DESIGN EXAMPLE REPORT

Title	***133 W Supply Using TOP261EN for Main Supply and TNY279PN for Standby Supply***
Specification	108 – 132 VAC (60 Hz) Input; 24 V / 4.1 A; 12 V / 2 A; 5 V_{SB} / 2 A (4.65 A_{PK}) Outputs
Application	LCD TV – SUPERLIPS Auxiliary and Standby Supply
Author	Applications Engineering Department
Document Number	DER-204
Date	April 20, 2009
Revision	1.4

Summary and Features

- Low component count, high efficiency
- Tight output cross regulation performance without linear regulators
- EcoSmart® – meets requirements for low no-load and standby power consumption
  - No-load power consumption <150 mW at 132 VAC during Remote Off
  - No-load power consumption <500 mW at 132 VAC during Remote On
  - Pin <600 mW at 132 V with 300 mW Standby load on 5 V SB output
- >84% full load efficiency at 108 V input
- Integrated safety/reliability features
  - Accurate, auto-recovering, hysteretic thermal shutdown function maintains safe PCB temperatures under all conditions
  - Auto-restart protects against output short circuits and open feedback loops
  - Output OVP protection configurable for latching or self recovering
  - Input UV prevents power up / power down output glitches
- Meets EN55022 and CISPR-22 Class B conducted EMI limits

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.

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 133 W power supply utilizing a TOP261EN for the main power and TNY279PN for the standby power. This power supply is intended as a general purpose evaluation platform for an LCD TV application.

SUPERLIPS TV architectures provide power to the CCFL backlight via an AC connected inverter. Auxiliary and standby power supplies are also required to provide power to the control circuitry, audio output, and to supply power to the TV while it is in sleep mode. This report describes a design for the standby and auxiliary power supplies.

The power supply is designed to work from 108 to 132 VAC (North America). It is fitted with a voltage-doubler on the input to increase the voltage (a high-line design could eliminate the voltage-doubler and operate from 176 to 264 V_{RMS}). As the input voltage to the standby supply comes after the voltage-doubler circuit, it operates over an input range of 305 to 375 VDC (2x peak-rectified AC input).

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

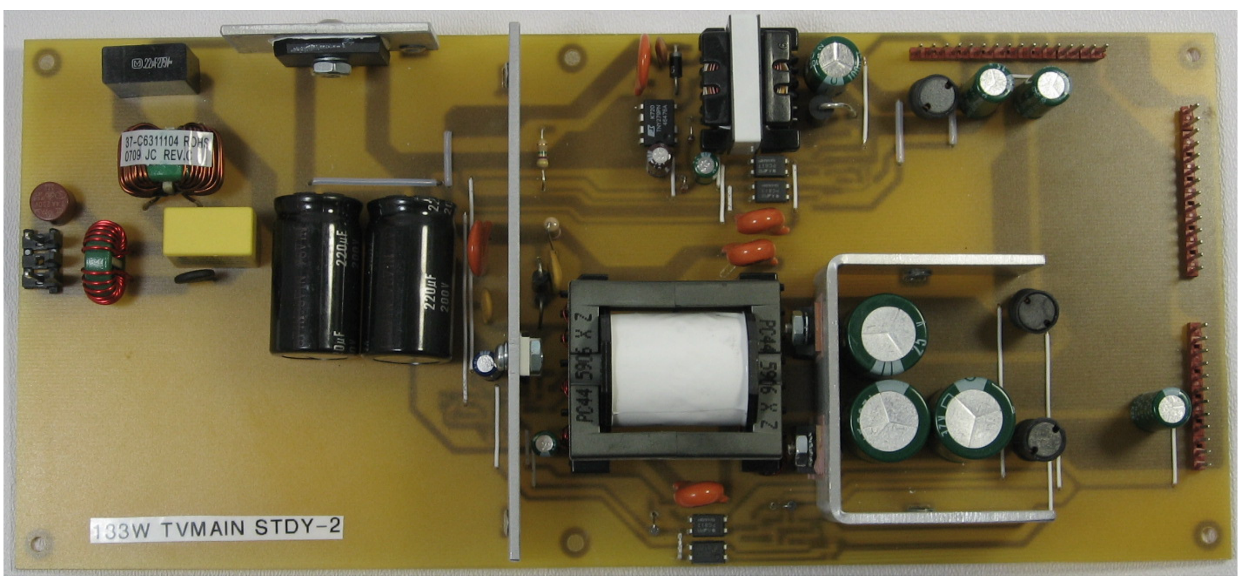


Figure 1 – Populated Circuit Board Photograph.

2 Power Supply Specification

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	108		132	VAC	2 Wire – no P.E.
Frequency	f_{LINE}	56	60	64	Hz	
Stand-by Input Power (132VAC)				0.6	W	0.3W at 5VSB output
Output						
Output Voltage 1	V_{OUT1}		24		V	± 5%
Output Ripple Voltage 1	$V_{RIPPLE1}$			720	mV	20 MHz bandwidth
Output Current 1	I_{OUT1}			4.1	A	
Output Voltage 2	V_{OUT2}		12		V	± 5%
Output Ripple Voltage 2	$V_{RIPPLE2}$			360	mV	20 MHz bandwidth
Output Current 2	I_{OUT2}			2	A	
Output Voltage 3	V_{OUT3}		5		V	± 5%
Output Ripple Voltage 3	$V_{RIPPLE3}$			150	mV	20 MHz bandwidth
Output Current 3	I_{OUT3}			2.0 4.65	A A_{PK}	
Total Output Power						
Continuous Output Power	P_{OUT}			133	W	
Peak Output Power	P_{OUT_PEAK}			133	W	
Efficiency						
Full Load	η	84			%	Measured at P_{OUT} 25 °C
Environmental						
Conducted EMI		Meets CISPR22B / EN55022B				
Safety		Designed to meet IEC950 / UL1950 Class II				
Line Surge Differential Mode (L1-L2) Common mode (L1/L2-PE)				 2 	 kV kV	1.2/50 µs surge, IEC 1000-4-5, Series Impedance: Differential Mode: 2 Ω Common Mode: 12 Ω
Ring Wave (100 kHz) Differential Mode (L1-L2) Common mode (L1/L2-PE)				 2 	 kV kV	500 A short circuit Series Impedance: Differential Mode: 2 Ω Common Mode: 12 Ω
ESD (contact discharge) (Air discharge				4 8	KV	
Ambient Temperature	T_{AMB}	0		50	°C	Free convection, sea level

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

3 Schematic

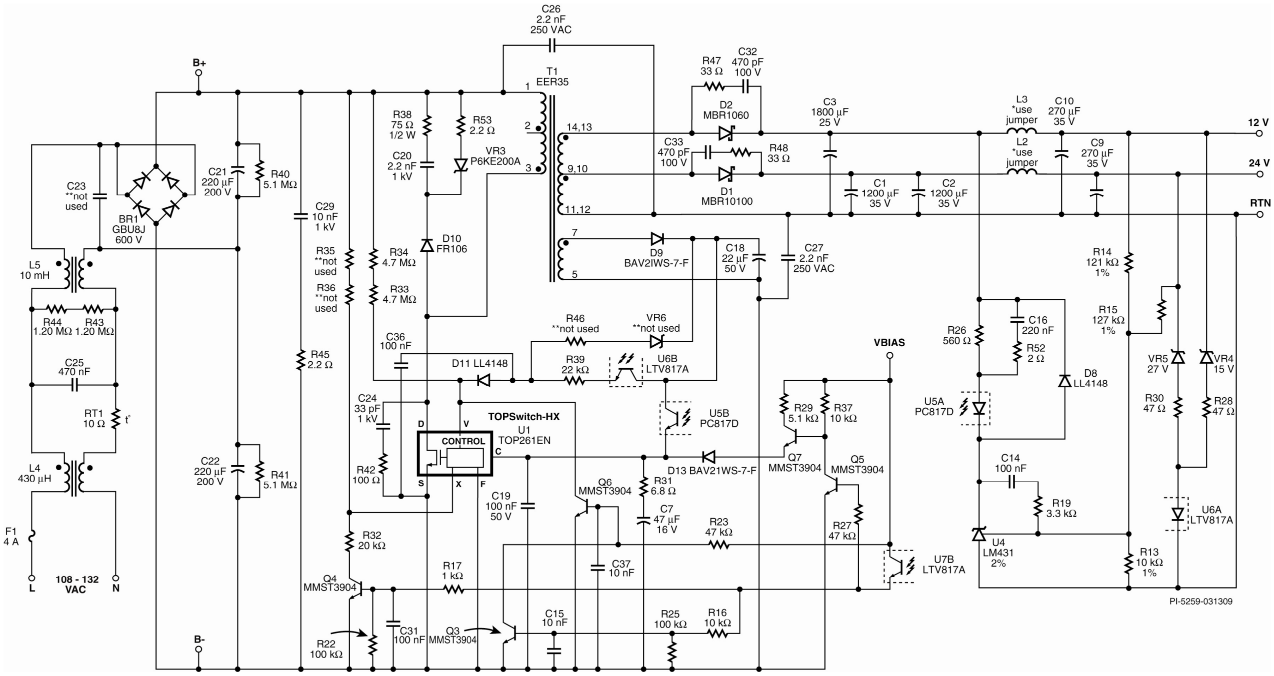


Figure 2 – Schematic of the Main Power Supply.

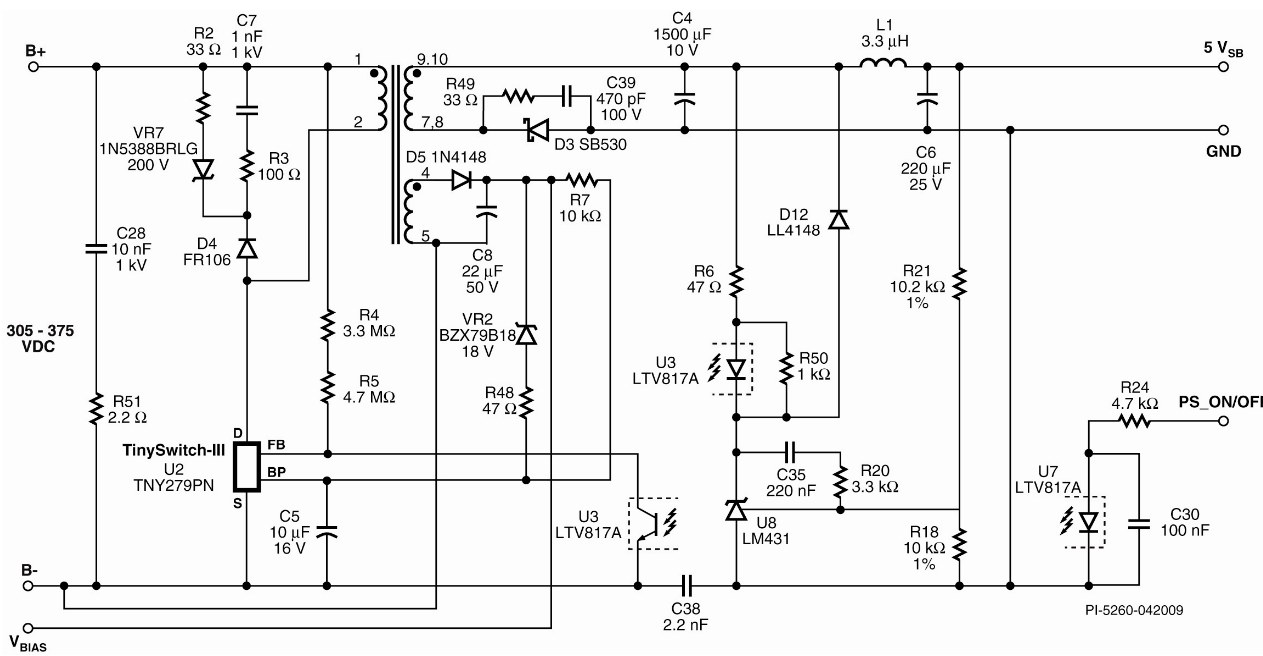


Figure 3 – Schematic of the Stand-by Supply.

4 Circuit Description

This is a 133 W LCD TV supply using two flyback topology converters with voltage doubler input and an operating range of 108 – 132 VAC. The main converter rated at 133 W has two outputs, 24 V output that can supply 4.1 A and 12 V that can supply 2 A. The second converter is a 22 W standby supply with a 5 V output that can supply 2 A continuously and 4.65 A peak.

4.1 Input EMI Filter

Fuse F1 provides protection against circuit faults and effectively isolates the circuit from the AC supply source. Thermistor RT1 limits the inrush current drawn by the circuit when AC is applied. Capacitors C26, C27 and C38 are Y1 capacitors connected the across the transformer's primary and secondary windings to reduce common mode EMI.

Capacitor C25 is the X capacitor and helps to reduce the differential mode EMI. Inductor L4 and L5 are a common-mode chokes that help in filtering common-mode and differential EMI from coupling back to the AC source.

Diode BR1 is the bridge rectifier. The bridge connection from the input AC supply allows the rectified voltage be doubled, which then filtered by capacitors C21 and C22. The value of capacitors C21 and C22 provide hold-up time of >15 ms.

4.2 TOPSwitch-HX (TOP261EN) Main Supply

Resistors R33 & R34 provide line voltage sensing and provide a current into V pin of U1, this current is proportional to the DC voltage across input capacitors C21 and C22. At approximately 235 V DC, the current through these resistors exceeds the line under-voltage threshold of 25 µA, which results in enabling of U1.

The TOPSwitch-HX regulates the output using PWM-based voltage mode control. At high loads the controller operates at full switching frequency (132 kHz for this design). The duty cycle is controlled based on the control pin current to regulate the output voltage.

The internal current limit provides cycle-by-cycle peak current limit protection. The TOPSwitch-HX controller has a second current limit comparator allowing monitoring the actual peak drain current (I_P) relative to the programmed current limit $I_{LIMITEXT}$. As soon as the ratio $I_P/I_{LIMITEXT}$ falls below 55%, the peak drain current is held constant. The output is then regulated by modulating the switching frequency (variable frequency PWM control). As the load decreases further, the switching frequency decreases linearly from full frequency down to 30 kHz.

Once the switching frequency has reached 30 kHz the controller keeps this switching frequency constant and the peak current is reduced to regulate the output (fixed frequency, direct duty cycle PWM control).

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

As the load is further reduced and the ratio $I_P/I_{LIMITEXT}$ falls below 25%, the controller will enter a multi-cycle-modulation mode for excellent efficiency at light load or standby operation and low no-load input power consumption.

Diode D10, together with C20, R38, R53 and VR3 form a clamp network that limits the drain voltage of U1 at the instant of turn-off. Resistor R53 is used for additional damping due to the choice of a fast recovery diode for D10. A fast versus ultra fast recovery diode allows some recovery of the clamp energy but requires R53 to limit reverse diode current and dampen high frequency ringing.

The output of the bias voltage is rectified through diode D9 which then filtered by capacitor C18. The filtered output provides current to the control pin through the opto-coupler U5B for regulation.

4.2.1 Over-voltage/ Open-loop Latch Protection

Should the feedback circuit fails (open loop condition), the output of the power supply will exceed the regulation limits. Once the voltage at output exceeds the avalanche voltage of Zener VR4 or VR5, current will flow into the “V” pin of IC U1 via R39 and optocoupler U6, thus initiating a latch OVP shutdown. Resistor R39 limits the current into the V pin; if hysteretic OVP is desired, the value of R39 can be increased to a value such that the current does not exceed 300 μA.

To reset the latch condition of U1, recycle the PS “on/off” function from on to off to on position. A low signal input at the PS “on/off” terminal will turn on transistor Q6 which pulls down the V-pin to less than 1 V, a condition that resets the internal latch circuit of U1.

The output voltage of the power supply is maintained in regulation by the feedback circuit on the secondary side of the circuit. The feedback circuit controls the output voltage by changing the optocoupler current. Change in the optocoupler diode current results in a change of current into the control pin of U1. Variation of this current results in variation of duty cycle and hence the output voltage of the power supply.

4.2.2 Over-current / Short Circuit Protection

The internal current limit provides cycle-by-cycle peak current limit protection. Resistor R32 connected to the X-pin sets the current limit of U1. In the event of over current or short circuit on any of the main outputs, U1 will enter into auto-restart mode which turns the power supply on and off at typically 2% duty cycle which minimizes U1 power dissipation under fault condition. Once the short circuit or over current condition stops the power supply resumes normal operation.

4.2.3 PS On/Off (Remote On/Off)

The power supply employs remote off/on through the X-pin for Standby mode operation. A high signal input at the PS On/Off enables optocoupler U7 to drive current into the base of transistor Q4 which grounds resistor R32 then enables U1 to start switching. R17 limits the current into the base of Q4, R22 pulls down the base when U7 is off while C31 bypasses noise.

Optocoupler U7 is also used to reset U1 from latch condition.

4.2.4 Output Rectification

Output rectification for the 24 V and 12 V outputs are provided by diodes D1 and D2 respectively. Low ESR capacitors C1, C2, C9, C3 and C10 provide filtering and smoothing of the output ripple.

Snubber networks comprising R47, C32 and R48, and C33 damp high frequency ringing across diodes D1 and D2, which results from leakage inductance of the transformer windings and the secondary trace inductances.

4.2.5 Output Feedback

Output voltage is controlled using the shunt regulator LM431 (U4). Resistor R14, R15 and R13 form a voltage divider network that senses the output voltage from both outputs to keep the outputs in regulation, this provides tight cross regulation between the 24 V and 12 V outputs.

Resistors R26, R19 and capacitor C14 set the frequency response of the feedback circuit.

Resistor R26 sets the overall AC loop gain and limits the current through U2A during transient conditions. R52 and C16 is a phase boost network to keep the output stable at light load.

4.2.6 IC bias current supply

To achieve low Standby mode consumption and low no load input power consumption current is fed from low voltage source V_{BIAS} through Q7 to the C-pin of U1 to disable the internal high voltage regulator of U1 during standby mode. Diode D13 prevents back biasing of Q7 emitter when Q5 is on during PS on.

4.3 TNY279PN Standby Supply

The supply provides 10 W continuous power and 22 W peak power at the 5 V SB output. It employed EE25 core and TNY279PN set to operate at increased current limit with 10 µF capacitor (C5) at the BYPASS pin to deliver the peak power.

Zener VR2 and R48 provides over voltage protection. Once the bias voltage exceeds the avalanche voltage of Zener VR2, current will flow into the “BP/M” pin of IC U2 via R48, thus initiating a latch OVP shutdown.

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

5 PCB Layout

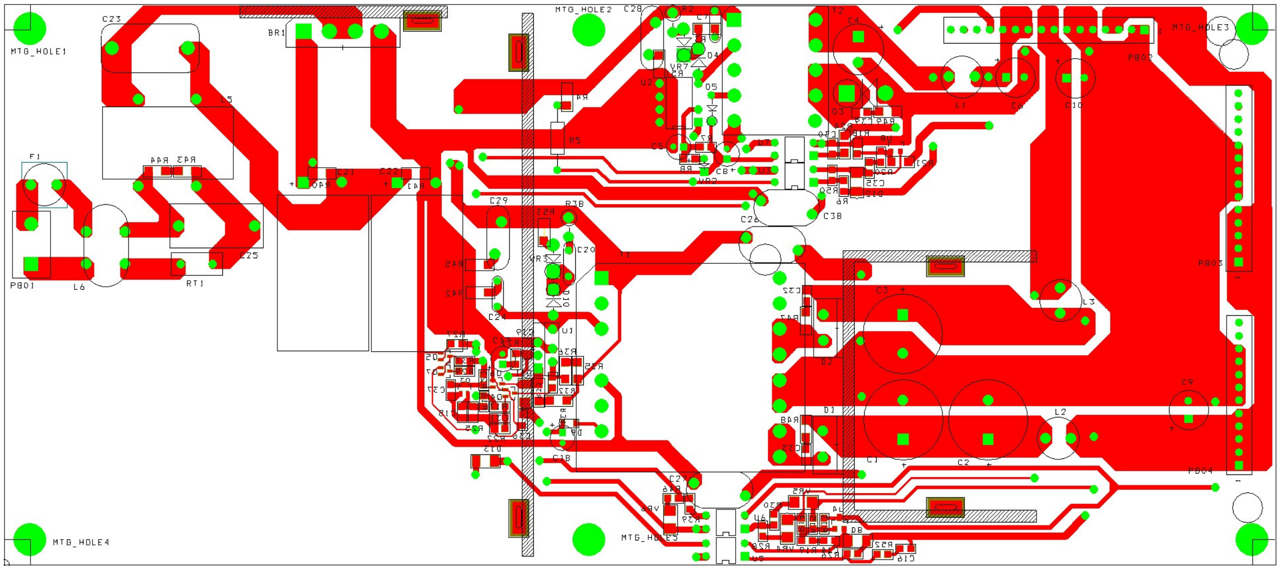


Figure 4 – Printed Circuit Layout Dimension: L-250 mm x W-110 mm.

6 Bill of Materials

Item	Qty	Ref Des	Description	Mfg Part Number	Mfg
1	1	BR1	600 V, 8 A, Bridge Rectifier, GBU Case	GBU8J	Vishay
2	2	C1 C2	1200 μF, 35 V, Electrolytic, Very Low ESR, 18 mΩ, (16 x 20)	EKZE350ELL122ML20S	Nippon Chemi-Con
3	1	C3	1800 μF, 25 V, Electrolytic, Very Low ESR, 18 mΩ, (16 x 20)	EKZE250ELL182ML20S	Nippon Chemi-Con
4	1	C4	1500 μF, 10 V, Electrolytic, Very Low ESR, 22 mΩ, (10 x 25)	EKZE100ELL152MJ25S	Nippon Chemi-Con
5	1	C5	10 μF, 16 V, Electrolytic, Gen. Purpose, (5 x 11)	KME16VB10RM5X11LL	Nippon Chemi-Con
6	1	C6	220 μF, 25 V, Electrolytic, Very Low ESR, 72 mΩ, (8 x 11.5)	EKZE250ELL221MHB5D	Nippon Chemi-Con
7	1	C7	1 nF, 1 kV, Disc Ceramic	ECK-D3A102KBP	Panasonic - ECG
8	2	C8 C18	22 μF, 50 V, Electrolytic, Very Low ESR, 340 mΩ, (5 x 11)	EKZE500ELL220ME11D	Nippon Chemi-Con
9	2	C9 C10	270 μF, 35 V, Electrolytic, Very Low ESR, 41 mΩ, (8 x 20)	EKZE350ELL271MH20D	Nippon Chemi-Con
10	5	C14 C19 C30 C31 C36	100 nF, 50 V, Ceramic, X7R, 0805	ECJ-2YB1H104K	Panasonic
11	2	C15 C37	10 nF, 50 V, Ceramic, X7R, 0805	ECJ-2VB1H103K	Panasonic
12	1	C17	47 μF, 16 V, Electrolytic, Low ESR, 500 mΩ, (5 x 11.5)	ELXZ160ELL470MEB5D	Nippon Chemi-Con
13	1	C20	2.2 nF, 1 kV, Disc Ceramic	NCD222K1KVY5FF	NIC Components Corp
14	2	C21 C22	220 μF, 200 V, Electrolytic, High Ripple, (18 x 31.5)	EEUEB2D221	Panasonic
15	2	C23 C25	470 nF, 275 VAC, Film, X2	PX474K31D5	Carli
16	1	C24	33 pF, 1 kV, Disc Ceramic	ECC-D3A330JGE	Panasonic
17	3	C26 C27 C38	2.2 nF, Ceramic, Y1	440LD22-R	Vishay
18	2	C28 C29	10 nF, 1 kV, Disc Ceramic	562R5HKMS10	Vishay/Sprague
19	3	C32 C33 C39	470 pF, 100 V, Ceramic, X7R, 0805	ECJ-2VB2A471K	Panasonic
20	2	C35 C16	220 nF, 25 V, Ceramic, X7R, 0805	ECJ-2YB1E224K	Panasonic
21	1	D1	100 V, 10 A, Schottky, TO-220AC	MBR10100	Vishay
22	1	D2	60 V, 10 A, Schottky, TO-220AC	MBR1060	Vishay
23	1	D3	30 V, 5 A, Schottky, DO-201AD	SB530	Vishay
24	2	D4 D10	800 V, 1 A, Fast Recovery Diode, 500 ns, DO-41	FR106	Diodes Inc.
25	1	D5	75 V, 300 mA, Fast Switching, DO-35	1N4148	Vishay
26	4	D8 D11 D12 D13	75 V, 0.15 A, Fast Switching, 4 ns, MELF	LL4148-13	Diode Inc.
27	1	D9	200 V, 0.2 A, Fast Switching, 50 ns, SOD-323	BAV21WS-7-F	Diode Inc.
28	1	F1	4 A, 250V, Slow, TR5	3721400041	Wickman
29	1	L3	3.3 uH, 5.5 A, 8.5 x 11 mm	R622LY-3R3M	Toko
	2	L1 L2	22 AWG wire		
30	1	L5	10 mH, Common mode choke	Custom	PI
31	1	L6	430 μH, Common Mode Choke	Custom	PI
33	1	P801	2 Position (1 x 2) header, 0.312 pitch, Vertical	26-50-3039	Molex
34	1	P802	16 Position (1 x 16) header, 0.1 pitch, Vertical	22-28-4160	Molex
35	1	P803	14 Position (1 x 14) header, 0.1 pitch, Vertical	22-28-4140	Molex
36	1	P804	12 Position (1 x 12) header, 0.1 pitch, Vertical	22-28-4120	Molex
37	5	Q3 Q4	NPN, Small Signal BJT, 40 V, 0.2 A, SOT-323	MMST3904-7-F	Diodes Inc

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

		Q5 Q6 Q7			
38	1	R2	33, 5%, 1/2 W, Carbon Film	CFR-50JB-330	Yageo
39	2	R3 R42	100 Ω, 5%, 1/4 W, Metal Film, 1206	ERJ-8GEYJ101V	Panasonic
40	1	R4	3.3 MΩ, 5%, 1/4 W, Metal Film, 1206	ERJ-8GEYJ335V	Panasonic
41	1	R5	4.7 MΩ, 5%, 1/4 W, Carbon Film	CFR-25JB-4M7	Yageo
42	4	R6 R8 R28 R30	47 Ω, 5%, 1/8 W, Metal Film, 0805	ERJ-6GEYJ470V	Panasonic
43	3	R7 R16 R37	10 kΩ, 5%, 1/8 W, Metal Film, 0805	ERJ-6GEYJ103V	Panasonic
44	2	R13 R18	10 kΩ, 1%, 1/8 W, Metal Film, 0805	ERJ-6ENF1002V	Panasonic
45	1	R14	121 kΩ, 1%, 1/8 W, Metal Film, 0805	ERJ-6ENF1213V	Panasonic
46	1	R15	127 kΩ, 1%, 1/8 W, Metal Film, 0805	ERJ-6ENF1273V	Panasonic
47	2	R17 R50	1 kΩ, 5%, 1/8 W, Metal Film, 0805	ERJ-6GEYJ102V	Panasonic
48	2	R19 R20	3.3 kΩ, 5%, 1/8 W, Metal Film, 0805	ERJ-6GEYJ332V	Panasonic
49	1	R21	10.2 kΩ, 1%, 1/4 W, Metal Film, 1206	ERJ-8ENF1022V	Panasonic
50	2	R22 R25	100 kΩ, 5%, 1/8 W, Metal Film, 0805	ERJ-6GEYJ104V	Panasonic
51	2	R23 R27	47 kΩ, 5%, 1/8 W, Metal Film, 0805	ERJ-6GEYJ473V	Panasonic
52	1	R24	4.7 kΩ, 5%, 1/4 W, Metal Film, 1206	ERJ-8GEYJ472V	Panasonic
53	1	R26	560 Ω, 5%, 1/8 W, Metal Film, 0805	ERJ-6GEYJ561V	Panasonic
54	1	R29	5.1 kΩ, 5%, 1/8 W, Metal Film, 0805	ERJ-6GEYJ512V	Panasonic
55	1	R31	6.8 Ω, 5%, 1/8 W, Metal Film, 0805	ERJ-6GEYJ6R8V	Panasonic
56	1	R32	20 kΩ, 5%, 1/8 W, Metal Film, 0805	ERJ-6GEYJ203V	Panasonic
57	3	R33 R34 R35	4.7 MΩ, 5%, 1/4 W, Metal Film, 1206	ERJ-8GEYJ475V	Panasonic
58	3	R36 R40 R41	5.1 MΩ, 5%, 1/4 W, Metal Film, 1206	ERJ-8GEYJ515V	Panasonic
59	1	R38	75 Ω, 5%, 1/2 W, Carbon Film	CFR-50JB-75R	Yageo
60	1	R39	22 kΩ, 5%, 1/8 W, Metal Film, 0805	ERJ-6GEYJ223V	Panasonic
61	2	R43 R44	1.20 MΩ, 1%, 1/4 W, Metal Film, 1206	ERJ-8ENF1204V	Panasonic
62	3	R45 R51 R53	2.2 Ω, 5%, 1/4 W, Metal Film, 1206	ERJ-8GEYJ2R2V	Panasonic
63	1	R46	10 Ω, 5%, 1/8 W, Metal Film, 0805	ERJ-6GEYJ100V	Panasonic
64	3	R47 R48 R49	33 Ω, 5%, 1/4 W, Metal Film, 1206	ERJ-8GEYJ330V	Panasonic
65	1	R52	2 Ω, 5%, 1/8 W, Metal Film, 0805	ERJ-6GEYJ2R0V	Panasonic
66	1	RT1	NTC Thermistor, 10 Ohms, 3.2 A	CL-110	Thermometrics
67	1	T1	Main transformer; Bobbin, EER35, Horizontal, 16 pins	PI custom	PI
68	1	T2	Standby transformer; Bobbin, EE25, Vertical, 10 pins	PI cusotm	PI
70	1	U1	TOPSwitch-HX, TNY261EN, eSIP-7C	TOP261EN	Power Integrations
71	1	U2	TinySwitch-III, TNY279PN, DIP-8C	TNY279PN	Power Integrations
72	3	U3 U6 U7	Optocoupler, 35 V, CTR 80-160%, 4-DIP	LTV-817A	Liteon
73	2	U4 U8	2.495 V Shunt Regulator IC, 2%, -40 to 85C, SOT23	LM431AIM	National Semiconductor
74	1	U5	Optocoupler, 35 V, CTR 300-600%, 4-DIP	PC817X4	Sharp
75	1	VR2	18 V, 500 mW, 2%, DO-35	BZX79-B18	Vishay
76	1	VR3	200 V, 5 W, 5%, TVS, DO204AC (DO-15)	P6KE200ARLG	OnSemi
77	1	VR4	15 V, 5%, 500 mW, DO-213AA (MELF)	ZMM5245B-7	Diodes Inc
78	2	VR5 VR6	27 V, 5%, 500 mW, DO-213AA (MELF)	ZMM5254B-7	Diodes Inc
79	1	VR7	200 V, 5%, 5 W, DO-41	1N5388BRLG	ON Semiconductor

7 Transformer Specification

7.1 24 V / 12 V Main Power Transformer

7.1.1 Electrical Diagram

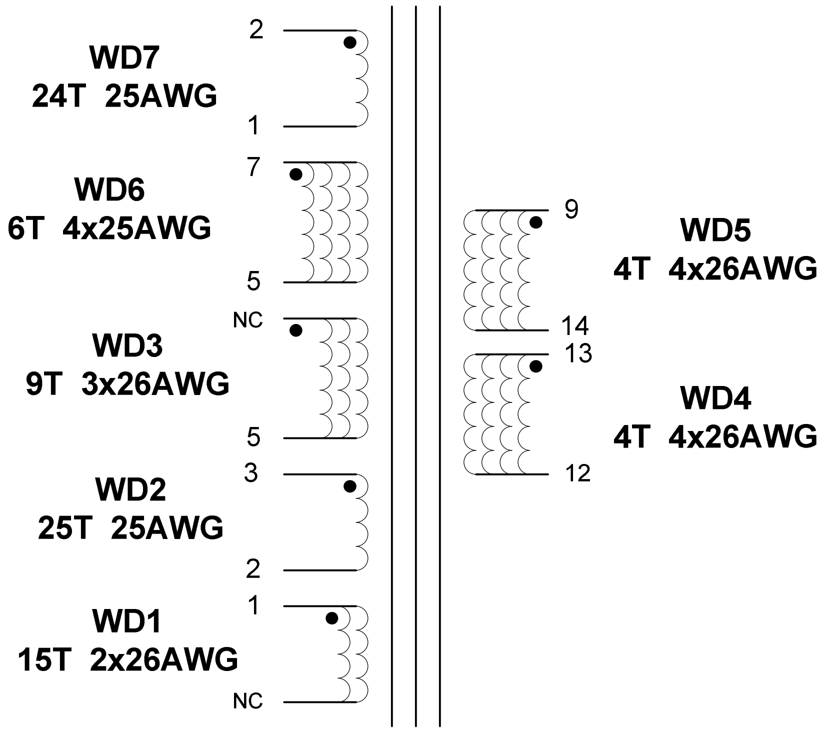


Figure 5 – Transformer Electrical Diagram.

7.1.2 Electrical Specifications

Electrical Strength	1 second, 60 Hz, from Pins 1-8 to Pins 9-16	3000 VAC
Primary Inductance	Pins 1-3, all other windings open, measured at 100 kHz, 0.4 VRMS	620 μH, ±10%
Resonant Frequency	Pins 1-3, all other windings open	500 kHz (Min.)
Primary Leakage Inductance	Pins 1-3, with Pins 9-16 shorted, measured at 100 kHz, 0.4 VRMS	12 μH (Max.)

7.1.3 Materials

Item	Description
[1]	Core: PC40EER35-Z; 258 nH/T^2 Gapped Core Effective Inductance
[2]	Bobbin: BEER-35-1116CPH
[3]	Magnet Wire: 25 AWG
[4]	Magnet Wire: 26 AWG
[5]	Tape: 14 mm
[6]	Tape, 26 mm
[7]	Margin Tape, 6 mm
[8]	Varnish

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

7.1.4 Transformer Build Diagram

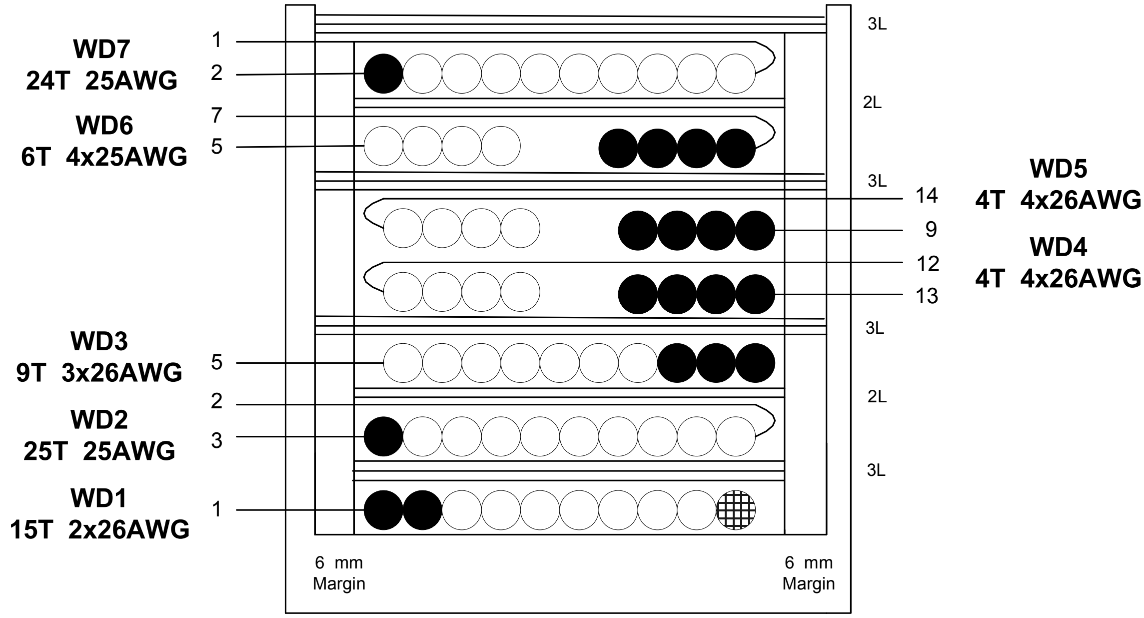


Figure 6 – Transformer Build Diagram.

7.1.5 Transformer Construction

Primary Margin	Apply 6 mm wide margin to both sides of bobbin. Match height of windings WD1, WD2 & WD3.
WD1	Start at Pin 1. Wind 15 bifilar turns of 26 AWG wire. Cut end and leave floating.
Basic Insulation	Use three layers of 14 mm tape for basic insulation.
WD2	½ Primary**:** Start at Pin 3. Wind 25 turns of 25 AWG wire. Finish at Pin 2.
Basic Insulation	Use two layers of 14 mm tape for basic insulation.
WD3	Start at Pin 9 temporarily, wind 9 trifilar turns of 26 AWG wire. Finish at Pin 6. Cut start leads and leave floating from pin 9.
Reinforced Insulation	Use three layers of 26 mm tape for reinforced insulation.
WD4	Start at Pin 13. Wind 4 quadrifilar turns of 26 AWG wires. Spread turns evenly across bobbin. Finish at Pin 12.
WD5	Start at Pin 9. Wind 4 quadrifilar turns of 26 AWG wires. Spread turns evenly across bobbin. Finish at Pin 14.
Reinforced Insulation	Use three layers of 32 mm tape for reinforced insulation.
Primary Margin	Apply 6 mm wide margin to both sides of bobbin. Match height of windings WD6 & WD7.
WD6	Start at Pin 9 temporarily. Wind 6 quadrifilar turns of 25 AWG wires. Finish at Pin 5. Bring back wires from Pin 9 then terminate at Pin 7.
Basic Insulation	Use two layers of 14 mm tape for basic insulation.
WD7	½ Primary**:** Start at Pin 2. Wind 24 turns of 25 AWG wire. Finish at Pin 1.
Outer Wrap	Wrap windings with 3 layers of 26 mm tape.
Final Assembly	Assemble and secure core halves. Dip varnish.

7.2 5 V Standby Transformer

7.2.1 Electrical Diagram

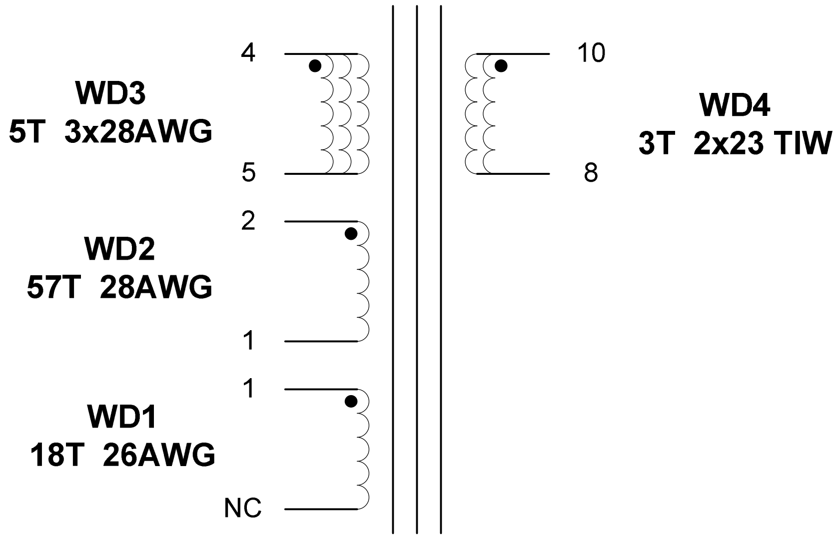


Figure 7 – Transformer Electrical Diagram.

7.2.2 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 100 kHz, 0.4 VRMS	828 µH, ±5%
Resonant Frequency	Pins 1-2, all other windings open	500 kHz (Min.)
Primary Leakage Inductance	Pins 1-2, with Pins 6-10 shorted, measured at 100 kHz, 0.4 VRMS	60 µH (Max.)

7.2.3 Materials

Item	Description
[1]	Core: PC40EE25-Z; 252 nH/T^2 Gapped Core Effective Inductance
[2]	Bobbin: EE25_BOBBIN
[3]	Magnet Wire: 26 AWG
[4]	Magnet Wire: 28 AWG
[5]	Magnet Wire: 23 AWG; Triple Insulated Wire
[6]	Tape, 11 mm
[7]	Varnish

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

7.2.4 Transformer Build Diagram

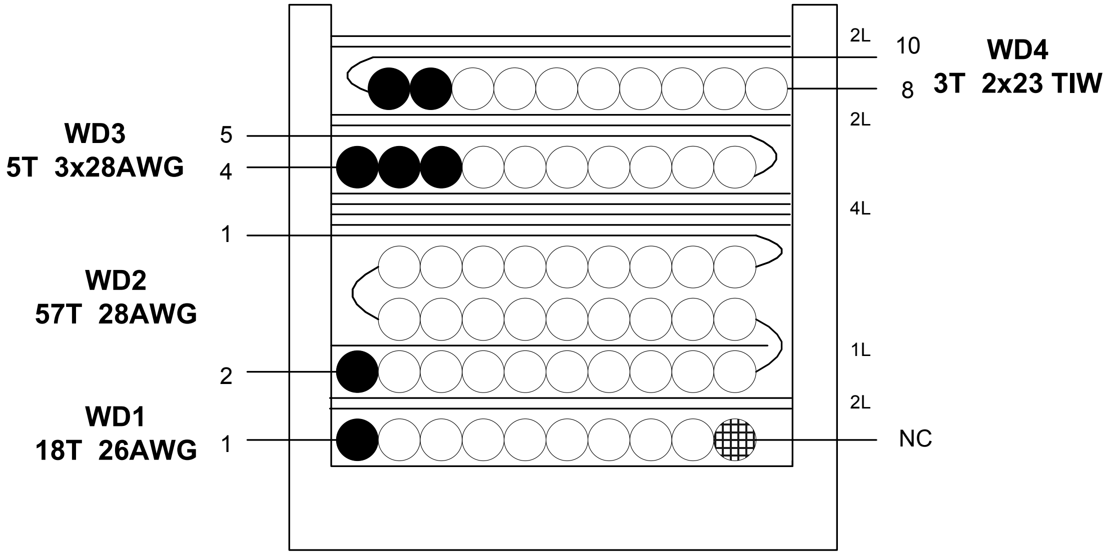


Figure 8 – Transformer Build Diagram.

7.2.5 Transformer Construction

WD1	Start at Pin 1. Wind 18 turns of 26 AWG wire. Cut end leave floating.
Basic Insulation	Use two layers of 11 mm tape for basic insulation.
WD2	Start at Pin 2, wind 20 turns of 28 AWG wire. Place 1 layer of 11 mm tape, continue winding 20 turns for the second layer, then continue winding the remaining 17 turns for the third layer. Finish at Pin 1.
Basic Insulation	Use four layers of 11 mm tape for basic insulation.
WD3	Start at Pin 4, wind 5 trifilar turns of 28 AWG. Finish at Pin 5.
Basic Insulation	Use two layers of 11 mm tape for basic insulation.
WD4	Start at Pin 5 temporarily, wind 3 bifilar turns of 23 AWG T.I.W. Finish at Pin 8. Bring back the wire from pin 5 then terminate pin 10.
Outer Wrap	Wrap windings with 3 layers of 11 mm tape.
Final Assembly	Assemble and secure core halves. Varnish impregnate (item [8]).

8 Transformer Spreadsheets

8.1 *Main Supply*

ACDC_TOPSwitchHX_021308; Rev.1.8; Copyright Power Integrations 2008	INPUT	INFO	OUTPUT	UNIT	TOP_HX_021308: TOPSwitch-HX Continuous/Discontinuous Flyback Transformer Design Spreadsheet
ENTER APPLICATION VARIABLES					**Customer**
VACMIN	108			Volts	Minimum AC Input Voltage
VACMAX	132			Volts	Maximum AC Input Voltage
fL	60			Hertz	AC Mains Frequency
VO	24.00			Volts	Output Voltage (main)
PO_AVG	133.00			Watts	Average Output Power
PO_PEAK			133.00	Watts	Peak Output Power
n	0.88			%/100	Efficiency Estimate
Z	0.50				Loss Allocation Factor
VB	15			Volts	Bias Voltage
tC	3.00			mSeconds	Bridge Rectifier Conduction Time Estimate
CIN	110.0		110	uFarads	Input Filter Capacitor
ENTER TOPSWITCH-HX VARIABLES					
TOPSwitch-HX	**TOP261EN**			Universal / Peak	115 Doubled/230V
Chosen Device		*TOP261EN*	Power Out	254 W / 254 W	333W
KI	0.35				External Ilimit reduction factor (KI=1.0 for default ILIMIT, KI <1.0 for lower ILIMIT)
ILIMITMIN_EXT			2.409	Amps	Use 1% resistor in setting external ILIMIT
ILIMITMAX_EXT			2.771	Amps	Use 1% resistor in setting external ILIMIT
Frequency (F)=132kHz, (H)=66kHz	**F**		F		Select 'H' for Half frequency - 66kHz, or 'F' for Full frequency - 132kHz
fS			132000	Hertz	TOPSwitch-HX Switching Frequency: Choose between 132 kHz and 66 kHz
fSmin			119000	Hertz	TOPSwitch-HX Minimum Switching Frequency
fSmax			145000	Hertz	TOPSwitch-HX Maximum Switching Frequency
High Line Operating Mode			FF		Full Frequency, Jitter enabled
VOR	150.00			Volts	Reflected Output Voltage
VDS			10	Volts	TOPSwitch on-state Drain to Source Voltage
VD	0.50			Volts	Output Winding Diode Forward Voltage Drop
VDB	0.70			Volts	Bias Winding Diode Forward Voltage Drop
KP	0.60				Ripple to Peak Current Ratio (0.3 < KRP < 1.0 : 1.0< KDP<6.0)

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

PROTECTION FEATURES					
LINE SENSING					
VUV_STARTUP			213	Volts	Minimum DC Bus Voltage at which the power supply will start-up
VOV_SHUTDOWN			1050	Volts	Typical DC Bus Voltage at which power supply will shut-down (Max)
RLS			9.4	M-ohms	Use two standard, 4.7 M-Ohm, 5% resistors in series for line sense functionality.
OUTPUT OVERVOLTAGE					
VZ			27	Volts	Zener Diode rated voltage for Output Overvoltage shutdown protection
RZ			5.1	k-ohms	Output OVP resistor. For latching shutdown use 20 ohm resistor instead
OVERLOAD POWER LIMITING					
Overload Current Ratio at VMAX			1.2		Enter the desired margin to current limit at VMAX. A value of 1.2 indicates that the current limit should be 20% higher than peak primary current at VMAX
Overload Current Ratio at VMIN			1.08		Margin to current limit at low line.
ILIMIT_EXT_VMIN			2.25	A	Peak primary Current at VMIN
ILIMIT_EXT_VMAX			2.13	A	Peak Primary Current at VMAX
RIL			16.11	k-ohms	Current limit/Power Limiting resistor.
RPL			N/A	M-ohms	Resistor not required. Use RIL resistor only

ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES					
Core Type	EER35		EER35		Core Type
Core		*EER35*		*P/N:*	PC40EER35-Z
Bobbin		*EER35_BOBBIN*		*P/N:*	BEER-35-1116CPH
AE			1.07	cm^2	Core Effective Cross Sectional Area
LE			9.08	cm	Core Effective Path Length
AL			2770	nH/T^2	Ungapped Core Effective Inductance
BW			26.1	mm	Bobbin Physical Winding Width
M	6.00			mm	Safety Margin Width (Half the Primary to Secondary Creepage Distance)
L	2.00				Number of Primary Layers
NS	8		8		Number of Secondary Turns

DC INPUT VOLTAGE PARAMETERS					
VMIN	250		250	Volts	Minimum DC Input Voltage
VMAX	365		365	Volts	Maximum DC Input Voltage

CURRENT WAVEFORM SHAPE PARAMETERS					
DMAX			0.38		Maximum Duty Cycle (calculated at PO_PEAK)

IAVG			0.60	Amps	Average Primary Current (calculated at average output power)
IP			2.25	Amps	Peak Primary Current (calculated at Peak output power)
IR			1.35	Amps	Primary Ripple Current (calculated at average output power)
IRMS			1.00	Amps	Primary RMS Current (calculated at average output power)

TRANSFORMER PRIMARY DESIGN PARAMETERS					
LP			620	uHenries	Primary Inductance
LP Tolerance			10		Tolerance of Primary Inductance
NP			49		Primary Winding Number of Turns
NB			5		Bias Winding Number of Turns
ALG			258	nH/T^2	Gapped Core Effective Inductance
BM			2657	Gauss	Maximum Flux Density at PO, VMIN (BM<3000)
BP			3607	Gauss	Peak Flux Density (BP<4200) at ILIMITMAX and LP_MAX. Note: Recommended values for adapters and external power supplies <=3600 Gauss
BAC			797	Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
ur			1871		Relative Permeability of Ungapped Core
LG			0.47	mm	Gap Length (Lg > 0.1 mm)
BWE			28.2	mm	Effective Bobbin Width
OD			0.58	mm	Maximum Primary Wire Diameter including insulation
INS			0.07	mm	Estimated Total Insulation Thickness (= 2 * film thickness)
DIA			0.51	mm	Bare conductor diameter
AWG			25	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CM			323	Cmils	Bare conductor effective area in circular mils
CMA			321	Cmils/Amp	Primary Winding Current Capacity (200 < CMA < 500)
Primary Current Density (J)			6.18	Amps/mm^2	Primary Winding Current density (3.8 < J < 9.75)

TRANSFORMER SECONDARY DESIGN PARAMETERS (SINGLE OUTPUT EQUIVALENT)					
Lumped parameters					
ISP			13.75	Amps	Peak Secondary Current
ISRMS			7.78	Amps	Secondary RMS Current
IO_PEAK			5.54	Amps	Secondary Peak Output Current
IO			5.54	Amps	Average Power Supply Output Current
IRIPPLE			5.46	Amps	Output Capacitor RMS Ripple Current
CMS			1555	Cmils	Secondary Bare Conductor minimum circular mils
AWGS			18	AWG	Secondary Wire Gauge (Rounded up to next larger standard AWG value)

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

DIAS			1.03	mm	Secondary Minimum Bare Conductor Diameter
ODS			1.76	mm	Secondary Maximum Outside Diameter for Triple Insulated Wire
INSS			0.37	mm	Maximum Secondary Insulation Wall Thickness

VOLTAGE STRESS PARAMETERS					
VDRAIN			655	Volts	Maximum Drain Voltage Estimate (Includes Effect of Leakage Inductance)
PIVS			84	Volts	Output Rectifier Maximum Peak Inverse Voltage
PIVB			53	Volts	Bias Rectifier Maximum Peak Inverse Voltage

TRANSFORMER SECONDARY DESIGN PARAMETERS (MULTIPLE OUTPUTS)					
1st output					
VO1			24	Volts	Output Voltage
IO1_AVG	4.10		4.10	Amps	Average DC Output Current
PO1_AVG			98.40	Watts	Average Output Power
VD1	0.55		0.55	Volts	Output Diode Forward Voltage Drop
NS1			8.02		Output Winding Number of Turns
ISRMS1			5.754	Amps	Output Winding RMS Current
IRIPPLE1			4.04	Amps	Output Capacitor RMS Ripple Current
PIVS1			84	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS1			1151	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS1			19	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS1			0.91	mm	Minimum Bare Conductor Diameter
ODS1			1.76	mm	Maximum Outside Diameter for Triple Insulated Wire

2nd output					
VO2	12.00			Volts	Output Voltage
IO2_AVG	2.00			Amps	Average DC Output Current
PO2_AVG			24.00	Watts	Average Output Power
VD2	0.55		0.55	Volts	Output Diode Forward Voltage Drop
NS2			4.10		Output Winding Number of Turns
ISRMS2			2.807	Amps	Output Winding RMS Current
IRIPPLE2			1.97	Amps	Output Capacitor RMS Ripple Current
PIVS2			43	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS2			561	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS2			22	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS2			0.65	mm	Minimum Bare Conductor Diameter
ODS2			3.44	mm	Maximum Outside Diameter for Triple Insulated Wire

3rd output					
VO3	5.00			Volts	Output Voltage
IO3_AVG	2.00			Amps	Average DC Output Current
PO3_AVG			10.00	Watts	Average Output Power
VD3	0.45		0.45	Volts	Output Diode Forward Voltage Drop
NS3			1.78		Output Winding Number of Turns
ISRMS3			2.807	Amps	Output Winding RMS Current
IRIPPLE3			1.97	Amps	Output Capacitor RMS Ripple Current
PIVS3			18	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS3			561	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS3			22	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS3			0.65	mm	Minimum Bare Conductor Diameter
ODS3			7.92	mm	Maximum Outside Diameter for Triple Insulated Wire
Total Continuous Output Power			132.4	Watts	Total Continuous Output Power
Negative Output			N/A		If negative output exists enter Output number; eg: If VO2 is negative output, enter 2

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

8.2 Standby Supply

ACDC_TinySwitch-III_022108; Rev.1.25; Copyright Power Integrations 2007	INPUT	INFO	OUTPUT	UNIT	ACDC_TinySwitch-III_022108_Rev1-25.xls; TinySwitch-III Continuous/Discontinuous Flyback Transformer Design Spreadsheet
ENTER APPLICATION VARIABLES					**Customer**
VACMIN	85			Volts	Minimum AC Input Voltage
VACMAX	265			Volts	Maximum AC Input Voltage
fL	50			Hertz	AC Mains Frequency
VO	5.00			Volts	Output Voltage (at continuous power)
IO	4.65			Amps	Power Supply Output Current (corresponding to peak power)
Power			23.25	Watts	Continuous Output Power
n	0.80				Efficiency Estimate at output terminals. Under 0.7 if no better data available
Z	0.50				Z Factor. Ratio of secondary side losses to the total losses in the power supply. Use 0.5 if no better data available
tC	3.00			mSeconds	Bridge Rectifier Conduction Time Estimate
CIN	110.00		110	uFarads	Input Capacitance

ENTER TinySwitch-III VARIABLES					
TinySwitch-III	**TNY279P**		**TNY279P**		User defined TinySwitch-III
Chosen Device		*TNY279P*			
Chose Configuration	**INC**		Increased Current Limit		Enter "RED" for reduced current limit (sealed adapters), "STD" for standard current limit or "INC" for increased current limit (peak or higher power applications)
ILIMITMIN			0.698	Amps	Minimum Current Limit
ILIMITTYP			0.750	Amps	Typical Current Limit
ILIMITMAX			0.833	Amps	Maximum Current Limit
fSmin			124000	Hertz	Minimum Device Switching Frequency
I^2fmin			66.825	A^2kHz	I^2f (product of current limit squared and frequency is trimmed for tighter tolerance)
VOR	105.00		105	Volts	Reflected Output Voltage (VOR < 135 V Recommended)
VDS			10	Volts	TinySwitch-III on-state Drain to Source Voltage
VD			0.5	Volts	Output Winding Diode Forward Voltage Drop
KP			0.92		Ripple to Peak Current Ratio (KP < 6)
KP_TRANSIENT			0.83		Transient Ripple to Peak Current Ratio. Ensure KP_TRANSIENT > 0.25

ENTER BIAS WINDING VARIABLES					
VB			22.00	Volts	Bias Winding Voltage
VDB			0.70	Volts	Bias Winding Diode Forward Voltage Drop
NB			12.00		Bias Winding Number of Turns
VZOV			28.00	Volts	Over Voltage Protection zener diode voltage.
UVLO VARIABLES					

V_UV_TARGET			335.50	Volts	Target DC under-voltage threshold, above which the power supply with start
V_UV_ACTUAL			327.20	Volts	Typical DC start-up voltage based on standard value of RUV_ACTUAL
RUV_IDEAL			13.33	Mohms	Calculated value for UV Lockout resistor
RUV_ACTUAL			13.00	Mohms	Closest standard value of resistor to RUV_IDEAL

ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES					
Core Type	EE25		EE25		Enter Transformer Core
Core		*EE25*		*P/N:*	PC40EE25-Z
Bobbin		*EE25_BOBBIN*		*P/N:*	EE25_BOBBIN
AE			0.404	cm^2	Core Effective Cross Sectional Area
LE			7.34	cm	Core Effective Path Length
AL			1420	nH/T^2	Ungapped Core Effective Inductance
BW			10.2	mm	Bobbin Physical Winding Width
M	0.00		0	mm	Safety Margin Width (Half the Primary to Secondary Creepage Distance)
L	2.00		2		Number of Primary Layers
NS	3		3		Number of Secondary Turns

DC INPUT VOLTAGE PARAMETERS					
VMIN	305.00		305	Volts	Minimum DC Input Voltage
VMAX	375.00		375	Volts	Maximum DC Input Voltage

CURRENT WAVEFORM SHAPE PARAMETERS					
DMAX			0.27		Duty Ratio at full load, minimum primary inductance and minimum input voltage
IAVG			0.10	Amps	Average Primary Current
IP			0.70	Amps	Minimum Peak Primary Current
IR			0.70	Amps	Primary Ripple Current
IRMS			0.25	Amps	Primary RMS Current

TRANSFORMER PRIMARY DESIGN PARAMETERS					
LP			828	uHenries	Typical Primary Inductance. +/- 5% to ensure a minimum primary inductance of 788 uH
LP_TOLERANCE	5.00		5	%	Primary inductance tolerance
NP			57		Primary Winding Number of Turns
ALG			252	nH/T^2	Gapped Core Effective Inductance
BM			2980	Gauss	Maximum Operating Flux Density, BM<3000 is recommended
BAC			1490	Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
ur			2053		Relative Permeability of Ungapped Core
LG			0.17	mm	Gap Length (Lg > 0.1 mm)
BWE			20.4	mm	Effective Bobbin Width
OD			0.36	mm	Maximum Primary Wire Diameter including insulation
INS			0.06	mm	Estimated Total Insulation Thickness (= 2 * film thickness)

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

DIA			0.30	mm	Bare conductor diameter
AWG			29	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CM			128	Cmils	Bare conductor effective area in circular mils
CMA		*Info*	509	Cmils/Amp	CAN DECREASE CMA < 500 (decrease L(primary layers),increase NS,use smaller Core)

TRANSFORMER SECONDARY DESIGN PARAMETERS					
Lumped parameters					
ISP			13.33	Amps	Peak Secondary Current
ISRMS			8.17	Amps	Secondary RMS Current
IRIPPLE			6.72	Amps	Output Capacitor RMS Ripple Current
CMS			1635	Cmils	Secondary Bare Conductor minimum circular mils
AWGS			17	AWG	Secondary Wire Gauge (Rounded up to next larger standard AWG value)

VOLTAGE STRESS PARAMETERS					
VDRAIN			616	Volts	Maximum Drain Voltage Estimate (Assumes 20% zener clamp tolerance and an additional 10% temperature tolerance)
PIVS			25	Volts	Output Rectifier Maximum Peak Inverse Voltage

TRANSFORMER SECONDARY DESIGN PARAMETERS (MULTIPLE OUTPUTS)					
1st output					
VO1			5	Volts	Main Output Voltage (if unused, defaults to single output design)
IO1			4.650	Amps	Output DC Current
PO1			23.25	Watts	Output Power
VD1			0.5	Volts	Output Diode Forward Voltage Drop
NS1			3.00		Output Winding Number of Turns
ISRMS1			8.174	Amps	Output Winding RMS Current
IRIPPLE1			6.72	Amps	Output Capacitor RMS Ripple Current
PIVS1			25	Volts	Output Rectifier Maximum Peak Inverse Voltage
Recommended Diodes			**MBR1060**		Recommended Diodes for this output
CMS1			1635	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS1			17	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS1			1.15	mm	Minimum Bare Conductor Diameter
ODS1			3.40	mm	Maximum Outside Diameter for Triple Insulated Wire

2nd output					
VO2				Volts	Output Voltage
IO2				Amps	Output DC Current
PO2			0.00	Watts	Output Power
VD2			0.7	Volts	Output Diode Forward Voltage Drop
NS2			0.38		Output Winding Number of Turns

ISRMS2			0.000	Amps	Output Winding RMS Current
IRIPPLE2			0.00	Amps	Output Capacitor RMS Ripple Current
PIVS2			3	Volts	Output Rectifier Maximum Peak Inverse Voltage
Recommended Diode					Recommended Diodes for this output
CMS2			0	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS2			N/A	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS2			N/A	mm	Minimum Bare Conductor Diameter
ODS2			N/A	mm	Maximum Outside Diameter for Triple Insulated Wire

3rd output					
VO3				Volts	Output Voltage
IO3				Amps	Output DC Current
PO3			0.00	Watts	Output Power
VD3			0.7	Volts	Output Diode Forward Voltage Drop
NS3			0.38		Output Winding Number of Turns
ISRMS3			0.000	Amps	Output Winding RMS Current
IRIPPLE3			0.00	Amps	Output Capacitor RMS Ripple Current
PIVS3			3	Volts	Output Rectifier Maximum Peak Inverse Voltage
Recommended Diode					Recommended Diodes for this output
CMS3			0	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS3			N/A	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS3			N/A	mm	Minimum Bare Conductor Diameter
ODS3			N/A	mm	Maximum Outside Diameter for Triple Insulated Wire
Total power			23.25	Watts	Total Output Power
Negative Output			N/A		If negative output exists enter Output number; eg: If VO2 is negative output, enter 2

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

9 Inductors

9.1 Common mode choke (L6)

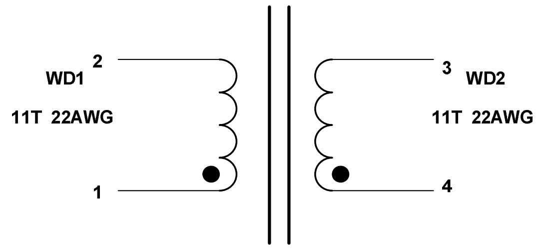


Figure 9 – L6 Common Mode Choke.

9.1.1 Build Diagram

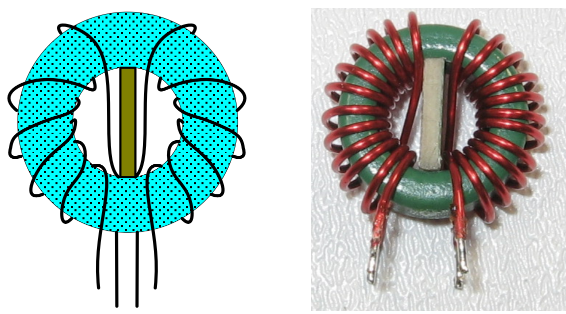
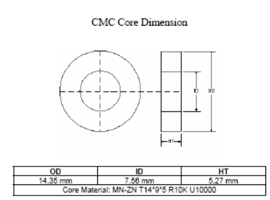


Figure 10 – Drawing and Photo of L6.

9.1.2 Electrical Specifications

Inductance	Pins 1-2, all other windings open, measured at 100 Hz, 0.4 VRMS	430 µH, ±10%
Resonant Frequency	Pins 1-2, all other windings open	1000 kHz (Min.)
Leakage Inductance	Pins 1-2, with Pins 3-4shorted, measured at 100 kHz, 0.4 VRMS	20 µH (Min)

9.1.3 Materials

Item	Description
[1]	Core: Toroid MN-ZN T14*9*5 R 10K U10000 
[2]	Magnet Wire: 22 AWG

9.2 Common Mode Choke (L5)

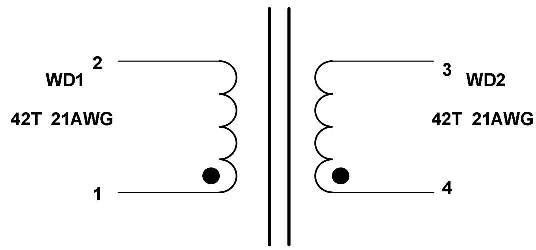
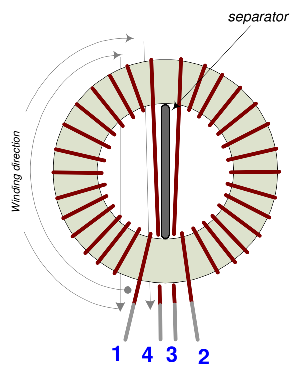


Figure 11 – L5 Common Mode Choke.

9.2.1 Build Diagram



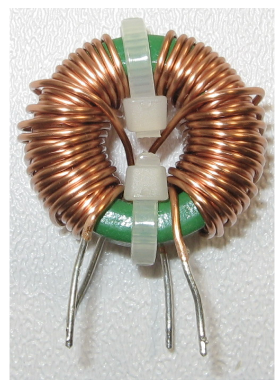


Figure 12 – Drawing and Photo of L5.

9.2.2 Electrical Specifications

Inductance	Pins 1-4, all other windings open, measured at 100 Hz, 0.4 VRMS	1000 µH, ±10%
Resonant Frequency	Pins 1-4, all other windings open	1000 kHz (Min.)
Leakage Inductance	Pins 1-4, with Pins 2-13 shorted, measured at 100 kHz, 0.4 VRMS	50 µH (Min.)

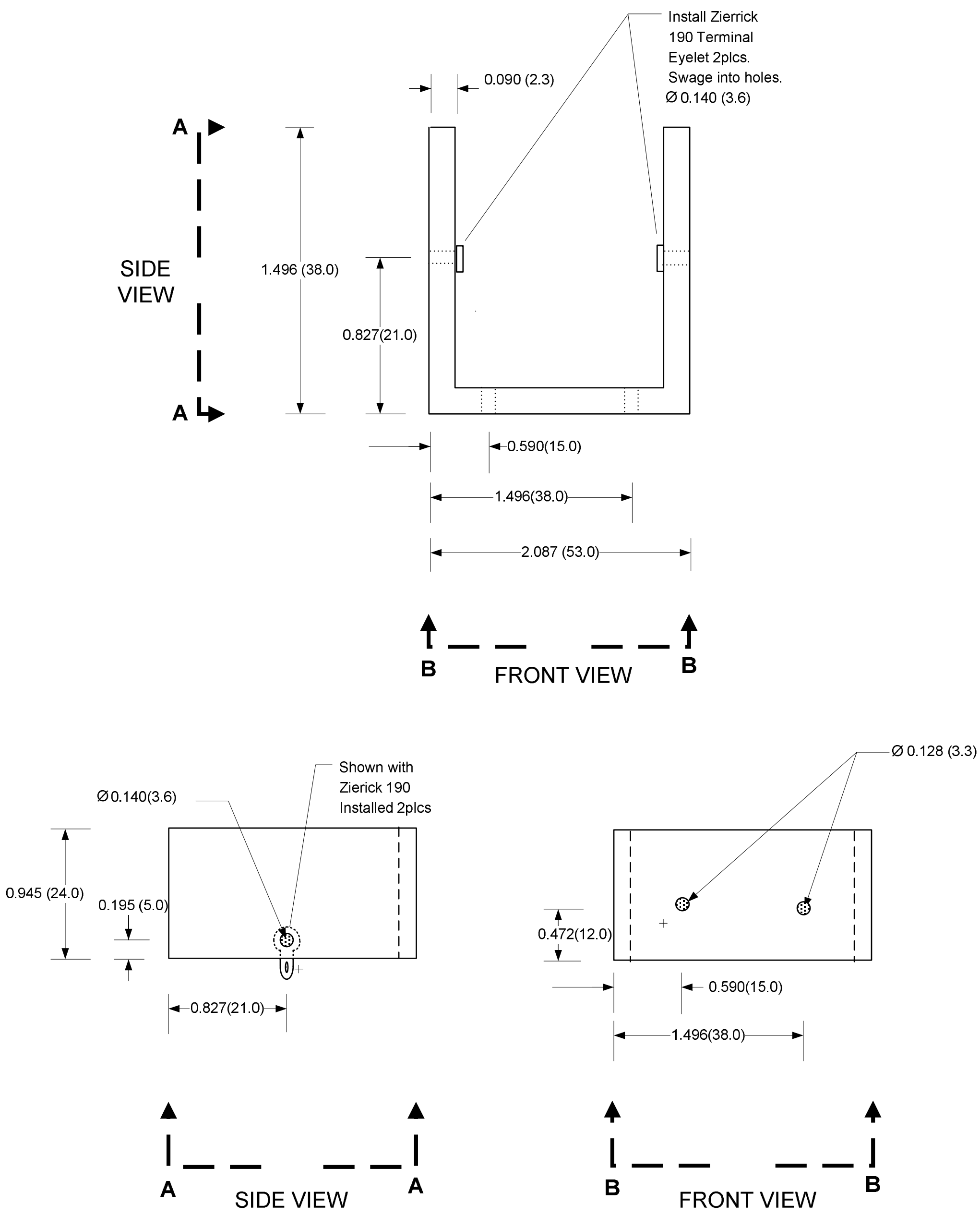
9.2.3 Materials

Item	Description
[1]	Assembly P/N: T22148-902S (used in RD-189)
[2]	Core: Toroid - OD: 22.3 mm; ID: 13.4 mm; TH: 8.7 mm
[3]	Wire: 21 AWG

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

10 Heatsink Specification

10.1 D1/D2 Secondary Heatsink

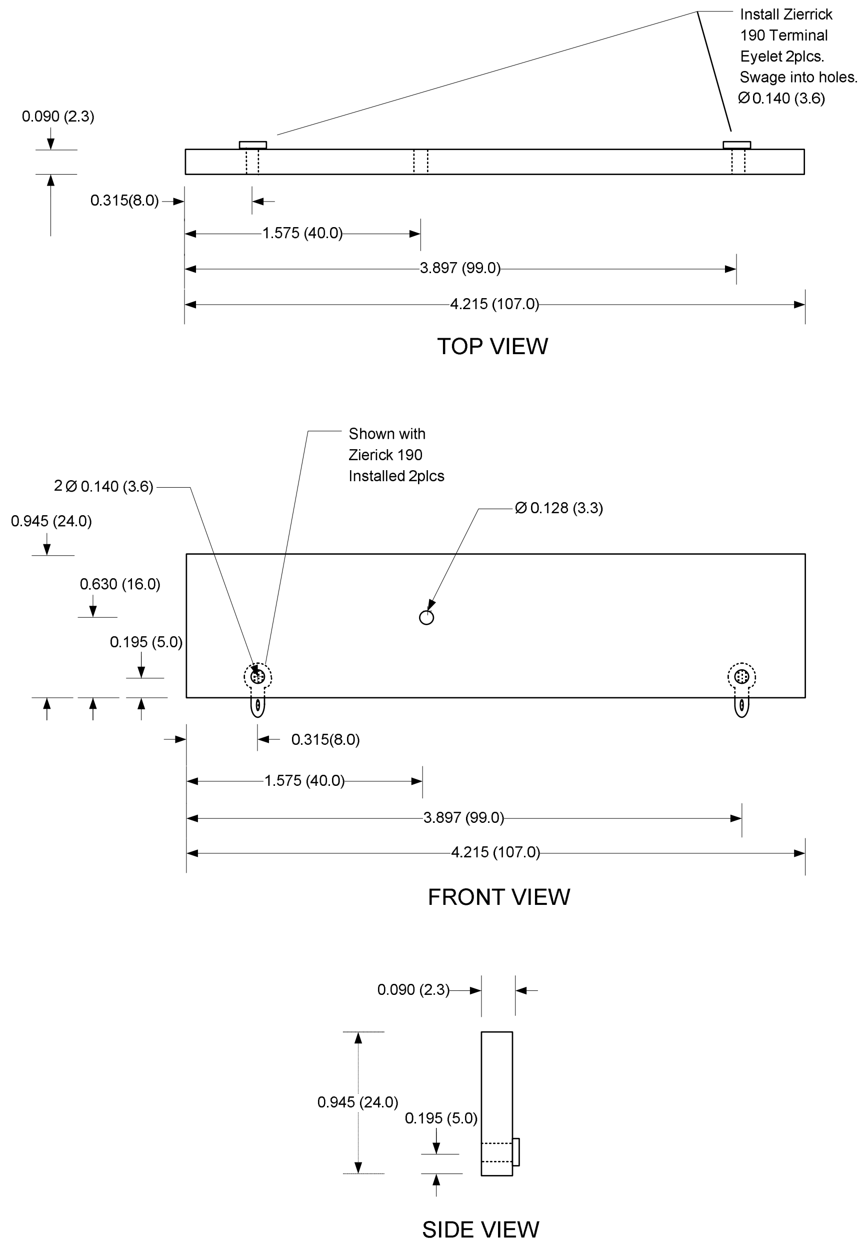


PI P/N 61-XXXXX-00
133W-TV heatsink A
Secondary
MBR10100(D1), MBR1060(D2)

Material Al 3003 0.090 inches thick
Tolerance +/- 0.001" (0.1mm)

Rev 01 Initial Release

10.2 U1 Heatsink



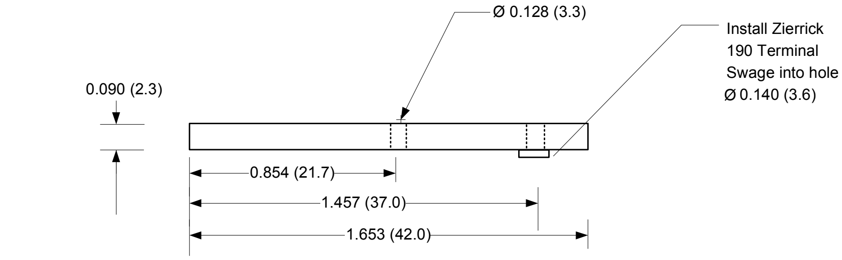
Rev 01 Initial Release

PI P/N 61-00004-00
133W-TV HEAT SINK B
Primary

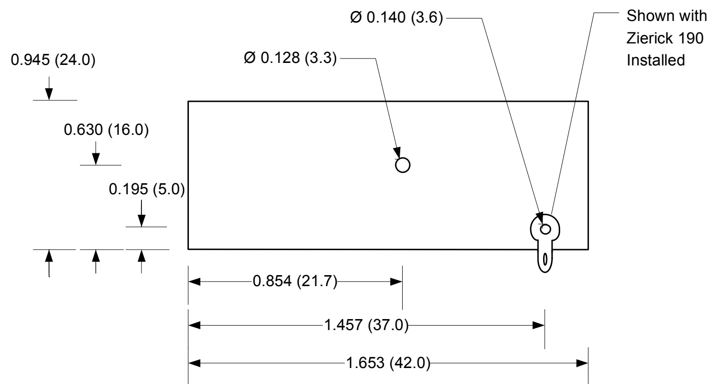
Material Al 3003 0.090 inches thick
Tolerance +/- 0.001" (0.1mm)
DO NOT SCALE DRAWING

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

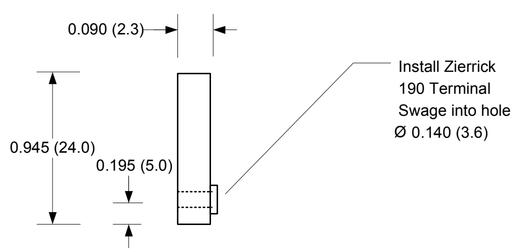
10.3 Bridge Diode Heatsink



TOP VIEW



FRONT VIEW



SIDE VIEW

PI P/N 61-00004-00

133W-TV HEAT SINK C
Primary
GBU8J (BR1)

Material Al 3003 0.090 inches thick
Tolerance +/- 0.001" (0.1mm)
DO NOT SCALE DRAWING

11 Performance Data

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

11.1 Active Mode Efficiency

Load condition: 2 A @ 5 V; 2 A @ 12 V; 4.1 A @ 24 V

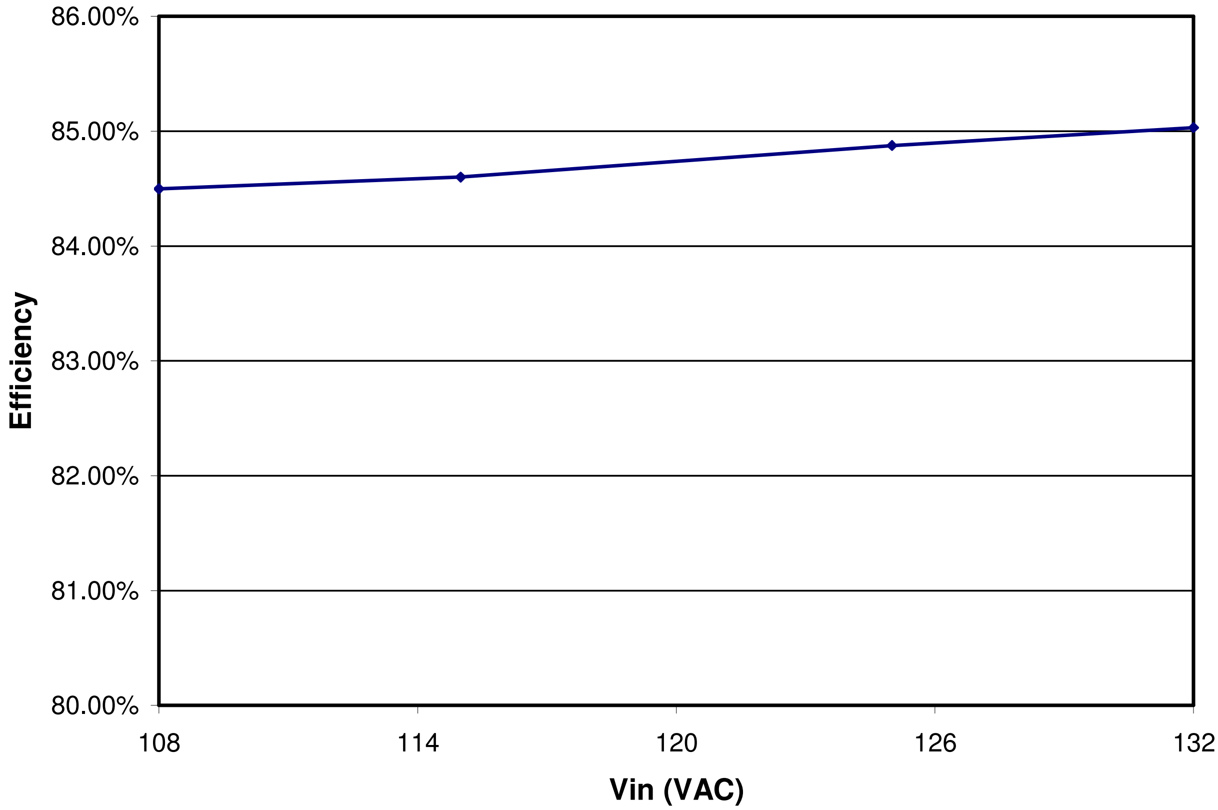


Figure 13 – Maximum Load Efficiency vs. Input Voltage, Room Temperature, 60 Hz.

Efficiency	Vin(VAC)	Freq(Hz)	Vo(V)	Io(A)	Vo(V)	Io(A)	Vo(V)	Io(A)	Po (W)	Pin (W)	Eff
Max load	108	60	24.26	4.1	11.99	2	5.03	2	133.506	158.000	84.50%
	115	60	24.23	4.1	11.98	2	5.03	2	133.363	157.640	84.60%
	125	60	24.23	4.1	11.98	2	5.03	2	133.363	157.130	84.87%
	132	60	24.23	4.1	11.98	2	5.03	2	133.363	156.840	85.03%

Table 1: Efficiency at Maximum Load Plotted in Figure 13.

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

11.2 No-load Input Power

Remote Off is when the Main supply (24 V / 12 V) is off.
Remote On is when both Main supply and Standby supply (5 Vsb) are on.

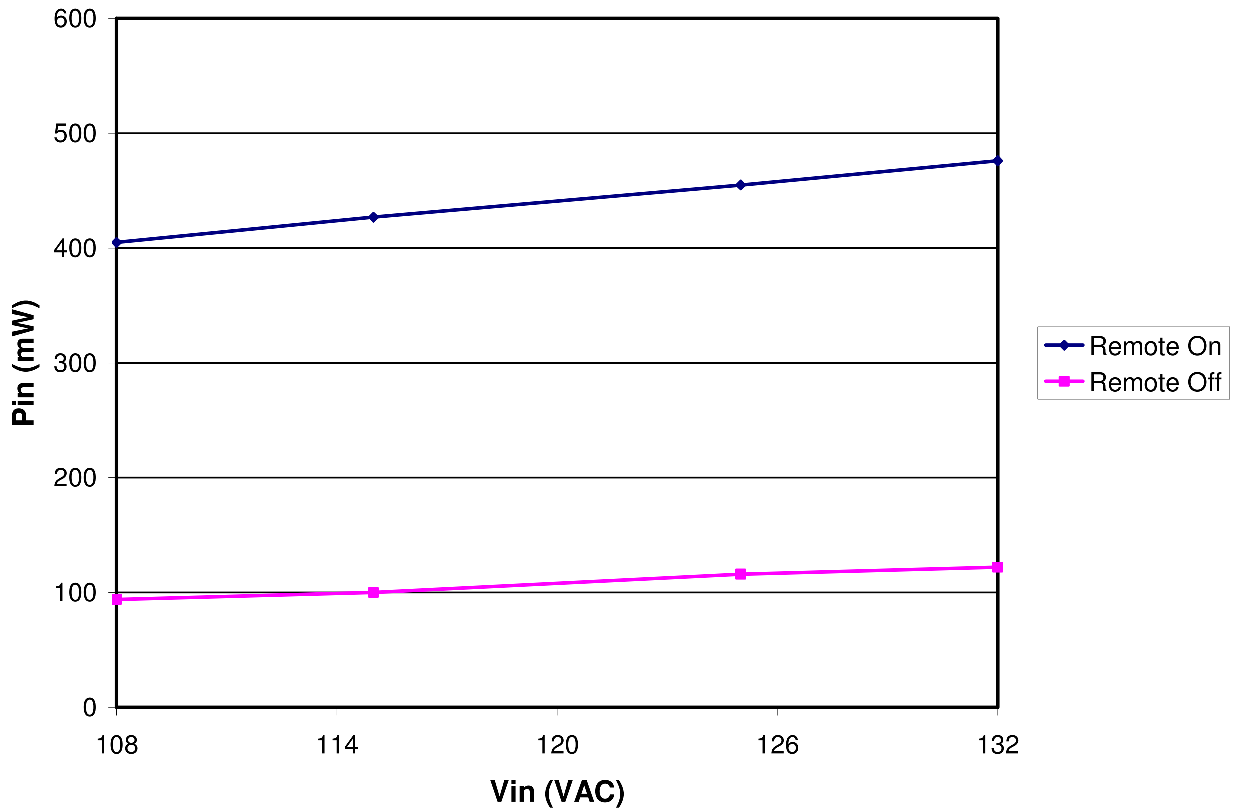


Figure 14 – Zero Load Input Power vs. Input Line Voltage, Room Temperature, 60 Hz.

No load	**Vin(VAC)**	**Freq(Hz)**	**Pin(mW)**
Remote On	108	60	405
	115	60	427
	125	60	455
	132	60	476

No load	**Vin(VAC)**	**Freq(Hz)**	**Pin(mW)**
Remote Off	108	60	94
	115	60	100
	125	60	116
	132	60	122

Table 2: Data of Pin (mW) Plotted in Figure 14.

11.3 Available Standby Output Power

The chart below shows the available output power vs. line voltage for an input power maintained at 0.6 W

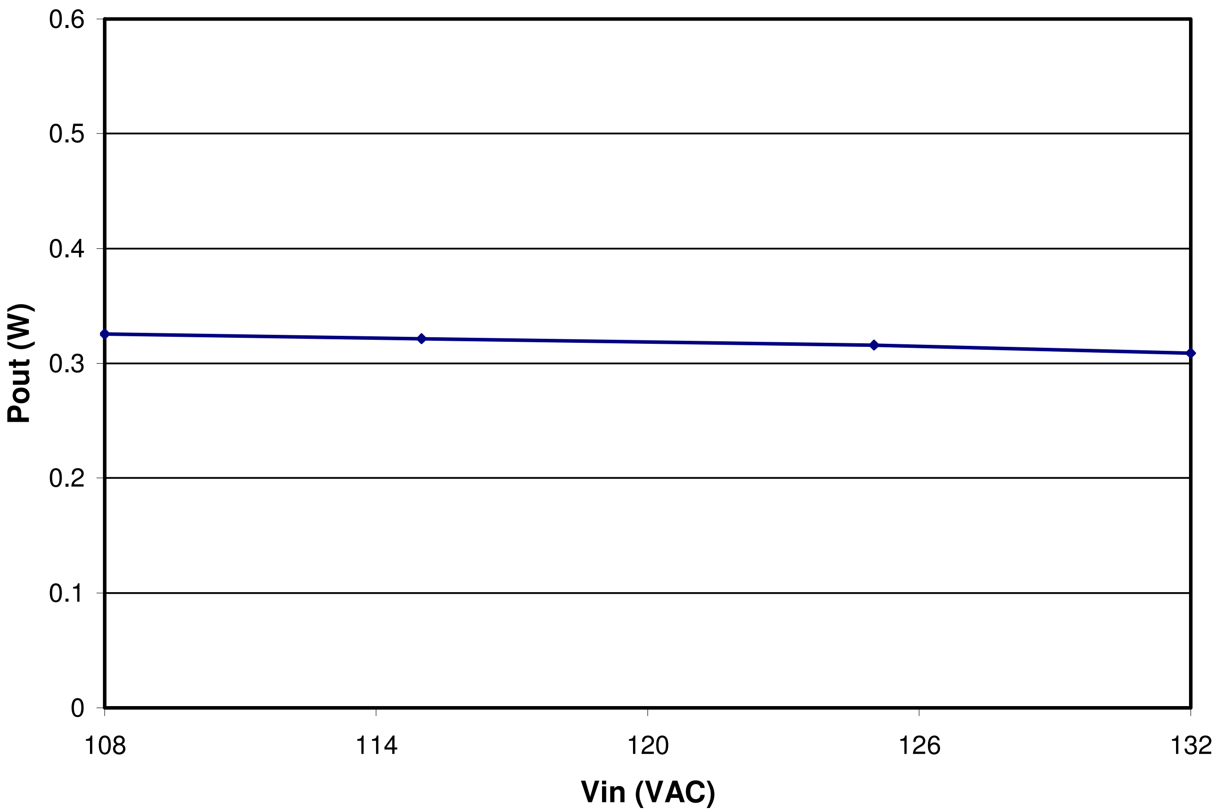


Figure 15 – Available Power Output at 5 V Load When Remote Off (Main supply is off). Pin is Maintained at 0.6 W.

Pin 0.6 W	Vin(VAC)	Freq(Hz)	Vo(V)	Io(A)	Po(W)
Remote Off	108	60	5.03	0.0647	0.325441
	115	60	5.03	0.0639	0.321417
	125	60	5.03	0.0628	0.315884
	132	60	5.03	0.0614	0.308842

Table 3: Data of Po (W) Plotted in Figure 15.

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

11.4 Cross Regulation

Cross Regulation		Load		Output		
108 VAC	**24 V**	**12 V**	**5 Vsb**	**24 V**	**12 V**	**5 Vsb**
	4.1	2	2.5	24.23	11.98	5.04
	4.1	0.2	0.01	24	12.21	5.04
	0.5	2	2.5	24.56	11.68	5.04
	0.5	0.2	0.01	24.2	12.03	5.04

Cross Regulation		Load		Output		
132 VAC	**24 V**	**12 V**	**5 Vsb**	**24 V**	**12 V**	**5 Vsb**
	4.1	2	2.5	24.24	11.99	5.03
	4.1	0.2	0.01	24.01	12.21	5.03
	0.5	2	2.5	24.57	11.67	5.03
	0.5	0.2	0.01	24.21	12.02	5.03

12 Thermal Performance

The supply was inside a carton box. The supply was heated, with no airflow, for at least two hours and measurements were taken immediately.

Load condition: 2 A @ 5 V; 2 A @ 12 V; 4.1 A @ 24 V

Item	Temperature (°C)	
	108 VAC	132 VAC
Ambient	46	47
Bridge (BR1)	75	72
Main Transformer 24/12 V (T1)	106	112
Standby Transformer 5 V (T2)	78	82
***TOP261EN* (U1)**	104	106
***TNY279PN* (U2)**	88	92
Rectifier 24 V (D1)	99	102
Rectifier 12 V (D2)	93	96
Rectifier 5 V (D3)	92	96

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

13 Waveforms

13.1 Drain Voltage and Current, Normal Operation

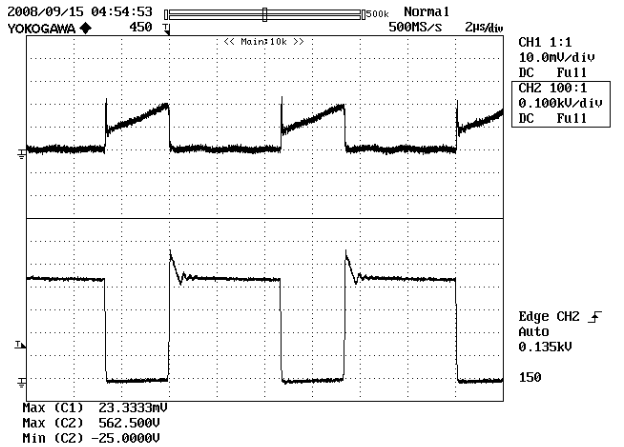


Figure 16 – 108 VAC, Full Load- Main Supply.
Upper: I_{DRAIN}, 1 A / div.
Lower: V_{DRAIN}, 100 V, 2 µs / div.

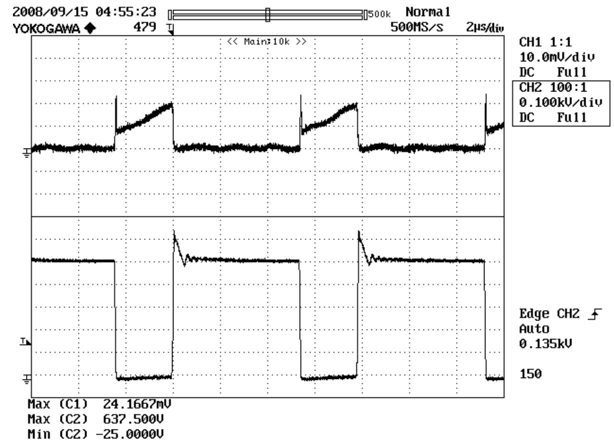


Figure 17 – 132 VAC, Full Load- Main Supply.
Upper: I_{DRAIN}, 1 A / div.
Lower: V_{DRAIN}, 100 V, 2 µs / div.

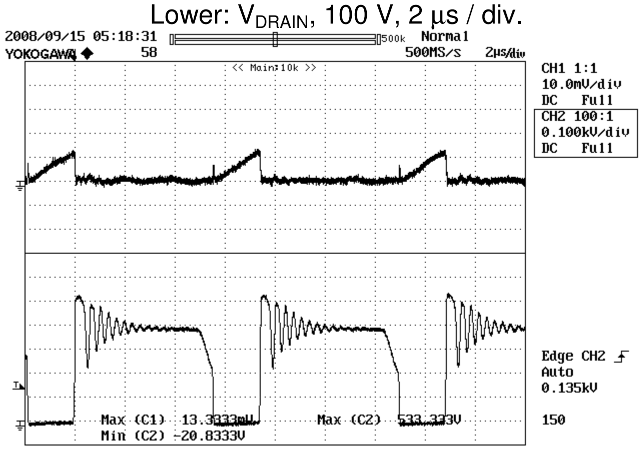


Figure 18 – 108 VAC, Full Load- Standby Supply.
Upper: I_{DRAIN}, 0.5 A / div.
Lower: V_{DRAIN}, 100 V, 2 µs / div.

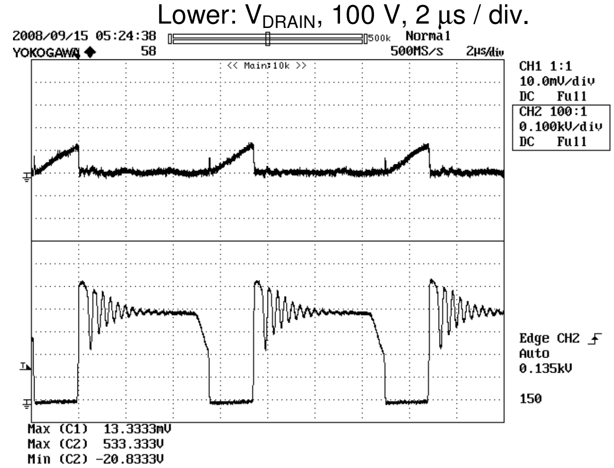


Figure 19 – 132 VAC, Full Load- Standby Supply.
Upper: I_{DRAIN}, 0.5 A / div.
Lower: V_{DRAIN}, 100 V, 2 µs / div.

13.2 Drain Voltage and Current Start-up Profile

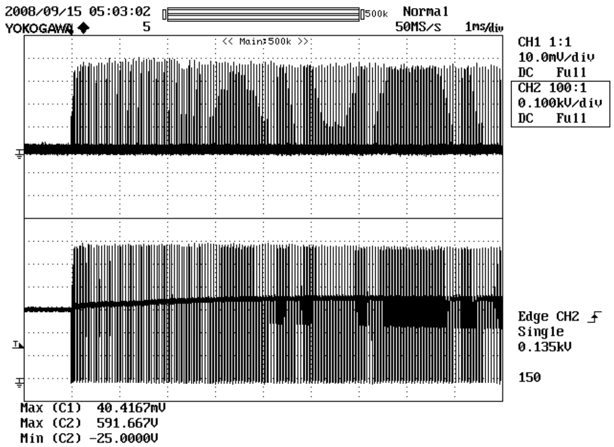


Figure 20 – 108 VAC, Full load- Main Supply.
Upper: I_{DRAIN}, 1 A / div.
Lower: V_{DRAIN}, 100 V & 1 ms / div.

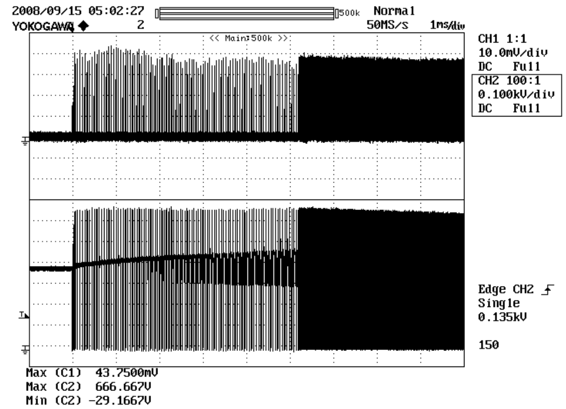


Figure 21 – 132 VAC, Full load- Main Supply.
Upper: I_{DRAIN}, 1 A / div.
Lower: V_{DRAIN}, 100 V & 1 ms / div.

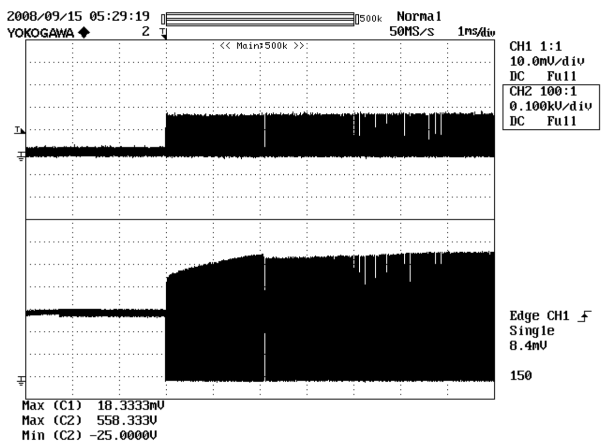


Figure 22 – 108 VAC, Full load- Standby Supply.
Upper: I_{DRAIN}, .5 A / div.
Lower: V_{DRAIN}, 100 V & 1 ms / div.

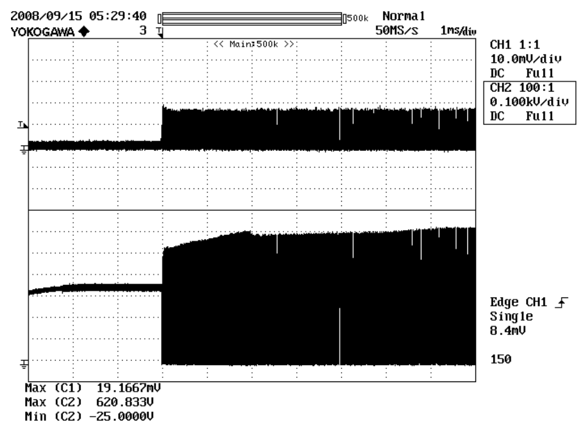


Figure 23 – 132 VAC, Full load- Standby Supply.
Upper: I_{DRAIN}, 0.5 A / div.
Lower: V_{DRAIN}, 100 V & 1 ms / div.

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

13.3 Output Voltage Start-up Profile

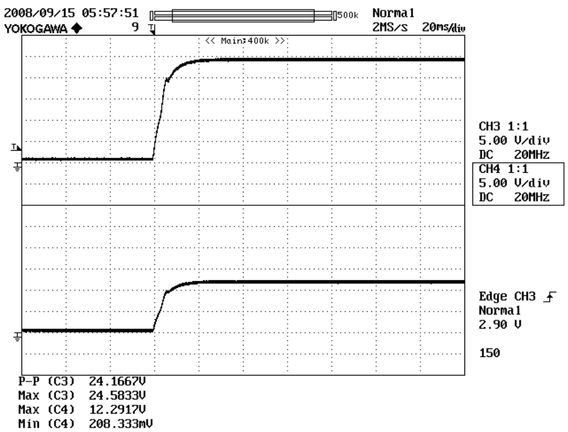


Figure 24 – Start-up Profile, 115 VAC- Main Supply
5 V, 20 ms / div.

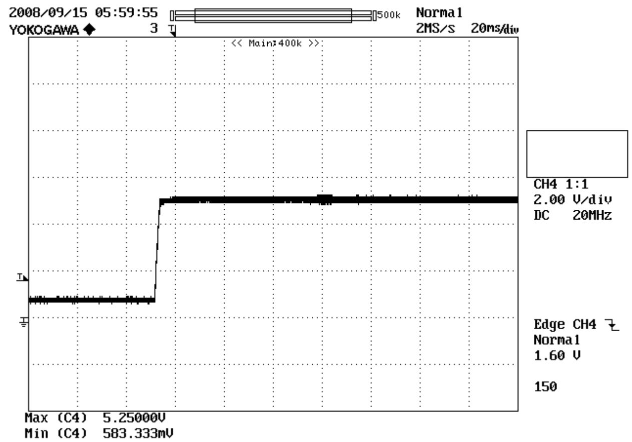


Figure 25 – Start-up Profile, 115 VAC- Standby Supply
2 V, 20 ms / div.

13.4 Load Transient Response (50% to 100% Load Step)

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

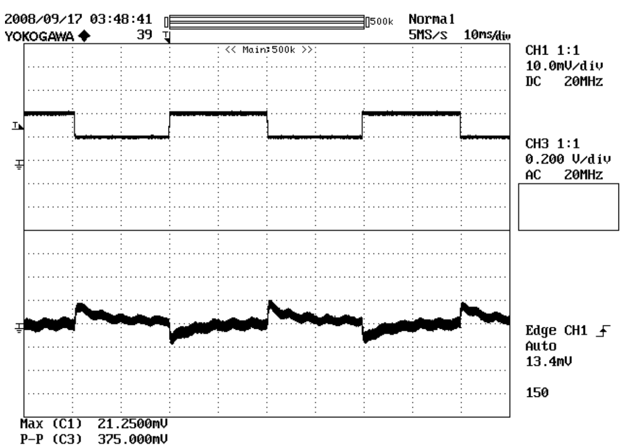


Figure 26 – 24 V Transient Response, 108 V, 50-100-50% Load Step.
Top: Load Current, 2 A/div.
Bottom: Output Voltage
200 mV, 10 mS / div.

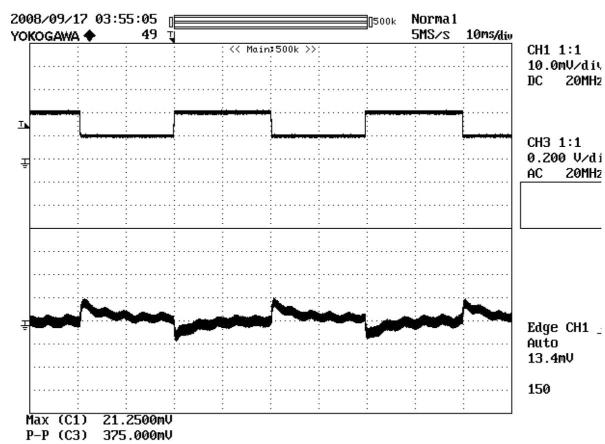


Figure 27 – 24 V Transient Response, 132 V, 50-100-50% Load Step.
Upper: Load Current, 2 A/ div.
Bottom: Output Voltage
200 mV, 10 ms / div.

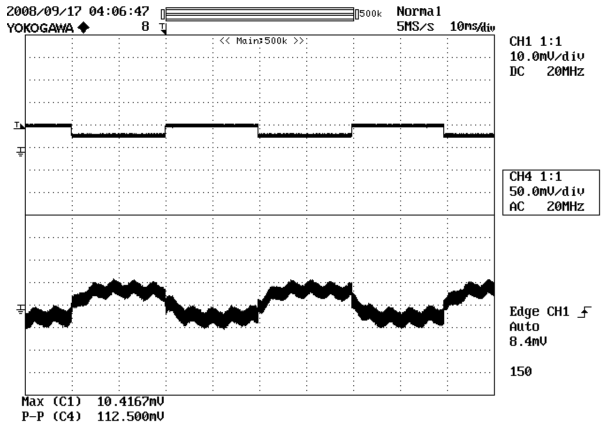


Figure 28 – 12 V Transient Response, 108 V, 50-100-50% Load Step.
Top: Load Current, 2 A/div.
Bottom: Output Voltage
50 mV, 10 ms / div.

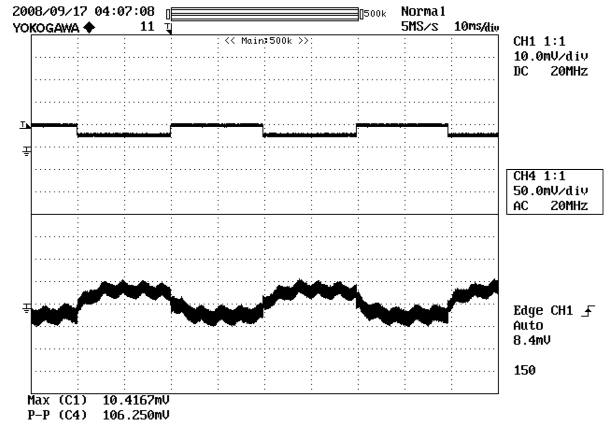


Figure 29 – 12 V Transient Response, 132 V, 50-100-50% Load Step.
Upper: Load Current, 2 A/ div.
Bottom: Output Voltage
50 mV, 10 ms / div.

13.5 Hold-up Time

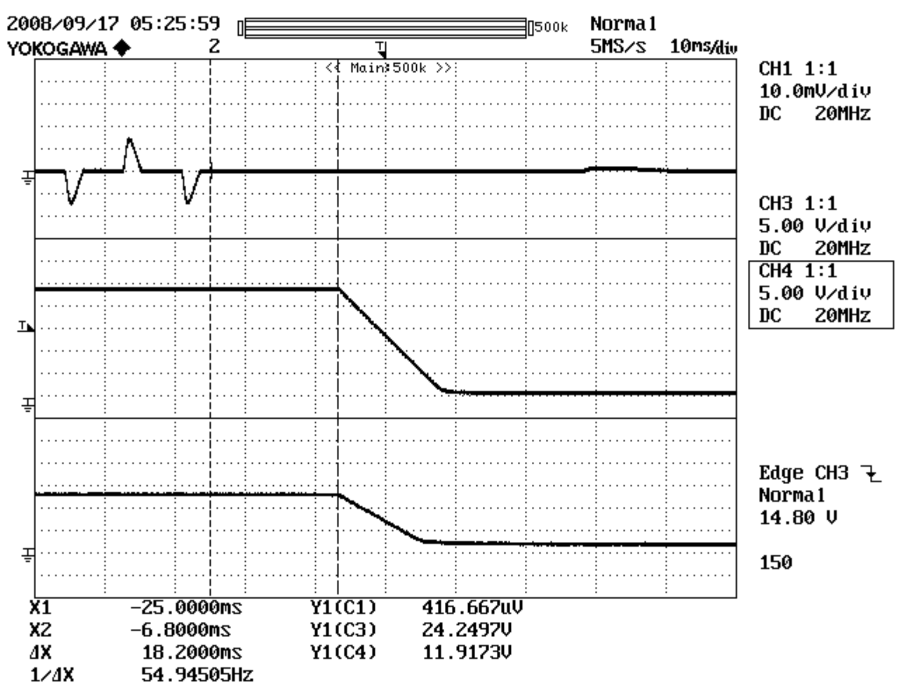


Figure 30 – Hold up Time at 100 VAC with Maximum Load From Removal of AC Supply to Output Starts Losing Regulation.

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

13.6 Over-voltage Protection

The UUT loaded at minimum during the overvoltage event.

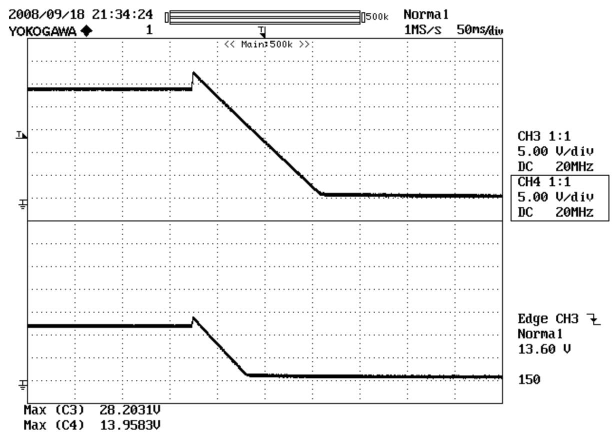


Figure 31 – Output Voltages 24 V and 12 V Shutdown and Latched During an Overvoltage Event.

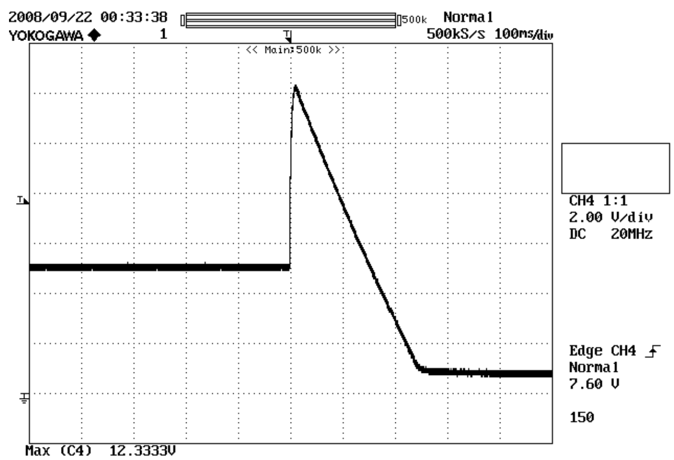


Figure 32 – Output Voltage 5 V SB Shutdown and Latched During an Overvoltage Event.

13.7 Short Circuit Protection

Test item	24 V	12 V	5 VSB	Remark
Output short circuit	Auto-restart	Auto-restart	Auto-restart	Pass

14 Output Ripple Measurements

14.1.1 Ripple Measurement Technique

For DC output ripple measurements, use a modified oscilloscope test probe to reduce spurious signals. Details of the probe modification are provided in the figures below.

Tie two capacitors in parallel across the probe tip of the 4987BA probe adapter. Use a 0.1 µF/50 V ceramic capacitor and a 1.0 µF/50 V aluminum-electrolytic capacitor. The aluminum-electrolytic capacitor is polarized, so always maintain proper polarity across DC outputs (see below).

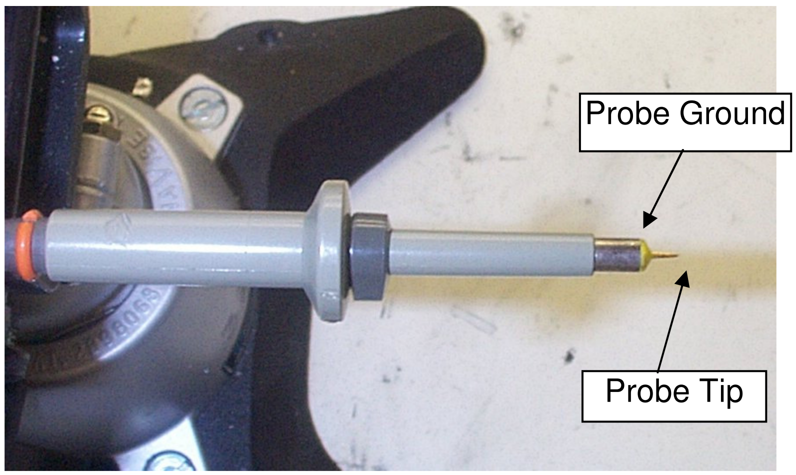


Figure 33 – Oscilloscope Probe Prepared for Ripple Measurement. (End Cap and Ground Lead Removed)

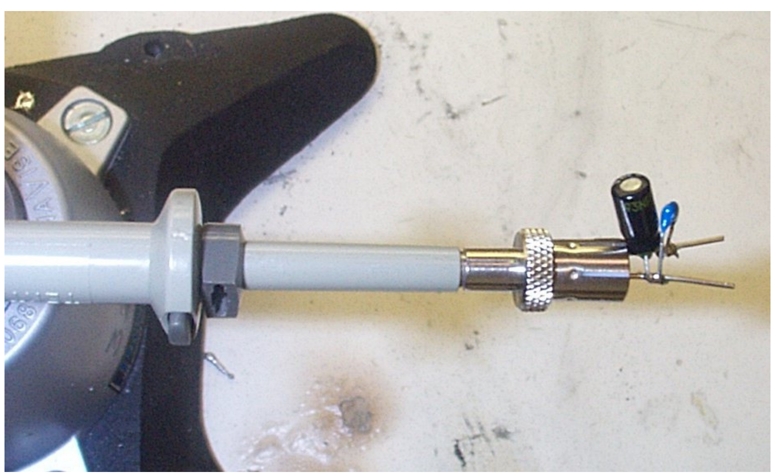


Figure 34 – Oscilloscope Probe with Probe Master (**www.probemaster.com**) 4987A BNC Adapter. (Modified with wires for ripple measurement, and two parallel decoupling capacitors added)

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

14.1.2 Measurement Results

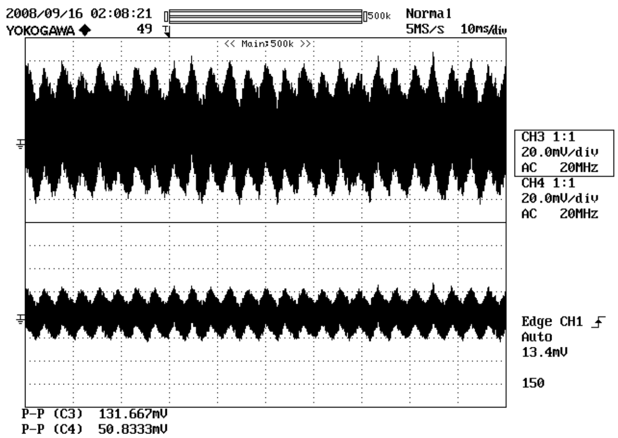


Figure 35 – CH3: 24 V / CH4: 12 V Ripple, 108 VAC, Full Load. 10 ms, 20 mV / div.

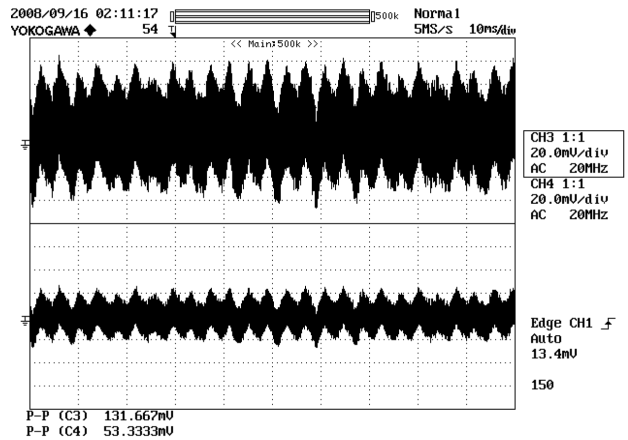


Figure 36 – CH3: 24 V / CH4: 12 V Ripple, 132 VAC, Full Load. 10 ms, 20 mV / div.

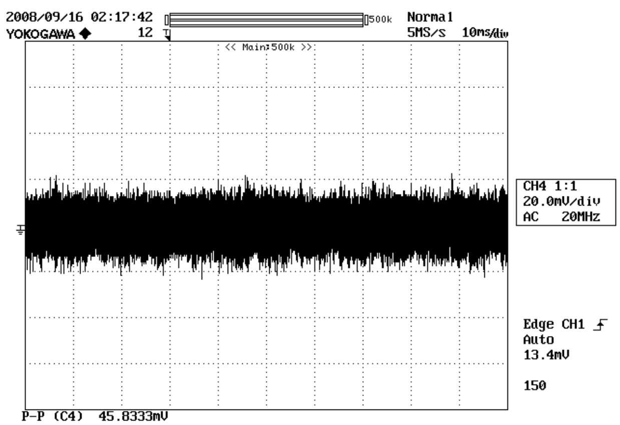


Figure 37 – 5 V SB Ripple, 108 VAC, Full Load. 10 ms, 20 mV /div.

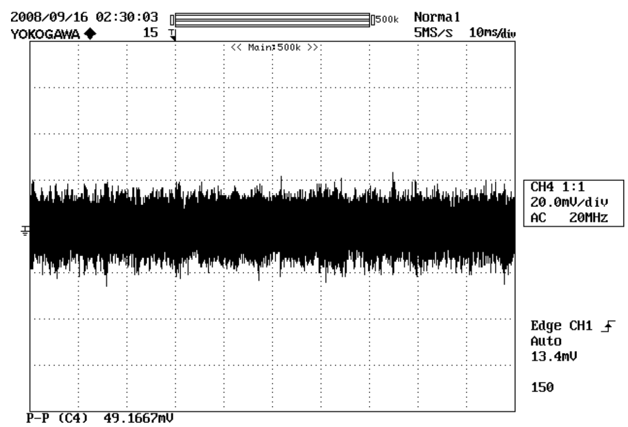


Figure 38 – 5 V SB Ripple, 132 VAC, Full Load. 10 ms, 20 mV /div.

15 Control Loop Measurements

Equipment: Venable 350 System; 5060A Frequency Response Analyzer

15.1 115 VAC Maximum Load on 24 V and 12 V

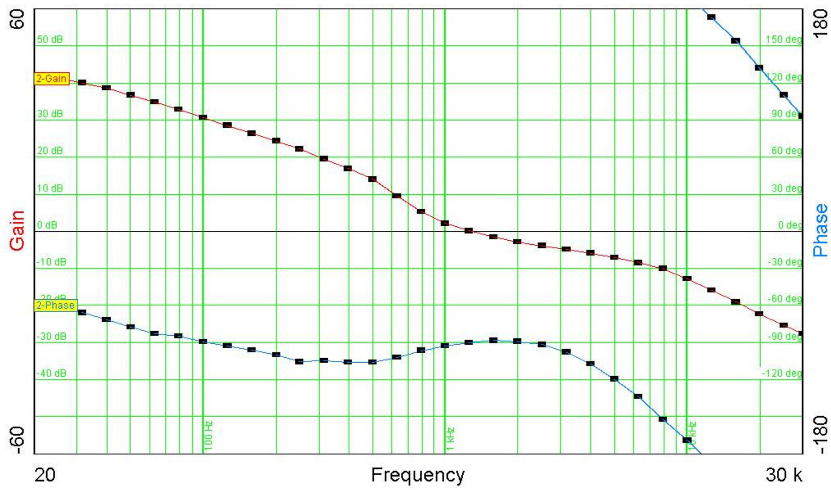


Figure 39 – Gain-Phase Plot, 115 VAC, 24V / 12V Maximum Steady State Load
Vertical Scale: Gain = 10 dB/div, Phase = 30 °/div.
Crossover Frequency = 1.3 kHz Phase Margin = 90°

15.2 115 VAC Minimum Load on 24 V and 12 V

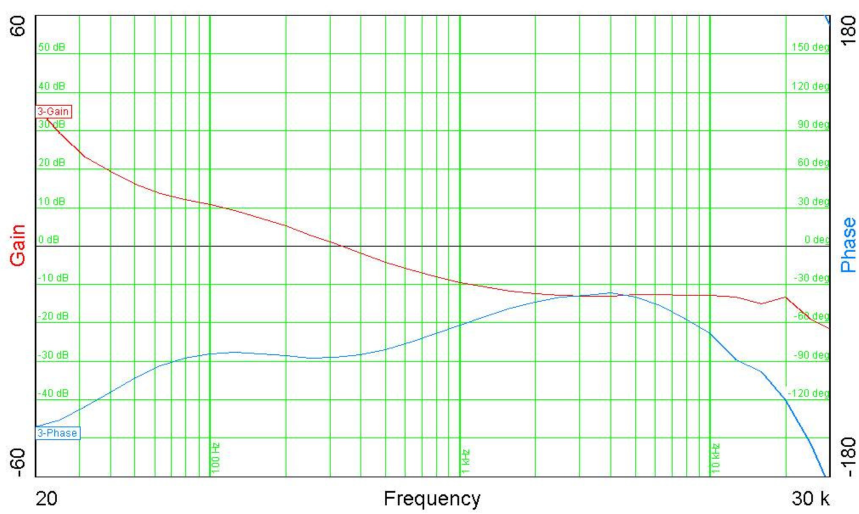


Figure 40 – Gain-Phase Plot, 115 VAC, 24V / 12V Minimum Steady State Load
Vertical Scale: Gain = 10 dB/div, Phase = 30 °/div.
Crossover Frequency = 0.35 kHz Phase Margin = 95°

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

16 Conducted EMI

Unit was running for 15 minutes to warm up before taking the measurements.
Load: 6 Ω at 24 V output; 6 Ω at 12 V output; 2.5 Ω at 5 V SB.

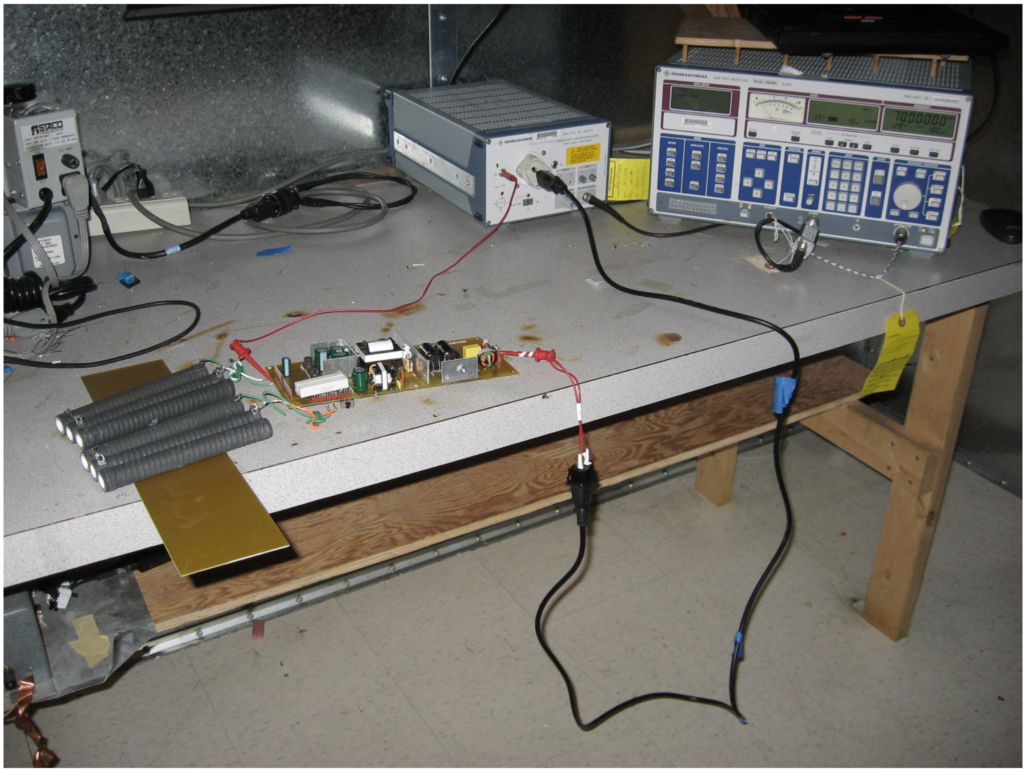


Figure 41 – EMI Set-up.

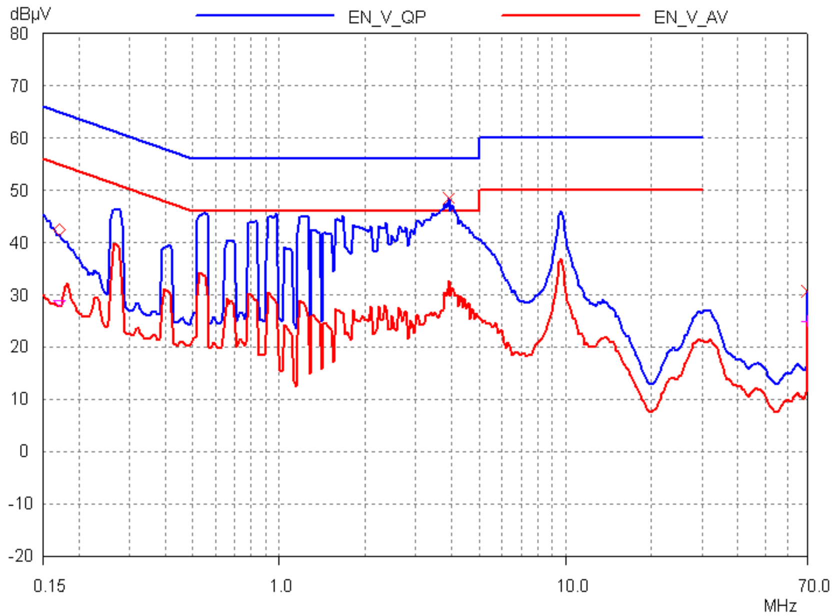


Figure 42 – Conducted EMI, Maximum Steady State Load, 115 VAC, 60 Hz, and EN55022 B Limits. Output Ground was Connected to the PE Terminal of the LISN.

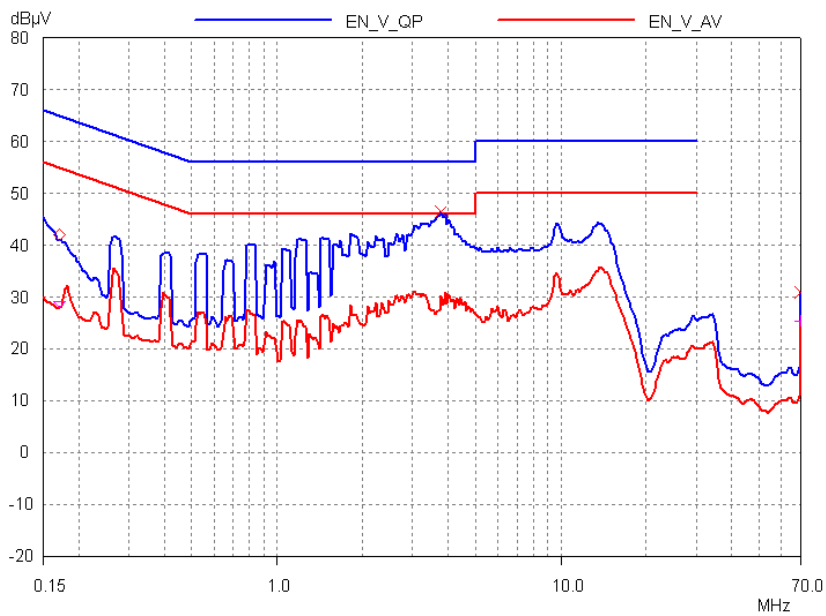


Figure 43 – Conducted EMI, Maximum Steady State Load, 230 VAC, 60 Hz, and EN55022 B Limits. Output Ground was not Connected to the PE Terminal of the LISN.

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

17 Revision History

Date	Author	Revision	Description & changes	Reviewed
10-Mar-09	Apps	1.3	Initial Release	Apps, Mktg
20-Apr-09	Mktg	1.4	Added SUPER LIPS information to page 4.	Apps, Mktg

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

Power Integrations Worldwide Sales Support Locations

WORLD HEADQUARTERS
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

GERMANY
Rueckertstrasse 3
D-80336, Munich
Germany
Phone: +49-89-5527-3911
Fax: +49-89-5527-3920
e-mail: eurosales@powerint.com

JAPAN
Kosei Dai-3 Bldg.,
2-12-11, Shin-Yokohama,
Kohoku-ku, Yokohama-shi,
Kanagawa 222-0033
Phone: +81-45-471-1021
Fax: +81-45-471-3717
e-mail: japansales@powerint.com

TAIWAN
5F, No. 318, Nei Hu Rd., Sec. 1
Nei Hu Dist.
Taipei, Taiwan 114, R.O.C.
Phone: +886-2-2659-4570
Fax: +886-2-2659-4550
e-mail: taiwansales@powerint.com

CHINA (SHANGHAI)
Rm 1601/1610, Tower 1,
Kerry Everbright City
No. 218 Tianmu Road West,
Shanghai, P.R.C. 200070
Phone: +86-21-6354-6323
Fax: +86-21-6354-6325
e-mail: chinasales@powerint.com

INDIA
#1, 14th Main Road
Vasanthanagar
Bangalore-560052 India
Phone: +91-80-41138020
Fax: +91-80-41138023
e-mail: indiasales@powerint.com

KOREA
RM 602, 6FL
Korea City Air Terminal B/D,
159-6
Samsung-Dong, Kangnam-Gu,
Seoul, 135-728, Korea
Phone: +82-2-2016-6610
Fax: +82-2-2016-6630
e-mail: koreasales@powerint.com

UNITED KINGDOM
1st Floor, St. James's House
East Street, Farnham
Surrey, GU9 7TJ
United Kingdom
Phone: +44 (0) 1252-730-141
Fax: +44 (0) 1252-727-689
e-mail: eurosales@powerint.com

CHINA (SHENZHEN)
Rm A, B & C 4th Floor, Block C,
Electronics Science and
Technology Building, 2070
Shennan Zhong Rd,
Shenzhen, Guangdong,
China, 518031
Phone: +86-755-8379-3243
Fax: +86-755-8379-5828
e-mail: chinasales@powerint.com

ITALY
Via De Amicis 2
20091 Bresso MI – Italy
Phone: +39-028-928-6000
Fax: +39-028-928-6009
e-mail: eurosales@powerint.com

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

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

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