Title	***Engineering Prototype Report for EP-29 - Multiple Output 11 W (15.5 W peak) AC-DC Power Supply using TNY268P (TinySwitch®-II)***
Specification	Universal Input, 3.3 V, 5 V, 12 V, -12 V Outputs
Application	DVD Player, Cable Box, DVB-T Receiver
Author	Power Integrations Application Department
Document Number	EPR-29
Date	7-Jul-03
Revision	1.3

Summary and Features

- Universal input operation (90 VAC to 265 VAC)
- High efficiency multiple output supply >79% (min.)
- High low-load efficiency
- Low parts count solution
- Good cross-regulation without linear post-regulators
- Very low cost EMI filter – no common-mode choke

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Important Note:
Although the EP-29 board is designed to satisfy safety isolation requirements, this engineering prototype has not been agency approved. Therefore, all testing should be performed using an isolation transformer to provide the AC input to the prototype board.

1 Introduction

This document is an engineering report describing an 11 W universal input, multiple output flyback power supply, utilizing a TNY268P device from the *TinySwitch-II* family. This power supply is intended to allow evaluation in such applications as DVD players, cable and DVB-T set-top boxes. As some applications have peak loads, accelerating a DVD disc up to speed for example, this supply will deliver 11 W continuously and up to 15.5 W peak (thermally limited).

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

Figure 1 – EP-29 Populated Circuit Board Photograph.

Note: Minimum loads are not provided on the board, hence for correct operation all outputs should be loaded according to the specification table.

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2 Power Supply Specification

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	90		265	VAC	2 Wire – no protective earth ground
Frequency	f_{LINE}	47	50/60	64	Hz	
Standby Input Power			0.8	0.9	W	0.55 W load (see below)
No-load Input Power			0.09	0.1	W	Zero load, measured at 230 VAC
Output (Normal Operation)						
Output Voltage 1	V_{OUT1}	3.2	3.3	3.4	V	±5%
Output Ripple Voltage 1	$V_{RIPPLE1}$			50	mV	p-p, 20 MHz Bandwidth
Output Current 1	I_{OUT1}	0.3	0.6	0.7	A	
Output Voltage 2	V_{OUT2}	4.75	5	5.25	V	±5%
Output Ripple Voltage 2	$V_{RIPPLE2}$			75	mV	p-p, 20 MHz Bandwidth
Output Current 2	I_{OUT2}	0.5	1.2	1.45	A	
Output Voltage 3	V_{OUT3}	11.16	12	12.84	V	±7%
Output Ripple Voltage 3	$V_{RIPPLE3}$			100	mV	p-p, 20 MHz Bandwidth
Output Current 3	I_{OUT3}	0.1	0.2	0.4	A	
Output Voltage 4	V_{OUT4}	-11.16	-12	-12.84	V	±7%
Output Ripple Voltage 4	$V_{RIPPLE4}$			100	mV	p-p, 20 MHz Bandwidth
Output Current 4	I_{OUT4}	0.03	0.05	0.1	A	
Total Output Power						
Continuous Output Power	P_{OUT}		11		W	At maximum ambient temperature
Peak Output Power	P_{OUT_PEAK}			15.5	W	Thermally limited
Efficiency	η	75			%	At P_{OUT} (15.5 W), 25 °C
Output (Standby)						
Output Voltage 1	$V_{OUT1(SB)}$	3.2	3.3	3.4	V	±5%
Output Current 1	$I_{OUT1(SB)}$	-	0.02	-	A	
Output Voltage 2	$V_{OUT2(SB)}$	4.75	5	5.25	V	±5%
Output Current 2	$I_{OUT2(SB)}$	-	0.1	-	A	
Output Voltage 3	$V_{OUT3(SB)}$	11.16	12	13.2	V	-7% / +15%
Output Current 3	$I_{OUT3(SB)}$	2	-	-	mA	
Output Voltage 4	$V_{OUT4(SB)}$	-11.16	-12	-13.2	V	-7% / +15%
Output Current 4	$I_{OUT4(SB)}$	2	-	-	mA	
Environmental						
Conducted EMI		Meets CISPR22B / EN55022B				
Safety		Designed to meet IEC950, UL1950 Class II				
Surge		2			kV	1.2/50 µs surge, IEC 1000-4-5, 2/12 Ω series impedance, differential/common mode
Ambient Temperature	T_{AMB}	0		50	°C	Free convection, sea level

3 Schematic

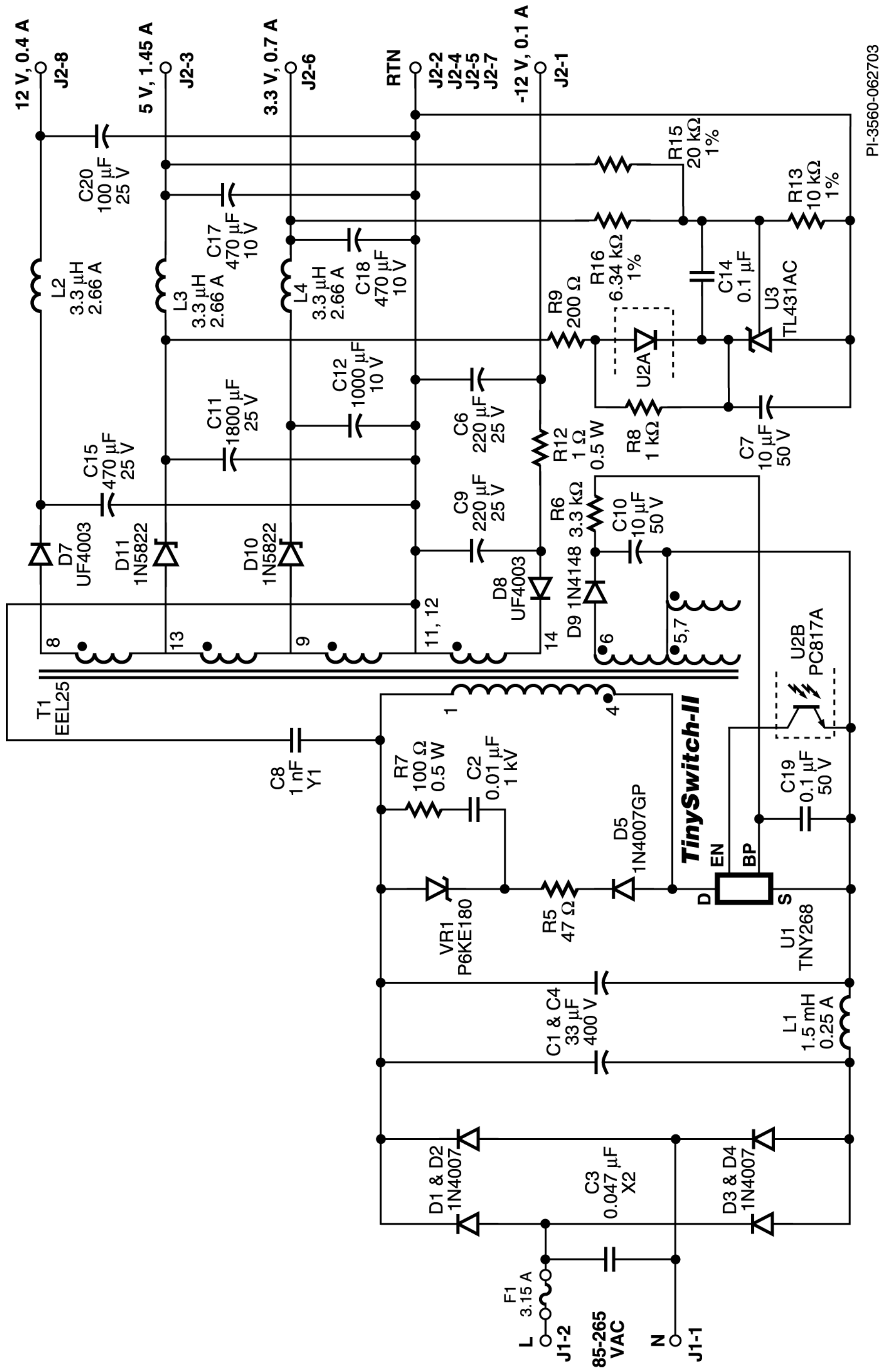

Figure 2 – EP-29 Schematic.

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4 Circuit Description

The circuit shown is an AC to DC multi-output flyback power supply using the highly integrated TNY268 power IC from the *TinySwitch-II* family. The circuit is designed for 90 VAC to 265 VAC input with 3.3 V, 5 V, 12 V, and -12 V outputs.

4.1 Input EMI Filtering

Capacitor C3, inductor L1 and capacitors C1 and C4 provide differential mode EMI filtering. Capacitor C8 (Y-capacitor) helps to reduce common-mode and radiated EMI. In conjunction with these components, the frequency jitter feature of the TNY268 and shields in the transformer, allow the unit to pass CISPR22B/EN55022B specifications for conducted emissions without the need for a common-mode choke.

4.2 TinySwitch-II Primary

Diodes D1, D2, D3, and D4 and capacitors C1 and C4 provide a high-voltage DC bus for the primary circuitry. The DC bus is applied to the high side of the transformer T1 primary winding. The other side of the transformer primary is driven by the integrated switching MOSFET of the *TinySwitch-II* U1. Components D5, R5, C2, R7, and VR1 form the clamp network to limit the voltage rise at MOSFET turn-off due to the transformer leakage inductance. This circuit clamps the MOSFET voltage to a safe level during normal power supply operation. The Zener VR1 actively clamps at peak output load, but does not contribute to the clamping at normal load conditions.

Diode D5 is a slow-recovery diode and allows some of the clamp energy to be recovered and transferred to the output. After clamping the leakage inductance energy, diode D5 does not turn off immediately. This allows some current to flow in the reverse direction, out of C2 and couple through the transformer to the secondary side. Resistors R5 and R7 damp ringing while R5 also limits the reverse current through D5 when U1 turns on. The energy recovery of this clamp scheme contributes to slightly higher efficiency and also better cross-regulation.

Diode D9 and capacitor C10 rectify and filter the voltage from the transformer bias winding. Current is fed from C10 via R6 to the BYPASS pin of U1. Supplying U1 from the bias winding reduces power consumption by inhibiting the internal DRAIN current source normally used to power the IC from the high voltage DC bus during the internal MOSFET off time. This helps improve the no-load power consumption and light load efficiency of the power supply. Capacitor C19 is the decoupling capacitor for the *TinySwitch-II*. Opto-transistor U2A provides feedback from the secondary side to control *TinySwitch-II* regulation.

4.3 Output Rectification

Diodes D7, D11, D10, and D8 together with capacitors C15, C11, C12, and C9 provide rectification and filtering of the secondary transformer voltages. Capacitors C20, C17, and C18 with inductors L2, L3, and L4 provide filtering to reduce high switching frequency ripple from the outputs. This is implemented with resistor R12 and capacitor C6 on the lower current –12 VDC output.

4.4 Output Feedback

Resistors R15 and R16 sense the 5 V and 3.3 V outputs and with resistor R13 form a voltage divider network at the input of the TL431 (U3). Capacitor C14 provides compensation for the TL431 (to provide high DC gain but low high frequency gain). The TL431 drives current through optocopler LED U2B, which in turn is fed from the 5 V rail (before the post filter) by resistor R9. The value of R9 programs the high frequency gain of the control loop. The ON/OFF control scheme used by *TinySwitch-II* (U1) ensures low output ripple, fast transient response, high low-load efficiency, and low no-load consumption while minimizing audible noise by ensuring the transformer flux density is low when the switching frequency enters the audible range.

Capacitor C7 provides a soft-finish characteristic to "close" the feedback loop early during power up, thus eliminating startup output overshoot. Resistor R8 provides a discharge path for C7 after power down.

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5 PCB Layout

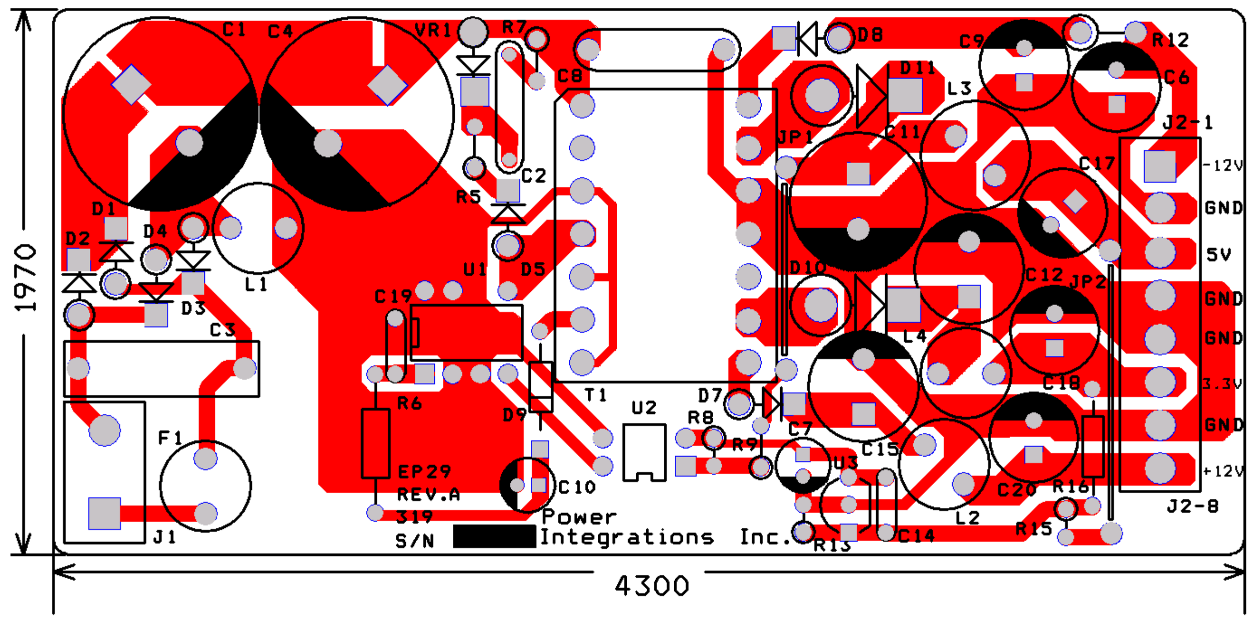

Figure 3 – Printed Circuit Layout (Dimensions 0.001″).

6 Bill Of Materials

EP-29 - TNY268 DVD 11 W (15.5 W pk) – 050203b

Item	Qty	Reference	Description	P/N	Manufacturer
1	2	C1, C4	33 µF, 400 V 16 mm x 25 mm, general purpose	KMG400VB33M	Nippon Chemi-Con
2	1	C2	0.01 µF, 1 kV, ceramic Z5U dielectric		Any
3	1	C3	0.047 µF, X2 Class		Any
4	2	C6, C9	220 µF, 25 V 8 mm x 11.5 mm, general purpose	KMG25VB220M	Nippon Chemi-Con
5	2	C7, C10	10 µF, 50 V 5 mm x 11 mm, general purpose	KMG50VB10M	Nippon Chemi-Con
6	1	C8	1 nF, Y1 class (safety)		Any
7	1	C11	1800 µF, 25 V, 24 mΩ 12.5 mm x 30 mm, low ESR	KY25VB1800MK30	Nippon Chemi-Con
8	1	C12	1000 µF, 10 V, 60 mΩ 10 mm x 16 mm, low ESR	KY10VB1000MJ16	Nippon Chemi-Con
9	2	C14, C19	0.1 µF, 50 V, ceramic Z5U dielectric		Any
10	3	C15	470 µF, 25 V, 38 mΩ 10 mm x 16 mm, low ESR	KZE25VB470MJ16	Nippon Chemi-Con
11	2	C17, C18	470 µF, 10 V 8 mm x 11.5 mm, general purpose	KMG10VB470M	Nippon Chemi-Con
12	1	C20	100 µF, 25 V 6.3 mm x 11 mm, general purpose	KMG25VB100M	Nippon Chemi-Con
13	4	D1, D2, D3, D4	1 A, 600 V	1N4007	Any
14	1	D5	1 A, 600 V, Glass Passivated	1N4007GP	Vishay / Any
15	2	D8, D7	UF4003		Any
16	1	D9	1N4148		Any
17	2	D10, D11	1N5822		Any
18	1	F1	3.15 A, 250 VAC		Any
19	1	L1	1.5 mH 0.25 A	SBC3-152-251	Tokin, or equiv.
20	3	L2, L3, L4	3.3 µH, 2.66 A	822LY-3R3M	Toko, or equiv.
21	1	R5	47 Ω, 1/4 W, 5%		Any
22	1	R6	3.3 kΩ, 1/4 W, 5%		Any
23	1	R7	100 Ω, 1/2 W, 5%		Any
24	1	R8	1 kΩ, 1/4 W, 5%		Any
25	1	R9	200 Ω, 1/4 W, 5%		Any
26	1	R12	1 Ω, 1/2 W, 5%		Any
27	1	R13	10 kΩ, 1/4 W, 1%		Any
28	1	R15	20 kΩ, 1/4 W, 1%		Any
29	1	R16	6.34 kΩ, 1/4 W, 1%		Any
30	1	T1	EEL25	SIL6026	Hical
31	1	U1	*TinySwitch-II*	TNY268P	Power Integrations
32	1	U2B, U2A	PC817A		Isocom / Any
33	1	U3	TL431AC		Any
34	1	VR1	P6KE180		Vishay / Any
35	1	J1	Header 0.156″ spacing, 3 position (pull middle pin)	26-48-1031	Molex
36	1	J2	Header 0.156″ spacing, 8 position		Molex
37	1		EP-29 Printed Circuit Board, Rev A		

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7 Transformer Specification

7.1 Electrical Diagram

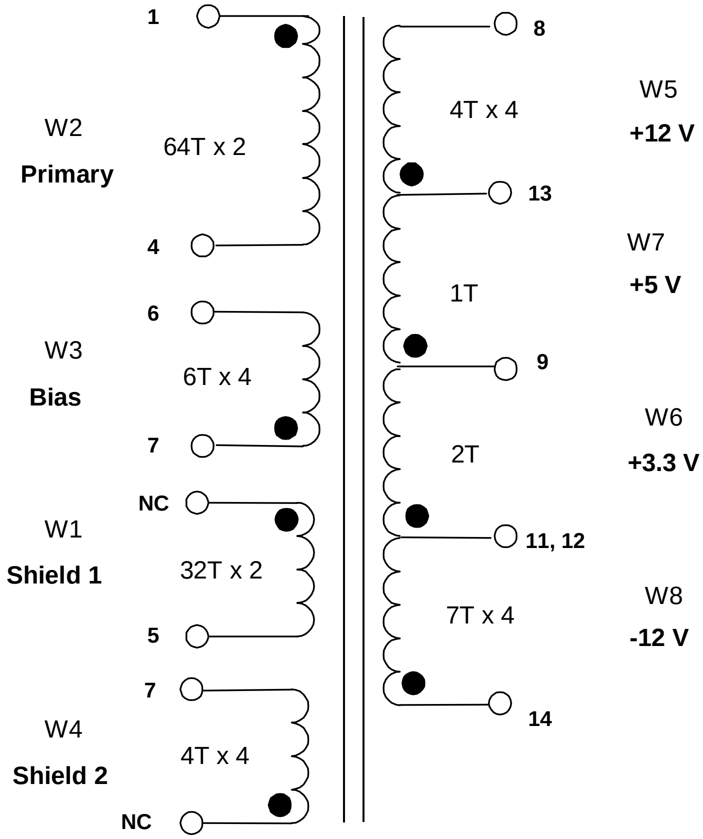

Figure 4 –Transformer Electrical Diagram.

7.2 Electrical Specifications

Electrical Strength	1 second, 60 Hz, from pins 1-7 to pins 8-14	3000 VAC
Primary Inductance	Pins 1-4, all other windings open. Measured at 132 kHz, 1 V RMS	1.33 mH -0 / +15%
Resonant Frequency	Pin 1-4, all other windings open	300 kHz (Min.)
Primary Leakage Inductance	Pins 1-4, with pins 8-14 shorted. Measured at 132 kHz, 1 V RMS	30 µH (Max.)

7.3 Materials

Item	Description
[1]	Core: EEL25, TDK Gapped for AL of 320 nH/T^2
[2]	Bobbin: EEL25 Vertical 14 pins
[3]	Magnet Wire: # 32 AWG
[4]	Teflon Tubing # 22
[5]	Copper Foil 0.12 mm thick, 14 mm wide.
[6]	Tape: 3M 1298 Polyester Film, 16.1 mm wide
[7]	Tape: 3M 1298 Polyester Film, 22.1 mm wide
[8]	Tape: 3M # 44 Polyester web. 3.0 mm wide
[9]	Copper Tape 2.0 mils thick, 16 mm wide.
[10]	Varnish

7.4 Transformer Build Diagram

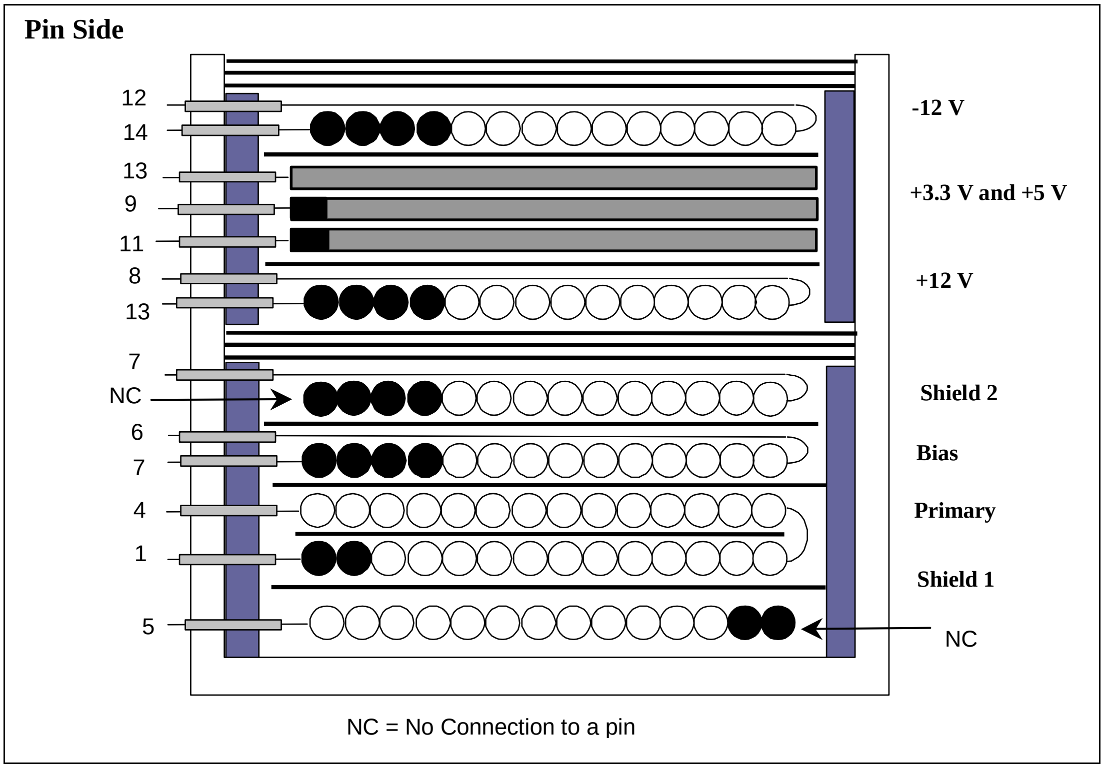

Figure 5 – Transformer Build Diagram.

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7.5 Copper Foil Preparation

The following figure shows the copper foils to be used for +3.3 V and +5 V outputs (W6 and W7)

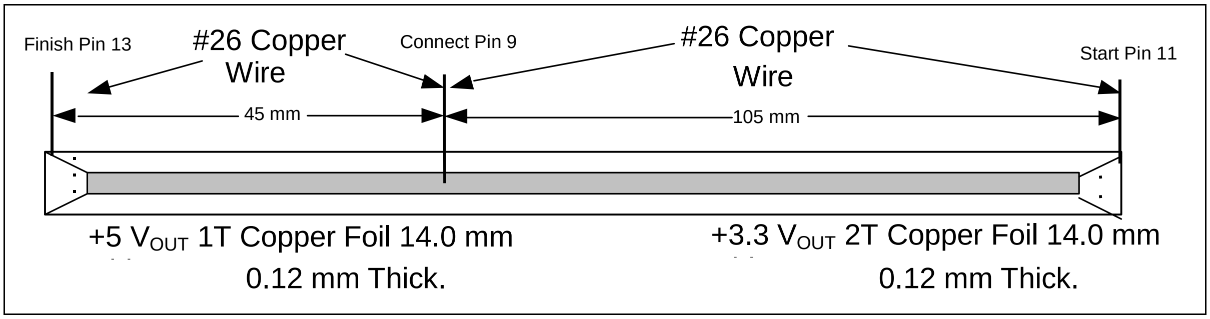

Figure 6 – Foil Winding Preparation Diagram.

7.6 Winding Instructions

Bobbin Set Up Orientation	Set up the bobbin with its pins oriented to the right hand side.
Margin Tape	Apply 3.0 mm margin at each side of bobbin using item [8]. Match combined height of primary, shield and bias windings.
W1 First Shield	Start with a floating lead. Wind 32 bifilar turns of item [3] from left to right. Wind tightly and uniformly across entire width of bobbin. Finish at pin 5 using item [4] at the finish leads. Cut the starting lead just at the starting of the winding.
Basic Insulation	Apply one layer of tape item [6].
W2 Two Layers Primary	Start on pin 1 using item [4] at the start leads. Wind 32 bifilar turns of item [3] from right to left . Apply one layer of item [6]. Continue the same wire on second layer. Wind 32 turns from left to right. The two layers should be wound tightly with the turns uniformly distributed across entire width of bobbin. Finish on pin 4 using item [4] at the finish leads.
Basic Insulation	Apply one layer of tape item [6].
W3 Bias	Start on pin 7 using item [4] at the start leads. Wind 6 turns of 4 parallel wires of item [3]. Wind from right to left in a single layer. The wires should be wound tightly and uniformly spread across the bobbin width. Finish on pin 6 using item [4] at the finish leads.
Basic Insulation	Apply one layer of tape item [6].
W4 Second shield.	Start with a floating lead. Wind 4 turns of 4 parallel wires of item [3]. Wind from right to left in a single layer. The wires should be wound tightly and uniformly spread across the bobbin width. Finish on pin 7 using item [4] at the finish leads. Cut the starting lead just at the starting of the winding.
Insulation	3 Layers of tape [7] for insulation.
Margin Tape	Apply 3.0 mm margin at each side of bobbin using item [8]. Match combined height of secondary windings.
W5 +12 V_{OUT}	Start on pin 13 using item [4] at the start leads. Wind tightly 4 turns of 4 parallel wires of item [3]. Wind from right to left in a single spread across the bobbin width. Finish on pin 8 using item [4] at the finish leads.
Basic Insulation	Apply one layer of tape item [6].

W6 and W7 +3.3 V and +5 V outputs.	Prepare copper foil item [5] and item [7] as shown in Figure 6. Start at pin 11 using item [4] at the start leads. Wind 2 turns. Connect the second lead to pin 9 using item [4] at the finish leads. Wind 1 turn. Connect the end lead to pin 13 using item [4] at the finish leads.
Basic Insulation	Apply one layer of tape item [6].
W7 -12 V output.	Start at pin 14 using item [4] at the start leads. Wind 7 turns of 4 parallel wires of item [3]. Wind tightly from right to left in a uniform spread across the bobbin width. Finish on pin 12 using item [4] at the finish leads.
Outer Insulation	3 Layers of tape [7] for insulation.
Core Assembly	Assemble and secure core halves. Item [1].
Belly band/ Flux band	Wind copper tape item [9] outside of core halves.
Outer Insulation	Wrap the core right over the belly band with three layers item [7].
Final Assembly	Dip varnish uniformly in item [10]. Do not vacuum impregnate. Note: vacuum impregnation may require re-optimization of shield windings for acceptable EMI performance.

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8 Transformer Spreadsheet

Design Warning (No Optimization)

Power Supply Input

VACMIN	Volts	90					Min Input AC Voltage
VACMAX	Volts	265					Max Input AC Voltage
FL	Hertz	50					AC Main Frequency
TC	mSeconds	2.21					Bridge Rectifier Conduction Time Estimate
Z		0.52					Loss Allocation Factor
N	%	79.0					Efficiency Estimate

Power Supply Outputs

VOx	Volts		3.30	5.00	12.00	12.00	Output Voltage
IOx	Amps		0.700	1.450	0.400	0.100	Output Current

Device Variables

Device		TNY268P/G					Device Name
PO	**Watts**	**15.56**					**Total Output Power Warning! Device may be too small or thermally limited for continuous power level (PO). Tip: Consider increasing device size. If P/G or R-package select larger device (reduce current limit via X-pin) or choose Y/F-package with appropriat**
VDRAIN	Volts	643					Maximum Drain Voltage Estimate (Includes Effect of Leakage Inductance)
VDS	Volts	2.9					Device On-State Drain to Source Voltage
FSNOM	Hertz	132000					TinySwitch-II Switching Frequency
FSMIN	Hertz	120000					TinySwitch-II Minimum Switching Frequency (inc. Jitter)
FSMAX	Hertz	144000					TinySwitch-II Maximum Switching Frequency (inc. Jitter)
KRPKDP		0.61					Ripple to Peak Current Ratio
ILIMITMIN	Amps	0.51					Device Current Limit Minimum
ILIMITMAX	Amps	0.59					Device Current Limit Maximum
IRMS	Amps	0.27					Primary RMS Current
DMAX		0.53					Maximum Duty Cycle

Power Supply Components Selection

CIN	uFarads	66.0					Input Filter Capacitor
VMIN	Volts	107					Minimum DC Input Voltage
VMAX	Volts	375					Maximum DC Input Voltage
VCLO	Volts	170					Clamp Zener Voltage
PZ	Watts	1.8					Estimated Primary Zener Clamp Loss

Power Supply Output Parameters

VDx	Volts		0.5	0.5	0.7	0.7	Output Winding Diode Forward Voltage Drop
PIVSx	Volts		15	23	53	53	Output Rectifier Maximum Peak Inverse Voltage
ISPx	Amps		2.36	4.90	1.35	0.34	Peak Secondary Current
ISRMSx	Amps		1.16	2.41	0.66	0.17	Secondary RMS Current
IRIPPLEx	Amps		0.93	1.92	0.53	0.13	Output Capacitor RMS Ripple Current

Transformer Construction Parameters

Core/Bobbin		EEL25					Core and Bobbin Type
Core Manuf.		Generic					Core Manufacturing
Bobbin Manuf		Generic					Bobbin Manufacturing
LPmin	uHenries	1309					Minimum Primary Inductance
NP		64					Primary Winding Number of Turns
AWG	AWG	32					Primary Wire Gauge (Rounded to next smaller standard AWG value)
CMA	Cmils/A	237					Primary Winding Current Capacity
VOR	Volts	118.00					Reflected Output Voltage
BW	**mm**	**22.00**					**Bobbin Physical Winding Width Warning! Large bobbin width (BW) may lead to increased audio emissions. Tip: Reduce the bobbin width, or length, of the core. Consider changing to an alternate device family (if using TinySwitch-II).**
M	mm	3.0					Safety Margin Width
L		1.1					Number of Primary Layers
AE	cm^2	0.40					Core Effective Cross Section Area
ALG	nH/T^2	319					Gapped Core Effective Inductance
BM	Gauss	3087					Maximum Operating Flux Density
BAC	Gauss	818					AC Flux Density for Core Curves

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LG	mm	0.12					Gap Length
LL	uHenries	26.2					Estimated Transformer Primary Leakage Inductance
LSEC	nHenries	20					Estimated Secondary Trace Inductance

Secondary Parameters

NSx			2.07	3.00	6.93	6.93	Secondary Number of Turns
Rounded Down NSx			2		6	6	Rounded to Integer Secondary Number of Turns
Rounded Down Vox	Volts		3.17		10.30	10.30	Auxiliary Output Voltage for Rounded to Integer NSx
Rounded Up NSx			3		7	7	Rounded to Next Integer Secondary Number of Turns
Rounded Up Vox	Volts		5.00		12.13	12.13	Auxiliary Output Voltage for Rounded to Next Integer NSx
AWGSx Range	AWG		23 - 27	20 - 24	25 - 29	31 - 35	Secondary Wire Gauge Range Comment: Primary wire gauge is less than recommended minimum (26 AWG) and may overheat Tip: Consider a parallel winding technique (bifilar, trifilar), increase size of transformer (larger BW) or reduce margin (M).

9 Performance Data

All measurements performed at room temperature, 60 Hz input frequency. Full load is: 3.3 V, 0.7 A; 5 V, 1.6 A; +12 V, 0.4 A; -12 V, 0.1 A.

9.1 *Efficiency*

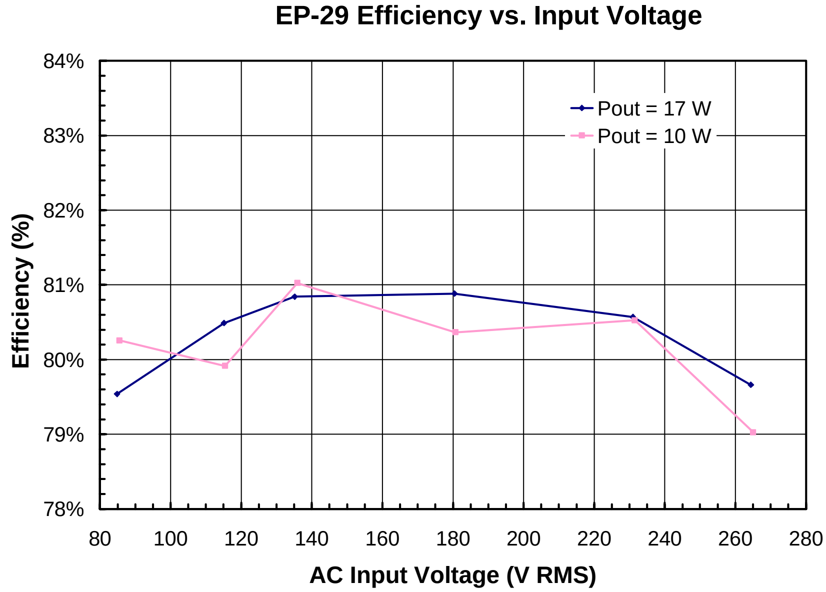

Figure 7 - Efficiency vs. Input Voltage, Room Temperature, 60 Hz.

9.2 *No-load Input Power*

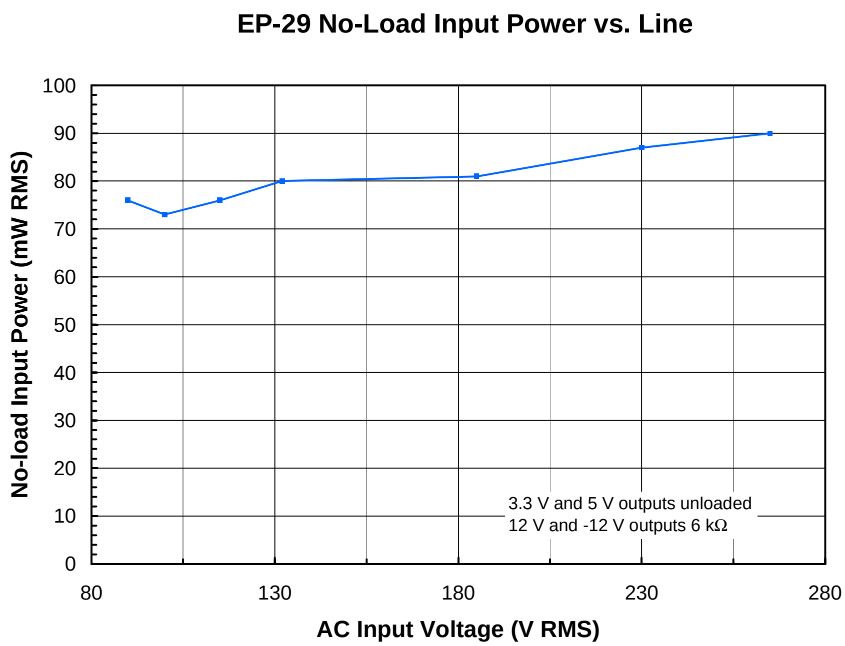

Figure 8 - Zero Load Input Power vs. Input Line Voltage, Room Temperature, 60 Hz.

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9.3 Standby Input Power

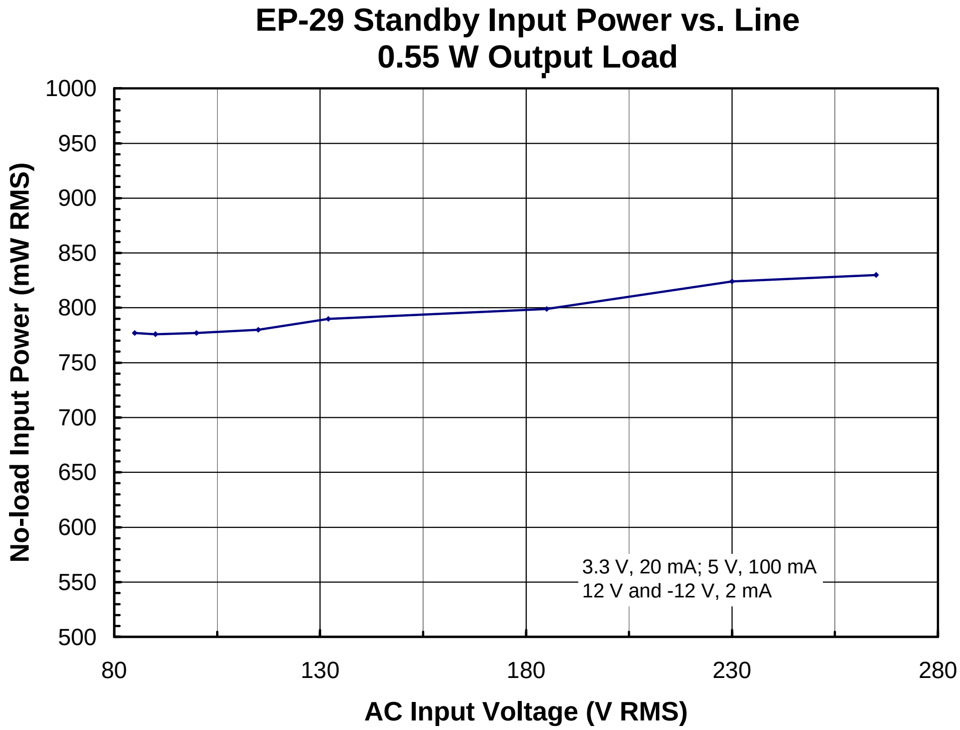

Figure 9 - Standby Input Power vs. Input Line Voltage, Room Temperature, 0.55 W load, 60 Hz.

9.4 Regulation

9.4.1 Load Regulation

Load regulation data was taken at four load conditions: (1) 3.3 V and 5 V min. load, (2) 3.3 V typ. load, 5 V min. load, (3) 3.3 V min. load, 5 V typ. load, and (4) 3.3 V and 5 V max. load.

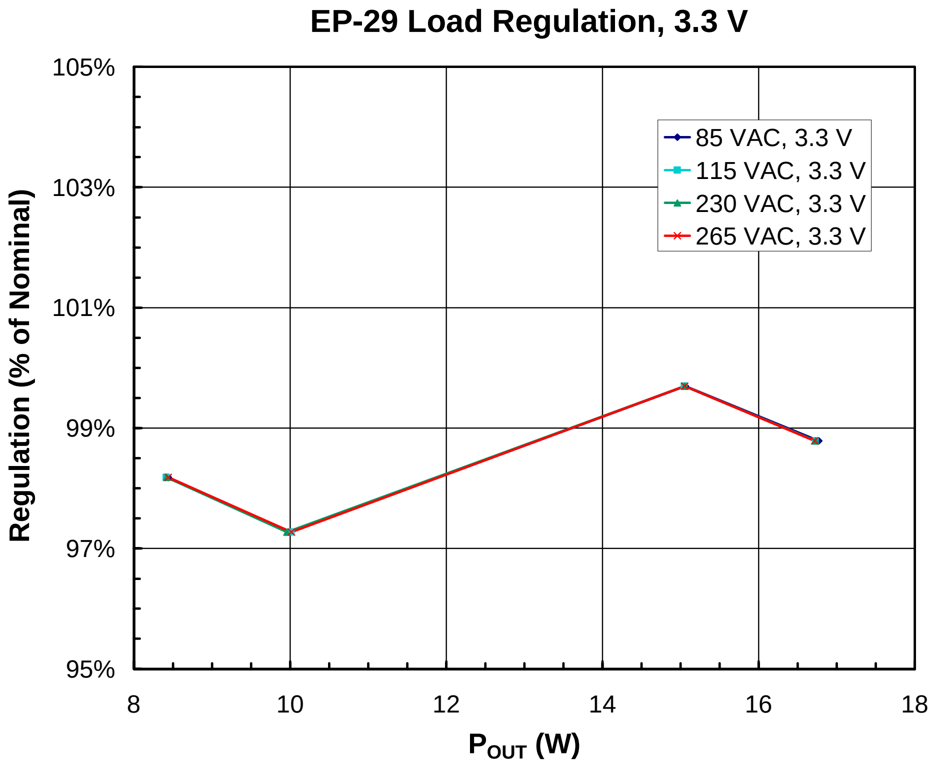

Figure 10 – Load Regulation, 3.3 V, Room Temperature.

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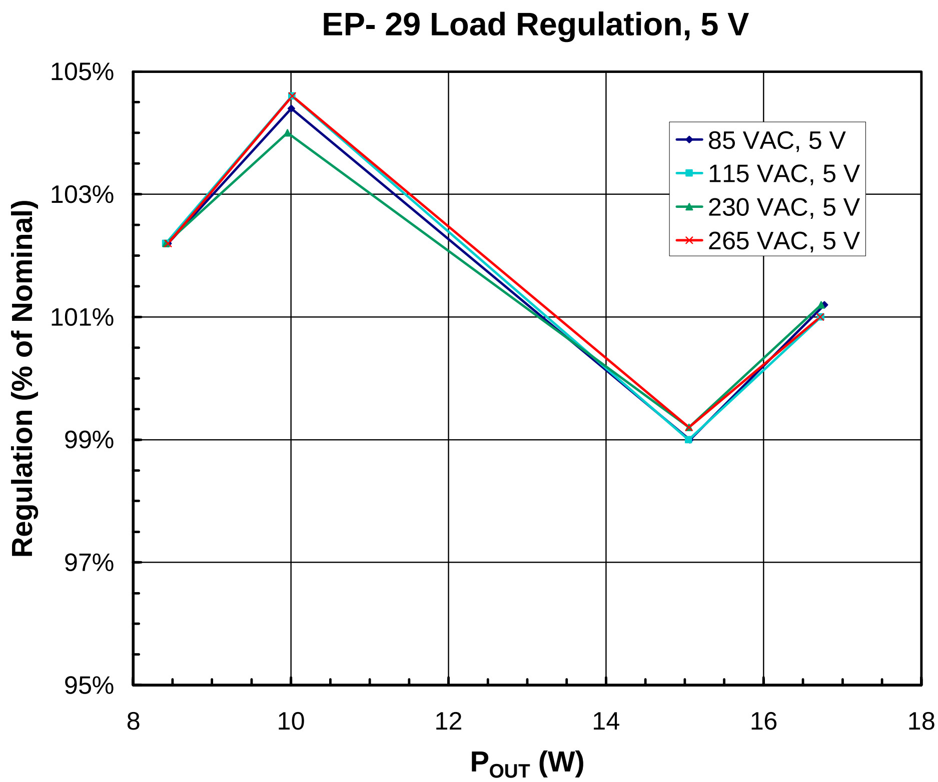

Figure 11 – Load Regulation, 5 V, Room Temperature.

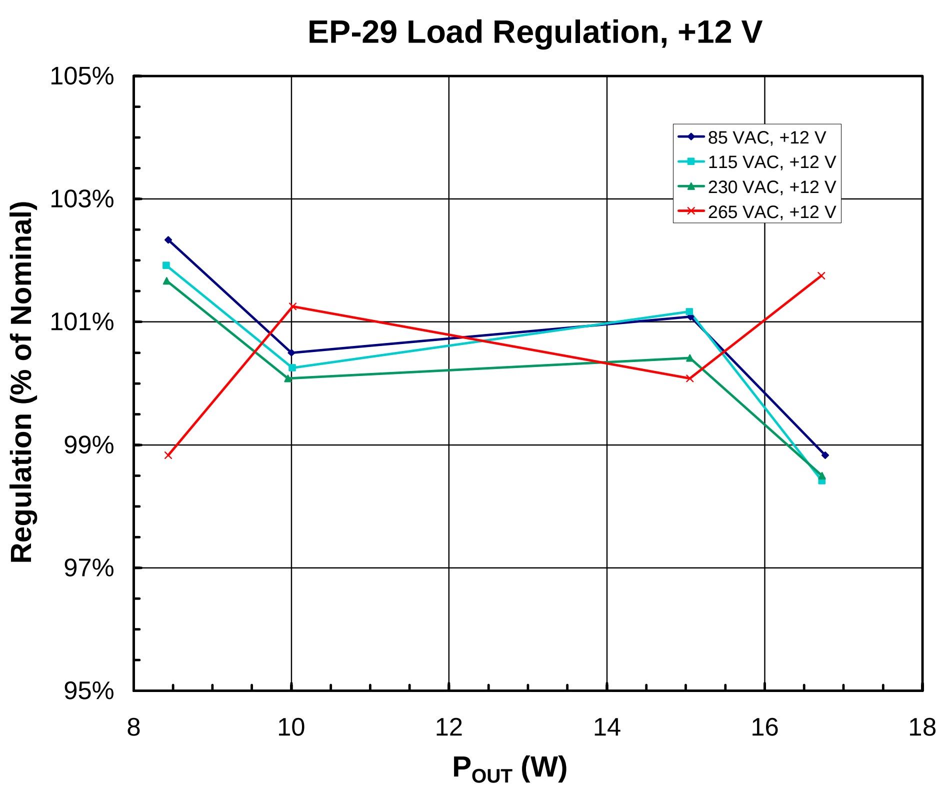

Figure 12 – Load Regulation, +12 V, Room Temperature.

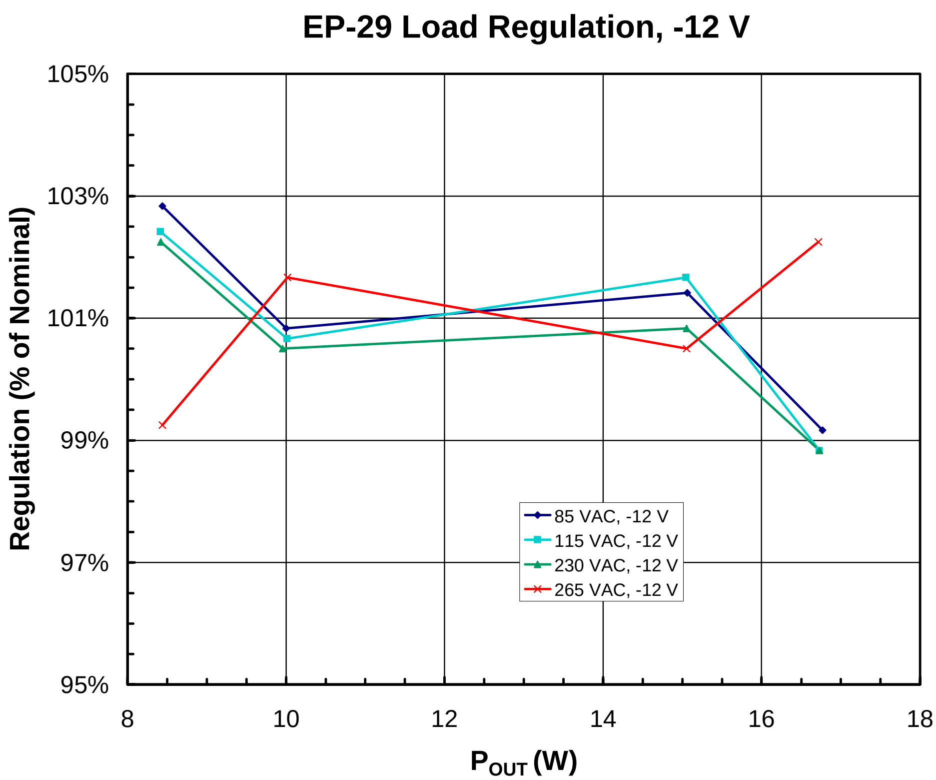

Figure 13 – Load Regulation, -12 V, Room Temperature.

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9.4.2 Line Regulation

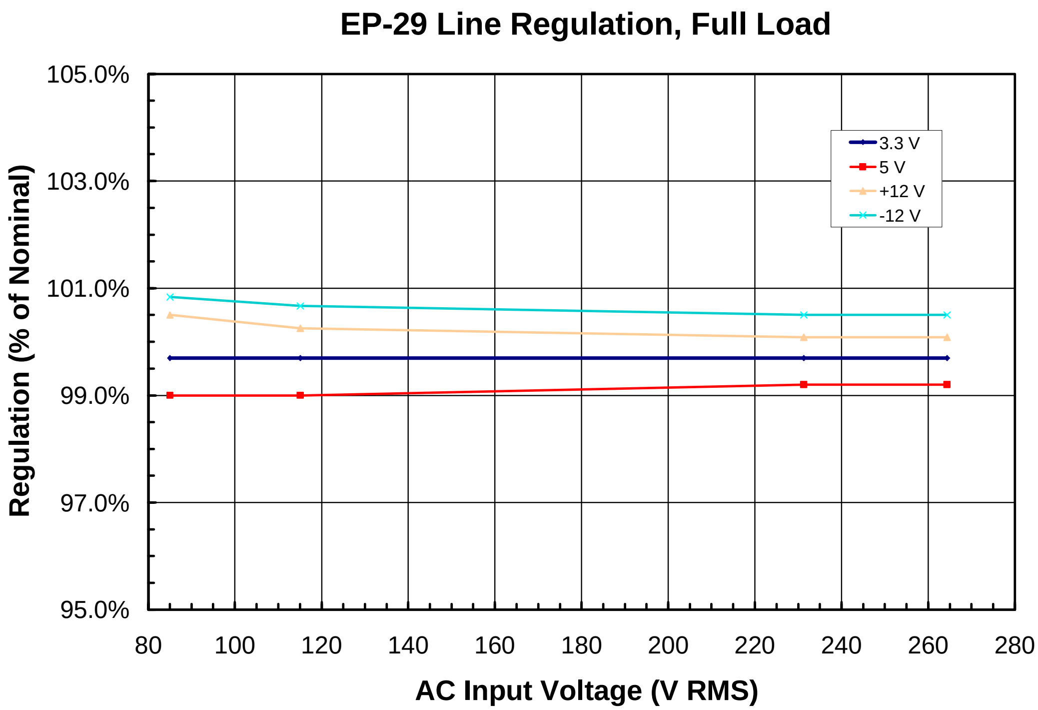

Figure 14 – Line Regulation, Room Temperature, Full Load.

10 Thermal Performance

A thermal image was taken of a unit painted matt black to indicate component temperatures. In addition a thermocouple was attached at the SOURCE pins of U1 to provide a more accurate measurement. For reference the board silk screen has been overlaid.

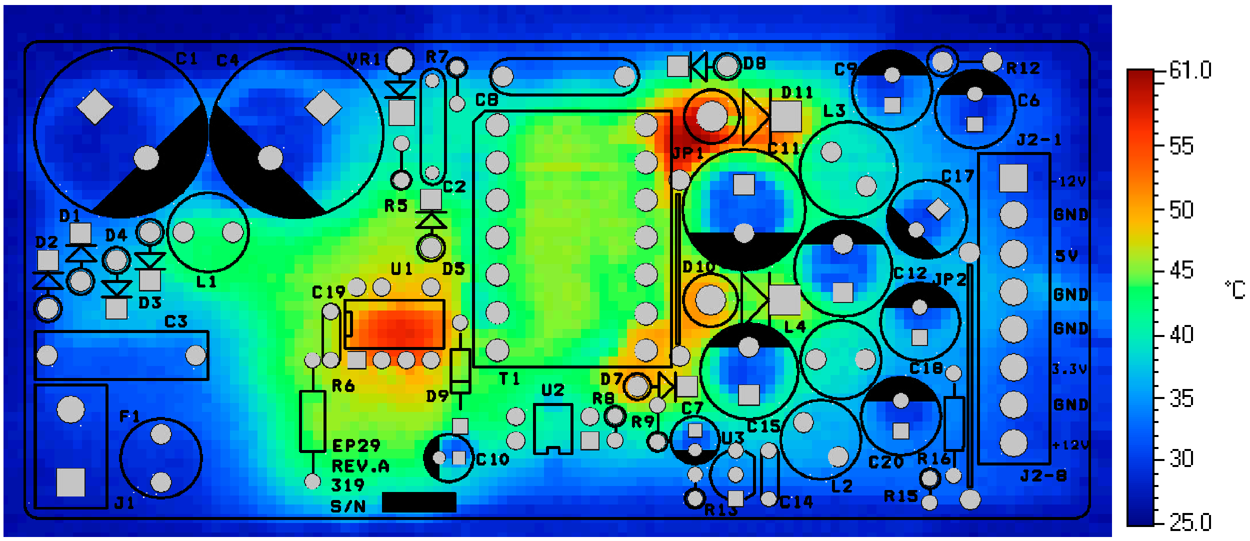

Figure 15 – EP-29 Thermal Performance.

Ambient temperature was 23 °C. The SOURCE pins of U1 were measured to be 54 °C at pin 7 and 8 under typical load (11 W) and 90 VAC input. The hottest component on the board can be seen to be D11 at approximately 60 °C.

These results are acceptable; under high ambient conditions all components would be expected to remain below 100 °C.

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11 Waveforms

11.1 Drain Voltage and Current, Normal Operation

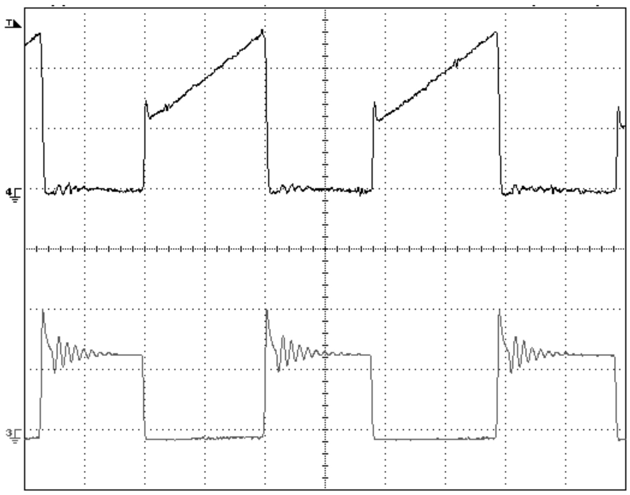

Figure 16 - 115 VAC, Full Load.
Upper: I_{DRAIN}, 0.2 A, 2 µs / div
Lower: V_{DRAIN}, 200 V, 2 µs / div

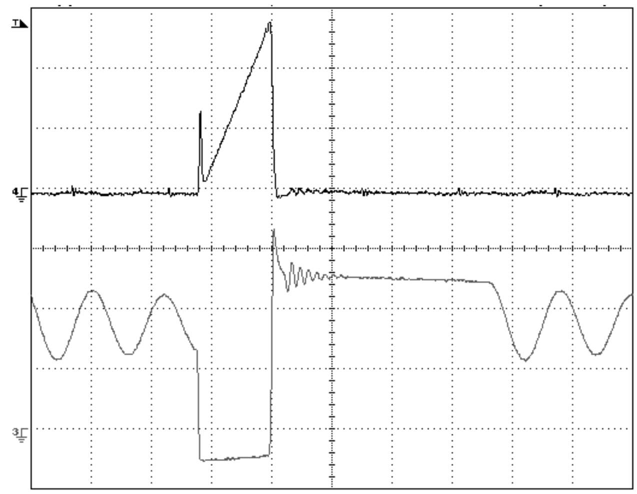

Figure 17 - 230 VAC, Full Load
Upper: I_{DRAIN}, 0.2 A, 2 µs / div
Lower: V_{DRAIN}, 200 V, 2 µs / div

11.2 Output Voltage Start-up Profiles

11.2.1 Start-up Profile for 3.3 V and 5 V Outputs

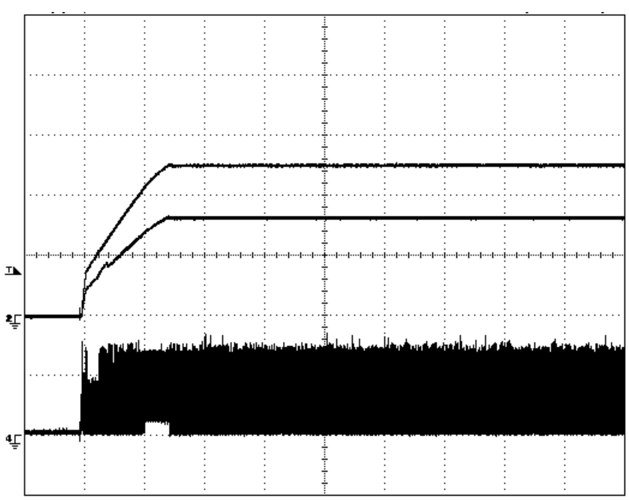

Figure 18 - Start-up Profile, 115 VAC
Upper plot: 5 V_{OUT}, 2 V / div.
Middle plot: 3.3 V_{OUT}, 2 V / div.
Lower plot: I_{DRAIN}, 0.2 A, 2 µs /div.

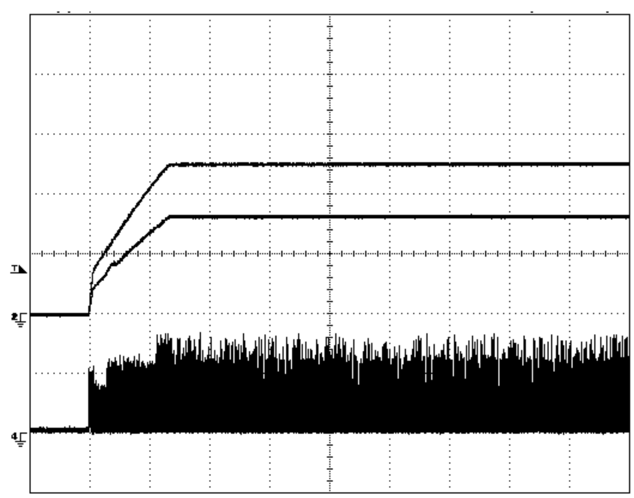

Figure 19 - Start-up Profile, 230 VAC
Upper plot: 5 V_{OUT}, 2 V / div.
Middle plot: 3.3 V_{OUT}, 2 V / div.
Lower plot: I_{DRAIN}, 0.2 A, 2 µs /div.

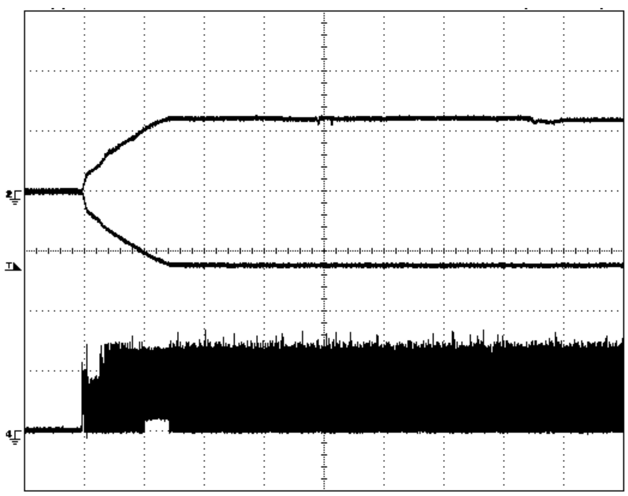

Figure 20 - Start-up Profile, 115 VAC
Upper plot: +12 V_{OUT}, 5 V / div.
Middle plot: -12 V_{OUT}, 5 V / div.
Lower plot: I_{DRAIN}, 0.2 A, 2 µs /div.

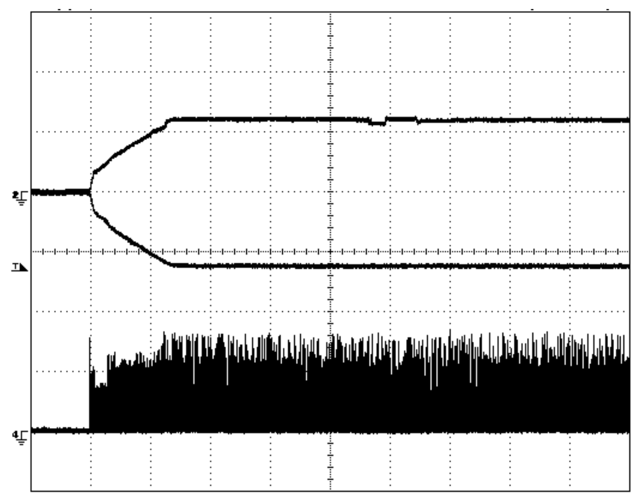

Figure 21 - Start-up Profile, 230 VAC
Upper plot: +12 V_{OUT}, 5 V / div.
Middle plot: -12 V_{OUT}, 5 V / div.
Lower plot: I_{DRAIN}, 0.2 A, 2 µs /div.

11.3 Drain Voltage and Current Start-up Profile

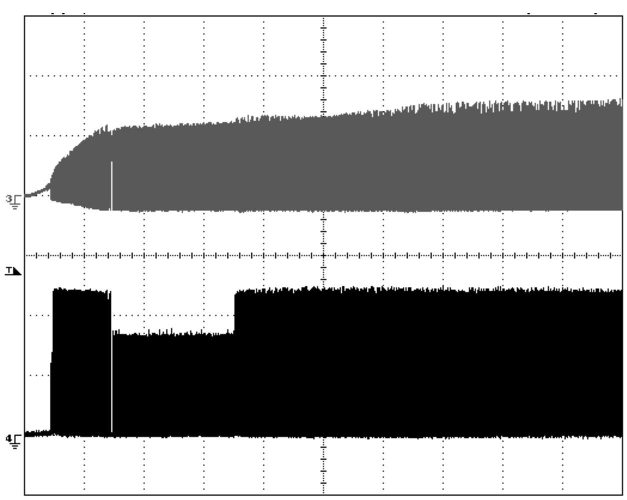

Figure 22 - 115 VAC Input and Maximum Load.
Upper: V_{DRAIN}, 200 V / div.
Lower: I_{DRAIN}, 0.2 A & 2 ms / div.

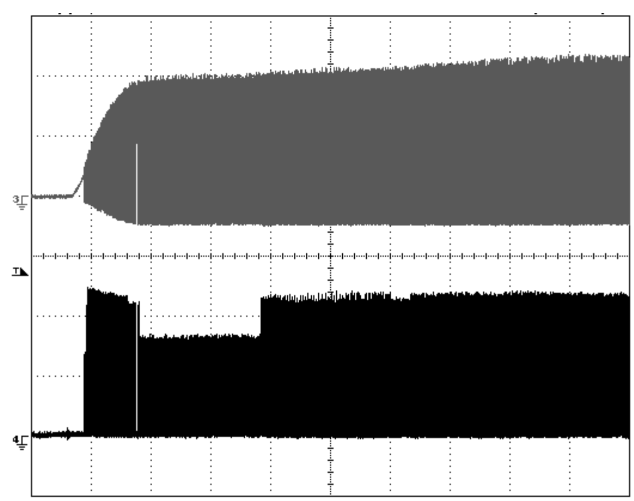

Figure 23 - 265 VAC Input and Maximum Load.
Upper: V_{DRAIN}, 200 V / div.
Lower: I_{DRAIN}, 0.2 A & 2 ms / div.

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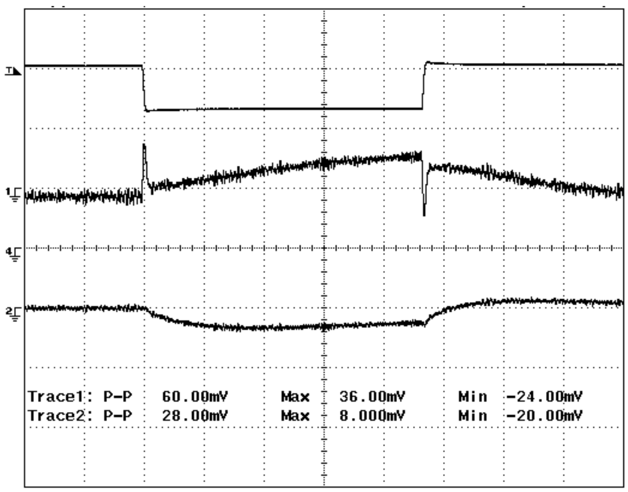
11.4 Load Transient Response (75% to 100% Load Step)

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.

11.4.1 Transient Response for 3.3 V and 5 V Outputs



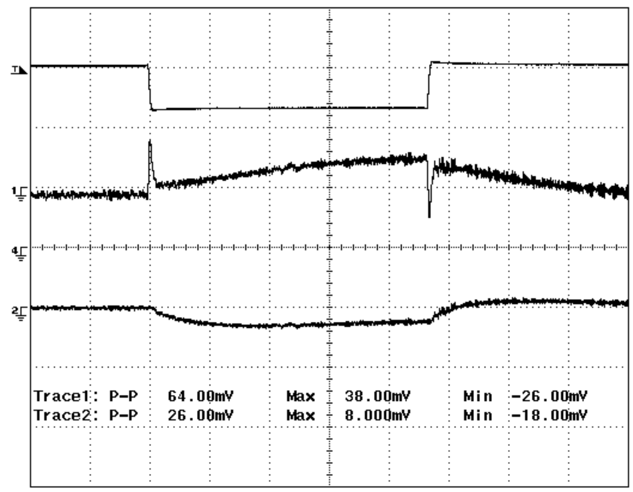


Figure 24 – Transient Response, 115 VAC,
75-100-75% Load step on 5 V
Upper: 5 V Load Current, 0.5 A / div.
Middle: 3.3 V output, 50 mV / div.
Lower: 5 V output, 50 mV / div.
All 500 μs / div.

Figure 25 – Transient Response, 230 VAC,
75-100-75% Load step on 5 V
Upper: 5 V Load Current, 0.5 A / div.
Middle: 3.3 V output, 50 mV / div.
Lower: 5 V output, 50 mV / div.
All 500 μs / div.

11.4.2 Transient Response for +12 V and –12 V Outputs

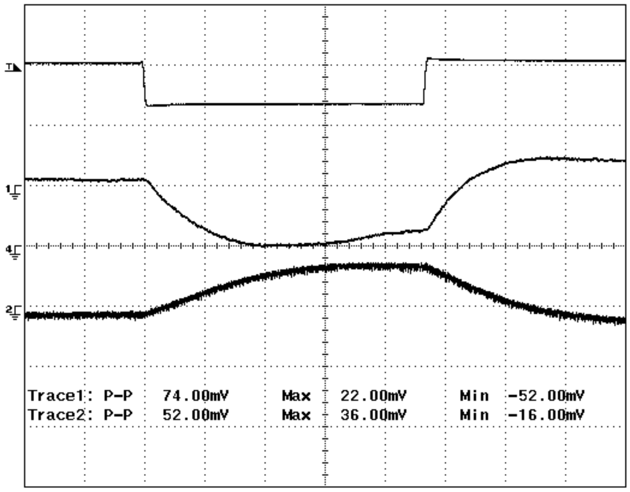


Figure 26 – Transient Response, 115 VAC,
75-100-75% Load step on 5 V
Upper: 5 V Load Current, 0.5 A / div.
Middle: +12 V output, 50 mV / div.
Lower: -12 V output, 50 mV / div.
All 500 µs / div.

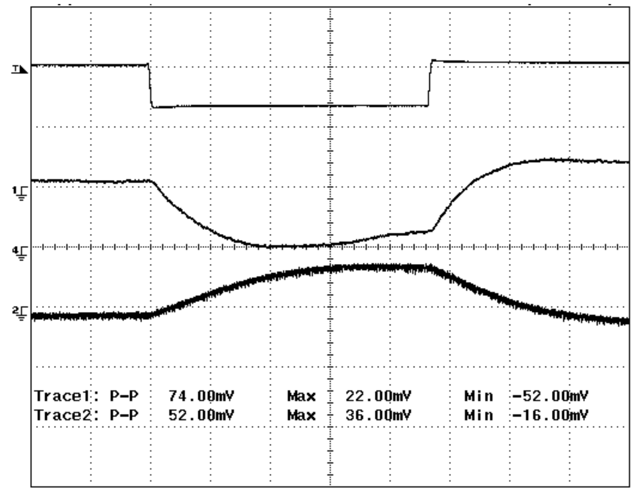


Figure 27 – Transient Response, 230 VAC,
75-100-75% Load step on 5 V
Upper: 5 V Load Current, 0.5 A / div.
Middle: +12 V output, 50 mV / div.
Lower: -12 V output, 50 mV / div.
All 500 µs / div.

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11.5 Output Ripple Measurements

11.5.1 Ripple Measurement Technique

For DC output ripple measurements, a modified oscilloscope test probe must be utilized in order to reduce spurious signals due to pickup. Details of the probe modification are provided in Figure 28 and Figure 29.

The 5125BA probe adapter is affixed with two capacitors tied in parallel across the probe tip. The capacitors include one (1) 0.1 μF/50 V ceramic type and one (1) 1.0 μF/50 V aluminum electrolytic. *The aluminum electrolytic type capacitor is polarized, so proper polarity across DC outputs must be maintained (see below).*

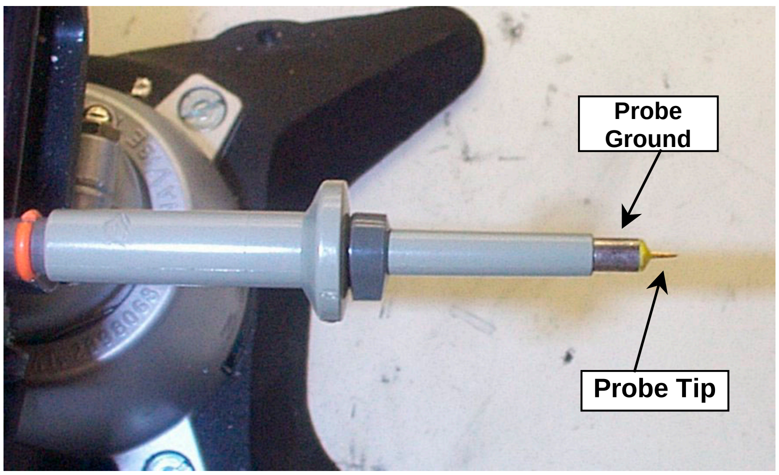

Figure 28 - Oscilloscope Probe Prepared for Ripple Measurement (end cap and ground lead removed).

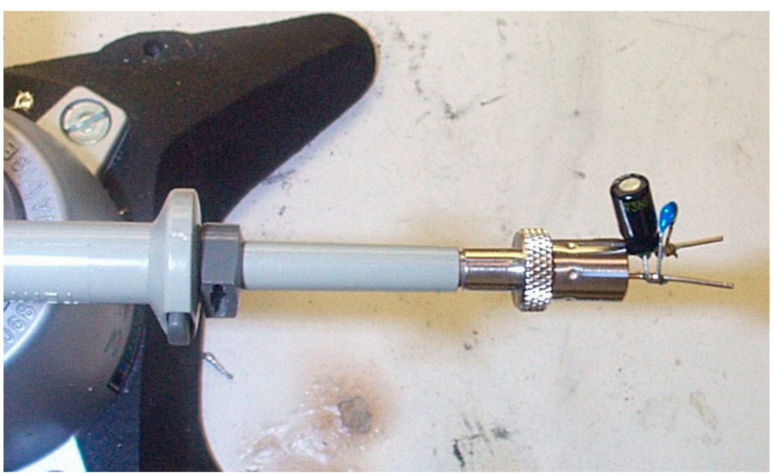

Figure 29 - Oscilloscope Probe with Probe Master 5125BA BNC Adapter (Modified with wires for probe ground for ripple measurement and two parallel decoupling capacitors added).

11.5.2 Ripple Measurements at 115 VAC

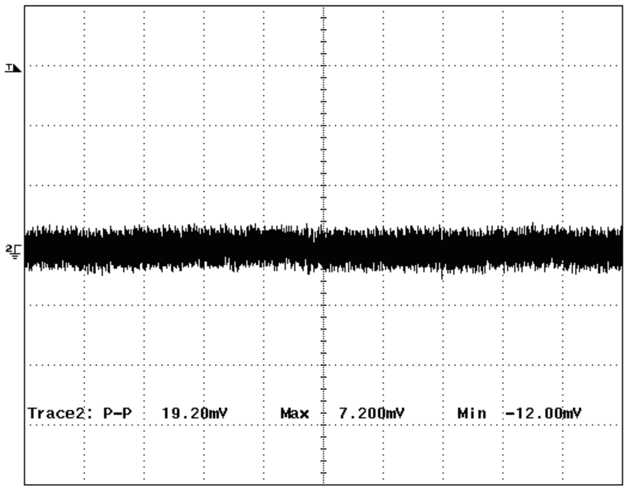

Figure 30 – 3.3 V Ripple, 115 VAC, Full Load
2 ms, 50 mV / div. 19 mV p-p

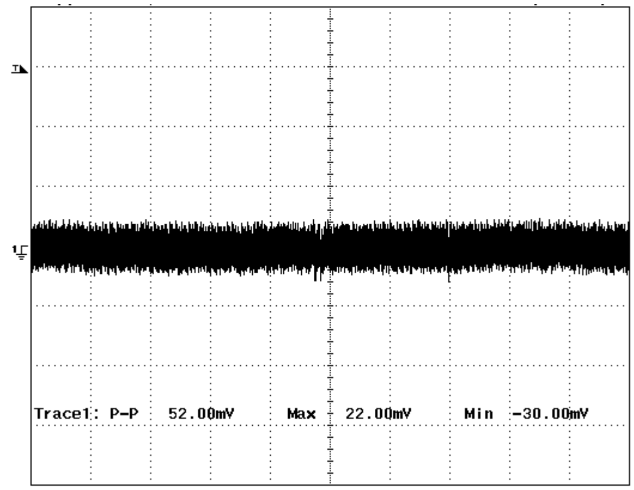

Figure 31 – 5 V Ripple, 115 VAC, Full Load
2 ms, 50 mV / div. 52 mV p-p

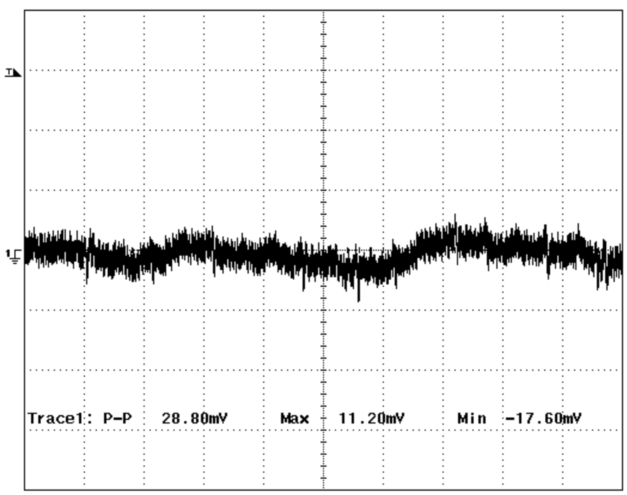

Figure 32 – 12 V Ripple, 115 VAC, Full Load
2 ms, 50 mV / div. 29 mV p-p

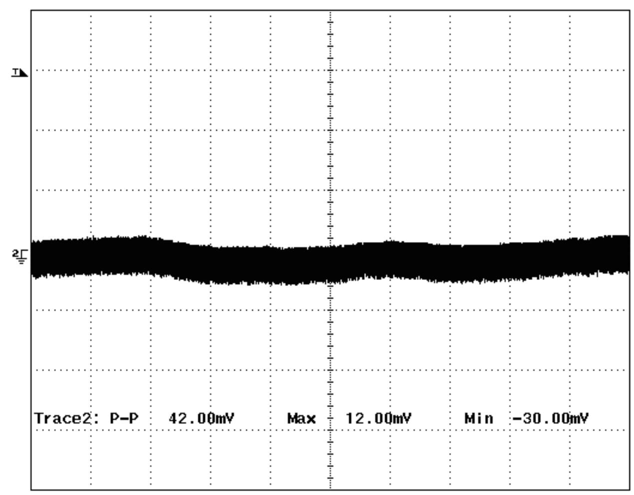

Figure 33 – -12 V Ripple, 115 VAC, All outputs at full load. 2 ms, 50 mV / div. 42 mV p-p

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11.5.3 Ripple Measurements at 230 VAC

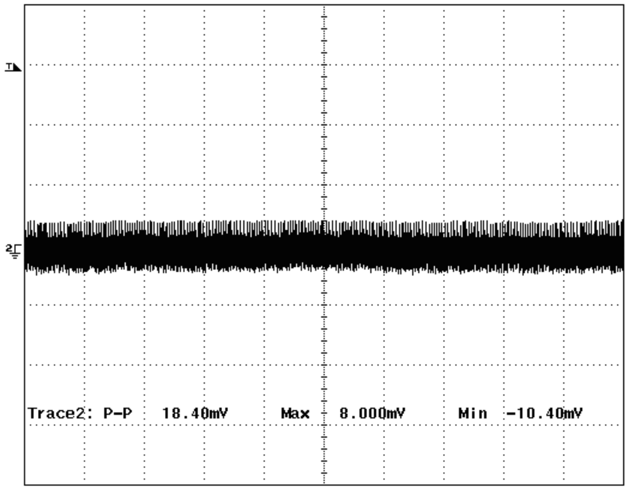

Figure 34 – 3.3 V Ripple, 230 VAC, Full Load.
2 ms, 50 mV / div. 18 mV p-p

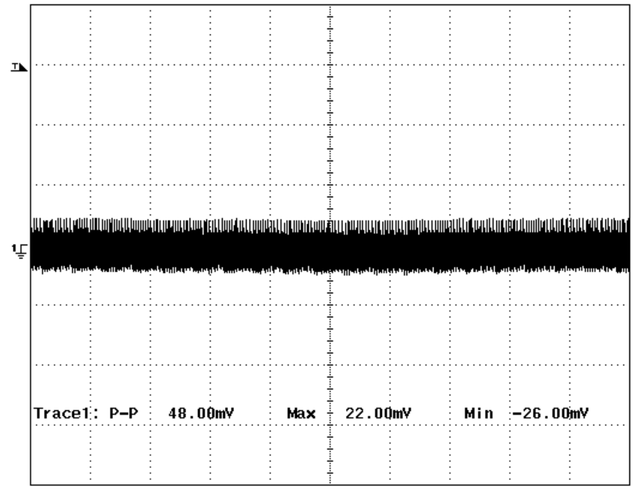

Figure 35 – 5 V Ripple, 230 VAC, Full Load.
2 ms, 50 mV / div. 48 mV p-p

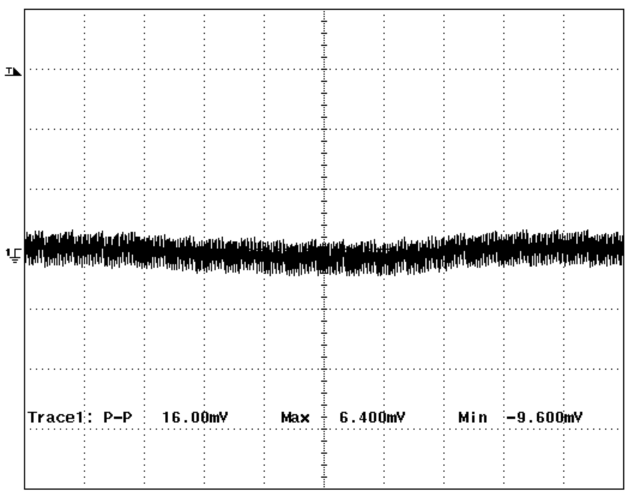

Figure 36 – 12 V Ripple, 230 VAC, Full :oad.
2 ms, 50 mV/div. 16 mV p-p

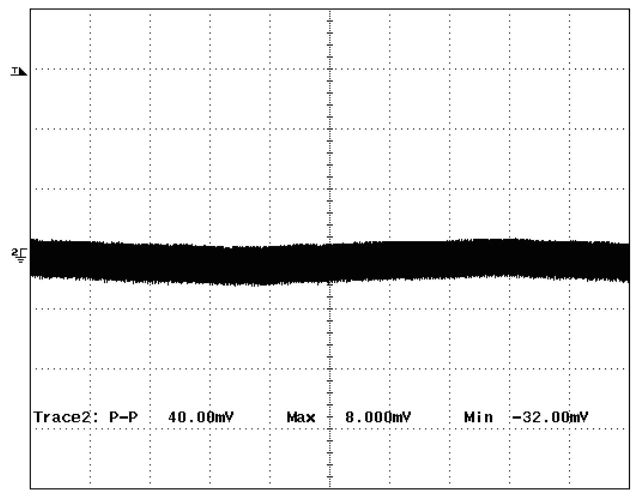

Figure 37 – -12 V Ripple, 230 VAC, Full Load.
2 ms, 50 mV/div. 40 mV p-p

11.6 Conducted EMI

Both measurements were taken with the artificial hand input on the LISN connected to output return. The results represent the worst case with respect to line and load conditions. In both cases >10 dB margin exists indicating very acceptable performance.

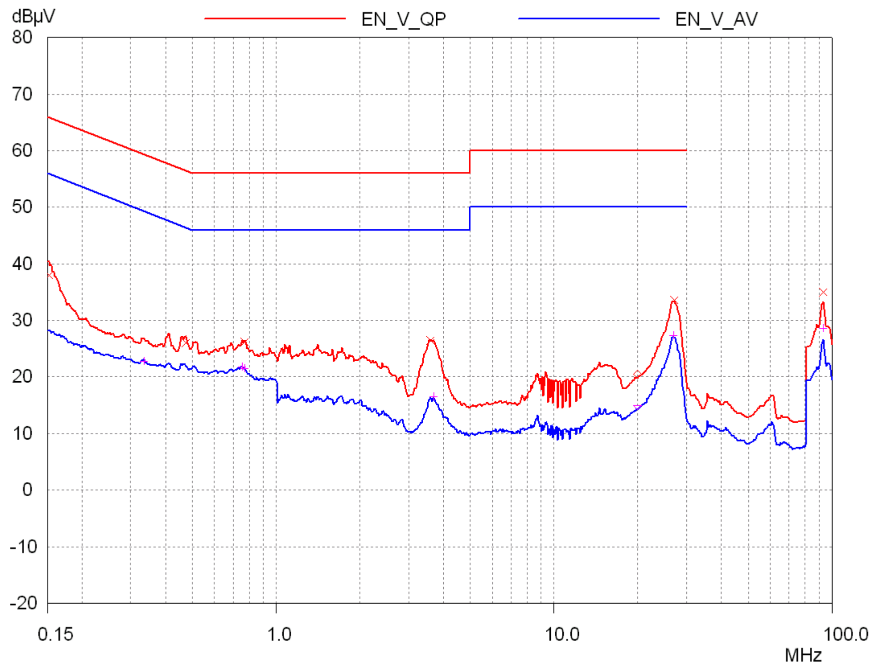

Figure 26 – Conducted EMI, 15 W Peak Load, 115 VAC, 60 Hz, and EN55022 B Limits.

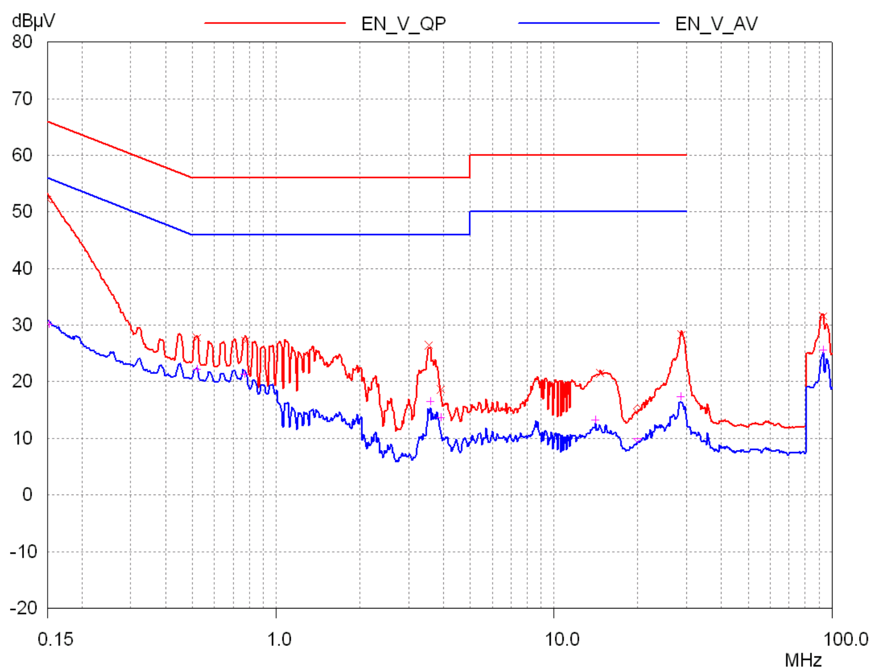

Figure 27 – Conducted EMI, 15 W Peak Load, 230 VAC, 60 Hz, and EN55022 B Limits.

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12 Revision History

Date	Author	Revision	Description & changes
08/08/02	VC	0.1	Original Document.
12/03/02	VC	0.12	Update Transformer Document
5/2/03	RM	0.90	Cleaned up all pages thru transformer section. Added layout, BOM, and revised all description text.
5/14/03	RM	0.91	Measurements / waveforms all re-taken. New data inserts and formatted.
5/14/03	RM	0.92	Xfmr spreadsheet included. Doc released for review
5/21/03	PV	0.95 to 0.98	Corrected circuit description, revised spec, transformer design to meet krp limits
06/15/03	IM	1.0	First Release
06/19/03	PV	1.1	Updated BOM/Schematic to remove R10 in series with C14 - not on PCB design.
06/20/03	PV	1.2	Added thermal, no-load and standby data, corrected L1 on schematic, added regulation test setup description.
07/07/03	PV	1.3	Updated Power Supply Specification table data for the Output Current 2.

Notes

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Notes

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