DI-210 Design Idea
LinkSwitch®-TN

High Efficiency, Constant Current, LED Driver Using the Boost Topology

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
LED Lighting	LNK306PN	11 W	85 – 265 VAC	554 V	Boost

Design Highlights

- Constant current output is ideal for driving LEDs
- High output voltage allows a single LED string – eliminates need to consider current sharing between LEDs
- Protected against disconnected load, short circuit and over temperature
- Very high efficiency (>80%) throughout operating range. (see Figure 2)
- Compact, lightweight, inexpensive, low part count design
- No transformer needed – simple off the shelf single inductor
- Meets EN55022B limits for conducted EMI (see Figure 3)

Operation

The power supply shown in Figure 1 uses a LinkSwitch-TN device in a boost converter configuration to deliver a constant current of 20 mA from a single positive voltage of 554 VDC referenced to the neutral input line. The supply provides an ideal solution for driving a single LED string.

Fusible resistor RF1, provides catastrophic failure protection and also limits input inrush when AC is first applied. Diode D1 is used to provide half wave rectification of the input AC voltage. Capacitors C2, C3 and inductor L2 form a pi π filter arrangement and reduce conducted EMI.

During the on time of LNK306 (U1), current ramps through the input section formed by U1 and boost inductor L1. The voltage across inductor L1 is equal to the rectified and filtered voltage across C3 (V_{IN}). This current ramp results in energy storage in inductor L1.

During U1's off time, in order to maintain the same inductor current, the polarity across L1 reverses, D2 is forward biased and current is delivered into C1 and the load. During the off-time of U1 the voltage across L1 is the difference between the output voltage and input voltage. It can be seen this voltage appears in series with the imput voltage (across C3) and therefore this configuration provides a step-up of the input voltage (boost).

Boost diode D2 is a high voltage ultra-fast recovery type diode. C1 acts as the output filter capacitor. VR1, VR2, VR3 are used to limit the output voltage to 600 V in case of open load or open loop fault conditions. Capacitor C5 and resistor R2 form an RC snubber circuit which is used to reduce conducted EMI contribution from the switching events involving D2.

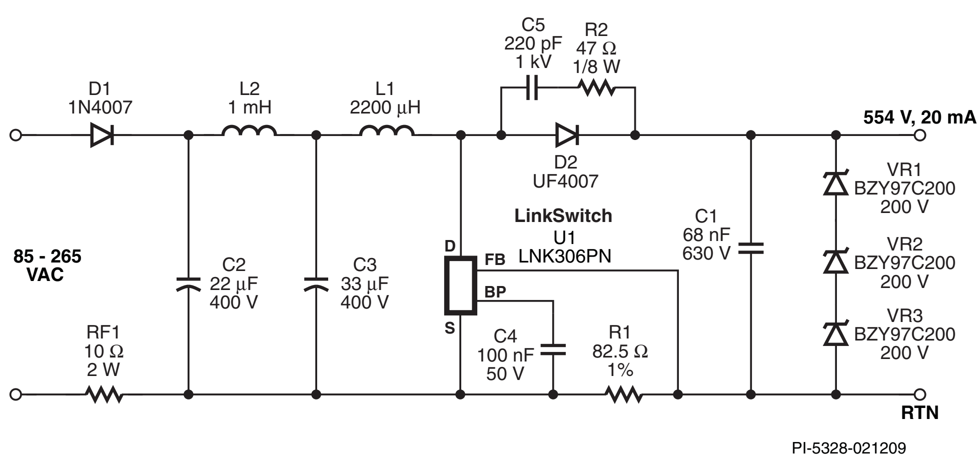

Figure 1. Schematic of a 554 V, 11 W Constant Current Boost Converter for Driving LED Arrays.

Inductor L1 is the boost inductor and its minimum value can be calculated using the expression

$$L_{MIN} = \frac{2 \times P_O}{I_{LIM}^2 \times F_{S(MIN)}}$$

Where P_O is the output power, I_{LIM} is the minimum current limit and $F_{S(MIN)}$ the minimum switching frequency of U1.

In this design a standard off the shelf 2200 µH inductor was used.

Resistor R1 acts as a current sensing resistor, the voltage developed being sensed by the FB pin. Output regulation is maintained by an ON/OFF control scheme whereby switching cycles are enabled and disabled (skipped) in response to changing line and load conditions. The feedback (FB) pin of U1 is sampled at the beginning of each cycle. If current in excess of 49 µA is delivered into the FB pin the current cycle is skipped.

Key Design Points

- Select diode D2 to be an ultrafast type with a reverse recovery time (t_{RR}) of 75 ns or less and a peak inverse rating in excess of V_{OUT}. In order to minimize D2 reverse recovery current spikes at turn on of U1 this design is operated in the discontinuous conduction mode.
- Fusible resistor RF1 should be a wire-wound flameproof type to survive both inrush and differential line surge conditions.
- The values of capacitors C2 and C3 can be greatly reduced by using full wave rectification of the AC input.
- Capacitor C4 is the bypass capacitor for the U1 and should be placed physically close to its Source and BP pins.
- Select output capacitor C1 based on the output ripple current requirement. If V_{RIPPLE} is the desired ripple then the output capacitor can be estimated as

$$C_{OUT} = \frac{L_{MAX} \times I_{LIM}^2}{(V_{OUT} - V_{RIPPLE})^2 \times V_{OUT}^2} \qquad \text{where}$$

Where L_{MAX} is the maximum value of boost inductor (to factor for tolerance of the inductor), I_{LIM} is the maximum current limit of U1 and V_{OUT} is the output voltage.

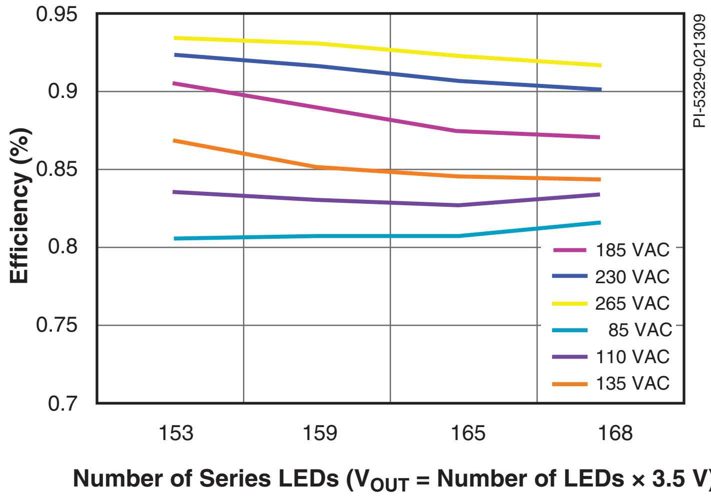

Figure 2. Efficiency vs. Input Voltage and Number of LEDs in String.

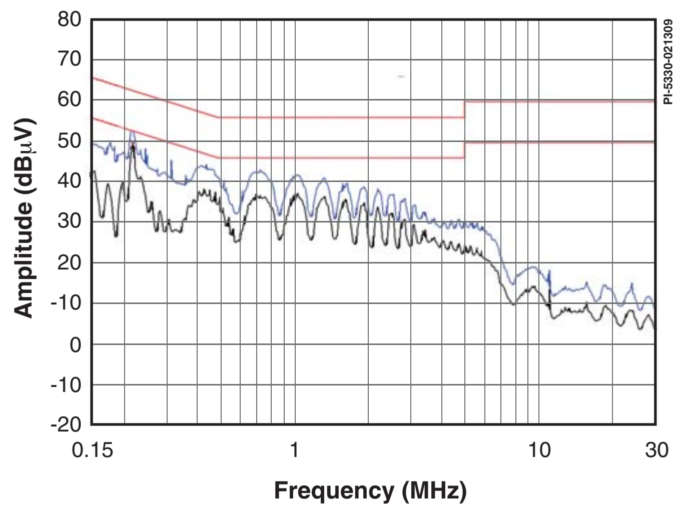

Figure 3. Worst Case EMI Plot. 230 VAC, Shown Full Load with EN55022B Limits.

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