NCP1337ADAPGEVB

60 W Adapter Documentation Package Evaluation Board User's Manual

ON Semiconductor®

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EVAL BOARD USER'S MANUAL

Overview

This reference document describes a built-and-tested, GreenPoint® solution for a 60 W power adapter.

The reference design circuit consists of one single-sided 100 mm × 52 mm printed circuit board. Height is 25 mm.

An overview of the entire circuit is provided by Figure 1. As shown in that figure, ON Semiconductor devices are available for every block of adapter; and by judicious choice of design tradeoffs, optimum performance is achieved at minimum cost.

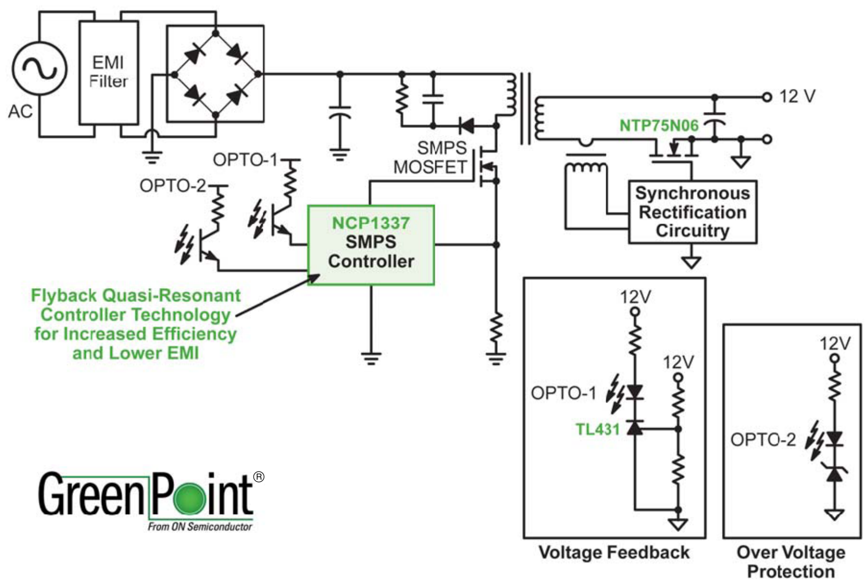


Figure 1. Circuit Schematic

Introduction

This design using NCP1337 offers a perfect solution for portable DVD, LCD TV, or monitor and notebook adapter applications. This adapter provides effective protection functions such as over-load protection, over-voltage protection, shortcircuit protection and brown-out protection. Thanks to the quasi-resonant operation and synchronous rectifier, this adapter has high efficiency and improved EMI performance. The standby consumption is lower because of the cycle skipping and soft ripple mode.

Regulatory requirements addressing low standby power consumption and efficiency in active mode for external power supply (EPS) add extra constraints in the design of the adapter.

These requirements target two issues:

- Get rid of the losses in a no load situation (e.g., when the notebook adapter is plugged in, even when it is not connected to the computer).
- Achieve a good average efficiency during various active mode load conditions (25%, 50%, 75% and 100%).

Many regulations have been proposed around the word. Hereafter is the list of some of the most important ones:

1. **Energy Star:** Applicable in the US and International Partners

- Energy Efficiency Criteria for Active Mode

Nameplate Output Power (P_{no})	Minimum Average Efficiency in Active Mode (Expressed as Decimal)
0 to < 1 W	≥ 0.49 * P_{no}
> 1 and ≤ 49 W	≥ (0.09 * Ln (P_{no})) + 0.49
> 49 W	≥ 0.84

- Energy Consumption Criteria for No Load

Nameplate Output Power (P_{no})	Minimum Average Efficiency in Active Mode (Expressed as Decimal)
0 to < 10 W	≤ 0.5 W
≥ 10 to ≤ 250 W	≤ 0.75 W

2. **California Energy Commission:**

- Effective January 1, 2007

Nameplate Output	Minimum Efficiency in Active Mode
0 to < 1 W	0.49 * Nameplate Output
> 1 and ≤ 49 W	0.09 * Ln (Nameplate Output) + 0.49
> 49 W	0.84

	Maximum Energy Consumption in No-Load Mode
0 to < 10 W	0.5 W
≥ 10 to ≤ 250 W	0.75 W
Where Ln (Nameplate Output) = Natural Logarithm of the Nameplate Output Expressed in Watts	

- Effective July 1, 2008

Nameplate Output	Minimum Efficiency in Active Mode
0 to < 1 W	0.5 * Nameplate Output
> 1 and ≤ 51 W	0.09 * Ln (Nameplate Output) + 0.5
> 51 W	0.85

	Maximum Energy Consumption in No-Load Mode
Any Output	0.5 W
Where Ln (Nameplate Output) = Natural Logarithm of the Nameplate Output Expressed in Watts	

3. **European Union Code of Conduct:**

- No-load Power Consumption

	No-Load Power Consumption	
Rated Output Power	Phase 1 (1.1.2005)	Phase 2 (1.1.2007)
> 0.3 W and < 15 W	0.30 W	0.30 W
> 15 W and < 50 W	0.50 W	0.30 W
> 50 W and < 60 W	0.75 W	0.30 W
> 60 and < 150 W	1.00 W	0.50 W

- Energy-Efficiency Criteria for Active Mode for Phase 1 (for the period 1.1.2005 to 31.12.2006)

Rated Output Power	Minimum Four Point Average (see Annex) or 100% Load Efficiency in Active Mode
0 < W < 1.5	30
1.5 < W < 2.5	40
2.5 < W < 4.5	50
4.5 < W < 6.0	60
6.0 < W < 10.0	70
10.0 < W < 25.0	75
25.0 < W < 150.0	80

- Energy-Efficiency Criteria for Active Mode for Phase 2 (valid after 1.1.2007)

Nameplate Output Power (P_{no})	Minimum Average Efficiency in Active Mode (Expressed as Decimal) (Note 1)
0 < W < 1	$\geq 0.49 * P_{no}$
1 < W < 49	$\geq (0.09 * \mathrm{Ln}\ (P_{no})) + 0.49$
49 < W < 150	≥ 0.84 (Note 2)

1. “Ln“ refers to the natural logarithm. The algebraic order of operations requires that the natural logarithm calculation be performed first and then multiplied by 0.09, with the resulting output added to 0.49. (b) An efficiency of 0.84 in decimal form corresponds to the more familiar value of 84% when expressed as a percentage.
2. Power supplies that have a power factor correction (PFC) to comply with EN61000−3−2 (above 75 W input power) have a 0.04 (4%) allowance, accordingly the minimum on mode load efficiency (100% or averaged) is relaxed to 0.80 (80%).

4. **Korea:**

- External Power Supply − No load: 0.8 W
- Battery Charger − No load: 0.8 W

This document provides a solution to address the design challenges brought about by these regulations: requirements for standby power reduction and active mode energy efficiency increase at a reasonable cost.

Adapter Requirements

More and more high-power adapters are being used in high end applications such as LCD monitors, LCD TVs, and notebook computers. These applications need adapters that are compliant with world-wide energy regulations, deliver high efficiency, and provide complete protection functions. In LCD TV applications, lower radio interference is also important.

Typically, in these applications, the output power range is 45 W to 60 W. No active PFC is needed. The input is universal voltage, and the output voltage is around 12 V.

Limitations of Existing Solutions

In many existing solutions, it is difficult to approach a most optimized design for adapters with minimum parts count and low cost. Brown out protection, overload protection with input voltage compensation, latch-off or disable protection, and soft start function would add about 20 external parts around the controller. Therefore, the reliability and reproducibility of the adapter would be negatively impacted, due to the increase in the complexity of the design.

Overcoming Limitations with NCP1337

NCP1337 combines all the requirements for adapter applications in a spaceefficient SO−7 package. The NCP1337 combines a true current mode modulator and a demagnetization detector, which ensures full Borderline/Critical Conduction Mode in any load/line conditions, together with minimum drain voltage switching (Quasi-Resonant operation). The transformer core reset detection is done internally, without using any external signal, due to the Soxyless concept. The frequency is internally limited to 130 kHz, preventing the controller from operating above the 150 kHz CISPR−22 EMI starting limit.

By monitoring the feedback pin activity, the controller enters ripple mode as soon as the power demand falls below a predetermined level. As each restart is softened by an internal soft-start, and as the frequency cannot go below 25 kHz, no audible noise can be heard.

The NCP1337 also features an efficient protective circuit which, in the presence of an overcurrent condition, disables the output pulses and enters a safe burst mode, trying to restart. Once the default has gone, the device auto-recovers.

Also included is a bulk voltage monitoring function (known as brown-out protection), an adjustable overpower compensation, and a V_{CC} OVP. Finally, an internal 4.0 ms soft-start eliminates the traditional startup stress.

The NCP1337 includes the following features:

- Free-Running Borderline/Critical Mode Quasi-Resonant Operation
- Current-Mode
- Soft Ripple Mode with Minimum Switching Frequency for Standby
- Auto-Recovery Short-Circuit Protection Independent of Auxiliary Voltage
- Overvoltage Protection
- Brown-Out Protection
- Two Externally Triggerable Fault Comparators (one for a disable function, and the other for a permanent latch)
- Internal 4.0 ms Soft-Start
- 500 mA Peak Current Drive Sink Capability
- 130 kHz Maximum Frequency
- Internal Leading Edge Blanking
- Internal Temperature Shutdown
- Direct Optocoupler Connection
- Dynamic Self-Supply with Levels of 12 V (On) and 10 V (Off)

Table 1. SPECIFICATIONS

Parameter	Test Condition	Min	Typ	Max	Unit
INPUT					
Voltage Range		90	–	265	Vac
Frequency Range		47	–	63	Hz
Brown Out Threshold		65	–	75	Vac
Brown Out Hysteresis		–	10	–	Vac
Input Inrush Current	Cold Start 230 Vac	–	–	65	A
No-load Input Power	Input 240 Vac	–	–	0.3	W
OUTPUT					
Output Voltage		–	12	–	V
Voltage Total Regulation	90 Vac to 265 Vac Input and 0 to 5 A Output	–	–	±2	%
Load Output Current	90 Vac to 265 Vac	0	–	5	A
Start-up Overshoot	90 Vac to 265 Vac	–	–	10	%
Transient Regulation	2.5 A to 5 A Step	–	–	300	mV
Transient Recovery Time	2.5 A to 5 A Step; Recovery to 1%	–	–	200	μs
Ripple	20 MHz Bandwidth, Full Load	–	–	100	mV
Over Current Protection	90 Vac to 265 Vac	5.5	–	7	A
Over Voltage Protection	Open Voltage Feedback Loop	13.5	14	14.5	V
TOTAL OUTPUT POWER					
Continuous Output Power	Total Power	–	–	60	W
Conducted EMI Margin	EN55022 Class B	6	–	–	dB
Efficiency	Input 230 Vac, Full Load	88	–	–	%
Operation Temperature	Full Load, Free Air Convection Cooling	0	–	40	°C

REFERENCE DESIGN PERFORMANCE

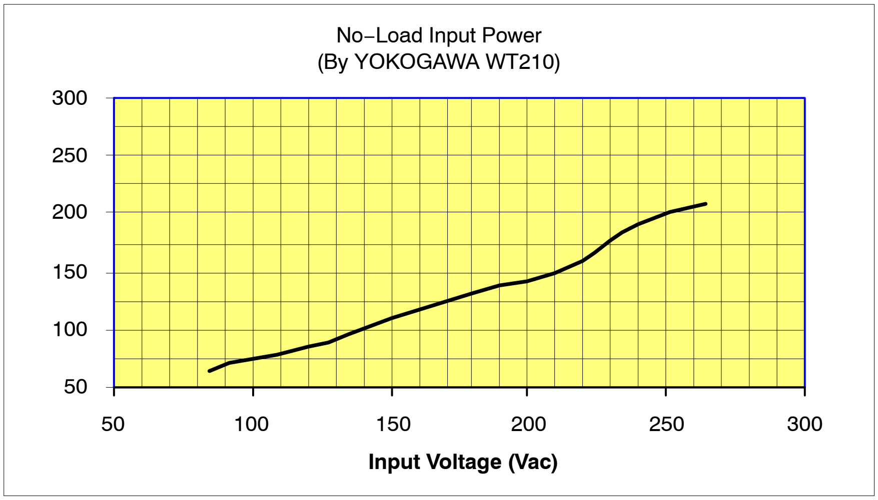


Figure 2. No−Load Consumption, Output Voltage 12.25 V, Output Current 0 A

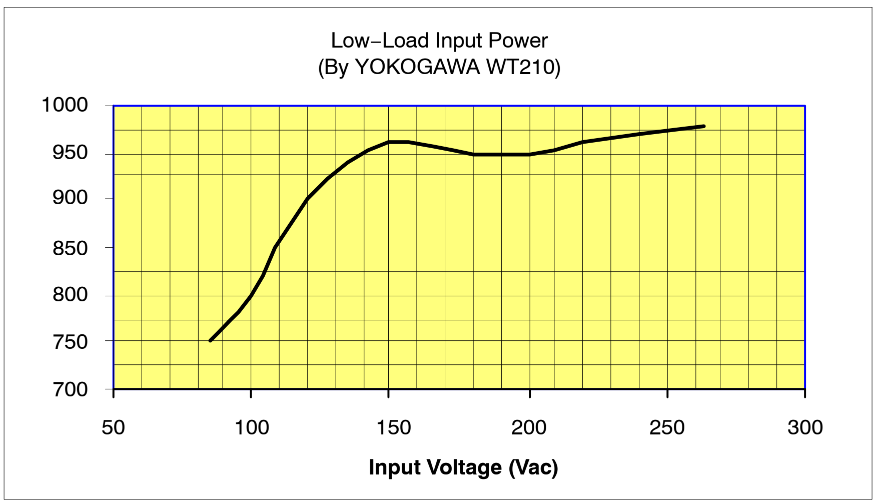


Figure 3. Low Load 0.5 W Consumption, Output Voltage 12.25 V, Output Current 42 mA

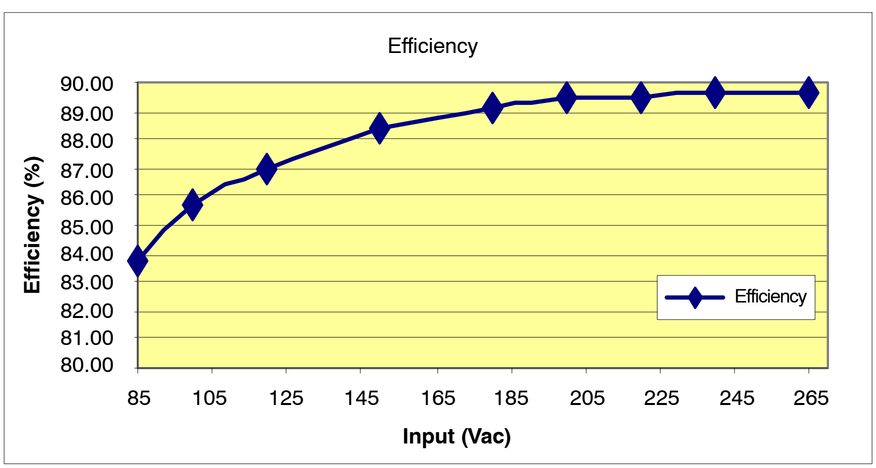


Figure 4. Efficiency vs Input Voltage at Full Load

REFERENCE DESIGN PERFORMANCE

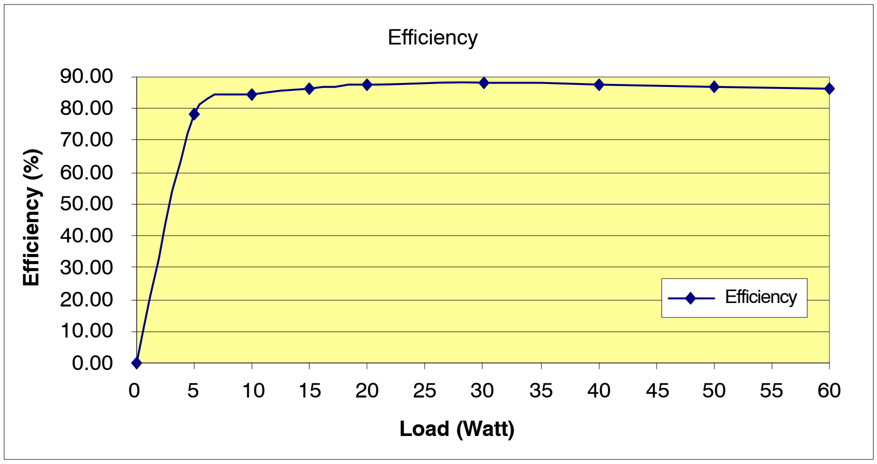


Figure 5. Efficiency vs Load at 110 Vac Input

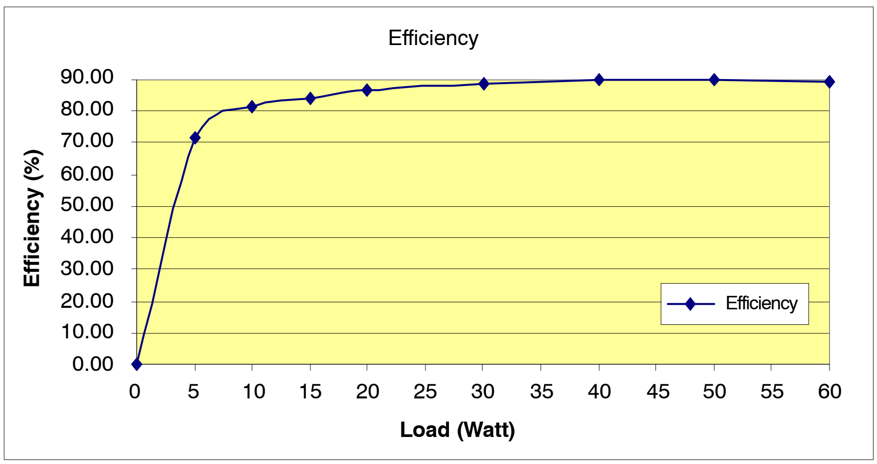
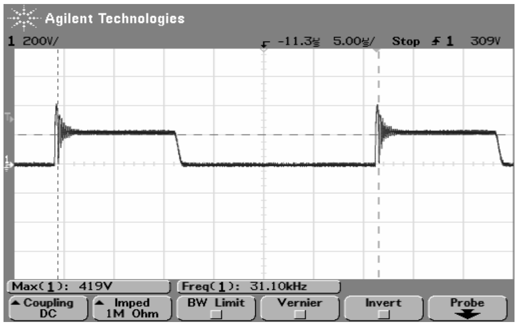
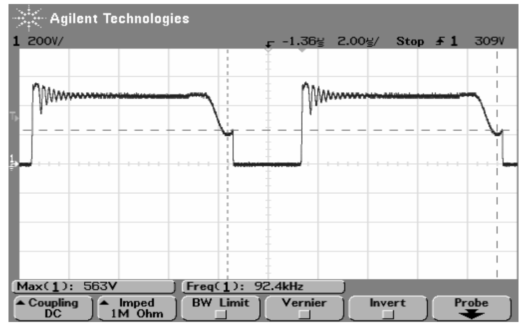


Figure 6. Efficiency vs Load at 220 Vac Input

REFERENCE DESIGN PERFORMANCE

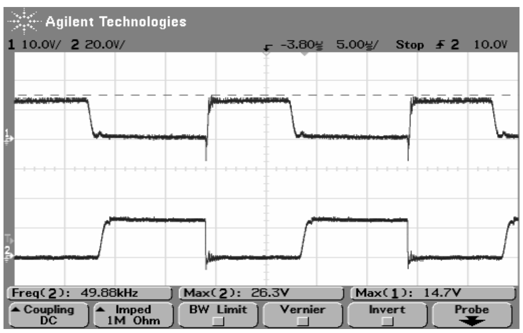


90 Vac Input, Switching Frequency 31 kHz

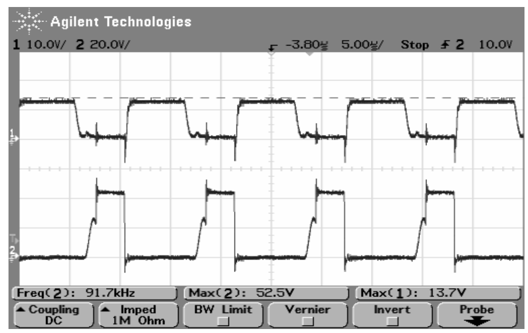


250 Vac Input, Switching Frequency 92 kHz

Figure 7. Voltage Waveform of MOSFET Q2 Drain @ Full Load

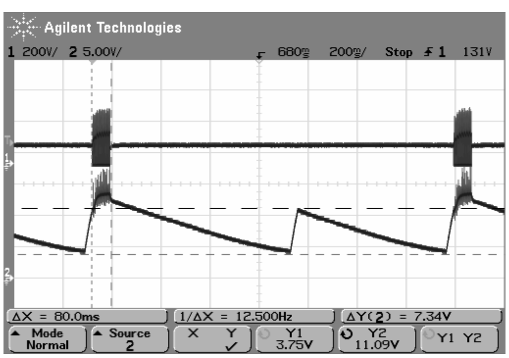


90 Vac Input, CH1 Vgs, CH2 Vds

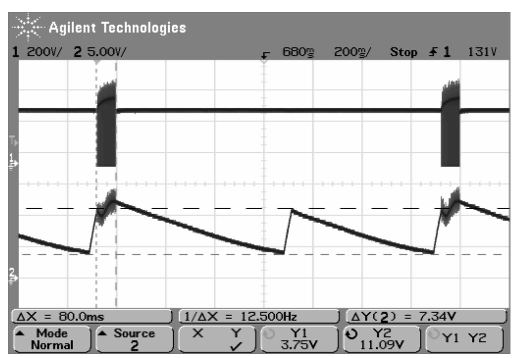


250 Vac Input, CH1 Vgs, CH2 Vds

Figure 8. Drive Waveform of MOSFET Q1 (Synchronous Rectifier) @ Full Load



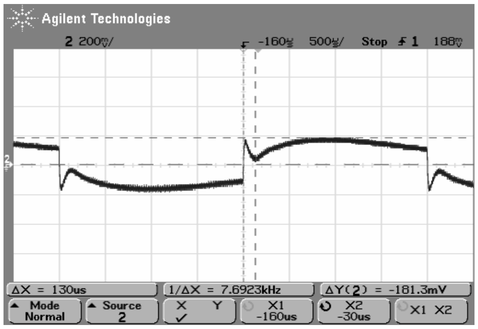
90 Vac Input, Over Load at 5.5 A, CH1 Vds, CH2 Vcc



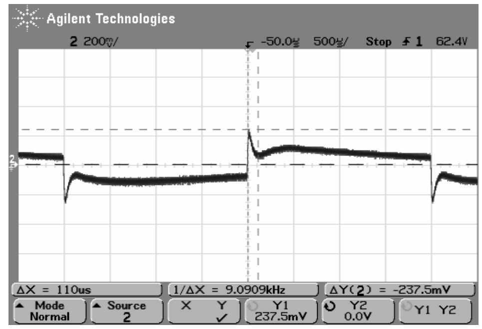
250 Vac Input, Over Load at 5.9 A, CH1 Vds, CH2 Vcc

Figure 9. VDS of Q2 and VCC Waveform @ Over Load

REFERENCE DESIGN PERFORMANCE

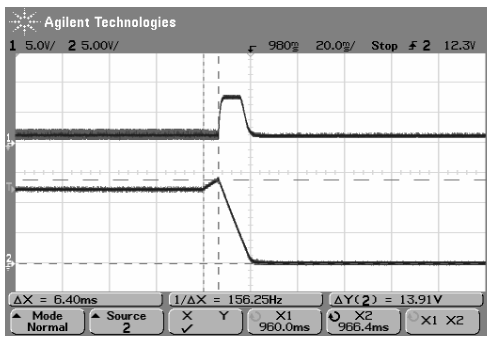


Input Voltage 90 Vac



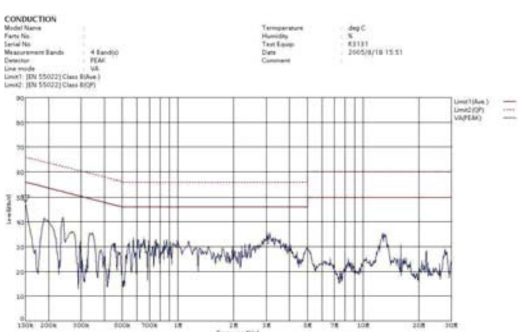
Input Voltage 250 Vac

Figure 10. Dynamic Load Transient Response @ Step Load 2.5 A to 5 A to 2.5 A

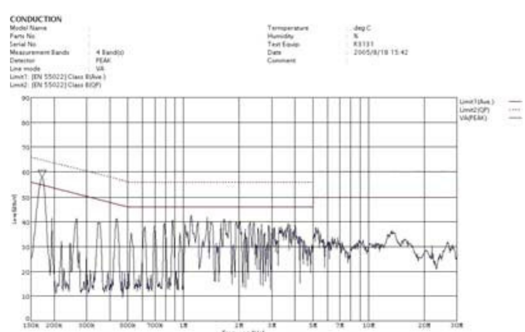


CH1: BO Pin, CH2: Output (OVP 13.91 V)

Figure 11. Over Voltage Protection (Voltage Feedback Open Circuit Mode) @ Full Load



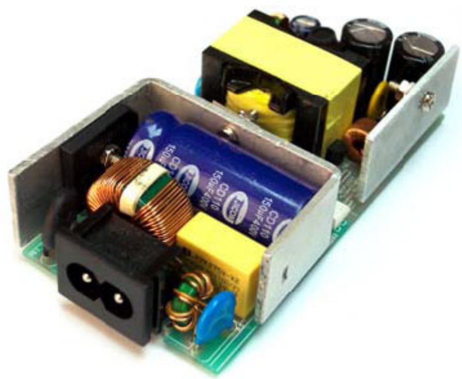
110 Vac Input

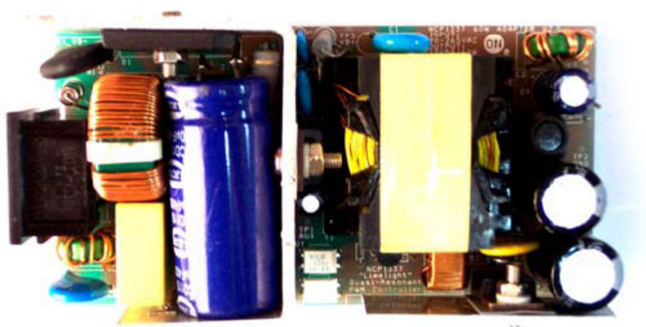


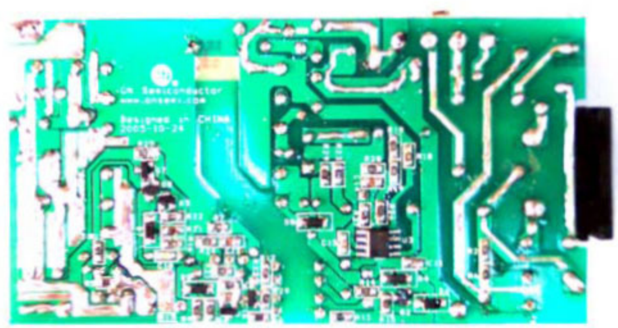
220 Vac Input

Figure 12. EMI @ Full Load

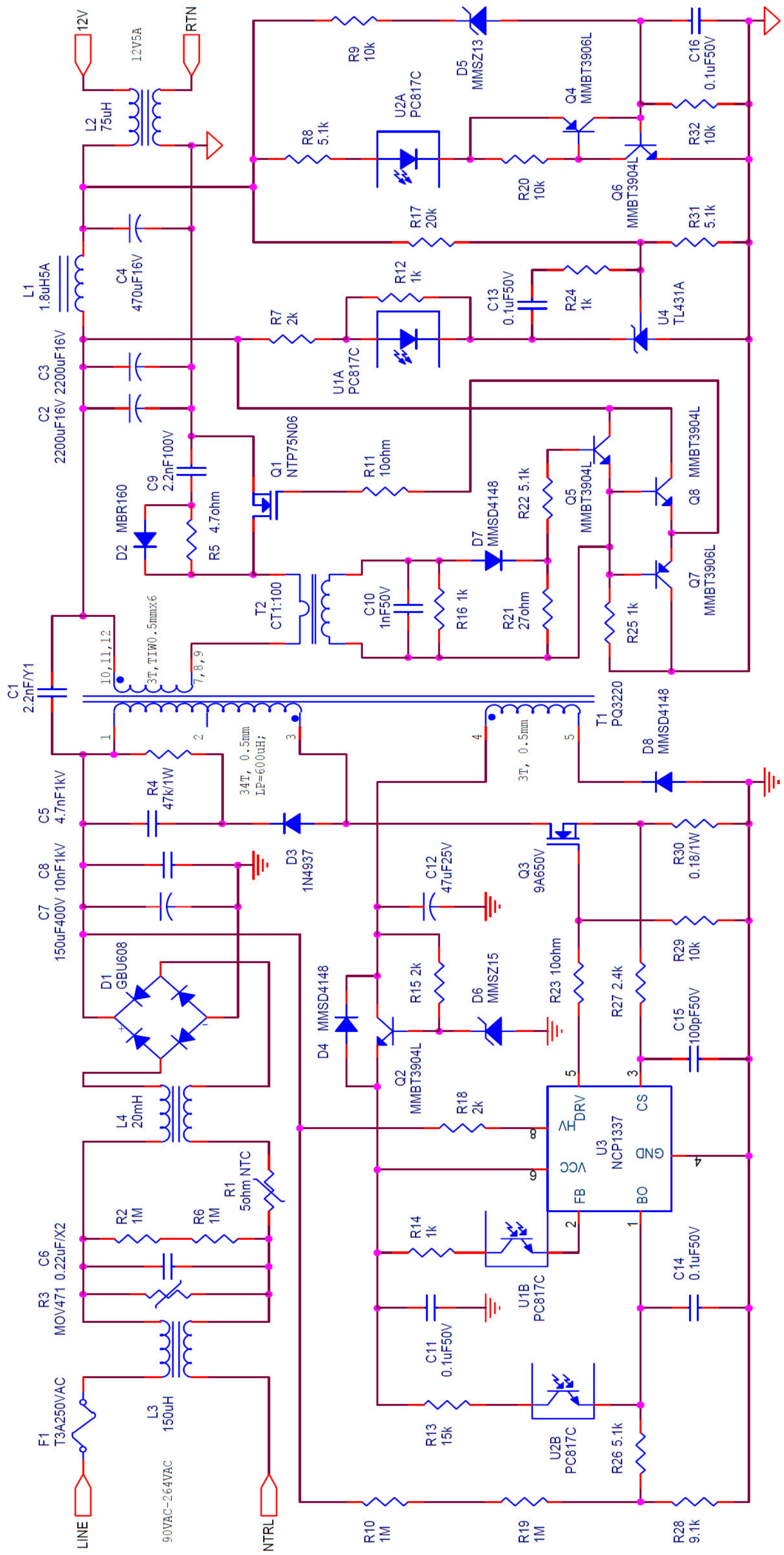
BOARD PICTURES







SCHEMATIC


12V
12V5A
RTN
L2 75uH
L1 1.8uH5A
C4 470uF16V
C3 2200uF16V
C2 2200uF16V
C9 2.2nF100V
D2 MBR160
R5 4.7ohm
Q1 NTP75N06
T2 CT1:100
C1 2.2nFY1
C5 4.7nF1kV
R4 47k/1W
C8 10nF1kV
C7 150uF400V
D3 1N4937
D1 GBU608
L4 20mH
R1 5ohm NTC
R2 1M
R6 1M
C6 0.22uF/X2
R3 MOV471
F1 T3A250VAC
L3 150uH
LINE
90VAC-264VAC
NTRL
R9 10k
D5 MMSZ13
Q4 MMBT3906L
C16 0.1uF50V
R8 5.1k
U2A PC817C
R20 10k
Q6 MMBT3904L
R32 10k
R17 20k
R31 5.1k
R12 1k
R7 2k
U1A PC817C
C13 0.1uF50V
R24 1k
U4 TL431A
R11 10ohm
Q5 MMBT3904L
Q8 MMBT3904L
R22 5.1k
D7 MMSD4148
Q7 MMBT3906L
C10 1nF50V
R16 1k
R21 27ohm
R25 1k
T1 PQ3220
3T,TIW0.5mmx6
34T, 0.5mm
LP=600uH;
3T, 0.5mm
D8 MMSD4148
C12 47uF25V
Q3 9A650V
R30 0.18/1W
D4 MMSD4148
Q2 MMBT3904L
R15 2k
D6 MMSZ15
R23 10ohm
R27 2.4k
R29 10k
C15 100pF50V
R18 2k
U3 NCP1337
DRV
VCC
FB
CS
GND
BO
R14 1k
U1B PC817C
C14 0.1uF50V
C11 0.1uF50V
R13 15k
U2B PC817C
R26 5.1k
R10 1M
R19 1M
R28 9.1k

BOARD LAYOUT

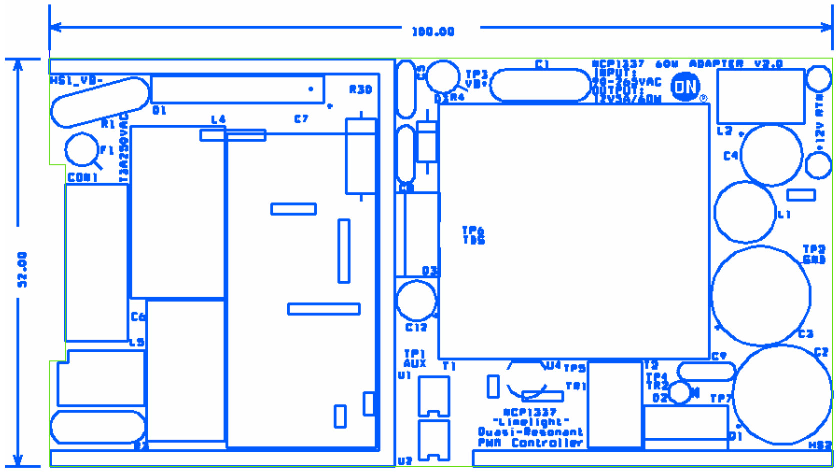


Figure 13. Assembly Drawing

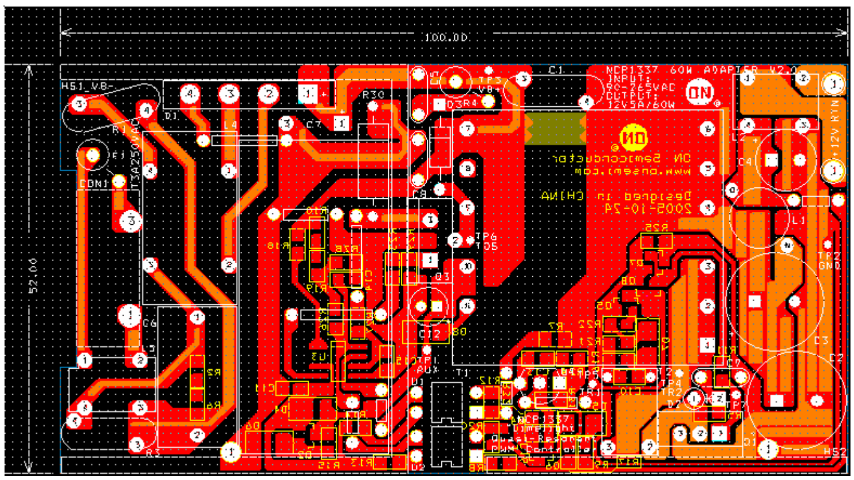


Figure 14. Global Layer

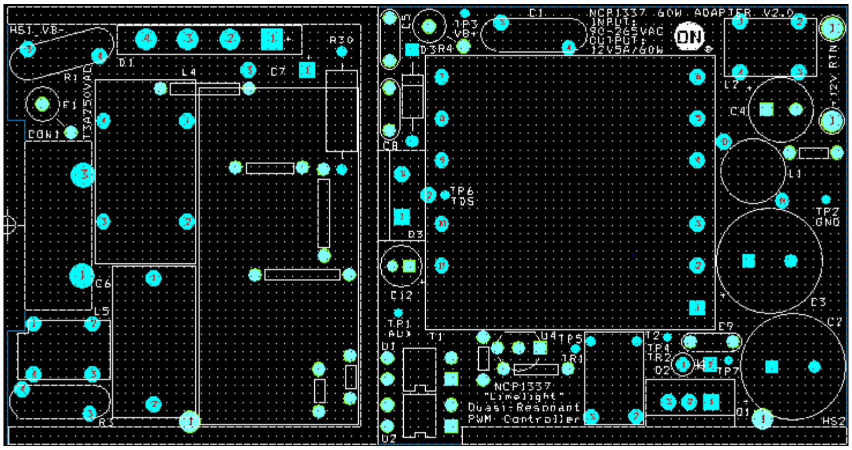


Figure 15. Top Layer

BOARD LAYOUT

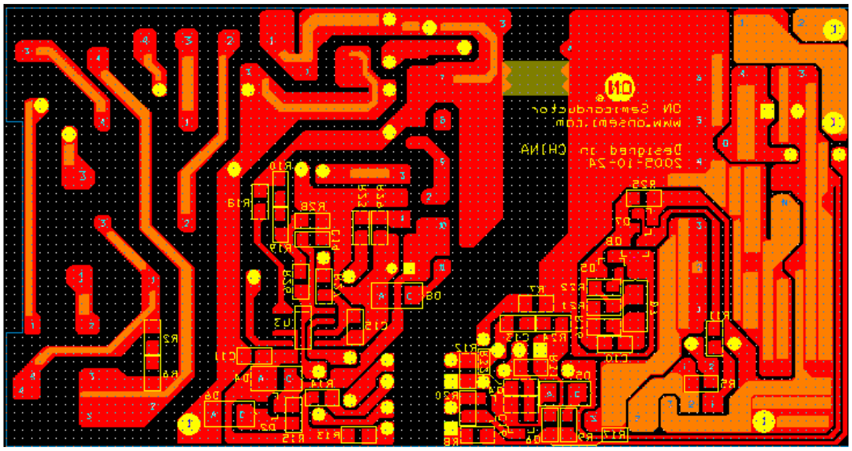


Figure 16. Bottom Layer

Table 2. BILL OF MATERIALS

Item	Quantity	Reference	Part	Manufacturer
1	1	C1	2.2 nF/Y1	
2	2	C2, C3	2200 μF, 16 V	
3	1	C4	470 μF, 16 V	
4	1	C5	4.7 nF, 1 kV	
5	1	C6	0.22 μF/X2	
6	1	C7	150 μF, 400 V	
7	1	C8	10 nF, 1 kV	
8	1	C9	2.2 nF, 100 V	
9	1	C10	1 nF, 50 V	
10	4	C11, C13, C14, C16	0.1 μF, 50 V	
11	1	C12	47 μF, 25 V	
12	1	C15	100 pF, 50 V	
13	1	D1	GBU608	
14	1	D2	MBR160	ON Semiconductor
15	1	D3	1N4937	ON Semiconductor
16	3	D4, D7, D8	MMSD4148	ON Semiconductor
17	1	D5	MMSZ13	ON Semiconductor
18	1	D6	MMSZ15	ON Semiconductor
19	1	F1	T3A250VAC	
20	1	L1	1.8 μH, 5A	
21	1	L2	75 μH	
22	1	L3	150 μH	
23	1	L4	20 mH	
24	1	Q1	NTP75N06	ON Semiconductor
25	4	Q2, Q5, Q6, Q8	MMBT3906L	ON Semiconductor
26	1	Q3	9 A, 650 V	
27	2	Q4, Q7	MMBT3906L	ON Semiconductor

Table 2. BILL OF MATERIALS

Item	Quantity	Reference	Part	Manufacturer
28	1	R1	5 Ω NTC	
29	4	R2, R6, R10, R19	1MΩ	
30	1	R3	MOV471	
31	1	R4	47kΩ/1 W	
32	1	R5	4.7 Ω	
33	3	R7, R15, R18	2 kΩ	
34	4	R8, R22, R26, R31	5.1 kΩ	
35	4	R9, R20, R29, R32	10 kΩ	
36	2	R11, R23	10 Ω	
37	5	R12, R14, R16, R24, R25	1 kΩ	
38	1	R13	15 kΩ	
39	1	R17	20 kΩ	
40	1	R21	27 Ω	
41	1	R27	2.4 kΩ	
42	1	R28	9.1 kΩ	
43	1	R30	0.18 Ω/1 W	
44	1	T1	PQ3220	
45	1	T2	CT1:100 Toroid or UU9.8	
46	2	U1, U2	PC817C	
47	1	U3	NCP1337	ON Semiconductor
48	1	U4	TL431A	ON Semiconductor
49	1	PCB	PCB5.2*10	

Appendix

Product Information

- NCP1337 Quasi Resonant Controller featuring Over Power Compensation
- TL431A Programmable Precision Reference
- 1N4937 Fast-Recovery Rectifier, 1 A, 600 V
- MBR160 Schottky Rectifier, 1 A, 60 V
- MMBT3904L General Purpose Transitor, NPN
- MMBT3906L General Purpose Transitor, PNP
- MMSD4148 Switching Diode
- MMSZ13 Zener Diode, 500 mW, 13 V
- MMSZ15 Zener Diode, 500 mW, 15 V
- NTP75N06 Power MOSFET, 75 A, 60 V

References

CECP (China):

- http://www.cecp.org.cn/englishhtml/index.asp

Energy Saving (Korea):

- http://weng.kemco.or.kr/efficiency/english/main.html#

Top Runner (Japan):

- http://www.eccj.or.jp/top_runner/index.html

EU Eco-label (Europe):

- http://europa.eu.int/comm/environment/ecolabel/index_en.htm
- http://europa.eu.int/comm/environment/ecolabel/product/pg_portablecomputers_en.htm

EU Code of Conduct (Europe):

- http://energyefficiency.jrc.cec.eu.int/html/standby_initiative.htm

GEEA (Europe):

- http://www.efficient-appliances.org/
- http://www.efficient-appliances.org/Criteria.htm

Energy Star:

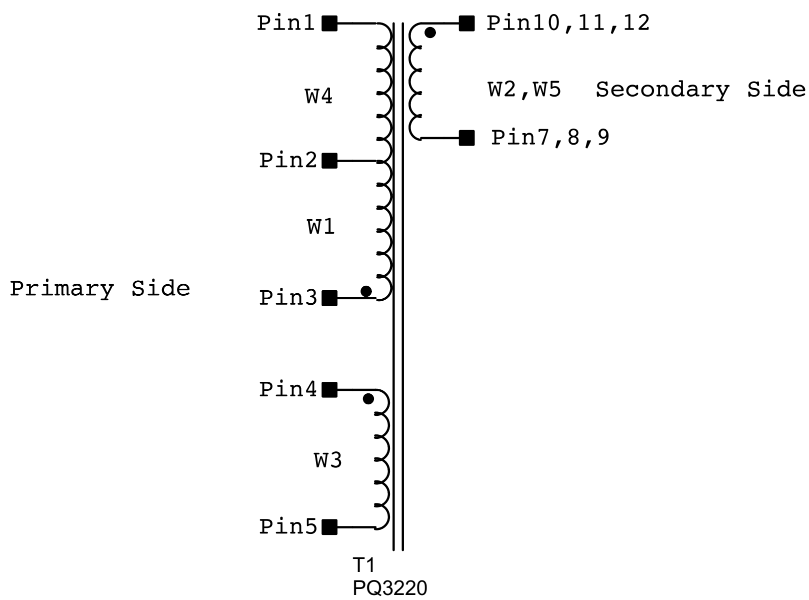
- http://www.energystar.gov/
- http://www.energystar.gov/index.cfm?c=ext_power_supplies.power_supplies_consumers

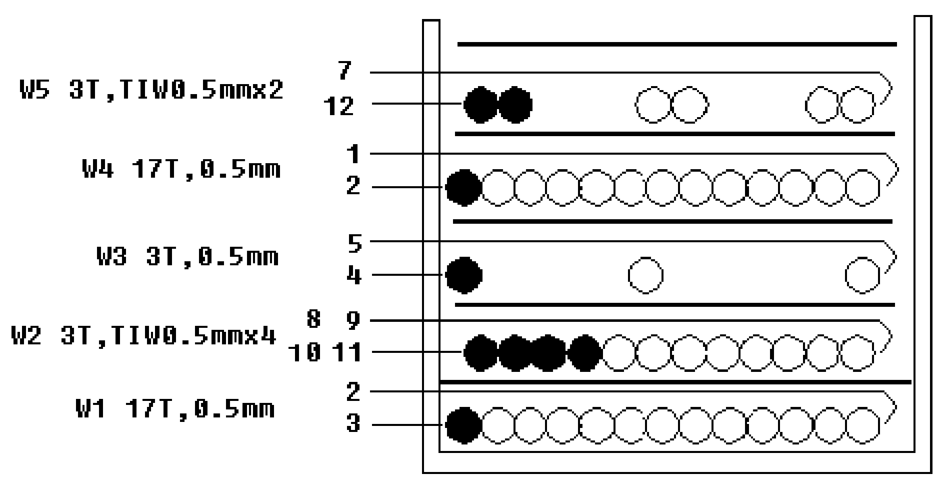
1 Watt Executive Order:

- http://oahu.lbl.gov/
- http://oahu.lbl.gov/level_summary.html

Transformer Specification

LP (W1 + W4) = 600 μH ±7% @ 10 kHz 1 V
Leaking Induction: 60 μH max
CORE: PQ32−20





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