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## Design Example Report

<b>Title</b>	<b><i>11W Power Supply using TNY267P</i></b>
<b>Specification</b>	Input: 200 – 264 VAC Output: 3.3V/0.7A, 5V/1.6A, 12V/0.4A, -12V/0.1A
<b>Application</b>	DVD Player
<b>Author</b>	Power Integrations Applications Department
<b>Document Number</b>	DER-5
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### Summary and Features

- 11W continuous, 17W peak
- 4 outputs
- No Load input power < 40 mW
- Very low cost EMI filter to meet CISPR-22
- Tight cross-regulation
- High efficiency (75% minimum)

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](http://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 isolation transformer to provide the AC input 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 220 Vac input and 4 outputs. The design, rated for 11 watts (17 watts peak), is implemented using a TNY267 controller and an EEL25 core with Flyback topology. This document shows specifications, schematic, performance, transformer construction, and BOM of the power supply.

## 2 Power Supply Specification.

Description	Symbol	Min	Typ	Max	Units	Comment
<b>Input</b>						
Voltage	$V_{IN}$	198	220	265	$V_{AC}$	2 Wire – no P.E.
Frequency	$f_{LINE}$	47	50	53	Hz	
No-load Input Power (230 $V_{AC}$ )				0.040	W	
<b>Output</b>						
Output Voltage 1	$V_{OUT1}$	3.20	3.30	3.40	V	± 3% 20 MHz Bandwidth
Output Ripple Voltage 1	$V_{RIPPLE1}$			50	mV	
Output Current 1	$I_{OUT1}$	0.30	0.60	0.70	A	
Output Voltage 2	$V_{OUT2}$	4.75	5.00	5.25	V	±5% 20 MHz Bandwidth
Output Ripple Voltage 2	$V_{RIPPLE2}$			75	mV	
Output Current 2	$I_{OUT2}$	0.30	1.20	1.60	A	
Output Voltage 3	$V_{OUT3}$	11.16	12.00	12.84	V	±7% 20 MHz Bandwidth
Output Ripple Voltage 3	$V_{RIPPLE3}$			100	mV	
Output Current 3	$I_{OUT3}$	100	200	400	A	
Output Voltage 4	$V_{OUT4}$	-11.16	-12.00	-12.84	V	±7% 20 MHz Bandwidth
Output Ripple Voltage 4	$V_{RIPPLE4}$			100	mV	
Output Current 4	$I_{OUT4}$	30	50	100	A	
<b>Total Output Power</b>						
Continuous Output Power	$P_{OUT}$		11		W	
Peak Output Power	$P_{OUT\_PEAK}$			17.00	W	
<b>Efficiency</b>	$\eta$	75			%	Measured at $P_{OUT}$ (16.31W), 25 °C
<b>Environmental</b>						
Conducted EMI						Meets CISPR22B / EN55022B Designed to meet IEC950, UL1950 Class II
Safety						
Ambient Temperature	$T_{AMB}$	0		50	°C	Free convection, Sea level

Table 1 – Power Supply Specifications





## 4 Circuit Description

### 4.1 Input EMI filtering

The voltage from the AC mains is converted into a DC voltage by the full bridge rectifier D1, D2, D3, and D4, and by the filters C1, and C4. Internal jitter of the TNY267P allows for simple EMI filtering. C3, C8, and L1 provide enough filtering for the supply to pass CISPR22B/EN55022B specifications for conducted emissions. The design does not need a common mode choke.

### 4.2 TinySwitch-II primary

The high end of T1 is connected to the high voltage DC bus. Pin 4, the lower end of the primary winding, is connected to the DRAIN pin of the TinySwitch-II. Every time the TinySwitch-II is turned ON, the primary winding of T1 conducts current and a magnetic field is built up in the core of the transformer. Every time the TinySwitch-II turns OFF, Flyback transformer T1 changes polarity. Output rectifiers D7, D8, D10, and D11, now in forward bias, conduct current and allow the energy stored in the core to be transferred to the secondary circuit.

The auxiliary winding of T1 powers the internal circuitry of the TinySwitch-II. This external bias helps to reduce the internal power consumed by the TinySwitch-II. Therefore the supply has very low power consumption under no load and light load conditions.

### 4.3 Output rectification

The switching voltage waveforms at the secondary windings of T1 are rectified by D7, D8, D10, and D11. After rectification, the waveforms are smoothed by capacitor, and inductor filters. This filtering produces output DC voltages with very low ripple.

### 4.4 Output Feedback

Sensing resistors R16 and R15 detect any variation in the amplitude of the 3.3V and 5V outputs. These changes, due to changes in the output load or input voltage, are sampled to the input pin of the TL431 shunt regulator. The shunt regulator compares these variations with its internal voltage reference and drives a feedback current through U2B proportional to the variations detected by R16 and R15. Opto-coupler U2 closes the control loop of the supply by transferring the feedback current to the output of the EN/UV pin on the primary side of the circuit.



## 5 Performance Data

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

### 5.1 Efficiency

$V_o$ (V)	$I_o$ (A)	$P_o$ (W)
5.06	1.20	6.07
3.25	0.60	1.95
12.30	0.205	2.52
12.40	0.052	0.64
$P_{O(Total)}$ (W)		11.18
$P_{IN}$ (W)		14.20
Efficiency (%)		78.73

Table 2 – Efficiency at 220 Vac input

### 5.2 Load Regulation

$V_{IN}$ (Vac)	$V_{O(3.3V)}$ (V)	$I_{O(3.3V)}$ (A)	$V_{O(5V)}$ (V)	$I_{O(5V)}$ (A)	$V_{O(12V)}$ (V)	$I_{O(12V)}$ (A)	$V_{O(-12V)}$ (V)	$I_{O(-12V)}$ (A)
220	3.26	0.3	5.04	0.3	11.87	0.4	-11.66	0.1
220	3.23	0.7	5.13	0.3	12.08	0.4	-11.87	0.1
220	3.32	0.3	4.86	1.6	12.15	0.4	-11.95	0.1
220	3.29	0.7	4.95	1.6	12.33	0.4	-12.14	0.1

Table 3 – Load Regulation. Line frequency 60HZ, ambient temperature

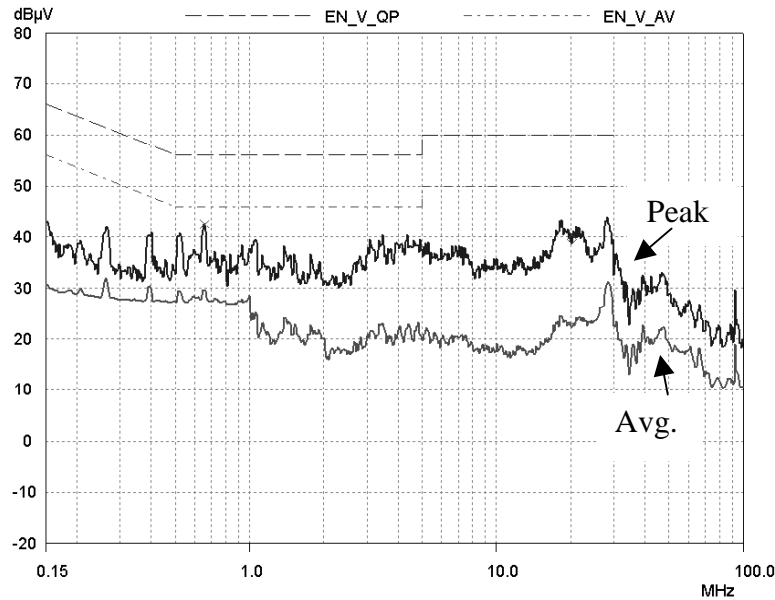
### 5.3 No Load Input Power

$V_{IN}$ (Vac)	$P_{IN}$ (mW)
200	26
220	29
264	37

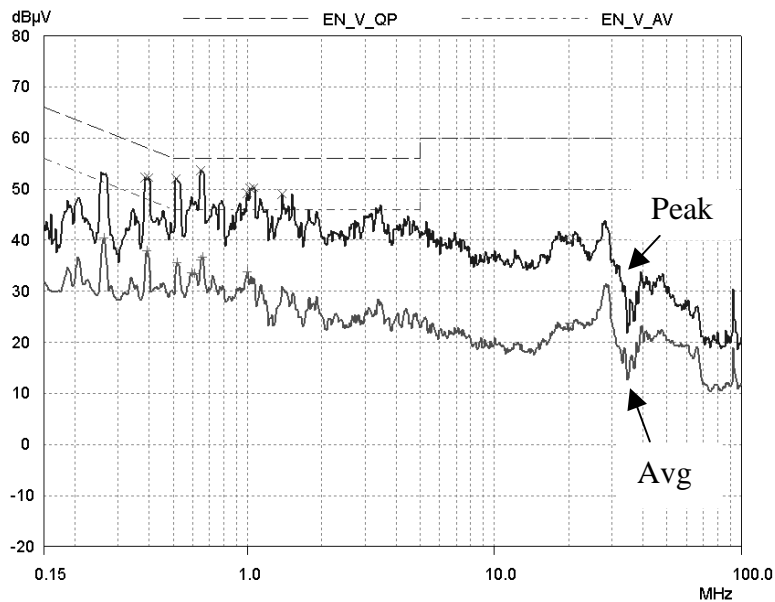
Table 4 – No Load Input Power



## 6 Conducted EMI



**Figure 2** – Conducted EMI EN550022 Class B, Line, Secondary return floating  
 $P_O = 11\text{ W}$ ,  $220\text{ V}_{AC}$ ,  $60\text{ Hz}$



**Figure 3** – Conducted EMI EN550022 Class B, Line, Secondary return connected to Artificial hand  
 $P_O = 11\text{ W}$ ,  $220\text{ V}_{AC}$ ,  $60\text{ Hz}$

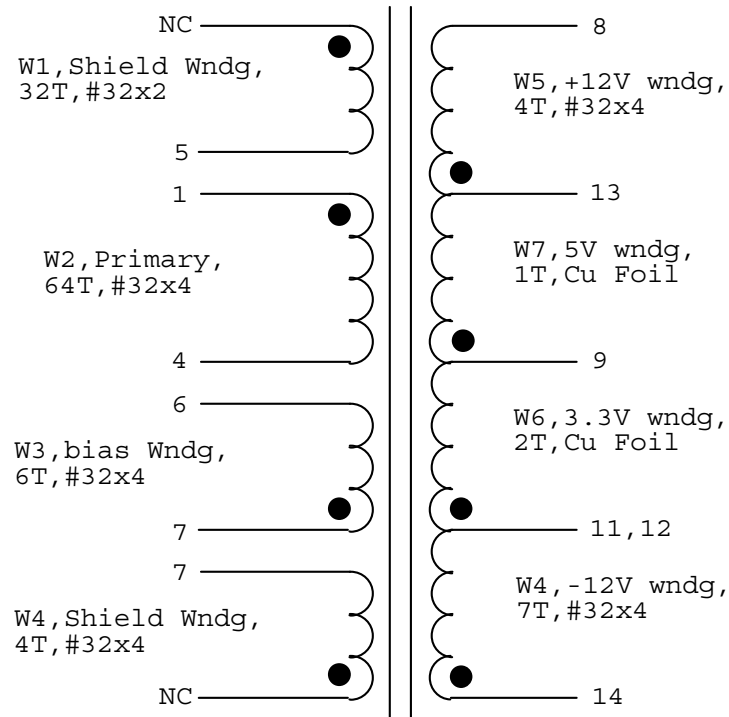
Note: Quasi-peak readings will be about 6 dB lower than Peak readings, yielding at least 9 dB margin.





## 7 Transformer

### 7.1 Transformer Schematic



**Figure 4** – Transformer Winding Diagram



## 7.2 Electrical Specifications

Electrical Strength	60Hz 1minute, from Pins 1-7 to Pins 8-14	3000 V ac
Primary Inductance	Pin 1 to Pin 4, all other windings open Measured at 132KHz.	1.42 mH $\pm$ 5 %
Resonant Frequency	Pin 1 to Pin 4, all other windings open	300 kHz (Min.)
Primary Leakage Inductance	Pin 1 to Pin 4, Pins 8-14 shorted	30 $\mu$ H Max.

**Table 5 – Transformer Electrical Specifications**

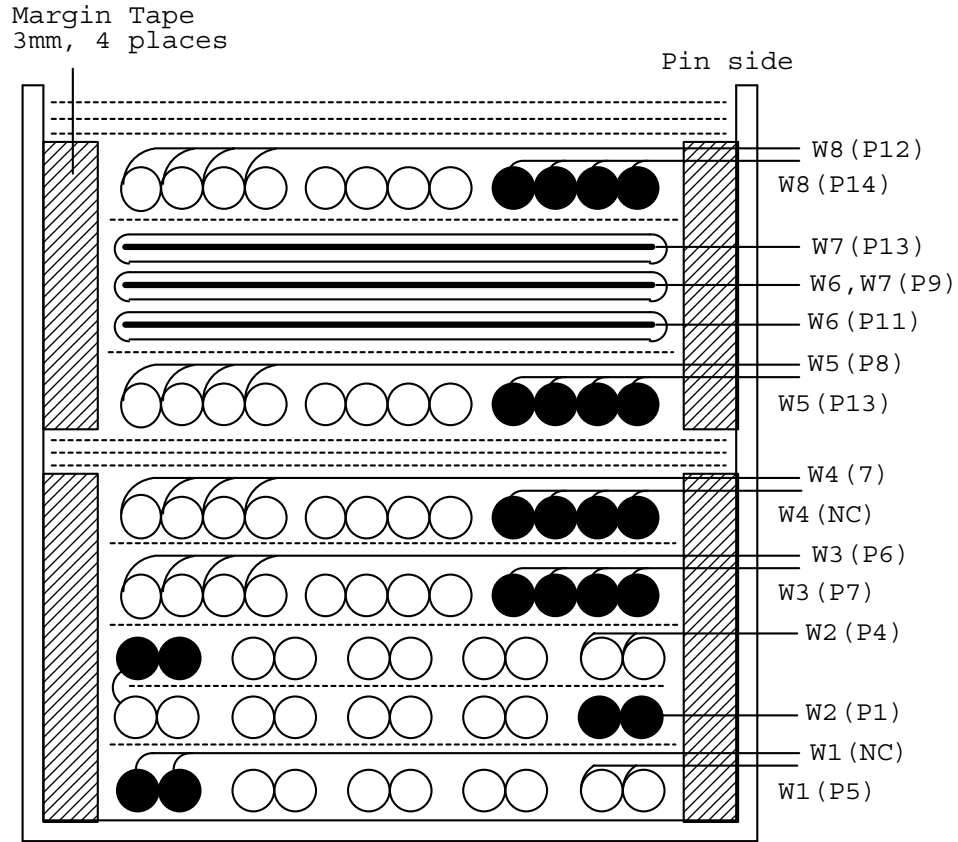
## 7.3 Materials

Item	Description
[1]	Core: EEL25, TDK Gapped for AL of 344 nH/T <sup>2</sup>
[2]	Bobbin: EEL25 Vertical 14 pins
[3]	Magnet Wire: # 32 AWG
[4]	Copper Foil 0.052 mm thick, 14 mm wide.
[5]	Tape: 3M 1298 Polyester Film, 16.1 mm wide
[6]	Tape: 3M 1298 Polyester Film, 22.1 mm wide
[7]	Tape: 3M # 44 Polyester web. 3.0 mm wide
[8]	Tape: 3M 1298 Polyester Film, 10 mm wide
[9]	Copper Tape 2.0 mils thick, 20mm wide.
[10]	Varnish

**Table 6 – Transformer Bill of Materials**



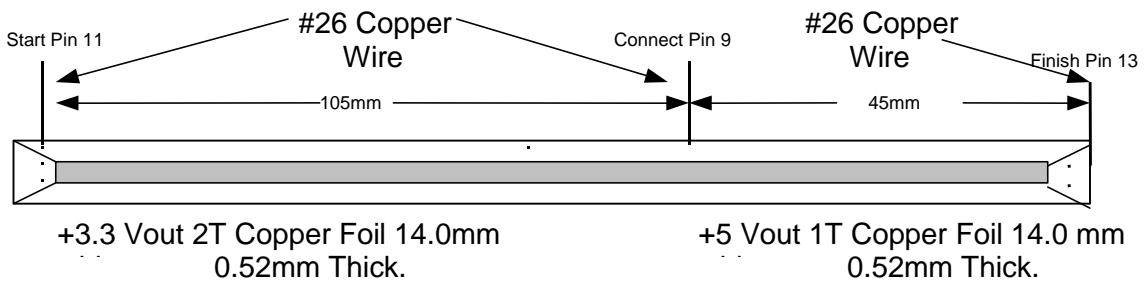
**7.4 Transformer Construction**



**Figure 5 – Transformer Construction Diagram.**

**7.5 Copper Foil Preparation.**

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



**Figure 6 – Transformer Foil Construction 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 tape at each side of bobbin. Match combines height of primary, shield and bias windings.
W1: Shield winding	Start with a floating lead. Wind 32 turns with # 32 x 2 (bifilar) magnet wire from left to right. Wind tightly and uniformly across entire width of bobbin. Finish at pin 5. Cut the starting lead jut at the starting of the winding.
Basic Insulation	Apply one layer of 16.1mm width tape.
W2: Primary winding	Start on pin 1. Wind 32 turns with # 32 x 2 (bifilar) magnet wire from right to left. Apply one layer of 16.1mm width tape. 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.
Basic Insulation	Apply one layer of 16.1mm width tape.
W3: Bias winding	Start on pin 7. Wind 6 turns with # 32 x 4 (quadfilar) magnet wire. Wind from right to left in a single layer. The wires should be tightly and uniformly wound. Finish on pin 6.
Basic Insulation	Apply one layer of 16.1mm width tape.
W4: Shield winding	Start with a floating lead. Wind 4 turns with # 32 x 4 (quadfilar) magnet wire. Wind from right to left in a single layer. The wires should be tightly and uniformly wound. Finish on pin 7. Cut the starting lead jut at the starting of the winding.
Insulation	Apply 3 layers of 22.1 mm width tape.
Margin Tape	Apply 3.0 mm margin tape at each side of bobbin. Match combines height of secondary windings.
W5: +12V winding	Start on pin 13. Wind 4 turns with # 32 x 4 (quadfilar) magnet wire. Wind from right to left in a single tightly wound layer. Finish on pin 8.
Basic Insulation	Apply one layer of 16.1mm width tape.
W6: + 3.3V and W7: + 5V windings	Prepare W6 and W7 by mummy wrapping the copper foil (item 4) with 22.1 mm tape as shown in figure 26. Start at pin 11. Wind 2 turns. Connect the second lead to pin 9 and wind 1 turn. Connect the end lead to pin 13.
Basic Insulation	Apply one layer of 16.1mm width tape.
W7: -12 V winding	Start at pin 14. Wind 7 turns with # 32 x 4 (quadfilar) magnet wire. Wind from right to left in a uniform and tightly wound layer. Finish on pin 12.
Outer Insulation	Apply 3 layers of 22.1 mm width tape.
Core Assembly	Assemble and secure core halves.
Belly band	Place outside short ring of item [9] with tight contact to winding surface.
Outer Insulation	Wrap the core right over the flux band with three layers of 22.1mm tape
Final Assembly	Impregnate uniformly with varnish.



## 8 Bill Of Materials

Item	Qty	Reference	Part Description.
1	2	C1, C4	10 $\mu$ F, 400V, Electrolytic
2	1	C2	0.01 $\mu$ F 1KV, Ceramic Disc
3	1	C3	0.047 $\mu$ F, 250VAC, X2
4	2	C6, C9	220 $\mu$ F, 25V, Electrolytic
5	2	C7, C10	10 $\mu$ F, 50V, Electrolytic
6	1	C8	1nF, 250V, Y1
7	1	C11	1000 $\mu$ F, 25V, Low ESR
8	1	C12	1000 $\mu$ F, 10V, Low ESR
9	2	C14, C19	0.1 $\mu$ F, 50V, Ceramic
10	1	C15	470 $\mu$ F, 25V, Low ESR
11	2	C17, C18	470 $\mu$ F, 10V, Electrolytic
12	1	C20	150 $\mu$ F, 25V, Electrolytic
13	5	D1, D2, D3, D4, D5	1N4007, 1A, 1KV, Rectifier
14		D5	IN4007GP, 1000V, 1A
15	2	D8, D7	UF4003, 1A, 200V,
16	1	D9	1N4148, 75V, Rectifier.
17	2	D10, D11	1N5822, 3.0A, 40V, Schottky
18	1	F1	3.15A, 250VAC
19	1	L1	1.4mH, 0.5A
20	1	L2	3.3 $\mu$ H, 1A, Inductor,
21	2	L3, L4	3.3 $\mu$ H, 2.7A, Inductor
22	2	R1, R2 (Optional)	1 M $\Omega$ , 1/2W
23	1	R5	47 $\Omega$ , 1/4W
24	1	R6	3.3 K $\Omega$ , 1/8W
25	1	R7	100 $\Omega$ , 1/4W
26	1	R8	1 K $\Omega$ , 1/8W
27	1	R9	200 $\Omega$ , 1/8W
28	1	R10	3.3 K $\Omega$ , 1/8W
29	1	R12	1 $\Omega$ , 1/2W
30	1	R13	10 K $\Omega$ , 1%, 1/8W,
31	1	R15	20 K $\Omega$ , 1%, 1/8W
32	1	R16	6.34 $\Omega$ , 1%, 1/8W
33	1	T1	Transformer
34	1	U1	TNY267P
35	1	U2	PC817B, Optocoupler, CTR = 200 %
36	1	U3	TL431, Shunt Regulator
37	1	VR1	P6KE180, TVS Zener, 180V, 600W.

Table 7 – Bill of Materials



## 9 Revision History

<b>Date</b>	<b>Author</b>	<b>Revision</b>	<b>Description &amp; changes</b>	<b>Reviewed</b>
February 4, 2004	MJ	1.0	Initial release	AM/VC



**Notes**



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