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Universal AC Input, 5 Volt Output, 10 Watt Power Supply

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1124 NCP431	Smart Meters, Electric Meters, White Goods	85 to 265 Vac	10W	CCM Flyback	Isolated (3 kV)

Output Specification	
Output Voltage	5 Vdc nominal
Ripple	100 mV p/p @ full load
Nominal Current	2 Amps continuous
Max Current	2.2 A maximum
Min Current	zero

PFC (Yes/No)	No(Pout ≤ 10 watts)
Input Protection	Fuse
Operating Temp. Range	0 to +50°C
Cooling Method	Convection
Standby Power	30 mW at 115 Vac 80 mW at 230 Vac

Circuit Description

This design note describes a simple 10 watt, universal AC input, constant output voltage power supply intended for AC adapters, industrial equipment, or white goods, where isolation from the AC mains is required, and low cost, high efficiency, and low standby power are essential.

The featured power supply is a simple CCM flyback topology utilizing ON Semiconductor's new NCP1124 monolithic with with integral 9-ohm, vertical channel MOSFET in a PDIP7 package (U1). This Design Note provides the complete circuit schematic details and BOM for 5V, 2A power supply. The simple input EMI filter (C1, L1) is adequate to pass Level B for FCC conducted EMI compliance. The NCP431 programmable zener is used as an error amplifier (U3), plus an optocoupler feedback scheme (U2) provides for excellent line and load regulation with high input-to-output safety isolation.

Performance characteristics for efficiency, output ripple, and internal MOSFET drain switching characteristics (Vds, Id) are shown in the figures and plots below. Enhanced input transient protection (lightning, etc.) can be accomplished with the addition of an appropriate TVS device across the input of the diode bridge.

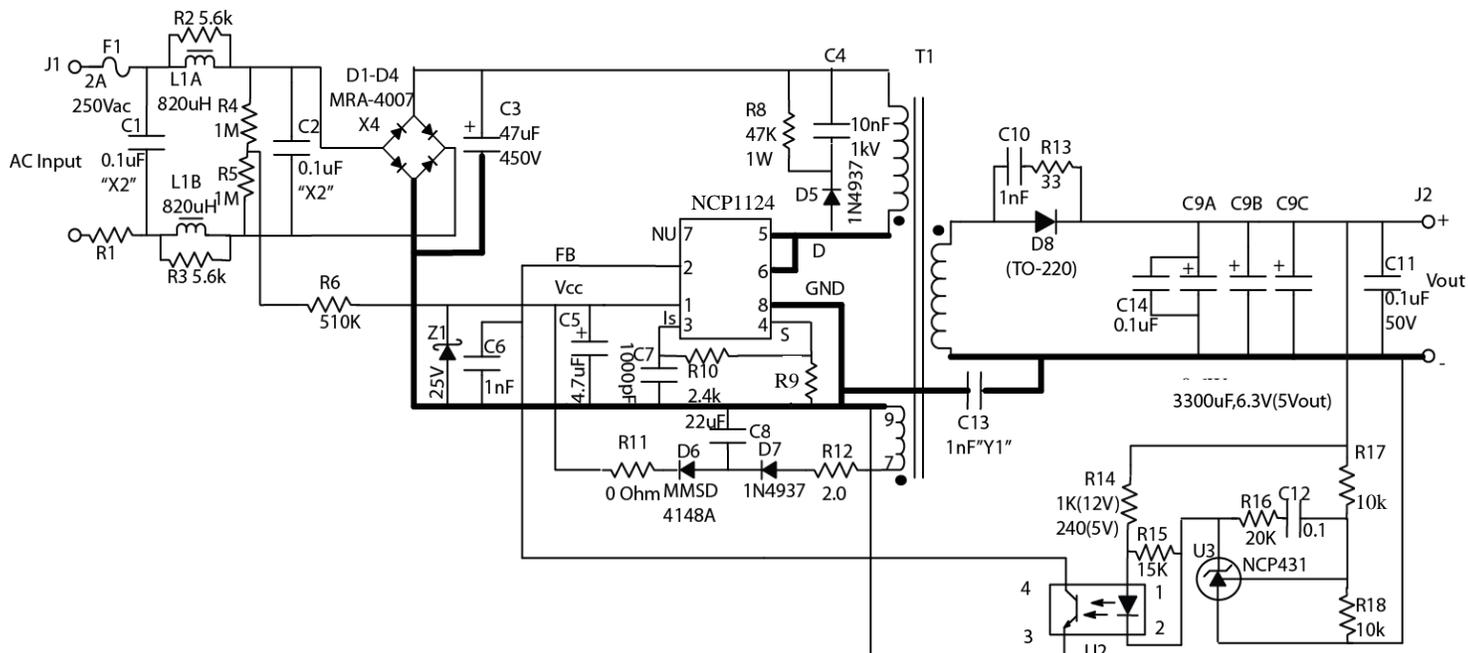
Key Features

- Universal AC input range (85 – 265 Vac).
- Input filter for conducted EMI attenuation.
- 650V Avalanche rated MOSFET.
- Input filter for conducted EMI attenuation.
- Very low standby (no load) power consumption.
- Frequency foldback under light load.
- Inherent over-current, over-voltage and over temperature protection.

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For optimum thermal characteristics, the printed circuit board should be laid out to include clad "pours" around pins 5 and 6 of the DIP8 package (MOSFET drain pins). Resistors 9 sets the peak current limit point for the internal overcurrent protection circuit of U1 and can be adjusted for desired max output current. For output voltages other than 5 volts, typical circuit changes include the transformer turns ratio for both the secondary and the primary aux winding, the value of R17 in the output voltage sense divider, and selecting appropriate voltage ratings for output rectifier D8 and output capacitors C9A, B & C. Depending on the transformer aux winding characteristics, it may be necessary to change R11 to a higher value resistance value to adjust the nominal Vcc voltage. Z1 can be added as an option in the event that the compliance range of the Vcc over the output load range exceeds the OVP trip point on pin 1 of U1 (28 volts). Such a scenario would be the result of a transformer with high leakage inductance.

Circuit Schematic



NOTES:

1. Crossed lines on schematic are NOT connected.
2. U2 is NEC PS2561L-1 or equivalent optocoupler(CTR>50%).
3. R1 is optional for increased inrush limiting- use wire wound only.
4. L1A/L1B are Wurth #7447728215 inductors (820uH, 500mA).
5. Output caps(C9A/B/C) are radial lead, low impedance types(UCC LXV series or similar).
6. R11 is for Vcc trimming(<28Vmax), typically zero ohms.
7. R9A/B sets max output current.
8. Heavy schematic lines indicate recommended ground plane areas.

10 Watt NCP 1124 Power Supply With Universal AC Input

Circuits Optimized for 650V 9ΩMOSFET (compared to MOSFET NCP1126/NCP1129)

A single 0.6 W, 1.5Ω resistor with 1% tolerance is used to limit the maximum current flowing through the MOSFET, instead of paralleling two 1.8Ω, 1/2W resistors with 5% tolerance.

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T1 Transformer Designs (Available from ICE Components Inc. and Würth Electronics)

5V/2A, 65 kHz Version (ICE # TO0915-1, Würth Electronics #750313860 Rev 01)

Core: E25/10/6 (812E250)

Primary A: 55 turns of 0.25mm mag wire

5V Secondary: 11 turns bifilar of 0.6mm Triple Insulated Wire (2 layers)

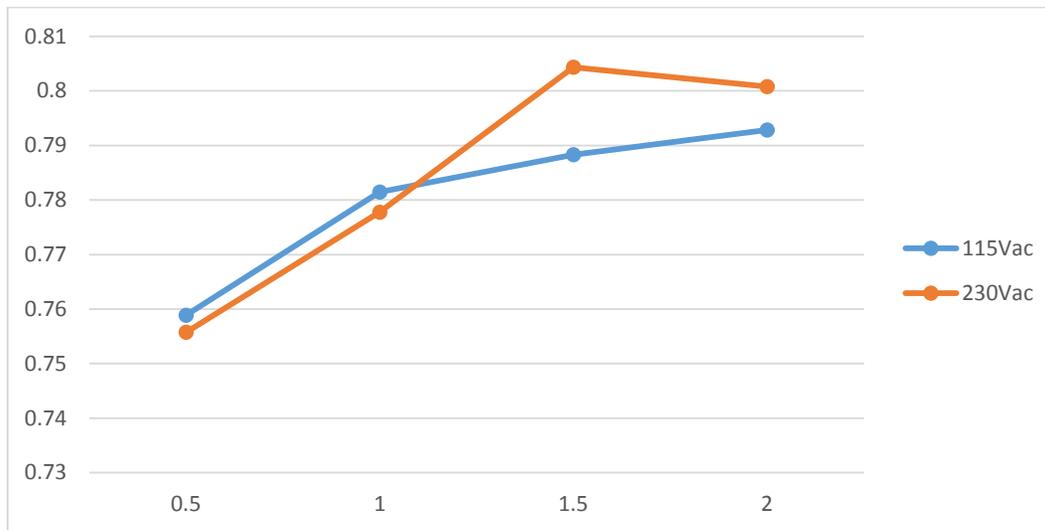
Aux/Vcc: 25 turns of 0.15mm mag wire spiral wound over 1 layer

Primary B: 55 turns of 0.25mm mag wire

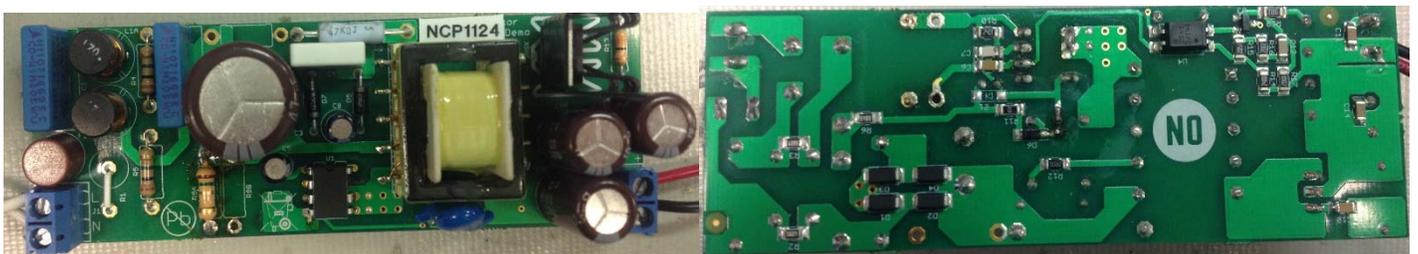
Primary Inductance (Pri A and B in series): 2 mH +/- 10% (gap in center leg)

Leakage Inductance (5Vsec & Aux shorted): 40 uH max

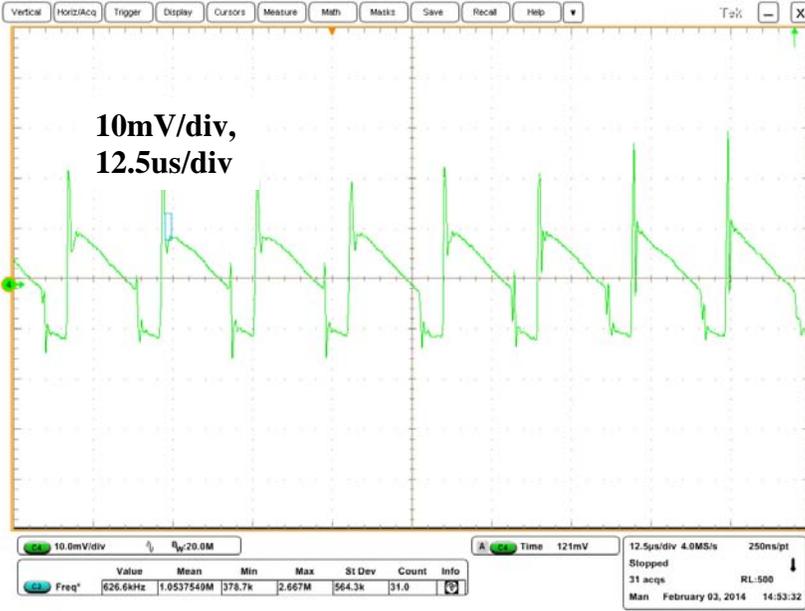
5 Volt Efficiency vs Output Load Curves



Board Picture

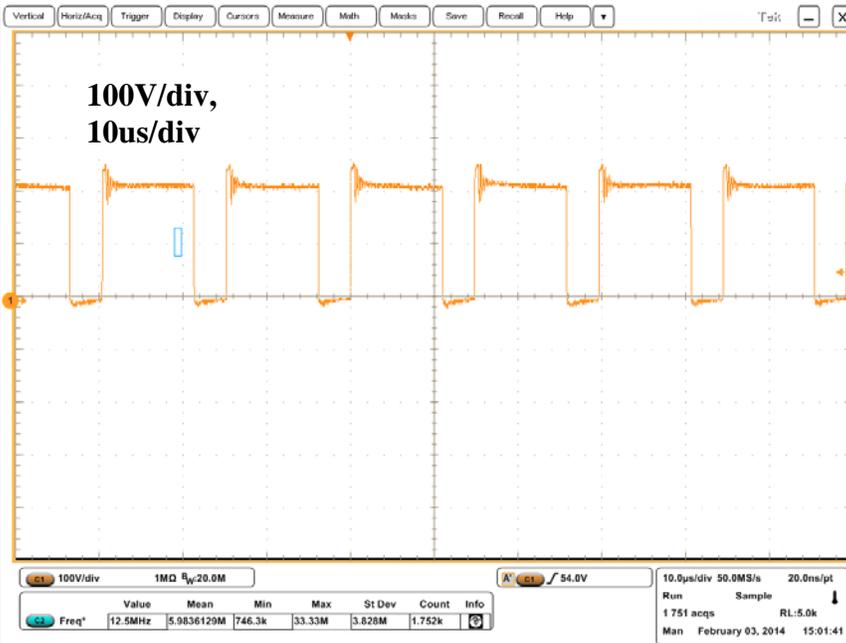


Full Load Output Ripple @ 120 Vac Input

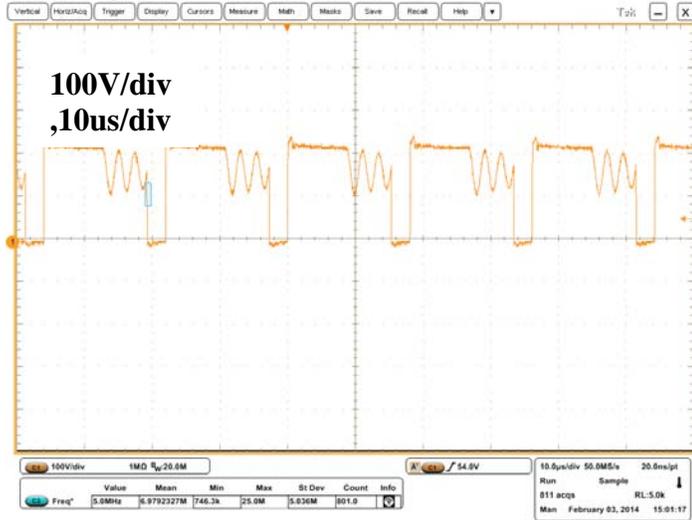


MOSFET Drain Voltage (120 Vac Input)

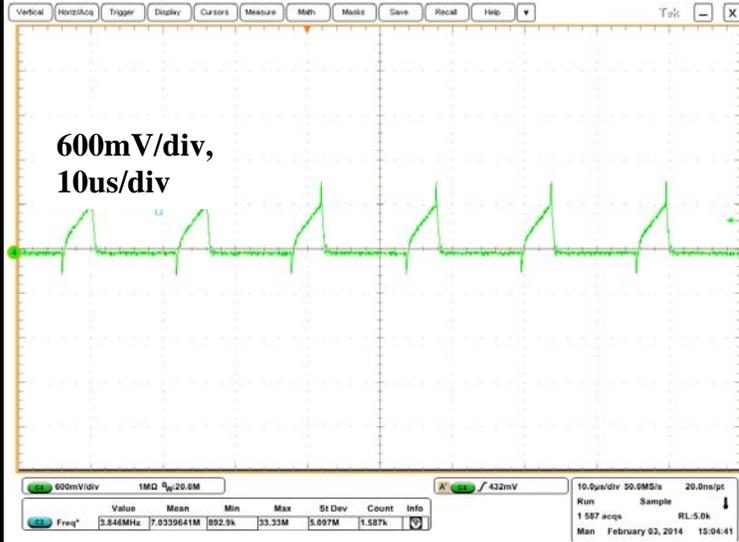
Full Load



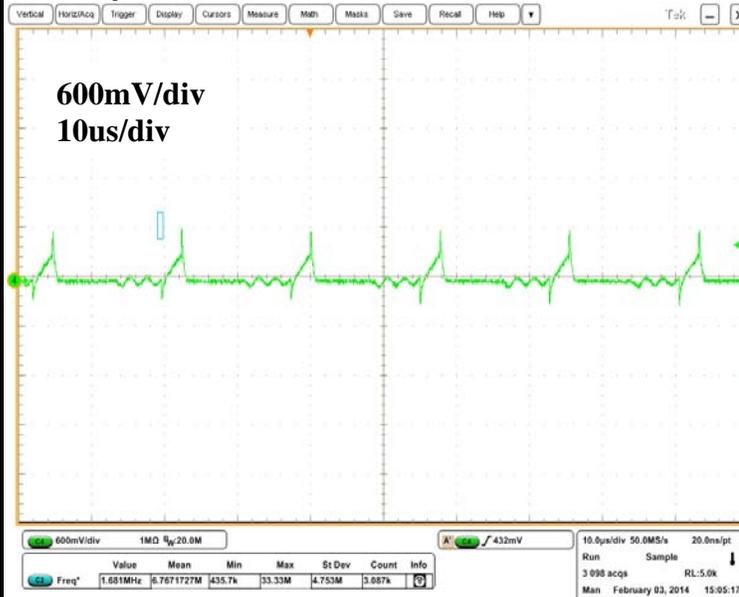
0.5 Amp Load



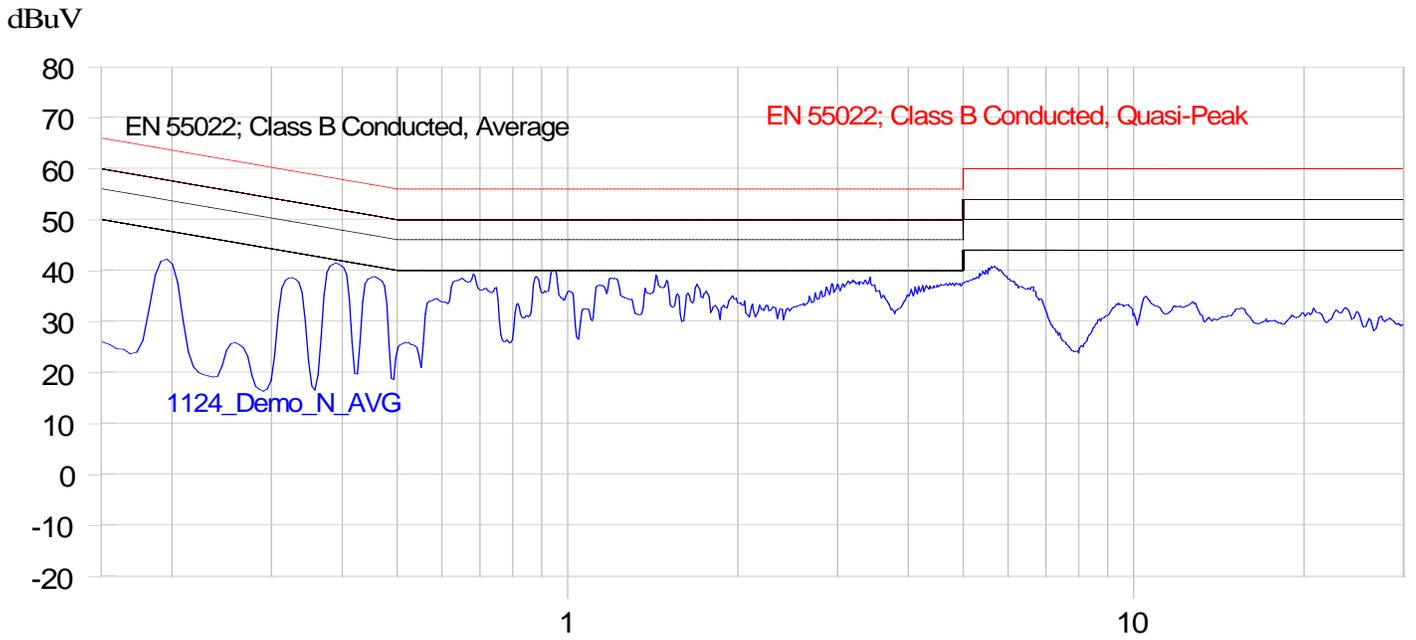
Mosfet Drain Current (120 Vac Input)
Full Load



0.5 Amp Load



Conducted EMI Plot



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(Start = 0.15, Stop = 30.00) MHz

References

ON Semiconductor data sheet for NCP1126, 1129 monolithic switcher.

ON Semiconductor Design Notes DN05012, DN05017, DN05018, DN05028, DN05029, DN05043/D

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