Title	***Engineering Prototype Report for EP-12 - 145 W PC Forward Converter with TOP247 and 10 W 5 V Output Standby Flyback with TNY266***
Specification	
Application	PC Main and PC Standby
Author	PI Applications
Document Number	EPR-12
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Revision	1.3

Objective

This document describes the operation and provides the performance data of a design using TOP247 as a forward converter for 145 W PC supply application and TNY266 as a 10 W flyback for PC standby.

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Important Note:
Although the EP-12 is designed to satisfy safety isolation requirements, this 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.

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1 Introduction

The following engineering report gives the detailed description and test data for a TOP247 forward converter designed for 145 W PC main applications and a TNY266 flyback for PC standby. The requirements listed below are typical of a PC power supply.

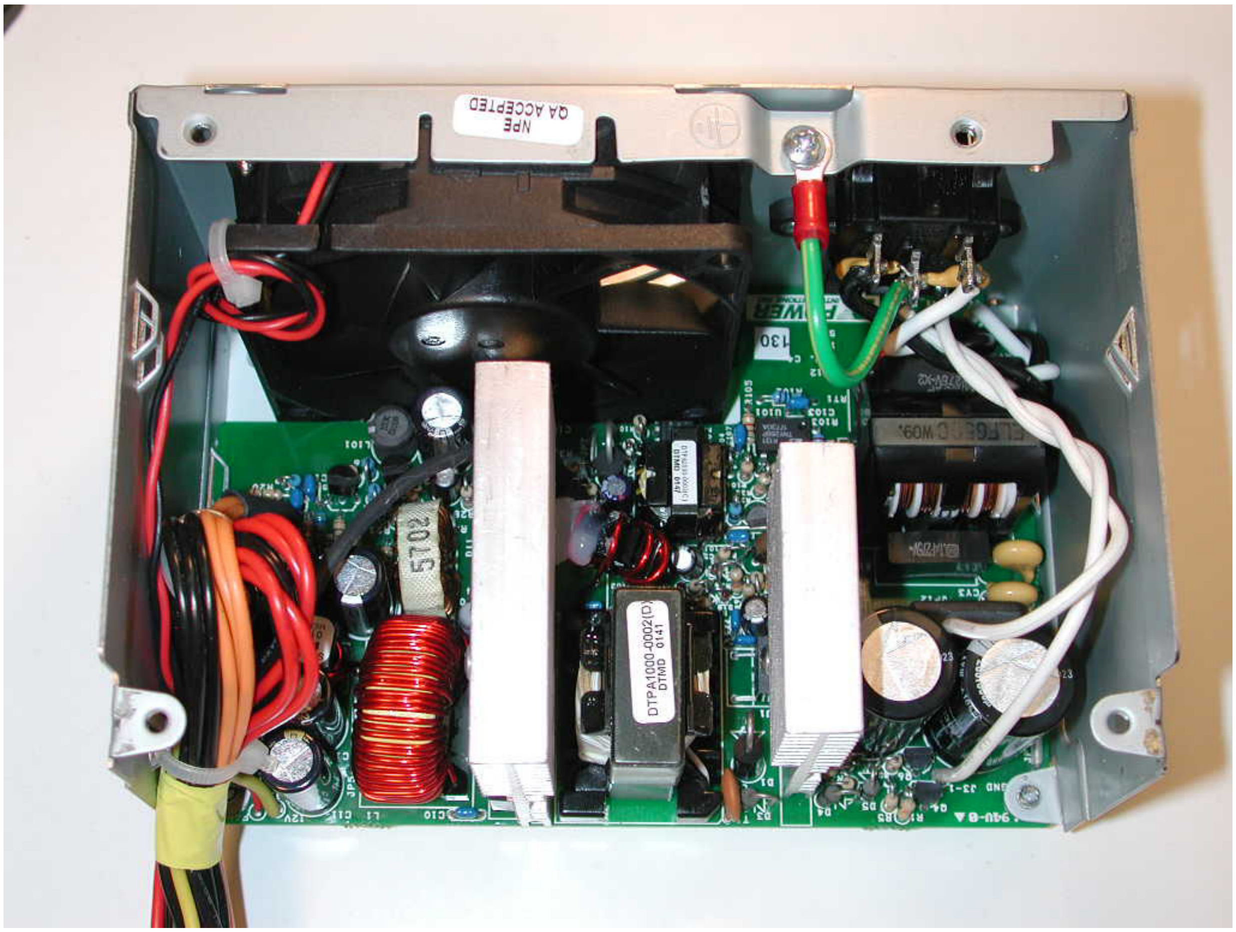

Figure 1 - EP-12 Populated Circuit Board.

2 Supply Requirements

2.1 Power Supply Specification

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	90	115	132	VAC	Doubler Input
Frequency	f_{LINE}	47	50/60	63	Hz	
Standby Input Power (115 VAC)			0.91	1	W	0.5 W Output From Standby
Blue Angel Input Power (240 VAC)			4.2	5	W	2.5 W output From Standby
Output						
Output Voltage 1	V_{OUT1}	3.17	3.30	3.43	V	±4%
Output Ripple Voltage 1	$V_{RIPPLE1}$			50	mV	20 MHz Bandwidth
Output Current 1	I_{OUT1}	0.5		12	A	
Output Voltage 2	V_{OUT2}	4.75	5.00	5.25	V	±5%
Output Ripple Voltage 2	$V_{RIPPLE2}$			50	mV	20 MHz Bandwidth
Output Current 2	I_{OUT2}	0.4		15	A	
Output Voltage 3	V_{OUT3}	11.16	12.0	12.84	V	±7%
Output Ripple Voltage 3	$V_{RIPPLE3}$			120	mV	20 MHz Bandwidth
Output Current 3	I_{OUT3}	0.05		3	A	5 A, 15 s Surge
Output Voltage 4 (standby)	V_{OUT4}	4.75	5.00	5.25	V	±5%
Output Ripple Voltage 4	$V_{RIPPLE4}$			50	mV	20 MHz Bandwidth
Output Current 4	I_{OUT4}	0		2.0	A	2.5 A, 15 s Surge
Total Output Power						
Continuous Output Power (main)	P_{O_main}		150	175	W	
Continuous Output Power (s/b)	$P_{O\_s/b}$		10	12.5	W	
Efficiency						
Main Converter	η_{main}	65	71		%	Measured at P_{O_main} =150 W
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, 12 Ω Series Impedance, Differential and Common Mode
Surge		4			kV	100 kHz Ring Wave, 500 A Short Circuit Current, Differential and Common Mode
Ambient Temperature	T_{AMB}	0		50	^{o}C	Free Convection, Sea Level

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2.2 Conditions for Cross Regulation Test

Load	+5 V	+3.3 V	+12 V
1	11 A	12 A	3 A
2	15 A	7 A	3 A
3	2 A	2 A	3 A
4	0.4 A	0.5 A	0.05 A
5	5 A	3 A	1 A
6	15 A	7 A	3 A
7	12 A	12 A	5 A (15 s)
8	0 A	0 A	0 A

2.3 Output Characteristics

a. Rise time: all outputs of the power supply must rise from 10% to 90% of their rated output voltages within 2 ms to 20 ms at nominal line, maximum load.

b. Turn-on delay time: 1000 ms maximum at nominal line, full load.

c. Hold-up time: 16 ms minimum for all outputs at 110 VAC, 60 Hz, and full load.

2.4 Transient Overshoot

a. +5 V, +12 V and +3.3 V dynamic load transient response. Transient response is measured by switching the output load from 80% to 100% to 80% of its maximum load, other outputs are under maximum load with an input voltage from 90 VRMS to 132 VRMS and at a frequency of 100 Hz and 50% duty cycle, step load change is 0.5 A/µs. The peak transient amplitude is less than or equal to +5% / -5% of +5 V, +12 V, +3.3 V output. The recovery time is less than 5 ms.

b. Overshoot: +5 V: 5.5 V maximum
+3.3 V: 3.63 V maximum

2.5 Short Circuit Protection

The main supply shall latch off from a shorted output condition. The latch is reset through toggling remote ON/OFF.

3 Schematics

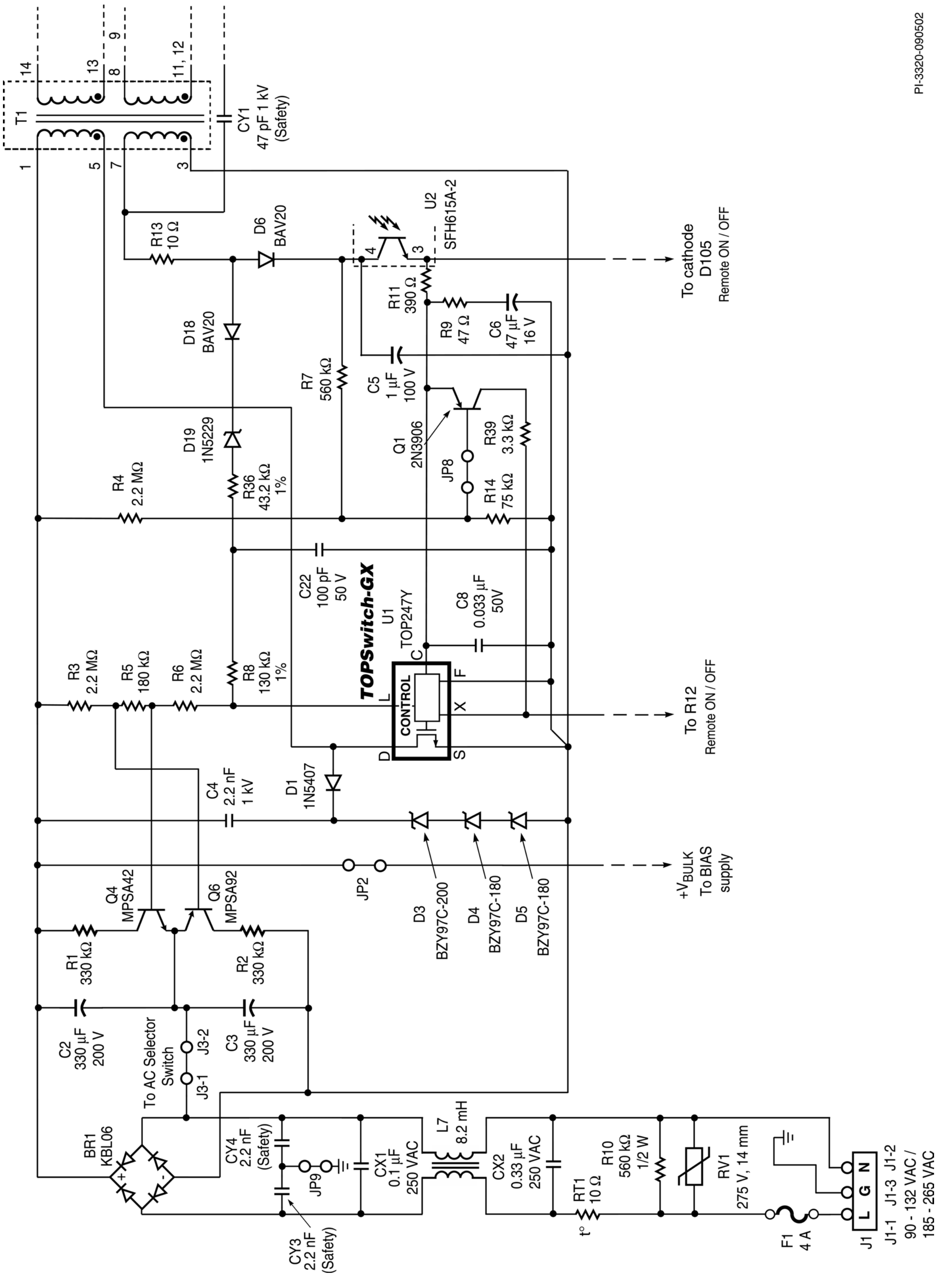

Figure 2 – EP-12 Main Forward Converter Primary Side.

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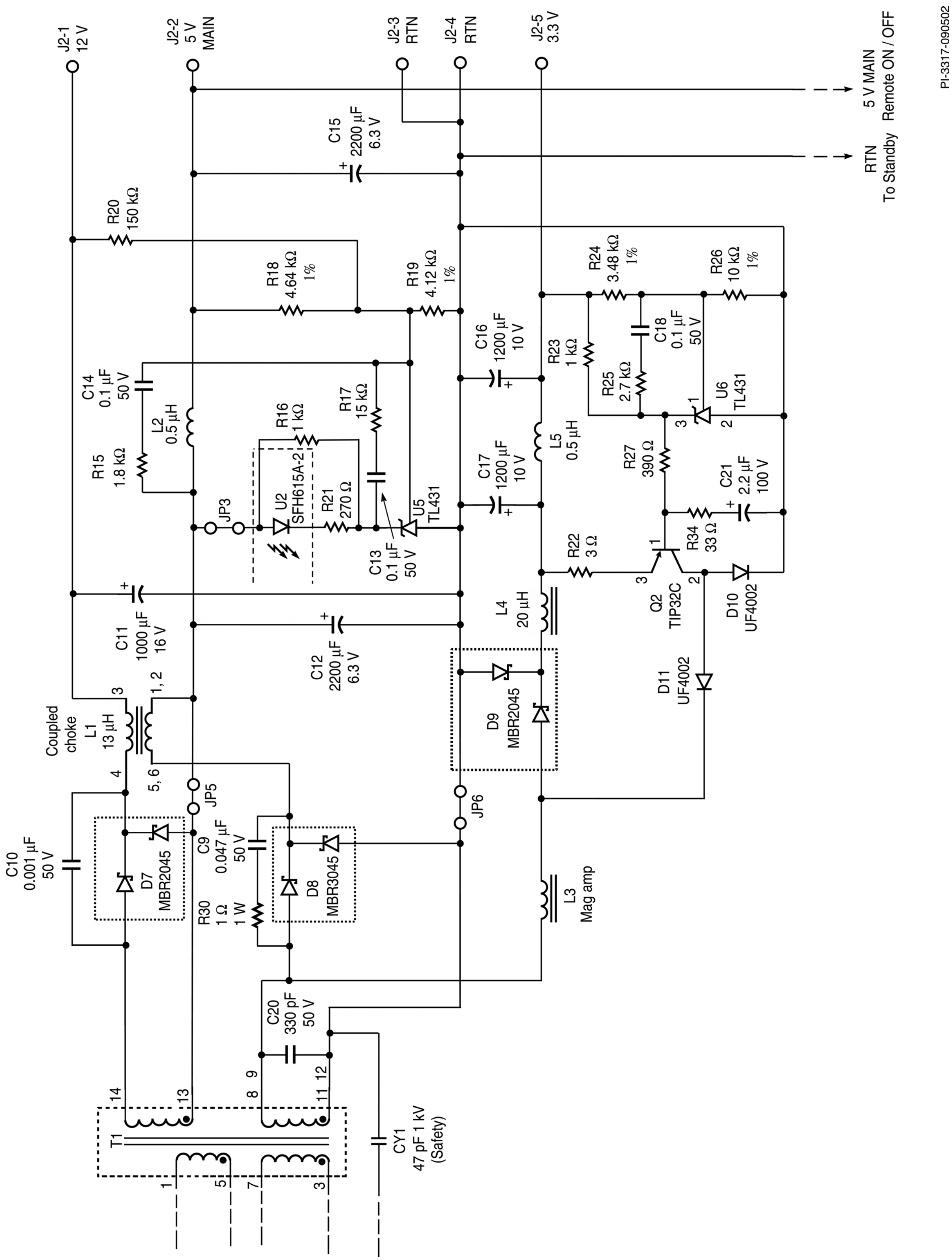

Figure 3 - EP-12 Main Forward Converter Secondary Side.

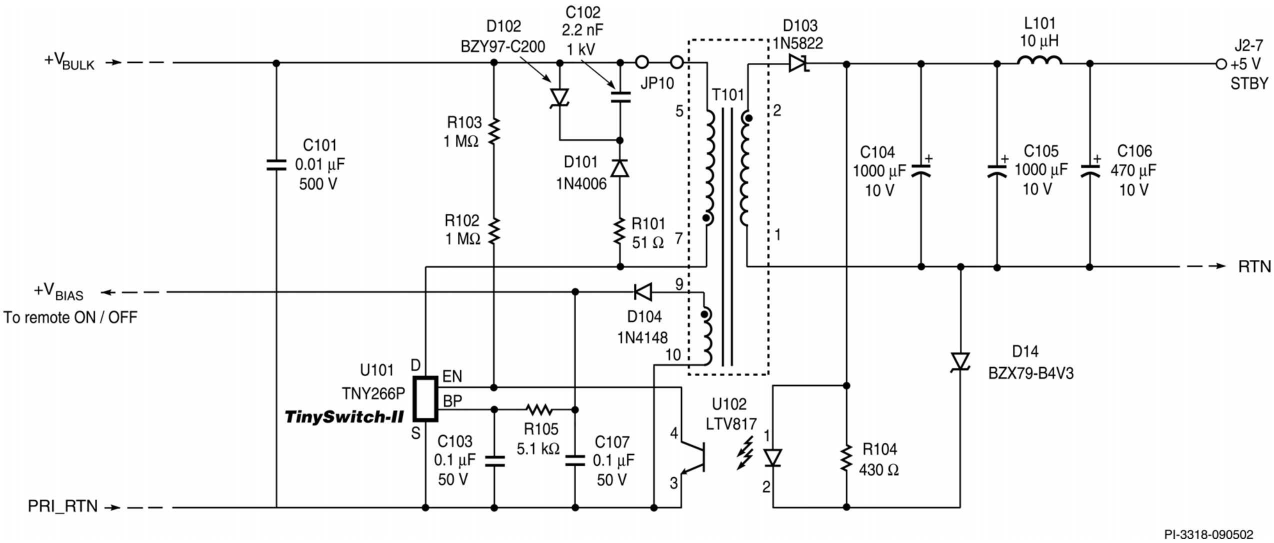

Figure 4 – EP-12 Standby Flyback Converter.

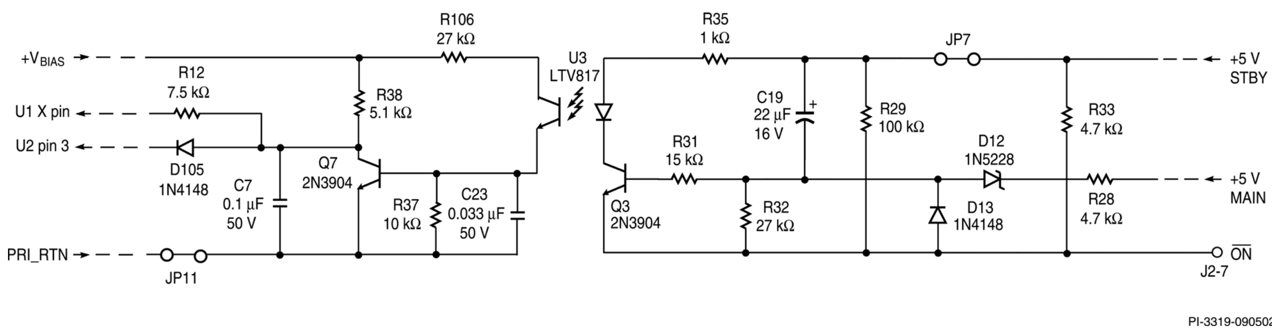

Figure 5 – EP-12 Remote ON / OFF Interface.

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4 Circuit Description

With line feed forward, duty factor reduction, programmable primary current limit, line-sense for input UV and OV, and soft-start function for smooth start-up, the *TOPSwitch–GX* family has all the needed functions to operate in an off-line, single-ended forward converter configuration. Also the *TOPSwitch–GX* family has a sufficient power capability to bring PC main applications easily within its reach.

In the present design the LINE-SENSE pin (L pin, please refer to *TOPSwitch–GX* data sheet) senses the rectified DC input voltage through the combination of R3, R5, and R6 and inhibits the supply from switching until the minimum voltage of 80 VAC (doubled mains) or 160 VAC is reached. Upon reaching this voltage and activation of switching, current sourced from R8 will immediately establish a maximum duty factor limit by injecting the appropriate amount of current into the LINE-SENSE pin (adjusting maximum duty factor, please refer to *TOPSwitch–GX* data sheet). The input from R8 is a quasi-integrated, DC-rectified forward voltage sourced from the bias winding and will restrict the duty factor to a greater degree as the line voltage is increased. This is a very significant function to ensure that the transformer will not saturate, even in extreme transient load conditions.

A TOP247 was selected for this 145 W application and its primary current limit was adjusted to limit at approximately 2.5 A by R12 when U3 is on. This allows approximately 170 W of peak output power.

Lowering the input voltage will cause the converter to shut off by means of the under-voltage lockout circuit around Q1. When input voltage is low enough to bias on Q1, the collector of Q1 will pull up the X pin of the TOP247 via R39 and shut off the main converter.

This design uses a Zener primary clamp (D3, D4, D5) with a capacitor (C4) in parallel that is coupled to the drain of the *TOPSwitch–GX* through a diode (D1). This is a very efficient snubber as it allows the maximum flyback voltage to develop during the off time which returns a significant amount of energy back to the transformer during the reverse time recovery of the diode D1. The total dissipation of the primary snubber clamp circuit was measured to be only 0.8 W at maximum load.

It is necessary to use voltage mode control in the regulation loop when using *TOPSwitch–GX*. As the data will show, the transient response is very good and there appears to be no difficulty in compensating the voltage mode control loop for optimal performance.

The remote ON/OFF function is implemented by using a very simple circuit around Q3. When the **ON** line (green wire in output cable) is grounded to secondary return, Q3 is turned on and drives the LED of U3 on, which will ground R12 on the primary side and enable the TOP247 via its X pin. If the output comes up into regulation before C19 completely discharges, Q3 is sustained on through R28 and the converter remains running. Upon loss of regulation, Q3 will turn off and the converter will shut off. Toggling the ON/OFF input will allow the converter to retry operation.

When the **ON** line is open, it is internally pulled up to the +5 V standby and the main converter remains in the inhibit state. The +5 V standby is always operating provided there is sufficient AC input to the supply. By connecting the **ON** line to output return, the main supply will turn on, provided there is sufficient input voltage and there is no fault condition. If there is a fault then the supply will latch off. A retry is accomplished by simply toggling the **ON** line.

Note: If the remote **ON** line is connected to output return (main power enabled) while turning on AC into the supply, the main converter will automatically turn on. However, if AC is brought up too slowly (i.e. adjusting a variac), the supply will not turn on and the **ON** line will have to be toggled to turn on the supply. **The output interconnect board provided has the ON line already connected to an ON/OFF switch for manual ON/OFF control via the ON line.**

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5 PCB Layout

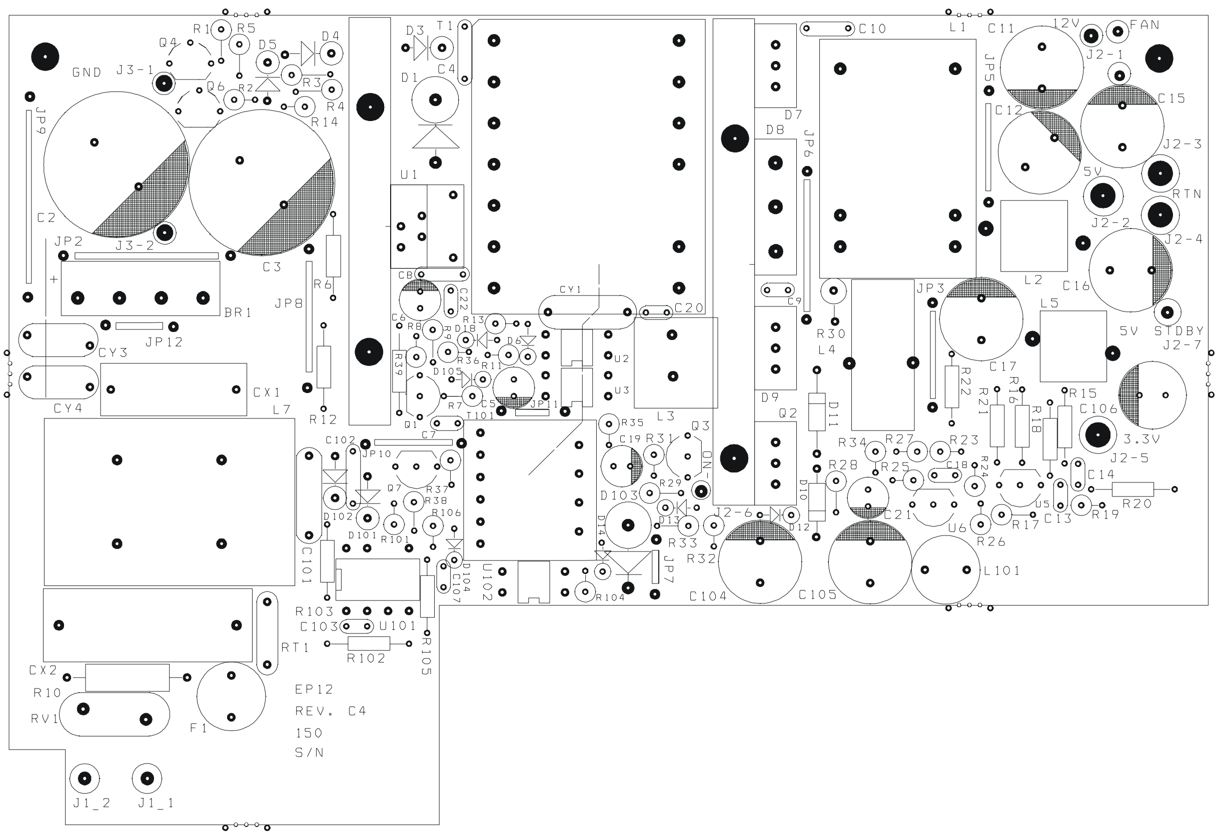

Figure 6 – EP-12 Assembly Diagram.

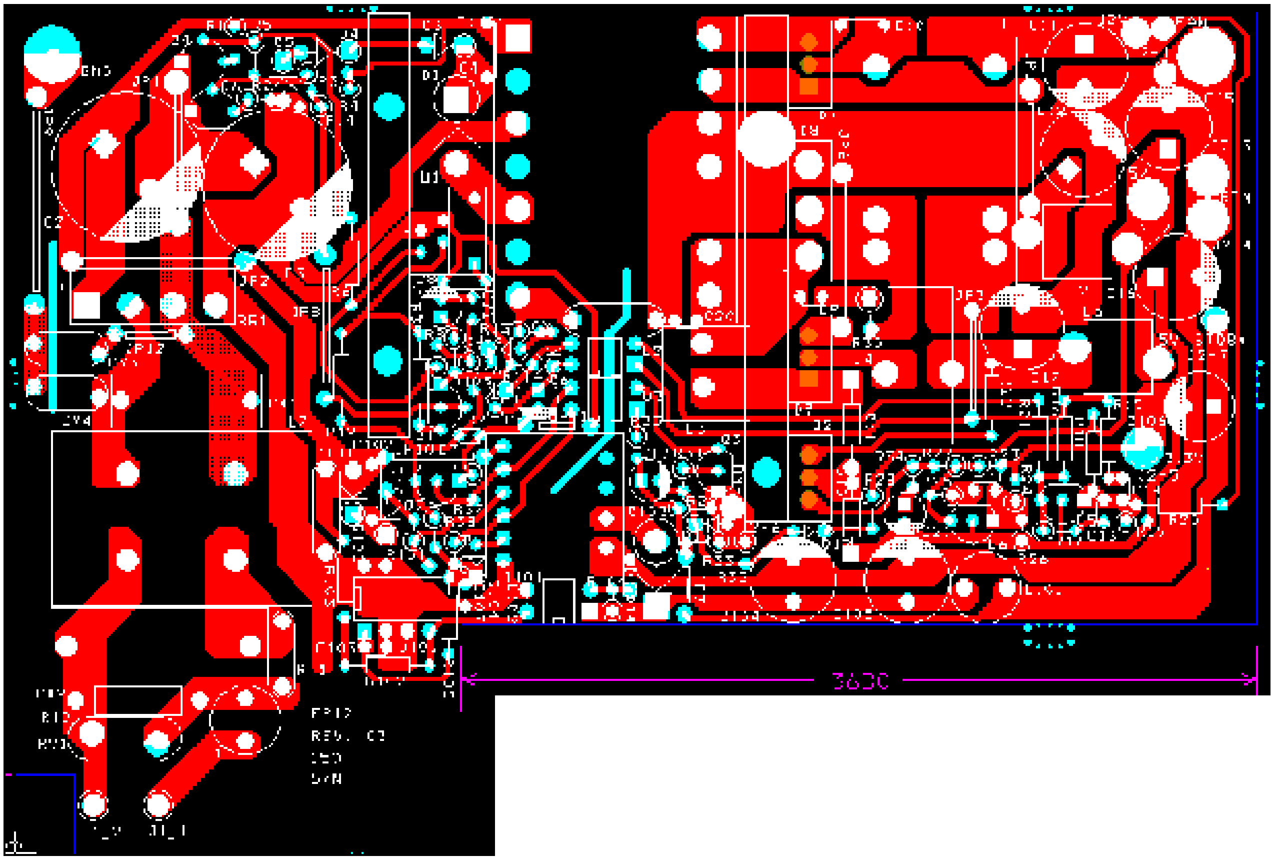

Figure 7 – EP-12 Top View.

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6 Bill Of Materials

6.1 Electrical Bill of Materials

Item	Qty	Reference	Part Number	Manufacturer	Description
1	1	BR1	KBL06	Gen. Semi.	KBL06
2	1	CX1	ECQ-U2A104ML	Panasonic	0.1 μF, 250 VAC
3	1	CX2	ECQ-U2A334MG	Panasonic	0.33 μF, 250 VAC
4	1	CY1	440LQ47	Vishay/Sprague	47 pF, 1 kV (Safety)
5	2	CY4, CY3	ECK-ATS222ME	Vishay/Sprague	2.2 nF(Safety)
6	2	C3, C2	200AXW330MK1835	Rubycon	330 μF, 200 V
7	2	C102, C4	200 pF, 1000 V, Y5P, 10%	Xicon	2.2 nF, 1 kV
8	1	C5	ECA-2AHG010	Panasonic	1 μF, 100 V
9	1	C19	ECA-1CHG220	Panasonic	22 μF, 16 V
10	2	C6	ECA-1CHG470	Panasonic	47 μF, 16 V
11	7	C7, C13, C14, C18, C103, C107	ECU-S1H104MEA	Panasonic	0.1 μF, 50 V
12	2	C8, C23	ECU-S1H333MEA	Panasonic	0.033 μF
13	1	C9	K473K15X7RF5TL2	BC Components	0.047 μF, 50 V
14	1	C10	ECU-S1H102JCB	Panasonic	0.001 μF, 50 V
15	1	C11	EEU-FC1C102	Panasonic	1000 μF, 16 V
16	2	C15, C12	EEU-FC0J222	Panasonic	2200 μF, 6.3 V
17	2	C16, C17	ECA-1AFQ122	Panasonic	1200 μF, 10 V
18	1	C20	ECU-S1H331JCA	Panasonic	330 pF, 50 V
19	1	C21	ECA-2AHG2R2	Panasonic	2.2 μF, 100 V
20	1	C22	ECU-SIH101JCA	Panasonic	100 pF, 50 V
21	1	C101	10,000 pF, 500 V, Y5P, 10%	Xicon	0.01 μF, 500 V
22	2	C104, C105	ECA-1AFQ102L	Panasonic	1000 μF, 10 V
23	1	C106	ECA-1AH6471	Panasonic	470 μF, 10 V
24	1	D1	1N5407	Diodes Inc.	1N5407
25	2	D4, D5	BZY97C-180	Philips	BZY97C-180
26	2	D6, D18	BAV20	Diodes Inc.	BAV20
27	2	D7, D9	MBR2045CT	Int. Rect.	MBR2045
28	1	D8	MBR3045WT	Int. Rect.	MBR3045
29	2	D11, D10	UF4002-1	Fagor	UF4002
30	1	D12	1N5228B-D7	Gen. Semi.	1N5228
31	3	D13, D104, D105	1N4148-T	Diodes Inc.	1N4148
32	2	D14, D19		Philips	BZX79-C B4V3
33	1	D101	1N4006G-T	Diodes Inc.	1N4006
34	2	D3, D102	BZY97-C200	Philips	BZY97-C200
35	1	D103	1N5822	Gen Semi	1N5822
36	1	F1	3721400041	Wickmann	4 A
37	1	JP9 Sleeving	Sleeving (Alpha TFT250 #18)	Alpha	Insulation/Sleeving
38	9	JP2, JP3, JP4, JP5, JP6, JP7 JP8, JP9, JP10, JP11	(cut from wire roll)	Belden 8019 000 #18	JUMPER
39	1	L1 coupled choke	13 μH/15 A	DT Magnetics	13 μH
40	2	L5, L2	SPE-119-0	Prem Mag	0.5 μH
41	1	L3		DT Magnetics	Mag amp
42	1	L4	5702	J.W. Miller	20 μH, 12 A
43	1	L7	ELF-18D650C	Panasonic	8.2 mH
44	1	L101	R622LY-100K	TOKO	10 μH, 2 A
45	1	Q1	TO-92 Transistor/PNP		2N3906

Item	Qty	Reference	Part Number	Manufacturer	Description
46	1	Q2	TO-220 Power Transistor/PNP		TIP32C
47	2	Q3, Q7	TO-92 Transistor/NPN		2N3904
48	1	Q4	TO-92 transistor/PNP 300 V		MPSA42
49	1	Q6	TO-92 transistor/NPN 300 V		MPSA92
50	1	RT1	RL3004-6.56-59-S7	Keystone	10 Ω
51	1	RV1	ERZ-V14D431	Panasonic	275 V, 14 mm
52	2	R1, R2	CFR-25JB-330k	Yageo	330 kΩ
53	1	R3	CFR-25JB-2M2	Yageo	2.2 MΩ
54	1	R4	CFR-25JB-2M2	Yageo	2.2 MΩ
55	1	R6	CFR-25JB-2M2	Yageo	2.2 MΩ
56	1	R7	CFR-25JB-560K	Yageo	560 kΩ
57	1	R8	MFR-25FBF-130K	Yageo	130 kΩ, 1%
58	1	R5	CFR-25JB-180K	Yageo	180 kΩ
59	1	R9	CFR-25JB-47R	Yageo	47 Ω
60	1	R10	CFR-50JB-560K	Yageo	560 kΩ, 1/2 W
61	1	R39	CFR-25JB-3K3	Yageo	3.3 kΩ
62	1	R12	CFR-25JB-7K5	Yageo	7.5 kΩ
63	1	R13	CFR-25JB-10R	Yageo	10 Ω
64	1	R14	CFR-25JB-75K	Yageo	75 kΩ
65	1	R15	CFR-25JB-1K8	Yageo	1.8 kΩ
66	3	R16, R23, R35	CFR-25JB-1K0	Yageo	1 kΩ
67	2	R31, R17	CFR-25JB-15K	Yageo	15 kΩ
68	1	R18	CFR-25JB-4K64	Yageo	4.64 kΩ, 1%
69	1	R19	CFR-25JB-4K12	Yageo	4.12 kΩ, 1%
70	1	R20	CFR-25JB-150K	Yageo	150 kΩ, 1%
71	1	R21	CFR-25JB-270R	Yageo	270 Ω
72	1	R22	CFR-25JB-3R0	Yageo	3 Ω
73	1	R24	CFR-25JB-3K48	Yageo	3.48 kΩ, 1%
74	1	R25	CFR-25JB-2K2	Yageo	2.7 kΩ
75	1	R26	CFR-25JB-10K	Yageo	10 kΩ
76	1	R11, R27	CFR-25JB-390R	Yageo	390 Ω
77	2	R28, R33	CFR-25JB-4K7	Yageo	4.7 kΩ
78	1	R29,	CFR-25JB-100K	Yageo	100 kΩ
79	1	R30	RSF100JB-1R0	Yageo	1 Ω, 1 W
80	1	R32	CFR-25JB-27K	Yageo	27 kΩ
81	1	R34	CFR-25JB-33R	Yageo	33 Ω
82	1	R36	MFR-25FBF-43K2	Yageo	43.2 kΩ, 1%
83	1	R37	CFR-25JB-10K	Yageo	10 kΩ
84	1	R101	CFR-25JB-51R	Yageo	51 Ω
85	2	R103, R102	CFR-25JB-4M0	Yageo	1 MΩ, 1%
86	1	R104	CFR-25JB-430R	Yageo	430 Ω
87	2	R105, R38	CFR-25JB-5k1	Yageo	5.1 kΩ
88	1	R106	CFR-25JB-27K	Yageo	27 kΩ
89	1	T1	EER-28L	DT Magnetics	PC Main Transformer
90	1	T101	EE-16	DT Magnetics	PC Standby Transformer
91	1	U1	TOP247Y1	Power Integrations	TOP247Y1
92	1	U2	SFH615A-2	Sharp	SFH615A-2
93	2	U102, U3	LTV817		LTV817
94	2	U6, U5	TL431		TL431
95	1	U101	TNY266P	Power Integrations	TNY266P

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6.2 Hardware Bill of Materials

Item	Qty	Reference	Description	P/N	Manufacturer
1	1 ea	PCB, Main	PCB, Assembly Main	DAK-12	Power Integrations
2	1 kit	Enclosure/Hardware	Top & Bottom Enclosure, Fan, Fan Screws (2 ea), AC Input Conn, Voltage Selection Switch	N/A	N/A
3	1 ea	Conn, Spade	Conn, Spade 16-22 AWG, #10 PIDG	31887	AMP
4	2 ea	Cap	Cap, 470 pF, 20% 250 V, Ceramic Y2/X1	ECK-ATS471MB	Panasonic
5	2.5”	N/A	Wire, Grn/Yel, 18 AWG UL1015, Pretinned		Any
6	4”	N/A	Wire, Wht, 18 AWG UL1015, Pretinned		Any
7	4”	N/A	Wire, Blk, 18 AWG UL1015, Pretinned	1015-18/1-0	Any
8	12”	N/A	Wire, Wht, 22 AWG UL1015, Pretinned		Any
9	4 ea	N/A	Tie Wrap, 4", Nylon	PLT1M	PANDUIT
10	2 ea	N/A	Screw, M3 X 5 mm		Any
11	7 ea	N/A	Screw, #6 X ¼ Pan Head, Type B, Self Tap, Zinc Pltd	6N25PPBZZ	Any
12	1 ea	N/A	Insulator, Fishpaper Rev D		

6.3 Output Cable Bill of Materials

Item	Qty	Reference	Description	P/N	Manufacturer
1	1 ea	P2	Recp, 2 X 10 4.2 mm Mini-Fit Jr	39-01-2205 (94V-0)	MOLEX
2	17 ea	N/A	Terminal, Crimp, Fem AWG 18-24, Tin	39-00-0039	MOLEX
3	70”	N/A	Wire, Blk, 18 AWG, UL 1015		Any
4	30”	N/A	Wire, Red, 18 AWG, UL 1015		Any
5	30”	N/A	Wire, Org, 18 AWG, UL 1015		Any
6	10”	N/A	Wire, Yel, 18 AWG, UL 1015		Any
7	10”	N/A	Wire, Grn, 22 AWG, UL 1015		Any
8	10”	N/A	Wire, Vio, 22 AWG, UL 1015		Any
9	4 ea	Conn A, B, C, F	Conn, Wire Pin Term 10-12 AWG	19211-0001	MOLEX
10		Tool	Tool, Hand Crimper Mini-Fit Jr. 18-24 AWG	11-01-0197	MOLEX
11		Tool	Tool, Extraction Mini-Fit Jr	11-03-0044	MOLEX
12		Tool	Tool, Hand Crimper Wire Pin Term (Molex 19211-0001)	19285-0063	MOLEX

6.4 Heatsinks Bill of Materials

Item	Qty	Part Reference	Description	P/N	Manufacturer
1	1		Fab, H.S. Primary, EP-12 Rev. D		
2	1		Fab, H.S. Secondary, EP-12 Rev. C		
3	4	U1, D7, D9, Q2	Scr, Phil Pan, M3 X 8, Stl, Znc		Olander Co.
4	1	D8	Scr, Phil Pan, M3 X 10, Stl, Znc		Olander Co.
5	1	U1	Wshr, Split Lock, M3		Olander Co.
6	4	U1, D7, D9, Q2	Wshr, Shldr, #4 [M2, 5]	3049	Keystone
7	4	U1, D7, D9, Q2	Sil-Pad 600, Heatsink, TO-220	BER102	Berquist
8	1	D8	Sil-Pad TO-3P Heatsink, TO-247	BER109	Berquist

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7 Transformer Specification

7.1 145 W Forward Transformer

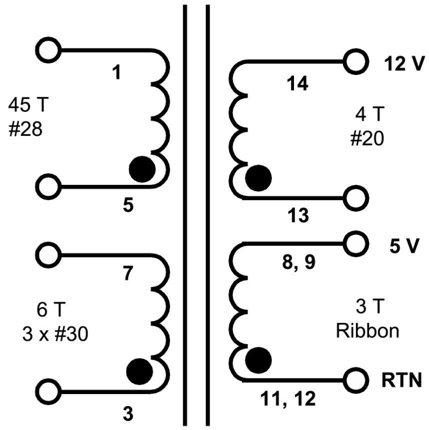

Figure 8 - EP-12 145 W Forward Transformer.

7.1.1 Electrical Specifications

Electrical strength	60 Hz, 1 min, from Pins 1-7 to Pins 10-14	3000 VAC
Primary Inductance	All windings open	4.5 mH or Higher
Resonant Frequency	All windings open	0.2 MHz minimum
Primary leakage inductance	Pins 6-14 shorted	8 µH maximum

7.1.2 Materials

Item	Description
[1]	Core: PC40 EER28L
[2]	Bobbin: BEER28L-1114CPH
[3]	Magnet Wire: #28 AWG Heavy Nyleze
[4]	Magnet Wire: #30 AWG Heavy Nyleze
[5]	Magnet Wire: #20 AWG Heavy Nyleze
[6]	Copper ribbon .670″ x .008″
[7]	Tape: 3M 1298 Polyester Film (white) 21.8 mm wide by 2.2 mils thick
[8]	Tape: 3M 1298 Polyester Film (white) 15.8 mm wide by 2.2 mils thick
[9]	Tape: 3M 44 Margin tape (cream) 3.0 mm wide by 5.5 mils thick

7.1.3 Transformer Build Diagram

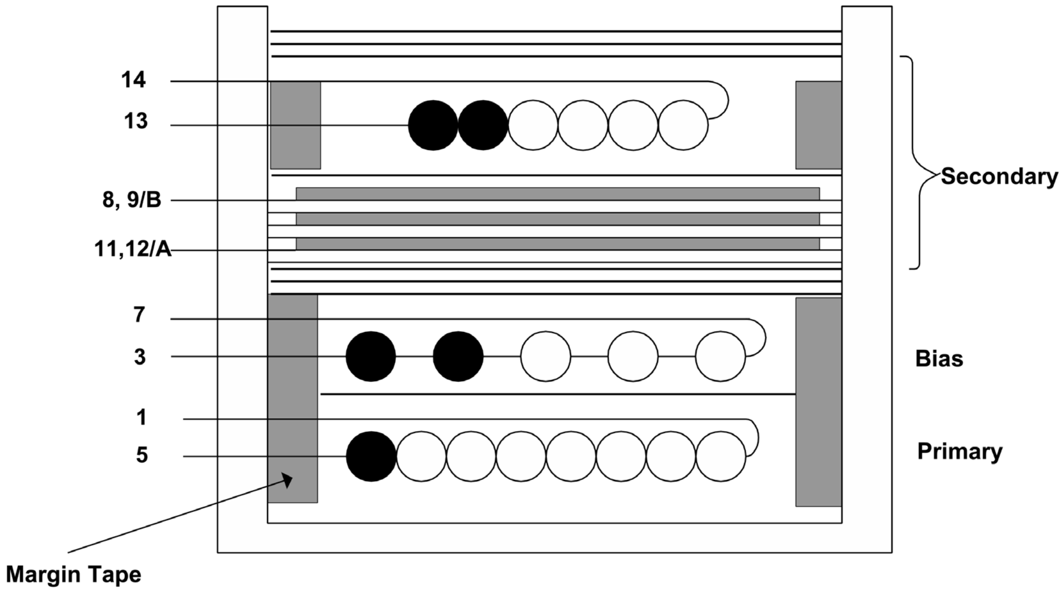

Figure 9 – EP-12 145 W Forward Transformer Build Diagram.

7.1.4 Transformer Construction

Margin Taping	Use item [9] for the right and left margins.
Primary Winding	Start at pin 5. Wind 45 turns of item [3] from left to right. Wind uniformly in a single layer. End at pin 1.
Basic Insulation	1 Layer of tape [8] for basic insulation.
Margin Taping	Use item [9] for the right and left margins.
Bias Winding	Start at pin 3. Wind trifilar 6 turns of item [4] from left to right. Wind uniformly in a single layer, across entire width of bobbin. Finish on pin 7.
Reinforce Insulation	3 Layers of tape [7] for insulation.
Copper Foil Winding (5 V)	Prepare copper ribbon [6] as shown in Figure 10. Match pin A of the foil to pin 11 or 12 of the bobbin. Wind 3 turns of item [6]. Finish by matching pin B of the foil to pins 8 and 9 of the bobbin.
Reinforce Insulation	3 Layers of tape [7] for insulation.
Margin Taping	Use item [9] for the right and left margins.
12 V Winding	Start at pin 13. Wind 4 turns of item [5] from left to right. Wires are populated in middle of bobbin. Finish at pin 14.
Outer Insulation	3 Layers of tape [7] for insulation.

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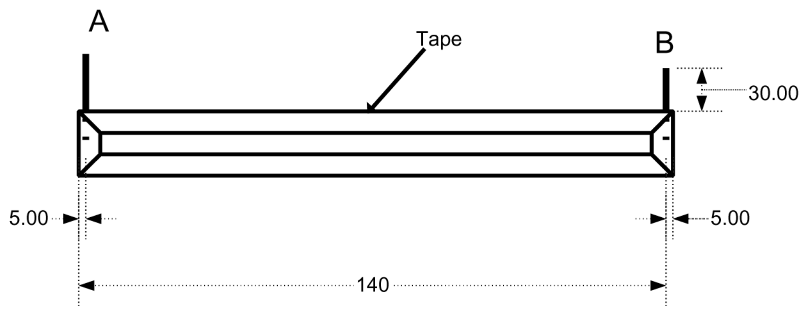

Figure 10 – +5 V Foil (measurements are in mm).

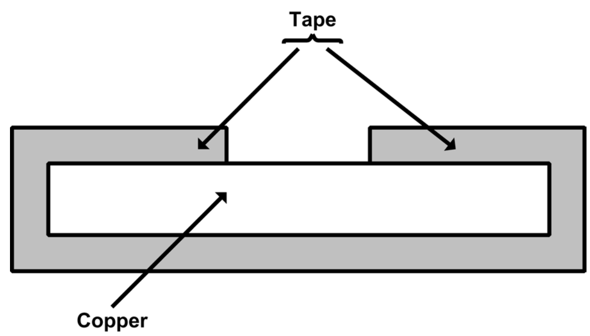

Figure 11 – +5 V Foil and Tape.

7.2 10 W PC Standby Transformer

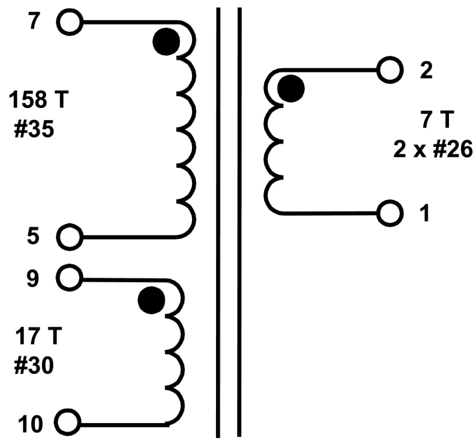

Figure 12 - EP-12 10 W Standby Transformer.

7.2.1 Electrical Specifications

Electrical Strength	1 min, 60 Hz, from pins 1-4 to pins 5-10	3000 VAC
Primary Inductance	All windings open	2.3 mH
Resonant Frequency	All windings open	800 kHz minimum
Primary Leakage Inductance	Pins 6-10 shorted	130 μH maximum

7.2.2 Materials

Item	Description
[1]	Core: EE16
[2]	Bobbin: BE-16
[3]	Magnet Wire: #35 AWG Heavy Nyleze
[4]	Triple Insulated Wire: #26 AWG
[5]	Magnet wire #30 AWG heavy Nyleze
[6]	Tape: 3M 1298 Polyester Film (white) 9.0 mm wide by 2.2 mils thick
[7]	Varnish

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7.2.3 Transformer Build Diagram

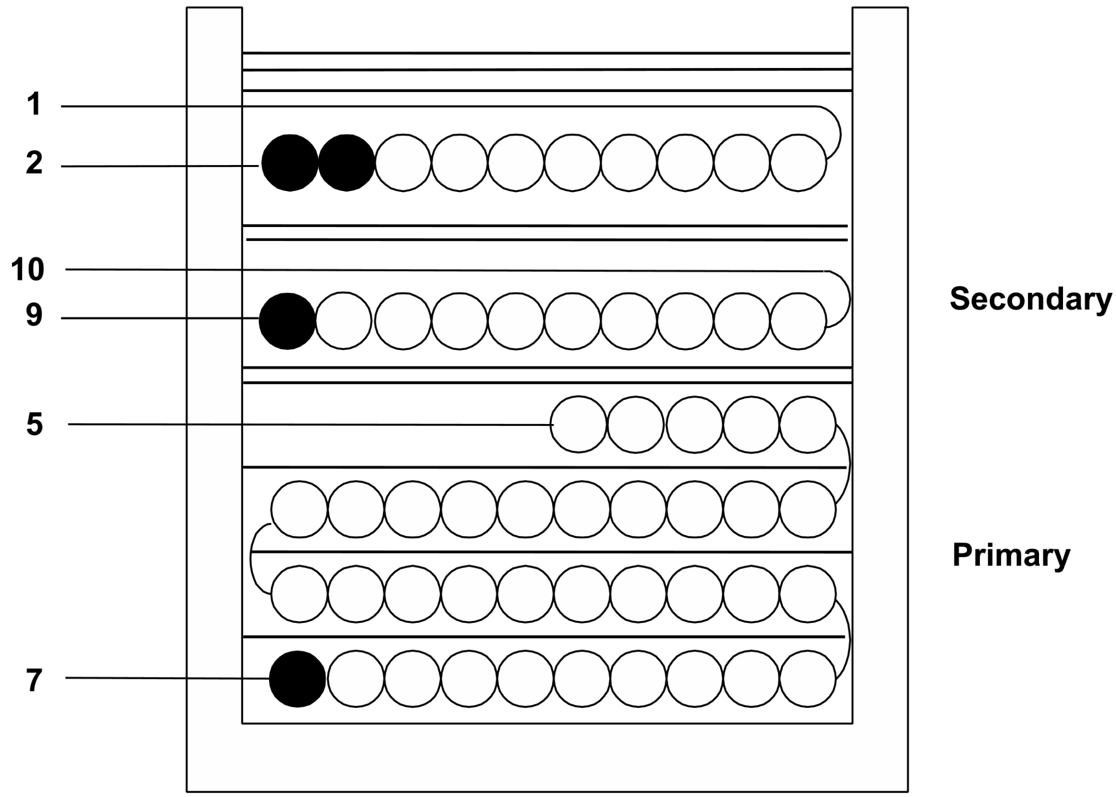

Figure 13 - EP-12 10 W Standby Transformer Build Diagram.

7.2.4 Transformer Construction

Primary Layer	Start at Pin 7. Wind 158 turns of item [3] from left to right, then from right to left until done. It takes about 3 1/4 layers. Apply 1 layer of tape, item [5] between each winding layer for basic insulation. Finish the wiring on Pin 5.
Insulation	1 Layer of tape [6] for insulation.
Bias Winding	Start at pin 9. Wind 17 turns of item [5] from left to right. Finish on pin 10.
Insulation	1 Layer of tape [6] for insulation.
Secondary Winding	Start at Pin 2. Wind 7 bifilar turns of item [4] from left to right. Wind uniformly, in a single layer, across entire width of bobbin. Finish on Pin 1.
Outer Insulation	3 Layer of tape [6] for insulation.
Final Assembly	Assemble and secure core halves. Impregnate uniformly [7].

7.3 Output Coupled Inductor

7.3.1 The Toroid Layout

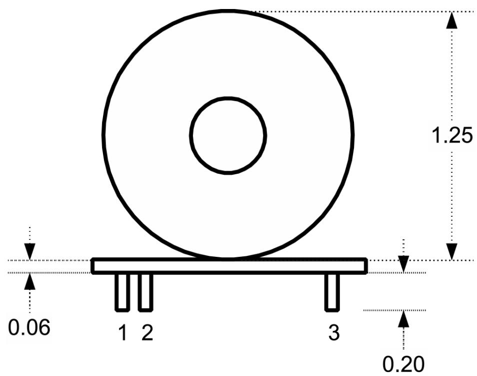

Figure 14 - The Side View.
(Measurements are in inches).

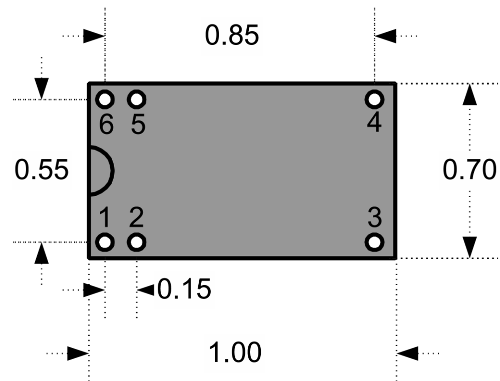

Figure 15 - Bottom Plate Viewed from Top.
(Measurements are in inches).

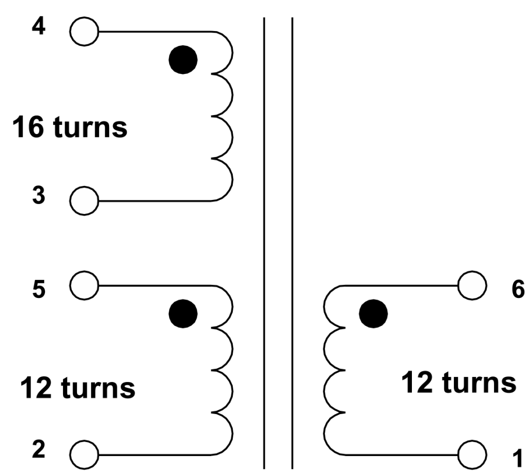

Figure 16 – EP-12 Inductor.

7.3.2 Inductances

Pin #	AWG #	Color	# of Turns	Inductance (μH)
6-1	18	Red	12	13 ±20%
5-2	18	Red	12	13 ±20%
3-4	18	Natural	16	23 ±20%

Note:
1 All dimensions are ±0.02”
2 Core = T 106 – 26

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7.4 The Mag Amp Inductor

7.4.1 Core Specification

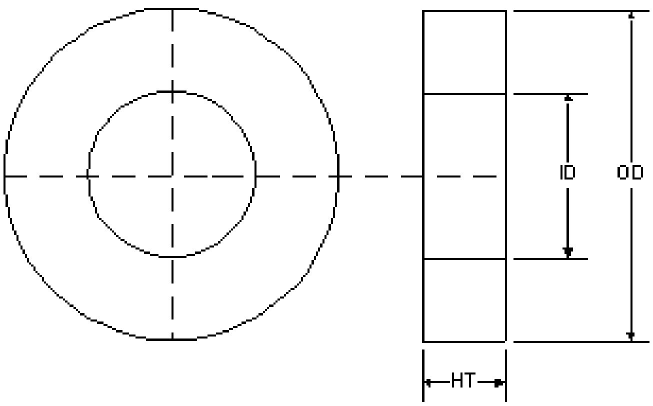

Figure 17 – EP-12 Core Measurements.

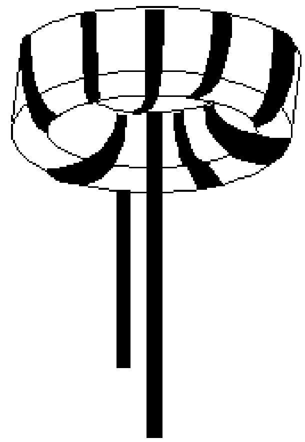

Figure 18 – EP-12 Core.

Core Number	OD	ID	HT
MP1305P-4AS	14.4 mm	7.9 mm	6.6 mm

7.4.2 Winding Instruction

Use number 18 AWG wire (heavy gauge Nyleze wire) to wind **7 turns** around the core as shown in Figure 18. Leave the wire legs about 1″ long.

8 PIXls Design Spreadsheet

ACDC_TOPGXForward_Rev_1.03_061802 Copyright Power Integrations Inc. 2002	**INPUT**	**INFO**	**OUTPUT**	**UNIT**	**ACDC_TOPGXFwd_061802_r103.xls: TOPSwitch-GX Forward Transformer Design Spreadsheet**
OUTPUT VOLTAGE AND CURRENT					**EP12 PC Main power supply**
VMAIN	5			Volts	Main output voltage
IMAIN	12			Amps	Main output current
VMAINMA	3.3			Volts	Magamp output voltage
IMAINMA	12			Amps	Magamp output current
VAUX1	12			Volts	Auxiliary output voltage
IAUX1	4			Amps	Auxiliary output current
VIND1				Volts	Independent output voltage
IND1				Amps	Independent output current
PO			**147.6**	Watts	Total output power
ENTER APPLICATION VARIABLES					
VACMIN	90			AC volts	Minimum AC input voltage. Input voltage doubler circuit is assumed.
VACMAX	132			AC volts	Maximum AC input voltage. Input voltage doubler circuit is assumed.
VMIN			188	Volts	Minimum DC Bus voltage at low line input
VMAX			373	Volts	Maximum DC Bus voltage at high line input
CIN	165			uFarads	Equivalent bulk input capacitance. Input voltage doubler circuit is assumed.
fL	50			Hz	Input AC line frequency
tc	3.0			mSeconds	Estimate input bridge diode conduction time
th	16.0			mSeconds	Minimum required hold-up time from VDROPOUT to VHOLDUP
EFF	0.75				Efficiency estimate to determine minimum DC bus voltage
VHOLDUP			188	Volts	DC Bus voltage at start of hold-up time (default VMIN)
VDROPOUT	132		132	Volts	DC Bus Voltage at end of hold-up time
DMAX GOAL	0.7		0.70		Maximum duty cycle at DC dropout voltage
VDSOP			580	Volts	Maximum operating drain voltage
KDI			0.15		Maximum output current ripple factor at maximum DC Bus voltage
REF AUX1	1		DC Stack		Enter one ("1") for DC stacked, zero ("0") Independent winding
ENTER TOPSWITCH VARIABLES					
TOPSwitch	**top247**			*Universal*	*Doubled 115V/230V*
Chosen Device	*TOP247*		*Power Out*	-	165 W
ILIMIT	*3.348*	*3.852*		Amps	From TOPSwitch-GX datasheet
fS	*124000*	*132000*		Hertz	From TOPSwitch-GX+H76 datasheet
KI	0.81				limit reduction (KI=1.0 for default ILIMIT, KI <1.0 for lower ILIMIT)
RX			7.78	kOhm	Maximum current limit resistance to ensure KI >= 0.81 setting
ILIMITEXT			2.712	Amps	External current limit
VDS			8.1	Volts	TOPSwitch-GX average on-state Drain to Source Voltage

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DIODE Vf SELECTION					
VDMAIN			0.5	Volts	Main output rectifiers forward voltage drop (Schottky)
VDMAINMA			0.5	Volts	Magamp output rectifiers forward voltage drop (Schottky)
VDAUX1			0.7	Volts	Auxiliary output rectifiers forward voltage drop (Ultrafast)
VDIND1			0	Volts	Independent output rectifiers forward voltage drop (Schottky)
VDB			0.7	Volts	Bias output rectifier conduction drop
BRIDGE RECTIFIER DIODE SELECTION					
VPIVAC			467	Volts	Maximum voltage across Bridge rectifier diode
IDAVBR			0.773	Amps	Average Bridge Rectifier Current
TRANSFORMER CORE SELECTION					
Core Type	**eer28l**				
Core		*EER28L*		P/N:	PC40EER28L-Z
Bobbin		*EER28L_BC*		P/N:	BEER-28L-112CPH
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			21.8	mm	Bobbin Physical Winding Width
LG MAX			0.02	mm	Maximum actual gap when zero gap specified
R FACTOR	9%		9%	%	Percentage of total PS losses lost in transformer windings; default 10%
M	3.0			mm	Transformer margin
L	0.80				Transformer primary layers
NMAIN			3		Main rounded turns
TRANSFORMER DESIGN PARAMETERS					
NP	45		45		Primary rounded turns
NB			6		Bias turns to maintain 8V minimum input voltage, light load
NAUX1			4		Auxiliary rounded turns (DC stacked on Main winding)
VAUX1 ACTUAL			11.63	Volts	Approx. Aux output voltage with NASUX1 = 4 Turns and DC stack
NIND1			0		Independent rounded turns (separate winding)
VIND1 ACTUAL			0.00	Volts	Approximate independent output voltage with NIND1 = 0 turns
BM			**1816**	Gauss	Maximum operating flux density at minimum switching frequency
BP			**2884**	Gauss	Maximum peak flux density at minimum switching frequency
LP MIN			3.419	mHenries	Minimum primary magnetizing inductance (assumes LGMAX=20um)
IMAG			**0.189**	Amps	Peak magnetizing current at minimum input voltage
OD_P			0.33	mm	Primary wire outer diameter
AWG_P			**28**	AWG	Primary Wire Gauge (rounded to maximum AWG value)

CURRENT WAVESHAPE PARAMETERS					
IP			**2.451**	Amps	Maximum peak primary current at maximum DC Bus voltage
IPRMS			1.460	Amps	Maximum primary RMS current at minimum DC Bus voltage
INDUCTOR OUTPUT PARAMETERS					
LMAIN			10.0	uHenries	Main / Auxiliary coupled output inductance (referred to Main winding)
WLMAIN			2286	uJoules	Main / Auxiliary coupled output inductor full-load stored energy
KDIMAIN			0.150		Current ripple factor for Magamp output
LMAINMA			12.3	uHenries	Magamp output inductance
WLMAINMA			888	uJoules	Magamp output inductor full-load stored energy
KDIMAINMA			0.150		Current ripple factor for Magamp output
LIND1			0.0	uHenries	Independent output inductance
WLIND1			0.0	uJoules	Independent output inductor full-load stored energy
KDIIND1			0.000		Current ripple factor for independent output
SECONDARY OUTPUT PARAMETERS					
ISMAINRMSLL			15.61	Amps	Maximum transformer secondary RMS current (DC Stack)
ISAUX1RMSLL			2.42	Amps	Maximum transformer secondary RMS current (DC Stack)
ISIND1RMSDLL			0.00	Amps	Maximum transformer secondary RMS current (DC Stack)
IDAVMAIN			12.3	Amps	Maximum average current, Main rectifier (single device rating)
IDAVMAINMA			9.3	Amps	Maximum average current, Magamp rectifier (single device rating)
IDAVAUX1			3.1	Amps	Maximum average current, Auxiliary rectifier (single device rating)
IDAVIND1			0.0	Amps	Maximum average current, Independent rectifier (single device rating)
IRMSMAIN			0.52	Amps	Maximum RMS current, Main output capacitor
IRMSMAINMA			0.52	Amps	Maximum RMS current, Magamp output capacitor
IRMSAUX1			0.17	Amps	Maximum RMS current, Auxiliary output capacitor
IRMSIND1			0.00	Amps	Maximum RMS current, Independent output capacitor
DIODE PIV					*No derating*
VPIVMAIN			29.5	Volts	Main output rectifiers peak-inverse voltage
VPIVMAINMA			29.5	Volts	Magamp output rectifiers peak-inverse voltage
VPIVAUX1			34.9	Volts	Auxiliary output rectifiers peak-inverse voltage
VPIVIND1			0.0	Volts	Independent output rectifiers peak-inverse voltage
VPIVB			102.1	Volts	Bias output rectifier peak-inverse voltage
					Optocoupler
VCEO OPTO			49.8	Volts	Maximum optocoupler collector-emitter

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					voltage
UNDER-VOLTAGE LOCKOUT CIRCUIT PARAMETERS					
VACUVL			68	AC volts	AC undervoltage lockout voltage; On-Off transition
VACUV			78	AC volts	AC undervoltage lockout voltage; Off-On transition
VACUVX			68		
RUVA			2.23	MOhm	Resistor RUVA value
RUVB			523.73	kOhm	Resistor RUVB value
RUVC			75.91	kOhm	Resistor RUVC value
VACUVL ACTUAL			67.50	AC volts	Actual AC undervoltage lockout voltage; On-Off transition
VACUVX ACTUAL			70.36	AC volts	Actual AC undervoltage lockout voltage; Off-On transition
DUTY CYCLE LIMIT CIRCUIT PARAMETERS					
VZ			6.80	Volts	Zener voltage used within DLIM circuit
VOV			**380**	Volts	Approximate frequency reduction voltage (determines CVS value)
RA			2.20	MOhm	Resistor RA value
RB			2.20	MOhm	Resistor RB value
RC			40.26	kOhm	Resistor RC value
RD			126.70	kOhm	Resistor RD value
CVS			92.98	pF	Capacitor CVS value
DUTY CYCLE PARAMETERS (see graph)					*Dropout Duty-Cycle Parameters*
DMAX ACTUAL			0.69		Operating Duty cycle at DC Bus dropout voltage
DMAX RESET			0.79		Transformer Reset Minimum duty cycle at DC Bus dropout voltage
DXDO MIN			0.70		Device Min Duty cycle limit at DC Bus dropout voltage
DXDO MAX		Caution	0.79		!!! >DMASRESET from VMIN to VDROPOUT. NOT hazardous
DLL ACTUAL			0.47		Duty cycle at minimum DC Bus voltage
DXLL MIN			**0.55**		Duty cycle minimum limit at minimum DC Bus voltage
DXLL MAX			0.67		Duty cycle maximum limit at minimum DC Bus voltage
DLL RESET			0.69		Minimum duty cycle to reset transformer at low line
					High Line Duty-Cycle Parameters
DHL ACTUAL			0.23		Duty cycle at minimum DC Bus voltage
DXHL MIN			0.24		Duty cycle minimum limit at maximum DC Bus voltage
DXHL MAX			**0.35**		Duty cycle maximum limit at maximum DC Bus voltage
DHL RESET			0.36		Minimum duty cycle to reset transformer at high line

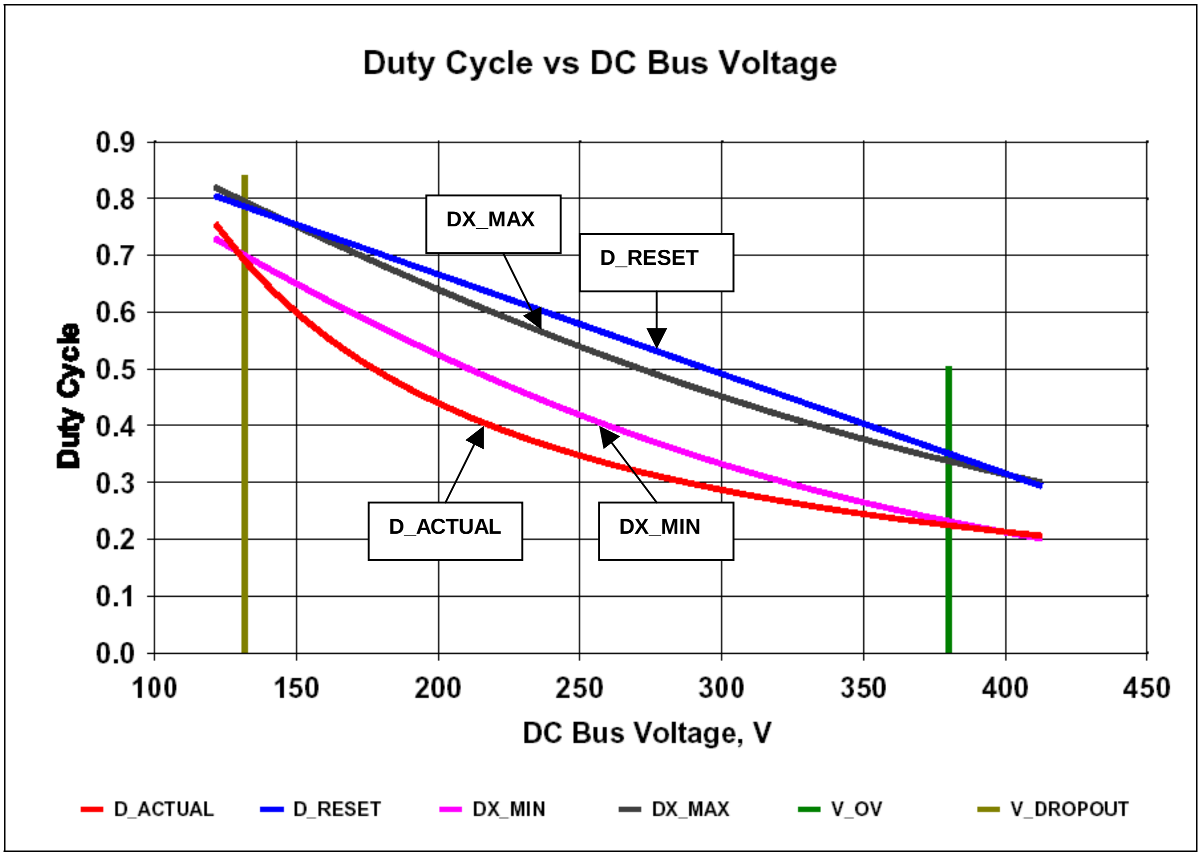

Figure 19 – PIXls Duty Cycle Reduction Parameters Chart.

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9 Test Results

Thermal and Dissipation Data

TOP247 dissipation at 90 VAC and 5 V at 15 A, 3.3 V at 7 A, 12 V at 4 A (approximately 140 W) was measured 5.4 W.

The unit was enclosed in a standard ATX enclosure. The ambient external temperature around the enclosure was 25 °C and the internal ambient in the enclosure in the box near TOP247 heatsink was measured 37 °C.

The TOP247 source tab temperature for above conditions was measured 53 °C.

10 Performance Data

10.1 Efficiency and Regulation

		Output Current				Output Voltage				Pin	Efficiency
Load	Input VAC	+5 V	+12 V	+3.3 V	+5 VSB	+5 V	+12 V	+3.3 V	+5 VSB		
		(A)	(A)	(A)	(A)	(V)	(V)	(V)	(V)	(W)	
1	132	0.4	0.05	0.5	0	5.09	12.02	3.31	5.05	10	43%
2	132	0.4	0.05	12	2	5.07	11.92	3.21	4.89	72	71%
3	132	0.4	3	0.5	2	5.11	11.6	3.29	4.84	62	77%
4	132	0.4	3	12	0	5.1	11.54	3.23	5.1	103	72%
5	90	15	0.05	0.5	2	5	12.41	3.28	4.8	114	76%
6	90	15	0.05	12	0	5	12.45	3.2	5.07	154	74%
7	90	15	3	0.5	0	5.02	11.95	3.28	5.13	146	77%
8	90	15	3	12	2	4.99	11.92	3.2	4.86	223	71%
9	115	15	3	12	2	4.99	11.93	3.21	4.83	217	73%
10	230				0.5				4.87	3.9	64%
11	115	0.4	0.0168	0.5	2	5.1	12.1	3.33	4.87	20	67%
12	115	15	1.9690	12	2	4.99	12.03	3.2	4.87	198	74%

Note: 12 V load table does not include the 100 mA internal load, which is equivalent to fan loading.

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10.2 Power Limit vs. Input Line

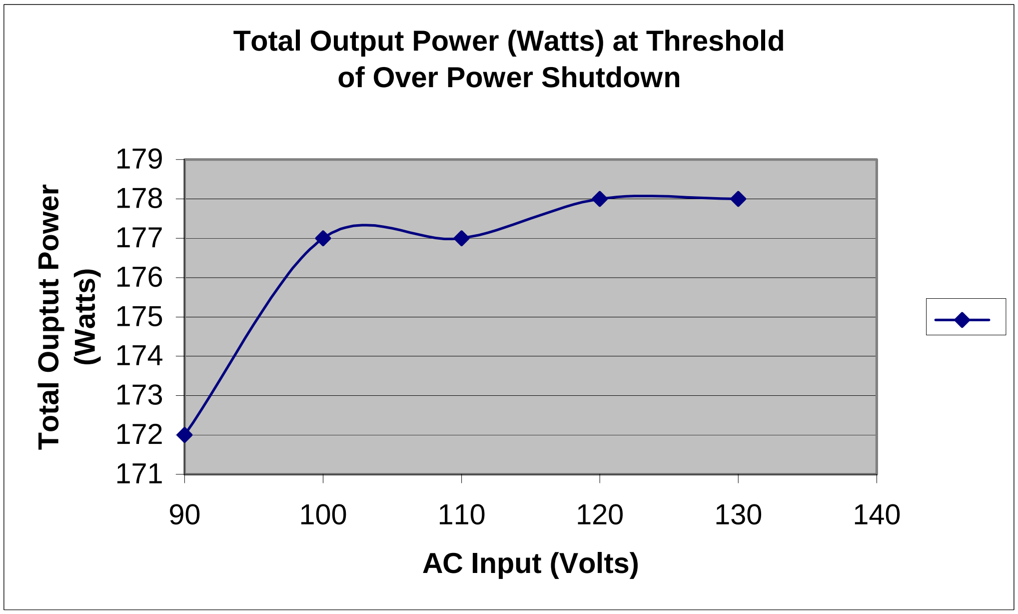

Figure 20 – Power Limit vs. Input Line.

Standby Input Power
The input power with standby loaded to 0.5 W and main supply off at 115 VAC input is 0.91 W.
Note: when measuring for less than 1 W input power spec and output interconnect board is used, the yellow **standby on** LED on the board dissipates 0.07 W. This should be considered part of the output loading.

Blue Angel
240 VAC input, main converter inhibited, +5 V standby loaded to 2.5 A.
Input power is 4.2 W.

11 Waveforms

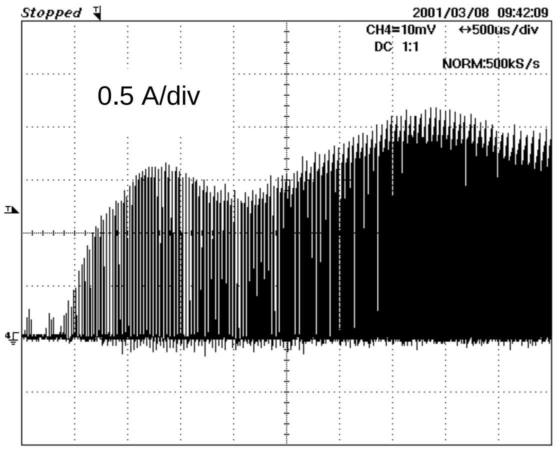

Figure 21 – Primary Drain Current at Start-up, Activated from Remote ON/OFF with 120 VAC Input.

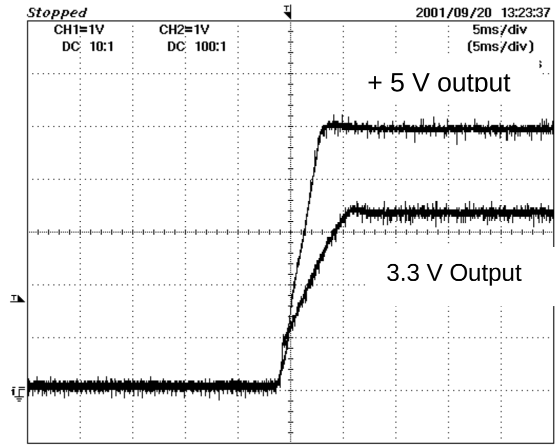

Figure 22 – +5 V and 3.3 V Rise at Turn-on from Remote ON/OFF , 120 VAC Input, 5 V out at 12 A, 3.3 V at 12 A, 0 A on +12 V.

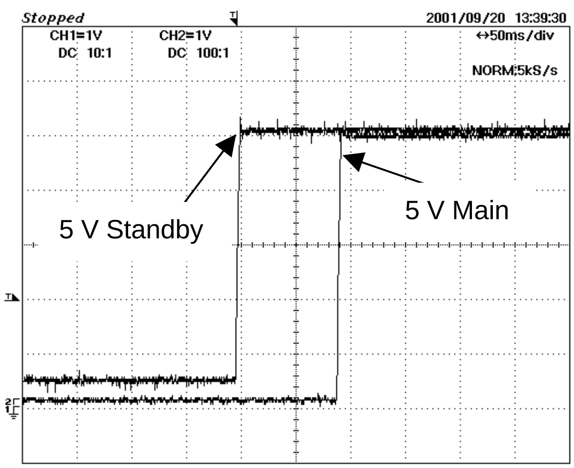

Figure 23 – 5 V Main and 5 V Standby Start-up (120 VAC). Max Load on all Outputs.

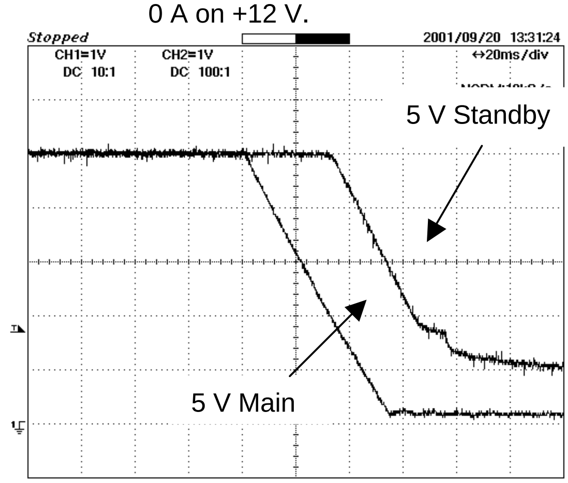

Figure 24 – 5 V and 5 V Standby Drop out After AC off Max Load on 5 V Standby, Min Load on all Other Outputs.

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11.1 Drain Switching Waveforms

5 V @ 12 A, 3.3 V @ 12 A, 12 V @ 3 A

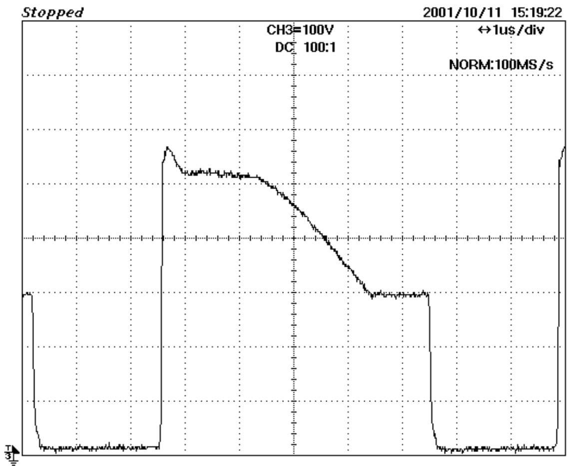

Figure 25 – Drain to Source Voltage of TOP247 at 220 VAC.

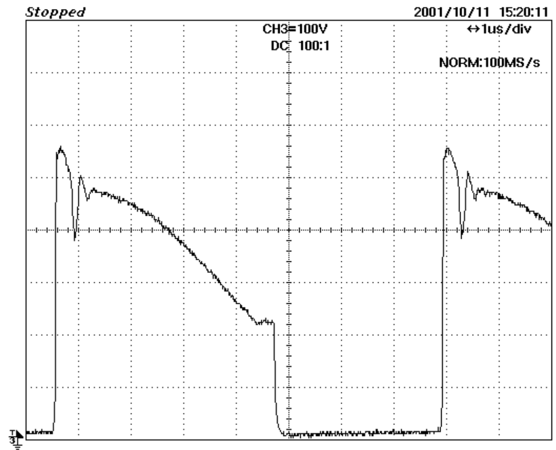

Figure 26 – Drain to Source Voltage of TOP247 at 165 VAC.

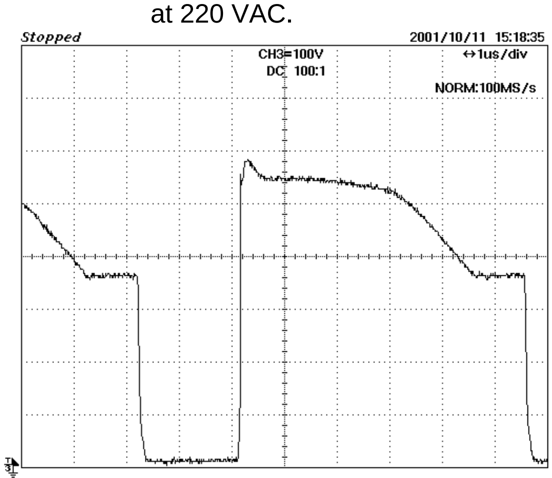

Figure 27 – Drain to Source Voltage of TOP247 at 270 VAC.

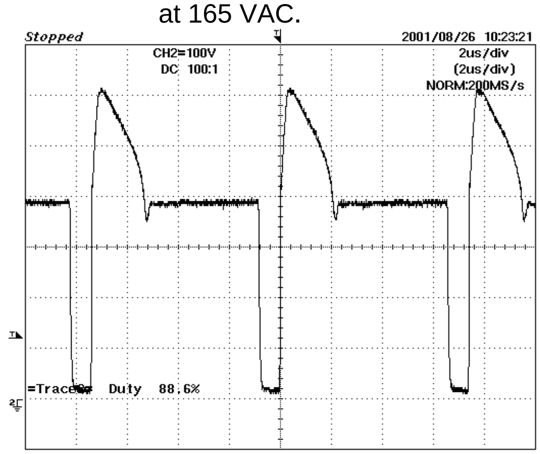

Figure 28 – Drain to Source Voltage of TOP247 at 270 VAC Input 3.3 V Output Shorted at PC Board.

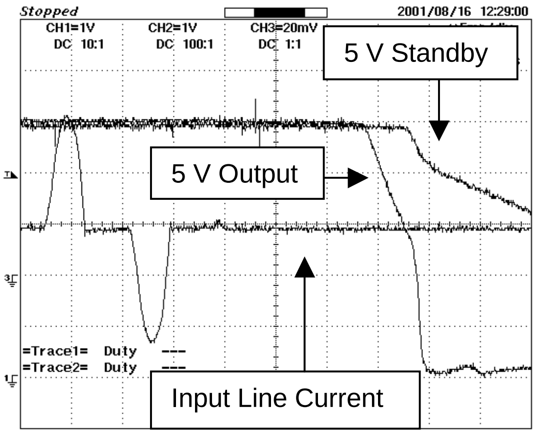

Figure 29 – 110 VAC Applied Line Terminated with Following Loads: 5 V at 13 A, 3.3 V at 12 A, 12 V at 3.5 A.

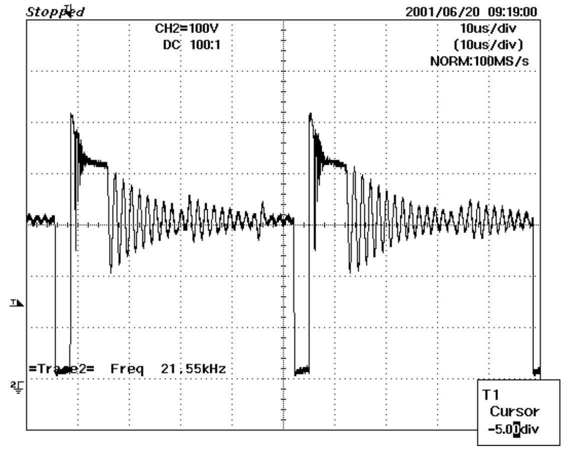

Figure 30 – Drain Switching Voltage of TNY266 (PC Standby) 230 VAC Input 5 V Loaded to 1.5 A.

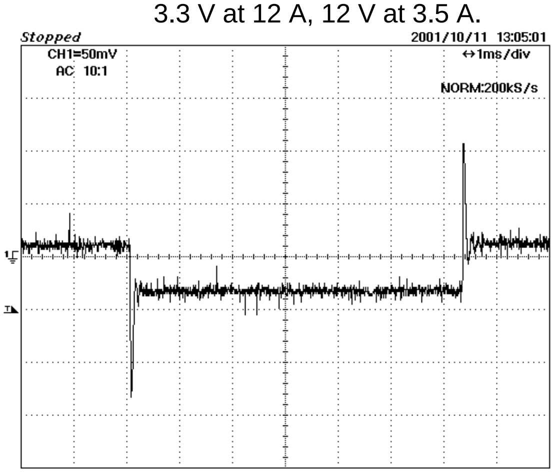

Figure 31 – 5 V Step Load (8 A/15 A) Maximum Continuous Load on Other Outputs.

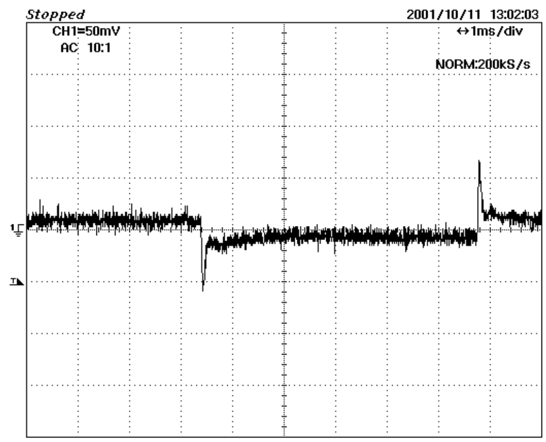

Figure 32 – 3.3 V Step Load 6 A/12 A.

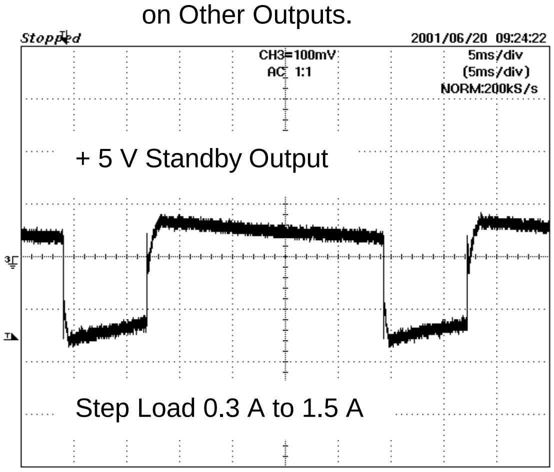

Figure 33 – +5 V Standby Step Load Response.

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11.2 Output Ripple Measurements

Output ripple measured with following load:
12 V @ 3 A, 5 V @ 12 A, 3.3 V @ 12 A, 5 V standby @ 2 A.

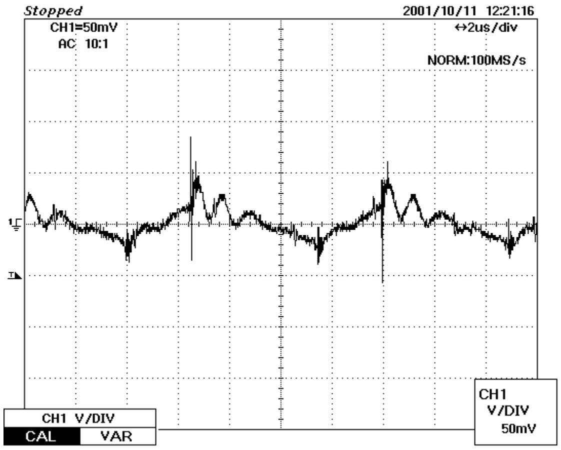


Figure 34 – +12 V Output Ripple.

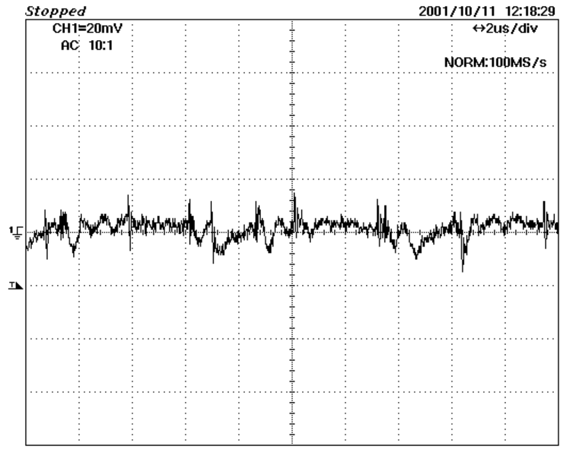


Figure 35 – +5 V Output Ripple.

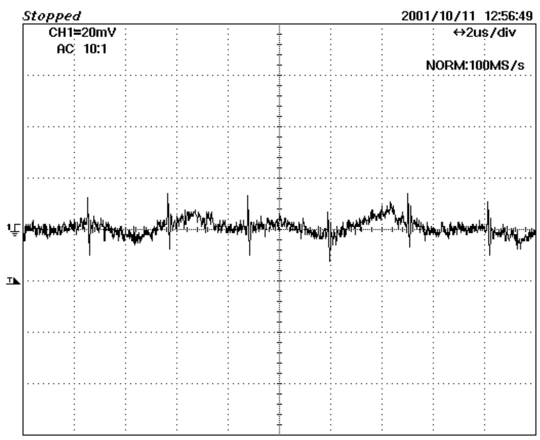


Figure 36 – +3.3 V Output Ripple.

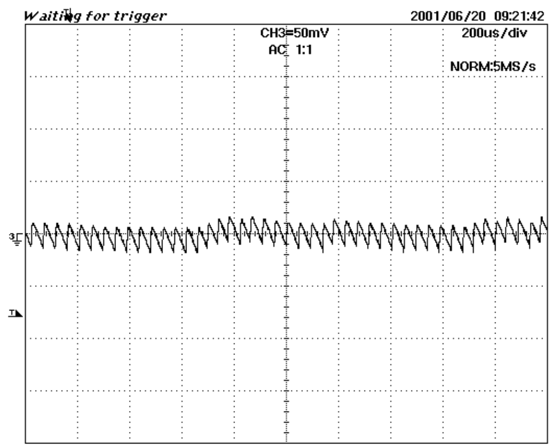
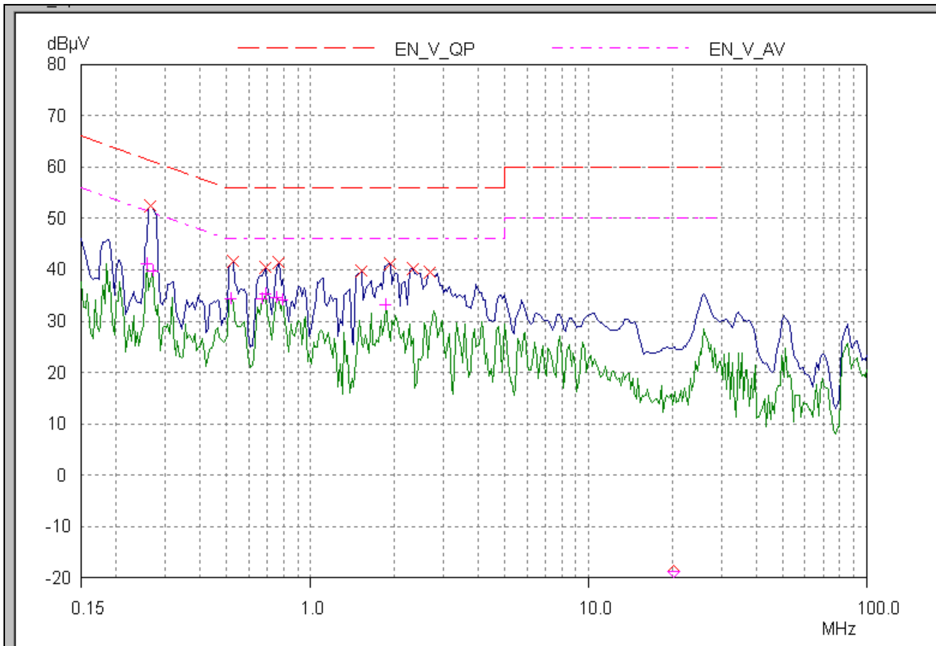


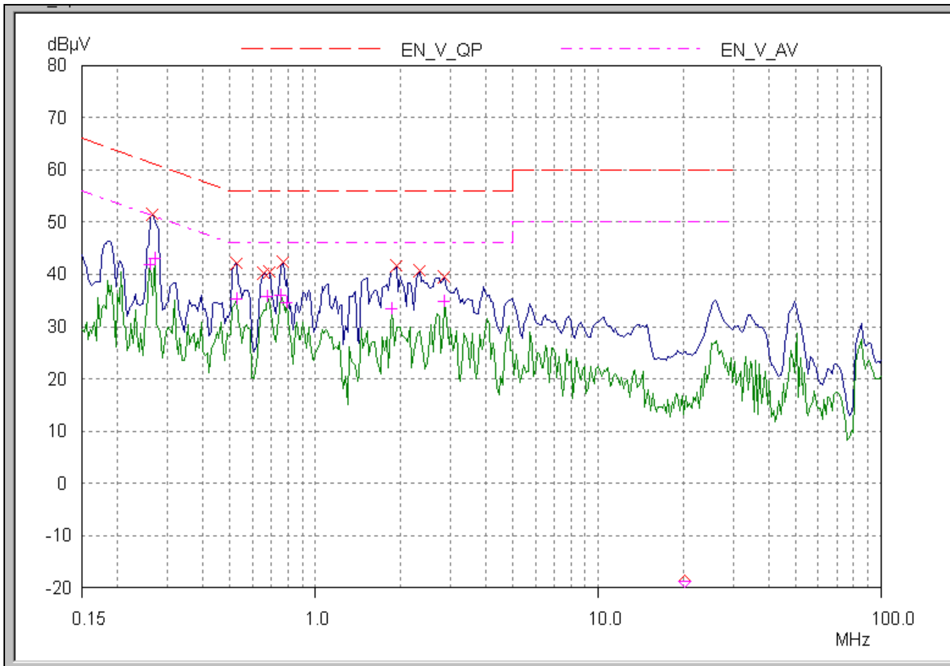
Figure 37 – +5 V Standby Output Ripple.

12 Conducted EMI



Frequency MHz	Quasi Pk dBµV	Average dBµV
0.25732		41.13
0.26562	52.48	
0.26987		39.74
0.51736		34.28
0.52564	41.60	
0.66696		34.28
0.68847	40.36	35.41
0.75726		34.59
0.76938	41.50	
0.7942		34.03
1.52255	39.82	
1.8715		33.07
1.93187	41.26	
2.33723	40.28	
2.69616	39.44	

Figure 38 – 230 VAC, Neutral Input, Maximum Load on all Outputs.



Frequency MHz	Quasi Pk dBµV	Average dBµV
0.26143		41.83
0.26562	51.50	
0.26987		42.99
0.52564	42.08	35.22
0.65645	40.12	
0.67763		35.86
0.68847	40.56	
0.75726		35.99
0.76938	42.32	
0.7942		34.49
1.8715		33.31
1.93187	41.54	
2.33723	40.60	
2.8729	39.58	34.82

Figure 39 – 230 VAC Line Input, Maximum Load on all Outputs.

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13 Revision History

Date	Author	Revision	Description & Changes
09-Jul-02	AO	1.0	First release
30-Aug-02	AO	1.1	Corrected schematic on page 8 and caption on Figure 22
21-Oct-02	AO	1.2	Corrected Figure 11
01-Feb-05	AO	1.3	Corrected 7.2.1 Primary Inductance on page 21 and added missing Part Numbers on page 15

Notes

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