ON Semiconductor

Design Note – DN06021/D

16 W, 12 Vdc Modem Power Supply

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1027	AC-DC adapter for modem, hub, router	90 to 264 Vac	16 W	DCM Flyback	Yes – 3 kV

Other Specifications				
	Output 1	Output 2	Output 3	Output 4
Output Voltage	12 V +/- 5%	N/A	N/A	N/A
Ripple	1% max (120 mV)	N/A	N/A	N/A
Nominal Current	1.3 A	N/A	N/A	N/A
Max Current	1.5 A (10 sec)	N/A	N/A	N/A
Min Current	zero	N/A	N/A	N/A

PFC (Yes/No)	No
Average Efficiency	76.4% at 120 Vac; 78% at 230 Vac averaged over 25%, 50%, 75% and 100% of the load
Inrush Limiting / Fuse	8 ohm resistor + 1 A fuse
Operating Temperature Range	0 to +45°C
Cooling Method/Supply Orientation	Convection

Others	Total regulation (line and load): better than 2%

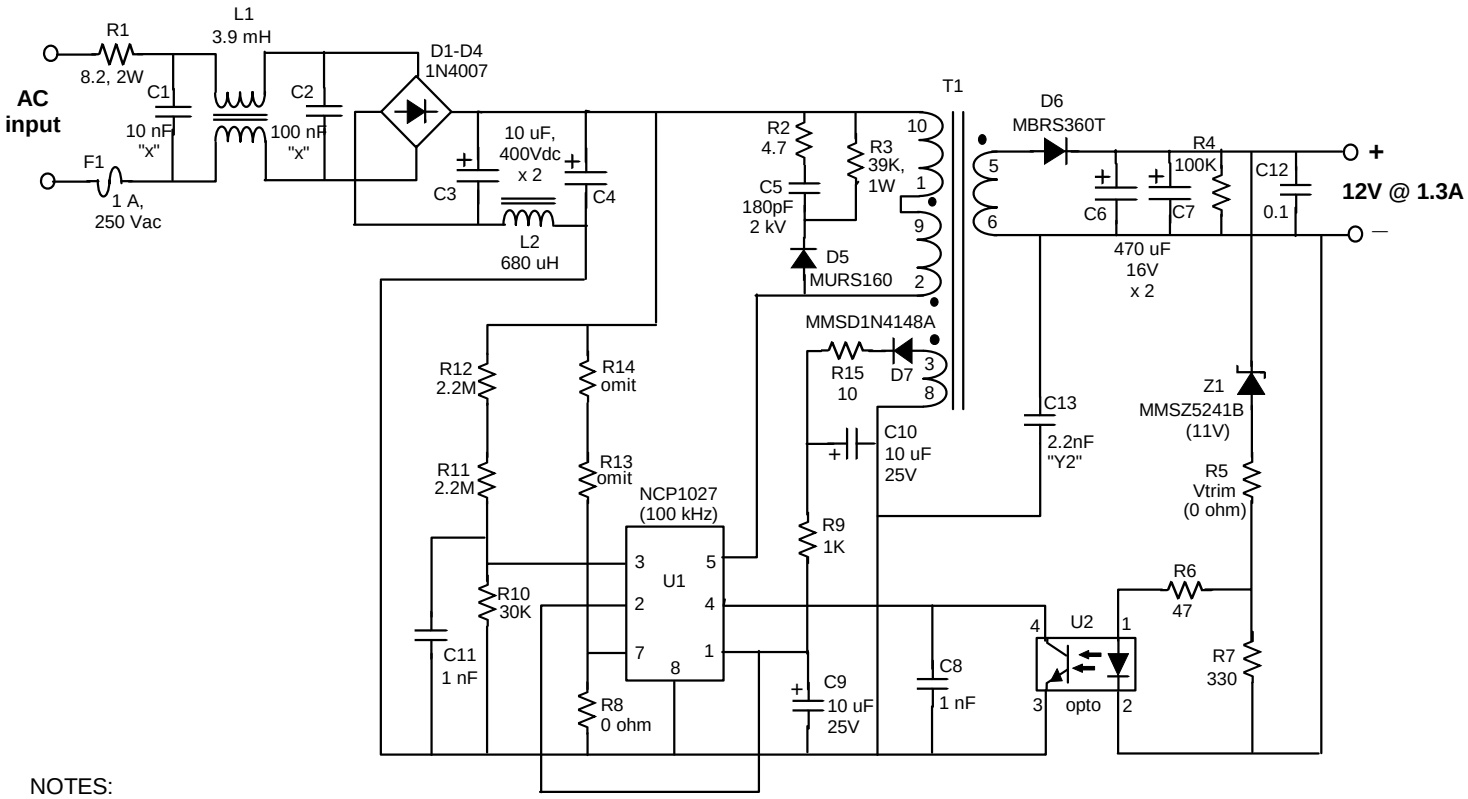
Circuit Description

This design note presents a simple yet feature loaded 16 watt output, universal AC input adapter power supply for modems, hubs or similar applications. The circuit is a discontinuous mode (DCM) flyback converter topology designed around ON Semiconductor's NCP1027 monolithic current mode controller with internal 700V Mosfet. The output will provide up to 1.5 amps peak and will regulate at full output as low as 85 Vac input. The supply also includes an EMI input filter as well as adjustable brown-out and power limit features. A very simple zener diode and optocoupler feedback scheme is used that provides good output regulation with a minimum of components. The schematic of an optional resonant snubber is also shown which will improve the efficiency an additional two percentage points over the standard RCD snubber for the 120 Vac input range (see figure 2 and plots).

Key Features

- Simple, low cost, yet highly effective power supply circuit
- Over-current, over-voltage and over- temperature protection
- Efficiency and no-load (standby) parameters meet Energy Star requirements (see data below)
- Small and simple flyback transformer construction for easy mass production
- Optional resonant snubber for even higher efficiency

Figure 1. Schematic for the 16 W, 12 V AC-DC modem adapter



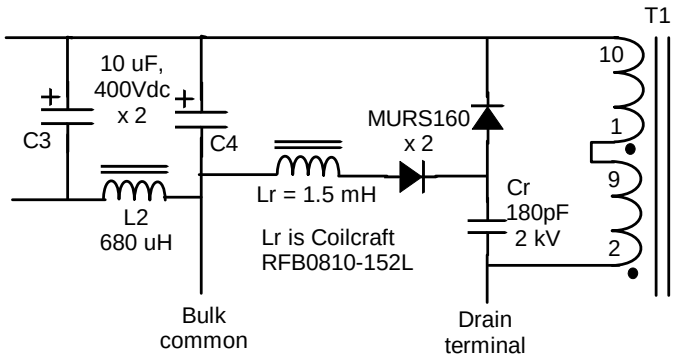
NOTES:

1. L1 is Coilcraft E3491-AL common mode EMI inductor (3.9 mH)
2. L2 is Coilcraft part RFB0810-681L or similar (680 uH, 500 mA)
3. See Magnetics Data Sheet for T1 construction details.
4. R9 sets OVP trip level.
5. R8, R13, R14 for optional power limit feature (see NCP1027 data sheet.)
6. Z1 zener sets Vout: Vout = Vz + 0.85V; R5 is optional voltage trim resistor
7. R10 sets AC input brownout level.
8. R1 is optional inrush limiter.
9. U1 requires Aavid #580100W00000G clip-on DIP8 heatsink or similar.
10. Crossed schematic lines are not connected

Snubber

Figure 2 shows an alternative to the classical RCD snubber network, using a non-dissipative resonant snubber. This resonant snubber not only recycles the leakage energy to the input bulk capacitor C4, but also provides more effective shaping of the Mosfet's load line, thus lowering switching losses. At Mosfet turn-off, the leakage inductance energy of T1 is transferred to Cr and the rate of rise of the drain voltage (dV/dt) is slowed. When the Mosfet turns back on the capacitor is discharged by transferring its energy to Lr in the resonant circuit formed by LR/Cr. During the next off-period the energy is then transferred back to the bulk cap through the series diodes. This action can actually be best interpreted as a resonant "charge pump" in which the leakage inductance energy is returned to the bulk cap. The additional component cost includes the small inductor Lr and another ultrafast diode. The overall converter circuit efficiency improvement should be several percentage points, particularly at light loads.

Figure 2. Non dissipative resonant snubber option



MAGNETICS DESIGN DATA SHEET

Project / Customer: ON Semiconductor - 16 - 18 watt, 12 vout adapter supply

Part Description: 18 watt NCP1027 flyback transformer, 100 kHz, 12V / 1.5 A (Rev 1)

Schematic ID: T1

Core Type: E24/25 (E25/10/6); 3C90 material or similar

Core Gap: Gap for 750 to 800 uH across pins 2 and 10 with pins 1 and 9 connected

Inductance: 775 uH +/-5% (across pins 2 and 10 with pins 1 and 9 connected)

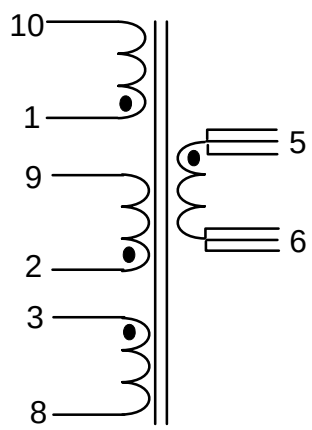
Bobbin Type: 10 pin horizontal mount for E24/25 (E25/10/6)

Windings (in order):

Winding # / type	Turns / Material / Gauge / Insulation Data
Primary A (1 - 10)	25 turns of #30HN over 1 layer. Insulate for 1 kV to next winding. Self leads to pins..
Vcc (3 - 8)	5 turns of #30 HN spiral wound over 1 layer with 3 mm end margins minimum. Self leads to pins. Insulate to 3 kV to next winding
12V Secondary (5 - 6)	5 turns of three strands of #26HN (trifilar) over previous winding with 1.5 mm end margins approximately. Winding ends should be cuffed with tape to avoid edge breakdown other windings. Insulate for 3 kV to next winding. Self leads to pins.
Primary B (2 - 9)	Same as Primary A.

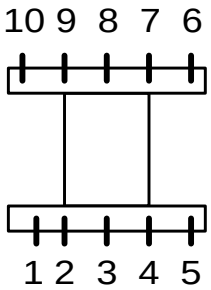
Hipot: 3 kV from primaries & Vcc to secondary for 1 minute.

Schematic



Lead Breakout / Pinout

(Top View)



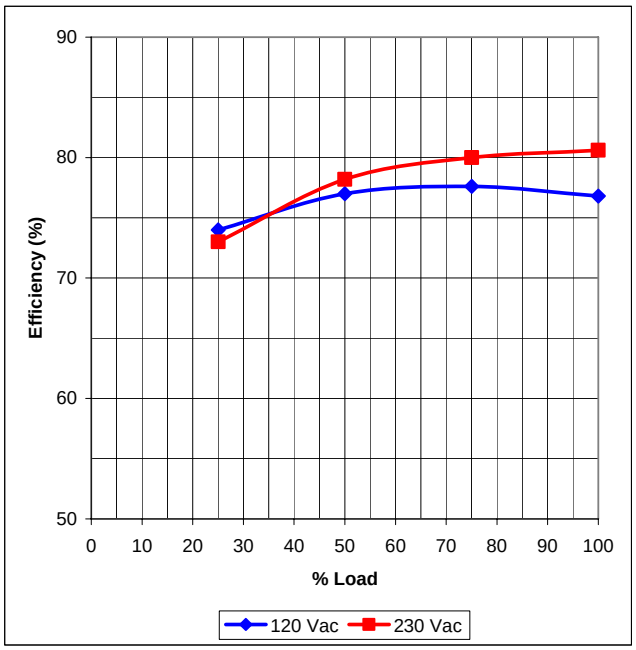
Vendor: Mesa Power Systems, Escondido, CA. 760-489-8162
Part # 13-1302

Results

Efficiency

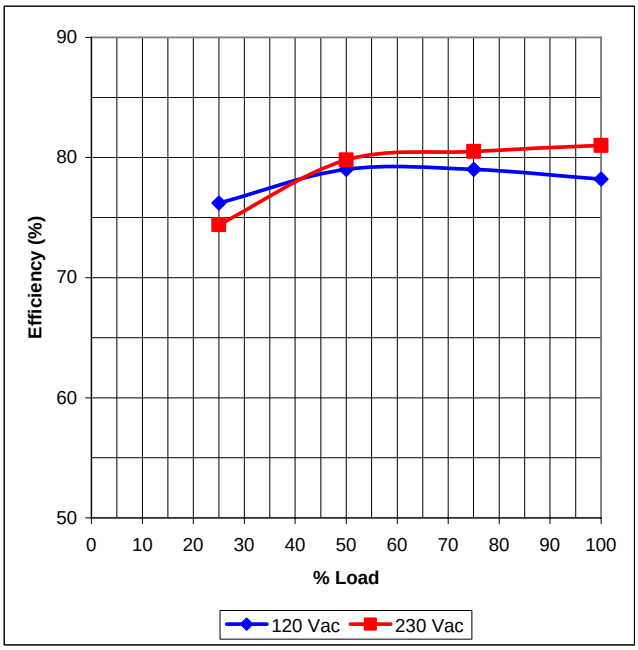
Traditional RCD snubber

Efficiency @ 25C		
% Load	120 Vac	230 Vac
25	74	73
50	77	78.2
75	77.6	80
100	76.8	80.6
Average efficiency	**76.4%**	**78.0%**
Minimum efficiency per ENERGY STAR: [0.09 * Ln(16W)] + 0.49	**74%**	**74%**



Non-Dissipative resonant snubber

Efficiency @ 25C		
% Load	120 Vac	230 Vac
25	76.2	74.4
50	79	79.8
75	79	80.5
100	78.2	81
Average efficiency	**78.1%**	**78.9%**
Minimum efficiency per ENERGY STAR: [0.09 * Ln(16W)] + 0.49	**74%**	**74%**



No load input power

Traditional RCD snubber

290 mW @ 120 Vac
210 mW @ 240 Vac

Non-Dissipative resonant snubber

240 mW @ 120 Vac
200 mW @ 240 Vac

Line Regulation: < 0.5%

Load Regulation: 2%

AC mains dropout voltage with full load: 84 Vac

Vout ripple (p/p):120 mV

Bill of Materials

16W, NCP10127 Adaptor BOM (Rev. 4)

Part	Qty	ID	Description	Comments
MRA4007	4	D1 - D4	1A, 800V diode	ON Semi
MURS160	1	D5	1A, 600V UFR diode	ON Semi
MBRS360T Schottky	1	D6	3A, 60V Schottky	ON Semi
MMSZ5241B zener diode	1	Z1	11V, 250 mW zener	ON Semi
Optocoupler, SFH6156A-4 (4 pin)	1	U2	Optocoupler	Vishay
NCP1027 (100 kHz)	1	U1	100 kHz current mode controller	ON Semi
"X" cap, disc type	2	C1, C2	10 nF "X2" capacitor, 250 Vac	Vishay
"Y" cap, disc type	1	C13	2.2 nF, "Y2" capacitor, 250 Vac	Vishay
Ceramic cap, disc	1	C5	4.7 nF, 2 kV capacitor (snubber)	Vishay
Ceramic cap, monolythic	1	C12	0.1 uF, 50V ceramic cap	Vishay
Ceramic cap, monolythic	2	C8, C11	1 nF, 50V ceramic cap	Vishay
Electrolytic cap	2	C3, C4	10 uf, 400Vdc	UCC, Rubycon
Electrolytic cap	2	C6, C7	470 uf, 16 V (low ESR)	UCC, Rubycon
Electrolytic cap	2	C9, C10	10uf, 25V	UCC, Rubycon
Resistor, 2W	1	R1	8.2 ohm, 2W ceramic	Ohmite
Resistor, 1W	1	R3	39K, 1W	Ohmite
Resistor, 1/4W	1	R2	4.7 ohm, 1/4W	Ohmite
Resistor, 1/4W	1	R8	0 ohms, 1/4 W (jumper - power limit)	Ohmite
Resistor, 1/8W	1	R7	330, 1/8 W	Ohmite
Resistor, 1/8W	1	R6	47 ohms, 1/8 W	Ohmite
Resistor, 1/4W	1	R4	100K, 1/4W	Ohmite
Resistor, 1/8W	1	R5	0 ohms, 1/8 W (jumper)	Ohmite
Resistor, 1/8W	1	R15	10 ohms	Ohmite
Resistor, 1/8W	1	R9	1K ohms	Ohmite
Resistor, 1/8W	1	R10	30K	Ohmite
Resistor, 1/4W	2	R11, R12	2.2Meg	Ohmite
Resistor, 1/4W	2	R13, R14	TBD (optional for power limit)	Ohmite
Heatsink for U1	1		Aavid 580100W00000G	Aavid
Inductor, 680 uH	1	L2	RFB0810-681L	Coilcraft
EMI Inductor, 3.9 mH	1	L1	E3491-AL	Coilcraft
Transformer	1	T1	Flyback Xfmr #13-1302	Mesa Power Systems

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