AND8262/D

8 W DVD Power Supply with NCP1027

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APPLICATION NOTE

Overview

Digital Video Disks players require a few different voltages to power the logic circuitry but also all servo−mechanisms linked to the tray and optical head actuators. The NCP1027 lends itself very well to this kind of applications where simple architectures lead to the lowest assembly cost. Despite the variety of low−end DVD players on the market, there is a common trend on the power supply requirements:

- Universal input voltage: 85 to 265 Vac, 2 wire power cord
- 5 different dc voltages, 1 non−filtered bias level:
  1. 5 V / 1 A
  2. 3.3 V / 1 A
  3. – 12 V / 20 mA
  4. + 12 V / 20 mA
  5. – 23 V / 10 mA
  6. Floating display bias
- Low standby power in no−load and partial load conditions

These specifications can fluctuate depending on a particular type of player but the basic power supply architecture remains the same. We will use a current−mode flyback regulator built around the integrated power switcher, the NCP1027. This DIP 8 package hosts a high performance controller together with a low $R_{DS(on)}$ 700 V BV_{dss} MOSFET. On top of the standby needs, we have packed other interesting goodies in this circuit. They are summarized below:

- *Brown−out Detection:* the controller will not allow operation in low mains conditions. You can adjust the level at which the circuit starts or stops operation.
- *Ramp Compensation:* designing in Continuous Conduction Mode helps to reduce conduction losses. However, at low input voltage (85 Vac), the duty−cycle might exceed 50% and the risk exists to enter a subharmonic mode. A simple resistor to ground injects the right compensation level.
- *Over Power Protection:* a resistive network to the bulk reduces the peak current capability and accordingly harnesses the maximum power at high line. As this is done independently from the auxiliary V_{CC}, the design gains in simplicity and execution speed.
- *Latch−off Input:* some manufacturers require a complete latch−off in presence of an external event, e.g. over temperature or a severe over−voltage protection. The controller offers this possibility via a dedicated input.
- *Frequency Dithering:* the switching frequency (here 65 kHz) is modulated during operation. This naturally spreads the harmonic content and reduces the peak value when analyzing the signature.

Design Description

Figure 2 shows the electrical schematic used for this application. The NCP1027 directly connects to the power transformer and a classical *RCD* clamping network prevents any BV_{dss} runaways. A string of resistors (R_{14}, R_{15} and R_9) set the minimum operating voltage to increase safety in case of a low input level: the circuit does not switch until enough voltage appears on the mains connector. During this time, V_{CC} goes up and down via the activated high−voltage current source and self−supplies the controller. When the mains reaches the adequate level (70 Vac here), the power supply automatically resumes operation and performs its duty. Please note that bringing pin 3 above a certain level (3.5 V) permanently latches off the switcher. It can be useful in case safety specifications impose a complete shutdown in presence of a stringent event: Over Temperature Protection (OTP), latched OverVoltage Protection (OVP)…

As this design enters the Continuous Conduction Mode (CCM) at low line, we have added some ramp compensation via a single resistor connected from pin 2 to ground: no sub−harmonic oscillations can be detected at low line input and full load.

Thanks to the NCP1027, the power supply is inherently protected against short−circuits, whatever the V_{CC} pin level is. An internal circuitry permanently monitors the feedback pin and starts a timer when pin 4 goes high (open−loop conditions in startup sequence or in a short−circuit condition). If the timer reaches completion before the fault has gone, the switcher stops all pulses and enters an auto−recovery protective mode. When the fault disappears,

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the switcher resumes operation. However, the point at which the controller detects the fault can move in relationship to the input rail: the power delivered at high line is slightly greater than at low line. The guilty is the total propagation delay from the current sense comparator to the output latch. Fortunately, it can easily be compensated via current injection in pin 7, as shown in AND8241/D. Again, if your design specifications impose a precise output over current protection, implementing this solution can represent a viable option.

The output feedback implements a so−called weighted control where two outputs are observed. Depending on the required precision, a weight is imposed on each control loop, let us select 30% for the 5 V and 70% for the 3.3 V. Calculation is as follows:

1. select a bridge current. We will use 250 μA with our TL431.
2. evaluate the lower side resistor given the considered output voltage:

$$R_{upper} - 5\ V = \frac{5 - 2.5}{250\ \mu} = 10\ k\Omega$$

$$R_{upper} - 3.3\ V = \frac{3.3 - 2.5}{250\ \mu} = 3.2\ k\Omega$$

3. now apply the selected weighting factor to each resistor:

$$R_{upper} - 5\ V = \frac{10\ k}{0.3} = 33.3\ k\Omega$$

$$R_{upper} - 3.3\ V = \frac{3.2\ k}{0.7} = 4570\ \Omega$$

These two resistors are respectively made of $R_4 - R_6$ and $R_3 - R_7$ on the final schematic. A simple 100 nF introduces a pole−zero combination together with C_{16}.

Finally, various inductors are placed on the outputs to reduce the switching ripple down to an acceptable level.

Transformer

The transformer is made by Pulse Engineering and has the reference 2472.0003A (please BOM details). The device exhibits the following turn ratios and inductance, its pinout appears on Figure 1:

L_p = 2.2 mH

L_{leak} < 40 μH @ 100 kHz

W_1:W_2 (aux. winding) = 74:14

W_1:W_4 (5 V) = 74:1

W_1:W_3 (3.3 V) = 74:2

W_1:W_5 (12 V) = 74:4

W_1:W_6 (– 22 V) = 74:12

W_1:W_7 (FL1 and FL2) = 74:3

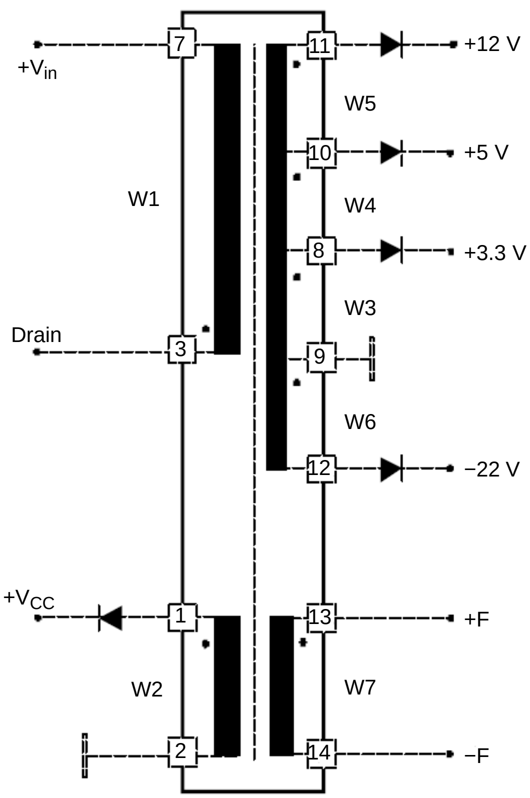

Figure 1. The Transformer Pinout Showing an AC Stacked Winding Configuration

Given the selected core, the transformer can deliver an output power up to 12 W. Thanks to pin 7, you can precisely alter the peak current limit and thus, the maximum output to the level of your choice: a wide range of DVD players applications can then be covered.

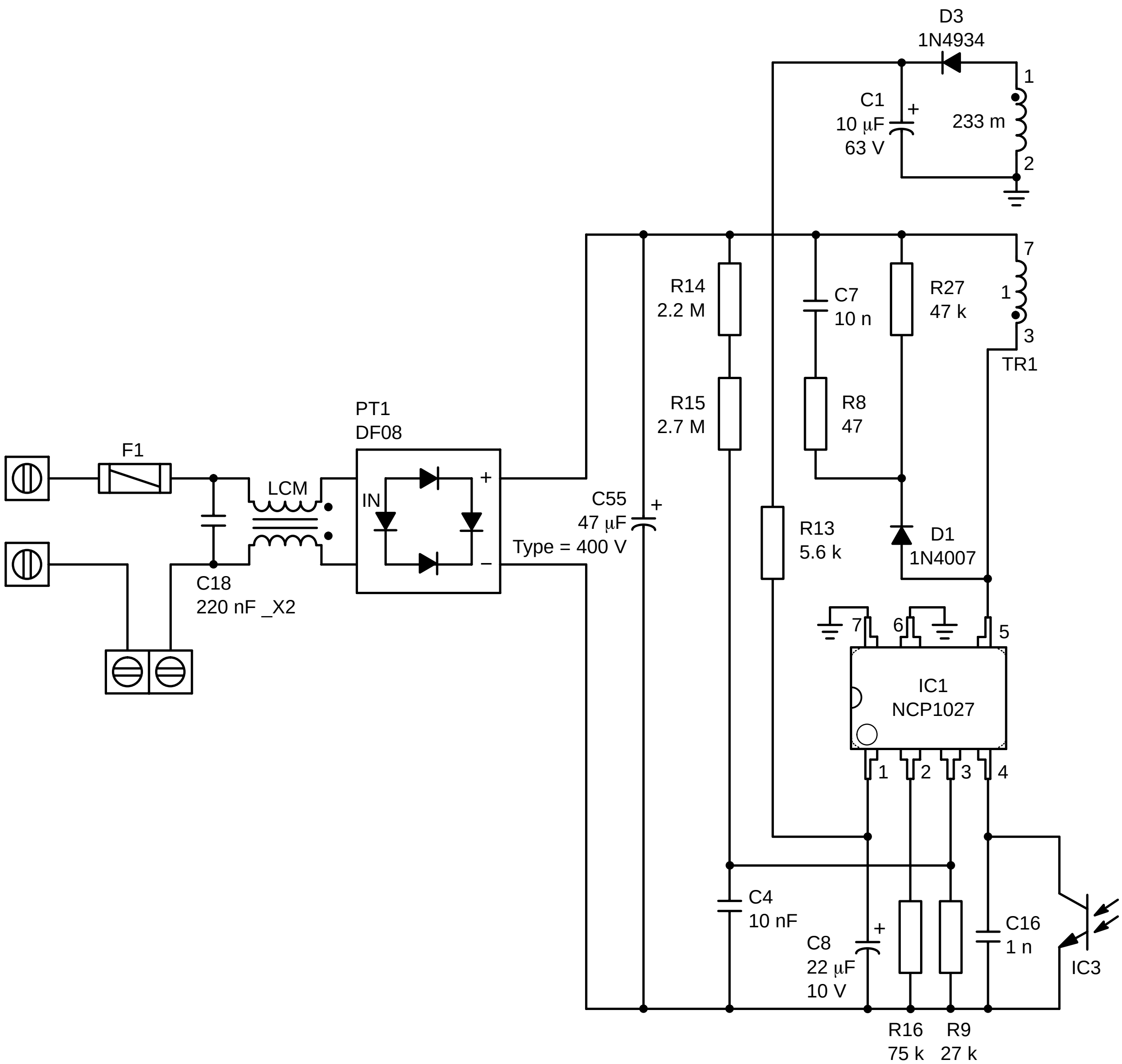

Figure 2. The Complete Application Schematic, Primary Side

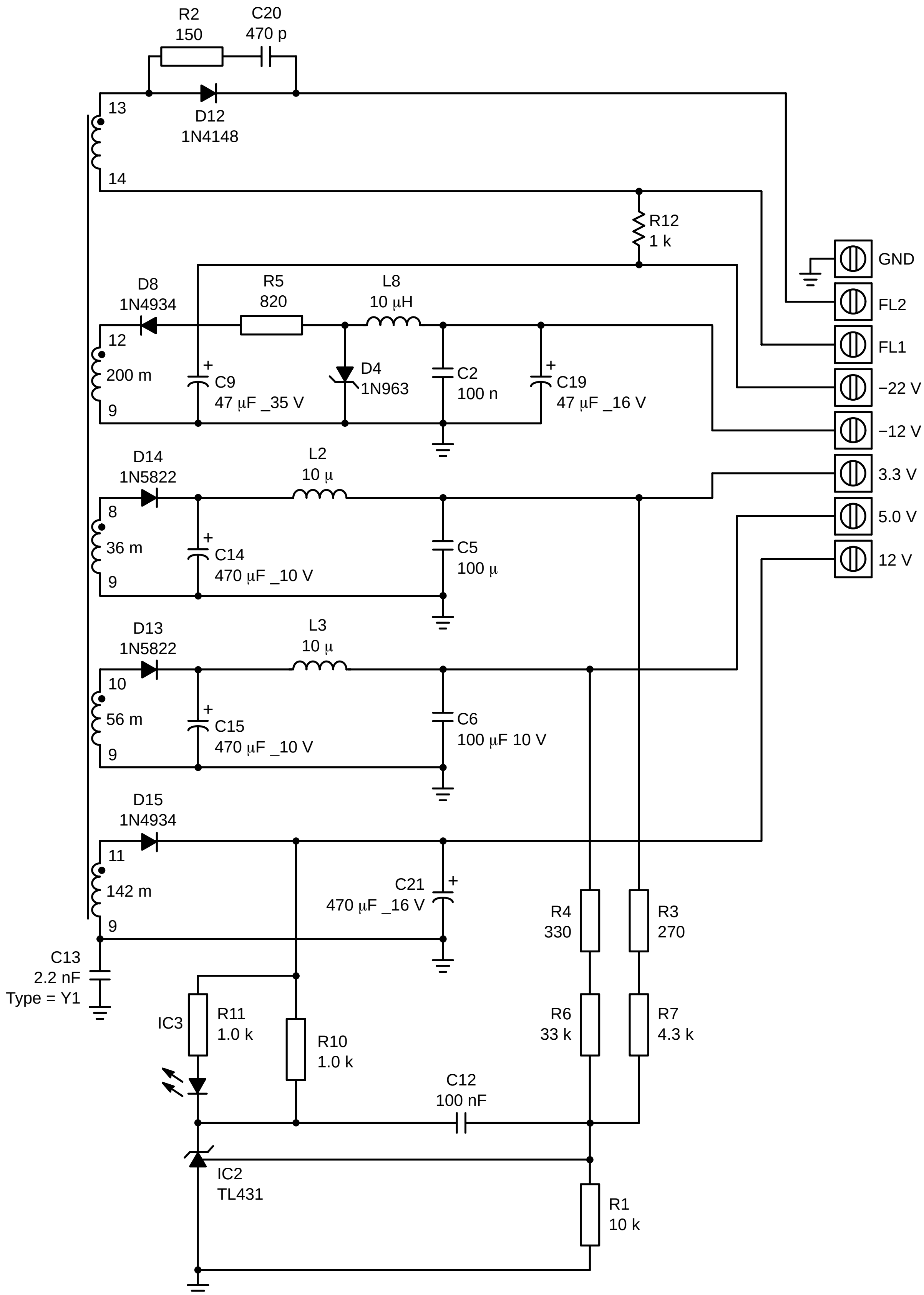

Figure 3. The Complete Application Schematic, Secondary Side

Operating Waveforms and Test Results

To perform some tests, we have loaded the prototype converter with a DVD player and artificially loaded some of its outputs, mainly the +3.3 V and the +5 V. The static board load is the following:

3.3 V = 700 mA
5 V = 500 mA
12 V = 20 mA
–12 V = 25 mA
– 23 V = 2 mA

A 520 mA peak current was then added on top of the 5 V or the 3.3 V output. Results are displayed below:

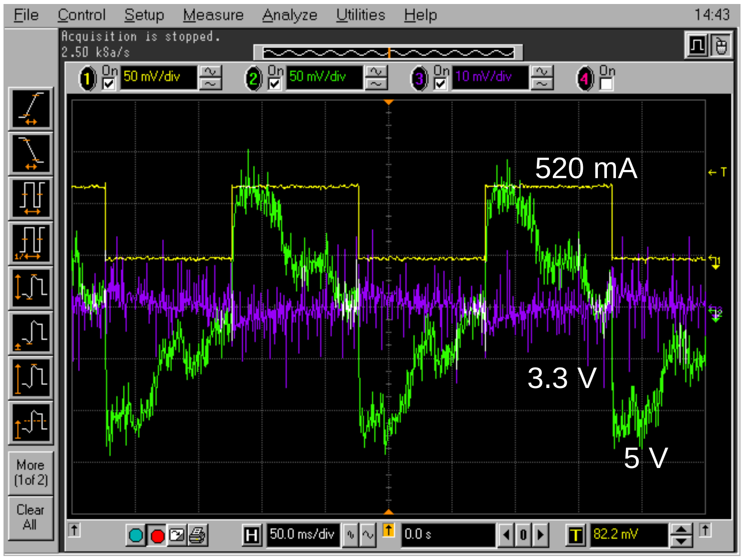

Figure 4. Both Input Levels Give the Same Performance when the 5 V is Loaded by 520 mA Peaks.

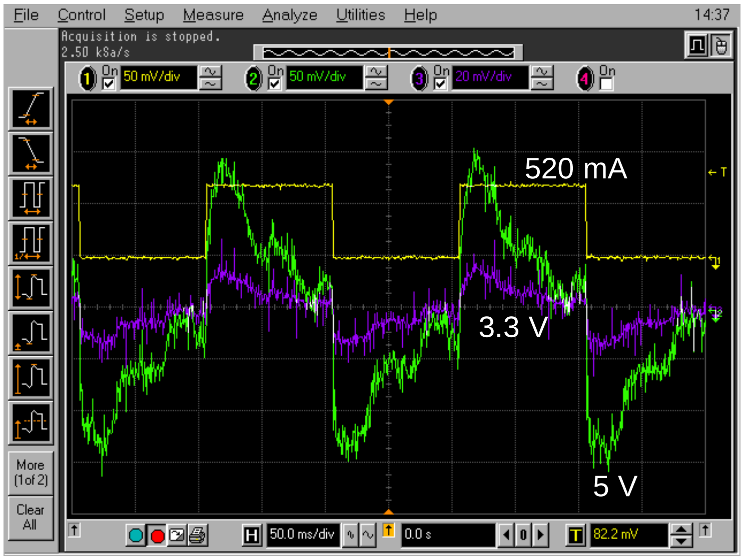

Figure 5. Here, the 3 V is Loaded by 520 mA Peaks on Top of its Current Consumption

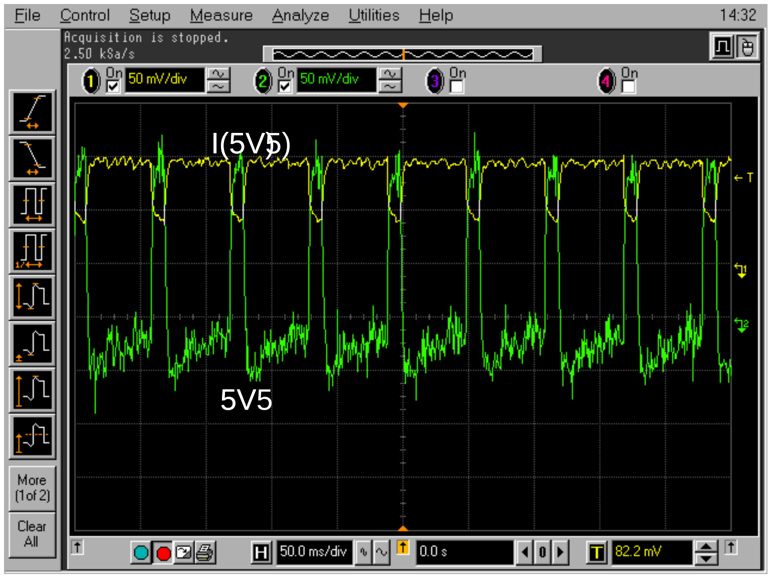

Figure 6. Opening the Tray Gives Birth to a Current Train of Pulses

As these plots reveal, the voltage variations stay well within 5% of the nominal output. When left operated at 230 Vac in no−load conditions, the input standby power is 0.5 W.

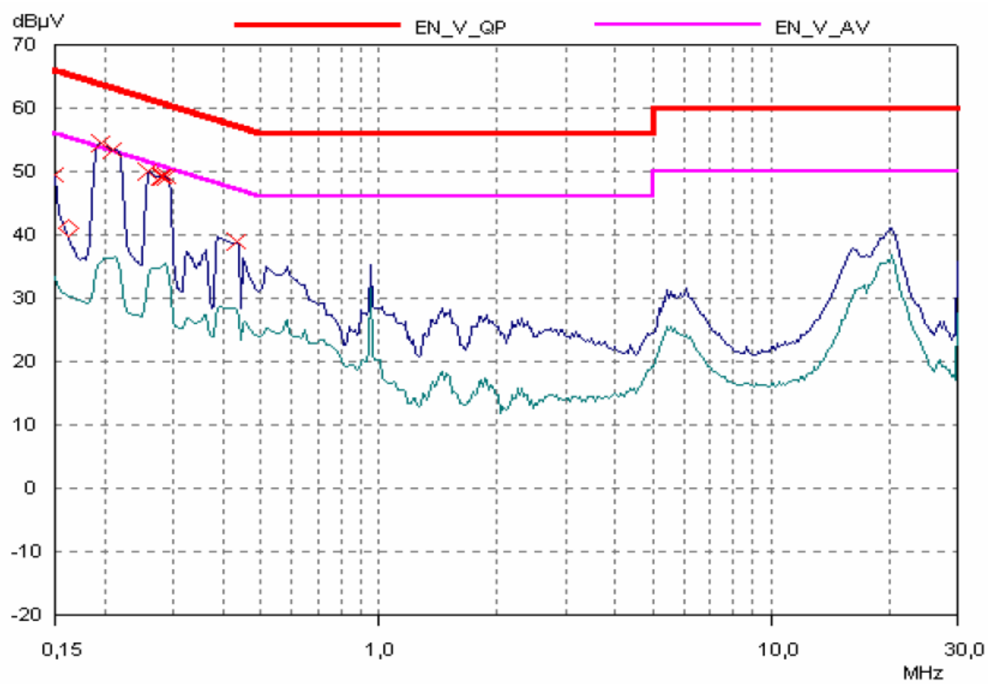

Figure 7. EMI plot of a DVD player powered by the power supply – the dark blue curve corresponds to the Quasi−Peak sweep whereas the light blue describes the Average sweep.

The efficiency lies around 75% from 90 Vac up to 265 Vac. The NCP1027 case temperature moves between 60°C (low line) and 54°C (high line). In both cases, the ambient was 25°C. The Brown−Out protection imposes an operating window above 82 Vac (start−up) and stops operations below 56 Vac. These numbers can of course be altered by playing on R_{14}, R_{15} and R_9 (for calculation details, please the NCP1027 data−sheet).

The front−end filter includes a simple 2 x 6.8 mH common mode inductor whose leakage inductance forms a differential mode filter together with C18. The EMI plot in both Quasi−Peak (QP) and Average modes looks good as testified by Figure 7. Both sweeps were obtained with the DVD chassis operating and connected to the earth via a wire.

Figure 8 and 9 show the pcb silkscreen and the copper traces.

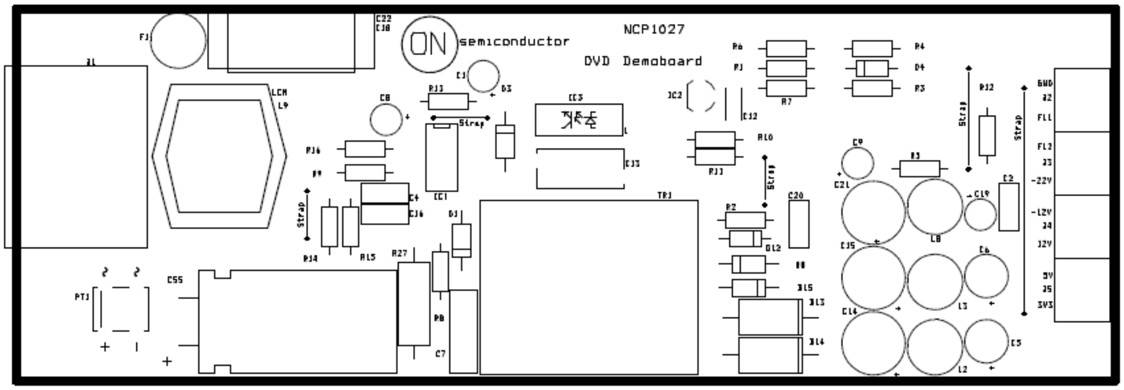

Figure 8. The Demoboard Silkscreen

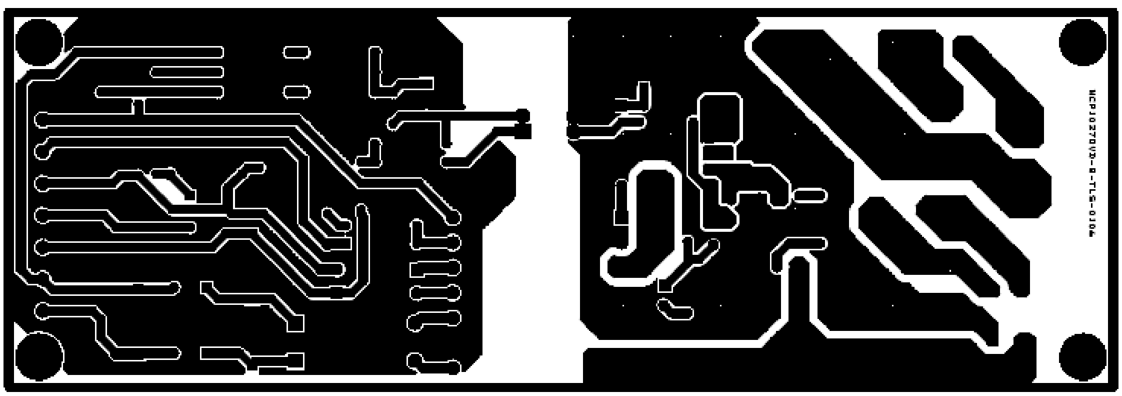

Figure 9. PCB Copper Layout

As we stated, the transformer is available from Pulse Engineering at the following address:

Pulse Italy s.r.l con s.u.
Via Ticino, 2C
I−22070 Senna Comasco (CO) − ITALY
Tel: +39031463071
Fax:+390314630790
e−mail: consumerdivision@pulseeng.com
website: www.pulseeng.com

Bill of Materials − NCP1027

Designator	Qty	Description	Value	Toler-ance	Foot-print	Manufacturer	Manufacturer Part Number	Sub-stitution Allowed	Lead Free
C1	1	electrolytic capacitor	10uF/63V	20%	radial	Panasonic	ECA1JM100	yes	no
C2,C12	2	capacitor	100nF/50V	10%	radial	Murata	rper71h104k2m1a05u	yes	no
C4	1	capacitor	10nF/100V	10%	radial	Murata	rper72a103k2m1b05a	yes	no
C7	1	capacitor	10nF/630V	10%	radial	Vishay	mkt1822310635	yes	no
C5,C6	2	electrolytic capacitor	100uF/16V	20%	radial	Panasonic	eca1cm101	yes	no
C8	1	electrolytic capacitor	22uF/16V	20%	radial	Panasonic	ECA1CM220	yes	no
C9	1	electrolytic capacitor	47uF/35V	20%	radial	Panasonic	ECA1VM470	yes	no
C13	1	y1 capacitor	2.2nF/250V	20%	radial	Ceramite	440ld22	yes	no
C14,C15, C21	3	electrolytic capacitor	470uF/16V	20%	radial	BC Comp.	2222−13555471	yes	no
C16	1	capacitor	1nF/100V	10%	radial	Murata	rper72a102k	yes	no
C18	1	x2 capacitor	220nF/630V	20%	radial	Evox Rifa	phe840md6220m	yes	no
C19	1	electrolytic capacitor	47uF/16V	20%	radial	Panasonic	ECA1CM470	yes	no
C20	1	capacitor	470pF/100V	5%	radial	AVX	sr211a471jtr	yes	yes
C22	1	x2 capacitor	100nF/630V	20%	radial	Evox Rifa	phe840mx6100m	yes	no
C55	1	electrolytic capacitor	47uF/400V	20%	radial	Panasonic	ECA2GM470	yes	yes
D1	1	rectifier diode	1A/1000V	0%	axial	ON Semiconductor	1n4007g	yes	yes
D3,D8, D15	3	rectifier diode	1A/100V	0%	axial	ON Semiconductor	1n4934g	yes	yes
D4	1	zener diode	12V/0.5W	0%	axial	Fairchild	1n963b	yes	yes
D12	1	hight−speed diode	0.2A/75V	0%	axial	Philips Semiconductor	1n4148	yes	no
D13,D14	2	schottky diode	3A/40V	0%	axial	ON Semiconductor	1n5822g	yes	yes
F1	1	fuse	500mA/temp	0%	radial	Schurter	0034.6612	yes	no
IC1	1	CMOS IC	NCP1027		dip8	ON Semiconductor	NCP1027	yes	yes
IC2	1	shunt regulator	2.5−36V/1−100mA	2%	to92	ON Semiconductor	tl431ilpg	yes	yes
IC3	1	optocoupler	sfh6156/	0%	SMD	Vishay	sfh6156−2t	yes	yes
J1	1	connector	2p/250V	0%	radial	Multicomp	jr−201s	yes	no
J2,J3,J4, J5	4	connector	2/	0%	rad5.0 8mm	Weidmuller	pm5.08/2/90	yes	no
LCM	1	inductor	2*6.8mH/1.2A	0%	radial	Schaffner	rn112−1.2/02	yes	no
L2,L3,L8	3	inductor	10uH/2.6A	20%	radial	Wurth Elektronik	744772100	yes	yes
L9	1	inductor	2*27mH/0.8A	0%	radial	Schaffner	rn114−0.8/02	yes	no
PT1	1	diode bridge	800V/1A	0%	dil	General Semiconductor	DB106G	yes	no
R1	1	resistor	10kR/0.33W	5%	axial	Neohm	cfr25j10k	yes	no
R2	1	resistor	150R/0.33W	5%	axial	Neohm	cfr25j150R	yes	no
R3	1	resistor	270R/0.33W	5%	axial	Neohm	cfr25j270R	yes	no
R4	1	resistor	330R/0.33W	5%	axial	Neohm	cfr25j330R	yes	no
R5	1	resistor	820R/0.33W	5%	axial	Neohm	cfr25j820R	yes	no
R6	1	resistor	33kR/0.33W	5%	axial	Neohm	cfr25j33k	yes	no
R7	1	resistor	4.3kR/0.6W	1%	axial	Phoenix Passive Components	mrs25−4k3−1%	yes	yes
R8	1	resistor	47R/0.33W	5%	axial	Neohm	cfr25j47R	yes	no
R9	1	resistor	27kR/0.33W	5%	axial	Neohm	cfr25j27k	yes	no
R10,R11, R12	3	resistor	1kR/0.33W	5%	axial	Neohm	cfr25j1k0	yes	no
R13	1	resistor	5.6kR/0.33W	5%	axial	Neohm	cfr25j15k	yes	no
R14	1	resistor	2.2MR/0.33W	5%	axial	Neohm	cfr25j2M2	yes	no
R15	1	resistor	2.7MR/0.4W	5%	axial	Phoenix Passive Components	sfr25−2m7−5%	yes	yes
R16	1	resistor	75kR/0.6W	1%	axial	Phoenix Passive Components	mrs25−75k−1%	yes	yes
R27	1	resistor	47kR/2W	5%	axial	Neohm	cfr200j47k	yes	no
TR1	1	2472.0003A − multi−output transformer from Pulse Engineering							

Figure 10. Demo Board

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
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Email: orderlit@onsemi.com

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