

# DI-178 Design Idea

## LinkSwitch-LP

### 2.4 W, Low Cost, High Efficiency Linear Replacement Power Supply

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
Microwave Oven	LNK564PN	2.4 W	90 – 265 VAC	12 V	Flyback

#### Design Highlights

- Low cost, low component count, compact, lightweight linear replacement power supply
  - No optocoupler required
- Highly energy efficient
  - Meets CEC 2008 requirements for active mode efficiency (66% vs 57.9% requirement)
  - Low input power at no-load (<300 mW at 265 VAC)
- Meets CISPR-22/EN55022 B conducted EMI limits with >8 dB $\mu$ V margin (see Figure 3)

#### Operation

The LinkSwitch-LP based flyback power supply shown in Figure 1 generates a single isolated DC output voltage from a 90 VAC to 265 VAC input voltage range. The power supply output is 12 V, 200 mA (2.4 W) and has a constant-voltage/constant-current (CV/CC) characteristic. Typical applications may include house-keeping power supplies for microwave ovens or other white goods.

Diodes D1, D2, D3 and D4, together with capacitors C1 and C2, rectify and smooth the AC input voltage. Resistor RF1 is a fusible, flameproof type, providing protection from primary-side short

circuit and line surge withstand capability. EMI filtering is provided by C1, C2, C7, and L1. The integrated frequency jitter feature of U1, along with transformer E-Shield™ techniques, allows such simple EMI filtering to comply with EN55022B limits (see Figure 3).

The primary clamp circuit (D5, R1, and C3) limits the maximum peak drain voltage to less than the 700 V  $BV_{DSS}$  rating of the internal MOSFET.

The LNK564PN (U1) operates at a constant current limit, providing cycle-by-cycle limitation of the primary current. The internal controller regulates the output voltage by skipping switching cycles (ON/OFF control) whenever the output voltage is above the reference level. During normal operation, MOSFET switching is disabled whenever the current flowing into the FEEDBACK (FB) pin is greater than 70  $\mu$ A. If a current less than 70  $\mu$ A flows into the FB pin when the oscillator's (internal) clock signal occurs, MOSFET switching is enabled for that particular switching cycle and the MOSFET turns on. That switching cycle terminates when the current through the MOSFET reaches  $I_{LIMIT}$ . By adjusting the ratio of enabled to disabled switching cycles, the output voltage is regulated.

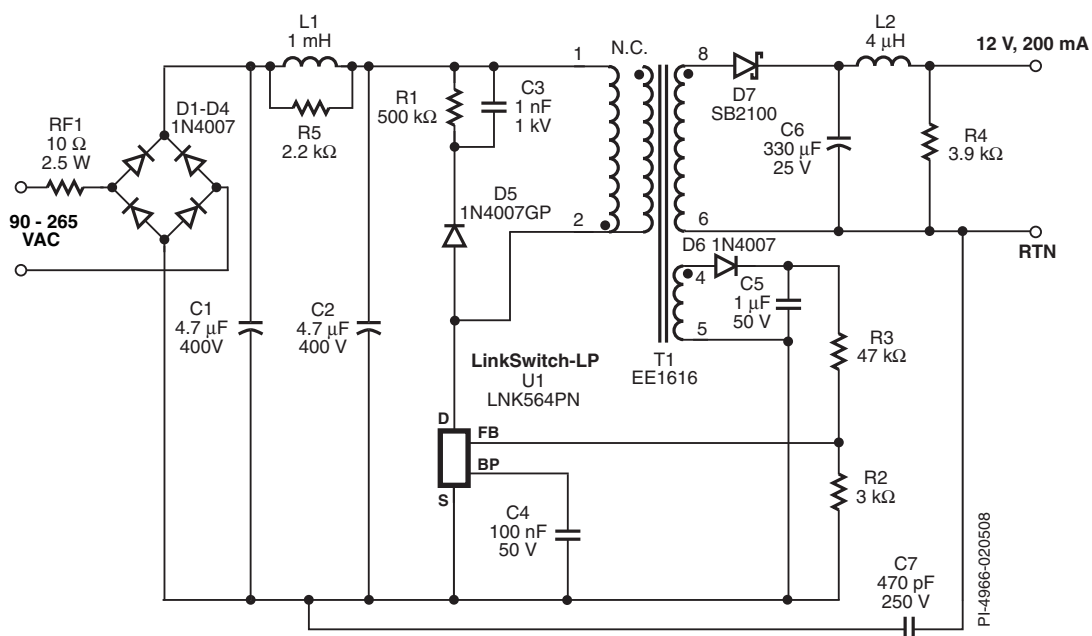


Figure 1. Schematic of a 12 V, 200 mA Power Supply Using LinkSwitch-LP, LNK564PN.

At increased loads beyond the rated power threshold, the FB pin voltage begins to reduce as the power supply output voltage falls. The internal oscillator frequency is linearly reduced in this region until the FB pin voltage reaches the auto-restart threshold voltage (typically 0.8 V on the FB pin, which is equivalent to 1 V to 1.5 V at the output of the power supply). This function limits the output current in this region without foldback.

A bias winding is used to provide feedback to U1. Resistors R2 and R3 should be chosen with 1% tolerance for best voltage and current accuracy. No optocoupler is required.

### Key Design Points

- Verify that the maximum drain voltage is <650 V at high line and maximum overload condition. Adjust the values of R1 and C3 as necessary. However, avoid making the clamp circuit too dissipative (i.e., low value of R1 and high value of C3), as this will increase the no-load power consumption.
- A slow blocking diode was selected for D5. Use only a glass passivated (GP) diode type to ensure a reverse recovery time of 2  $\mu$ s or less. If unavailable, a fast diode such as FR107 may be substituted. These diode selections recycle some of the clamp energy and increase overall efficiency.
- The post filter formed by L2 and R4 is optional and is used to reduce switching frequency ripple on the output voltage waveform.
- Output voltage regulation was 12 V to 17 V across load and line variation.

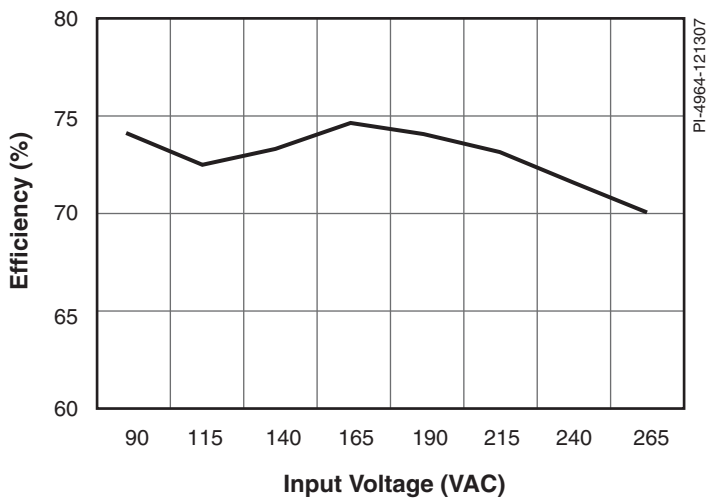


Figure 2. Efficiency (at Full Load) vs Line Voltage (VAC).

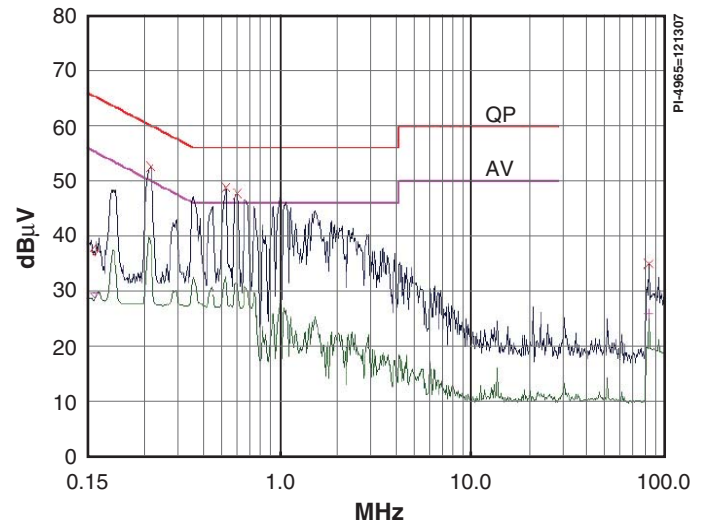


Figure 3. Conducted EMI Scan to EN55022 B Limits. Measurements Made at 230 VAC With Output RTN Floating.

### Transformer Parameters

<b>Core Material</b>	EE1616 NC-2H or equivalent, gapped for ALG of 236 nH/t <sup>2</sup>
<b>Bobbin</b>	EE16, 8 pin, Horizontal
<b>Winding Details</b>	Bias: 29T $\times$ 1, 0.2 mm, tape Primary: 120T $\times$ 1, 0.15 mm, tape Shield: 12T $\times$ 2, 0.25 mm, 2 layers tape 12 V: 14T $\times$ 1, 0.3 mm TIW, tape
<b>Winding Order</b>	Bias (3–4), Primary (2–1), Shield (NC–2), 12 V (8–6)
<b>Primary Inductance</b>	3440 $\mu$ H, $\pm$ 10%
<b>Primary Resonant Frequency</b>	600 kHz (minimum)
<b>Leakage Inductance</b>	130 $\mu$ H (maximum)

Table 1. Transformer Parameters. (AWG = American Wire Gauge, TIW = Triple Insulated Wire, NC = No Connection)

Power Integrations  
5245 Hellyer Avenue  
San Jose, CA 95138, USA.  
Main: +1 408-414-9200  
Customer Service  
Phone: +1-408-414-9665  
Fax: +1-408-414-9765  
Email: usasales@powerint.com

On the Web  
www.powerint.com

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. POWER INTEGRATIONS MAKES NO WARRANTY HEREIN AND SPECIFICALLY DISCLAIMS ALL WARRANTIES INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF THIRD PARTY RIGHTS. The products and applications illustrated herein (transformer construction and circuits external to the products) 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). Power Integrations grants its customers a license under certain patent rights as set forth at <http://www.powerint.com/ip.htm>.

The PI logo, TOPSwitch, TinySwitch, LinkSwitch, DPA-Switch, PeakSwitch, EcoSmart, Clampless, E-Shield, Filterfuse, StackFET, PI Expert and PI FACTS are trademarks of Power Integrations, Inc. Other trademarks are property of their respective companies. ©2007, Power Integrations, Inc.