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Design Note – DN05012/D

A 20 to 25 Watt, Low Cost, Off-line Power Supply

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1251B NCP431 NDD04N60	White Goods, Small Instruments, E-Meters, Industrial Equipment	90 – 267 Vac	20 to 25 Watts	DCM Flyback	3 kV

Other Specification

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

PFC (Yes/No)	No
Minimum Efficiency	78% for 5Vout; 81% for 12Vout
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, yet high performance off-line flyback power supply using ON Semiconductor's NCP1251B controller (TSOP6 package), NDD04N60 D-Pak Mosfet, and the NCP431 programmable zener (SOT23 package).

The flyback design operates in discontinuous conduction mode and uses the conventional optocoupler (U2) feedback scheme for the voltage loop and an auxiliary Vcc winding on the flyback transformer to power the NCP1251. The Design Note provides the complete circuit and transformer design details for 5 volt, 4 amp, and 12 volt, 1.8 amp output models. Other output voltages from 3.3 up to 28 Vdc are easy to implement by modifying the values (or ratings) of R11, R12, D9, C9 and T1's secondary turns.

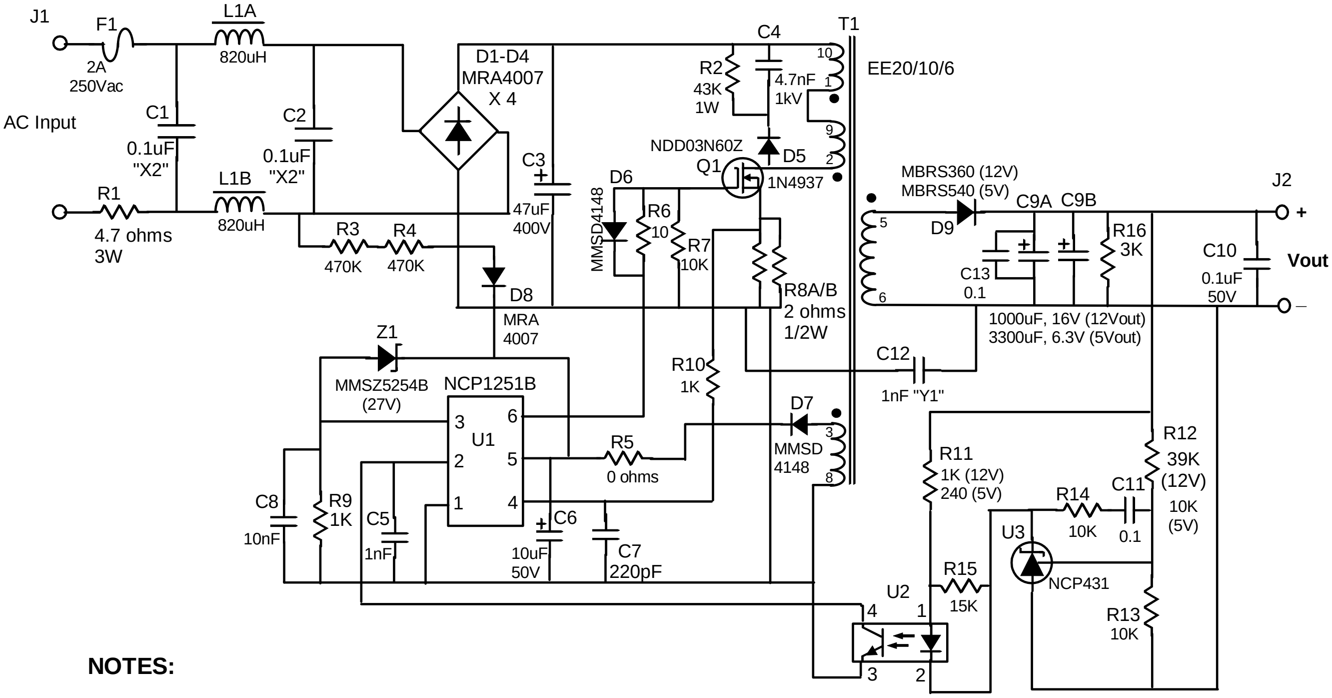
Over-current limiting is provided by sensing the peak current in the MOSFET Q1 via R8. Once the 800 mV threshold level on U1's pin 4 is exceeded the circuit will go a "hiccup" mode until the over-current condition is removed. An optional OVP circuit is implemented via Z1.

Depending on the application, it may be necessary to add a small pi-network ripple filter to the output as shown in the lower section of the schematic below.

Key Features

- Input EMI filter for conducted EMI compliance
- Schottky output rectifier for high efficiency
- Very low standby (no load) power
- Current mode control with adjustable output current
- Small pc board footprint
- Low cost components

Schematic

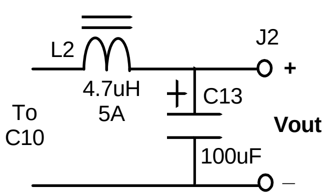


NOTES:

1. Crossed lines on schematic are NOT connected.
2. U2 is NEC PS2561L-1 or equivalent optocoupler (CTR > 50%).
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. Z1 sets OVP trip level.
7. R5 is for Vcc trimming (< 28Vmax), typically zero ohms.
8. R8A/B sets max output current.
9. U1 is 100 kHz version
10. See drawing for T1 details.

20 Watt NCP1251 Power Supply with Universal AC Input (Rev 5A)

Optional Ripple Filter



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

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MAGNETICS DESIGN DATA SHEET

Project / Customer: ON Semiconductor - 20 watt, 5 Vout NCP1251 Flyback

Part Description: 20 watt, 100 kHz flyback transformer, 5Vout (Wurth # 750312279)

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

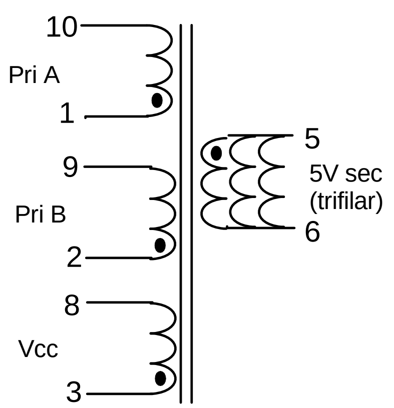
Bobbin Type: 10 pin horizontal mount for EE20/10/6

Windings (in order):

Winding # / type	Turns / Material / Gauge / Insulation Data
Primary A (1 - 10)	30T of #28HN over 1 layer (30 TPL). Insulate for 1 kV to next winding. Self leads to pins.
Vcc (3 - 8)	8 turns of #28 HN over 1 layer, spiral wound over primary A. Self leads to pins. Insulate to 1 kV to next winding with tape.
5V Secondary (5 - 6)	3 turns trifilar of #24 triple insulated wire over one. layer (three strands). Self leads to single pins as shown in drawing below.
Primary B (2 - 9)	Same as Primary A. Insulate with tape and self-leads to pins.

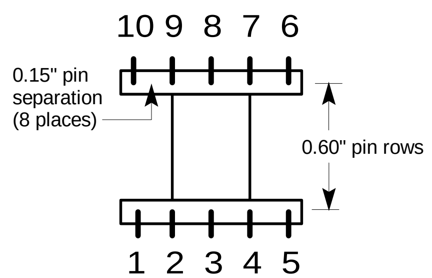
Hipot: 3 kV from primaries & Vcc to secondary for 1 minute.

Schematic



Lead Breakout / Pinout

(Top View of Bobbin)



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MAGNETICS DESIGN DATA SHEET

Project / Customer: ON Semiconductor - 24 watt, 12 vout NCP1251 Flyback

Part Description: 24 watt flyback transformer, 12vout, 100 kHz (Wurth part # 750312495)

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

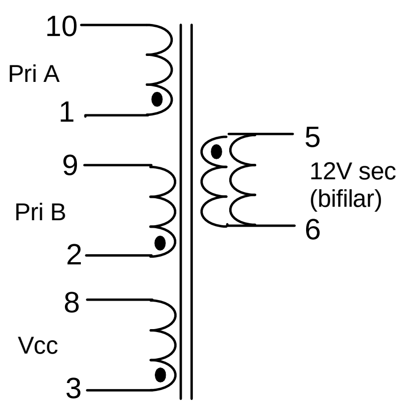
Bobbin Type: 10 pin horizontal mount for EE20/10/6

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.
Vcc (3 - 8)	7 turns of #28 HN over 1 layer, spiral wound over primary A. Self leads to pins. Insulate to 1 kV to next winding with tape.
12V Secondary (5 - 6)	6 turns bifilar of #24 triple insulated wire over one. layer (two strands). Self leads to pins. (Note: #26 is also acceptable here if the fit is too tight for one layer)
Primary B (2 - 9)	Same as Primary A. Insulate with tape and self-leads to pins.

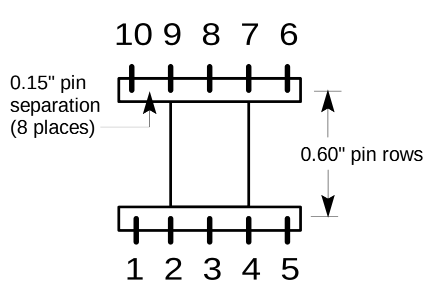
Hipot: 3 kV from primaries & Vcc to secondary for 1 minute.

Schematic



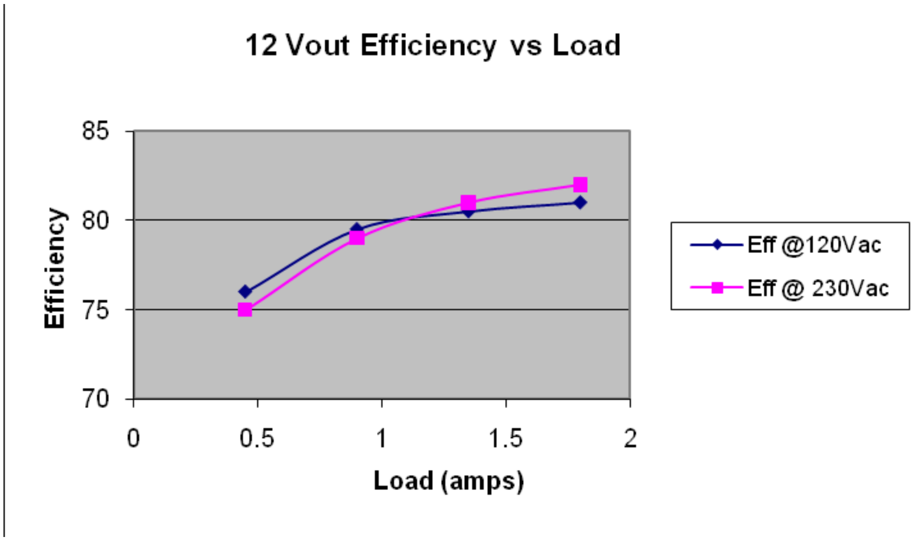
Lead Breakout / Pinout

(Top View of Bobbin)

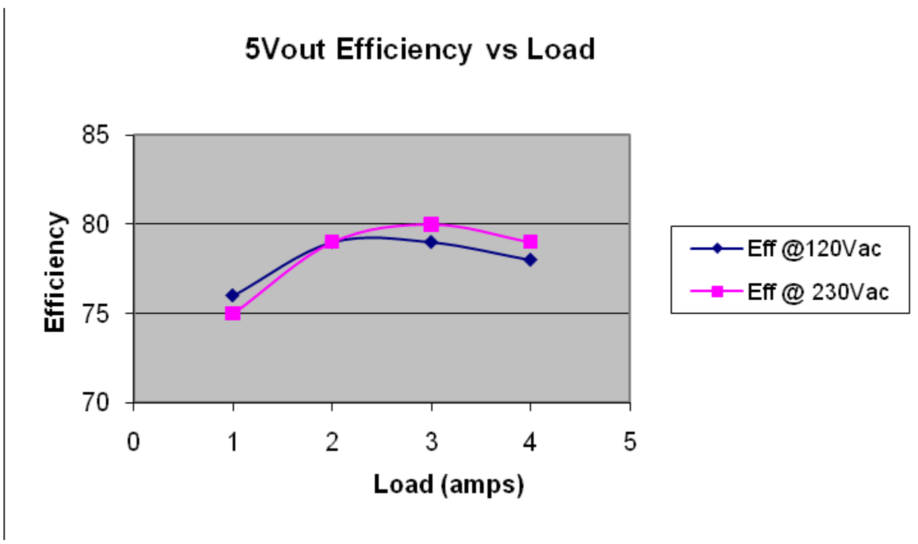


Efficiency Plots

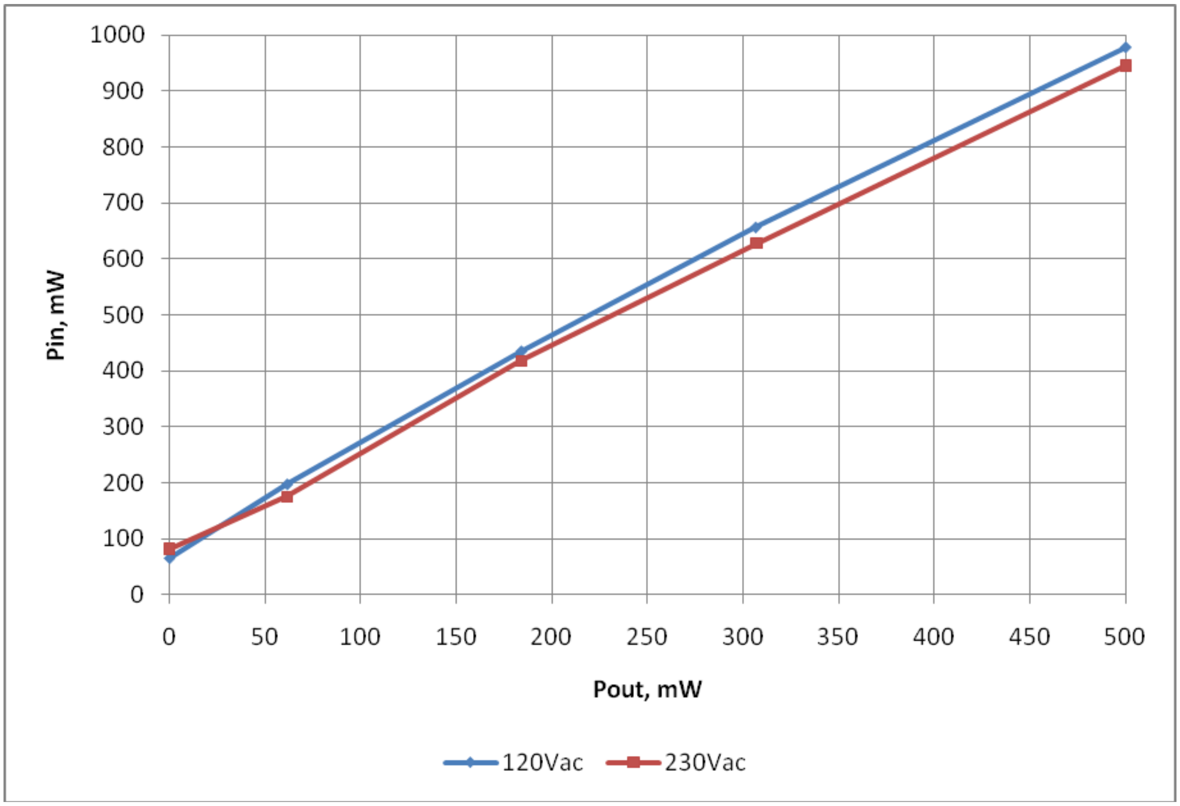
12 Volt Output



5 Volt Output



Light Load (< 500mW out) and Standby (no load) Power Plots



Bill of Materials for 12Vout, 20W NCP1251 Flyback (Rev5)

ON Semiconductor

6/2/2011

Designator	Qty	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number	Substitution Allowed	Lead Free	Comments
D9 (12Vout)	1	Schottky diode	3A, 60V		SMC	ON Semi	MBRS360T3G	No	Y	12V version
D9 (5Vout)	1	Schottky diode	5A, 40V		SMC	ON Semi	MBRS540T3	No	Y	5V version
Q1	1	Mosfet - NDD04N60Z	4A, 600V		DPak	ON Semi	NDD04N60Z	No	Y	
D1, 2, 3, 4, 8	5	Diode - 60 Hz,	1A, 800V		SMA	ON Semi	MRA4007	No	Y	
D5	1	Diode - fast recov	1A, 600V		axial lead	ON Semi	1N4937	No	Y	
D6, D7	2	Signal diode	100mA, 100V		SOD-123	ON Semi	MMSD4148A	No	Y	
Z1	1	Zener diode	27V (OVP)		SOD-123	ON Semi	MMSZ5254B	No	Y	
U3	1	Programmable zener	2.5V		SOIC8 / SOT23	ON Semi	NCP431A	No	Y	
U2	1	Optocoupler	CTR >/= 0.5		4-pin	Vishay or NEC	SFH6156A-4 or PS2561L-1	Yes	Y	
U1	1	Controller - NCP1251B	100 kHz		TSOP6	ON Semi	NCP1251BSN100	No	Y	
C1, C2	2	"X" cap, box type	100nF, X2	20%	LS = 15 mm	Rifa, Wima	Digi-Key P/N = 399-5426-ND	Yes	Y	
C12	1	"Y1" cap, disc type	1nF, Y1	20%	LS = 7.5 mm	Rifa, Wima	Mouser P/N = 75-WKP102MCPEJ0KR	Yes	Y	
C4	1	Ceramic cap, disc	4.7nF, 1kV	5%	LS = 7.5 mm	Rifa, Wima	Digi-Key P/N = 490-4266-ND	Yes	Y	
C5	1	Ceramic cap, monolythic	1 nF, 50V	10%	1206	AVX, Murata	Digi-Key P/N = 311-1170-1-ND	Yes	Y	
C10, 11, 13	3	Ceramic cap, monolythic	100nF, 50V	10%	1206	AVX, Murata	Digi-Key P/N = 311-1179-1-ND	Yes	Y	
C7	1	Ceramic cap, monolythic	220pF, 50V	5%	1206	AVX, Murata	Digi-Key P/N = 478-1484-1-ND	Yes	Y	
C8	1	Ceramic cap, monolythic	10nF, 50V	5%	1206	AVX, Murata	Digi-Key P/N = 445-7688-1-ND	Yes	Y	
C3	1	Electrolytic cap	47uF, 400V	10%	LS=7.5mm, D=16mm	UCC, Panasonic	Mouser P/N = 647-UCY2G470MHD	Yes	Y	
C6	1	Electrolytic cap	10uF, 25Vdc	10%	LS=2.5mm, D=6.3mm	UCC, Panasonic	Digi-Key P/N = 565-1055-ND	Yes	Y	
C9A, C9B	2	Electrolytic cap	1000uF, 16V	10%	LS=5mm, D=12.5mm	UCC, Panasonic	Mouser P/N = 661-EKY160ELL102MK1	Yes	Y	12V version
(5Vout)	2	Electrolytic cap	3300uF, 6.3V	10%	LS=5mm, D=12.5mm	UCC, Panasonic	Newark P/N = 23K4009	Yes	Y	5V version
R1	1	Resistor, 3W, Wire wound	4.7 ohm, 3W	5%	LS=7.5mm, D=7mm	Ohmite, Dale	Digi-Key P/N = 4.7AECT-ND	Yes	Y	
R2	1	Resistor, 1W, metal film	43K, 1W	5%	Axial lead; LS=25mm	Ohmite, Dale	Digi-Key P/N = PPC43KW-1CT-ND	Yes	Y	
R8A/B	2	Resistor, 1/2W metal film	2 ohms, 1/2W	1%	Axial lead; LS=12.5mm	Ohmite, Dale	Mouser P/N = 660-MF1/2DCT52R2R00F	Yes	Y	
R6	1	Resistor, 1/4W SMD	10 ohms	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-10.0FCT-ND	Yes	Y	
R3, R4	2	Resistor, 1/4W SMD	470K	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-470KFCT-ND	Yes	Y	
R7, 13, 14	3	Resistor, 1/4W SMD	10K	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-10.0KFCT-ND	Yes	Y	
R11 (12Vout)	1	Resistor, 1/4W SMD	1K	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-1.00KFCT-ND	Yes	Y	12V version
R11 (5Vout)	1	Resistor, 1/4W SMD	240 ohms	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-240FCT-ND	Yes	Y	5V version
R5	1	Resistor, 1/4W SMD	Zero ohm	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-0.0ECT-ND	Yes	Y	
R9, 10, 15	3	Resistor, 1/4W SMD	1K	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-1.00KFCT-ND	Yes	Y	
R16	1	Resistor, 1/4W SMD	3K	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-3.00KFCT-ND	Yes	Y	
R12 (12Vout)	1	Resistor, 1/4W SMD	39K	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-39.0KFCT-ND	Yes	Y	12V version
R12 (5Vout)	1	Resistor, 1/4W SMD	10K	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-10.0KFCT-ND	Yes	Y	5V version
F1	1	Fuse, TR-5 style	2A		TR-5, LS=5mm	Minifuse	Newark P/N = 67K2094	Yes	Y	
L1A/B	1	Inductor (EMI choke)	820 uH, 500 mA		See Wurth Drawing	Wurth Magnetics	7447728215	Yes	Y	
T1 (12Vout)	1	Transformer	E20/10/6 core		See Mag Drawing	Wurth Magnetics	750312495	Yes	Y	12V version
T1 (5Vout)	1	Transformer	E20/10/6 core		See Mag Drawing	Wurth Magnetics	750312279	Yes	Y	5V version
J1, J2	2	Screw Terminal			LS = 0.2"	DigiKey	# 281-1435-ND	Yes	Y	
J1, J2	2	Screw Terminal			LS = 0.2"	DigiKey	# 281-1435-ND	Yes	Y	

Blue indicates part change with Vout change

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