DI-154 Design Idea
LinkSwitch®-LP

3 W, Low Cost High Efficiency CV/CC Charger

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
Hair Clippers	LNK564PN	3 W	90 – 265 VAC	2 V	Flyback

Design Highlights

- High efficiency (>60% at full load)
- Low cost, low component count, compact, lightweight linear replacement power supply
  - No opto-coupler required
  - No CC sensing resistors required
- Highly Energy efficient
  - Meets CEC/ENERGY STAR 2008 requirements for active mode efficiency (64% vs 59% required)
  - Low input power at no-load (<300 mW at 230 VAC vs 500 mW requirement)
- Excellent CV/CC characteristics over temperature
- Meets CISPR-22/EN55022 B conducted EMI limits with >8 dBμV margin.

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 2 V, 1.5 A (3 W) and has a constant-voltage/constant-current (CV/CC) characteristic. Typical applications may include chargers for clippers and hair trimmers that use single rechargeable batteries.

Diodes D1, D2, D3 and D4, together with capacitors C1 and C2, rectify and smooth the AC input voltage.

Differential EMI filtering is provided by C1, C2, L1 and L3. The integrated frequency jitter feature of U1, along with transformer E-Shield techniques, allows such simple EMI filtering to meet compliance with EN55022B limits (see Figure 3).

The primary clamp circuit (D7, R2, R3, and C4) limits the maximum peak drain voltage to less than the 700 V BV_{DSS} rating of the internal MOSFET. Resistor R3 attenuates high-frequency leakage inductance ringing and thereby reduces EMI.

The LNK564PN 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. The feedback input circuit at the FB pin consists of a low impedance source follower output set at 1.69 V. During normal operation, MOSFET switching is disabled whenever the current flowing into the FEEDBACK (FB) pin is greater than 70 μA. If a current less than 70 μA flows into the FB pin when the oscillator's 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.

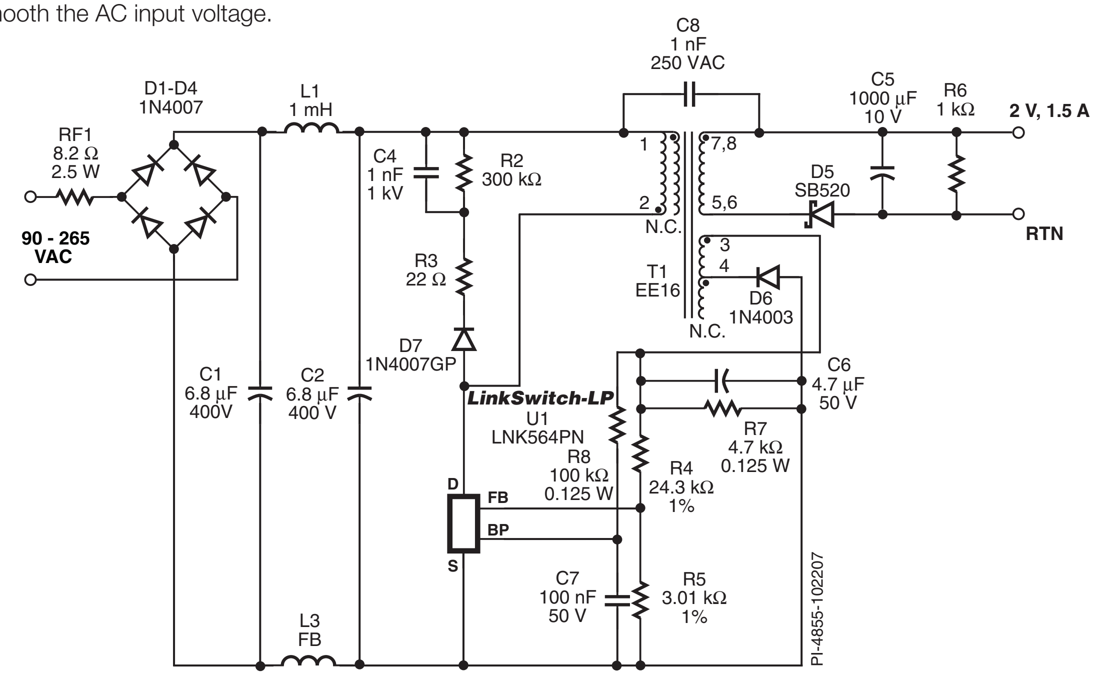

Figure 1. Schematic of a 2 V, 1.5 A CV/CC Charger Using LNK564PN.

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A bias winding is used to provide feedback to U1. Resistors R4 and R5 should be chosen with 1% tolerance for best voltage and current accuracy. No opto-coupler or CC sense resistor is required to obtain the CV/CC characteristic shown in Figure 2.

To provide constant current regulation at the programmed CC set point, the switching frequency of U1 is reduced linearly as the voltage on the FB reduces below 1.69 V until the unit enters auto-restart at an FB pin voltage of 0.8 V.

Diode D5 rectifies the output from transformer T1. This rectifier is a low drop Schottky diode in order to maximize efficiency. This is particularly significant for this design due to the low output voltage. Output filtering is provided by a low ESR type capacitor, C5. Resistor R6 is a pre-load resistor.

Key Design Points

- Verify that the maximum drain voltage is <650 V at high line and maximum overload conditions. Adjust the values of R2 and C4 as necessary. However, avoid making the clamp circuit too dissipative (i.e., low value of R2 and high value of C4), as this will increase the no-load power consumption.
- Use PIXls spreadsheet to create a complete transformer design.
- A slow blocking diode was selected for D7, with a 22 Ω series resistor. Use only a glass passivated (GP) diode type to ensure a reverse recovery time of 2 µs 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.
- To save space and lower leakage, the shield winding is tapped off the bias winding and placed alongside it on the same layer.

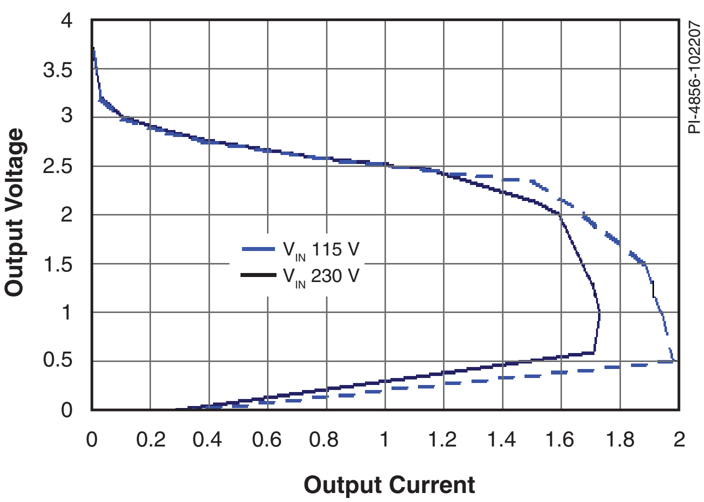

Figure 2. Output VI Characteristics Across Line Voltage (Measured at Ambient Temperature) .

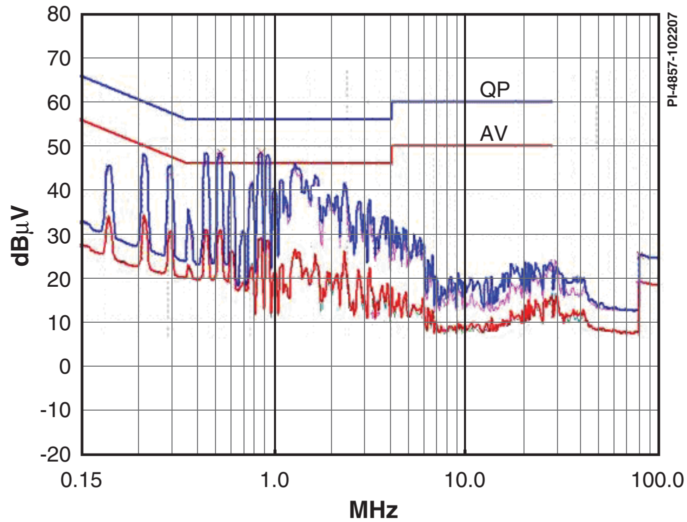

Figure 3. Conducted EMI scan to EN55022 B Limits. Measurements Made at 230 VAC With Output RTN Connected to Artificial Hand Representing Worst Case Conditions.

Transformer Parameters

Core Material	EE16 NC-2H or equivalent, gapped for ALG of 197 nH/t^2
Bobbin	EE16, 8 pin
Winding Details	Bias*: 16T x 2, AWG 26 Shield*: 10T x 2, AWG 26, 1 layer tape Primary: 145T x 1, AWG 36, 1 layer tape Shield: 4T x 4, AWG 28, 1 layer tape 2 V: 3T x 4, AWG 27 TIW, 3 layers tape
Winding Order	Bias (3–4), Shield (4-NC), Primary (2–1), Shield (1-NC), 2 V (7,8–5,6)
Primary Inductance	4166 µH, ±5%
Primary Resonant Frequency	600 kHz (minimum)
Leakage Inductance	130 µH (maximum)

** Bias and Shield windings Placed on the Same Layer.*

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

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