$			50	mV	20 MHz Bandwidth
Output Current 3	I_{OUT3}	0.2	0.8	2.5	A	
Output Voltage 4	V_{OUT4}	-9	-10	-11	V	± 10%
Output Ripple Voltage 4	$V_{RIPPLE4}$			50	mV	20 MHz Bandwidth
Output Current 4	I_{OUT4}		0.05	0.10	A	
Total Output Power						
Continuous Output Power	P_{OUT}			41.8	W	
Peak Output Power	P_{OUT_PEAK}			52.7	W	
Efficiency	η	80			%	Measured at P_{OUT} (42 W), 25 ^{o}C
Environmental						
Conducted EMI		Meets CISPR22B / EN55022B				
Safety		Designed to meet IEC950, UL1950 Class II				
Surge		4			kV	1.2/50 µs surge, IEC 1000-4-5, Series Impedance: Differential Mode: 2 Ω Common Mode: 12 Ω
Surge		3			kV	100 kHz ring wave, 500 A short circuit current, differential and common mode
Ambient Temperature	T_{AMB}	0		60	^{o}C	Free convection, sea level

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

3 Schematic

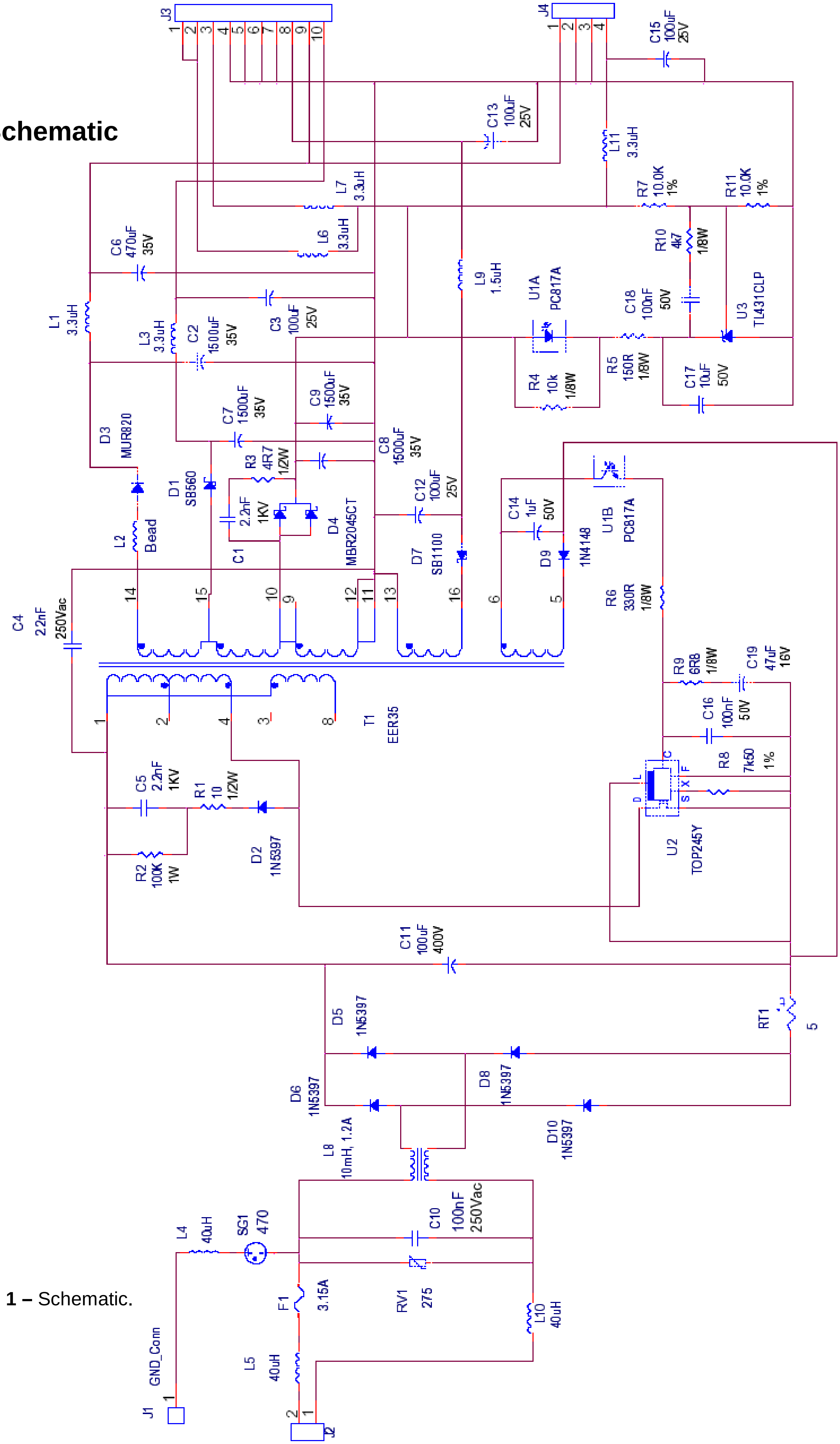


Figure 1 – Schematic.

4 Circuit Description

4.1 Input EMI Filtering

Components L5, L8, L10, C4, and C10 provide EMI filtering, while L4, L5, L10, SG1, and RV1 provide line surge protection.

4.2 TOPSwitch Primary

Components D2, R1-2, and C5 comprise an RCD clamp with damping to limit the primary leakage spike. Use of a normal recovery diode in this clamp circuit allows some leakage energy to be recycled. Capacitors C16 and C19 bypass the U2 control pin. Components C19 and R9 also provide frequency compensation for U2. Resistor R8 sets the U2 current limit to 90% of its nominal value.

4.3 Output Rectification

Output rectification and filtering is provided by D4 and C8-9 for the 5V output, D1 and C7 for the 6.8V output, D3 and C2 for the 12V output, and D7 and C12 for the –10V output. Components L1, 3, L6, L7, L9, C3, C6, C13 and C15 are used for additional high frequency filtering. Ferrite bead L2 is used to center the 12V output closer to its nominal value.

4.4 Output Feedback

Output feedback is provided from the 5V output. Resistors R7 and R11 program the output voltage. The output error signal is coupled back to the supply primary via R5 and U1. Capacitor C18 and 10 compensate U3, while C17 allows current through U1 during startup to prevent output overshoot. Resistor R4 discharges C17 when the supply is off.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

5 PCB Layout

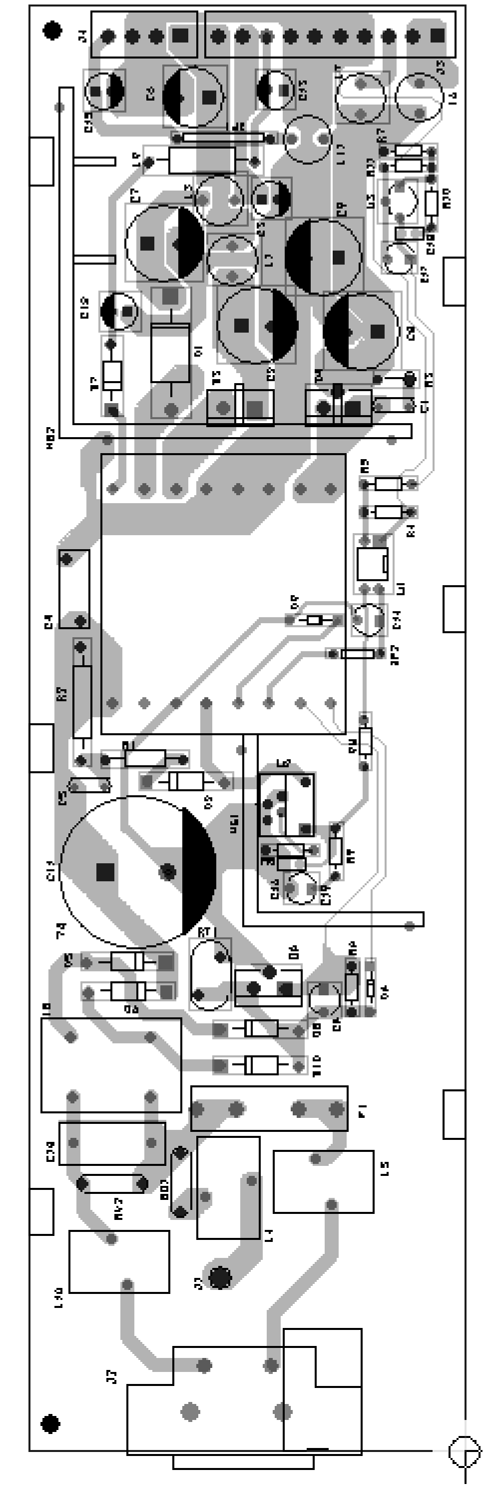


Figure 2 – Printed Circuit Layout.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

6 Bill Of Materials

Item	Qty	Part Reference	Description	Mfg Part Number	Mfg
1	2	C1 C5	Cap,Cer,2200pF, 1KV, 10%	DD-222	Vishay
2	4	C2 C7 C8 C9	Cap,Al Elect,1500uF,35V,12.5mmX35mm,LXZ Series,NIPPON CHEMI-CON	LXZ35VB152MK35LL	Nippon Chemi-Con
3	3	C3 C13 C15	Cap,Al Elect,100uF,25V,6.3mmX11.5mm,NHG Series,Panasonic	ECA-1EHG101	Panasonic
4	1	C4	Cap,Cer,2.2nF, Y2, 250VAC	440LD22	Cera-Mite
5	1	C6	Cap,Al Elect,470uF,35V,10mmX20mm,LXZ Series,NIPPON CHEMI-CON	LXZ35VB471MJ20LL	Nippon Chemi-Con
6	1	C10	Cap,Metal Poly,0.1uF, 250/275VAC	ECQ-U2A104ML	Panasonic
7	1	C11	Cap,Al Elect,100uF,400V,30mmX25mm,TSED Series, Panasonic	ECO-S2GP101CA	Panasonic
8	1	C12	Cap,Al Elect,100uF,25V,6.3mmX11.5mm,LXZ Series,NIPPON CHEMI-CON	LXZ25VB101MF11LL	Nippon Chemi-Con
9	1	C14	Cap,Al Elect,1uF,50V,5mmX11.5mm,NHG Series,Panasonic	ECA-1HHG010	Panasonic
10	2	C16 C18	Cap,Cer, 0.10 uF, 50V, X7R, 10%	ECU-S1H104KBB	Panasonic
11	1	C17	Cap,Al Elect,10uF,50V,5mmX11.5mm, NHG Series,Panasonic	ECA-1HHG100	Panasonic
12	1	C19	Cap,Al Elect,47uF,16V,5mmX11.5mm,NHG Series,Panasonic	ECA-1CHG470	Panasonic
13	1	D1	Rectifier Schottky 5A 60V DO-201AD	SB560	General Semiconductor
14	5	D2 D5 D6 D8 D10	Rectifier GPP 600V 1.5A DO-204	1N5397	Rectron
15	1	D3	Diode,Ultrafast, 8A, 100V	MUR820	ON Semiconductor
16	1	D4	Diode Schottky 45V 20A TO-220AB	MBR2045CT	General Semiconductor
17	1	D7	Diode Schottky,100V 1A DO-41	SB1100	Diodes, Inc.
18	1	D9	Diode SGL JUNC 100V 4.0NS DO-35	1N4148	
19	1	F1	FUSE T-LAG 3.15A, 250V,Slo-Blo		Bel Fuse
20	1	J1	Geound Wire Assembly		
21	1	J2	AC Input Receptacle	HJC-028	Singatron
22	1	J3	CONN HEADER 10POS(1 X10) .156 VERT TIN		Molex
23	1	J4	CONN HEADER 4POS(1 X 4) .156 VERT TIN		Molex
24	5	L1 L3 L6 L7 L11	Inductor,3.3uH,2.66A	822LY_3R3M	Toko

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

25	2	L2	Bead,Ferrite, 3.25X3.5 mm,43 material	2643001501	Fair-Rite
26	3	L4 L5 L10	Inductor,40uH,Toroid		
27	1	L8	LINE FILTER,10mH,1.2A		TDK
28	1	L9	Bead, Ferrite, 6.7mm X 3.5mm, 43 material	2743004112	Fair-rite
29	1	R1	Res, 10.0, 1/2W, 5%, Carbon Film	CFR-50JB-10R	Yageo
30	1	R2	Res, 100K ,1W, 5%, Metal Film	RSF200JB-100K	Yageo
31	1	R3	Res, 4.7, 1/2W, 5%, Carbon Film	CFR-50JB-4R7	Yageo
32	1	R4	Res, 10K, 1/8W, 5%, Carbon Film	CFR-12JB-10K	Yageo
33	1	R5	Res, 150, 1/8W, 5%, Carbon Film	CFR-12JB-150R	Yageo
34	1	R6	Res, 330, 1/8W, 5%, Carbon Film	CFR-12JB-330R	Yageo
35	2	R7 R11	Res,10.0K, 1/4W, 1%, M-FILM	MFR-25FBF-10K0	Yageo
36	1	R8	Res,7.50K, 1/4W, 1%, M-FILM	MFR-25FBF-7K50	Yageo
37	1	R9	Res, 6.8, 1/8W, 5%, Carbon Film	CFR-12JB-6R8	Yageo
38	1	R10	Res, 4.7K, 1/8W, 5%, Carbon Film	CFR-12JB-4K7	Yageo
39	1	RT1	Thermistor,5 Ohms,3 A	SCK-053	THINKING ELECTRONICS
40	1	RV1	VARISTOR 275V 75J 14MM RADIAL LA	V275LA20A	Littlefuse
41	1	SG1	Gas Tube,470V,5kA,Axial	B88069X5740S102	Epcos
42	1	T1	XFMR,HORIZ,16 Pin,776uH,EER35 Core		
43	1	U1	IC,PC817A,PHOTOCOUPLER TRAN OUT CTR 80-160% 4-DIP	ISP817A	ISOCOM
44	1	U2	IC,TOP245Y,INT. OFF-LINE SWITCHER,60W,TO220-7C	TOP245Y	Power Int.
45	1	U3	IC,TL431CLP, ADJ SHUNT REG TO-92	TL431CLP	TI

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

7 Transformer Specification

7.1 Electrical Diagram

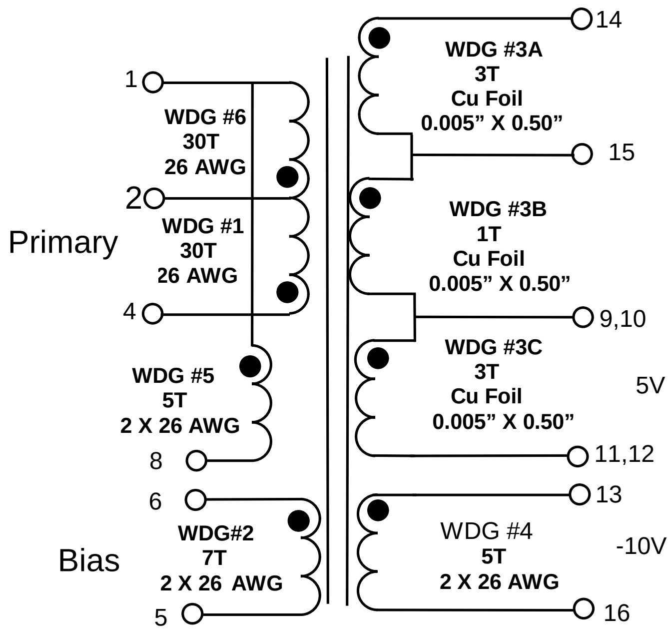


Figure 3 –Transformer Electrical Diagram

7.2 Electrical Specifications

Electrical strength	60 Hz 1 second, From Pins 1-6 to Pins 7-12	3000 Vac
Primary Inductance	Pins 1-4, All other windings open, 100 kHz	791uH+/-10%
Resonant Frequency	Pins 1-4, All other windings open	1.3 MHz (min)
Primary leakage inductance	Pins 1-4, Pins 7-12 shorted, 100 kHz	<15 uH

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

7.3 Materials

Item	Description
[1]	Core: EER35, ungapped, Nippon Ceramic NC-2H material or equiv. Gap for A_L of 220 nH/T^2
[2]	Bobbin: EER35 Horizontal 12 pin, TDK BEER35-1116CPH or equivalent
[3]	Magnet Wire: #26 AWG Solderable Double Coated
[4]	Copper Foil, 0.50” X 0.005” thick
[5}	Tinned Bus Wire, 24 AWG
[6]	Tape: 3M Type 1298 Polyester Film or equiv. 1.03” wide
[7]	Tape: 3M Type 1298 Polyester Film or equiv. 0.65” wide
[8]	Tape: 3M Type 1298 Polyester Film or equiv. 0.55” wide
[9]	Tape: 3M Type 44. Polyester web or equiv. 0.24” wide (min)
[10]	Transformer Varnish

7.4 Transformer Build Diagram

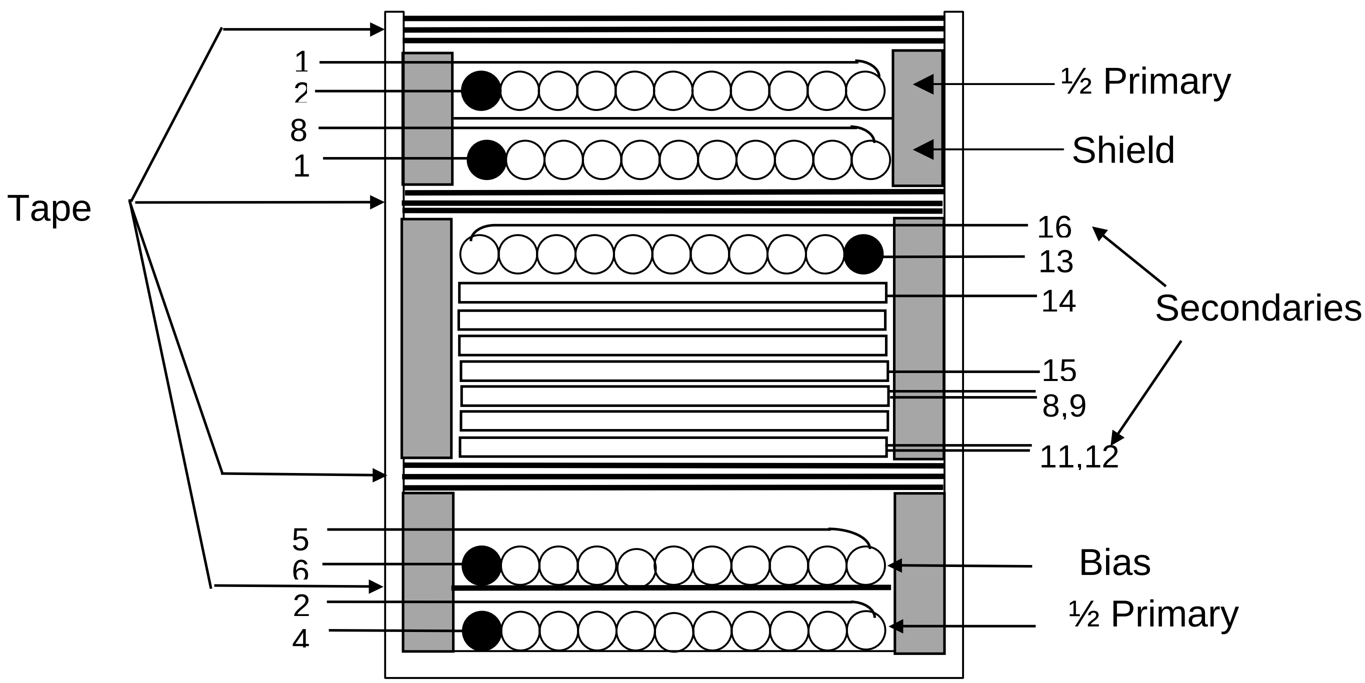


Figure 4 – Transformer Build Diagram.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

7.5 Transformer Construction

WINDING INSTRUCTIONS:

Margin Taping	Apply a 0.24" margin at each side of bobbin using item [9]. Match combined height of primary and bias windings.
½ Primary Winding	Start at pin 4. Wind 30 turns of item [3] in a single layer. Finish at pin
Basic Insulation	Apply one layer of tape [8] for basic insulation.
Bifilar Bias Winding	Start at pin 6. Wind 7 bifilar turns of item [3] uniformly in a single layer, across entire width of bobbin. Finish on pin 5.
Reinforced Insulation	Apply three layers of tape [6] for reinforced insulation.
Margin Taping	Apply a 0.24" margin at each side of bobbin using item [9]. Match combined height of secondary windings.
Secondary Foil Winding	Prepare a cuffed foil assembly using items [4], [5], [7], and [8]. Starting at pin 14, wind 3 turn of foil, finish at pin 15. Wind one turn of foil, finish at pins 9 and 10, Wind three remaining turns, finish at pins 11 and 12.
10 V Bifilar Winding	Starting at pin 13, wind 5 bifilar turns of item [4] directly on top of the foil winding. Space turns evenly across bobbin. Finish at pin 16.
Reinforced Insulation	Apply three layers of tape [6] for reinforced insulation.
Margin Taping	Apply a 0.24" margin at each side of bobbin using item [9]. Match combined height of primary and shield windings.
Shield Winding	Starting at Pin 1, wind 5 bifilar turns of item [3]. Spread turns evenly across bobbin. Finish at pin 8.
Basic Insulation	Apply one layer of tape [9] for basic insulation.
½ Primary Winding	Starting at pin 2, wind 30 turns of item [3] in a single layer. Finish at pin 1.
Outer Insulation	Apply 3 Layers of tape [6] for outer insulation
Varnish	Impregnate transformer using item [10]

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

8 Transformer Spreadsheets

ACDC_TOPGX_Rev1.7_082203 Copyright Power Integrations Inc. 2003	INPUT	INFO	INFO	OUTPUT	OUTPUT	UNIT	TOP_GX_FX_082203.xls: TOPSwitch-GX/FX Continuous/Discontinuous Flyback Transformer Design Spreadsheet
ENTER APPLICATION VARIABLES							
VACMIN	190					Volts	Minimum AC Input Voltage
VACMAX	265					Volts	Maximum AC Input Voltage
fL	50					Hertz	AC Mains Frequency
VO	5					Volts	Output Voltage
PO	53					Watts	Output Power
n	0.8						Efficiency Estimate
Z	0.5						Loss Allocation Factor
VB	12					Volts	Bias Voltage
tC	3					mSeconds	Bridge Rectifier Conduction Time Estimate
CIN	100					uFarads	Input Filter Capacitor
ENTER TOPSWITCH-GX VARIABLES							
TOP-GX		TOP245				Universal	115 Doubled/230V
Chosen Device		TOP245	TOP245	Power Out	Power Out	60W	85W
KI	0.8						External Ilimit reduction factor (KI=1.0 for default ILIMIT, KI <1.0 for lower ILIMIT)
ILIMITMIN				1.296	1.296	Amps	Use 1% resistor in setting external ILIMIT
ILIMITMAX				1.584	1.584	Amps	Use 1% resistor in setting external ILIMIT
Frequency - (F)=132kHz, (H)=66kHz	F						Full (F) frequency option - 132kHz
fS	132000			132000	132000	Hertz	TOPSwitch-GX Switching Frequency: Choose between 132 kHz and 66 kHz
fSmin				124000	124000	Hertz	TOPSwitch-GX Minimum Switching Frequency
fSmax				140000	140000	Hertz	TOPSwitch-GX Maximum Switching Frequency
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	0.60						Ripple to Peak Current Ratio (0.4 < KRP < 1.0 : 1.0< KDP<6.0)
ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES							
Core Type	EER35						
Core		EER35	EER35			P/N:	PC40EER35-Z
Bobbin		EER35_BOBBIN	EER35_BOBBIN			P/N:	BEER-35-1116CPH
AE				1.07	1.07	cm^2	Core Effective Cross Sectional Area
LE				9.08	9.08	cm	Core Effective Path Length
AL				2770	2770	nH/T^2	Ungapped Core Effective Inductance
BW				26.1	26.1	mm	Bobbin Physical Winding Width
M	6					mm	Safety Margin Width (Half the Primary to Secondary Creepage Distance)

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

L	2				Number of Primary Layers
NS	3				Number of Secondary Turns
DC INPUT VOLTAGE PARAMETERS					
VMIN		251	251	Volts	Minimum DC Input Voltage
VMAX		375	375	Volts	Maximum DC Input Voltage
CURRENT WAVEFORM SHAPE PARAMETERS					
DMAX		0.31	0.31		Maximum Duty Cycle
IAVG		0.26	0.26	Amps	Average Primary Current
IP		1.20	1.20	Amps	Peak Primary Current
IR		0.72	0.72	Amps	Primary Ripple Current
IRMS		0.49	0.49	Amps	Primary RMS Current
TRANSFORMER PRIMARY DESIGN PARAMETERS					
LP		791	791	uHenries	Primary Inductance
NP		60	60		Primary Winding Number of Turns
NB		7	7		Bias Winding Number of Turns
ALG		220	220	nH/T^2	Gapped Core Effective Inductance
BM		1482	1482	Gauss	Maximum Flux Density at PO, VMIN (BM<3000)
BP		1951	1951	Gauss	Peak Flux Density (BP<4200)
BAC		445	445	Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
ur		1871	1871		Relative Permeability of Ungapped Core
LG		0.56	0.56	mm	Gap Length (Lg > 0.1 mm)
BWE		28.2	28.2	mm	Effective Bobbin Width
OD		0.47	0.47	mm	Maximum Primary Wire Diameter including insulation
INS		0.06	0.06	mm	Estimated Total Insulation Thickness (= 2 * film thickness)
DIA		0.41	0.41	mm	Bare conductor diameter
AWG		27	27	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CM		203	203	Cmils	Bare conductor effective area in circular mils
CMA		418	418	Cmils/Amp	Primary Winding Current Capacity (200 < CMA < 500)
TRANSFORMER SECONDARY DESIGN PARAMETERS (SINGLE OUTPUT / SINGLE OUTPUT EQUIVALENT)					
Lumped parameters					
ISP		24.07	24.07	Amps	Peak Secondary Current
ISRMS		14.38	14.38	Amps	Secondary RMS Current
IO		10.60	10.60	Amps	Power Supply Output Current
IRIPPLE		9.72	9.72	Amps	Output Capacitor RMS Ripple Current
CMS		2876	2876	Cmils	Secondary Bare Conductor minimum circular mils
AWGS		15	15	AWG	Secondary Wire Gauge (Rounded up to next larger standard AWG value)
DIAS		1.45	1.45	mm	Secondary Minimum Bare Conductor Diameter
ODS		4.70	4.70	mm	Secondary Maximum Outside Diameter for Triple Insulated Wire
INSS		1.62	1.62	mm	Maximum Secondary Insulation Wall Thickness
VOLTAGE STRESS PARAMETERS					
VDRAIN		626	626	Volts	Maximum Drain Voltage

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

					Estimate (Includes Effect of Leakage Inductance)
PIVS		24	24	Volts	Output Rectifier Maximum Peak Inverse Voltage
PIVB		55	55	Volts	Bias Rectifier Maximum Peak Inverse Voltage

TRANSFORMER SECONDARY DESIGN PARAMETERS (MULTIPLE OUTPUTS)

1st output					
VO1	5.0			Volts	Output Voltage
IO1	2.500			Amps	Output DC Current
PO1		12.50	12.50	Watts	Output Power
VD1	0.5			Volts	Output Diode Forward Voltage Drop
NS1		3.00	3.00		Output Winding Number of Turns
ISRMS1		3.391	3.391	Amps	Output Winding RMS Current
IRIPPLE1		2.29	2.29	Amps	Output Capacitor RMS Ripple Current
PIVS1		24	24	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS1		678	678	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS1		21	21	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS1		0.73	0.73	mm	Minimum Bare Conductor Diameter
ODS1		4.70	4.70	mm	Maximum Outside Diameter for Triple Insulated Wire
2nd output					
VO2	6.8			Volts	Output Voltage
IO2	1.500			Amps	Output DC Current
PO2		10.20	10.20	Watts	Output Power
VD2	0.5			Volts	Output Diode Forward Voltage Drop
NS2		3.98	3.98		Output Winding Number of Turns
ISRMS2		2.035	2.035	Amps	Output Winding RMS Current
IRIPPLE2		1.37	1.37	Amps	Output Capacitor RMS Ripple Current
PIVS2		32	32	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS2		407	407	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS2		24	24	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS2		0.51	0.51	mm	Minimum Bare Conductor Diameter
ODS2		3.54	3.54	mm	Maximum Outside Diameter for Triple Insulated Wire
3rd output					
VO3	12.0			Volts	Output Voltage
IO3	2.500			Amps	Output DC Current
PO3		30.00	30.00	Watts	Output Power
VD3	0.7			Volts	Output Diode Forward Voltage Drop

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

NS3	6.93	6.93		Output Winding Number of Turns
ISRMS3	3.391	3.391	Amps	Output Winding RMS Current
IRIPPLE3	2.29	2.29	Amps	Output Capacitor RMS Ripple Current
PIVS3	55	55	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS3	678	678	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS3	21	21	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS3	0.73	0.73	mm	Minimum Bare Conductor Diameter
ODS3	2.04	2.04	mm	Maximum Outside Diameter for Triple Insulated Wire

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

9 Performance Data

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

9.1 Thermal Performance

Thermal measurements were made with the power supply mounted in the chassis, using a slip-on heat sink on the TOPSwitch. A thermocouple was attached to the heat sink next to the TOPSwitch source tab using solder. Another thermocouple was soldered to a length of adhesive-backed copper tape, which was attached to the transformer. A thermocouple was taped in the center of the chassis, with the junction in free air. This thermocouple was used to measure the ambient air temperature inside the chassis. All holes in chassis were sealed with tape except ventilation holes in chassis and holes used for load and thermocouple wires. A solid cardboard sheet was used as the chassis top lid. The thermal chamber temperature outside the chassis was adjusted until the desired temperature was attained inside the chassis. Due to the limited size of the thermal chamber, the chassis was inserted diagonally into the chamber, with the power supply side tilted up. This may mean that the local ambient temperature of the supply was higher than that that measured by the thermocouple, which was located in the chassis center.

The internal ambient temperature was allowed to rise with the unit running at the worst case power dissipation (e.g. 180VAC) until the unit shutdown (S/D) and the maximum ambient temperature was then recorded. The device was allowed to cool and restart, and the thermals measured using the nominal supply voltage at both normal room ambient and the elevated temperature at which shut down occurred at low line.

Item	180 VAC	230 VAC	230 VAC
Ambient	58	59	23
***TOPSwitch* (U3)**	S/D	122	87
Transformer (T1)	S/D	73	52

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

10 Waveforms

10.1 12V Output Turn Off

The waveforms shown below were taken with output loads set to 5V/4A, 6.8V/1.5A, and 12V/0.5A, with a fixed 100 ohm resistor on the –10V output. The 5V and 12V outputs were monitored with an oscilloscope. The oscilloscope was triggered on the falling edge of the 5V output. The waveforms show the rise in the lightly loaded 12V output just before the heavily loaded +5V output goes out of regulation after removal of AC power. Use of a heavy foil on the transformer secondaries, along with a small ferrite bead in series with the 12V rectifier, keeps the 12V overshoot within 5%. The ferrite bead also helps to center the 12V output.

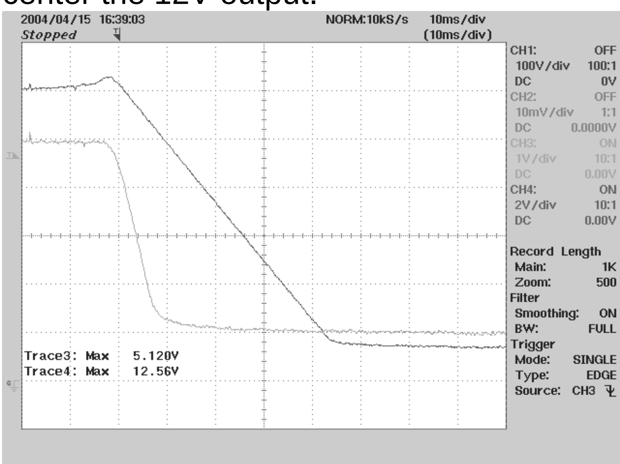


Figure 5 - 180 VAC, 5V/4A, 12V/0.5A, 6.8V/1.5A, 10msec/div
Upper: 12V, 2V / div
Lower: 5V, 1V / div

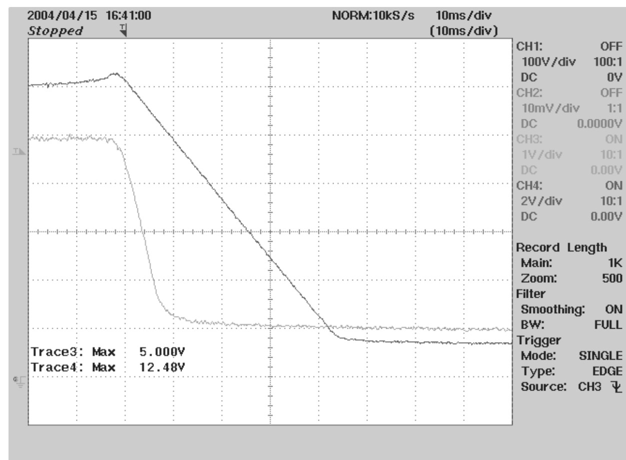
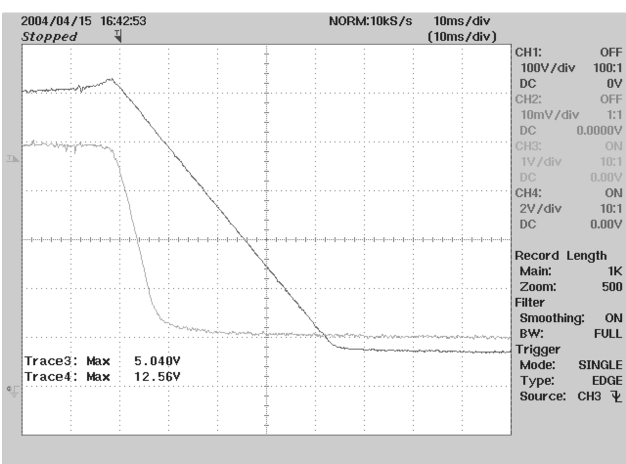


Figure 6 - 230 VAC, 5V/4A, 12V/0.5A, 6.8V/1.5A, 10msec/div
Upper: 12V, 2V / div
Lower: 5V, 1V / div



Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

Figure 7 - 180VAC, 5V/4A, 12V/0.5A, 6.8V/1.5A,
10msec/div. Upper: 12V Output, 2V / div
Lower: 5V Output, 1V / div.

10.2 5V Transient Response

Transient response measurements were taken for the 5V output using a 1A-2.5A-1A current step, with the 12V output loaded to 0.5A, and the 6.8v output at 1.5A. The cathode terminal of the TL431 error amplifier was loaded to determine its voltage excursion under these transient conditions. As shown below, the cathode excursion of the TL431 does not approach saturation, under these load conditions.

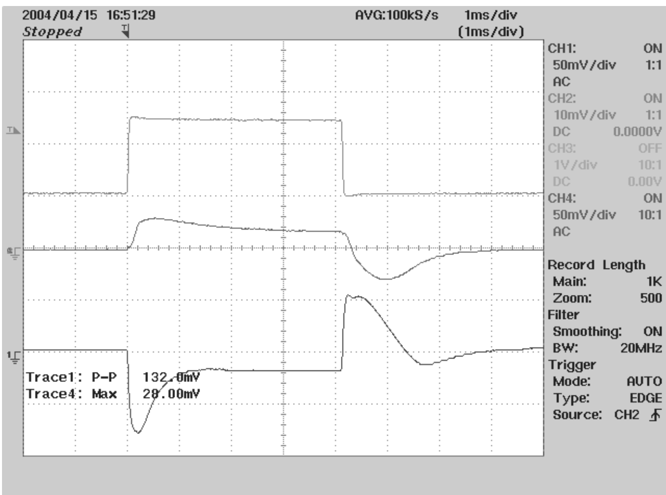


Figure 11 - 230VAC Input, 5V Load Step of 1A-2.5A-1A, 1msec/div. Upper: 5V Load, 1A/div. Middle: TL431 Drain Voltage, 50mV/div. Lower: 5V Output, 50mV/div

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

11 Conducted EMI

Tests were performed in open air with resistive load. The supply was mounted inside the chassis. The secondary return was connected to the chassis at the end of the load cable. The primary ground lead (when used) was connected to the chassis using the fast-on terminal provided at the chassis rear panel. The chassis was hard wired to the LISN ground. The margin at the second harmonic will be 2-3dB better using the TDK choke instead of the Panasonic choke.

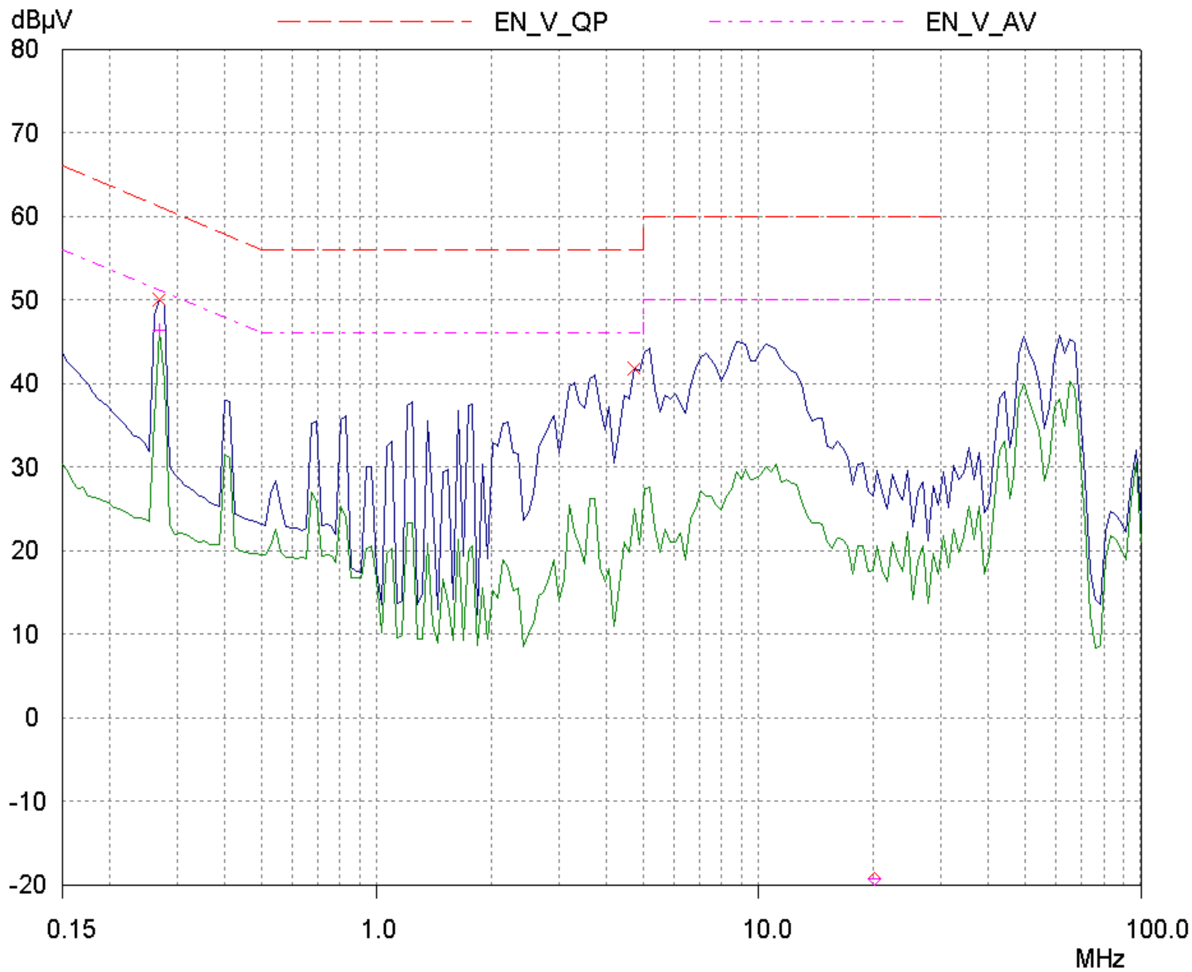


Figure 30 - Conducted EMI, Maximum Steady State Load, 230 VAC, 60 Hz, and EN55022 B Limits, ground wire connected to chassis.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

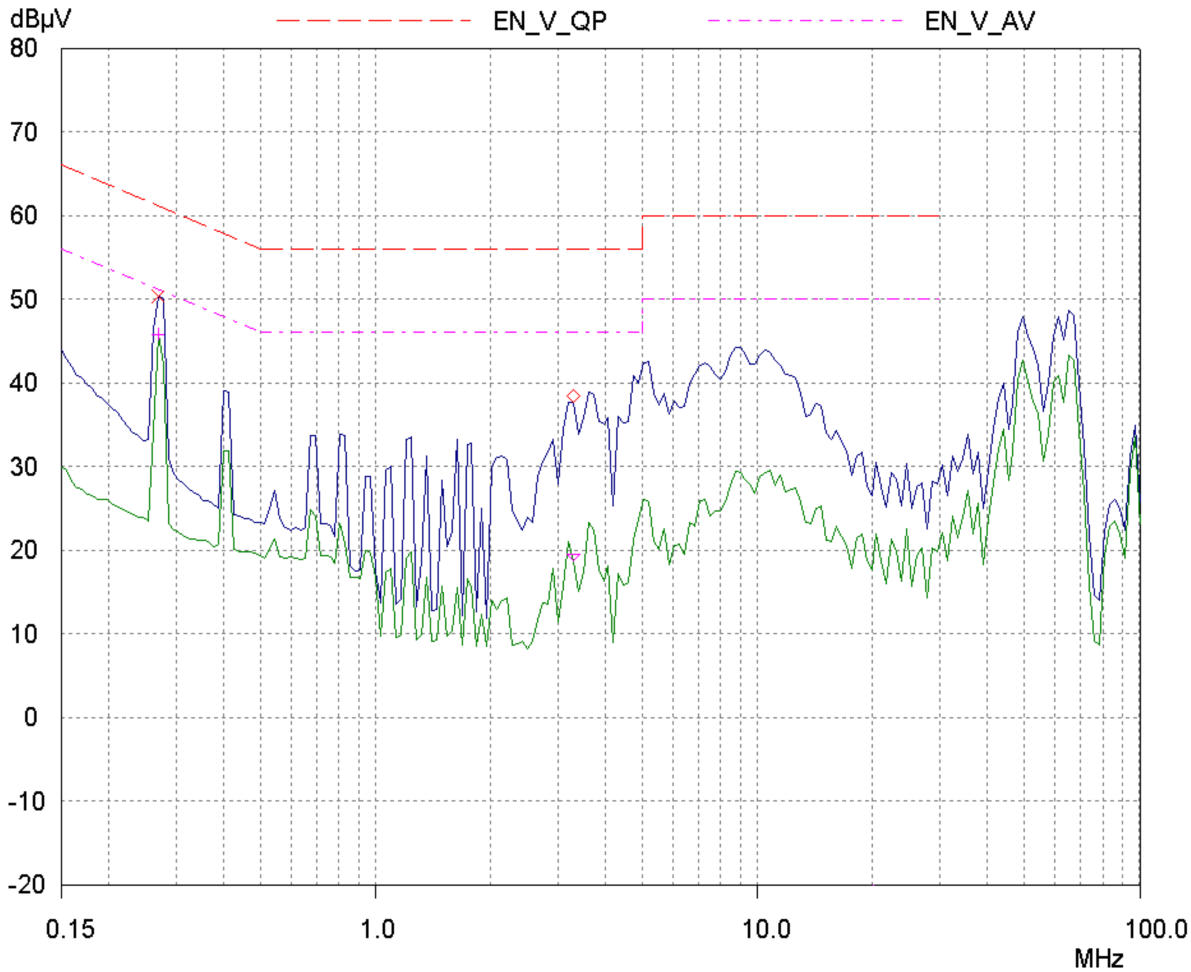


Figure 30 - Conducted EMI, Maximum Steady State Load, 230 VAC, 60 Hz, and EN55022 B Limits, ground wire left open.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

12 Revision History

Date	Author	Revision	Description & changes	Reviewed
April 27, 2004	RH	1.0	First Release	VC

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.powerint.com

For the latest updates, visit our Web site: *www.powerint.com*

PATENT INFORMATION

The products and applications illustrated herein (including circuits external to the products and transformer construction) may be covered by one or more U.S. and foreign patents or potentially by pending U.S. and foreign patent applications assigned to Power Integrations. A complete list of Power Integrations' patents may be found at *www.powerint.com*.

WORLD HEADQUARTERS
Power Integrations
5245 Hellyer Avenue,
San Jose, CA 95138, USA
Main: +1-408-414-9200
Customer Service:
Phone: +1-408-414-9665
Fax: +1-408-414-9765
e-mail:
usasales@powerint.com

CHINA (SHENZHEN)
Power Integrations
International Holdings, Inc.
Rm# 1705, Bao Hua Bldg.
1016 Hua Qiang Bei Lu,
Shenzhen, Guangdong,
518031, China
Phone: +86-755-8367-5143
Fax: +86-755-8377-9610
e-mail: chinasales@powerint.com

ITALY
Power Integrations s.r.l.
Via Vittorio Veneto 12,
Bresso, Milano,
20091, Italy
Phone: +39-028-928-6001
Fax: +39-028-928-6009
e-mail:
eurosales@powerint.com

SINGAPORE (ASIA PACIFIC HEADQUARTERS)
Power Integrations, Singapore
51 Newton Road,
#15-08/10 Goldhill Plaza,
Singapore, 308900
Phone: +65-6358-2160
Fax: +65-6358-2015
e-mail:
singaporesales@powerint.com

AMERICAS
Power Integrations, Inc.
4335 South Lee Street,
Suite G,
Buford, GA 30518, USA
Phone: +1-678-714-6033
Fax: +1-678-714-6012
e-mail:
usasales@powerint.com

GERMANY
Power Integrations, GmbH
Rueckertstrasse 3,
D-80336, Munich, Germany
Phone: +49-895-527-3910
Fax: +49-895-527-3920
e-mail: eurosales@powerint.com

JAPAN
Power Integrations, K.K.
Keihin-Tatemono 1st Bldg.
12-20 Shin-Yokohama,
2-Chome,
Kohoku-ku, Yokohama-shi,
Kanagawa 222-0033, Japan
Phone: +81-45-471-1021
Fax: +81-45-471-3717
e-mail:
japansales@powerint.com

TAIWAN
Power Integrations
International Holdings, Inc.
17F-3, No. 510,
Chung Hsiao E. Rd., Sec. 5,
Taipei, Taiwan 110, R.O.C.
Phone: +886-2-2727-1221
Fax: +886-2-2727-1223
e-mail:
taiwansales@powerint.com

CHINA (SHANGHAI)
Power Integrations
International Holdings, Inc.
Rm 807, Pacheer,
Commercial Centre,
555 Nanjing West Road,
Shanghai, 200041, China
Phone: +86-21-6215-5548
Fax: +86-21-6215-2468
e-mail:
chinasales@powerint.com

INDIA (TECHNICAL SUPPORT)
Innovatech
261/A, Ground Floor
7th Main, 17th Cross,
Sadashivanagar
Bangalore, India, 560080
Phone: +91-80-5113-8020
Fax: +91-80-5113-8023
e-mail: indiasales@powerint.com

KOREA
Power Integrations
International Holdings, Inc.
8th Floor, DongSung Bldg.
17-8 Yoido-dong,
Youngdeungpo-gu,
Seoul, 150-874, Korea
Phone: +82-2-782-2840
Fax: +82-2-782-4427
e-mail:
koreasales@powerint.com

UK (EUROPE & AFRICA HEADQUARTERS)
1st Floor, St. James's House
East Street
Farnham, Surrey GU9 7TJ
United Kingdom
Phone: +44-1252-730-140
Fax: +44-1252-727-689
e-mail: eurosales@powerint.com

APPLICATIONS HOTLINE
World Wide +1-408-414-9660

APPLICATIONS FAX
World Wide +1-408-414-9760

ER or EPR template – Rev 3.4 – Single sided