DESIGN EXAMPLE REPORT

Title	***Ultra-low Profile (15.4 mm) 65 W Adapter Using TOP261LN***
Specification	90 – 265 VAC Input; 19.7 V, 3.33 A Output
Application	Notebook Computer
Author	Applications Engineering Department
Document Number	DER-196
Date	April 20, 2009
Revision	3.0

Summary and Features

- Low cost, low component count
- Very compact design in a 15.4 mm thin case
- Very low no-load input power (<250 mW at 230 VAC)
- Meets Energy Star 2.0 Efficiency Requirements: >88% at 115 V / 60 Hz, and 230 V / 50 Hz, with very high efficiency in both standby and sleep modes
- Excellent transient load response
- Hysteretic thermal overload protection with automatic recovery
- Latching OVP with fast AC reset
- Meets limited power source requirements (<100 VA) with single point failure
- Power Integrations eSIP low-profile package
- Ultra-low profile transformer bobbin design (PI proprietary SLIMCORE™)
- No potting required to meet thermal specifications
- Meets radiated EMI with > -6dB margin

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.

1 Introduction

This engineering report describes a notebook adapter power supply demonstration board employing the TOPSwitch-HX TOP261LN. This power supply operates from a universal input and provides a 19.7 V, continuous 65 W output.

TOPSwitch-HX maintains constant efficiency across a very wide load range without needing special operating modes for specific load thresholds. This optimizes performance for existing and emerging energy efficiency regulations, such as 1 W standby, 1.7 W and 2.4 W sleep modes, and the Energy Star 2.0 >87% average-efficiency requirements. The constant efficiency delivered by the TOPSwitch products to meet the average-efficiency requirements ensures design optimization for future energy efficiency regulation changes without redesign.

This power supply offers these various protection features:

- Overvoltage protection (OVP) with latching shutdown and fast AC reset
- Primary-side sensed output overload protection, even with a single fault
- Latching open-loop protection with fast AC reset
- Auto-restart overload protection with fast AC reset
- Auto-restart during brownout or line sags
- Accurate thermal overload protection with auto-recovery using a large hysteresis

This document provides complete design information including the specifications, the schematic, and bill of materials for this power supply design. Performance results including regulation, efficiency, standby, transient load, power-limit data, and conducted EMI test results are provided as well.

Figure 1 – Top View: 65 W Adapter Power Supply in Plastic Case (60 mm x 119 mm x 15.4 mm).

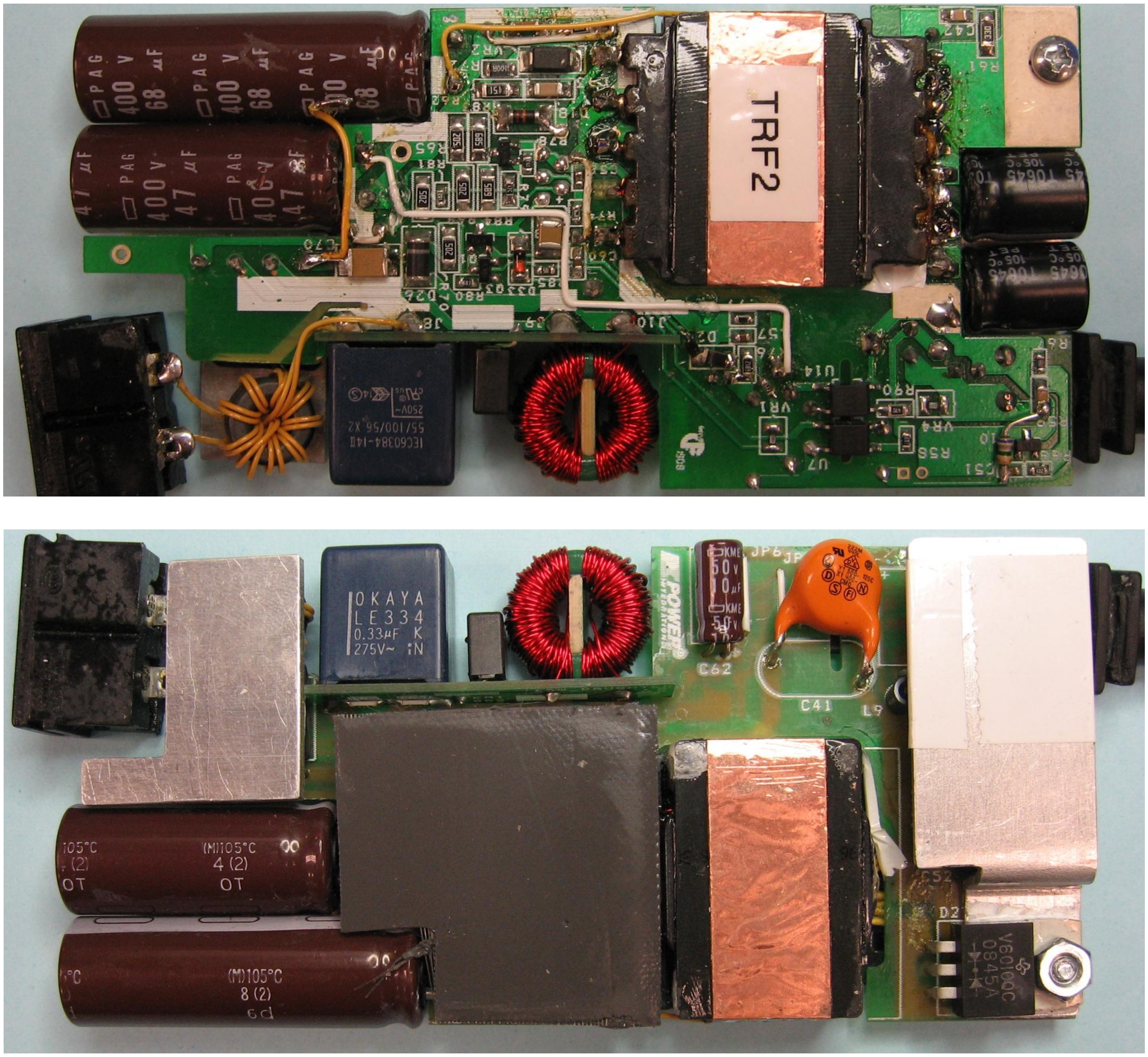


Figure 2 – Top and Bottom View: 65 W Adapter Power Supply.

Figure 3 – Photograph of Assembled Unit with Heat Spreader in Place.

2 Power Supply Specification

Description	Min.	Typ.	Max.	Unit	Notes
Input					2 Wire Input
Voltage	90	115/230	265	VAC	
Frequency	47	50/60	63	Hz	
Output					
Output Voltage 1	18.5	19.5	20.5	V	
Output Ripple Voltage 1			350	mV	20 MHz bandwidth
Output Current 1	0	3.33		A	
Total Output Power		65		W	
Efficiency					
No-Load Input Power			300	mW	
Full Load Efficiency	85			%	65 W, 115/230 VAC
Average Efficiency	87			%	115/230 V; ES 2.0
Sleep Mode Efficiency					
Output Efficiency	64%			W	P_{IN} = 1 W at 230 VAC
Output Efficiency	71%			W	P_{IN} = 1.7 W at 230 VAC
Output Efficiency	77%			W	P_{IN} = 2.4 W at 230 VAC
Standby Efficiency	83%			%	10% output load
Environmental					
Conducted EMI	Designed to meet EN55022B				RTN connected to PE
Safety	Designed to meet IEC950, Class II				
Surge Differential	1			kV	IEC 61000-4-5, 2/12 Ω generator impedance
Surge Common Mode	2			kV	
ESD Air Discharge			±15	kV	
ESD Contact Discharge			±8	kV	
Ambient Temperature	0		40	℃	Power supply ambient
Miscellaneous					
Startup Time			3	s	AC applied to outputs in regulation
Output Rise Time			50	ms	10% to 90% of steady state output
Holdup Time	10			ms	65 W, 90 VAC
AC Reset Time After Latching Shutdown			2	s	AC input is disconnected and reconnected
Overload Latching Shutdown Time	120			ms	>3.5 A load on 24 V output
Over voltage protection			24	V	No load
Over power protection			<100	VA	Auto-restart
Dynamic step load (50%-100%-50%)			1.8	V_{P-P}	

3 Schematic

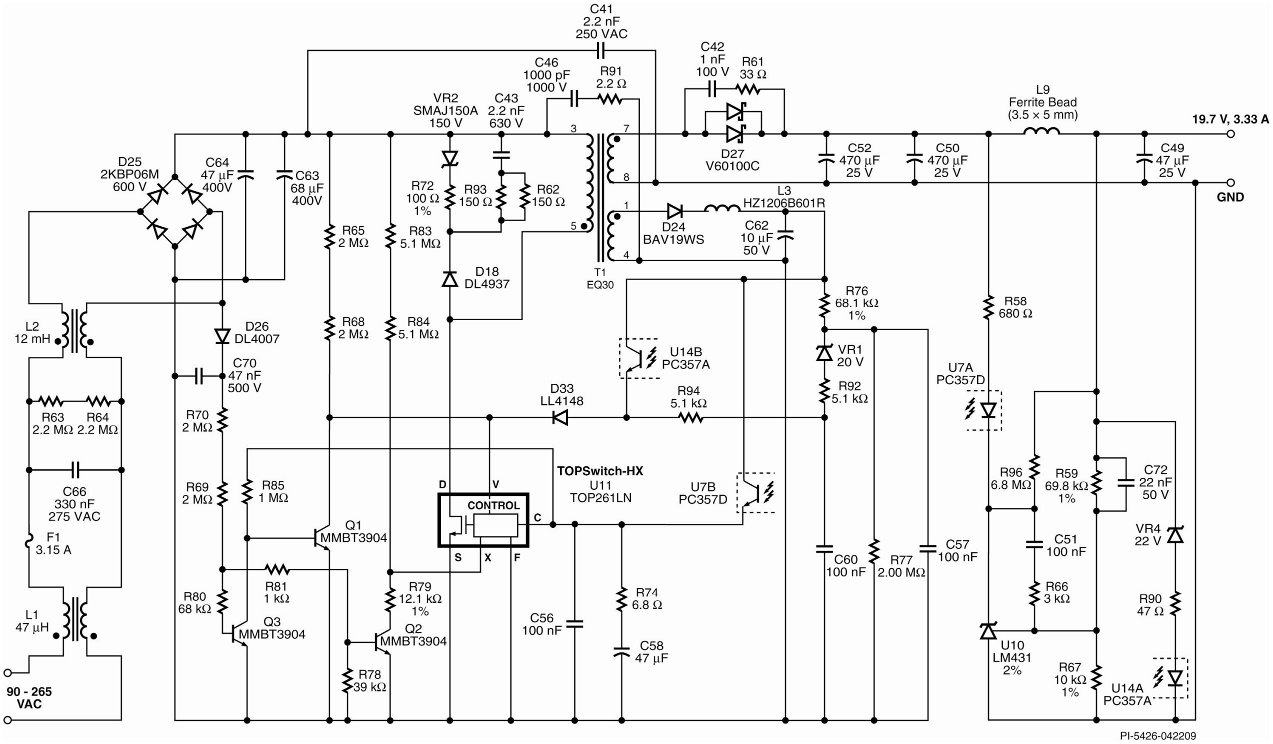


Figure 4 – Schematic.

4 Bill of Materials

Item	Qty	Ref Des	Description	Mfg Part Number	Mfg
1	1	C41	2.2 nF, Ceramic, Y1	440LD22-R	Vishay
2	1	C42	1 nF, 100 V, Ceramic, X7R, 0805	ECJ-2VB2A102K	Panasonic
3	1	C43	2.2 nF, 630 V, Ceramic, X7R, 1206	ECJ-3FBJ222K	Panasonic
4	1	C46	1000 pF, 50 V, Ceramic, X7R, 1206	ECJ-3FB2J102K	Panasonic
5	1	C49	47 μF, 25 V, Electrolytic, Very Low ESR, 300 mΩ, (5 x 11)	EKZE250ELL470ME11D	Nippon Chemi-Con
6	2	C50 C52	470 μF, 25 V, Electrolytic, Very Low ESR, 39 mΩ, (10 x 13.5)	25VZLH47010X12.5	Rubycon
7	4	C51 C56 C57 C60	100 nF 25 V, Ceramic, X7R, 0603	ECJ-1VB1E104K	Panasonic
8	1	C58	47 μF, 10 V, Tantalum Electrolytic, B Case, SMD	T491B476M010AS	Kemet
9	1	C62	10 μF, 50 V, Electrolytic, Gen Purpose, (5 x 11)	ECA-1HHG100	Panasonic
10	1	C63	68 μF, 400 V, Electrolytic, Low ESR, (12.5 x 40)	EPAG401ELL680MK40S	Nippon Chemi-Con
11	1	C64	47 μF, 400 V, Electrolytic, Low ESR, (12.5 x 30)	EPAG401ELL470MK30S	Nippon Chemi-Con
12	1	C66	330 nF, 275 VAC, Film, X2	LE334-M	OKAYA
13	1	C70	47 nF, 500 V, Ceramic, X7R, 1812	VJ1812Y473KXEAT	Vishay
14	1	C72	22 nF, 50 V, Ceramic, X7R, 0805	ECJ-2VB1H223K	Panasonic
15	1	D18	600 V, 1 A, Rectifier, Fast Recovery, MELF (DL-41)	DL4937-13-F	Diodes Inc
16	1	D24	120 V, 0.2 A, Fast Switching, 50 ns, SOD-323	BAV19WS	Diode Inc.
17	1	D25	600 V, 2 A, Bridge Rectifier, Glass Passivated	2KBP06M	Vishay
18	1	D26	1000 V, 1 A, Rectifier, Glass Passivated, DO-213AA (MELF)	DL4007-13-F	Diodes Inc
19	1	D27	100 V, 60 A, Dual Schottky, TO-220AB	V60100C-E3/45	Vishay
20	1	D33	75 V, 0.15 A, Fast Switching, 4 ns, MELF	LL4148-13	Diode Inc.
21	1	F1	3.15 A, 250 V, Slow, RST	507-1181	Belfuse
22	1	L1	47 μH, Common Mode Inductor, 4 Pins, Custom Common-mode Choke - refer to Specification of L1		
23	1	L2	12 mH,xA, Ferrite Toroid, 4 Pin, Custom Common-mode Choke - refer to Specification of L2		
24	1	L3	Ferrite bead 600 Ω, 0.5 A	HZ1206B601R or HZ1206E601R-00	Steward
25	1	L9	3.5 mm X 5 mm, 213Ω at 10MHz, 24AWG Hole, Ferrite Bead		Fair-Rite
26	3	Q1 Q2 Q3	NPN, Small Signal BJT, 40 V, 0.2 A, SOT-23	MMBT3904	Vishay
27	1	R58	680 Ω, 5%, 1/8 W, Metal Film, 0805	ERJ-6GEYJ681V	Panasonic
28	1	R59	69.8 kΩ, 1%, 1/8 W, Metal Film, 0805	ERJ-6ENF6982V	Panasonic
29	1	R61	33 Ω, 5%, 1/4 W, Metal Film, 1206	ERJ-8GEYJ330V	Panasonic
30	2	R62 R93	150 Ω, 5%, 1/4 W, Metal Film, 1206	ERJ-8GEYJ151V	Panasonic
31	2	R63 R64	2.2 MΩ, 5%, 1/4 W, Metal Film, 1206	ERJ-8GEYJ225V	Panasonic
32	4	R65 R68 R69 R70	2 MΩ, 5%, 1/4 W, Metal Film, 1206	ERJ-8GEYJ205V	Panasonic
33	1	R66	3 kΩ, 5%, 1/10 W, Metal Film, 0603	ERJ-3GEYJ302V	Panasonic
34	1	R67	10 kΩ, 1%, 1/16 W, Metal Film, 0603	ERJ-3EKF1002V	Panasonic
35	1	R72	100 Ω, 1%, 1/4 W, Metal Film, 1206	ERJ-8ENF1000V	Panasonic
36	1	R74	6.8 Ω, 5%, 1/10 W, Metal Film, 0603	ERJ-3GEYJ685V	Panasonic
37	1	R76	68.1 kΩ, 1%, 1/8 W, Metal Film, 0805	ERJ-6ENF6812V	Panasonic

38	1	R77	2.00 MΩ, 1%, 1/16 W, Metal Film, 0603	ERJ-3EKF2004V	Panasonic
39	1	R78	39 kΩ, 5%, 1/10 W, Metal Film, 0603	ERJ-3GEYJ393V	Panasonic
40	1	R79	12.1 kΩ, 1%, 1/16 W, Metal Film, 0603	ERJ-3EKF1212V	Panasonic
41	1	R80	68 kΩ, 5%, 1/10 W, Metal Film, 0603	ERJ-3GEYJ683V	Panasonic
42	1	R81	1 kΩ, 5%, 1/10 W, Metal Film, 0603	ERJ-3GEYJ102V	Panasonic
43	2	R83 R84	5.1 MΩ, 5%, 1/4 W, Metal Film, 1206	ERJ-8GEYJ515V	Panasonic
44	1	R85	1 MΩ, 5%, 1/10 W, Metal Film, 0603	ERJ-3GEYJ105V	Panasonic
45	1	R90	47 Ω, 5%, 1/8 W, Metal Film, 0805	ERJ-6GEYJ470V	Panasonic
46	1	R91	2.2 Ω, 5%, 1/4 W, Metal Film, 1206	ERJ-8GEYJ2R2V	Panasonic
47	2	R92 R94	5.1 kΩ, 5%, 1/10 W, Metal Film, 0603	ERJ-3GEYJ512V	Panasonic
48	1	R96	6.8 MΩ, 5%, 1/8 W, Metal Film, 0805	ERJ-6GEYJ685V	Panasonic
49	1	T1	Custom Transformer, EQ30, 10pins		
50	1	U10	IC, 2.495 V Shunt Regulator, SOT23	LM431AIM3D	National Semiconductor
51	1	U11	TOPSwitch-HX, TOP261LN, eSIP-7C	TOP261EN	Power Integrations
52	1	U14	Optocoupler, 80 V, CTR 4-Mini Flat	PC357N1TJ00F (Type A)	Sharp
53	1	U7	Optocoupler, 80 V, CTR 4-Mini Flat	PC357N3TJ00F (Type D)	Sharp
54	1	VR1	20 V, 5%, 150 mW, SSMINI-2	MAZS2000ML	Panasonic-SSG
55	1	VR2	150 V, 1 W, 11%, DO214AC (SMA)	SMAJ150A-13	Diodes, Inc
56	1	VR4	22 V, 5%, 150 mW, SSMINI-2	MAZS2200ML	Panasonic-SSG

5 Circuit Description

This adapter power supply employs the TOPSwitch TOP261LN (U11), with an integrated high voltage MOSFET and a PWM controller, in a flyback configuration. The TOP261LN regulates the output by adjusting the duty cycle based on the current into its CONTROL (C) pin. The power supply output voltage is sensed on the secondary side by shunt regulator U10 and provides a feedback signal to the primary side through optocoupler U7.

5.1 Energy Efficiency

The EcoSmart® feature of U11 provides constant efficiency over the entire load range. The proprietary Multi-cycle Modulation function automatically achieves this performance, eliminating special operating modes triggered at specific loads, which greatly simplifies circuit design.

5.2 Startup and Power Down

The line-sensing network formed by D26 and C70 provides input voltage information without the long time constant incurred by detecting the voltage across bulk input capacitors C63 and C64. This supports the advanced power up, power down, and reset behaviors provided by U11

5.2.1 Normal Input Voltage Range

While the input voltage is within normal operating range, Q3 pulls the base of Q1 down, keeping Q1 off. The point at which U11 begins to switch is therefore determined by the combination of resistors R65 and R68, and the 25 μA UV threshold of U11's VOLTAGE MONITOR (V) pin. IC U11 switches once current into the V pin exceeds 25 μA (at a line voltage of 100 VDC or approximately 72 VAC). Transistor Q2 provides a defined lower UV threshold that disables U11 when the AC is removed. When Q2 is off the X pin floats, keeping U11 disabled. This prevents output glitches that may otherwise occur due to C83 and C84 discharging when the AC input is cycled to reset U11 after latching shutdown. Resistor divider R70, R69, R81, and R78 determines the point at which Q2 turns on to enable U11 and start operation when the UV threshold at the V pin is exceeded.

5.2.2 AC Loss (Power Down)

During power down, the power supply operates until output regulation is lost and does not restart until the UV threshold is once again exceeded. This prevents glitches on the output during power down.

5.3 Fast AC reset

Once U11 enters latching shutdown, removal of the input AC is necessary to reset U11. Removal of the input AC turns off Q3, turns on Q1, and pulls the V pin below the reset threshold. Reapplying AC at a level to exceed the UV threshold restarts the supply.

5.4 Output Overload Shutdown

This power supply has a time-triggered overload protection function sensed from the primary-side bias winding. During overload the voltage across C62 rises. Once it exceeds approximately 20 V, it triggers the shutdown feature on the V pin. The values of C57, R76, and R77 set the value of the delay, before shutdown is triggered. Change the overload shutdown feature from non-latching to latching by replacing R92 with a resistor greater than 100 Ω.

5.5 Output Power Limiting with Line Voltage

To provide constant output power with varying line voltage, R83, R84, and R79 reduce the internal current limit of U11 as the line voltage increases. This allows the supply to limit the output power to <100 VA at high line and deliver the rated output power at low line.

5.6 Output Over-voltage Protection and Fast AC Reset

Open-loop faults cause the output voltage to rise and exceed the specified maximum value. To keep output voltages below the specified maximum during such fault conditions, a simple latching shutdown is implemented by VR4 and U14. When the output reaches approximately 23 V, U14 conducts and current into the V pin exceeds the latching shutdown current threshold. This shuts down the supply.

Once the power supply goes through the latch-off process, to reset it immediately, cycle the AC input.

5.7 Thermal Overload Protection

IC U11 has an integrated, 100% tested, accurate hysteretic thermal-overload protection feature. If the junction temperature reaches +142 °C (during a fault condition), U11 shuts down. It automatically recovers once the junction temperature has decreased by approximately 75 °C.

6 PCB Layout

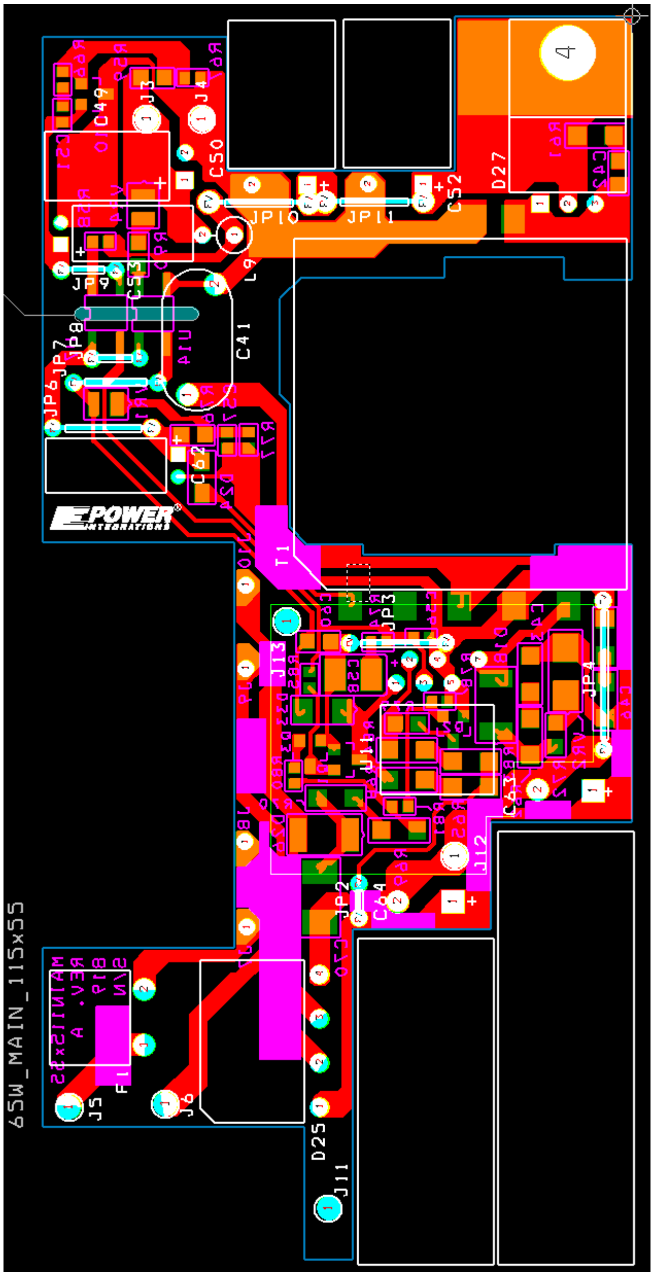


Figure 5 – Power Supply PCB (115 mm x 55 mm).

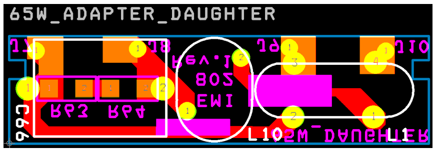


Figure 6 – EMI Filter Daughter Board PCB.

7 Transformer Specifications

7.1 Electrical Diagram

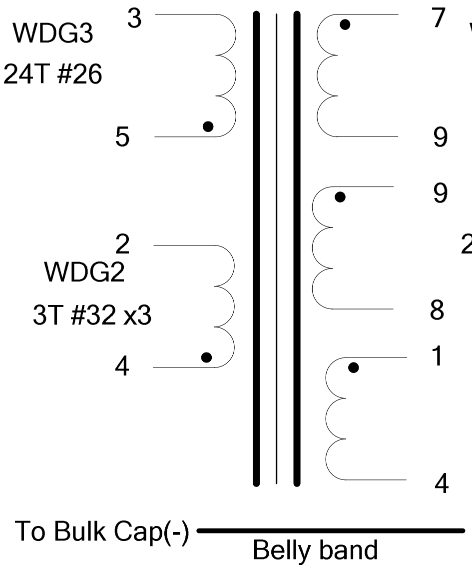


Figure 7 – Transformer Electrical Diagram.

7.2 Electrical Specifications

Electrical Strength	1 minute, 60 Hz, from pins 1 - 5 to pins 6 - 10	3000 VAC
Primary Inductance	Pins 5 - 3, all other windings open, measured at 100 kHz, 0.4 VRMS	375 - 400 µH
Resonant Frequency	Pins 5 - 3, all other windings open	1000 kHz (Min.)
Primary Leakage Inductance	Pins 5 - 3, with pins 6 -10 shorted, measured at 100 kHz, 0.4 VRMS	6 µH (Max.)

7.3 Materials

Item	Description
[1]	Core: 3F35 Ferroxcube EQ30, PLT30/20/3 AL= 4600 nH/T^2 (UNGAPPED)
[2]	Bobbin: PIEQ30 (Power Integrations Slimcore ^{TM} bobbin; PI PN/ 25-00887-00) vertical, 5 – 5 pins
[3]	Magnet Wire: #32 AWG Triple-insulated Wire
[4]	Magnet Wire: #26 AWG
[5]	Magnet Wire: #24 AWG Triple-insulated wire
[6]	Tape: 3M 1298 polyester film, 3.5 mm width
[7]	Tape: Copper foil 2 mil, 10 mm width
[8]	Varnish

7.4 Transformer Build Diagram

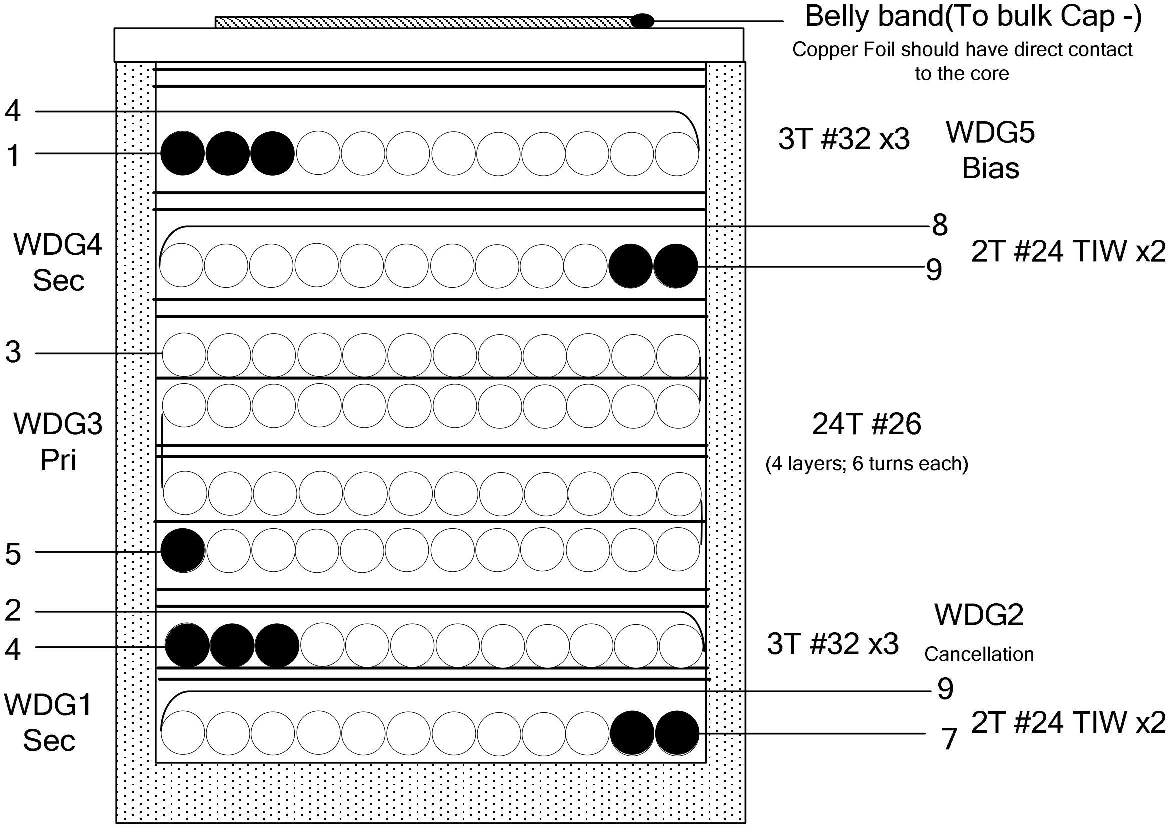


Figure 8 – Transformer Build Diagram.

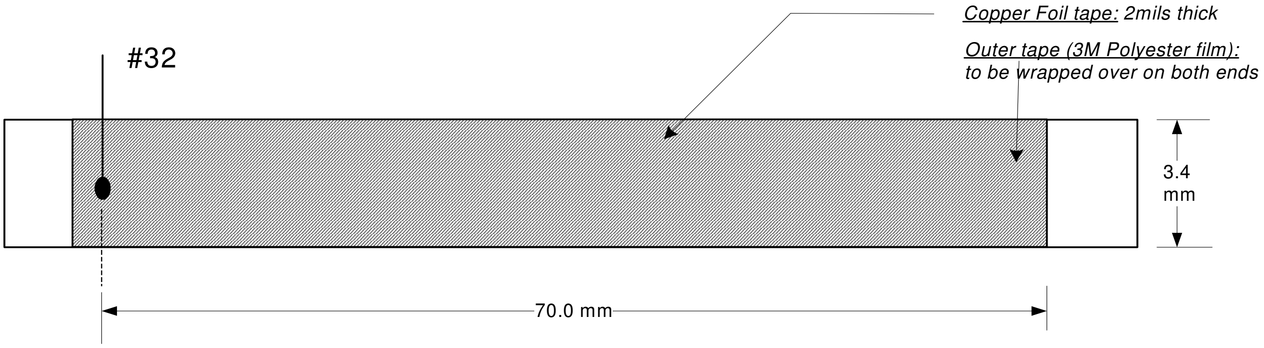


Figure 9 – Shield 1.

7.5 Transformer Construction

Bobbin Preparation	Position the bobbin such that the pins are on the right side of the bobbin chuck. Machine rotates in forward direction.
WDG1 Secondary	Start at pin 7, wind with firm tension 2 turns bifilar of item [5] from right to left. Finish at pin 9.
Insulation	2 Layers of tape [6] for insulation.
WDG 2 Cancellation	Start at pin 4; wind 3 trifilar turns of item [3], with firm tension, from right to left. Finish at pin 2
Insulation	2 Layers of tape [6] for insulation.
WDG3	Start at pin 5; wind with firm tension 6 turns of item [4] from right to left for the 1st layer. Add one layer insulation tape; continue winding remaining 6 turns from left to right for the 2nd layer. Add two layer insulation tape; continue wind with firm tension 6 turns of item [4] from right to left for the 3rd layer. Add one layer insulation tape; continue winding remaining 6 turns from left to right for the 4th layer Finish at pin 3.
Insulation	2 Layers of tape [6] for insulation.
WDG4 Secondary	Start at pin 9, wind with firm tension 2 turns bifilar of item [5] from right to left. Finish at pin 8.
Insulation	2 Layers of tape [6] for insulation.
WDG5 Bias	Start at pin 1; wind 3 trifilar turns of item [3], with firm tension, from right to left. Finish at Pin 4.
Insulation	2 Layers of tape [6] for insulation.
Assemble core	Gap core to meet inductance specification (ALG 657 nH/t^2). Assemble and secure the cores with tape and glue.
Belly Band	Wrap core with item [7], solder wire to the side of the foil. This wire will be terminated to the bulk (-) of capacitor.
Finish	Varnish transformer assembly.
Bobbin Preparation	Position the bobbin such that the pins are on the right side of the bobbin chuck. Machine rotates in forward direction.

7.6 Completed Transformer

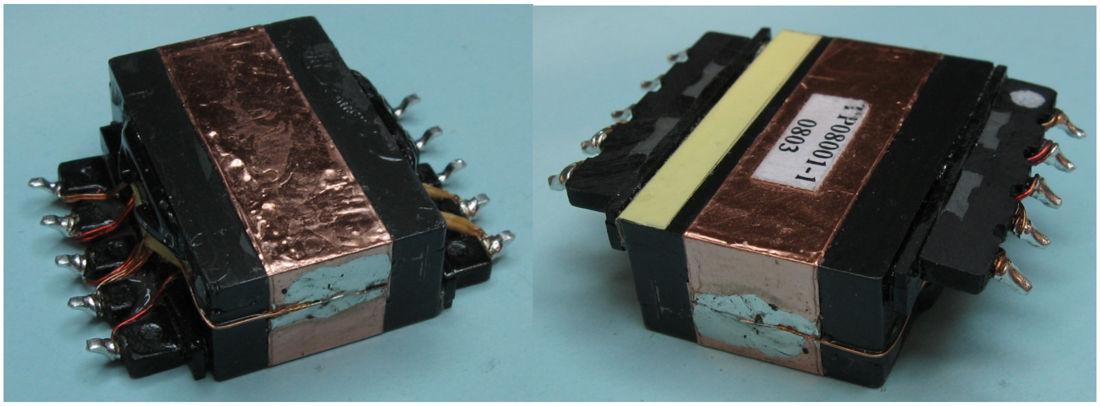


Figure 9 – Completed Transformer; Top (Right) and Bottom (Left) Views.

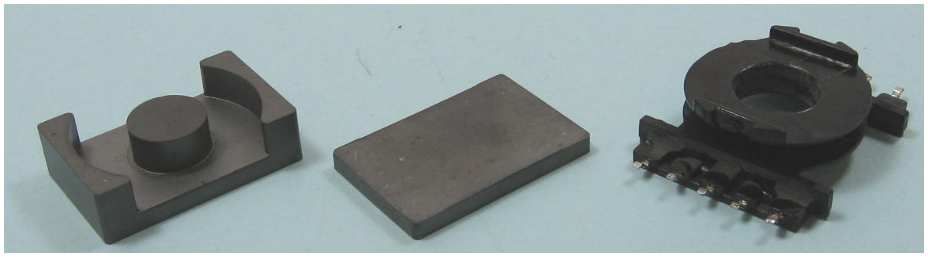


Figure 10 – Transformer Materials Showing EQ30. PLT30 Core, and Ultra-low Profile Wire-wound Bobbin.

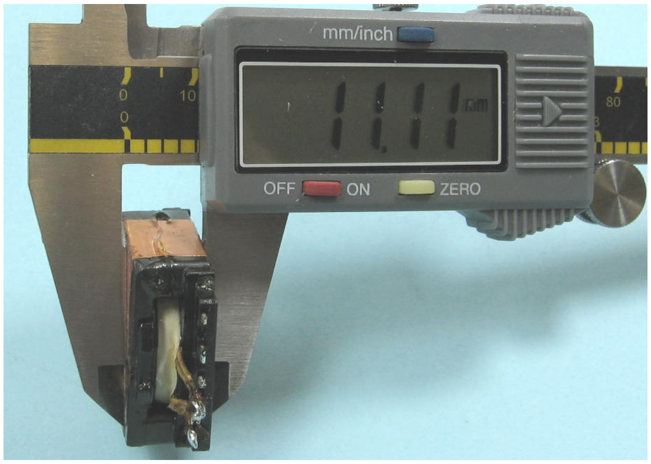


Figure 11 – Measured Height of the Complete Transformer.

7.7 Common-mode Choke Specifications (L1)

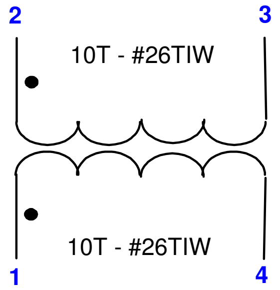


Figure 12 – CMC Electrical Diagram.

7.8 Electrical Specifications

Inductance (LCM)	Pins 1 - 4 or 2 - 3. measured at 100 kHz	47 µH ±10%
Leakage (LL)	Pins 1 - 4 with pins 2 - 3 shorted or versa at 100 kHz	0.5 µH (max) ±20%
Core Effective Inductance		460 nH/N²

7.9 Materials

Item	Description
[1]	Toroid Core: K5B T10X5X5 (King Core); PI P/N 32-00086-00
[2]	Magnet Wire: #26 AWG, Triple-insulated Wire.

7.10 Winding Instructions

- Use 1 ft of item [2], start at pin 1 and 2 wind 10 turns end at pin 4 and 3.

7.11 Illustrations

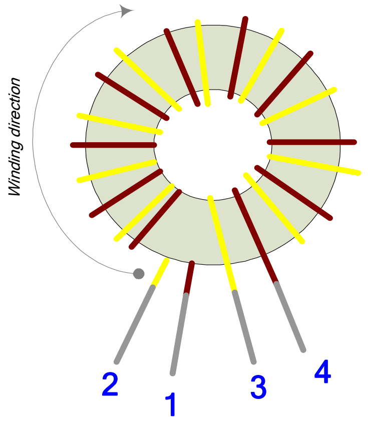


Figure 13 – CMC Build Illustration.

7.12 Common-mode Choke Specifications (L2)

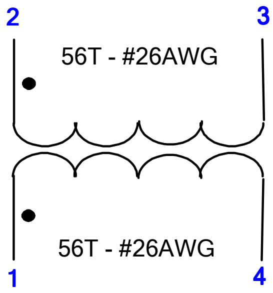


Figure 14 – CMC Electrical Diagram.

7.13 Electrical Specifications

Inductance (LCM)	Pins 1 - 4 or 2 - 3. measured at 100 kHz	12 mH ±10%
Leakage (LL)	Pins 1 - 4 with pins 2 - 3 shorted or versa at 100 kHz	80 µH (max) ±20%
Core Effective Inductance		3795 nH/N²

7.14 Materials

Item	Description
[1]	Toroid Core: MN-ZN T14X9X5 R10K U1000; Dimension: OD:14.35 mm/ID:7.5 mm/ HT:5.3 mm
[2]	Magnet Wire: #26 AWG, Heavy Nyleze

7.15 Winding Instructions

- Use 4 ft of item [2], start at pin 1 wind 56 turns end at pin 4.
- Do the same for another half of Toroid, start at pin 2 and end at pin 3.

7.16 Illustrations

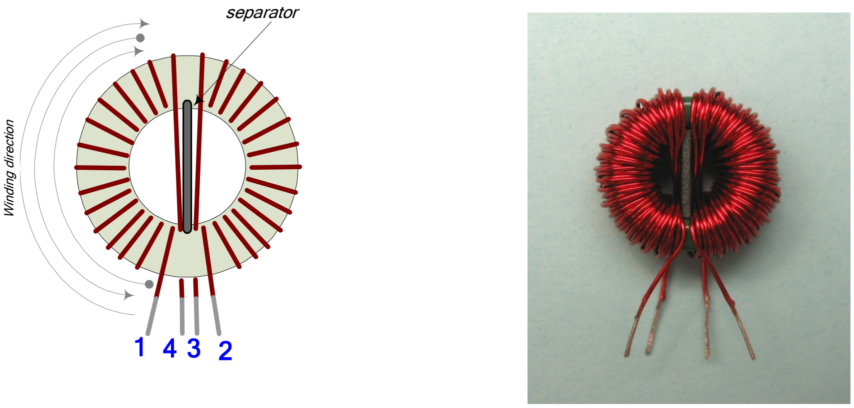


Figure 15 – CMC Build Illustration.

8 Transformer Design Spreadsheet

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					
VACMIN	90			Volts	Minimum AC Input Voltage
VACMAX	265			Volts	Maximum AC Input Voltage
fL	50			Hertz	AC Mains Frequency
VO	19.50			Volts	Output Voltage (main)
PO_AVG	65.00			Watts	Average Output Power
PO_PEAK	65.00		65.00	Watts	Peak Output Power
n	0.85			%/100	Efficiency Estimate
Z	0.50				Loss Allocation Factor
VB	15			Volts	Bias Voltage
tC	3.00			mSeconds	Bridge Rectifier Conduction Time Estimate
CIN	115.0		115	uFarads	Input Filter Capacitor
ENTER TOPSWITCH-HX VARIABLES					
TOPSwitch-HX	**TOP261LN**			Universal / Peak	115 Doubled/230V
Chosen Device		*TOP261LN*	Power Out	254 W / 254 W	333W
KI	0.32				External Ilimit reduction factor (KI=1.0 for default ILIMIT, KI <1.0 for lower ILIMIT)
ILIMITMIN_EXT			2.202	Amps	Use 1% resistor in setting external ILIMIT
ILIMITMAX_EXT			2.534	Amps	Use 1% resistor in setting external ILIMIT
Frequency (F)=132kHz, (H)=66kHz	**F**		F		Select 'H' for Half frequency – 66 kHz, or 'F' for Full frequency – 132 kHz
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	120.00			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	0.55				Ripple-to-Peak Current Ratio (0.3 < KRP < 1.0 : 1.0 < KDP < 6.0)

PROTECTION FEATURES					
LINE SENSING					
VUV_STARTUP			101	Volts	Minimum DC Bus Voltage at which the power supply will start-up
VOV_SHUTDOWN			490	Volts	Typical DC Bus Voltage at which power supply will shut-down (Max)
RLS			4.4	M-ohms	Use two standard, 2.2 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			1.07		Margin to current limit at low line.
ILIMIT_EXT_VMIN			2.04	A	Peak primary Current at VMIN
ILIMIT_EXT_VMAX			1.89	A	Peak Primary Current at VMAX
RIL			17.14	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	Auto		EI30		Core Type
Core		*EQ30*		*P/N:*	PC40EI30-Z
Bobbin		*EQ30_BOBBIN*		*P/N:*	BE-30-1112CP
AE	1.0800		1.08	cm^2	Core Effective Cross Sectional Area
LE	3.6200		3.62	cm	Core Effective Path Length
AL	4600.0		4600	nH/T^2	Ungapped Core Effective Inductance
BW	3.5		3.5	mm	Bobbin Physical Winding Width
M	0.00			mm	Safety Margin Width (Half the Primary to Secondary Creepage Distance)
L	4.00				Number of Primary Layers
NS	4		4		Number of Secondary Turns

DC INPUT VOLTAGE PARAMETERS					
VMIN			83	Volts	Minimum DC Input Voltage
VMAX			375	Volts	Maximum DC Input Voltage

CURRENT WAVEFORM SHAPE PARAMETERS

DMAX		0.62		Maximum Duty Cycle (calculated at PO_PEAK)
IAVG		0.92	Amps	Average Primary Current (calculated at average output power)
IP		2.04	Amps	Peak Primary Current (calculated at Peak output power)
IR		1.12	Amps	Primary Ripple Current (calculated at average output power)
IRMS		1.20	Amps	Primary RMS Current (calculated at average output power)

TRANSFORMER PRIMARY DESIGN PARAMETERS

LP		378	uHenries	Primary Inductance
LP Tolerance	6	6		Tolerance of Primary Inductance
NP		24		Primary Winding Number of Turns
NB		3		Bias Winding Number of Turns
ALG		657	nH/T^2	Gapped Core Effective Inductance
BM		2983	Gauss	Maximum Flux Density at PO, VMIN (BM<3000)
BP		3920	Gauss	Peak Flux Density (BP<4200) at ILIMITMAX and LP_MAX. Note: Recommended values for adapters and external power supplies <=3600 Gauss
BAC		820	Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
ur		1227		Relative Permeability of Ungapped Core
LG		0.18	mm	Gap Length (Lg > 0.1 mm)
BWE		14	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		24	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CM		406	Cmils	Bare conductor effective area in circular mils
CMA		340	Cmils/Amp	Primary Winding Current Capacity (200 < CMA < 500)
Primary Current Density (J)		5.84	Amps/mm^2	Primary Winding Current density (3.8 < J < 9.75)

TRANSFORMER SECONDARY DESIGN PARAMETERS (SINGLE OUTPUT EQUIVALENT)

Lumped parameters

ISP		12.26	Amps	Peak Secondary Current
ISRMS		5.60	Amps	Secondary RMS Current
IO_PEAK		3.33	Amps	Secondary Peak Output Current

IO	3.33	Amps	Average Power Supply Output Current
IRIPPLE	4.50	Amps	Output Capacitor RMS Ripple Current
CMS	1119	Cmils	Secondary Bare Conductor minimum circular mils
AWGS	19	AWG	Secondary Wire Gauge (Rounded up to next larger standard AWG value)
DIAS	0.91	mm	Secondary Minimum Bare Conductor Diameter
ODS	0.88	mm	Secondary Maximum Outside Diameter for Triple Insulated Wire
INSS	-0.02	mm	Maximum Secondary Insulation Wall Thickness

VOLTAGE STRESS PARAMETERS			
VDRAIN	611	Volts	Maximum Drain Voltage Estimate (Includes Effect of Leakage Inductance)
PIVS	82	Volts	Output Rectifier Maximum Peak Inverse Voltage
PIVB	64	Volts	Bias Rectifier Maximum Peak Inverse Voltage

TRANSFORMER SECONDARY DESIGN PARAMETERS (MULTIPLE OUTPUTS)				
1st output				
VO1		19.5	Volts	Output Voltage
IO1_AVG		3.33	Amps	Average DC Output Current
PO1_AVG		65.00	Watts	Average Output Power
VD1		0.5	Volts	Output Diode Forward Voltage Drop
NS1		4.00		Output Winding Number of Turns
ISRMS1		5.597	Amps	Output Winding RMS Current
IRIPPLE1		4.50	Amps	Output Capacitor RMS Ripple Current
PIVS1		82	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS1		1119	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		0.88	mm	Maximum Outside Diameter for Triple Insulated Wire

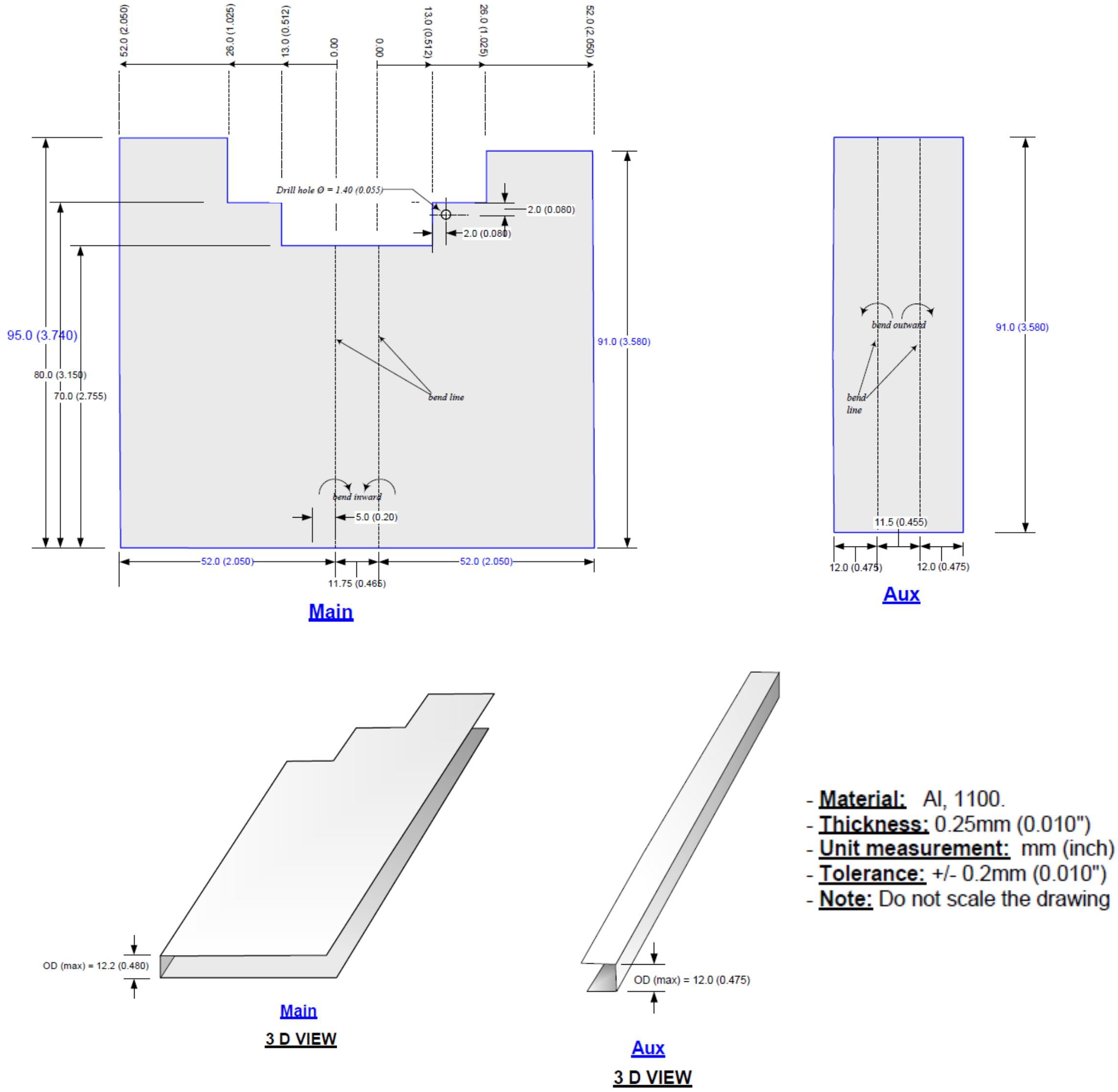
Total Continuous Output Power		65	Watts	Total Continuous Output Power
Negative Output		N/A		If negative output exists enter Output number; eg: If VO2 is negative output, enter 2

Table 1 – Transformer Design Spreadsheet.

9 Mechanical Drawings

The following mechanical drawings are for the custom mechanical designs used in this power supply.

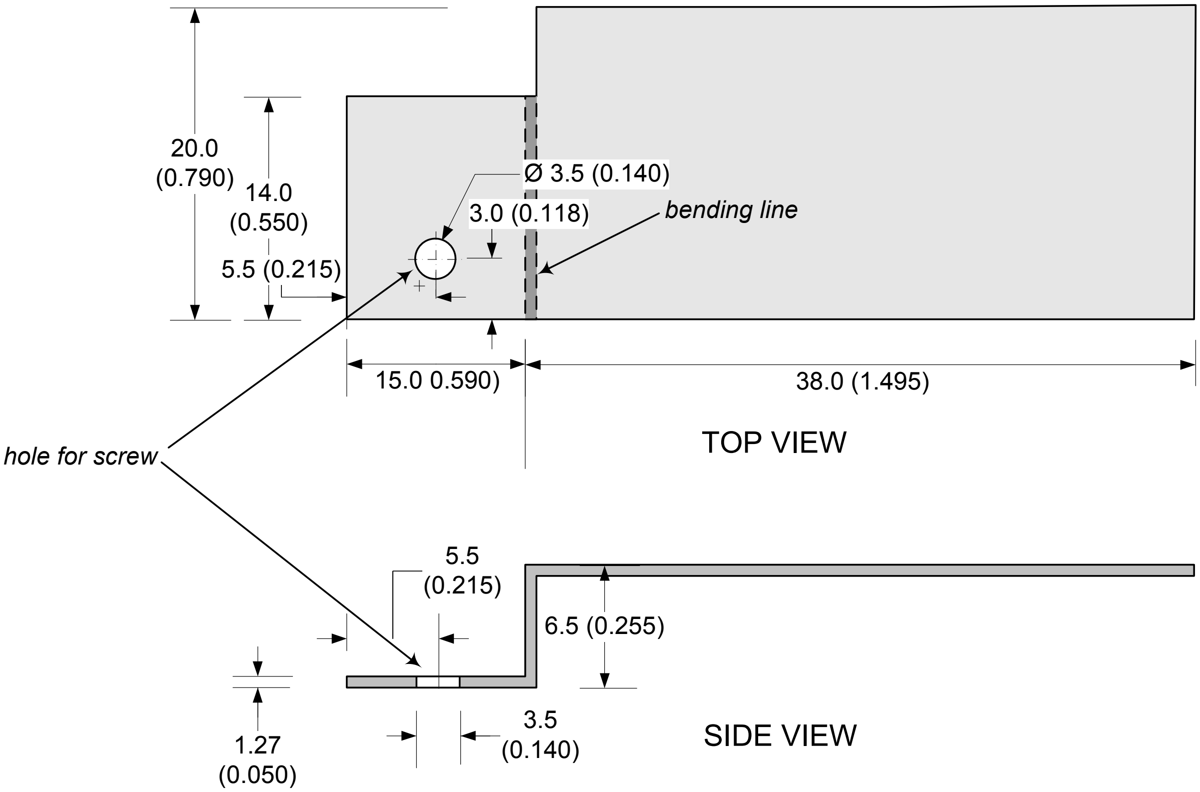
9.1 Heat Spreader



- **Material:** Al, 1100.
- **Thickness:** 0.25mm (0.010")
- **Unit measurement:** mm (inch)
- **Tolerance:** +/- 0.2mm (0.010")
- **Note:** Do not scale the drawing

Figure 16 – Aluminum Heat-Spreader.

9.2 Output Rectifier Heatsink

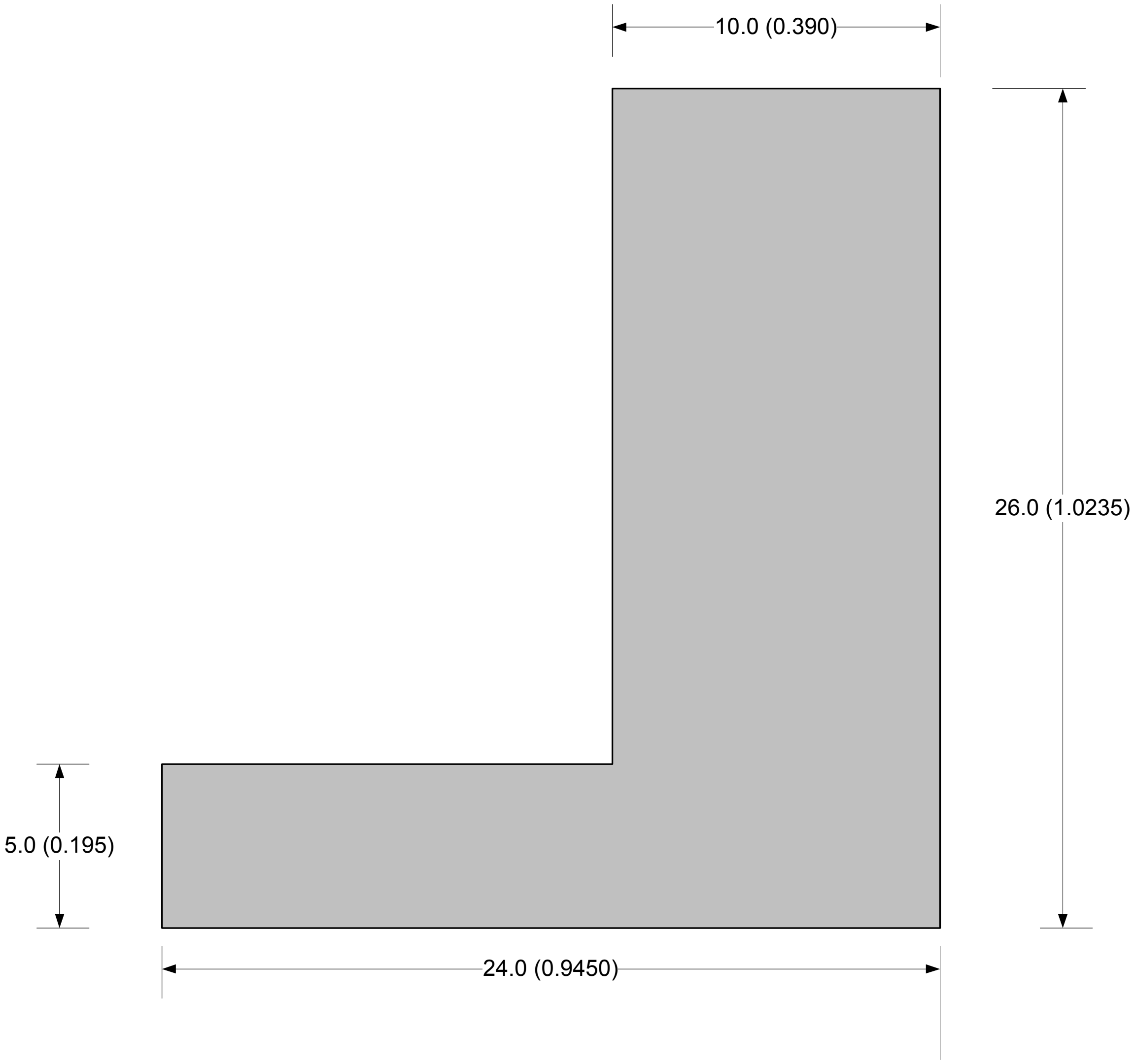


Note:
- *Tolerance: +/- 0.2mm(0.010)*
- *measurement units in:* ***mm(inch)***
- *do not scale drawing*

Material: Al 3003 26 ga
Thickness: 1.27mm (0.050")

Figure 17 – Output Rectifier (D27) Aluminum Heatsink.

9.3 Bridge Rectifier Heatsink



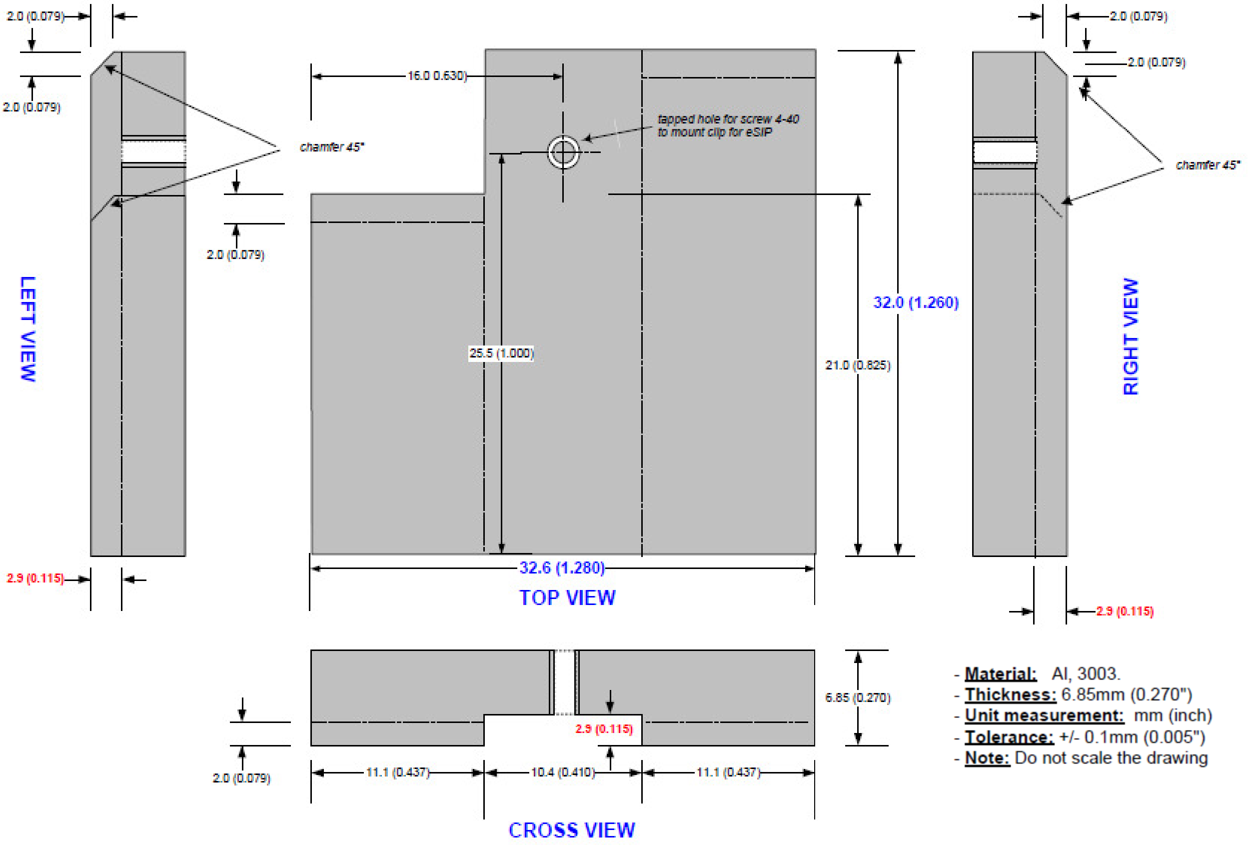
<u>Material:</u> Al 1100   ga
<u>Thickness:</u> 2.30mm (0.090")

<u>Note:</u>
- Tolerance: +/- 0.2mm(0.010)
- measurement units in: ***mm(inch)***
- do not scale drawing

Figure 18 – Bridge Rectifier (D25) Heatsink.

9.4 TOP261LN Heatsink

To assemble U11 with a heatsink, the IC package was attached to the custom heatsink using thermal grease and heatsink clip. The sub-assembly consisting of the heatsink and U11 was inserted in place on the PCB. The use of thermally conductive grease removes stress from U11 and heatsink clip provides mechanically reliable contact between U11 and the heatsink.



- **Material:** Al, 3003.
- **Thickness:** 6.85mm (0.270")
- **Unit measurement:** mm (inch)
- **Tolerance:** +/- 0.1mm (0.005")
- **Note:** Do not scale the drawing

Figure 19 – eSIP Heatsink (U11).

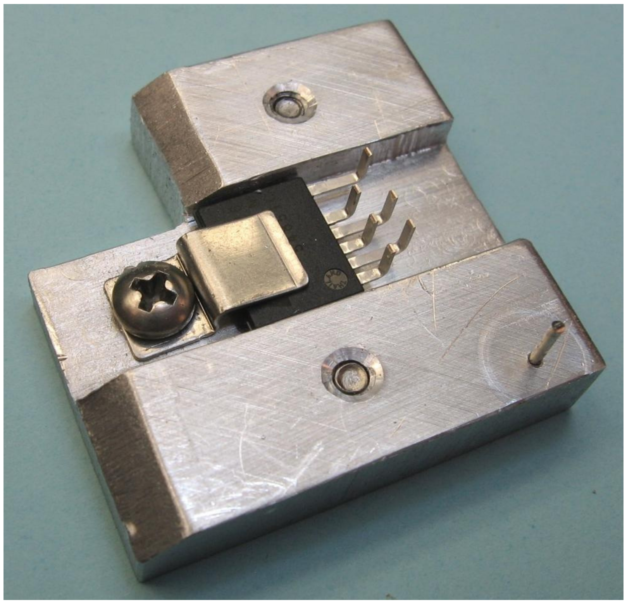
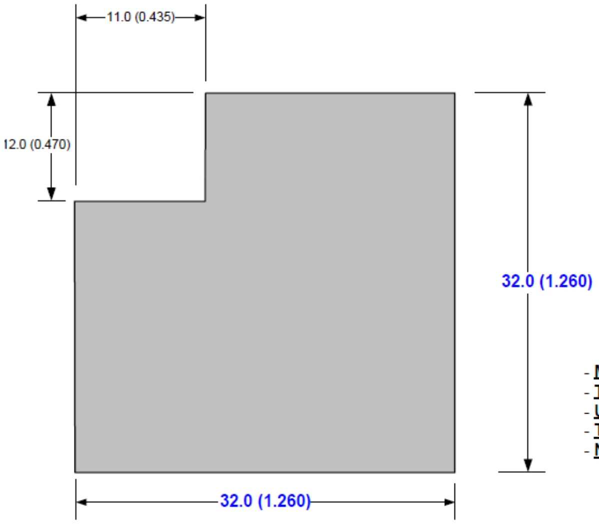


Figure 20 – Photograph of U11 Mounted to Heatsink.
(Surface Visible to Viewer Makes Contact with PCB when Assembled.)

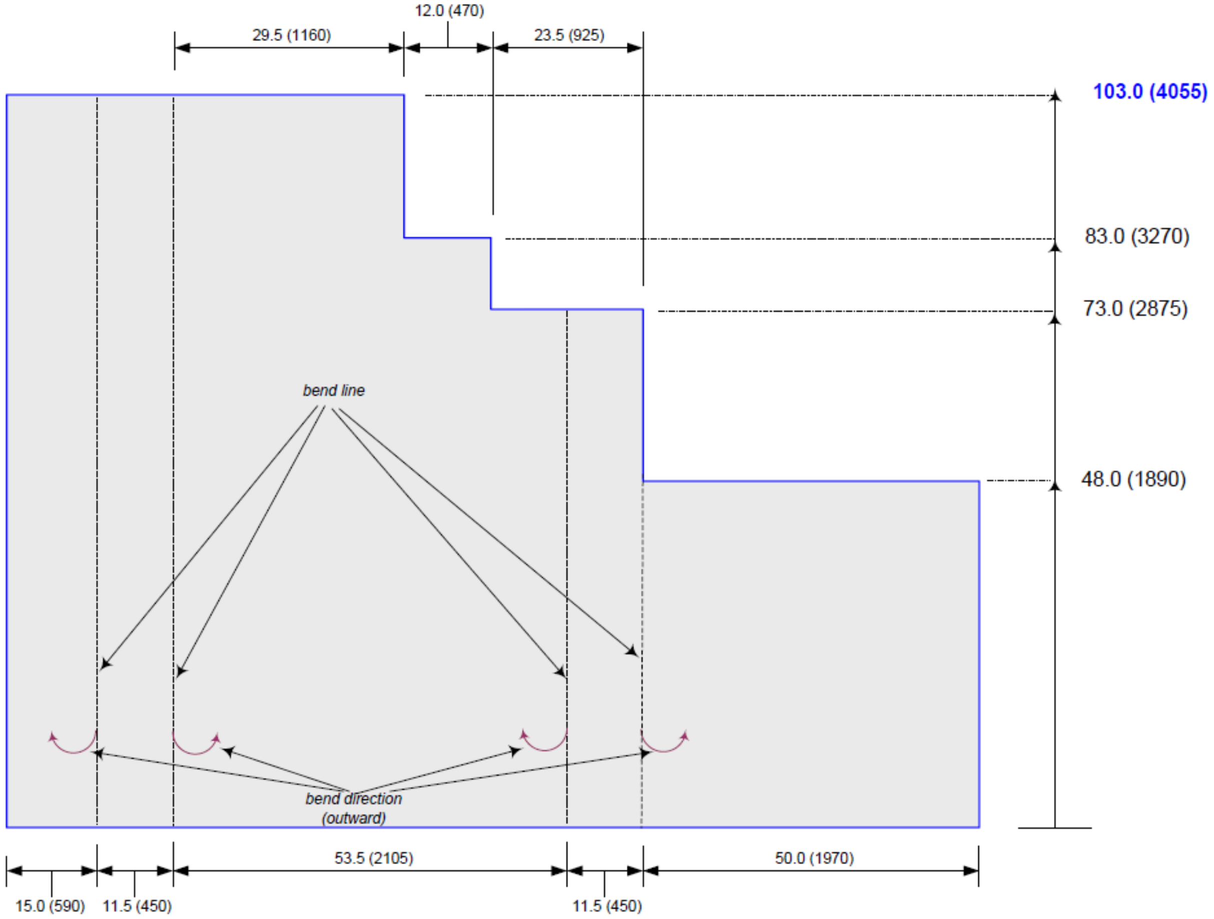
9.5 TOP261LN Thermal Pad



- **Material:** Bergquist, (P/N: BER233-ND)
- **Thickness:** 0.5mm (0.020")
- **Unit measurement:** mm (inch)
- **Tolerance:** +/- 0.2mm (0.010")
- **Note:** Do not scale the drawing

Figure 21 – U11 Thermal Pad.

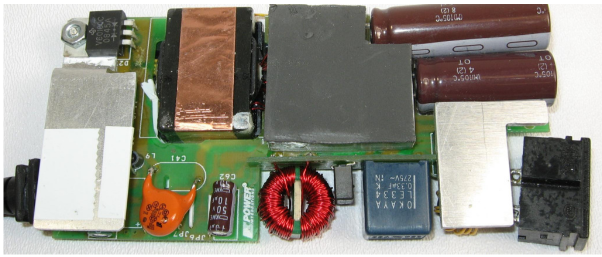
9.6 Insulator



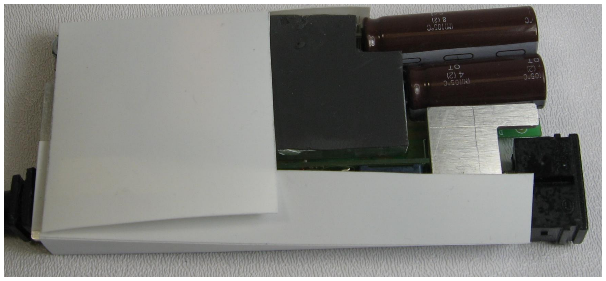
- **Material:** Polypropylene, (PI#: 66-00014-00).
- **Thickness:** 0.25mm (0.010")
- **Unit measurement:** mm (inch)
- **Tolerance:** +/- 0.2mm (0.010")
- **Note:** Do not scale the drawing

Figure 22 – Insulator.

10 Assembly of Unit



1. Assembled PCB



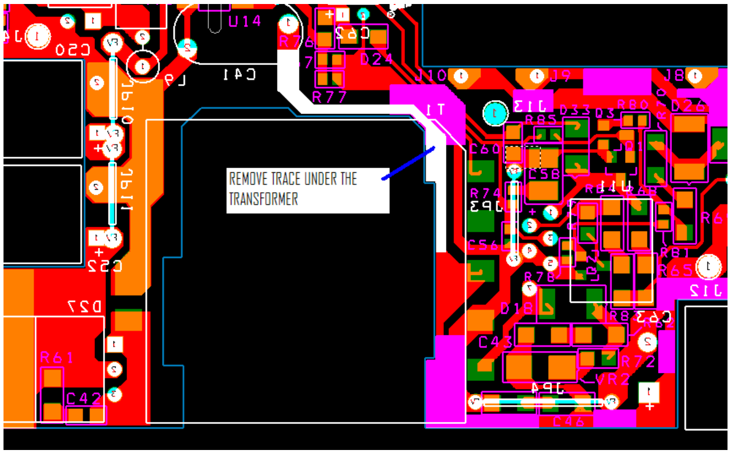
2. Add Insulator

3. Add 0.25 mm Al Heatspreader

4. Ground Heatspreader and Place in Case

5. Assembled Unit

11 Special Assembly Note (Reworked Rev. A PCB)

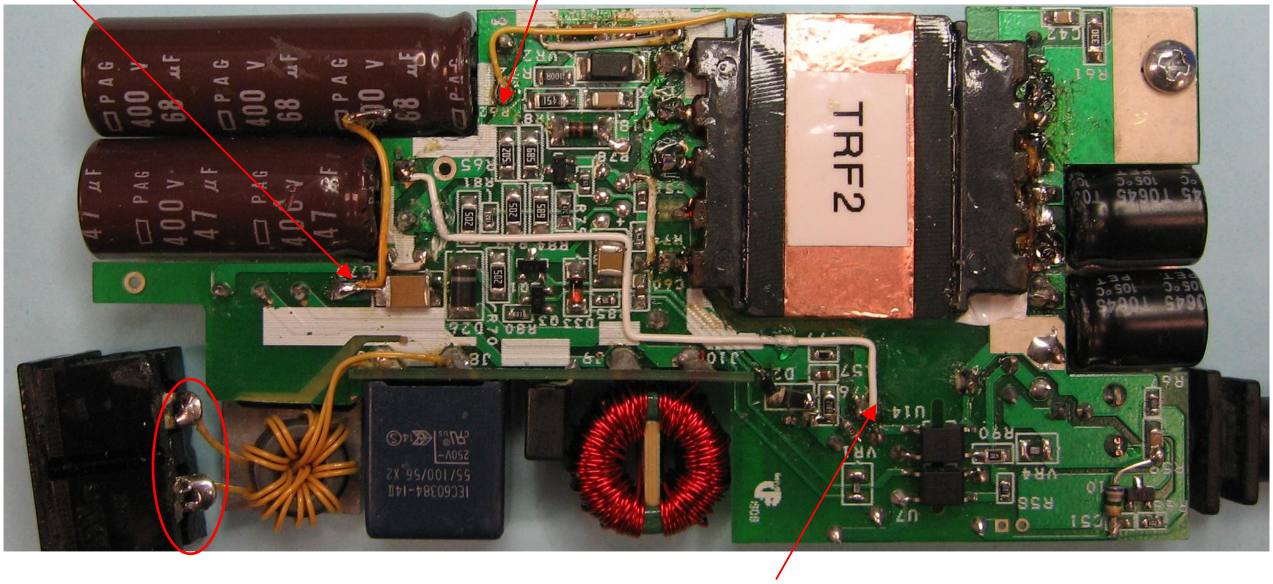


Remove the trace under the transformer (bottom trace connecting C41 and pin 4 of transformer).

Figure 23 – PCB Bottom View.
(Guide for removing the trace under the transformer.)

#26 AWG-TIW terminated to Heatspreader

#32 AWG-TIW TRF shield terminated to Bulk (-)



CMC L1 terminated to AC inlet

Connect Y-cap C41 to Bulk (+) of C41 using #24 AWG

Figure 24 – PCB Bottom View.
(Guide for Placing the Jumper Wires.)

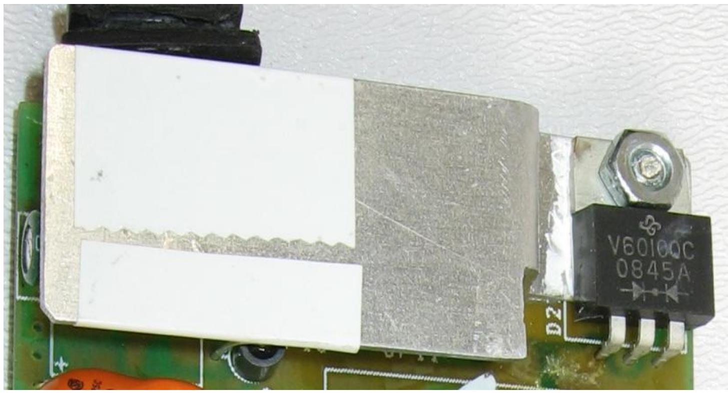


Figure 25 – Wrap Diode Heatsink Diode with Tape.

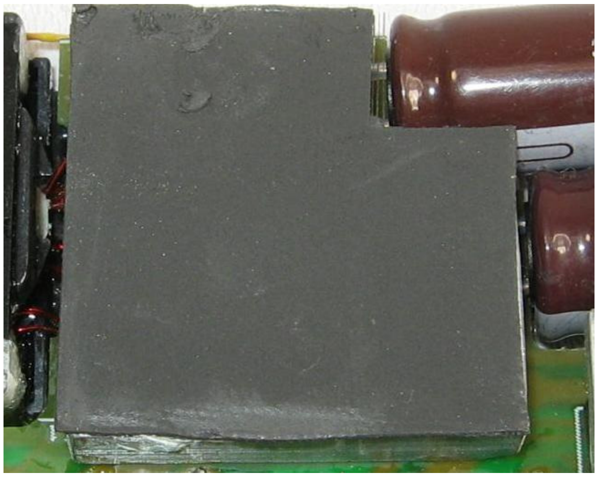


Figure 26 – Thermal Pad Placement.

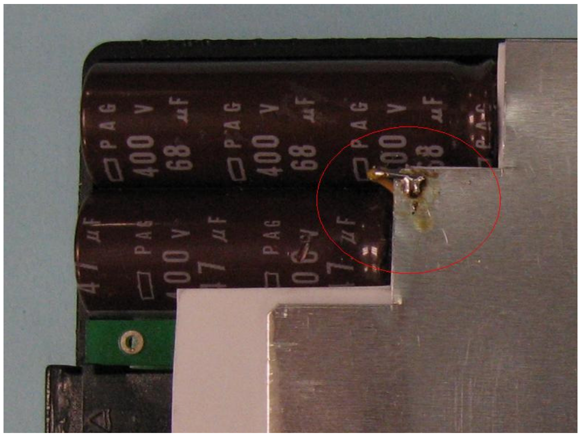


Figure 27 – #26 AWG-TIW Terminated to Heatspreader.

12 Power Supply Performance

All tests were performed at room temperature with 90 V / 50 Hz, 115 V / 60 Hz, 230 V / 50 Hz, and 265 V / 50 Hz line-input voltages and corresponding frequencies unless otherwise noted. The power supply was put in a plastic case (120 mm x 60 mm x 15.4 mm, and allowed to warm up for 30 minutes at full load. The input was provided via a 1 meter AC cable (#18 AWG). The output was measured at the end of a 2 meter cable (#18 AWG), with an impedance of 105 mΩ.

12.1 Full Load Efficiency

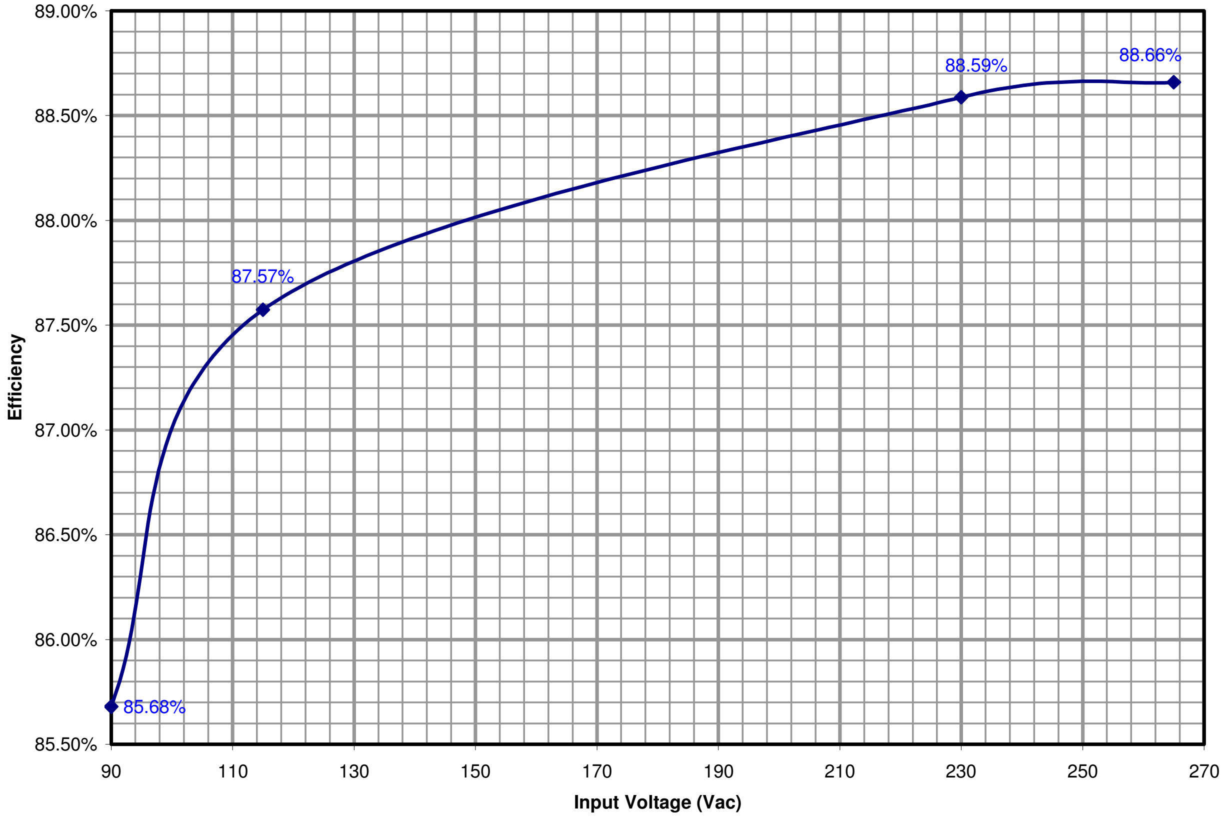


Figure 28 – Efficiency vs Line Voltage at 65 W Load.

Input (VAC / Hz)		V_{OUT} (V)	I_{OUT} (A)	P_{IN} (W)	Efficiency (%)
90	50	19.57	3.33	76.06	85.68
115	60	19.65	3.33	74.72	87.57
230	50	19.67	3.33	73.94	88.59
265	50	19.63	3.33	73.73	88.66

Table 2 – Data for Figure 24.

12.2 No-load Input Power

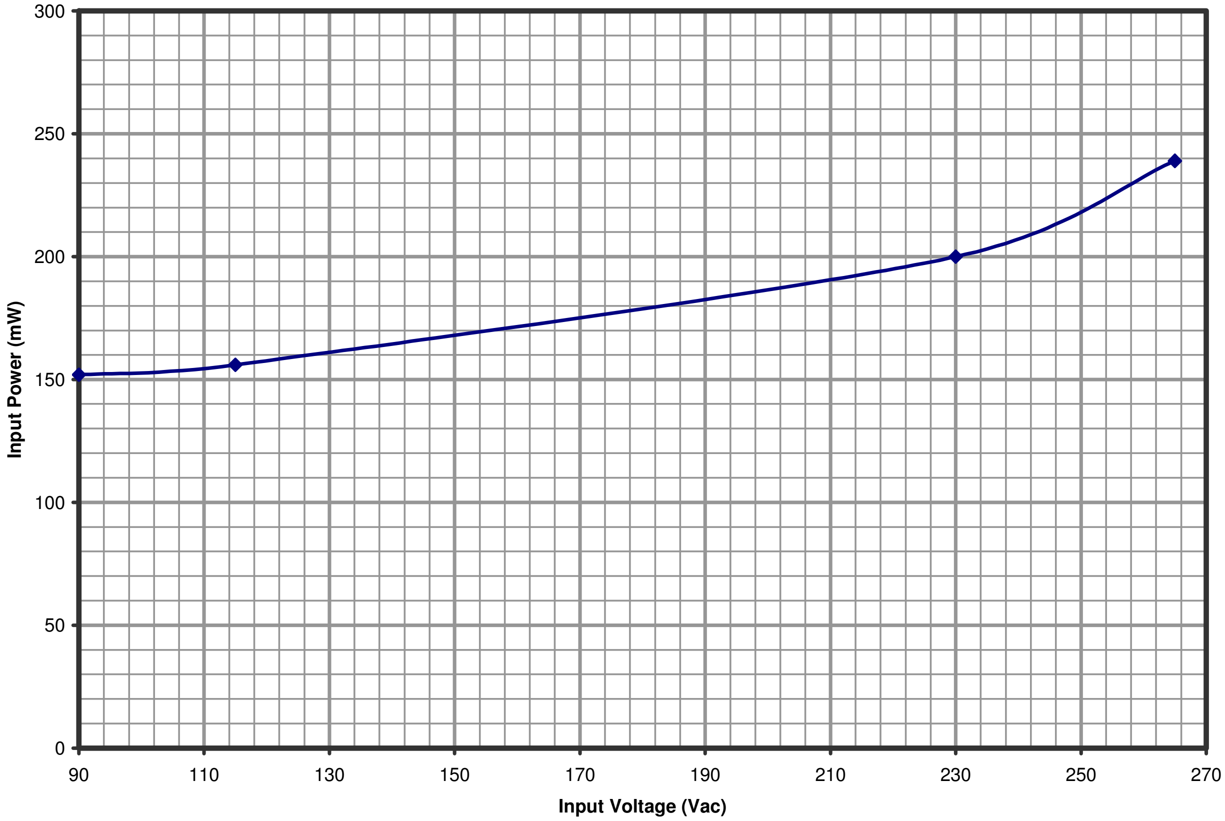


Figure 29 – No Load Power Consumption.

Freq (Hz)	Input (VAC)	P_{IN} (mW)
50	90	153
60	115	155
50	230	210
50	265	236

Table 3 – Data for Figure 25.

12.3 Active Mode CEC Measurement Data

All single output adapters, including those provided with products, for sale in California after January 1, 2007 must meet the California Energy Commission (CEC) requirement for minimum active-mode efficiency and no-load input power. Minimum active-mode efficiency is the average efficiency of 25%, 50%, 75%, and 100% of the rated output power, with the limit based on the nameplate output power:

Nameplate Output Power (P_O)	Minimum Active-mode Efficiency
< 1 W	0.49 × P_O
≥ 1 W to ≤ 49 W	0.09 × ln (P_O) + 0.49 [ln = natural log]
> 49 W	0.85 W

For single-input adapters the measurement is taken at the rated single nominal input voltage (115 VAC or 230 VAC), for universal input adapters the measurement is made at both nominal input voltages (115 VAC and 230 VAC).

To meet the standard the measured average efficiency (or efficiencies for universal input supplies) must be greater than or equal to the efficiency specified by the CEC/Energy Star standard.

Percent of Full Load (%)	Efficiency (%)	
	115 VAC	230 VAC
25	89.70	89.01
50	89.70	88.52
75	88.57	88.53
100	87.67	88.25
Average	88.91	88.52
CEC specified minimum average efficiency (%)	85	
Energy Star 2.0 (%)	87	

Table 4 – Average Efficiency Data.

More states within the USA, and other countries, are adopting this standard. For the latest up-to-date information visit the Power Integrations Green Room: http://www.powerint.com/greenroom/regulations.htm

12.3.1 Active Mode Efficiency

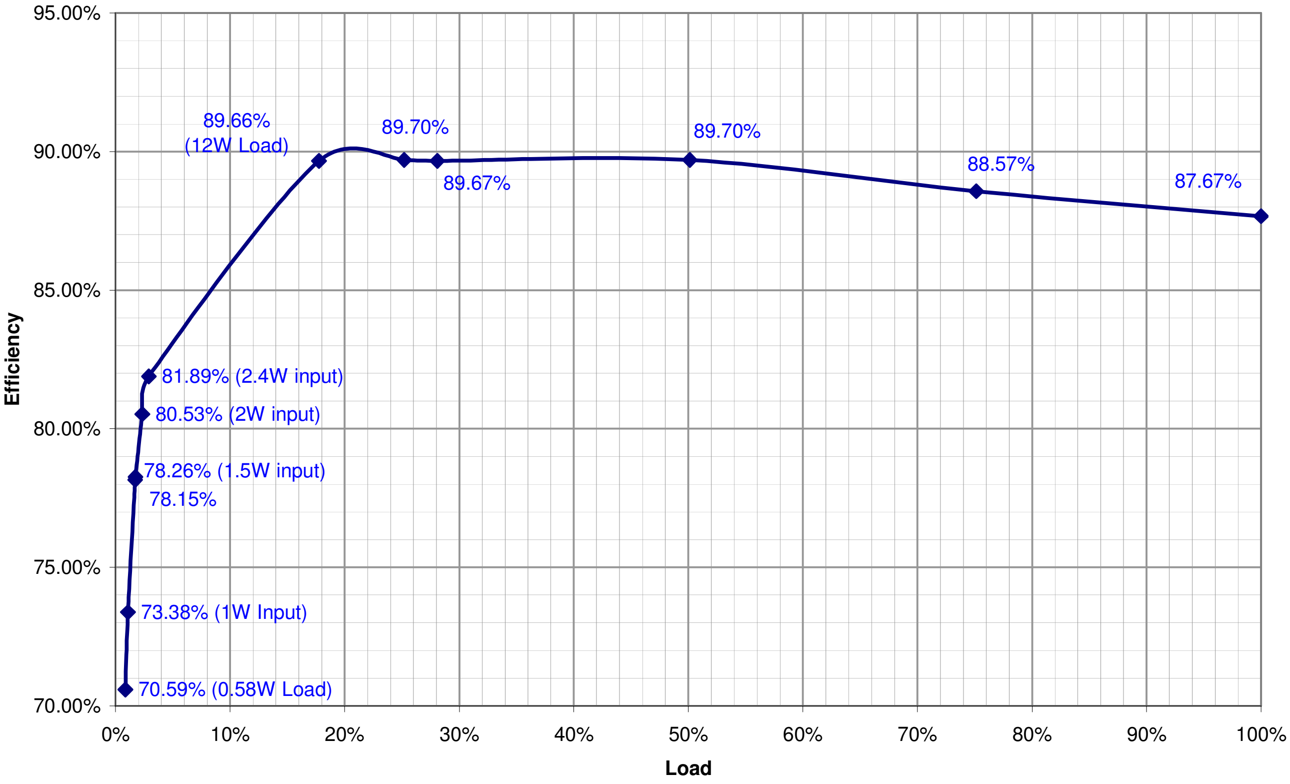


Figure 30 – Efficiency vs. Output Load, Room Temperature (115 VAC, 60 Hz).

Measured end of 2 meter cable #18 AWG; UUT in the plastic case					
115 VAC / 60Hz	Verified after 30 minutes soak time at 25 ºC				
% Load	**I_{OUT} (A)**	**V_{OUT} (V)**	**P_{OUT} (W)**	**P_{IN} (W)**	**Efficiency (%)**
25	0.839	20.11	16.87	18.81	89.70
50	1.669	20.02	33.41	37.25	89.70
75	2.502	19.77	49.46	55.85	88.57
100	3.33	19.58	65.20	74.37	87.67
				Average Efficiency	**88.91**

Table 5 – Data for Figure 26.

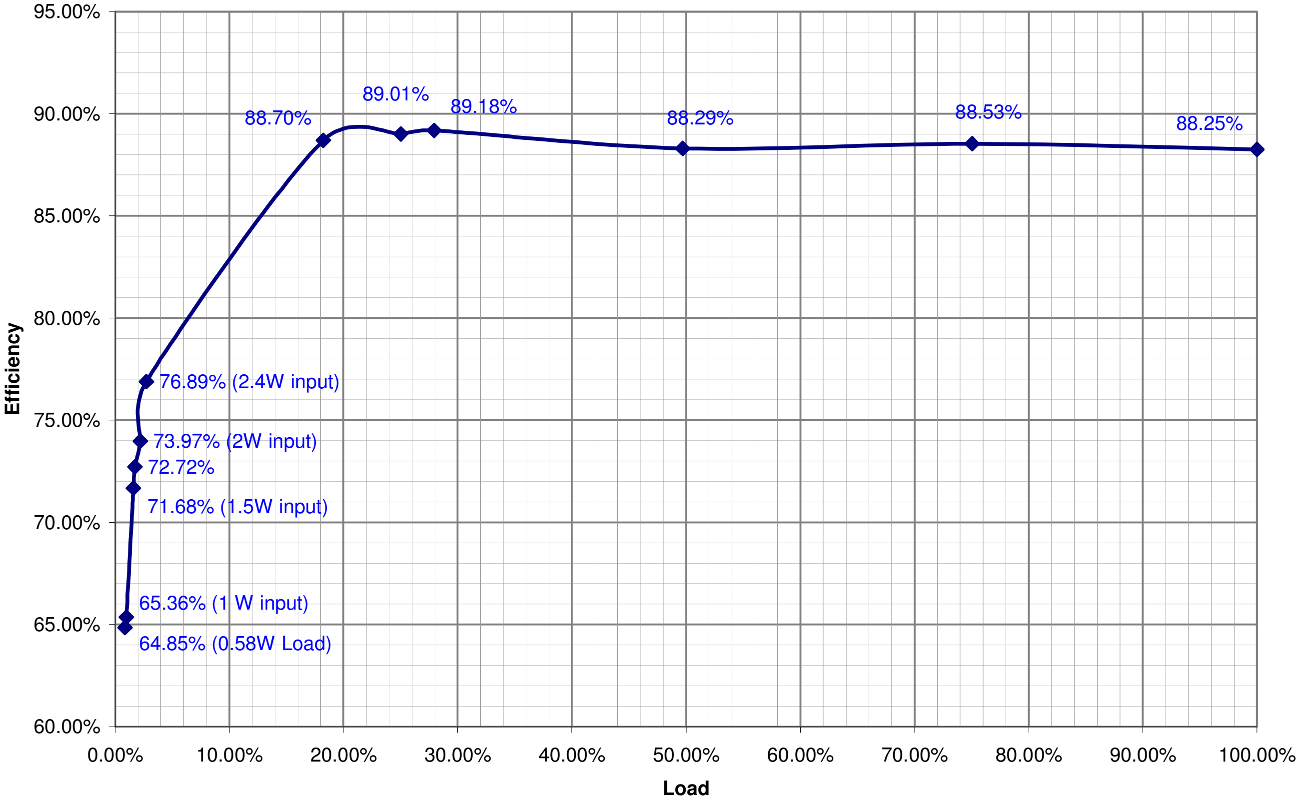


Figure 31 – Efficiency vs. Output Load, Room Temperature (230 VAC, 50 Hz).

<table>
<tr><td colspan="6">Measured end of 2 meter cable #18 AWG; UUT in plastic area</td></tr>
<tr><td>230 VAC / 50Hz</td><td colspan="5">Verified after 30 minutes soak time at 25 ºC</td></tr>
<tr><th>% Load</th><th>I_{OUT} (A)</th><th>V_{OUT} (V)</th><th>P_{OUT} (W)</th><th>P_{IN} (W)</th><th>Efficiency (%)</th></tr>
<tr><td>25</td><td>0.833</td><td>20.12</td><td>16.76</td><td>18.83</td><td>89.01</td></tr>
<tr><td>50</td><td>1.655</td><td>19.83</td><td>32.82</td><td>37.17</td><td>88.29</td></tr>
<tr><td>75</td><td>2.499</td><td>19.76</td><td>49.38</td><td>55.78</td><td>88.53</td></tr>
<tr><td>100</td><td>3.337</td><td>19.63</td><td>65.51</td><td>74.23</td><td>88.25</td></tr>
<tr><td colspan="5">Average Efficiency</td><td>88.52</td></tr>
</table>

Table 6 – Data for Figure 27.

12.4 Available Standby Output Power

The chart below shows the available output power vs. line voltage, with input power levels of 1 W, 1.5 W, and 2.4 W.

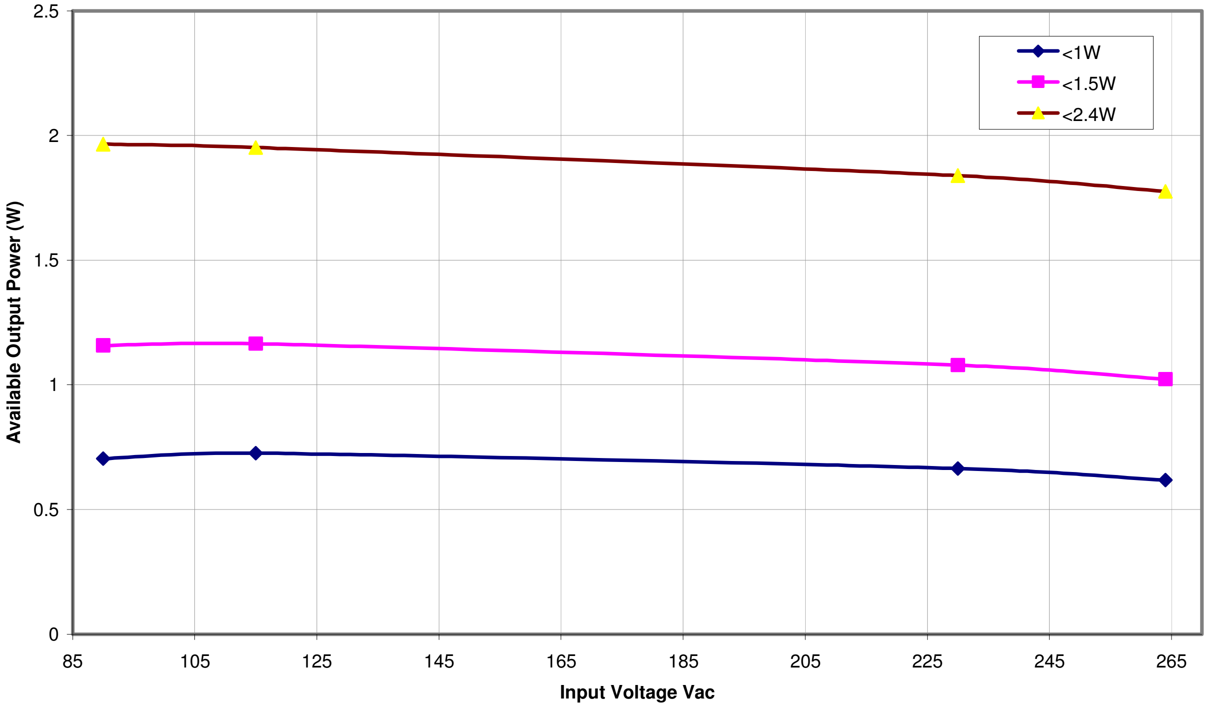


Figure 32 – Output Power Corresponding to Varying Input Power.

12.5 Line and Load Regulation

All data was measured at the end of the output cable.

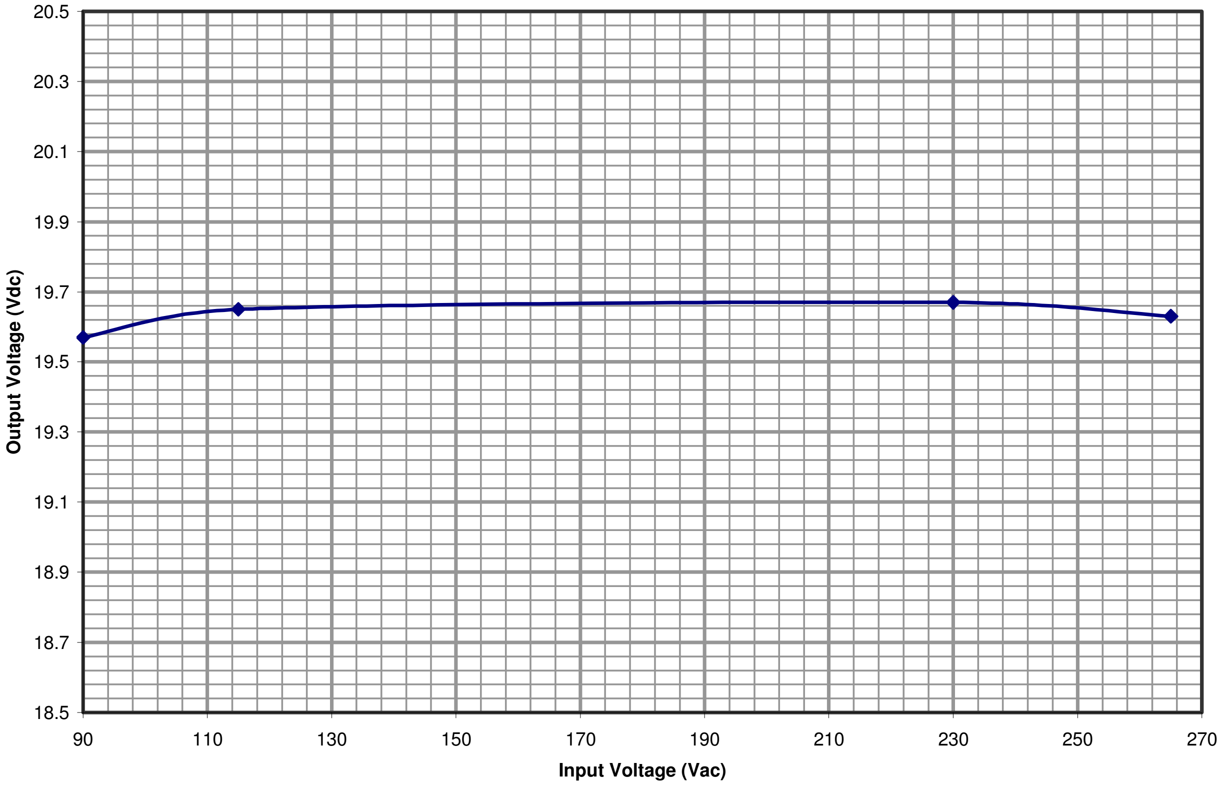


Figure 33 – Output Voltage vs. Line Voltage, with 3.3 A Load, Room Temperature.

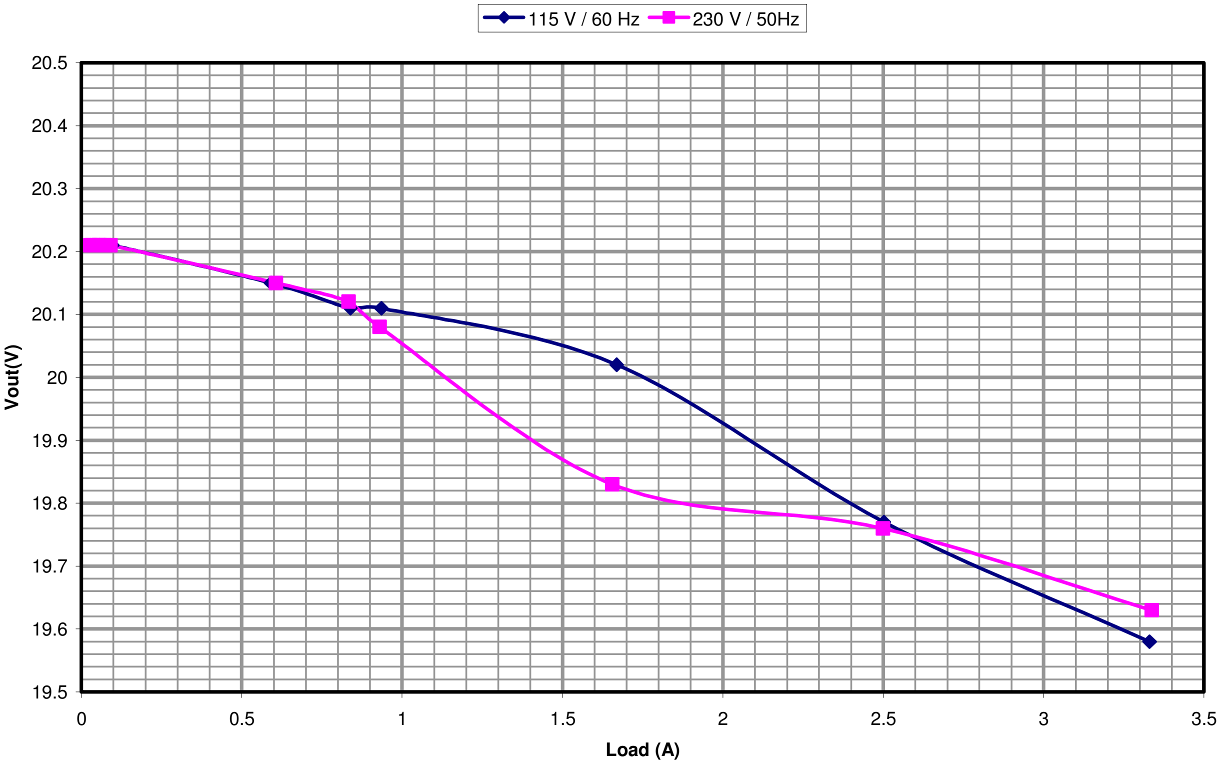


Figure 34 – Load Regulation, Room Temperature.

13 Thermal Performance

The power supply was placed inside a custom Power Integrations plastic case and sealed, without potting material. The supply was heated, with no airflow, for at least two hours and measurements were taken immediately.

For reliability testing, the power supply went through a burn-in cycle, which involved running it inside an oven overnight in a 40 °C ambient temperature condition at maximum load. The unit did not at any time go into thermal shutdown.

Load conditions: 65 W at the end of a 2 meter, #18 AWG cable (105 mΩ).

Figure 35 – Power Supply Adapter Inside Carton Box and on Top of Bakelite Board for Burn-In Test.

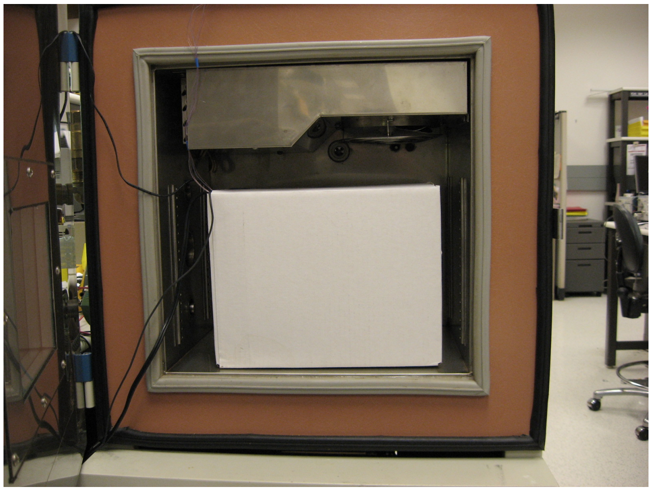


Figure 36 – Carton box, with Power Supply Adapter Inside, Placed in Oven for Burn-in.

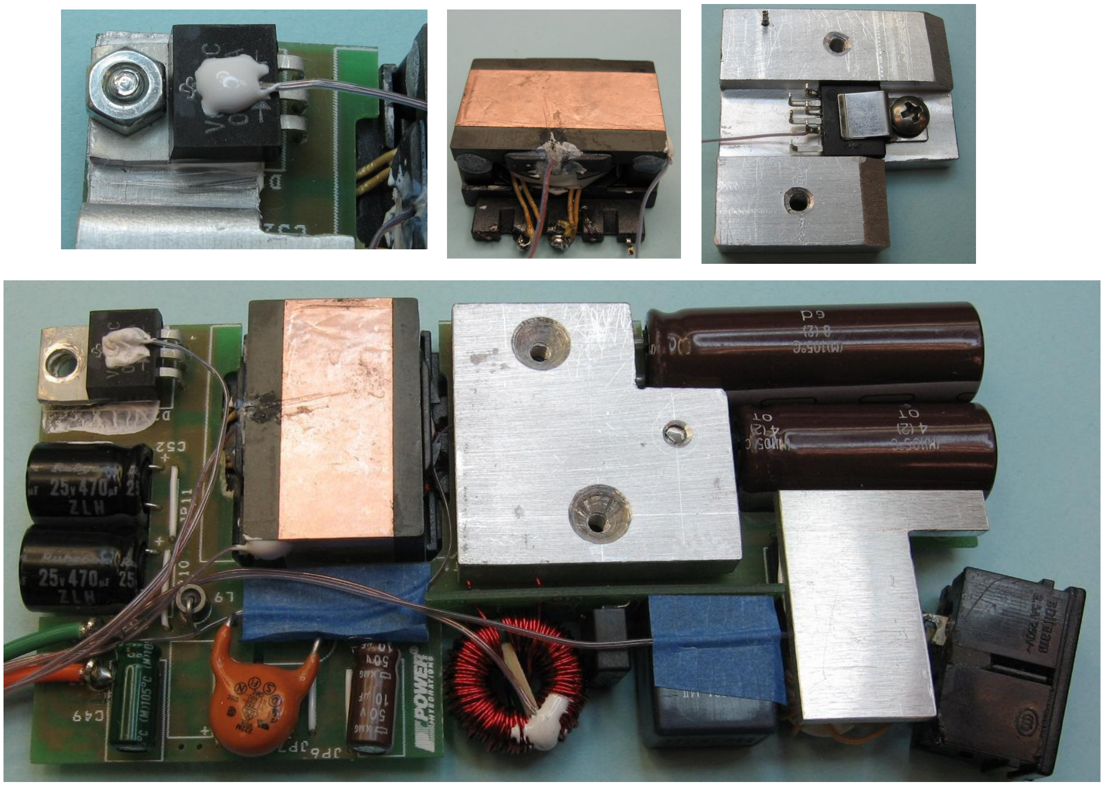


Figure 37 – Thermocouple Locations.

13.1 Chamber Temperature data

Item	**Temperature (°C)**	
	90 VAC / 50 Hz Input	**265 VAC / 50 Hz Input**
Ambient Temperature in the Box	40	40
U11(at Source)	98.5	90.2
D25 (Case of Bridge)	97.4	79.3
T1 (Core / Winding)	94.9	92.1
D27 (Case of Output Rec)	92.1	90.7
Measured Input Power (W)	76.21	73.73
Output Voltage (V)	19.55	19.63
Output Load (A)	3.333	3.33

Table 7 – Thermal Data.

13.2 *Case Surface Temperature (IR Thermal Image)*

Condition: Unit was running for two hours inside the plastic case as shown when the measurement was taken. The output was continuous at 3.33 A at 90 VAC / 50Hz.

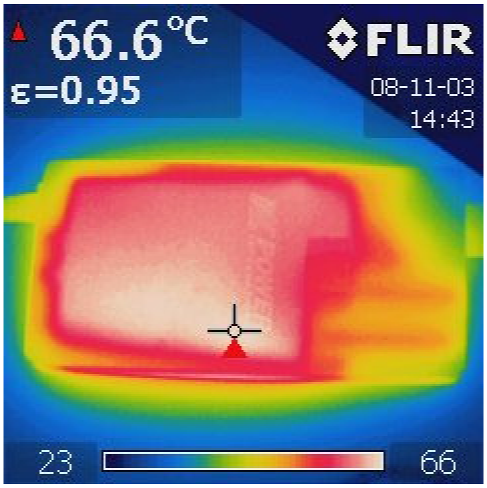


Figure 38 – Top of Case**.**

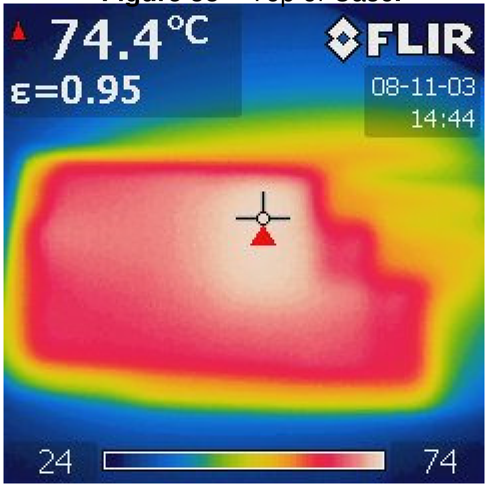


Figure 39 – Bottom of the Case.

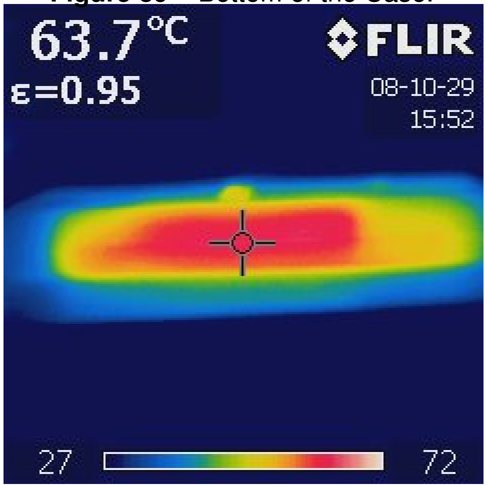


Figure 40 – Hottest Side of the Case.

11.2 Case Surface Temperature (Thermocouple Wire)

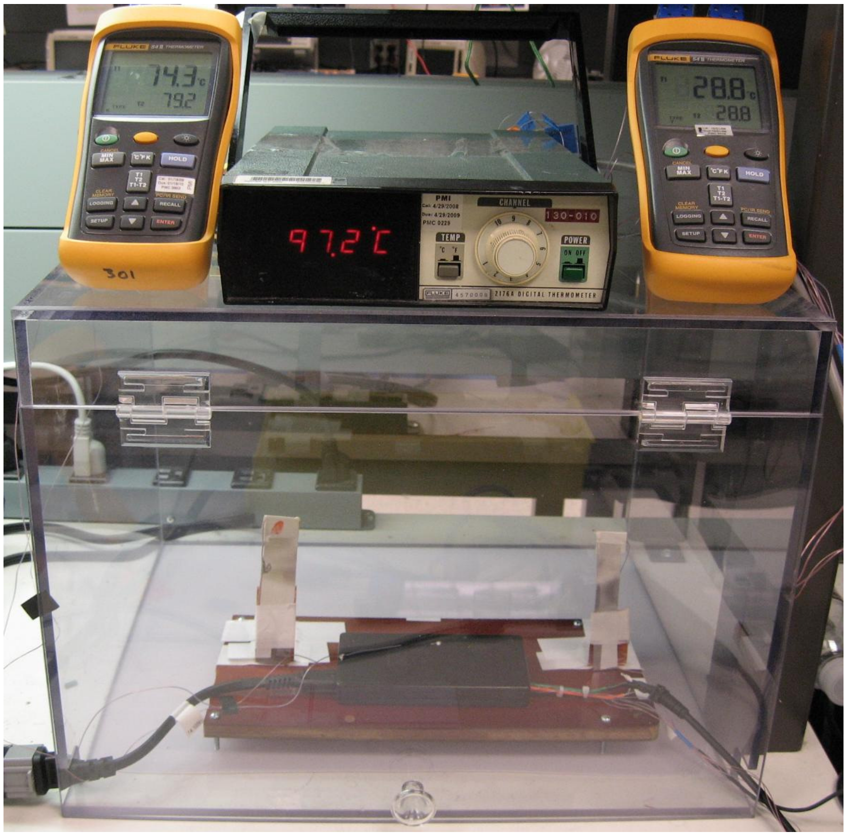
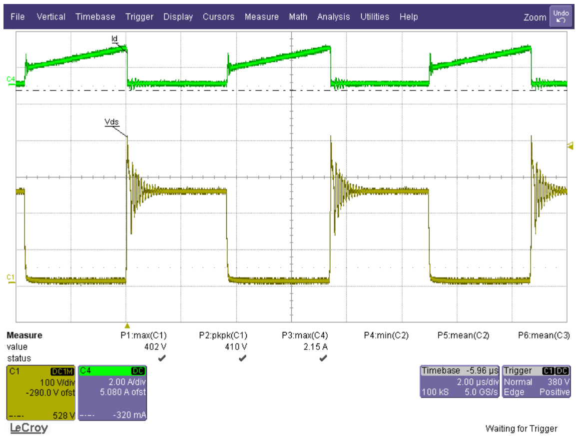


Figure 41 – Unit Placed on a Bakelite Board and Inside a Customer Specified Plastic-glass Chamber. Ambient Temperature: 28.8 ºC; Case Temperature (Top): 74.3 ºC; TOPSwitch Temperature: 97.2 ºC.

14 Waveforms

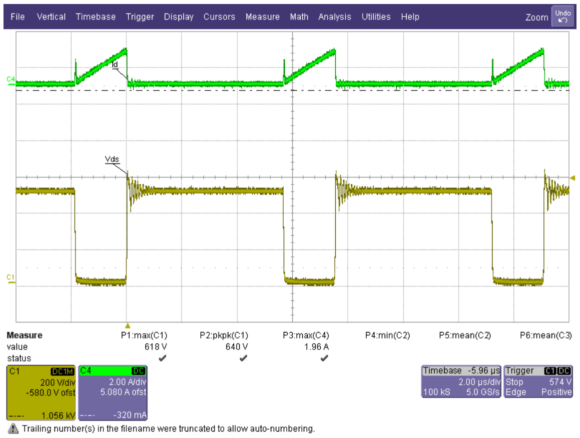
14.1 Drain Voltage and Current



Measure	P1:max(C1)	P2:pkpk(C1)	P3:max(C4)	P4:min(C2)	P5:mean(C2)	P6:mean(C3)
value	402 V	410 V	2.15 A			
status	✓	✓	✓			

C1 DC1M 100 V/div -290.0 V ofst 528 V
C4 DC 2.00 A/div 5.080 A ofst -320 mA
Timebase -5.96 µs 2.00 µs/div 100 kS 5.0 GS/s
Trigger C1 DC Normal 380 V Edge Positive
Waiting for Trigger

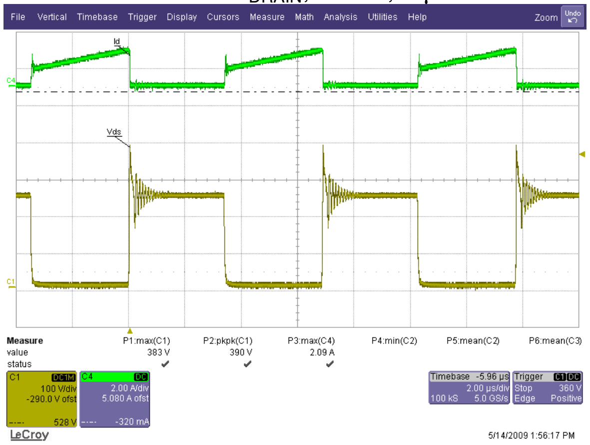
Figure 42 – 90 VAC, Overload Condition. Without OCP Protection.
Upper: I_{DRAIN}, 2 A / div.
Lower: V_{DRAIN}, 100 V, 2 µs / div.



Measure	P1:max(C1)	P2:pkpk(C1)	P3:max(C4)	P4:min(C2)	P5:mean(C2)	P6:mean(C3)
value	618 V	640 V	1.96 A			
status	✓	✓	✓			

C1 DC1M 200 V/div -580.0 V ofst 1.056 kV
C4 DC 2.00 A/div 5.080 A ofst -320 mA
Timebase -5.96 µs 2.00 µs/div 100 kS 5.0 GS/s
Trigger C1 DC Stop 574 V Edge Positive
⚠ Trailing number(s) in the filename were truncated to allow auto-numbering.

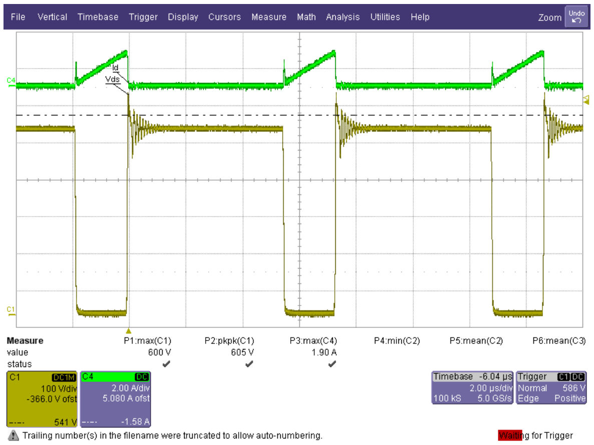
Figure 43 – 265 VAC, Overload Condition. Without OCP Protection.
Upper: I_{DRAIN}, 2 A / div.
Lower: V_{DRAIN}, 200 V / div.



Measure	P1:max(C1)	P2:pkpk(C1)	P3:max(C4)	P4:min(C2)	P5:mean(C2)	P6:mean(C3)
value	383 V	390 V	2.09 A			
status	✓	✓	✓			

C1 DC1M 100 V/div -290.0 V ofst 528 V
C4 DC 2.00 A/div 5.080 A ofst -320 mA
Timebase -5.96 µs 2.00 µs/div 100 kS 5.0 GS/s
Trigger C1 DC Stop 360 V Edge Positive
5/14/2009 1:56:17 PM

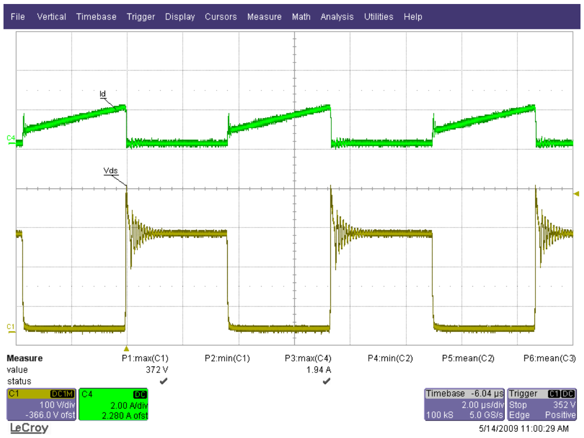
Figure 44 – 90 VAC, Overload Condition. With OCP Protection.
Upper: I_{DRAIN}, 2 A / div.
Lower: V_{DRAIN}, 100 V, 2 µs / div.



Measure	P1:max(C1)	P2:pkpk(C1)	P3:max(C4)	P4:min(C2)	P5:mean(C2)	P6:mean(C3)
value	600 V	605 V	1.90 A			
status	✓	✓	✓			

C1 DC1M 100 V/div -366.0 V ofst 541 V
C4 DC 2.00 A/div 5.080 A ofst -1.58 A
Timebase -6.04 µs 2.00 µs/div 100 kS 5.0 GS/s
Trigger C1 DC Normal 586 V Edge Positive
⚠ Trailing number(s) in the filename were truncated to allow auto-numbering.
Waiting for Trigger

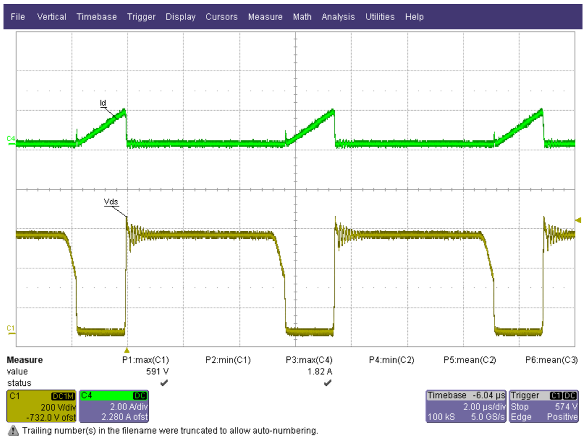
Figure 45 – 265 VAC, Overload Condition. With OCP Protection.
Upper: I_{DRAIN}, 2 A / div.
Lower: V_{DRAIN}, 200 V / div.



Measure	P1:max(C1)	P2:min(C1)	P3:max(C4)	P4:min(C2)	P5:mean(C2)	P6:mean(C3)
value	372 V		1.94 A			
status	✓		✓			

C1 DC1M 100 V/div -366.0 V ofst
C4 DC 2.00 A/div 2.280 A ofst
Timebase -6.04 µs 2.00 µs/div 100 kS 5.0 GS/s
Trigger C1 DC Stop 352 V Edge Positive
5/14/2009 11:00:29 AM

Figure 46 – 90 VAC, Full-load Condition.
Upper: I_{DRAIN}, 2 A / div.
Lower: V_{DRAIN}, 100 V, 2 µs / div.

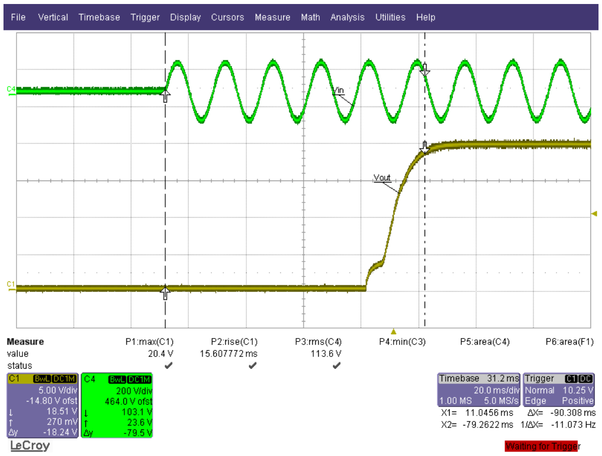


Measure	P1:max(C1)	P2:min(C1)	P3:max(C4)	P4:min(C2)	P5:mean(C2)	P6:mean(C3)
value	591 V		1.82 A			
status	✓		✓			

C1 DC1M 200 V/div -732.0 V ofst
C4 DC 2.00 A/div 2.280 A ofst
Timebase -6.04 µs 2.00 µs/div 100 kS 5.0 GS/s
Trigger C1 DC Stop 574 V Edge Positive
Trailing number(s) in the filename were truncated to allow auto-numbering.

Figure 47 – 265 VAC, Full-load Condition.
Upper: I_{DRAIN}, 2 A / div.
Lower: V_{DRAIN}, 200 V / div.

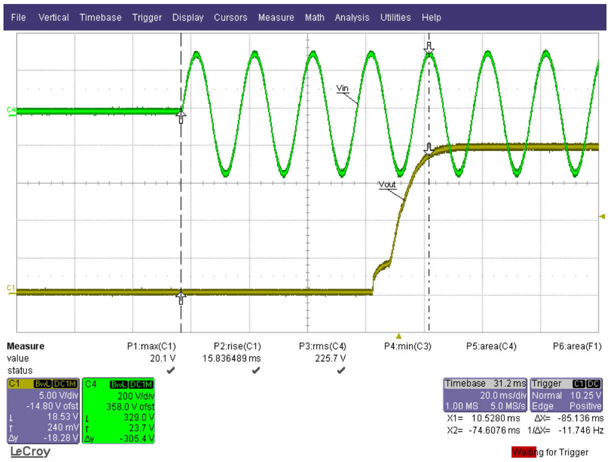
14.2 Output Voltage Start-up Profile



Measure	P1:max(C1)	P2:rise(C1)	P3:rms(C4)	P4:min(C3)	P5:area(C4)	P6:area(F1)
value	20.4 V	15.607772 ms	113.6 V			
status	✓	✓	✓			

C1 BwL DC1M 5.00 V/div -14.80 V ofst ↓ 18.51 V ↑ 270 mV Δy -18.24 V
C4 BwL DC1M 200 V/div 464.0 V ofst ↓ 103.1 V ↑ 23.6 V Δy -79.5 V
Timebase 31.2 ms 20.0 ms/div 1.00 MS 5.0 MS/s
Trigger C1 DC Normal 10.25 V Edge Positive
X1= 11.0456 ms ΔX= -90.308 ms
X2= -79.2622 ms 1/ΔX= -11.073 Hz
Waiting for Trigger

Figure 48 – Start-up Profile, 115 VAC
5 V, 50 ms / div.

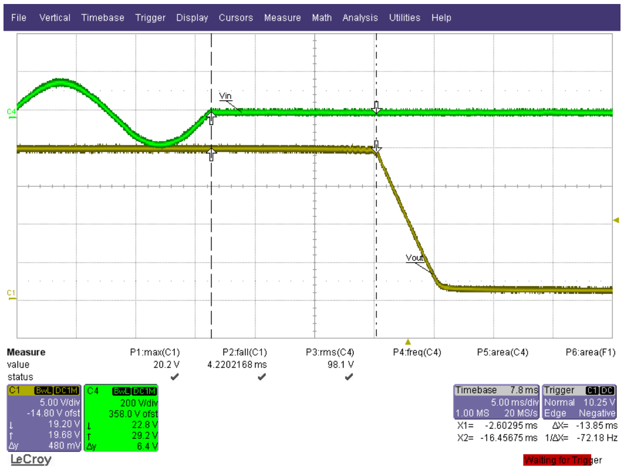


Measure	P1:max(C1)	P2:rise(C1)	P3:rms(C4)	P4:min(C3)	P5:area(C4)	P6:area(F1)
value	20.1 V	15.836489 ms	225.7 V			
status	✓	✓	✓			

C1 BwL DC1M 5.00 V/div -14.80 V ofst ↓ 18.53 V ↑ 240 mV Δy -18.28 V
C4 BwL DC1M 200 V/div 358.0 V ofst ↓ 329.0 V ↑ 23.7 V Δy -305.4 V
Timebase 31.2 ms 20.0 ms/div 1.00 MS 5.0 MS/s
Trigger C1 DC Normal 10.25 V Edge Positive
X1= 10.5280 ms ΔX= -85.136 ms
X2= -74.6076 ms 1/ΔX= -11.746 Hz
Waiting for Trigger

Figure 49 – Start-up Profile, 230 VAC
5 V, 50 ms / div.

14.3 Hold-up Time



Measure	P1:max(C1)	P2:fall(C1)	P3:rms(C4)	P4:freq(C4)	P5:area(C4)	P6:area(F1)
value	20.2 V	4.2202168 ms	98.1 V			
status	✓	✓	✓			

C1 BwL DC1M 5.00 V/div -14.80 V ofst ↓ 19.20 V ↑ 19.68 V Δy 480 mV

C4 BwL DC1M 200 V/div 358.0 V ofst ↓ 22.8 V ↑ 29.2 V Δy 6.4 V

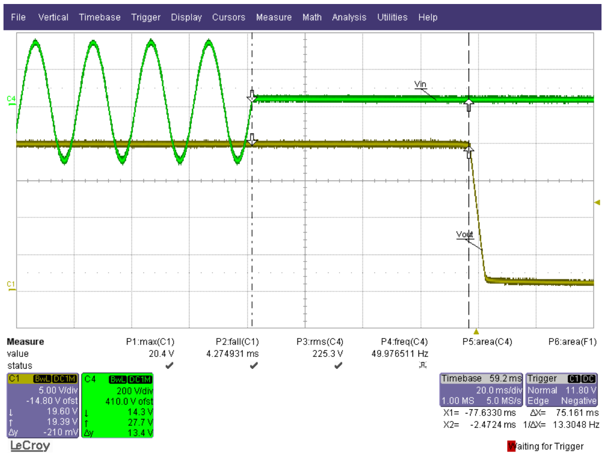
Timebase 7.8 ms 5.00 ms/div 1.00 MS 20 MS/s

Trigger C1 DC Normal 10.25 V Edge Negative

X1= -2.60295 ms ΔX= -13.85 ms

X2= -16.45675 ms 1/ΔX= -72.18 Hz

Figure 50 – Hold Time; Full Load.
115 VAC / 60 Hz; 5 ms / div.
Upper: V_{IN}, 200 V / div.
Lower: V_{OUT}, 5 V / div.



Measure	P1:max(C1)	P2:fall(C1)	P3:rms(C4)	P4:freq(C4)	P5:area(C4)	P6:area(F1)
value	20.4 V	4.274931 ms	225.3 V	49.976511 Hz		
status	✓	✓	✓			

C1 BwL DC1M 5.00 V/div -14.80 V ofst ↓ 19.60 V ↑ 19.39 V Δy -210 mV

C4 BwL DC1M 200 V/div 410.0 V ofst ↓ 14.3 V ↑ 27.7 V Δy 13.4 V

Timebase 59.2 ms 20.0 ms/div 1.00 MS 5.0 MS/s

Trigger C1 DC Normal 11.80 V Edge Negative

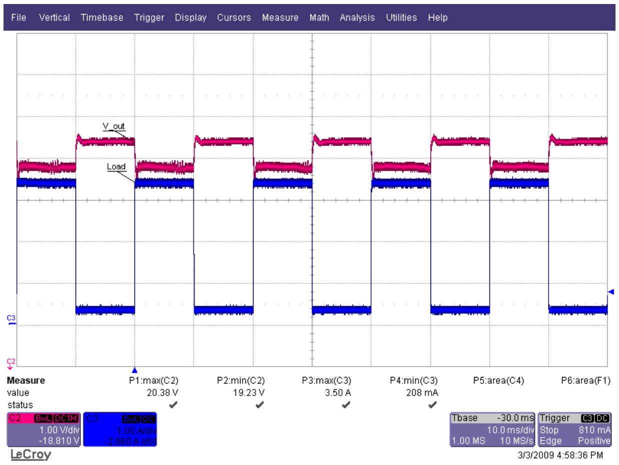
X1= -77.6330 ms ΔX= 75.161 ms

X2= -2.4724 ms 1/ΔX= 13.3048 Hz

Figure 51 – Hold Time; Full Load.
230 VAC / 50 Hz; 20 ms / div.
Upper: V_{IN}, 200 V / div.
Lower: V_{OUT}, 5 V / div.

15 Load Transient Response

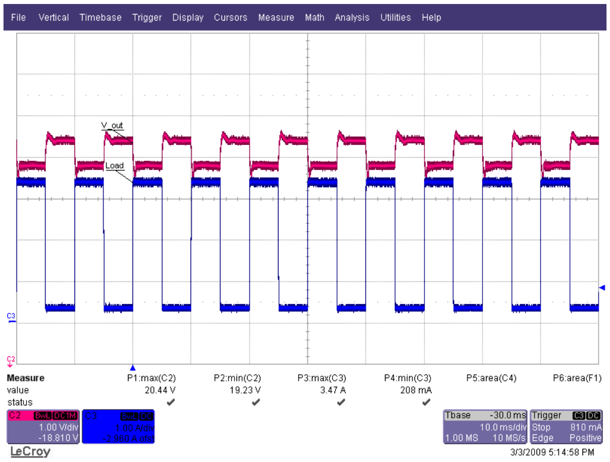
In the figures below, signal averaging was used to better enable viewing the load transient response. The oscilloscope was triggered using the load current step as a trigger source. Since the output switching and line frequency occur essentially at random with respect to the load transient, contributions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



Measure	P1:max(C2)	P2:min(C2)	P3:max(C3)	P4:min(C3)	P5:area(C4)	P6:area(F1)
value	20.38 V	19.23 V	3.50 A	208 mA		
status	✓	✓	✓	✓		

C2 BwL DC1M 1.00 V/div -18.810 V
C3 BwL DC 1.00 A/div -2.960 A ofst
Tbase -30.0 ms 10.0 ms/div 1.00 MS 10 MS/s
Trigger C3 DC Stop 810 mA Edge Positive
3/3/2009 4:58:36 PM

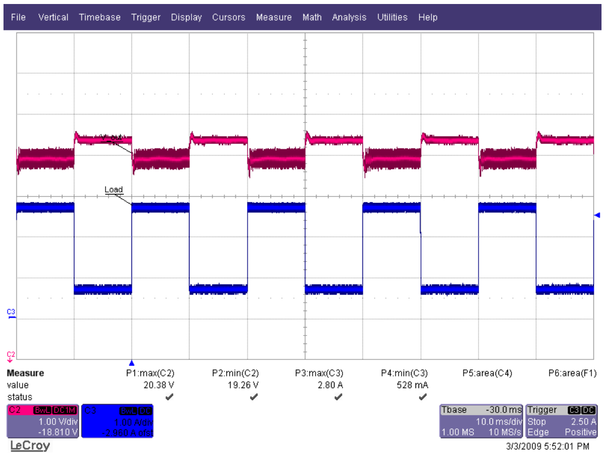
Figure 52 – 0.3 A - 3.33 A (10 to 80%) Load, 50 Hz;
Slew Rate = 0.1 A / µs;
Terminated with 180 µF Load.
Vin: 90 VAC / 47 Hz.
Upper: V_{OUT},1 V / div.
Lower: I_{OUT}, 1 A / div.



Measure	P1:max(C2)	P2:min(C2)	P3:max(C3)	P4:min(C3)	P5:area(C4)	P6:area(F1)
value	20.44 V	19.23 V	3.47 A	208 mA		
status	✓	✓	✓	✓		

C2 BwL DC1M 1.00 V/div -18.810 V
C3 BwL DC 1.00 A/div -2.960 A ofst
Tbase -30.0 ms 10.0 ms/div 1.00 MS 10 MS/s
Trigger C3 DC Stop 810 mA Edge Positive
3/3/2009 5:14:58 PM

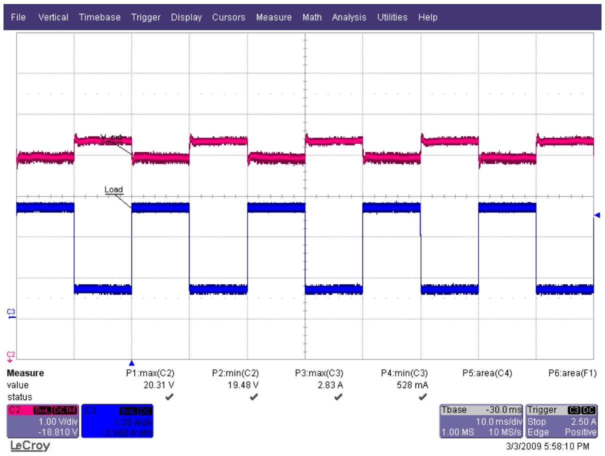
Figure 53 – 0.3 A - 3.33 A (10 to 80%) Load 100
Hz; Slew Rate = 0.1 A / µs;
Terminated with 180 µF Load.
Vin: 90 VAC / 47 Hz.
Upper: V_{OUT},1 V / div.
Lower: I_{OUT}, 1 A / div.



Measure	P1:max(C2)	P2:min(C2)	P3:max(C3)	P4:min(C3)	P5:area(C4)	P6:area(F1)
value	20.38 V	19.26 V	2.80 A	528 mA		
status	✓	✓	✓	✓		

C2 BwL DC1M 1.00 V/div -18.810 V
C3 BwL DC 1.00 A/div -2.960 A ofst
Tbase -30.0 ms 10.0 ms/div 1.00 MS 10 MS/s
Trigger C3 DC Stop 2.50 A Edge Positive
3/3/2009 5:52:01 PM

Figure 54 – 20 to 80% Load; Slew Rate = 0.1 A / µs
Non-capacitive Termination.
Vin: 90 VAC / 47 Hz.
Upper: V_{OUT}, 1 V / div.
Lower: I_{OUT}, 1 A / div.



Measure	P1:max(C2)	P2:min(C2)	P3:max(C3)	P4:min(C3)	P5:area(C4)	P6:area(F1)
value	20.31 V	19.48 V	2.83 A	528 mA		
status	✓	✓	✓	✓		

C2 BwL DC1M 1.00 V/div -18.810 V
C3 BwL DC 1.00 A/div -2.960 A ofst
Tbase -30.0 ms 10.0 ms/div 1.00 MS 10 MS/s
Trigger C3 DC Stop 2.50 A Edge Positive
3/3/2009 5:58:10 PM

Figure 55 – 20 to 80% Load; Slew Rate = 0.1 A /
µs Non-capacitive Termination.
Vin: 264 VAC / 63 Hz.
Upper: V_{OUT}, 1 V / div.
Lower: I_{OUT}, 1 A / div.

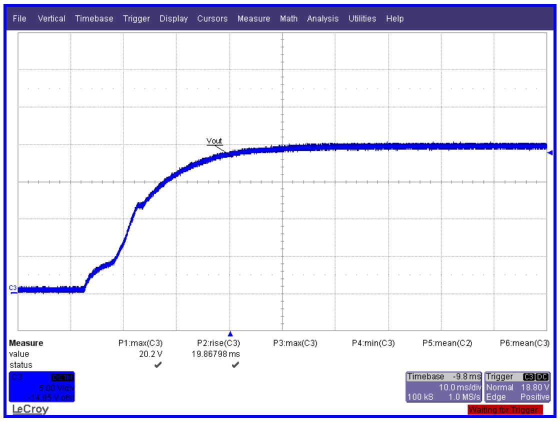
Dynamic Load Condition Terminated with 180 µF Load	Vout Limits		Output Reading			Remarks
	Vo_max (V)	Vo_min (V)	Vpk_H (V)	Vpk_L (V)	Vp-p (V)	
0.3 - 3.33 A Load 50 Hz; 0.1 A / µs; 90 VAC /47 Hz	20.475	18.525	20.38	19.23	1.15	Pass
0.3 - 3.33 A Load 50 Hz; 0.1 A / µs;100 VAC / 60 Hz	20.475	18.525	20.41	19.26	1.15	Pass
0.3 - 3.33 A Load 50 Hz; 0.1 A / µs; 240 VAC / 50 Hz	20.475	18.525	20.38	19.39	0.99	Pass
0.3 - 3.33 A Load 50 Hz; 0.1 A / µs; 264 VAC / 63 Hz	20.475	18.525	20.38	19.42	0.96	Pass
0.3 - 3.33 A Load 100 Hz; 0.1 A / µs; 90 VAC / 47 Hz	20.475	18.525	20.44	19.23	1.21	Pass
0.3 - 3.33 A Load 100 Hz; 0.1 A / µs; 100 VAC / 60 Hz	20.475	18.525	20.44	19.26	1.18	Pass
0.3 - 3.33 A Load 100 Hz; 0.1 A / µs; 240 VAC / 50 Hz	20.475	18.525	20.41	19.39	1.02	Pass
0.3 A – 3.33 A Load 100 Hz; 0.1 A / µs; 264 VAC / 63 Hz	20.475	18.525	20.41	19.42	0.99	Pass
0.0334 - 1.67 A 50 Hz; 0.2 A / µs ; 90 VAC / 47 Hz	21	18	20.6	19.55	1.05	Pass
1.67 - 3.33 A 50 Hz; 0.2 A / µs; 90 VAC / 47 Hz	21	18	20.12	19.48	0.64	Pass
0.0334 - 1.67 A 10 kHz; 0.2 A / µs; 90 VAC / 47 Hz	21	18	20.31	19.93	0.38	Pass
1.67 - 3.33 A 10 kHz; 0.2 A / µs; 90 VAC / 47 Hz	21	18	19.96	19.58	0.38	Pass
0.0334 - 1.67 A 50 Hz; 0.2 A / µs; 115 VAC / 60 Hz	21	18	20.57	19.61	0.96	Pass
1.67 - 3.34 A 50 Hz; 0.2 A / µs ; 115 VAC / 60 Hz	21	18	20.12	19.48	0.64	Pass
0.0334 - 1.67 A 10 kHz; 0.2 A / µs; 115 VAC / 60 Hz	21	18	20.31	19.93	0.38	Pass
1.67 - 3.33 A 10 kHz; 0.2 A / µs ; 115 VAC / 60 Hz	21	18	19.96	19.58	0.38	Pass
0.0334 - 1.67 A 50 Hz;0.2 A / µs ; 230 VAC / 50 Hz	21	18	20.47	19.71	0.76	Pass
1.67 - 3.33 A 50 Hz; 0.2 A / µs; 230 VAC / 50 Hz	21	18	20.12	19.55	0.57	Pass
0.0334 - 1.67 A 10 kHz; 0.2 A / µs; 230 VAC / 50 Hz	21	18	20.31	19.93	0.38	Pass
1.67 - 3.33 A 10 kHz; 0.2 A / µs; 230 VAC / 50 Hz	21	18	19.99	19.58	0.41	Pass
0.0334 - 1.67 A 50 Hz; 0.2 A / µs; 264 VAC / 63 Hz	21	18	20.51	19.74	0.77	Pass
1.67 - 3.33 A 50 Hz; 0.2 A / µs; 264 VAC / 63 Hz	21	18	20.12	19.55	0.57	Pass
0.0334 - 1.67 A 10 kHz; 0.2 A / µs; 264 VAC / 63 Hz	21	18	20.35	19.93	0.42	Pass
1.67 - 3.33 A 10 kHz; 0.2 A / µs; 264 VAC / 63 Hz	21	18	19.96	19.58	0.38	Pass

Table 8 – Dynamic Data with Capacitive Load.

Dynamic Load Condition Non-Capacitive Load	Vout Limits		Output Reading			Remarks
	Vo_max (V)	Vo_min (V)	Vpk_H (V)	Vpk_L (V)	Vp-p (V)	
20 - 80%;0.1 A / µs 90 VAC / 47 Hz	20.5	18.5	20.38	19.26	1.12	Pass
20 - 80%;0.1 A / µs 115 VAC / 60 Hz	20.5	18.5	20.41	19.29	1.12	Pass
20 - 80%;0.1 A / µs 230 VAC / 50 Hz	20.5	18.5	20.35	19.45	0.9	Pass
20 - 80%;0.1 A / µs 264 VAC / 63 Hz	20.5	18.5	20.31	19.48	0.83	Pass

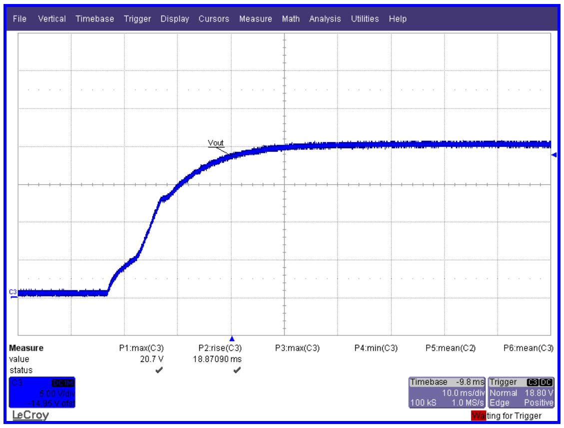
Table 9 – Dynamic Data for Non-capacitive Load.

16 Output Rise Time Profile <20 ms



Measure	P1:max(C3)	P2:rise(C3)	P3:max(C3)	P4:min(C3)	P5:mean(C2)	P6:mean(C3)
value	20.2 V	19.86798 ms				
status	✓	✓				

Figure 56 – 90 VAC / 47 Hz; Maximum Load.



Measure	P1:max(C3)	P2:rise(C3)	P3:max(C3)	P4:min(C3)	P5:mean(C2)	P6:mean(C3)
value	20.7 V	18.87090 ms				
status	✓	✓				

Figure 57 – 264 VAC / 47 Hz; Maximum Load.

17 Over Voltage Protection – Latching

To take these measurements, the feedback loop was opened (by breaking it at the optocoupler) to cause a rise in the output voltage and trigger an OV shutdown.

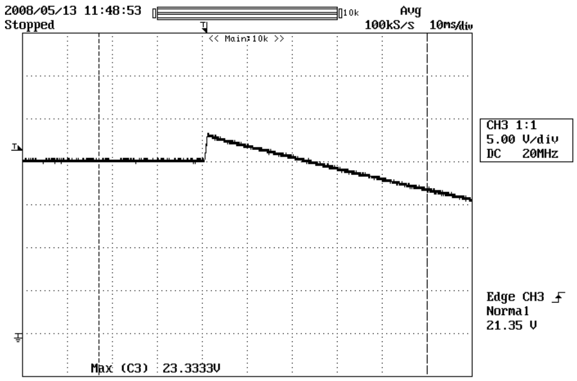


Figure 58 – Output Voltage: 0.1 A Load, 90 VAC; 5 V / div.

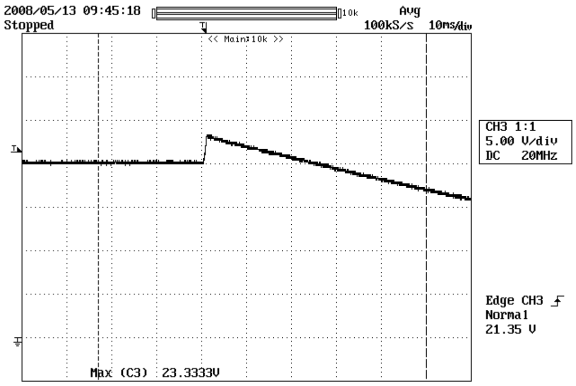


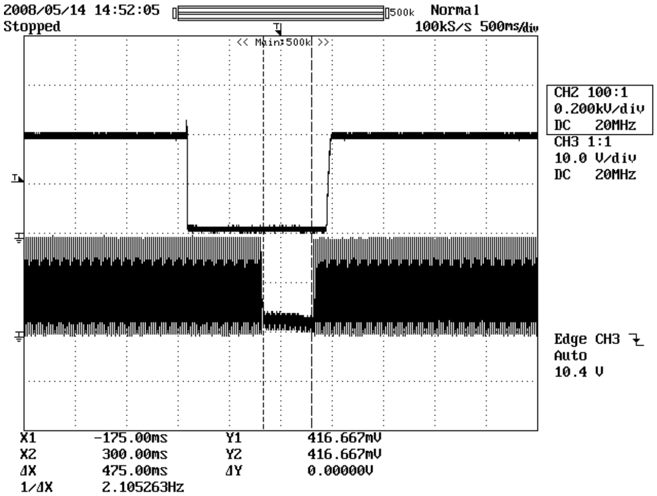
Figure 59 – Output Voltage: 0.1 A Load, 265 VAC; 5 V / div.

17.1 Overload Protection

	VIN (VAC)			
	90 V	**115 V**	**230 V**	**265 V**
Overload current before auto-restart (Vout ~19.68 V)	3.95 A	4.6 A	4.71 A	4.32 A

18 AC Reset

This shows operation of the fast AC reset function. An overvoltage was applied and the AC input was cycled to reset the latch.

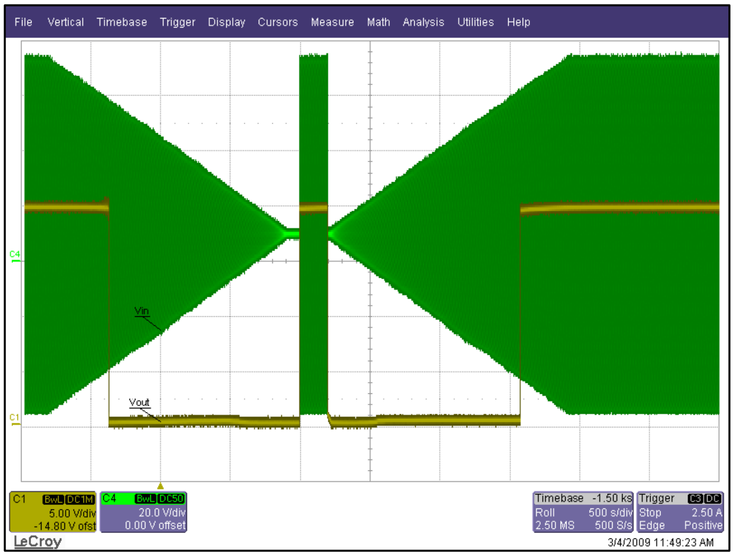


```
2008/05/14 14:52:05        500k  Normal
Stopped                          100kS/s 500ms/div

CH2 100:1
0.200kV/div
DC   20MHz
CH3 1:1
10.0 V/div
DC   20MHz

X1     -175.00ms     Y1   416.667mV
X2      300.00ms     Y2   416.667mV
ΔX      475.00ms     ΔY   0.00000V
1/ΔX    2.105263Hz
```

Figure 60 – AC Reset and Recovery After Overvoltage Latch, 265 VAC.
Ch2: Rectified AC Source.
Ch3: Output Voltage; 10 V, 500 ms / div.

19 Brownout and Recovery

The input voltage decreases from 90 VAC / 50 Hz down to zero in 30 minutes. Then input voltage increases from 0 VAC up to 90VAC / 50 Hz in 30 minutes. The UUT output should recover.



```
C1   BwL DC1M      C4   BwL DC50      Timebase  -1.50 ks   Trigger  C3 DC
      5.00 V/div          20.0 V/div  Roll      500 s/div  Stop     2.50 A
   -14.80 V ofst       0.00 V offset  2.50 MS   500 S/s    Edge   Positive
                                                  3/4/2009 11:49:23 AM
```

Figure 61 – Brownout and Recovery.
Ch1: Output Voltage; 5 V / div.
Ch2: AC Input Voltage; 20 V / div , 500 ms / div.

20 Line Cycle Dropout

The unit is subjected to a dropout of the AC line voltage from 100 VAC / 50 Hz to zero voltage for duration which equal to 10 ms repeated 10 times with a period of 1 second. The unit is fully loaded. Dropout shall occur at any input phase angle.

Ch2: Output Voltage; 5 V / div
Ch4: Input Voltage; 100 V / div

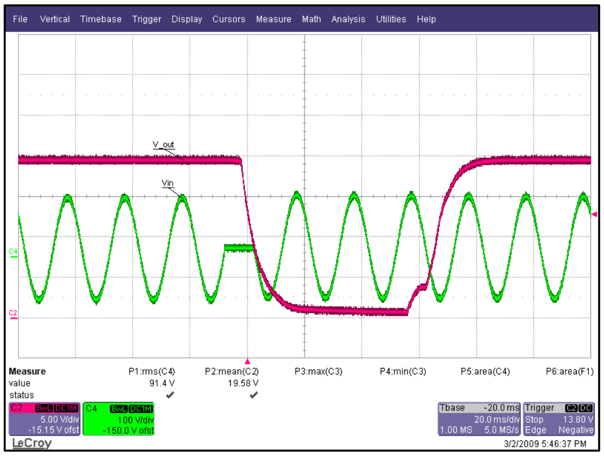


Figure 62 – 90 V / 50 Hz at 0º Dropout.

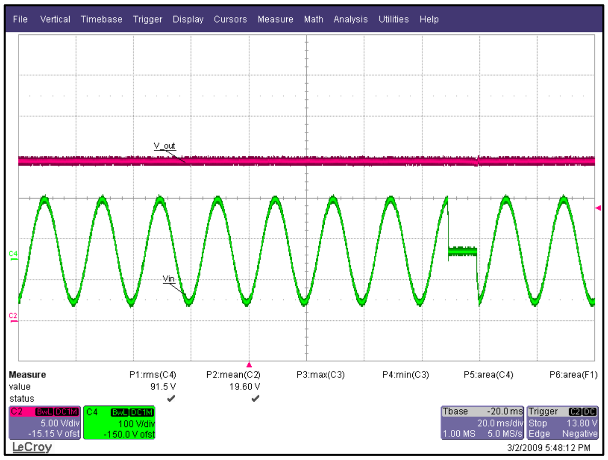


Figure 63 – 80 V / 50 Hz at 90º Dropout.

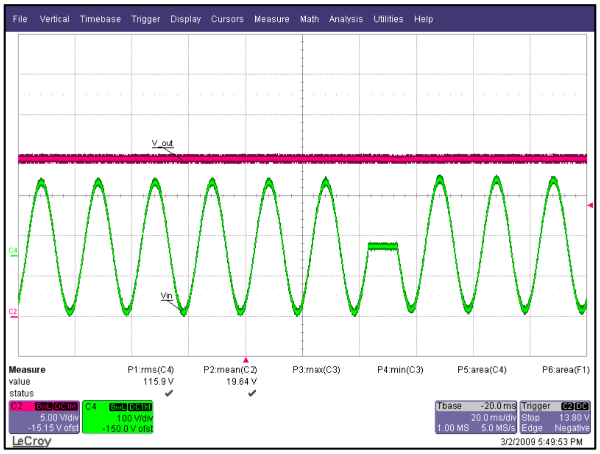


Figure 64 – 100 V / 50 Hz at 0º Dropout.

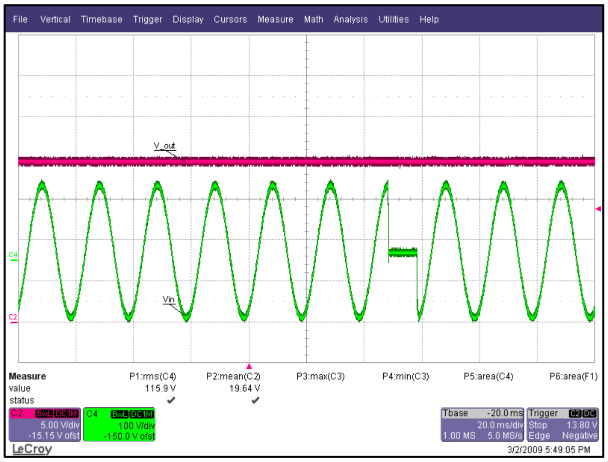


Figure 65 – 100 V / 50 Hz at 90º Dropout.

21 Line Sag

While the unit is operating with maximum continuous load, the line voltage is switched to the sag voltage as indicated below:

100 VAC to 80 VAC for 0.5 sec., and back to 100 VAC at 50 Hz, repeated 10 times with 10 seconds interval.

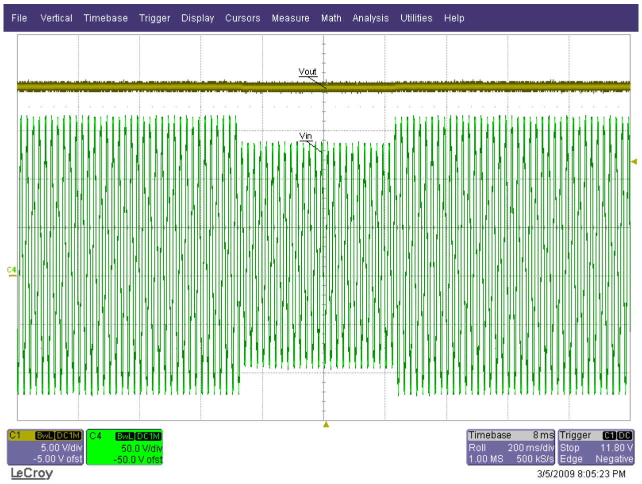


Figure 66 – Line Sag; Ch1: 5 V / div (V_{OUT}); Ch4: 50 V / div (V_{IN}).

22 Line Swell

While the unit is operating with maximum continuous load, the line voltage is switched to the swell voltage as indicated below:

220 VAC to 286 VAC for 1 sec, and back to 220 VAC at 50 Hz, repeated 10 times with 10 seconds interval.

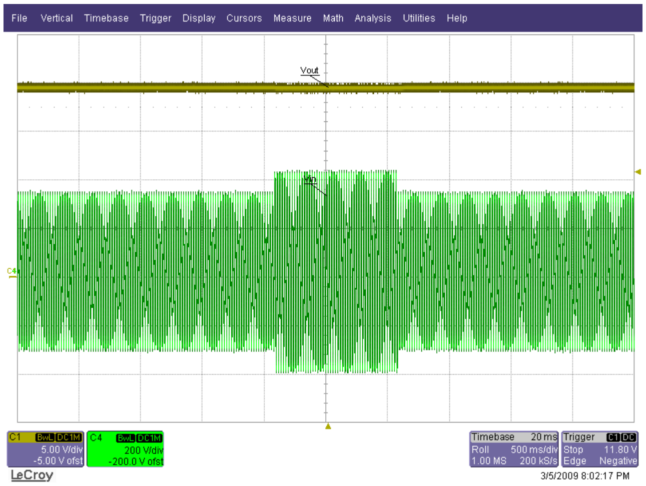


Figure 67 – Line Swell; Ch1: 5 V / div (V_{OUT}); Ch4: 200 V / div (V_{IN}).

23 Output Ripple Measurements

23.1.1 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 figures below. The waveforms were captured at the end of the output cord.

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

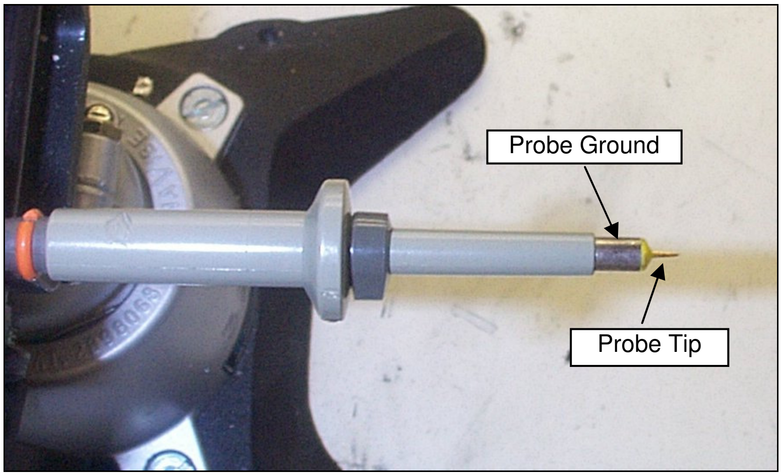


Figure 68 – Oscilloscope Probe Prepared for Ripple Measurement. (End cap and ground lead removed)

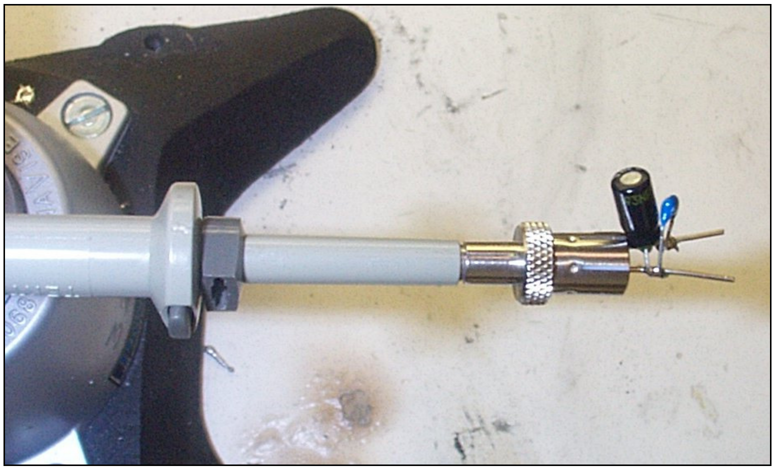
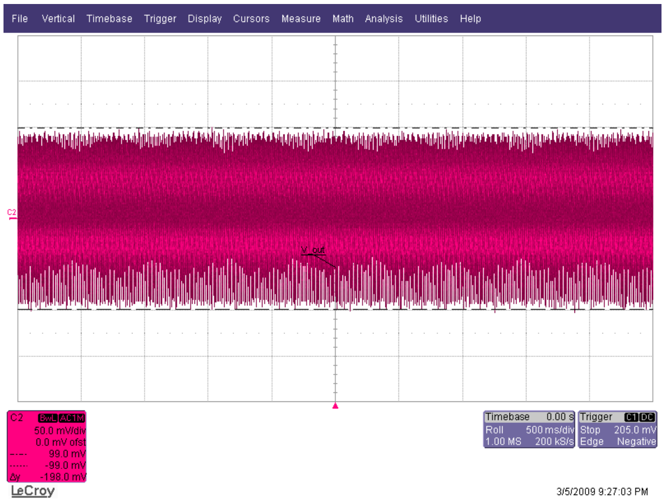


Figure 69 – Oscilloscope Probe with Probe Master 4987BA BNC Adapter. (Modified with wires for probe ground for ripple measurement, and two parallel decoupling capacitors added)

23.1.2 Measurement Results



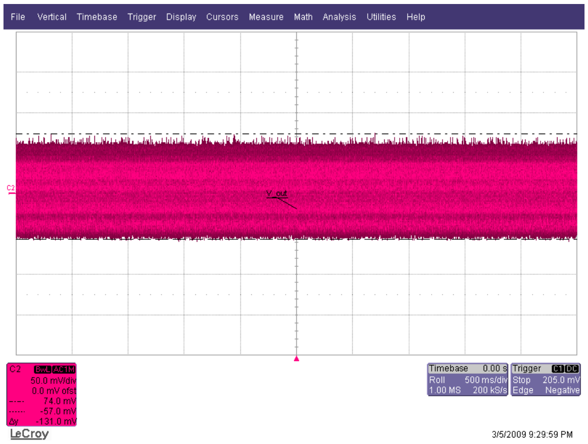
C2 BwL AC1M
50.0 mV/div
0.0 mV ofst
99.0 mV
-99.0 mV
Δy -198.0 mV

Timebase 0.00 s
Roll 500 ms/div
1.00 MS 200 kS/s

Trigger C1 DC
Stop 205.0 mV
Edge Negative

3/5/2009 9:27:03 PM

Figure 70 – Ripple, 90 VAC, Full Load.
500 ms / div, 50 mV / div.



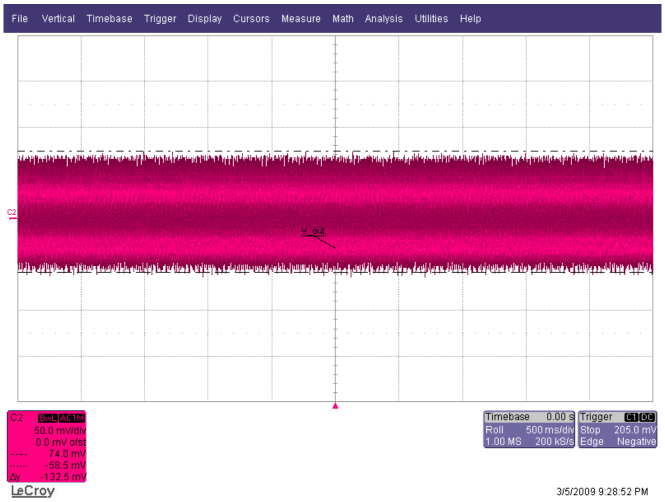
C2 BwL AC1M
50.0 mV/div
0.0 mV ofst
74.0 mV
-57.0 mV
Δy -131.0 mV

Timebase 0.00 s
Roll 500 ms/div
1.00 MS 200 kS/s

Trigger C1 DC
Stop 205.0 mV
Edge Negative

3/5/2009 9:29:59 PM

Figure 71 – Ripple, 265 VAC, Full Load.
500 ms / div, 50 mV / div.



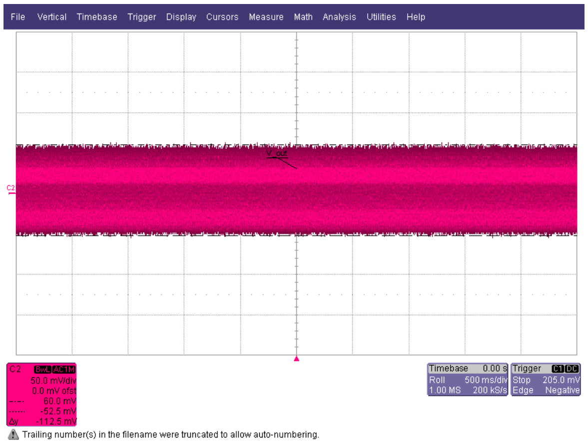
C2 BwL AC1M
50.0 mV/div
0.0 mV ofst
74.0 mV
-58.5 mV
Δy -132.5 mV

Timebase 0.00 s
Roll 500 ms/div
1.00 MS 200 kS/s

Trigger C1 DC
Stop 205.0 mV
Edge Negative

3/5/2009 9:28:52 PM

Figure 72 – Ripple, 115 VAC, Full Load.
500 ms / div, 50 mV / div.



C2 BwL AC1M
50.0 mV/div
0.0 mV ofst
60.0 mV
-52.5 mV
Δy -112.5 mV

Timebase 0.00 s
Roll 500 ms/div
1.00 MS 200 kS/s

Trigger C1 DC
Stop 205.0 mV
Edge Negative

⚠ Trailing number(s) in the filename were truncated to allow auto-numbering.

Figure 73 – Ripple, 230 VAC, Full Load.
500 ms / div, 50 mV / div.

24 Control Loop Measurements

Venable System equipment was used to gather this data.

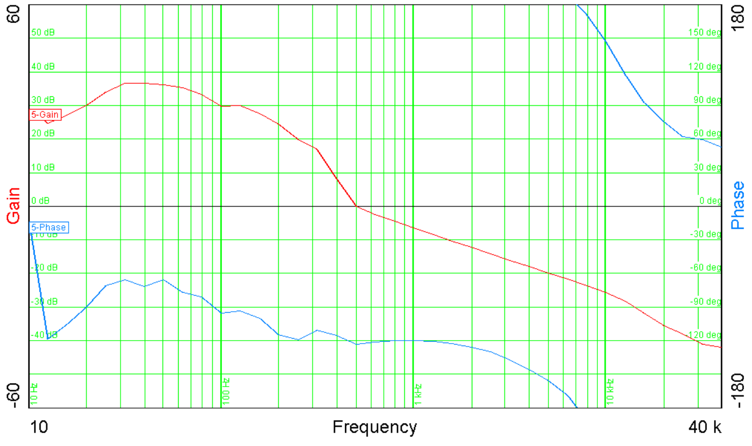


Figure 74 – Gain-Phase Plot, 115 VAC, Maximum Steady State Load.
Vertical Scale: Gain = 10 dB / div, Phase = 30 °/ div.
Crossover Frequency = 0.5 kHz Phase Margin = 60°.

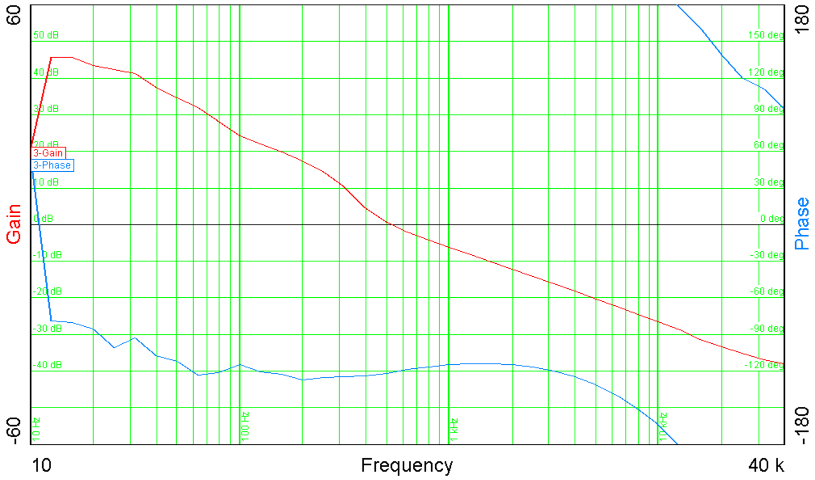


Figure 75 – Gain-Phase Plot, 230 VAC, Maximum Steady State Load.
Vertical Scale: Gain = 10 dB / div, Phase = 50 °/ div.
Crossover Frequency = 500 Hz, Phase Margin = 60°.

25 Conducted EMI

Equipment used: Rohde and Schwarz ESPI3 (PN: m1142.8007.03 / EMI Test Receiver 9 kHz to 3 GHz).

The unit left running at least 15minutes to warm before the measurement were taken.

V_{OUT} = 19.5 V
R_{LOAD} = 5.85 Ω

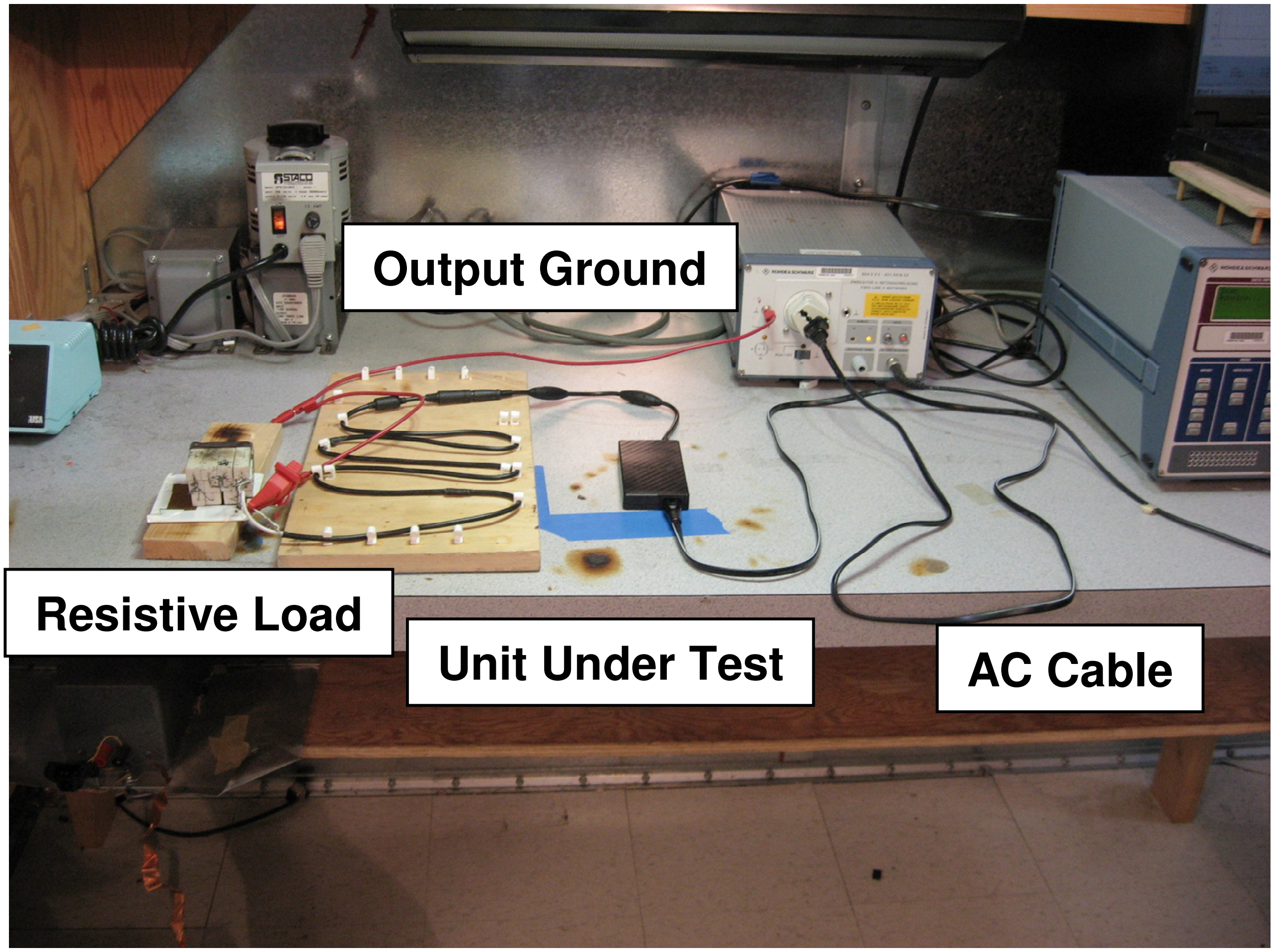


Figure 76 – Conducted EMI Set-Up.

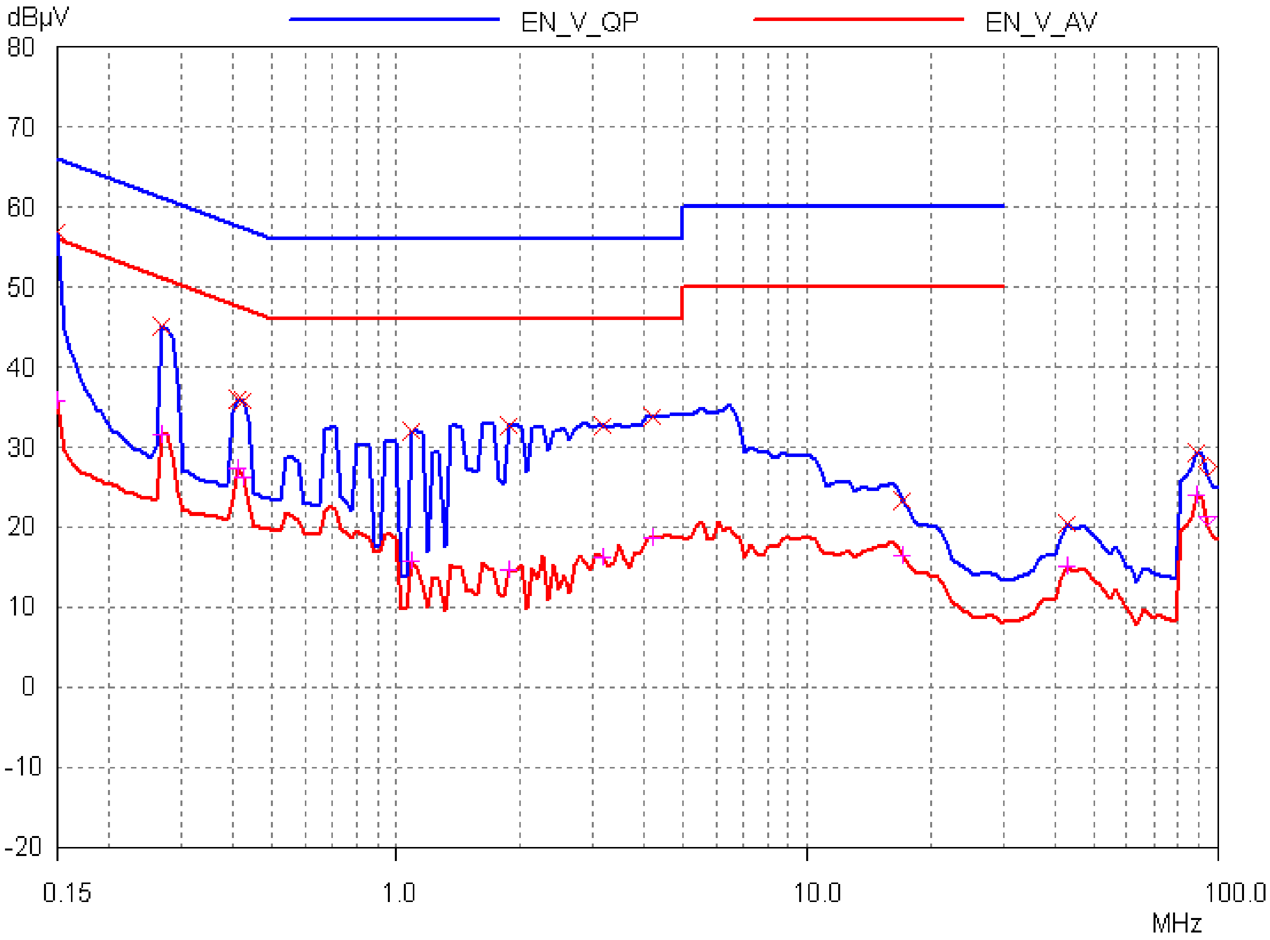
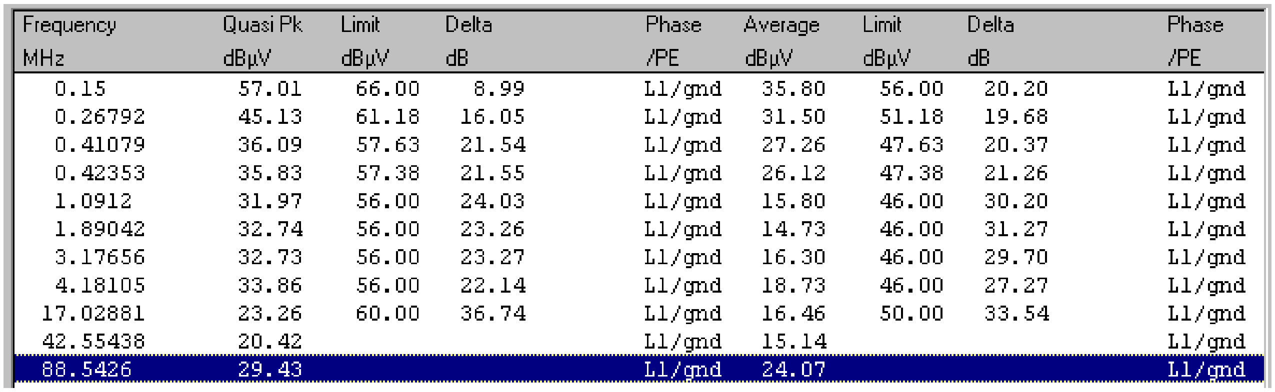


Figure 77 – Conducted EMI with 115 VAC Input, 6 Ω Resistive Load, Output Return Not-Connected to PE.



Frequency MHz	Quasi Pk dBμV	Limit dBμV	Delta dB	Phase /PE	Average dBμV	Limit dBμV	Delta dB	Phase /PE
0.15	57.01	66.00	8.99	L1/gnd	35.80	56.00	20.20	L1/gnd
0.26792	45.13	61.18	16.05	L1/gnd	31.50	51.18	19.68	L1/gnd
0.41079	36.09	57.63	21.54	L1/gnd	27.26	47.63	20.37	L1/gnd
0.42353	35.83	57.38	21.55	L1/gnd	26.12	47.38	21.26	L1/gnd
1.0912	31.97	56.00	24.03	L1/gnd	15.80	46.00	30.20	L1/gnd
1.89042	32.74	56.00	23.26	L1/gnd	14.73	46.00	31.27	L1/gnd
3.17656	32.73	56.00	23.27	L1/gnd	16.30	46.00	29.70	L1/gnd
4.18105	33.86	56.00	22.14	L1/gnd	18.73	46.00	27.27	L1/gnd
17.02881	23.26	60.00	36.74	L1/gnd	16.46	50.00	33.54	L1/gnd
42.55438	20.42			L1/gnd	15.14			L1/gnd
88.5426	29.43			L1/gnd	24.07			L1/gnd

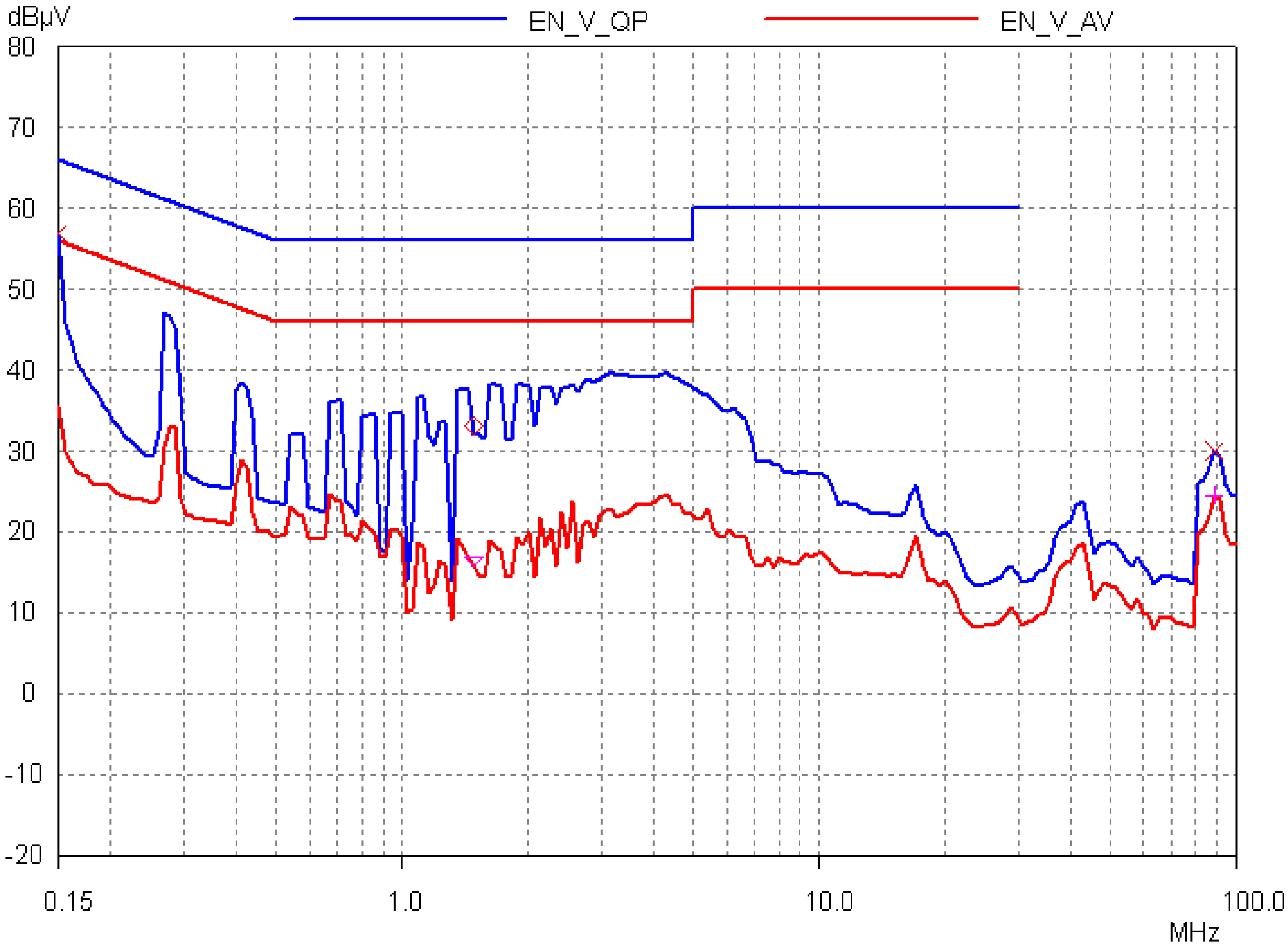
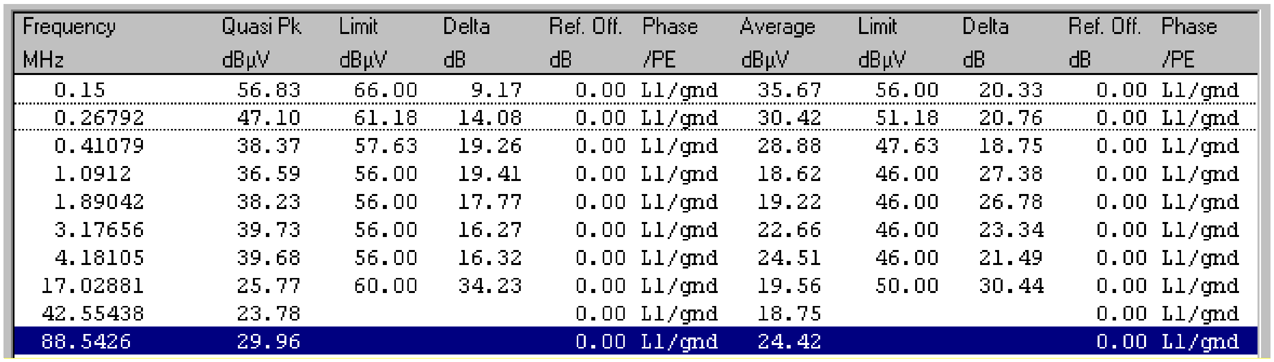


Figure 78 – Conducted EMI with 115 VAC Input, 6 Ω Resistive Load, Output Return Connected to PE.



Frequency MHz	Quasi Pk dBµV	Limit dBµV	Delta dB	Ref. Off. dB	Phase /PE	Average dBµV	Limit dBµV	Delta dB	Ref. Off. dB	Phase /PE
0.15	56.83	66.00	9.17	0.00	L1/gnd	35.67	56.00	20.33	0.00	L1/gnd
0.26792	47.10	61.18	14.08	0.00	L1/gnd	30.42	51.18	20.76	0.00	L1/gnd
0.41079	38.37	57.63	19.26	0.00	L1/gnd	28.88	47.63	18.75	0.00	L1/gnd
1.0912	36.59	56.00	19.41	0.00	L1/gnd	18.62	46.00	27.38	0.00	L1/gnd
1.89042	38.23	56.00	17.77	0.00	L1/gnd	19.22	46.00	26.78	0.00	L1/gnd
3.17656	39.73	56.00	16.27	0.00	L1/gnd	22.66	46.00	23.34	0.00	L1/gnd
4.18105	39.68	56.00	16.32	0.00	L1/gnd	24.51	46.00	21.49	0.00	L1/gnd
17.02881	25.77	60.00	34.23	0.00	L1/gnd	19.56	50.00	30.44	0.00	L1/gnd
42.55438	23.78			0.00	L1/gnd	18.75			0.00	L1/gnd
88.5426	29.96			0.00	L1/gnd	24.42			0.00	L1/gnd

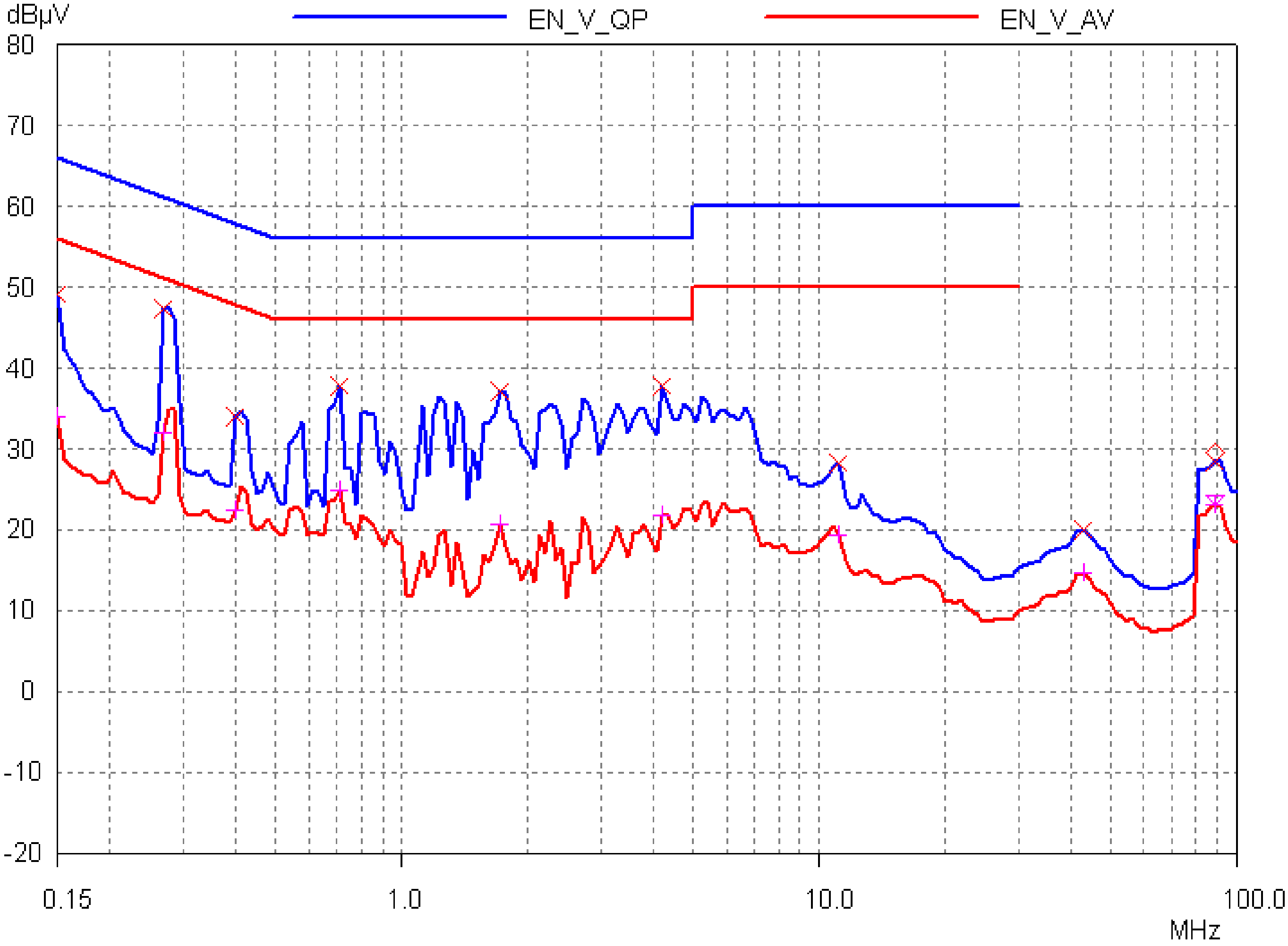
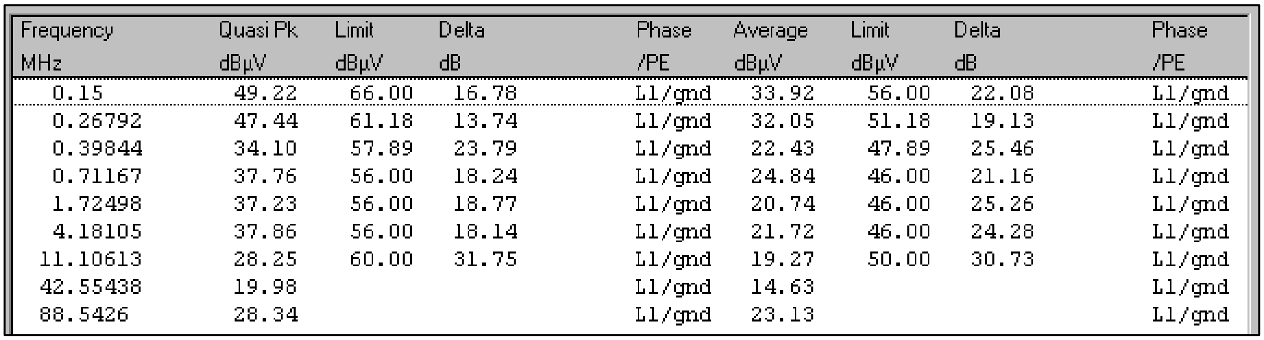


Figure 79 – Conducted EMI with 230 VAC Input, 6 Ω Resistive Load, Output Return Not-Connected to PE.



Frequency MHz	Quasi Pk dBµV	Limit dBµV	Delta dB	Phase /PE	Average dBµV	Limit dBµV	Delta dB	Phase /PE
0.15	49.22	66.00	16.78	L1/gnd	33.92	56.00	22.08	L1/gnd
0.26792	47.44	61.18	13.74	L1/gnd	32.05	51.18	19.13	L1/gnd
0.39844	34.10	57.89	23.79	L1/gnd	22.43	47.89	25.46	L1/gnd
0.71167	37.76	56.00	18.24	L1/gnd	24.84	46.00	21.16	L1/gnd
1.72498	37.23	56.00	18.77	L1/gnd	20.74	46.00	25.26	L1/gnd
4.18105	37.86	56.00	18.14	L1/gnd	21.72	46.00	24.28	L1/gnd
11.10613	28.25	60.00	31.75	L1/gnd	19.27	50.00	30.73	L1/gnd
42.55438	19.98			L1/gnd	14.63			L1/gnd
88.5426	28.34			L1/gnd	23.13			L1/gnd

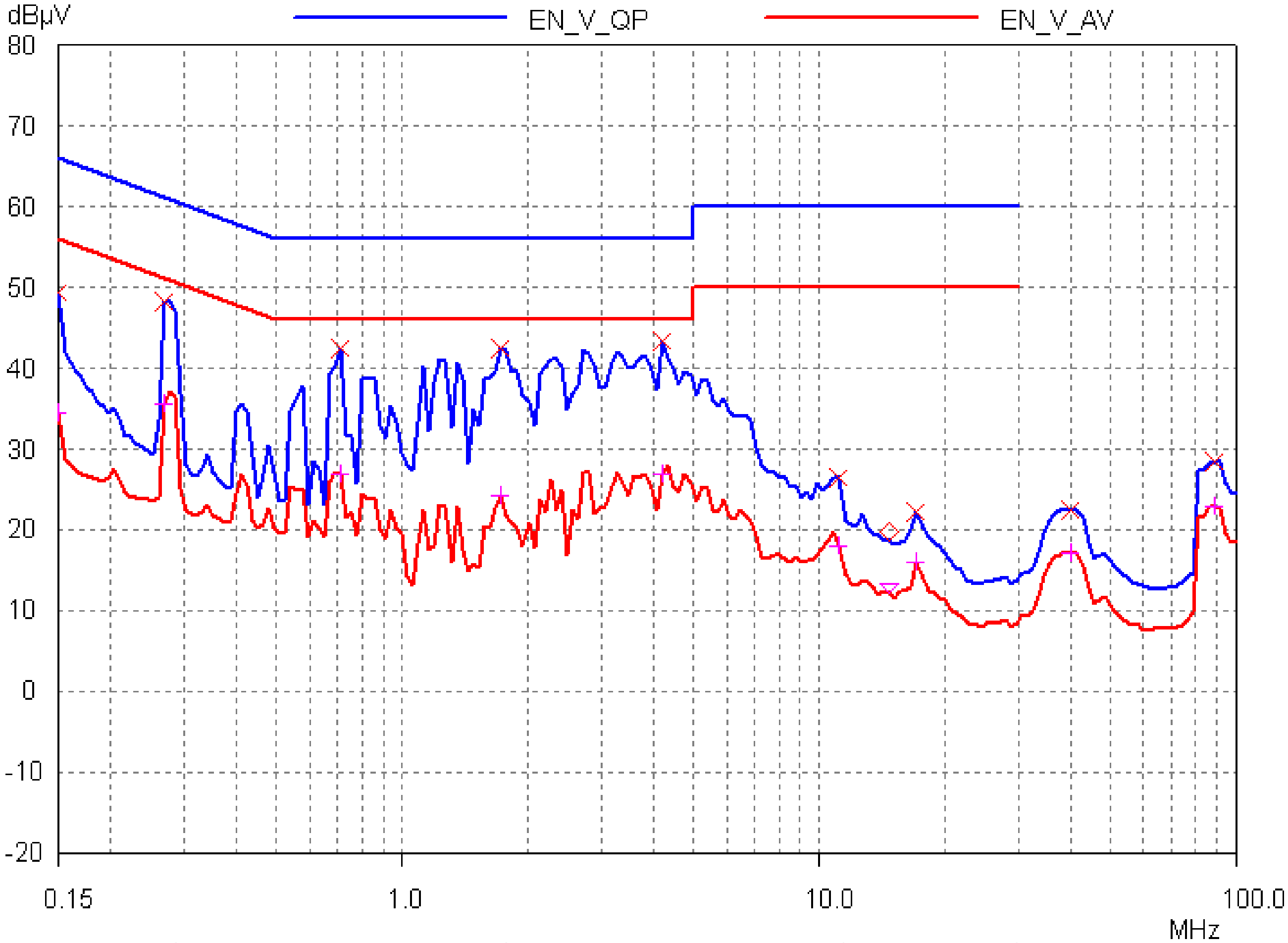
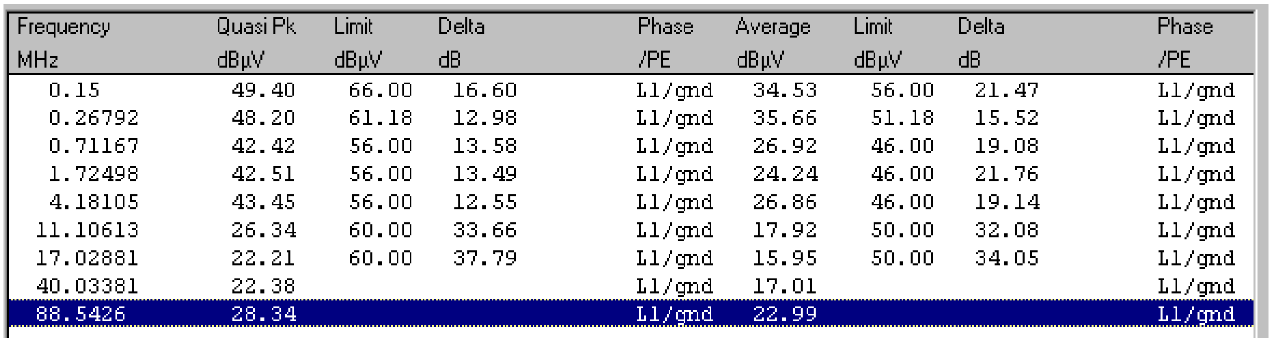


Figure 80 – Conducted EMI with 230 VAC Input, 6 Ω Resistive Load, Output Return Connected to PE.



Frequency MHz	Quasi Pk dBµV	Limit dBµV	Delta dB	Phase /PE	Average dBµV	Limit dBµV	Delta dB	Phase /PE
0.15	49.40	66.00	16.60	L1/gnd	34.53	56.00	21.47	L1/gnd
0.26792	48.20	61.18	12.98	L1/gnd	35.66	51.18	15.52	L1/gnd
0.71167	42.42	56.00	13.58	L1/gnd	26.92	46.00	19.08	L1/gnd
1.72498	42.51	56.00	13.49	L1/gnd	24.24	46.00	21.76	L1/gnd
4.18105	43.45	56.00	12.55	L1/gnd	26.86	46.00	19.14	L1/gnd
11.10613	26.34	60.00	33.66	L1/gnd	17.92	50.00	32.08	L1/gnd
17.02881	22.21	60.00	37.79	L1/gnd	15.95	50.00	34.05	L1/gnd
40.03381	22.38			L1/gnd	17.01			L1/gnd
88.5426	28.34			L1/gnd	22.99			L1/gnd

26 Radiated EMI

Testing was performed at external test house in a 5 meter chamber.

The unit left running at least 15 minutes to warm before the measurement were taken.

V_{OUT} = 19.5 V
R_{LOAD} = 5.85 Ω

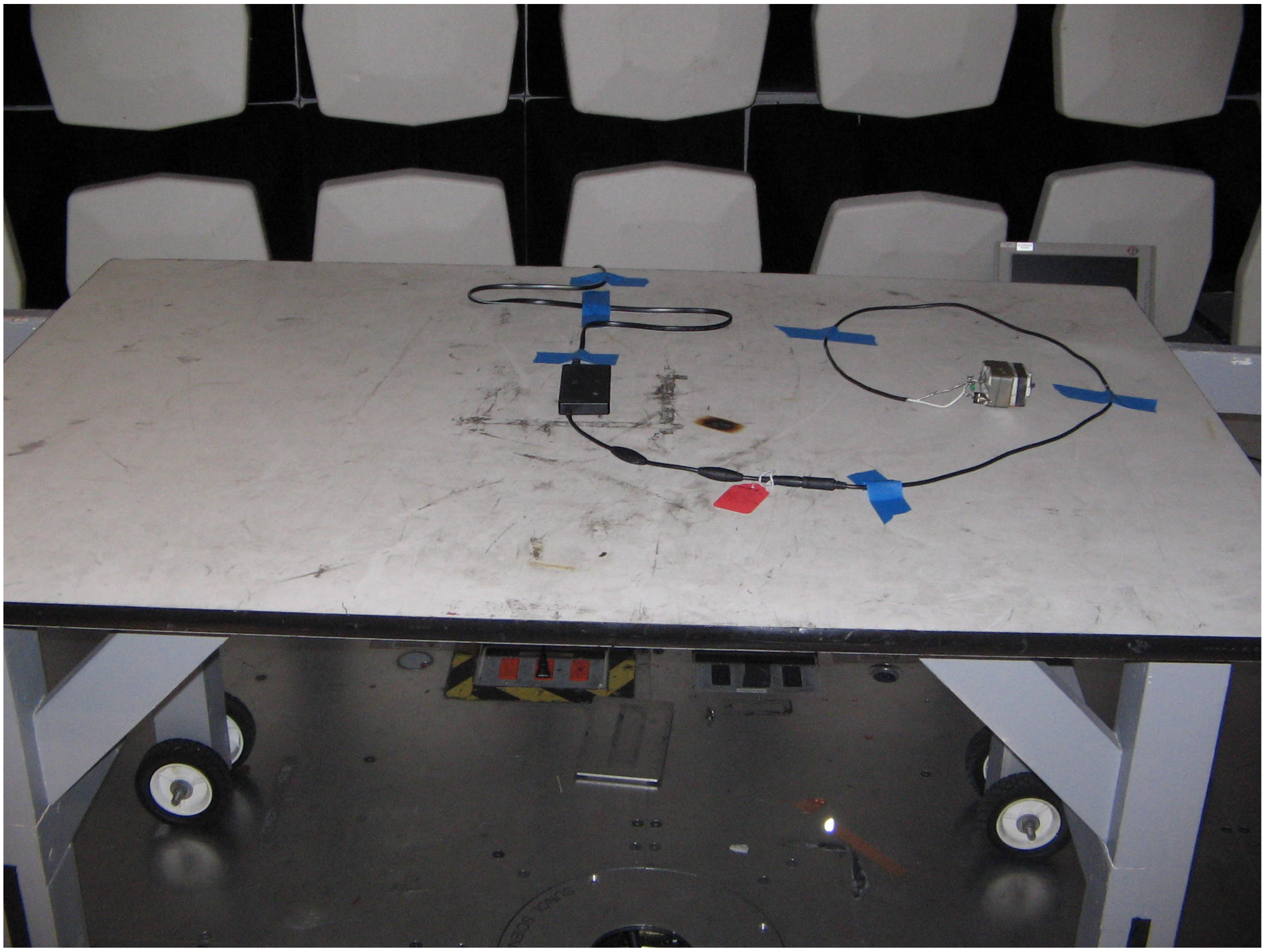
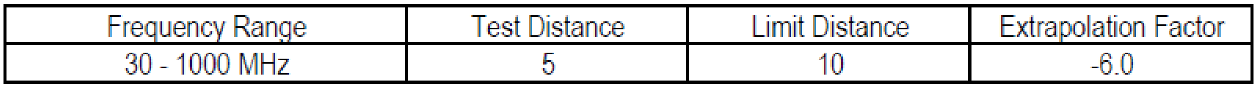


Figure 81 – Radiated Emission Set-Up.



Frequency Range	Test Distance	Limit Distance	Extrapolation Factor
30 - 1000 MHz	5	10	-6.0

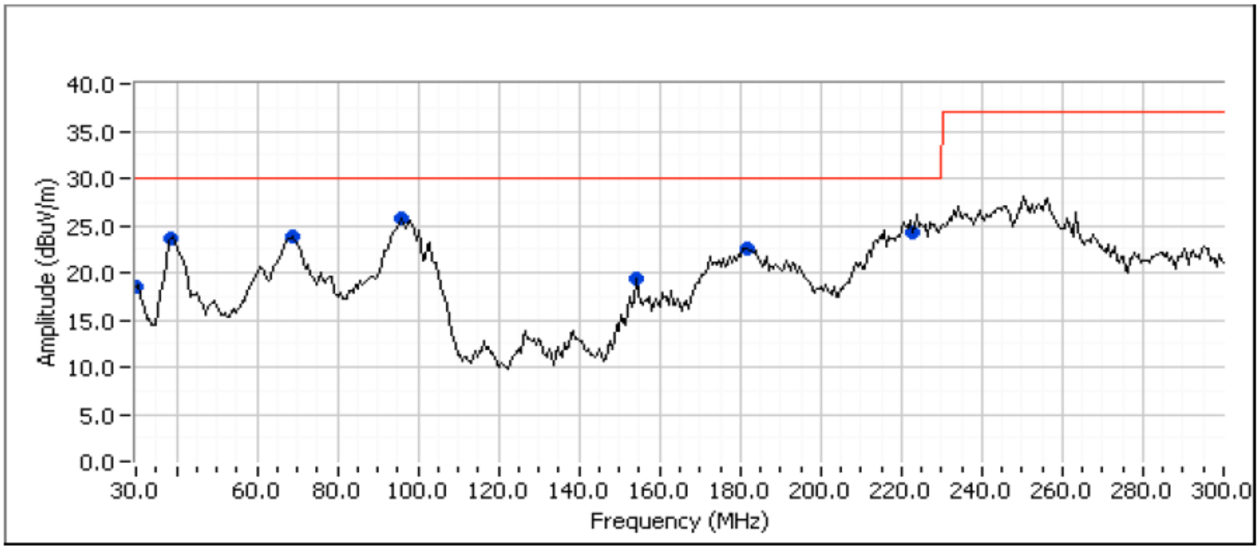
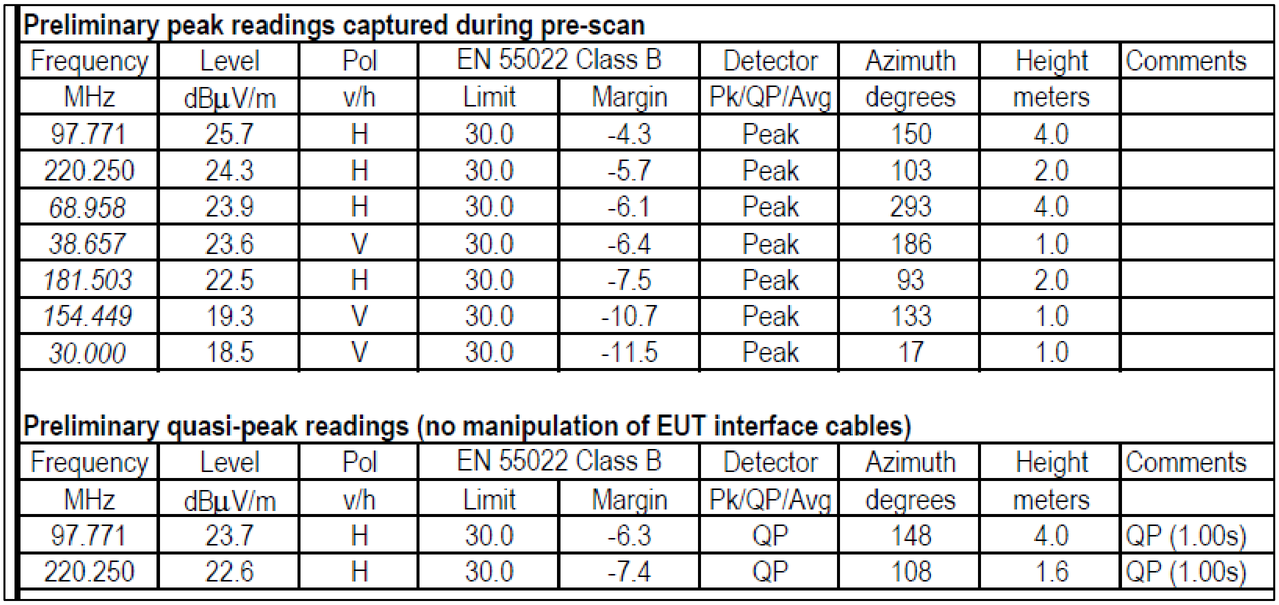


Figure 82 – Radiated Emission Scan at 120 VAC / 60 Hz.



Preliminary peak readings captured during pre-scan

Frequency	Level	Pol	EN 55022 Class B		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
97.771	25.7	H	30.0	-4.3	Peak	150	4.0	
220.250	24.3	H	30.0	-5.7	Peak	103	2.0	
68.958	23.9	H	30.0	-6.1	Peak	293	4.0	
38.657	23.6	V	30.0	-6.4	Peak	186	1.0	
181.503	22.5	H	30.0	-7.5	Peak	93	2.0	
154.449	19.3	V	30.0	-10.7	Peak	133	1.0	
30.000	18.5	V	30.0	-11.5	Peak	17	1.0	

Preliminary quasi-peak readings (no manipulation of EUT interface cables)

Frequency	Level	Pol	EN 55022 Class B		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
97.771	23.7	H	30.0	-6.3	QP	148	4.0	QP (1.00s)
220.250	22.6	H	30.0	-7.4	QP	108	1.6	QP (1.00s)

Frequency Range	Test Distance	Limit Distance	Extrapolation Factor
30 - 1000 MHz	5	10	-6.0

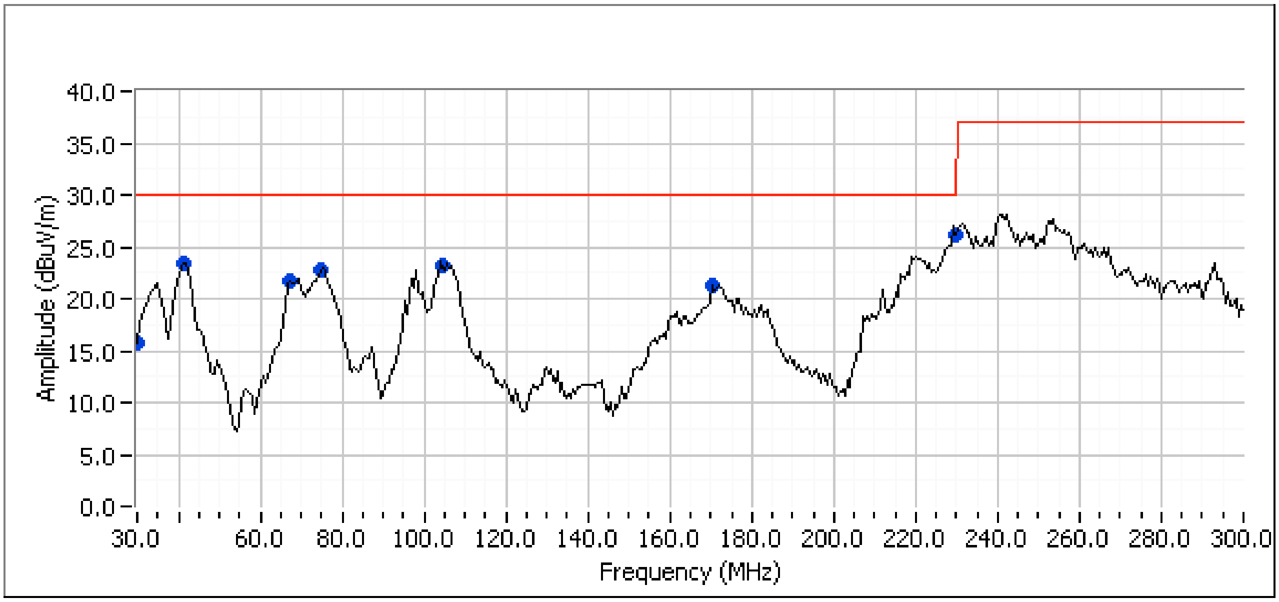


Figure 83 –Radiated Emission Scan at 230 VAC / 50 Hz.

Preliminary peak readings captured during pre-scan

Frequency	Level	Pol	EN 55022 Class B		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
231.493	26.1	H	30.0	-3.9	Peak	133	2.0	
41.363	23.5	V	30.0	-6.5	Peak	56	1.0	
104.669	23.1	V	30.0	-6.9	Peak	206	1.0	
74.910	22.7	V	30.0	-7.3	Peak	144	1.0	
67.335	21.7	H	30.0	-8.3	Peak	263	4.0	
170.140	21.2	H	30.0	-8.8	Peak	81	4.0	
30.000	15.7	V	30.0	-14.3	Peak	77	1.0	

Preliminary quasi-peak readings (no manipulation of EUT interface cables)

Frequency	Level	Pol	EN 55022 Class B		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
231.493	26.8	H	37.0	-10.2	QP	124	2.0	QP (1.00s)

27 Revision History

Date	Author	Rev.	Description	Reviewed
17-Jul-08	ME	1.0	Initial Release	PV / KM
14-Oct-08	JDC	2.0	Added Appendix A for EMC-RE Improvement details	ME
24-Nov-08	ME	2.1	Added Appendix B	PV / KM
15-April-09	JDC	3.0	Updated latest test result for thermal, and EMC. Updated mechanical drawings and schematic. Incorporate Appendix A and B into main document.	ME, DN

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

PATENT INFORMATION

The products and applications illustrated herein (including transformer construction and circuits external to the products) may be covered by one or more U.S. and foreign patents, or potentially by pending U.S. and foreign patent applications assigned to Power Integrations. A complete list of Power Integrations' patents may be found at www.powerint.com. Power Integrations grants its customers a license under certain patent rights as set forth at http://www.powerint.com/ip.htm.

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