Single Stage, Off-line, Isolated 12 Volt, 800 mA Converter with High Power Factor

Device | Application | Input Voltage | Output Power | Topology | I/O Isolation |
-------|-------------|---------------|--------------|----------|--------------|
NCP1028 | LED lighting, white goods, bias supplies | 90 to 265 Vac | 10 W nominal | DCM Flyback | Yes – 3 kV |

| Output Voltage | 12 V |
| Nominal Current | 100 to 700 mA |
| Peak Current | 800 mA |

PFC (Yes/No) | Yes |
Inrush Limiting / Fuse | 1 A fuse |
Operating Temp. Range | 0 to +60°C |
Cooling Method / Supply Orientation | Convection |
Signal Level Control | None |

**Others** | Isolated, step-down conversion with high power factor in a single converter.

**Circuit Description**

This design note (DN) describes an off-line, low power, isolated power supply which has inherent active power factor correction (PFC) integrated into the single stage flyback power topology. This power supply is intended for LED lighting, white goods, industrial, and other applications where a high input power factor is required despite the low power output. For example, Energy Star requires PF > 0.9 for commercial lighting applications; and PF > 0.7 for similar residential lighting applications above 5 watts output. In this design example, the power supply output can provide in excess of 750 mA at 12 volts nominal. Other output configurations are possible by merely changing the transformer design (secondary turns) and the output sensing zener diode (Z1).

Since this is a monolithic current mode control chip, the ramp compensation pin was utilized to negate some of the feed-forward effects of current mode control to improve the power factor. Feed-forward pre-regulates off the 120 Hz rectified line ripple which is detrimental to the overall power factor because it prevents true fixed on-time duty ratio through a complete ac line cycle. This is essential for high power factor when using a discontinuous mode (DCM) flyback topology to implement an isolated, single stage PFC converter.

Details and additional application notes on the NCP1028 monolithic controller can be found at the ON Semiconductor website. For higher power, single stage PFC converters please see information on the NCP1608, NCP1652A, NCL30000, and the NCL30001 controllers.

**Key Features**

- Simple, low power converter with high input PF
- Power factor above 0.9 for 120 vac operation for most typical loads
- Inherent over-current and over-temperature protection
- Input EMI filter
- Easily adjustable for other output voltage/current configurations
NOTES:

1. L1 is Coilcraft E3491-AL common mode EMI inductor (3.9 mH)
2. See Magnetics Data Sheet for T1 construction details (EF-16 core & horizontal bobbin)
3. Z1 zener sets Vout: Vout = Vz + 0.85V; R5 is optional voltage trim (up) resistor
4. R10 sets slope compensation (which optimizes PF)
5. Values of "X" caps C1 & C2 will influence power factor at light loads (more C = lower PF)
6. Crossed schematic lines are not connected

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

Project / Customer: ON Semiconductor - 10 watt single stage PFC xfmr
Part Description: 10 watt NCP1028 DCM PFC transformer, 100 kHz, 12V / 800mA (Rev 1)
Schematic ID: T1
Core Type: E24/25 (E25/10/6); 3C90 material or similar
Core Gap: Gap for 725 to 775 uH across pins 2 and 10 with pins 1 and 9 connected
Inductance: 750 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):

<table>
<thead>
<tr>
<th>Winding # / type</th>
<th>Turns / Material / Gauge / Insulation Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary A (1 - 10)</td>
<td>25 turns of #30HN over 1 layer. Insulate with tape for 1.5 kV to next winding. Self leads to pins.</td>
</tr>
<tr>
<td>Vcc (3 - 8)</td>
<td>5 turns of #30 HN spiral wound over 1 layer with 3 mm end margins minimum. Self leads to pins. Insulate with 1 layer of Mylar tape.</td>
</tr>
<tr>
<td>12V Secondary (5 - 6)</td>
<td>5 turns of two pieces of #26 triple insulated wire wound bifilar over previous winding evenly and in 1 layer. Insulate with 1 layer of tape; Self leads to pins.</td>
</tr>
<tr>
<td>Primary B (2 - 9)</td>
<td>Same as Primary A.</td>
</tr>
</tbody>
</table>

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

Schematic

Lead Breakout / Pinout
(Top View)
Power Factor and Efficiency versus Load Plots

**PF versus Iout**

- 120 Vac
- 230 Vac

**Efficiency % versus Iout**

- Eff -120Vac
- Eff - 230Vac

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

700 mA Load; Cout = 2000 uF (2 volts per division vertical)

350 mA Load; Cout = 2000 uF

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