



Design Example Report

Title	<i>15W Flyback Power Supply using TOP244P</i>
Specification	Input: 90 – 265 VAC 50/60Hz Output: +24 VDC @ 625mA
Application	Refrigerator
Author	Power Integrations Applications Department
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Revision	1.1

Summary and Features

- Low part count, Low-cost Isolated Flyback Power Supply
- E-SHIELD® Transformer Construction for reduced common-mode EMI (small 220pF Y1 capacitor and small 10mH Common-mode choke)
- 132kHz Switching Frequency with jitter to reduce conducted EMI
- Auto-restart function for automatic and self-resetting open-loop, overload and short-circuit protection
- Built-in Hysteretic thermal shutdown at 135C
- Enhanced 8-pin DIP package with increased creepage from Drain to low-voltage control pins
- EcoSmart® for extremely low standby power consumption <800 mW at 230 VAC

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

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Important Notes:

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 isolated source to provide power to the prototype board.

Design Reports contain a power supply design specification, schematic, bill of materials, and transformer documentation. Performance data and typical operation characteristics are included. Typically only a single prototype has been built.

1 Introduction

This document is an engineering report describing the design of an AC-DC power supply with universal input providing a regulated +24 VDC at 625 mA. The design, rated for 15 W is implemented using a TOP244P device from the *TOPSwitch-GX* IC family and an EEL19 core in a Flyback topology. This power supply is intended to be used in a refrigerator appliance where the maximum ambient temperature can reach 70C.

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

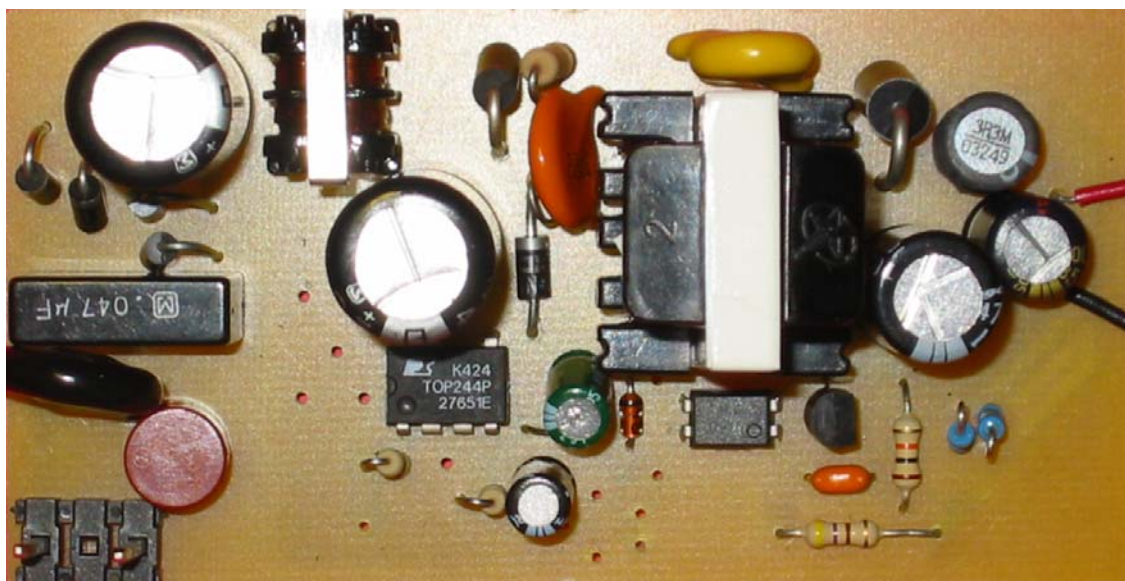


Figure 1 – Populated Circuit Board Photograph

2 Power Supply Specification

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	90		265	VAC	2 Wire – no P.E.
Frequency	f_{LINE}	47	50/60	64	Hz	
No-load Input Power (230 VAC)				0.8	W	
Output						
Output Voltage 1	V_{OUT1}		24		V	± 5% 20 MHz bandwidth
Output Ripple Voltage 1	$V_{RIPPLE1}$		100		mV	
Output Current 1	I_{OUT1}			0.625	A	
Total Output Power						
Continuous Output Power	P_{OUT}			15	W	
Peak Output Power	P_{OUT_PEAK}			20	W	
Efficiency	η	82			%	Measured at P_{OUT} (15 W), 25 °C
Environmental						
Conducted EMI			Meets CISPR22B / EN55022B			1.2/50 μ s surge, IEC 1000-4-5, Series Impedance: Differential Mode: 2 Ω Common Mode: 12 Ω
Safety			Designed to meet IEC950, UL1950 Class II			
Surge		4			kV	
Surge		3			kV	100 kHz ring wave, 500 A short circuit current, differential and common mode
Ambient Temperature	T_{AMB}	0		70	°C	Free convection, sea level

3 Schematic

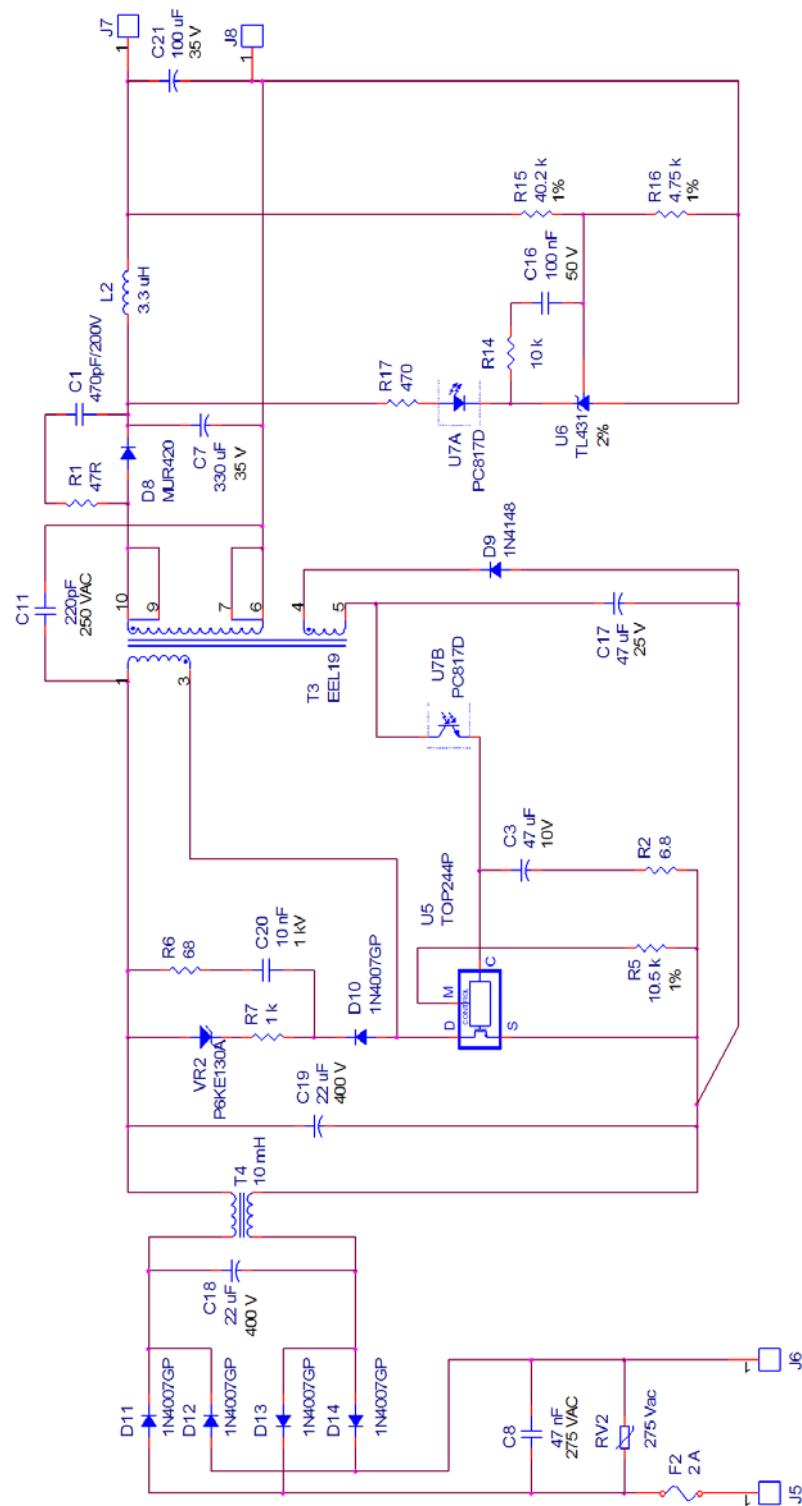


Figure 2 – Schematic

4 Circuit Description

The schematic in Figure 2 shows an off-line Flyback converter using the TOP244P. The circuit is designed for 90 VAC to 265 VAC input and provides a single output; +24 V @ 625 mA.

4.1 Input EMI Filtering

Conducted EMI filtering is provided by C8, C11, C18 and T4. The switching frequency jitter feature of the *TOPSwitch-GX* family allows the use of a small, low cost common mode choke for T4 and reduces the value of C8 and C11 needed to meet EN55022 / CISPR22 Class B with good margin. A safety rated Y capacitor bridges the isolation barrier from the rectified DC rail to output return. This returns common mode EMI currents generated by the primary and secondary switching-waveforms, reducing conducted EMI. EMI results are presented in a later section of this document. Returning the Y capacitor to the DC rail ensures high currents present during line transients are routed away from U1.

4.2 TOPSwitch Primary

To keep the peak DRAIN voltage acceptably below the BV_{DSS} (700 V) of U5, diode D10, R7, VR2, C20, and R6 form a primary clamp. This network clamps the voltage spike seen on the DRAIN due to primary and secondary reflected leakage inductance. Capacitor C20 together with R6 form the main clamp with VR2 providing a hard limit for the maximum voltage seen across the primary. Resistor R7 ensures that VR2 only conducts at the end of the leakage inductance spike event, limiting dissipation. Diode D10 is deliberately selected as a slow recovery type, but must be a glass-passivated type to guarantee the reverse recovery time as defined by the manufacturer. Standard 1N4007 diodes should not be used as their potential for very long reverse recovery times can cause excessive drain ringing. The slow recovery time, compared to fast or ultra-fast diodes, allows recovery of some of the clamp energy, improving efficiency.

The discrete full bridge rectifier bridge comprised of D11-D14 and C18 provide a high voltage DC BUS for the primary circuitry. The DC rail is applied to the primary winding of T5. The other side of the transformer primary is driven by the integrated MOSFET in U5. R5 sets the U5 current limit to approximately 70% of its nominal value. This limits the output power delivered during fault conditions. C3 has 3 functions. It provides the energy required by U5 during startup, sets the auto-restart frequency during fault conditions, and also acts to roll off the gain of U5 as a function of frequency. R2 adds a zero to stabilize the power supply control loop. Diode D9 and C17 provide rectified and filtered bias power for U5 and U7.

4.3 Output Rectification

The output of T5 is rectified and filtered by D8 and C7. Inductor L2 and C21 provide additional high frequency filtering. Resistor R1 and C1 provide snubbing for D8. Choosing the proper snubber values is important for low zero-load power consumption and for high frequency EMI suppression. The snubber components were chosen so that the turn-on

voltage spike at the D8 anode is slightly under-damped. Increasing C1 and reducing R1 will improve damping and high frequency EMI, at the cost of higher zero-load power consumption.

4.4 Output Feedback

Resistors R15 and R16 divide down the supply output voltage and apply it to the reference pin of error amplifier U6. Shunt regulator U6 drives Optocoupler U7 through resistor R17 to provide feedback information to the U1 CONTROL pin. The Optocoupler output also provides power to U5 during normal operating conditions.

Components R2, R17, R14, C3 and C16 all play a role in compensating the power supply control loop. Capacitor C3 rolls off the gain of U1 at relatively low frequency. Resistor R2 provides a zero to cancel the phase shift of C3. Resistor R17 sets the gain of the direct signal path from the supply output through U7 and U6. Components C16 and R14 roll off the gain of the error amplifier (U6).

5 PCB Layout

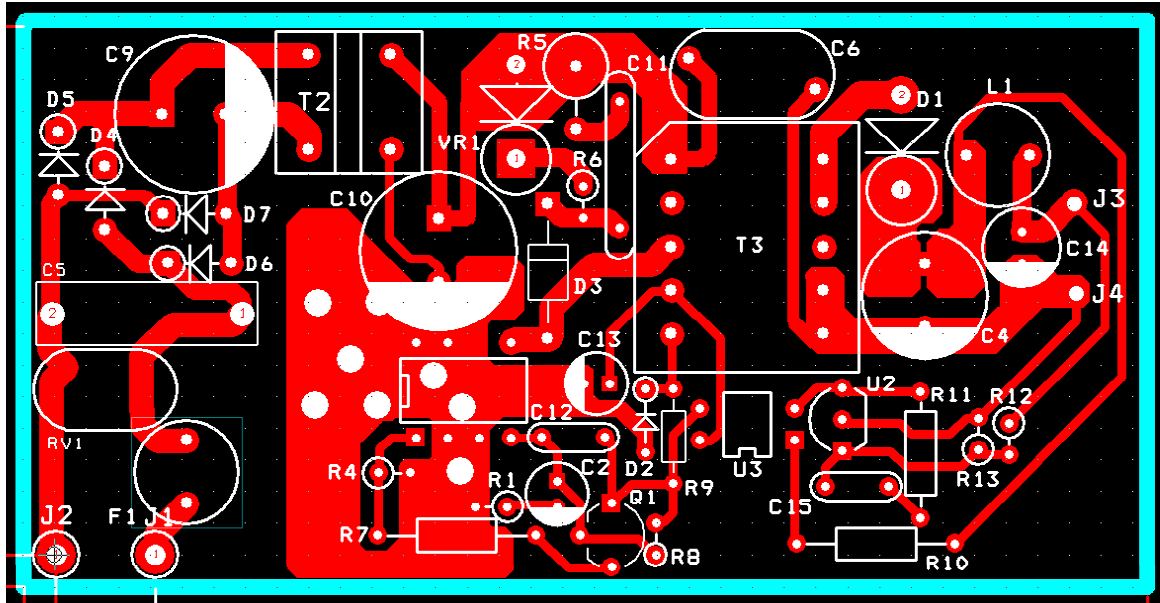


Figure 3 – Printed Circuit Layout

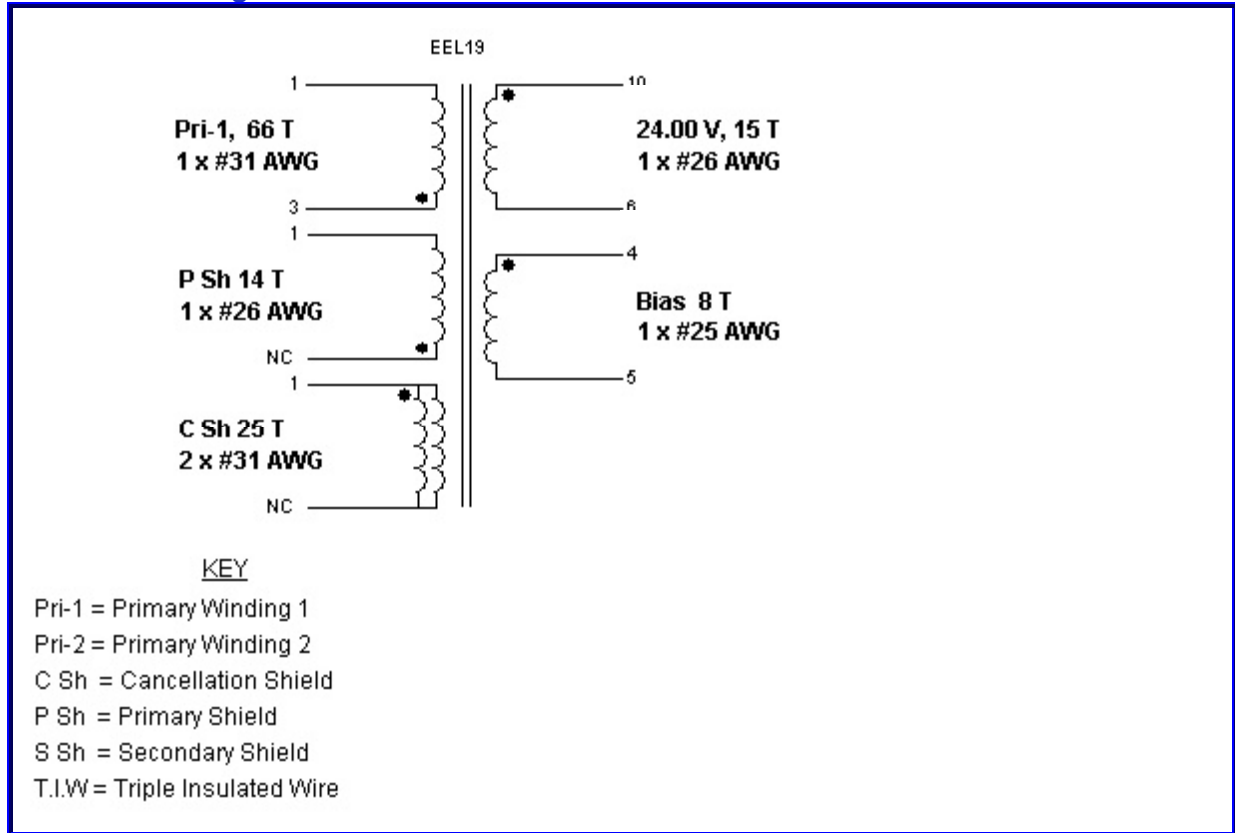
6 Bill of Materials

Item	QTY	Ref Des	Value	Mfg Part Number	Description
1	1	C1	470pF/200V		470pF, 200 V, Ceramic, NPO
2	2	C3 C17	47uF	LXZ25VB47RME11LL	47uF, 25 V, Electrolytic, Low ESR, 500mOhm, (5 x 11.5)
3	1	C7	330uF	KZE35VB331MJ16LL	330uF, 35 V, Electrolytic, Very Low ESR, 38mOhm, (10 x 16)
4	1	C8	47nF	ECQ-U2A473ML	47nF, 275 VAC, Film, X2
5	1	C11	220pF		220pF, Ceramic, Y1
6	1	C16	100nF	ECU-S1H104KBB	100nF, 50 V, Ceramic, X7R
7	2	C18 C19	22uF	EEU-EB2G220	22uF, 400 V, Electrolytic, High Ripple, (12.5 x 25)
8	1	C20	10nF	ECK-D3A103KBP	10nF, 1 kV, Disc Ceramic
9	1	C21	100uF	LXZ35VB101M515LL	100uF, 35 V, Electrolytic, Low ESR, 180mOhm, (6.3 x 15)
10	1	D8	MUR420	MUR420	200 V, 4 A, Ultrafast Recovery, 25 ns
11	1	D9	1N4148	1N4148	75 V, 300mA, Fast Switching, DO-35
12	5	D10 D11 D12 D13 D14	1N4007GP	1N4007GP	1000 V, 1 A, Rectifier, Glass Passivated, 2 us, DO-41
13	1	F2	2 A	3-721-200-041	2 A, 250V, Slow, TR5
16	1	L2	3.3uH	822LY-3R3M	3.3uH, 2.66 A
17	1	R1	47R	CFR-25JB-47R	47R, 5%, 1/4 W, Carbon Film
18	1	R2	6.8	CFR-25JB-6R8	6.8 R, 5%, 1/4 W, Carbon Film
19	1	R5	10.5 k	MFR-25FBB-10K5	10.5 k, 1%, 1/4 W, Metal Film
20	1	R6	68	CFR-25JB-68R	68 R, 5%, 1/4 W, Carbon Film
21	1	R7	1 k	CFR-25JB-1K0	1 k, 5%, 1/4 W, Carbon Film
22	1	R14	10 k	CFR-25JB-10K	10 k, 5%, 1/4 W, Carbon Film
23	1	R15	40.2 k	MFR-25FBB-40K2	40.2 k, 1%, 1/4 W, Metal Film
24	1	R16	4.75 k	MFR-25FBB-4K75	4.75 k, 1%, 1/4 W, Metal Film
25	1	R17	470	CFR-25JB-470R	470 R, 5%, 1/4 W, Carbon Film
26	1	RV2	275Vac	V275LA4	275 V, 23 J, 7 mm, RADIAL
27	1	T4	10mH	SC-01-E100G	10mH, 1A, Common Mode Choke
28	1	T5	EEL19	YW-379-02B	Bobbin, EEL19, Vertical, In built margins, 10 pins
29	1	U5	TOP244P	TOP244P	TOPSwitch-GX, TOP244P, DIP-8B
30	1	U6	TL431	TL431CLP	2.495 V Shunt Regulator IC, 2%, 0 to 70C, TO-92
31	2	U7	PC817D	ISP817D, PC817X4	Opto coupler, 35 V, CTR 300-600%, 4-DIP
32	1	VR2	P6KE130A	P6KE170A	170 V, 5 W, 5%, TVS, DO204AC (DO-15)

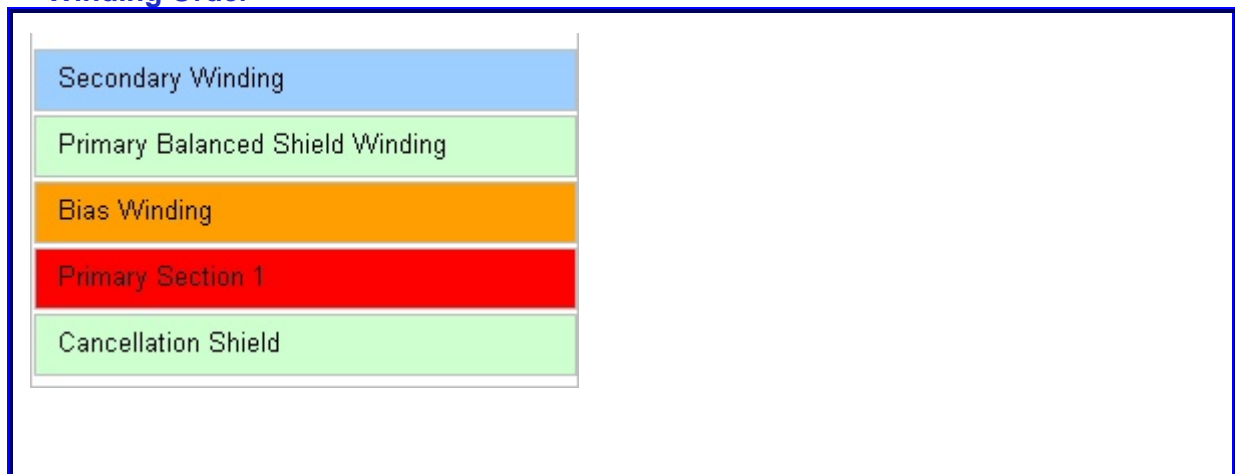
7 Transformer Specification

Transformer Construction

▼ Electrical Diagram



▼ Winding Order



▼ **Core Information**

Core Type	EEL19
Core Material	NC-2H or Equivalent
Gap length, mm	0.109
Gapped Effective Inductance, nH/t ²	203
Primary Inductance, uH	884

▼ **Bobbin Information**

Bobbin Reference	Generic, 5 pri. + 5 sec.
Bobbin Orientation	Vertical
Number of Primary pins	5
Number of Secondary pins	5
Margin on Left, mm	3.0
Margin on Right, mm	3.0

▼ **Primary Winding**

<i>Parameter</i>	<i>Section 1</i>
Number of Turns	66
Wire Size, AWG	28
Filar	1
Layers	2
Start Pin(s)	3
Termination Pin(s)	1

▼ **BIAS Winding**

<i>Parameter</i>	<i>Value</i>
Number of Turns	8.0
Wire Size, AWG	25
Filar	1
Layers	0.30
Start Pin(s)	5
Termination Pin(s)	4

▼ **Shield Information**

<i>Parameter</i>	<i>Primary</i>	<i>Cancellation</i>
Number of Turns	14	25
Wire Size, AWG	26	31
Filar	2	2
Layers	1	1
Start Pin(s)	NC	1
Termination Pin(s)	1	NC

▼ **Secondary Winding**

<i>Parameter</i>	<i>Output 1 (main)</i>
Spec Voltage, V	24.00
Spec Current, A	0.65
Actual Voltage, V	24.00
Number of Turns	15
Wire Size, AWG	26 T.I.W.
Filar	1

Filar	1
Layers	0.50
Start Pin(s)	9,10
Termination Pin(s)	6,7

▼ Winding Instruction

Use 3.0 mm margin on the left side. Use 3.0 mm margin on the right side.

Cancellation Shield Winding

Start on pin(s) 1 using item [6] at the start leads and wind 25 turns (x 2 filar) of item [8]. in exactly 1 layer. Leave this end of cancellation shield winding not connected. Bend the end 90 deg and cut the wire in the middle of the bobbin.

Add 1 layer of tape, item [4], to secure the winding in place.

Primary Winding

Start on pin(s) 3 using item [6] at the start leads and wind 66 turns of item [8] in 2.00 layer(s) from left to right. Add 1 layer of tape, item [5], in between each primary winding layer. At the end of 1st layer, continue to wind the next layer from right to left. On the final layer, spread the winding evenly across entire bobbin. Finish winding on pin(s) 1 using item [6] at the finish leads.

Add 1 layer of tape, item [4], for insulation.

Bias Winding

Start on pin(s) 5 using item [6] at the start leads and wind 8.0 turns (x 1 filar) of item [9]. Spread the winding evenly across entire bobbin. Finish on pin(s) 4 using item [6] at the finish leads.

Add 1 layer of tape, item [4], for insulation.

Primary Balanced Shield Winding

Start on any (temp) pin on the secondary side and wind 14 turns (x 2 filar) of item [10]. Spread the winding evenly across entire bobbin. Finish this winding on pin(s) 1 using item [6] at the finish leads.

Cut out wire connected to temp pin on secondary side. Leave this end of primary shield winding not connected. Bend the end 90 deg and cut the wire in the middle of the bobbin.

Add 3 layers of tape, item [4], for insulation.

Secondary Winding

Start on pin(s) 9,10 using item [6] at the start leads and wind 15 turns (x 1 filar) of item [10]. Spread the winding evenly across entire bobbin. Finish on pin(s) 6, 7 using item [6] at the start leads.

Add 2 layers of tape, item [4], for insulation.

Core Assembly

Assemble and secure core halves. Item [1].

Varnish

Dip varnish uniformly in item [7]. Do not vacuum impregnate.

▼ Materials

<i>Item</i>	<i>Description</i>
[1]	Core: EEL19, NC-2H or Equivalent, gapped for ALG of 203 nH/t ²
[2]	Bobbin: Generic, 5 pri. + 5 sec.
[3]	Tape: Polyester web 3.0 mm wide
[4]	Barrier Tape: Polyester film 19.70 mm wide
[5]	Separation Tape: Polyester film 13.7 mm wide
[6]	Teflon Tubing # 22
[7]	Varnish
[8]	Magnet Wire: 31 AWG, Solderable Double Coated
[9]	Magnet Wire: 25 AWG, Solderable Double Coated
[10]	Magnet Wire: 26 AWG, Triple Insulated Wire

▼ Electrical Test Specifications

<i>Parameter</i>	<i>Condition</i>	<i>Spec</i>
Electrical Strength, VAC	60 Hz 1 minute, from pins 1 - 2 to pins 6 - 10.	3000
Primary Inductance, uH	Measured between Pin 1 to Pin 2, with all other Windings open.	884 uH +/- 10%
Primary Leakage, uH	Measured between Pin 1 to Pin 2, with all other Windings shorted.	44 uH (max)



8 Transformer Spreadsheets

Design Passed (Optimization Done)

Note: For a list of transformer vendors click [here](#)



▼ Power Supply Input

<i>Var</i>	<i>Value</i>	<i>Output 1 (main)</i>	<i>Units</i>	<i>Description</i>
VACMIN	85		Volts	Min Input AC Voltage
VACMAX	265		Volts	Max Input AC Voltage
FL	50		Hertz	Line Frequency
TC	2.28		mSeconds	Diode Conduction Time
Z	0.45			Loss Allocation Factor
N	84.0		%	Efficiency Estimate

▼ Power Supply Outputs

<i>Var</i>	<i>Value</i>	<i>Output 1 (main)</i>	<i>Units</i>	<i>Description</i>
VOx		24.00	Volts	Output Voltage
IOx		0.65	Amps	Output Current
VB	12.0		Volts	Bias Voltage
IB	0.006		Amps	Bias Current

▼ Device Variables

<i>Var</i>	<i>Value</i>	<i>Output 1 (main)</i>	<i>Units</i>	<i>Description</i>
Device	TOP244P			PI Device Name
PO	15.7		Watts	Total Output Power
VDRAIN	626		Volts	Maximum Drain Voltage
VDS	3.14		Volts	Drain to Source Voltage
FS	132000		Hertz	Switching Frequency
KRPKDP	0.70			Continuous/Discontinuous Operating Ratio
KI	0.72			KI Factor
ILIMITEXT	0.67		Amps	Device Current Limit External Minimum
ILIMITMIN	0.93		Amps	Current Limit Minimum
ILIMITMAX	1.07		Amps	Current Limit Maximum
IP	0.57		Amps	Peak Primary Current
IRMS	0.29		Amps	Primary RMS Current
DMAX	0.56			Maximum Duty Cycle

▼ Power Supply Components Selection

<i>Var</i>	<i>Value</i>	<i>Output 1 (main)</i>	<i>Units</i>	<i>Description</i>
CIN	47.0		uFarads	Input Capacitance
VMIN	91.2		Volts	Minimum DC Input Voltage
VMAX	374.8		Volts	Maximum DC Input Voltage
VCLO	170		Volts	Clamp Zener Voltage

PZ	1.1	Watts	Primary Zener Clamp Loss
VDB	0.70	Volts	Bias Diode Forward Voltage Drop
PIVB	55	Volts	Bias Rectifier Max Peak Inverse Voltage
RLS1	2.0	MOhms	Line sense resistor
VUVON_MIN	90.57	Volts	Minimum undervoltage threshold beyond which Power supply will start-up
VUVON_MAX	110.59	Volts	Maximum undervoltage threshold before which Power Supply will start-up
VOVOFF_MIN	422.86	Volts	Minimum overvoltage threshold after which Power Supply will turn off after an over voltage condition
VOVOFF_MAX	482.91	Volts	Maximum overvoltage threshold before the Power Supply will turn off after an over voltage condition Comment: Drain voltage close to BVDSS at maximum OV threshold Tip: Verify BVDSS during line surge, decrease VUVON_MAX or reduce VOR.

▼ Power Supply Output Parameters

<i>Var</i>	<i>Value</i>	<i>Output 1 (main)</i>	<i>Units</i>	<i>Description</i>
VDx	1.00	Volts	Output Winding Diode Forward Voltage Drop	
PIVSx	109	Volts	Output Rectifier Maximum Peak Inverse Voltage	
ISPx	2.41	Amps	Peak Secondary Current	
ISRMSx	1.09	Amps	Secondary RMS Current	
IRIPPLEx	0.88	Amps	Output Capacitor RMS Ripple Current	

▼ Transformer Construction Parameters

<i>Var</i>	<i>Value</i>	<i>Output 1 (main)</i>	<i>Units</i>	<i>Description</i>
Core/Bobbin	EEL19			Core Type
Core Manuf.	Generic			Core Manufacturer
Bobbin Manuf	Generic			Bobbin Manufacturer
LP	884		uHenries	Primary Inductance
NP	66.0			Primary Number of Turns
NB	7.6			Bias Winding Number of Turns
OD Actual	0.23		mm	Primary Actual Wire Diameter
Primary Current Density	7		A/mm ²	Primary Winding Current Density
VOR	110.00		Volts	Reflected Output Voltage
BW	19.70		mm	Bobbin Winding Width
M	3.0		mm	Safety Margin Width
L	1.40			Primary Number of Layers
AE	24.50		mm ²	Core Cross Sectional Area



ALG	203	nH/T ²	Gapped Core Effective Inductance
BM	310	milliTesla	Maximum Flux Density
BP	419	milliTesla	Peak Flux density
BAC	108	milliTesla	AC Flux Density for Core Loss
LG	0.11	mm	Gap Length
LL	17.7	uHenries	Primary Leakage Inductance
LSEC	30	nHenries	Secondary Trace Inductance

▼ **Secondary Parameters**

Var	Value	Output 1 (main)	Units	Description
NSx		15.0		Secondary Number of Turns
Rounded Down NSx				Rounded to Integer Secondary Number of Turns
Rounded Down Vox			Volts	Auxiliary Output Voltage for Rounded down to Integer Secondary Number of Turns
Rounded Up NSx				Rounded to Next Integer Secondary Number of Turns
Rounded Up Vox			Volts	Auxiliary Output Voltage for Rounded up to Next Integer Secondary Number of Turns
ODS Actual Range		0.36 - 0.57	mm	Secondary Actual Wire Diameter Range Comment: Secondary wire size is greater than recommended maximum (0.4 mm) Tip: Consider a parallel winding technique (bifilar, trifilar) for >1.5 A outputs, increase size of transformer (larger BW), reduce margin (M).

9 Performance Data

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

9.1 Efficiency

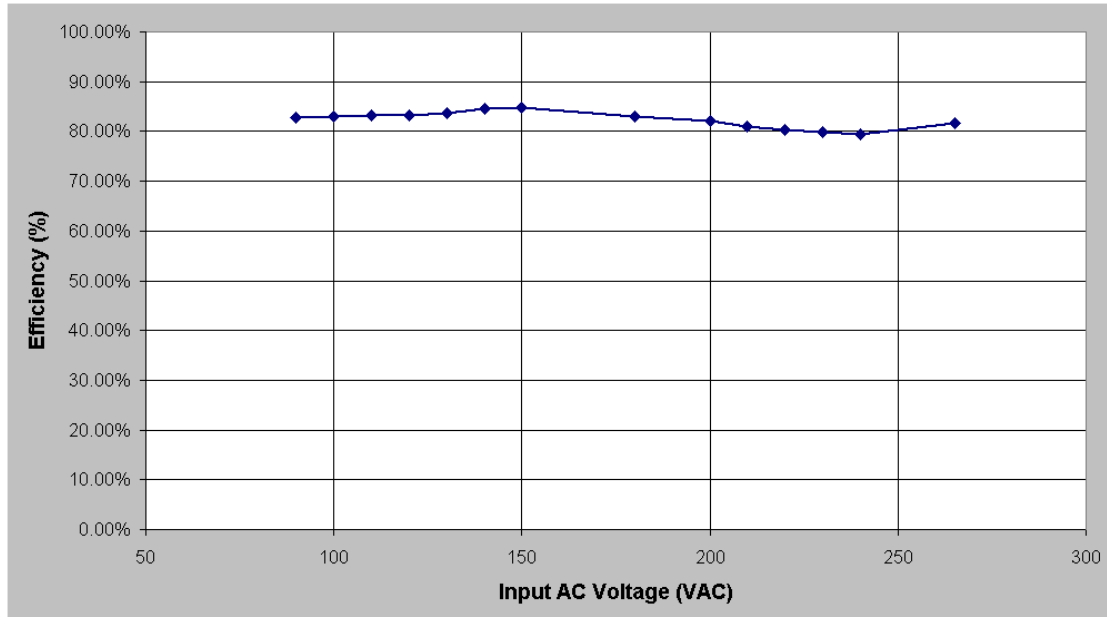


Figure 4 – Efficiency vs. Input Voltage, Room Temperature, 60 Hz.

9.2 No-load Input Power

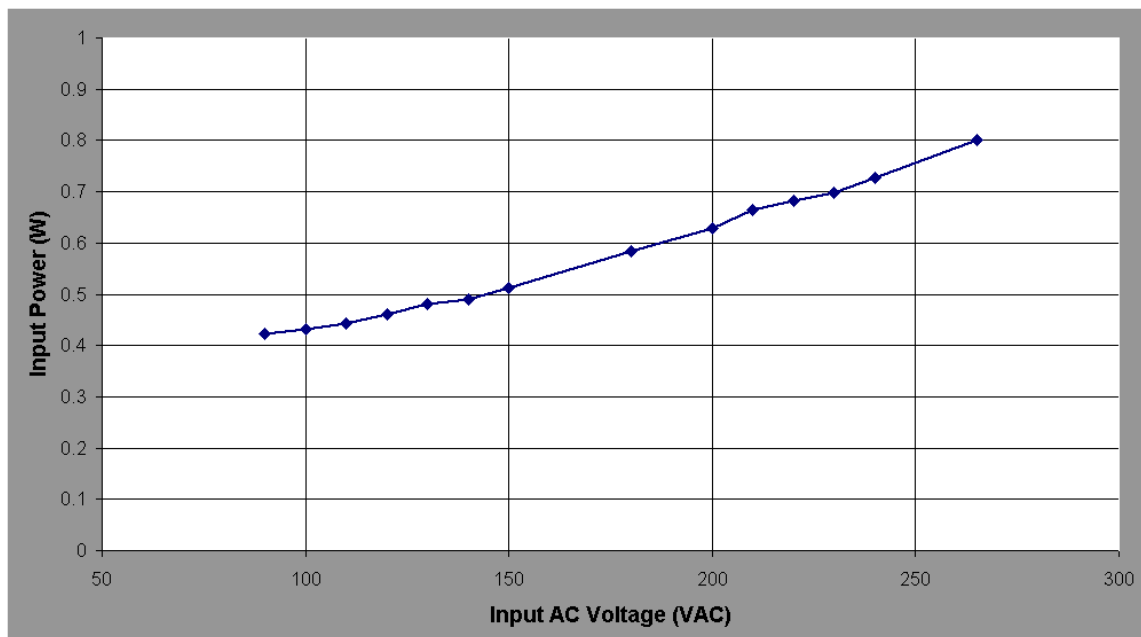


Figure 5 – Zero Load Input Power vs. Input Line Voltage, Room Temperature, 60 Hz.

9.3 Regulation

9.3.1 Load

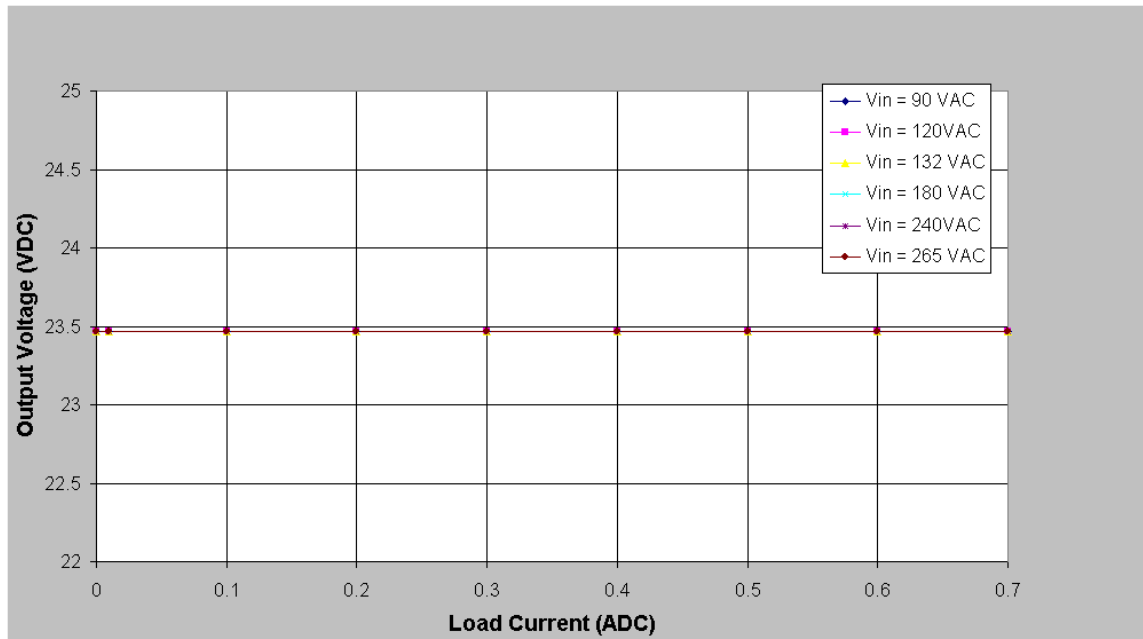


Figure 6 – Load Regulation, Room Temperature

9.3.2 Line

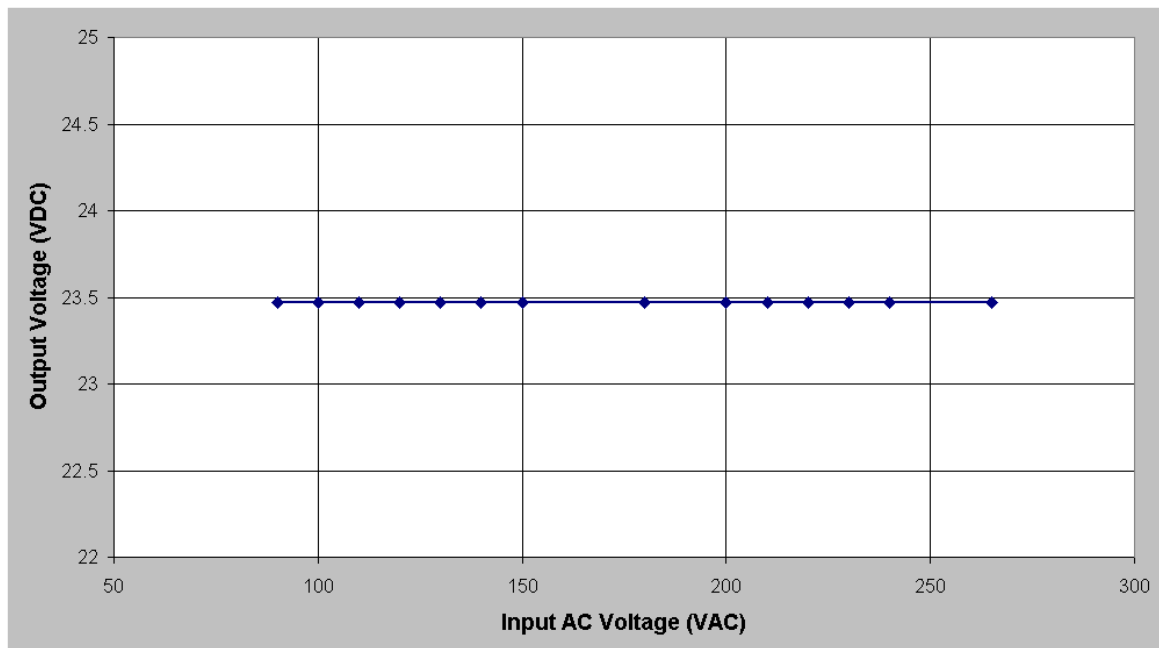


Figure 7 – Line Regulation, Room Temperature, Full Load

10 Waveforms

10.1 Drain Voltage and Current, Normal Operation

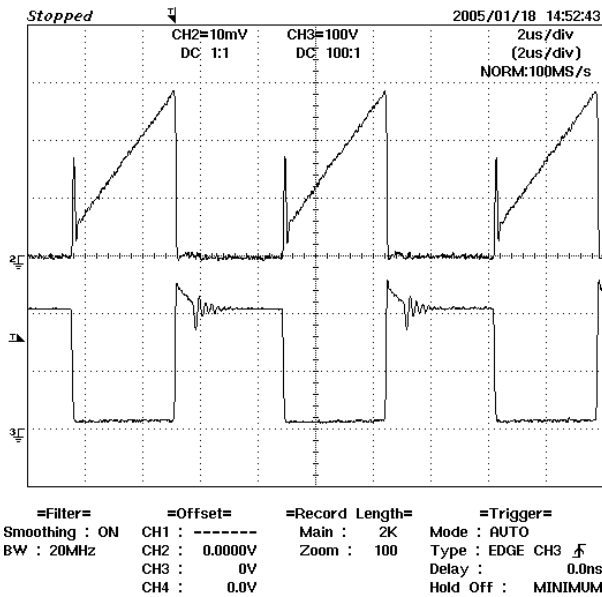


Figure 8 – 90 VAC, Full Load.
 Upper: I_{DRAIN} , 0.2 A / div
 Lower: V_{DRAIN} , 100 V, 2 μ s / div

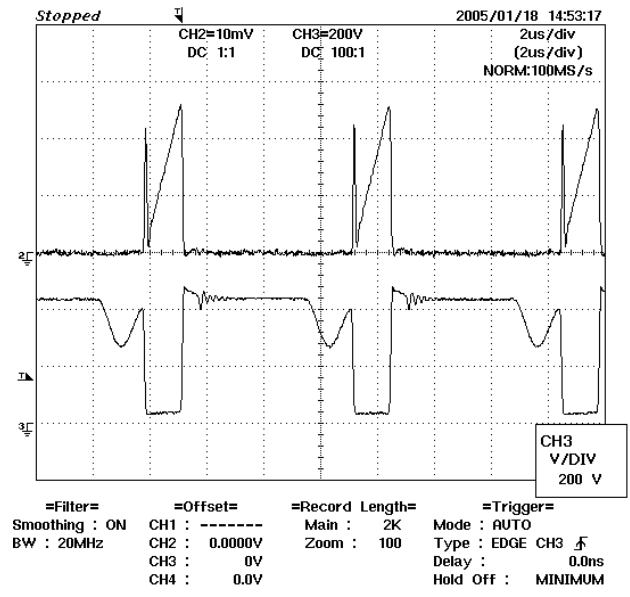


Figure 9 – 265 VAC, Full Load
 Upper: I_{DRAIN} , 0.2 A / div
 Lower: V_{DRAIN} , 200 V / div

10.2 Output Voltage Start-up Profile

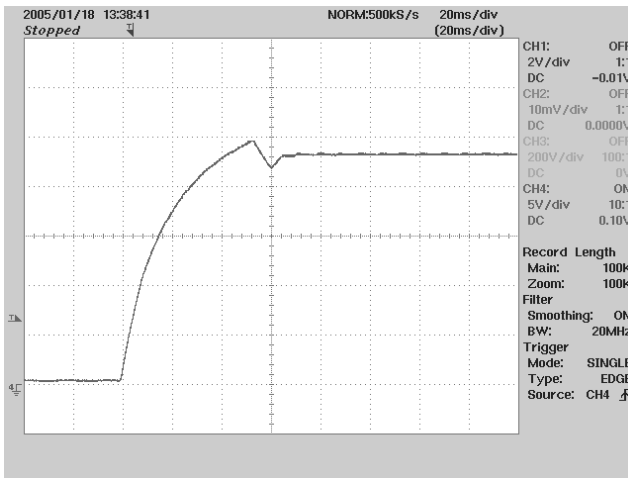


Figure 10 – Start-up Profile, 120 VAC
 2 V, 20 ms / div.

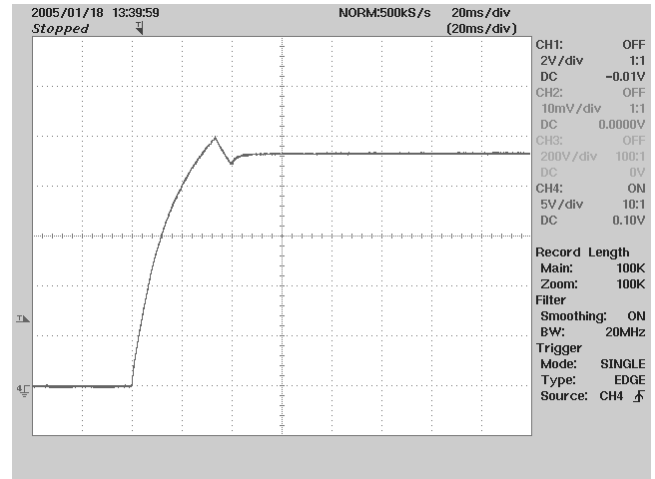
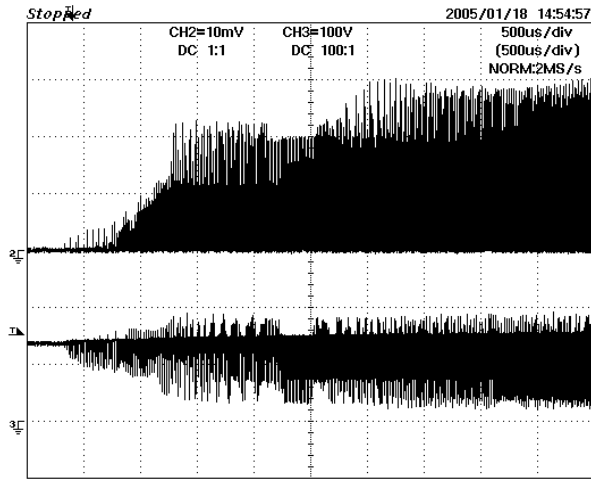


Figure 11 – Start-up Profile, 240 VAC
 2 V, 20 ms / div.

10.3 Drain Voltage and Current Start-up Profile



=Filter= =Offset= =Record Length= =Trigger=
 Smoothing : ON CH1 : ----- Main : 10K Mode : SGL(S)
 BW : 20MHz CH2 : 0.0000V Zoom : 400 Type : EDGE CH3 ⌘
 CH3 : 0V Delay : 0.0ns
 CH4 : 0.0V Hold Off : MINIMUM

Figure 12 – 90 VAC Input and Maximum Load.
 Upper: I_{DRAIN} , 0.5 A / div.
 Lower: V_{DRAIN} , 100 V & 1 ms / div.

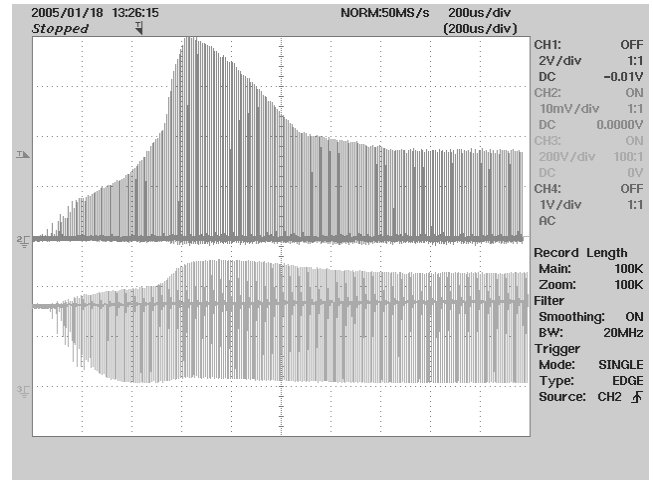


Figure 13 – 265 VAC Input and Maximum Load.
 Upper: I_{DRAIN} , 0.5 A / div.
 Lower: V_{DRAIN} , 200 V & 1 ms / div.

10.4 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.

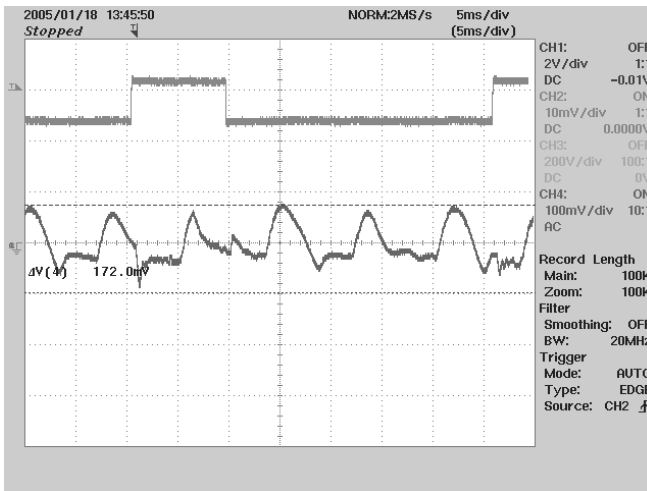


Figure 14 – Transient Response, 120 VAC, 75-100-75% Load Step.
Top: Load Current, 0.5 A/div.
Bottom: Output Voltage
100 mV, 5msec / div.

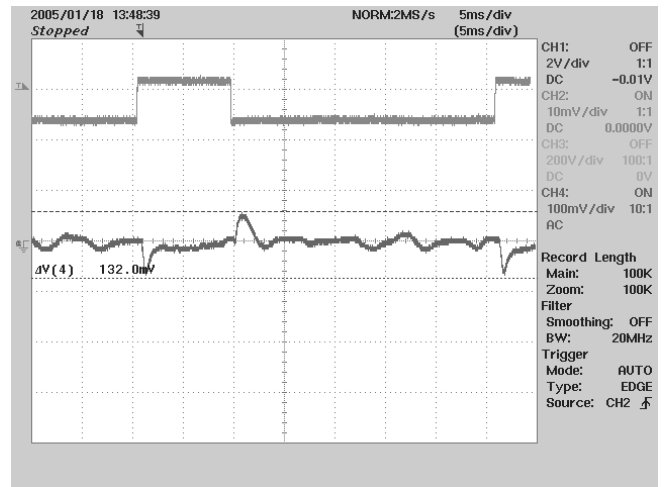


Figure 15 – Transient Response, 240 VAC, 75-100-75% Load Step
Upper: Load Current, 0.5 A/ div.
Bottom: Output Voltage
100 mV, 5 ms / div.

10.5 Output Ripple Measurements

10.5.1 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 16 and Figure 17.

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

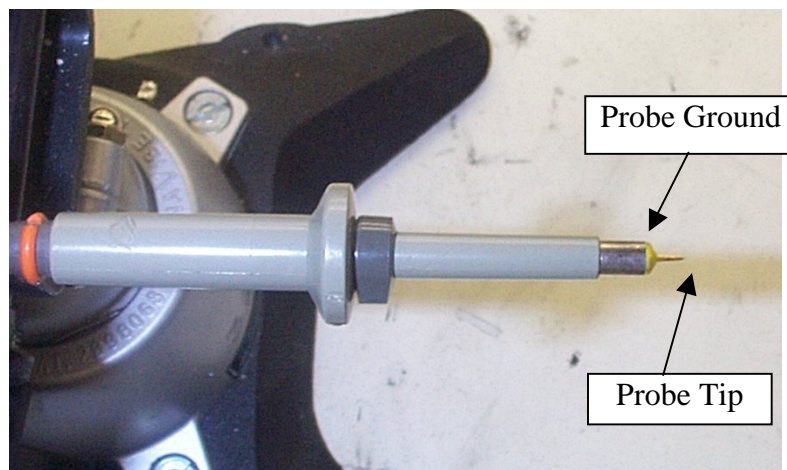


Figure 16 – Oscilloscope Probe Prepared for Ripple Measurement. (End Cap and Ground Lead Removed)



Figure 17 – Oscilloscope Probe with Probe Master 5125BA BNC Adapter. (Modified with wires for probe ground for ripple measurement, and two parallel decoupling capacitors added)

10.5.2 Measurement Results

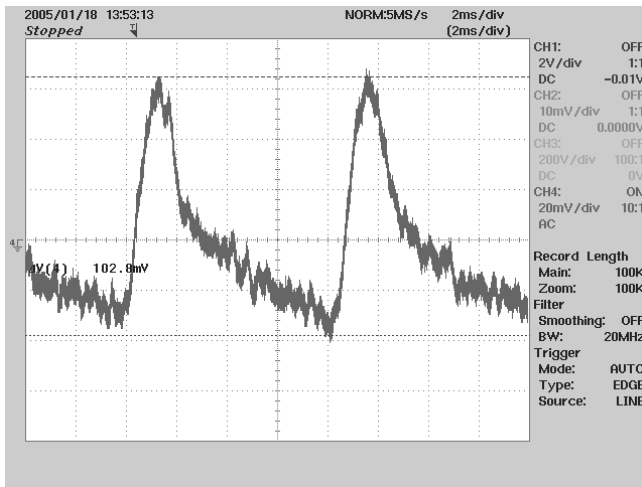


Figure 18 – +24 V Ripple, 90 VAC, Full Load.
2 ms, 20 mV / div

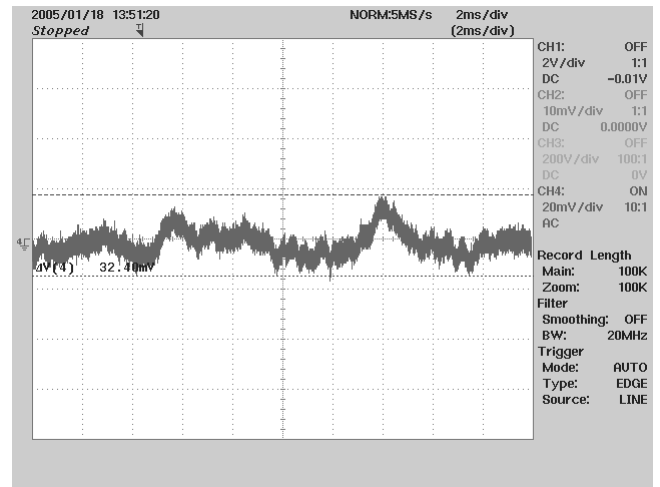


Figure 19 – +24 V Ripple, 265 VAC, Full Load.
2 ms, 20 mV / div

11 Control Loop Measurements

11.1 90 VAC Maximum Load

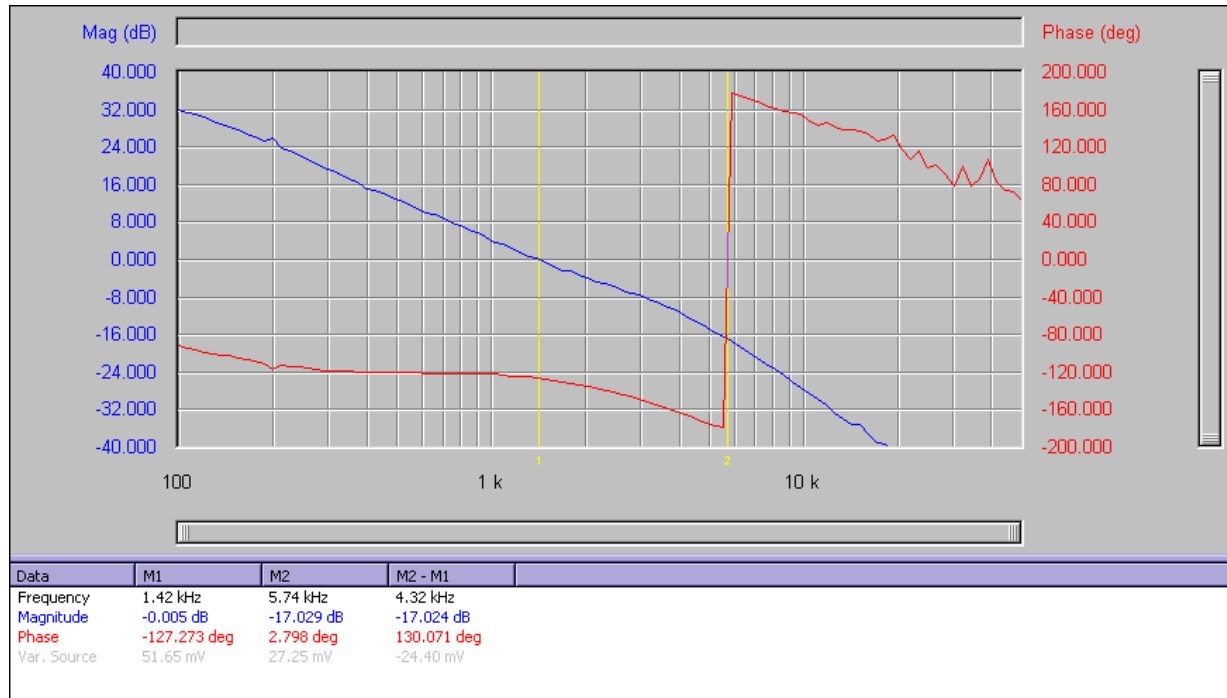


Figure 20 – Gain-Phase Plot, 90 VAC, Maximum Steady State Load
 Vertical Scale: Gain = 8 dB/div, Phase = 40 °/div.
 Crossover Frequency = 1.42 kHz Phase Margin = 52.7°

11.2 265 VAC Maximum Load

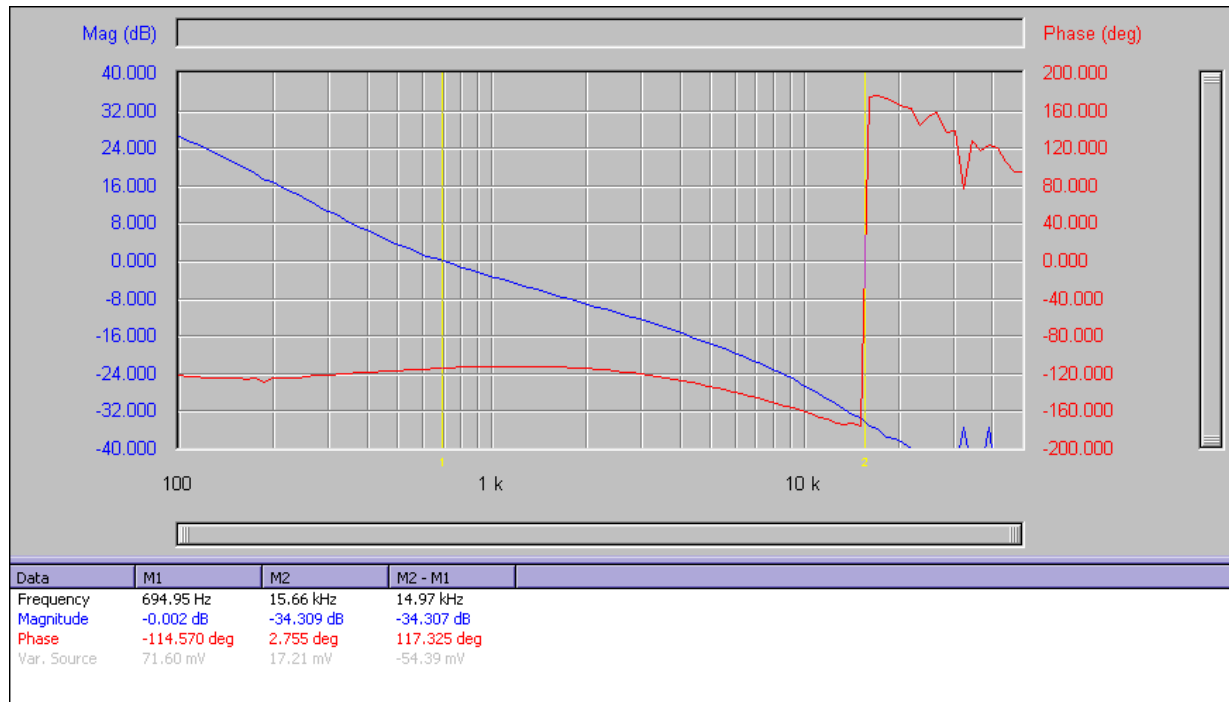


Figure 21 – Gain-Phase Plot, 265 VAC, Maximum Steady State Load
 Vertical Scale: Gain = 8 dB/div, Phase = 40 °/div.
 Crossover Frequency = 695Hz, Phase Margin = 65.4°

12 Conducted EMI

A conducted EMI scan of the prototype was taken to determine the effectiveness of the input filter and transformer ESHIELD® construction. The following plots show the peak performance of the converter against quasi-peak (QP) and average (AVG) limits of EN55022 Class B. Both scans were taken at 120 VAC / 60Hz input with maximum load applied to the outputs. Since the peak scans are below the average limits, it is expected that the QP and Average scans would have greater than 5db of margin below the limits.

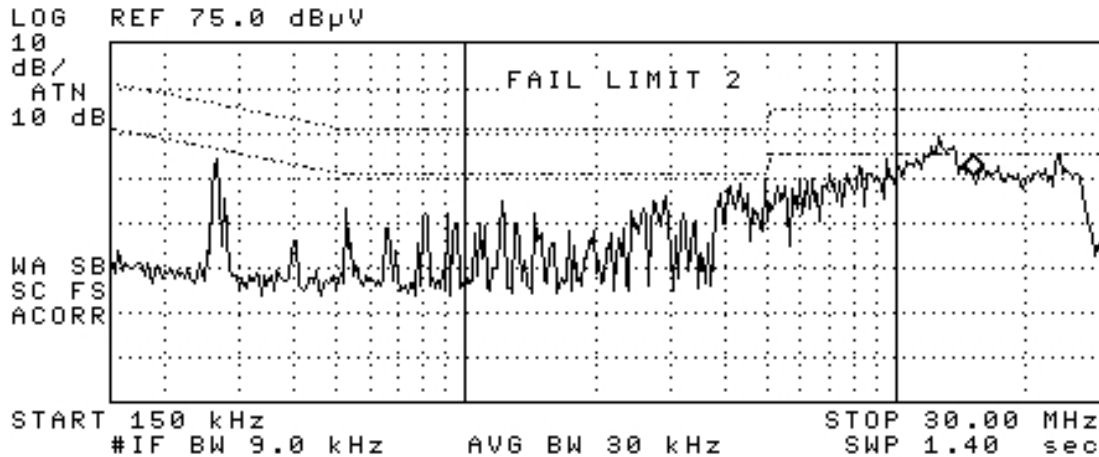


Figure 22 – Conducted EMI (Neutral), Maximum Load, 120 VAC, 60 Hz, and EN55022 B Limits

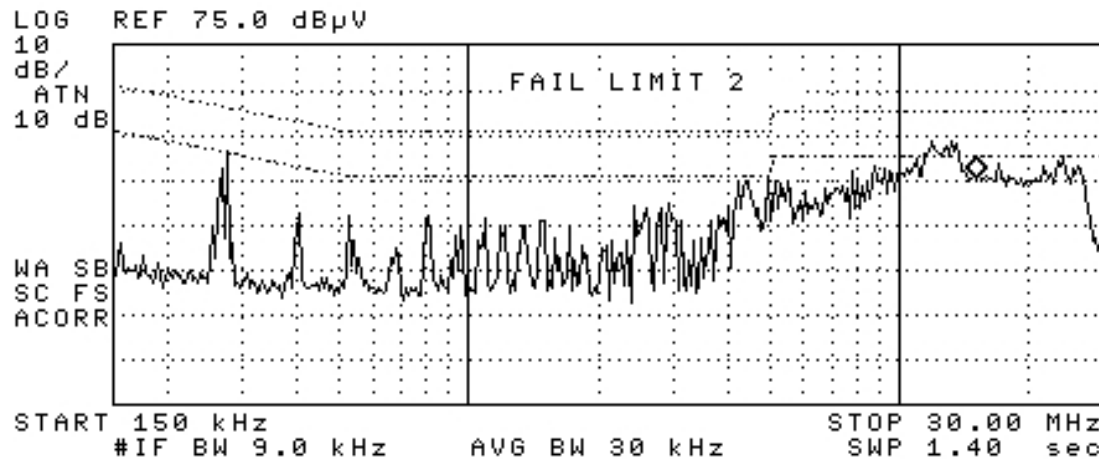


Figure 23 – Conducted EMI (Line), Maximum Load, 120 VAC, 60 Hz, and EN55022 B Limits

13 Revision History

Date	Author	Revision	Description & changes	Reviewed
10-26-05	RSP	1.0	Initial Release	KM/JC/VC
05-19-06	RSP	1.1	Corrected Schematic	

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