

DI-135 Design Idea

LinkSwitch[®]-XT

2.75 W, High Efficiency CV/CC Output USB Charger

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
USB Charger	LNK363DN	2.75 W	90 – 264 VAC	5 V	Flyback

Design Highlights

- Standard USB Output Connector
- High Efficiency (> 60% at Full load)
- Meets CEC/ENERGY STAR 2008 requirements for active mode efficiency (63% vs 59.1% requirement)
- Low input power at no-load (< 200 mW at 230 VAC)
- Excellent CVCC characteristics over temperature
- Meets all Chinese USB charger specifications
- Meets CISPR-22/EN55022 B conducted EMI limits with > 10 dB μ V margin, without using a Y-capacitor

Operation

The LinkSwitch-XT based flyback power supply shown in Figure 1 generates a single isolated DC output voltage from a 90 VAC to 264 VAC input voltage range. The power supply output is 5 V, 550 mA (2.75 W) constant-voltage/constant-current (CV/CC). Typical applications include cell phone chargers, portable audio players, digital cameras or other products with a USB charger interface. 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 L2. The integrated frequency jitter feature of U1, along with transformer E-Shield techniques, allows such simple EMI filtering to meet compliance with EN55022B, even without a Y-capacitor across the primary to secondary isolation barrier (see Figure 3).

The primary clamp (D6, R1, R2, and C3) limits the maximum peak drain voltage to less than the 700 V B_{VDS} rating of the internal MOSFET. Resistor R2 damps the high-frequency leakage inductance ringing and thereby reduces EMI. Resistor R3 and capacitor C5 form a snubber network across the secondary diode and reduce high frequency conducted as well as radiated EMI.

The output voltage (CV operation) is regulated by a reference shunt regulator (U2). Resistors R6 and R8, both 1% resistors, program the output voltage to 5 V. Resistor R7 and capacitor C7 provide loop compensation. The constant-current (CC operation) is provided by sensing the voltage across sense resistors R4 and R9. Resistor R5 limits the opto-coupler current during transients and provides supply current for U2. At the programmed CC set point, the voltage across resistors R4 and R9 exceeds the opto-coupler diode voltage drop and controls transitions from CV to CC operation, giving the constant current characteristic shown in Figure 2.

In both CV and CC operation, regulation is maintained by cycle skipping. When the optocoupler current fed into the FB pin of U1 exceeds 49 μ A at the start of a new switching cycle, then that switching cycle is disabled or skipped. By adjusting the ratio of enabled to disabled switching cycles, regulation is provided. This control method also maximizes efficiency as the effective switching frequency reduces with load, optimizing switching losses.

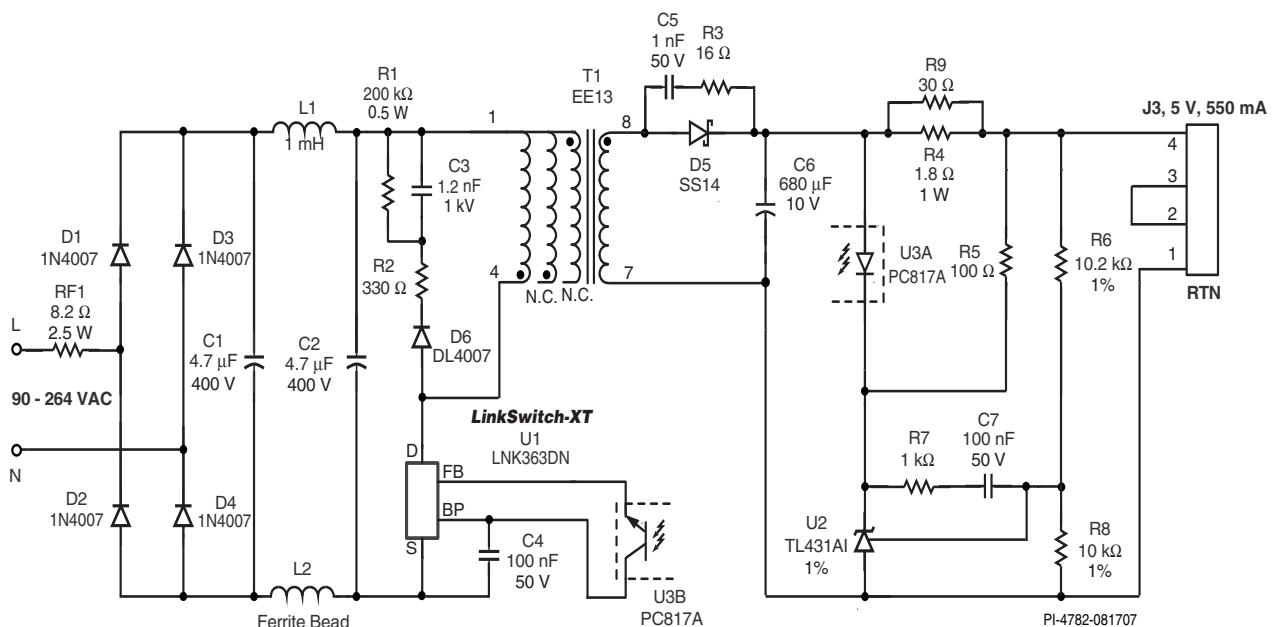


Figure 1. Schematic of a 5 V, 550 mA USB charger using LinkSwitch-XT, LNK363DN.

The switching device U1 (LNK363DN) is an industry standard SO-8 (D) package allowing for a very compact design with no external heatsink required. (The second suffix, N, indicates a lead free device).

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 standard recovery blocking diode was selected for D6, with a 330 ohm series resistor. Use only a Glass Passivated (GP) diode type to ensure a reverse recovery time of 2 μ s or less. If a GP diode type is unavailable, a fast recovery diode such as FR107 may be substituted. These diode selections recycle some of the clamp energy and increase efficiency.
- A 1% reference Shunt regulator (U2) was selected for better CV regulation.
- Use PIXIs spreadsheet to create a complete transformer design. Keep the maximum flux density BM < 1500 Gauss (150 mT) to minimize audible noise.

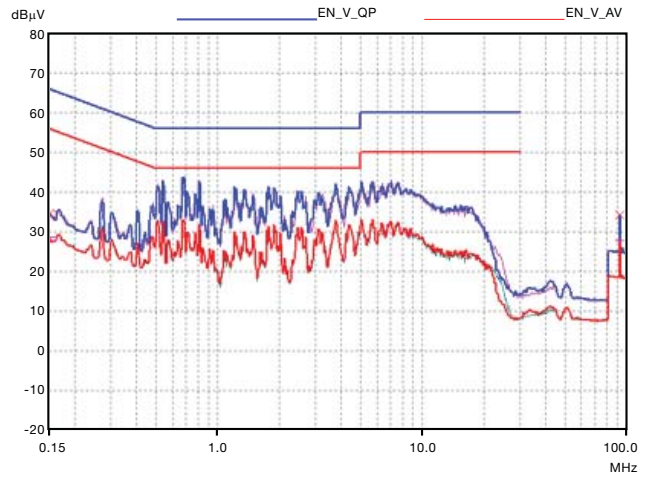


Figure 3. Conducted EMI scan to EN55022 B Limits. Measurements made at 230 VAC with output RTN connected to Earth Ground representing worst case conditions.

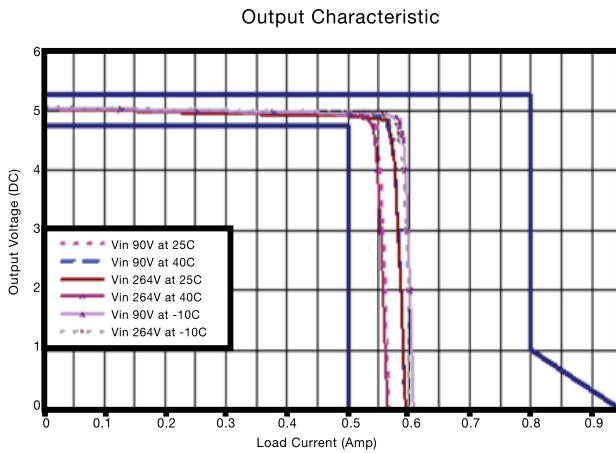


Figure 2. Output VI Characteristics Across Line Voltage and Ambient Temperature.

Transformer Parameters

Core Material	EE13 NC-2H or equivalent, gapped for ALG of 71 nH/t ²
Bobbin	EE13, 8 pin
Winding Details	Shield: 44T x 1, AWG 37, tape Primary: 159T x 1, AWG 37, 2 layers, tape Shield: 7T x 1, AWG26 Secondary 11T x 1, AWG32 TIW
Winding Order	Shield (1 - NC), Primary (4 - 1), Shield(NC - 1), Secondary (8 - 7)
Primary Inductance	1800 μ H, \pm 10%
Primary Resonant Frequency	50 kHz (minimum)
Leakage Inductance	100 μ H (maximum)

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

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