



12 Watt “Mini” Boost Power Factor Corrector

ON Semiconductor

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1014	PFC Circuit for Low Power Lighting Applications	90 to 265 Vac	12 Watts	DCM Boost	None

	Output 1
Output Voltage	400 Vdc +/- 5%
Ripple	< 10%
Nominal Current	30 mA @ 400 Vdc
Max Current	36 mA surge
Min Current	zero

PFC (Yes/No)	Yes
Nominal Efficiency	85 - 90%
Inrush Limiting / Fuse	Optional
Operating Temp. Range	0 to +60°C
Cooling Method / Supply Orientation	Convection
Signal Level Control	NA

Introduction

This Design Note contains a very simple yet effective design for a “mini” off-line, boost power factor corrector (PFC) circuit with a nominal output of 12 watts and a peak capability of 14 watts. The output voltage is set at the typical 400 Vdc level as would be required by an isolated “down stream” dc-to-dc converter, but can be adjusted to a lower voltage value via resistor R5 to fit the specific application. The intended use of this PFC circuit is to drive an isolated, off-line dc-to-dc converter that is designed to provide power to commercial lighting applications (or similar) where a power factor of 0.9 or greater is still required for power levels of 14 watts and below.

Circuit Description

The circuit design is implemented as a discontinuous conduction mode (DCM) boost converter PFC utilizing ON Semiconductor’s NCP1014 monolithic current mode controller with internal MOSFET. Unlike a conventional dc-dc boost converter, this circuit has low input capacity (C3) after the input bridge rectifier BD1. This is to minimize the effect of the normally large bulk

capacitor on the power factor at the input. The full-wave rectified ac haversine is presented directly to the converter’s input boost choke L2. A simple input EMI filter comprised of C1, C2 and L1 is included to help attenuate conducted RFI line emissions.

Signal level MOSFET Q1 functions as an error amplifier to sense the output voltage via resistor divider R4/R5 and drive the feedback pin of U1, the NCP1014. The sense level threshold is just the gate threshold of the VN2222 MOSFET and Vout can be set by adjusting the ratio of resistors R4/R5. Because the control chip U1 operates in current mode by sensing the peak internal MOSFET current, R2 is required to inject a sample of the rectified ac line haversine envelope to improve the power factor by modulating the feedback signal and neutralizing some of the feed-forward effect caused by the current mode control algorithm. In addition, ac feedback capacitor C7 is necessary to provide a small amount of phase shift and band width reduction to allow a decent power factor at the high end of the line voltage range. Since the controller has an internal Vcc supply (DSS), no aux winding on the boost choke L2 is necessary.

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The power factor (PF) is maintained above 0.9 from 90 to 240 Vac from roughly half-load to max load at 14 watts (see table on page 4). Although the power factor for typical loads meets Class C for commercial lighting standards, the harmonic content is higher than would be if the input were a pure sine wave (see line current plots page 4 & 5). At power levels below 25 watts, however, these harmonic levels are below the agency specified levels, so the trapezoidal line current wave shape is inconsequential as long as the PF is greater than 0.9.

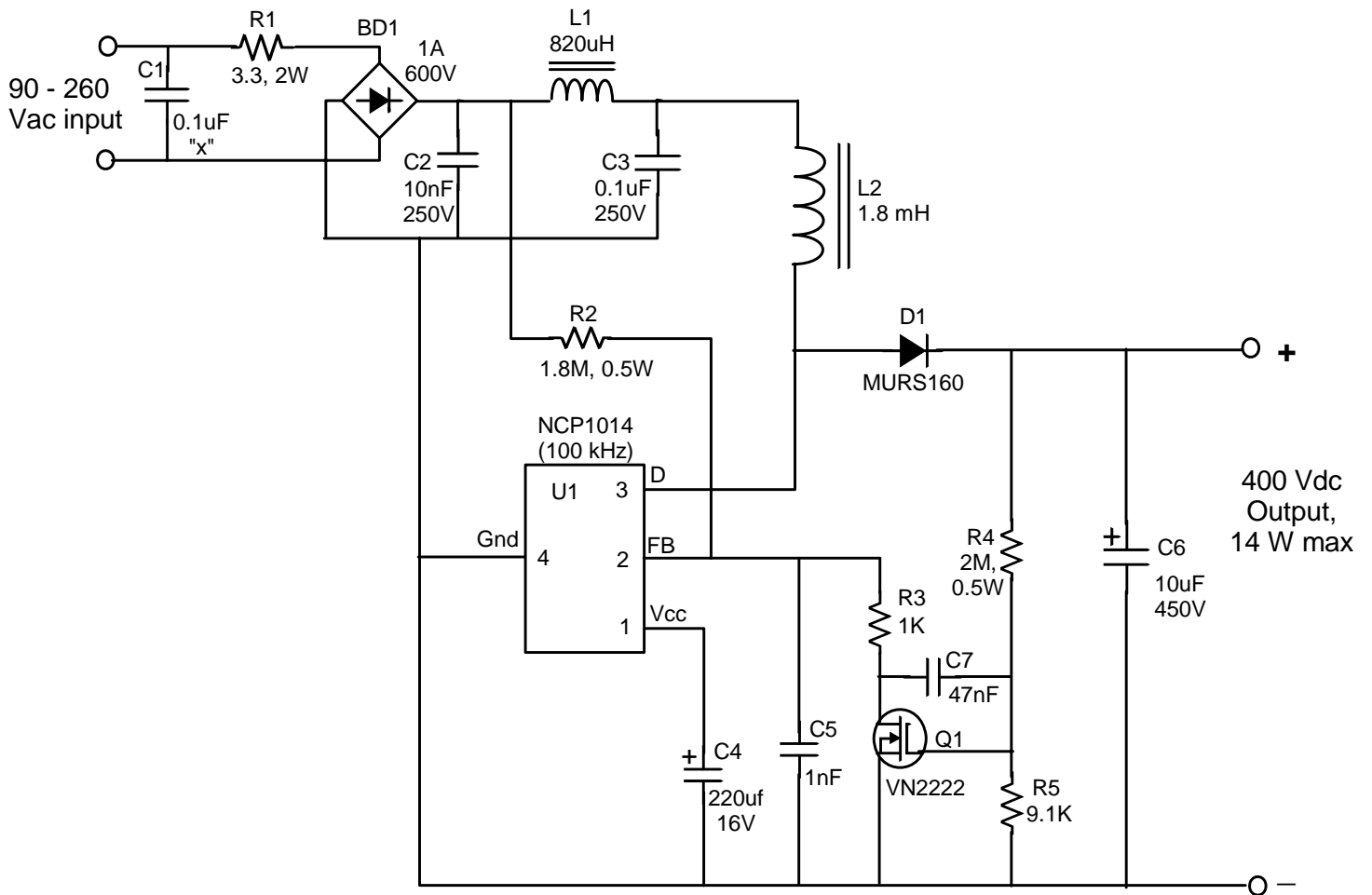
If the circuit is tailored for voltages less than 400 Vdc output, components R2 and C7 can probably be modified for additional optimization of the power factor.

Key Features

- Extremely simple yet effective boost PFC circuit for low power “downstream” converters.
- Uses essentially “off-the-shelf” components.
- Inherent overcurrent and undervoltage protection in NCP1014 (U1).
- High efficiency and good power factor for low power level.

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Schematic



Notes:

1. Crossed lines on schematic are not connected.
2. L1 is Coilcraft RFB0807-821L (820 uH, 320 mA)
3. L2 is Coilcraft RFB1010-182L (1.8 mH, 450 mA)
4. R5 sets Vout

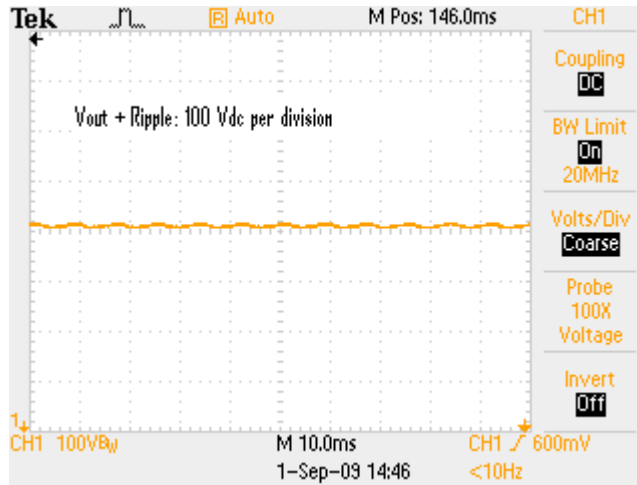
Test Results (Vout nominal = 400 Vdc)

- Load Regulation (3.5 to 14 watts): 4%
- Line Regulation (90 to 260 Vac, 8 watts out): 5%

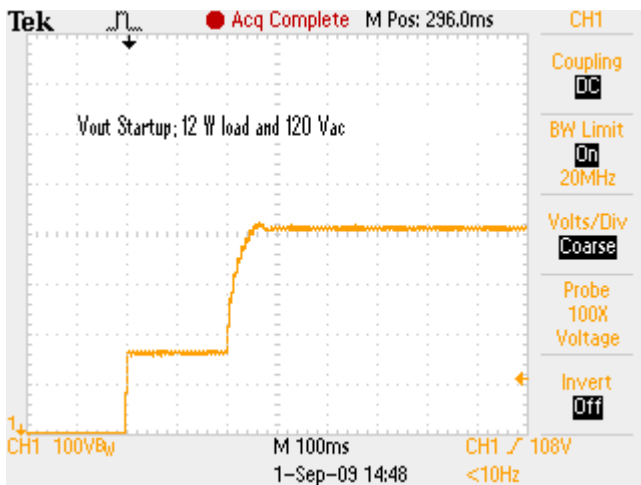
• **Power Factor and Efficiency Measurements:**

	<u>P_{out}</u> =	<u>14 W</u>	<u>8 W</u>	<u>3.5 W</u>
120 Vac in				
PF		0.97	0.95	0.90
Efficiency		88%	86%	83%
230 Vac in				
PF		0.95	0.91	0.75
Efficiency		92%	91%	85%

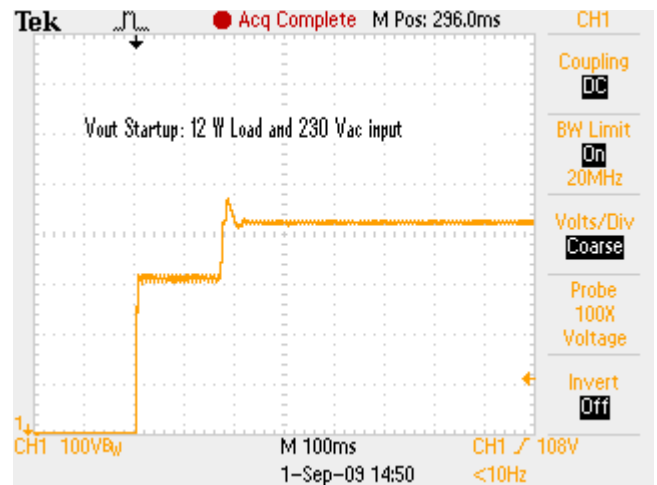
Measurements



Output Voltage and Ripple at 12 Watt Output

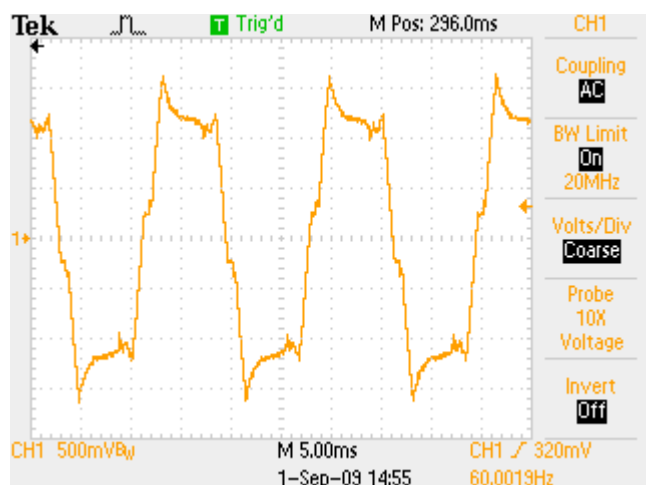


Vout during Startup with 120 Vac Input and 12 W Output

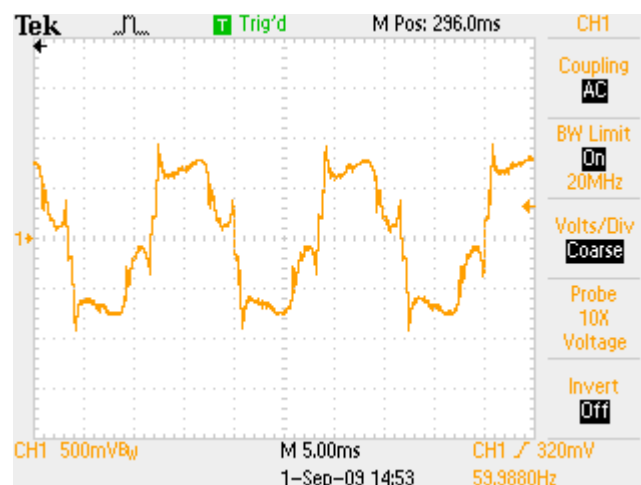


Vout during Startup with 230 Vac Input and 12 W Output

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**Line Current at 12 Watt Load and
120 Vac Input**



**Line Current at 12 Watt Load
and 230 Vac Input**

References:

- ON Semiconductor Design Note [DN06051](#): *Improving the Power Factor of Isolated Flyback Converters for Residential ENERGY STAR® LED Luminaire Power Supplies*
- ON Semiconductor Application Note [AND8123](#): *Power Factor Correction Stages Operating in Critical Conduction Mode*
- ON Semiconductor Application Note [AND8353](#): *Implementing Cost Effective & Robust Power Factor Correction with NCP1607*
- ON Semiconductor PFC Handbook [HBD853](#)

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