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Design Note – DN05033/D

A 12V, Off-line Power Supply With Primary Side Feedback

ON Semiconductor

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1251B NDD04N60	White Goods, Small Instruments, E-Meters, Industrial Equipment	90 – 267 Vac	20 Watts	DCM Flyback	2.5 kV primary to secondary

Other Specification

	Output 1	Output 2	Output 3	Output 4
Output Voltage	12 Vdc +/- 5%	N/A	N/A	N/A
Ripple	< 2%	N/A	N/A	N/A
Nominal Current	1.8 Amps	N/A	N/A	N/A
Max Current	2 Amps	N/A	N/A	N/A
Min Current	zero	N/A	N/A	N/A

PFC (Yes/No)	No
Nominal Efficiency	>80%
Inrush Limiting / Fuse	Yes
Operating Temp. Range	0 to 50C
Cooling Method / Supply Orientation	Convection NA
Signal Level Control	No

Others	Input EMI filter

Circuit Description

This Design Note describes a very simple, low cost, primary side controlled, off-line flyback power supply using ON Semiconductor's NCP1251B current mode controller (TSOP6 package) and an NDD04N60 D-Pak Mosfet.

The design dispenses with the conventional TL431/optocoupler feedback scheme and uses primary side voltage sensing on the NCP1251's Vcc rail which is derived from an aux winding on the transformer. This scheme provides tight line regulation and a load regulation of +/- 5% which is more than adequate for most applications. The acceptable load regulation is achieved by tight coupling (bifilar wound) between the main 12V secondary and the 12V aux winding in the transformer. The voltage sensing circuit is comprised of Z2 and Q2. The zener voltage of Z2 plus the V_{BE} drop of Q2 sets the nominal

output voltage. The load regulation over the usable load range and the nominal output voltage can be further optimized by adjusting the values of R5 and R11, respectively.

Over-current limiting is provided by sensing the peak current in the MOSFET Q1 via R8. Once the 800 mV threshold level on U1's pin 4 is exceeded, the circuit will go a "hiccup" mode until the over-current condition is removed. An optional output OVP clamp is implemented via Z1 to limit the maximum no load output voltage.

Key Features

- Primary side voltage sensing – no optocoupler
- Input EMI filter for conducted EMI compliance
- Schottky output rectifier for high efficiency
- Current mode control with adjustable output current limit setpoint
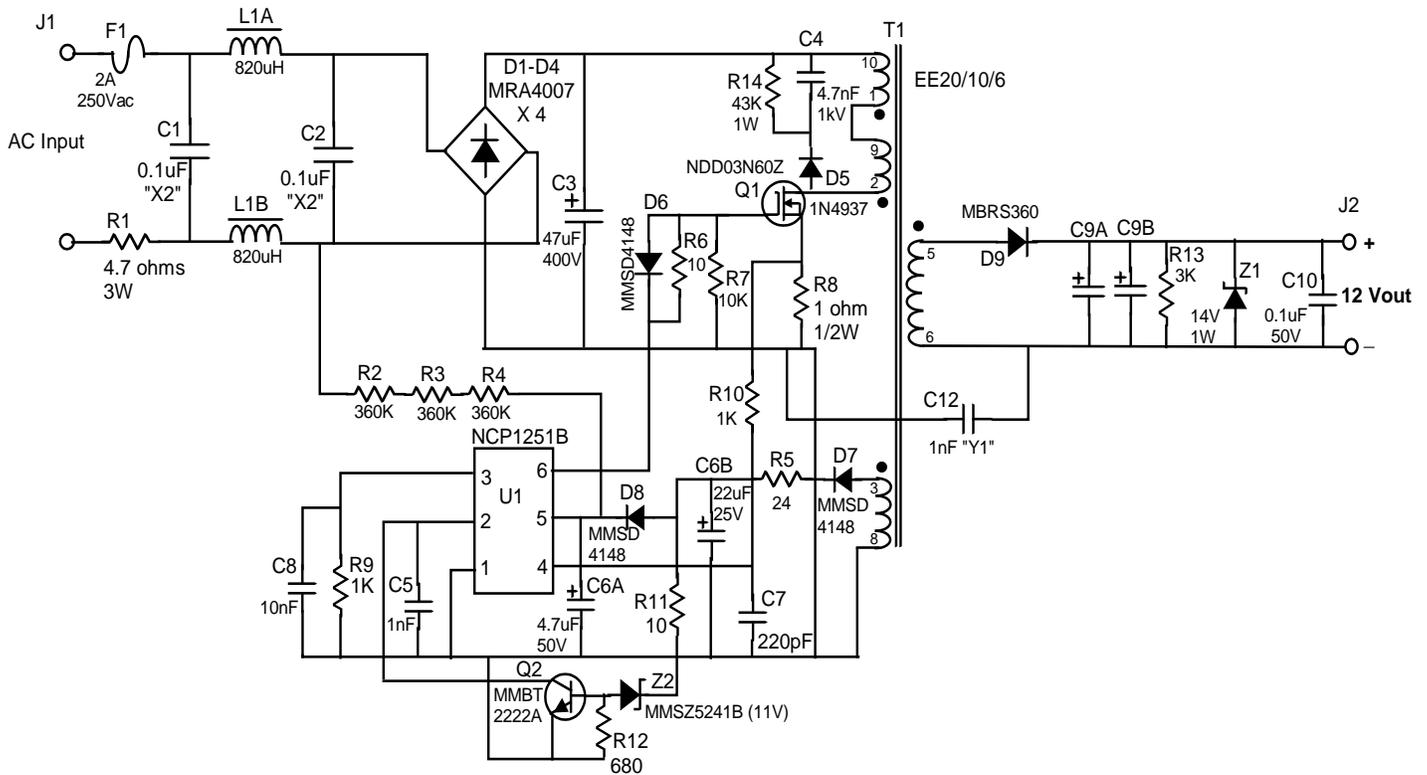
Schematic

NOTES:

1. Crossed lines on schematic are NOT connected.
2. Z1/R13 are optional OV clamp/pre-load for zero load protection.
3. R1 is for inrush limiting - use carbon comp or wire wound.
4. L1A/L1B are Wurth 7447728215 components (820 uH, 500mA).
5. Output caps (C9A/B) are radial lead, low impedance types (UCC LXV series or similar).
6. R5 should be adjusted for optimum load regulation depending aux winding leakage
   inductance (typically 15 to 68 ohms).
7. Z2 sets nominal Vout.
8. R11 is for Vcc/Voutput trimming.
9. R8 sets max output current.
10. See drawing for T1 details.

**20 Watt NCP1251 Power Supply
with Primary Side Sense (Rev 7A)**

Design note created by Frank Cathell, e-mail: f.cathell@onsemi.com

MAGNETICS DESIGN DATA SHEET

Project / Customer: 24 watt, 12 vout NCP1251 Flyback with primary side sensing

Part Description: 24 watt flyback transformer, 12Vout   (Wurth part # 750313284)

Schematic ID: T1

Core Type: EE20/10/6 ferrite core; 3C90 material or similar

Core Gap: Gap for 190 +/- 200uH across Primary A (pins 1 - 10)

Inductance: 750 uH total (+/- 5%) measured from pin 1 to pin 9 with pins 2 and 10 connected

Bobbin Type: 10 pin horizontal mount for EE20/10/6

Windings (in order):

| Winding # / type	Turns / Material / Gauge / Insulation Data
Primary A (1 - 10)	30T of #28HN over 1 layer (25 TPL). Insulate for 1 kV to next winding. Self leads to pins.
12V Secondary/Vcc (5 - 6, 3 - 8)	6 turns trifilar of #26 triple insulated wire over one. layer. The outer winding on schematic is Vcc (3 - 8). The 12V secondary (5 - 6) uses two wires. Self leads to pins per drawing.
Primary B (2 - 9)	Same as Primary A. Insulate with tape and self-leads to pins.

Hipot: 2.5 kV from primaries & Vcc to secondary for 1 minute.

| Schematic	Lead Breakout / Pinout

Output Load Regulation

Vout vs Load (R5 = 24 ohms, Z1 = 15V)
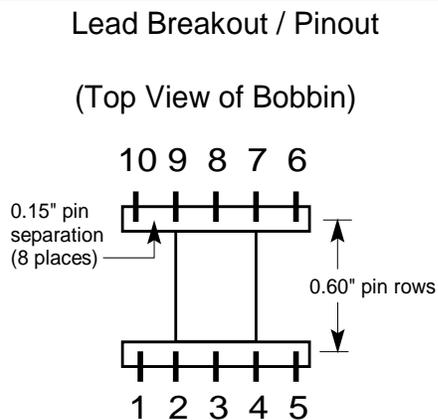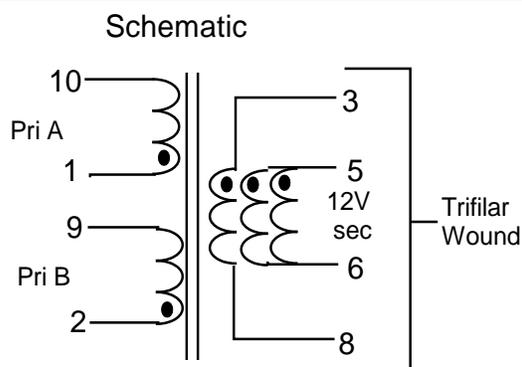
Efficiency Plot
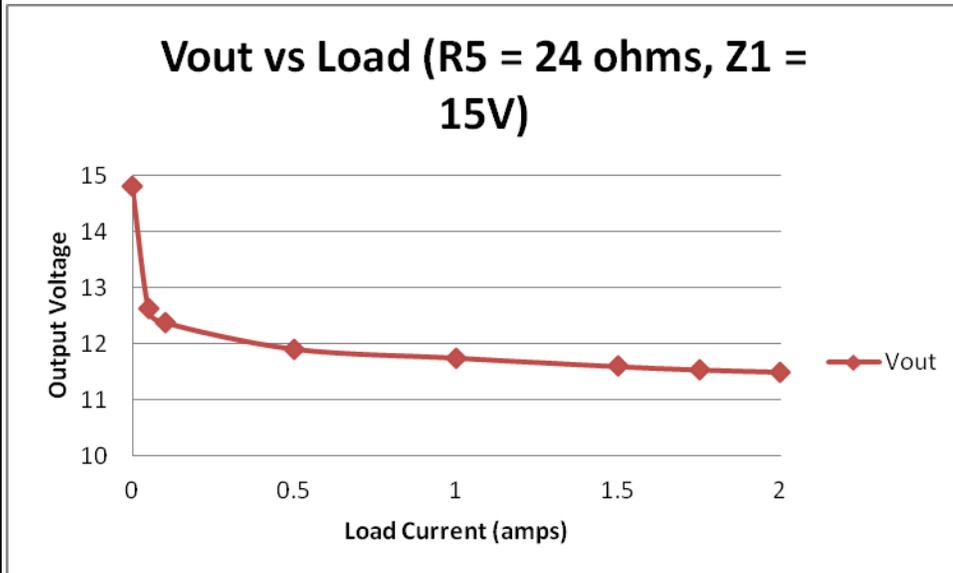
Efficiency % (120 Vac input)
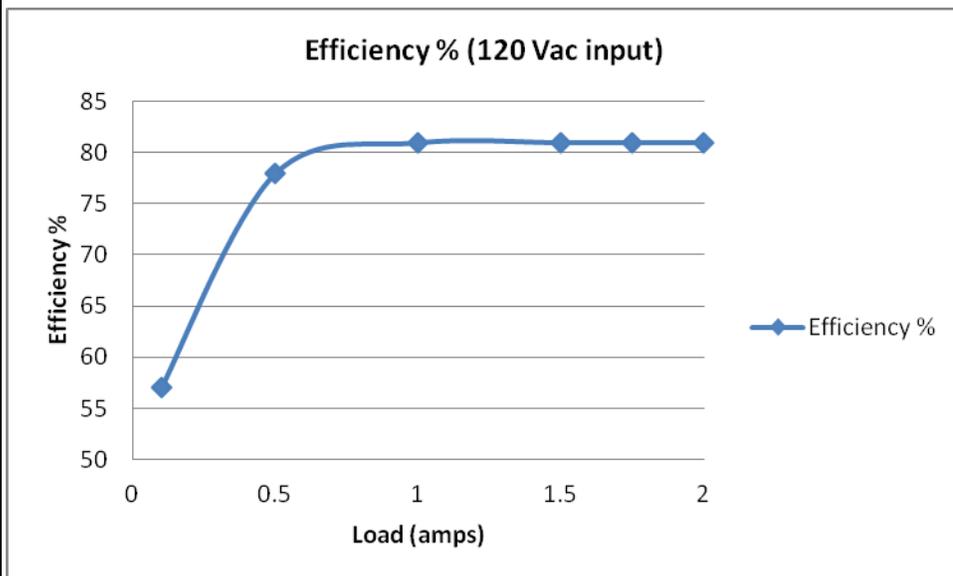
References:

NCP1251 Data Sheet: http://www.onsemi.com/pub_link/Collateral/NCP1251-D.PDF

ON Semiconductor NCP1251 Design Notes: DN05012, DN05017, DN05028, DN05029

Flyback Transformer Design Aid:
http://www.onsemi.com/PowerSolutions/supportDoc.do?type=tools&rpn=NCP1075