## Design Example Report

<table>
<thead>
<tr>
<th>Title</th>
<th>1.8W non-isolated Power Supply using LNK304</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specification</td>
<td>Input: $85-265\text{V}_\text{AC}$</td>
</tr>
<tr>
<td></td>
<td>Output: $12\text{V}/150\text{mA}$</td>
</tr>
<tr>
<td>Application</td>
<td>Home Appliance</td>
</tr>
<tr>
<td>Author</td>
<td>Power Integrations Applications Department</td>
</tr>
<tr>
<td>Document Number</td>
<td>DER-45</td>
</tr>
<tr>
<td>Date</td>
<td>April 8, 2005</td>
</tr>
<tr>
<td>Revision</td>
<td>1.0</td>
</tr>
</tbody>
</table>

### Objective

This report lists a design for a single output offline non-isolated power supply for white goods low cost applications.

- Highly integrated solution
- Lowest possible component count
- No optocoupler or zener diode required for regulation
- Integrated thermal overload protection with automatic recovery
- Less than 300mW no-load consumption
- Very high efficiency at full load

The products and applications illustrated herein (including circuits external to the products and transformer construction) may be covered by one or more U.S. and foreign patents or potentially by pending U.S. and foreign patent applications assigned to Power Integrations. A complete list of Power Integrations’ patents may be found at [www.powerint.com](http://www.powerint.com).
Table Of Contents

1 Introduction ................................................................. 3
2 Power Supply Specification ........................................... 3
3 Schematic ................................................................. 4
4 Circuit Description ....................................................... 4
5 Bill Of Materials ......................................................... 5
6 Performance Data ......................................................... 6
   6.1 Efficiency .............................................................. 6
      6.1.1 Full load efficiency ........................................ 6
      6.1.2 No load consumption .................................... 6
   6.2 Regulation ........................................................... 7
      6.2.1 Line regulation ............................................. 7
      6.2.2 Load regulation .......................................... 7
7 Revision History .......................................................... 8

Important Note:
This board is designed to be non-isolated. Please take necessary safety precautions.

Design Reports contain a power supply design specification, schematic, bill of materials, and transformer documentation. Performance data and typical operation characteristics are included. Typically only a single prototype has been built.
1 Introduction

This document is an engineering report describing a 12V, 150mA non-isolated power supply using a LNK304 from Power Integrations.

This document contains the power supply specification, schematic, bill of materials and measurements results.

2 Power Supply Specification

<table>
<thead>
<tr>
<th>Description</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage</td>
<td>V_{IN}</td>
<td>85</td>
<td>265</td>
<td>V_{AC}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>f_{LINE}</td>
<td>47</td>
<td>50/60</td>
<td>63</td>
<td>Hz</td>
<td></td>
</tr>
<tr>
<td><strong>Outputs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Voltage</td>
<td>V_{OUT}</td>
<td>12</td>
<td>n.sp.</td>
<td>V</td>
<td>[±10%]</td>
<td>20 MHz Bandwidth</td>
</tr>
<tr>
<td>Output Ripple Voltage</td>
<td>V_{RIPPLE}</td>
<td></td>
<td></td>
<td>mV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Current</td>
<td>I_{OUT}</td>
<td>150</td>
<td></td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Output Power</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous Output Power</td>
<td>P_{OUT}</td>
<td>1.8</td>
<td></td>
<td>W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Output Power</td>
<td>P_{OUT_PEAK}</td>
<td></td>
<td></td>
<td>W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambient Temperature</td>
<td>T_{AMB}</td>
<td>0</td>
<td>70</td>
<td>°C</td>
<td>Open frame</td>
<td></td>
</tr>
</tbody>
</table>

| Table 1 – Power Supply Specifications |
3 Schematic

![Schematic Diagram]

Figure 1 – Complete Schematic

4 Circuit Description

The LNK304 is used in a non-isolated buck-boost topology. The voltage across L1 is rectified and smoothed by D1 and C2 during U1’s off-time. To a first order the forward voltage drop of D2 (slow diode used in the tests) and D1 (must be an ultrafast) can be considered similar. Therefore the voltage across Cfb tracks the output voltage. The voltage across Cfb is sensed and regulated via the resistor divider Rfb-Rbias connected to U1’s FB pin. The LNK304 switching algorithm regulates the FB pin to 1.65V +/- 7% over temperature. A small pre-load resistor has been added (Rload with 5mA current consumption) for operation down to 0mA output current.
5 Bill Of Materials

<table>
<thead>
<tr>
<th>Ref</th>
<th>Description</th>
<th>Uprice</th>
<th>QTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rfuse</td>
<td>10R 2W fusible</td>
<td>0.0400</td>
<td>1</td>
</tr>
<tr>
<td>Din</td>
<td>1N4007</td>
<td>0.0072</td>
<td>1</td>
</tr>
<tr>
<td>Cin1, Cin2</td>
<td>4u7 400V</td>
<td>0.0570</td>
<td>2</td>
</tr>
<tr>
<td>Lin</td>
<td>1mH</td>
<td>0.0290</td>
<td>1</td>
</tr>
<tr>
<td>C1</td>
<td>100nF</td>
<td>0.0100</td>
<td>1</td>
</tr>
<tr>
<td>D1</td>
<td>UF4005</td>
<td>0.0450</td>
<td>1</td>
</tr>
<tr>
<td>Rbias</td>
<td>2K2 1%</td>
<td>0.0033</td>
<td>1</td>
</tr>
<tr>
<td>Rfb</td>
<td>13K 1%</td>
<td>0.0033</td>
<td>1</td>
</tr>
<tr>
<td>Cfb</td>
<td>1uF 50V</td>
<td>0.0100</td>
<td>1</td>
</tr>
<tr>
<td>D2</td>
<td>1N4007</td>
<td>0.0072</td>
<td>1</td>
</tr>
<tr>
<td>Rload</td>
<td>2K4 5% 0.25W</td>
<td>0.0015</td>
<td>1</td>
</tr>
<tr>
<td>L1</td>
<td>1mH 220mA Arms</td>
<td>0.0700</td>
<td>1</td>
</tr>
<tr>
<td>C2</td>
<td>47uF 50V</td>
<td>0.0450</td>
<td>1</td>
</tr>
<tr>
<td>U1</td>
<td>LNK304P</td>
<td>0.0000</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2 - Bill of Materials
6 Performance Data

All measurements performed at room temperature, 50 Hz input frequency.

6.1 Efficiency

6.1.1 Full load efficiency

Figure 2 – Efficiency measurements vs. input voltage (@150mA load)

6.1.2 No load consumption

Figure 3 - Input power in mW at no load output
6.2 Regulation

6.2.1 Line regulation

![Line regulation graph]

Figure 4 – Output voltage tolerance (in % of the nominal output voltage level) Vs. input voltage, @ 0.150mA load

6.2.2 Load regulation

![Load regulation graph]

Figure 5 - Load regulation (in % of the nominal output voltage level)
7 Revision History

<table>
<thead>
<tr>
<th>Date</th>
<th>Author</th>
<th>Revision</th>
<th>Description &amp; changes</th>
<th>Reviewed</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/8/05</td>
<td>TP</td>
<td>1.0</td>
<td>Initial release</td>
<td>VC/JC / AM</td>
</tr>
</tbody>
</table>
For the latest updates, visit our Web site: www.powerint.com

PATENT INFORMATION
Power Integrations reserves the right to make changes to its products at any time to improve reliability or manufacturability. Power Integrations does not assume any liability arising from the use of any device or circuit described herein, nor does it convey any license under its patent rights or the rights of others.

The products and applications illustrated herein (including circuits external to the products and transformer construction) may be covered by one or more U.S. and foreign patents or potentially by pending U.S. and foreign patent applications assigned to Power Integrations. A complete list of Power Integrations’ patents may be found at www.powerint.com.

The PI Logo, **TOPSwitch**, **TinySwitch**, **LinkSwitch**, and **EcoSmart** are registered trademarks of Power Integrations. **PI Expert** and **DPA-Switch** are trademarks of Power Integrations.

© Copyright 2003, Power Integrations.

---

**WORLD HEADQUARTERS**
Power Integrations
5245 Hellyer Avenue,
San Jose, CA 95138, USA
Main: +1-408-414-9200
Customer Service:
Phone: +1-408-414-9655
Fax: +1-408-414-9765
e-mail: usasales@powerint.com

**CHINA (SHENZHEN)**
Power Integrations
International Holdings, Inc.
Rm# 1705, Bao Hua Bldg.
1016 Hua Qiang Bei Lu,
Shenzhen, Guangdong,
518031, China
Phone: +86-755-8367-5143
Fax: +86-755-8377-9610
e-mail: chinasales@powerint.com

**GERMANY**
Power Integrations, GmbH
Rueckerstrasse 3,
D-80336, Munich, Germany
Phone: +49-89-527-3910
Fax: +49-89-527-3920
e-mail: eurosales@powerint.com

**ITALY**
Power Integrations s.r.l.
Via Vittorio Veneto 12,
Bresso, Milano,
20091, Italy
Phone: +39-028-928-6001
Fax: +39-028-928-6009
e-mail: eurosales@powerint.com

**JAPAN**
Power Integrations, K.K.
Keihin-Tatemono 1st Bldg.
12-20 Shin-Yokohama,
2-Chome,
Kohoku-ku, Yokohama-shi,
Kanagawa 222-0033, Japan
Phone: +81-45-471-1021
Fax: +81-45-471-3717
e-mail: japansales@powerint.com

**KOREA**
Power Integrations
International Holdings, Inc.
8th Floor, DongSung Bldg.
17-F-3, No. 510,
Chung Hsiao E. Rd., Sec. 5,
Taipei, Taiwan 110, R.O.C.
Phone: +886-2-2727-1221
Fax: +886-2-2727-1223
e-mail: tawansales@powerint.com

**SINGAPORE (ASIA PACIFIC HEADQUARTERS)**
Power Integrations, Singapore
51 Newton Road,
#15-08/10 Goldhill Plaza,
Singapore, 308900
Phone: +65-6358-2160
Fax: +65-6358-2015
e-mail: singaporesales@powerint.com

**UK (EUROPE & AFRICA HEADQUARTERS)**
Power Integrations
1st Floor, St. James’s House
East Street
Farnham, Surrey GU9 7TJ
United Kingdom
Phone: +44-1252-730-140
Fax: +44-1252-727-689
e-mail: eurosales@powerint.com

---

**APPLICATIONS HOTLINE**
World Wide +1-408-414-9660

**APPLICATIONS FAX**
World Wide +1-408-414-9760