

DI-173 Design Idea

TinySwitch-III

14 W, LED Driver Power Supply With High Efficiency

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
LED Driver	TNY279GN	14 W	195 – 265 VAC	20 V	Flyback

Design Highlights

- High ambient temperature operation (75 °C)
- Highly energy efficient
 - Meets EU CoC/CEC 2008/ENERGY STAR 2.0 requirements
 - Active mode efficiency (86% vs 79.6% requirement)
 - No-load input power <250 mW (265 VAC) vs 300 mW requirement
- Hysteretic over-temperature shutdown protection
- Disconnected load protection
- Meets EN55015B conducted EMI limits with >8 dB μ V of margin (see Figure 3)

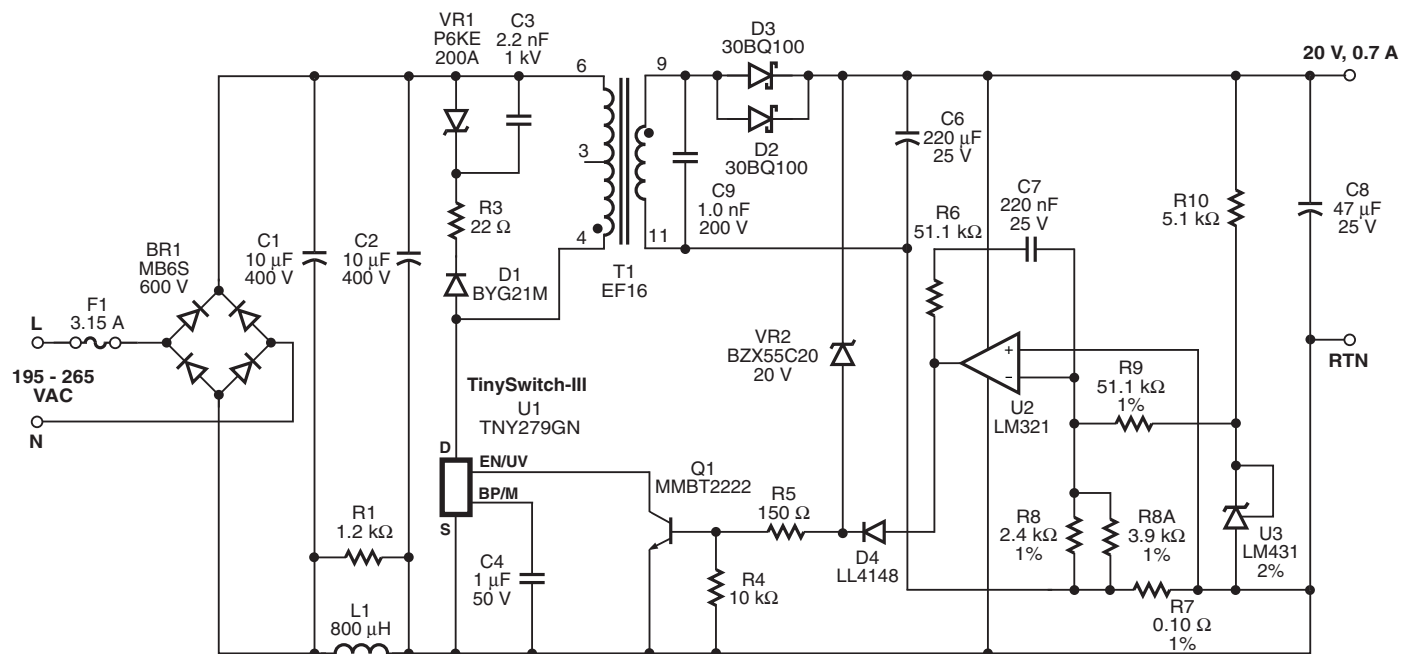
Operation

The schematic shown in Figure 1 is a 20 V, 14 W constant voltage (CV) and constant current (CC) output power supply. The light output from an LED array is proportional to the current flowing through it. As such, LED drivers should have a constant current as opposed to a constant voltage output. In this design, the DC output is not isolated from the AC input, and therefore the LED array and enclosure must provide safety isolation from the user.

The AC input is rectified and filtered by BR1, C1 and C2. Inductor L1 forms a π filter with C1 and C2 and provides EMI filtering. Fuse F1 provides protection against catastrophic failure.

To allow the supply to operate unloaded without damage, CV regulation at ~21 V is provided by Zener diode VR2.

The CC characteristic is achieved by sensing the voltage drop across the current sense resistor R7. Shunt regulator IC U3, together with R9, R8 and R8A, is used to generate an accurate voltage reference of 0.07 V at the inverting input of op-amp U2. At the programmed current, the voltage across R7 exceeds the reference voltage, causing the op-amp output to rise. This forward biases D4, driving the base of Q1, which pulls current out of the EN/UV pin of U1. Capacitor C7 and resistor R6 provide loop compensation. An op-amp based current limit was used to minimize the current sense voltage and, therefore, losses to maximize efficiency.



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Figure 1. Schematic of 14 W LED Driver Power Supply Using a TNY279GN in High Ambient Temperature Applications.

The MOSFET in U1 is disabled on a cycle by cycle basis (On/Off control) whenever the current drawn out of the EN/UV pin is $>115 \mu\text{A}$. By adjusting the ratio of enabled to disabled switching cycles, the feedback loop can regulate the output voltage or current. On/Off control also optimizes the efficiency of the converter across load to ensure compliance with energy efficiency standards.

Due to the high ambient temperature, U1 is operated in the reduced current limit mode. This allows for overall higher efficiency and better thermal management of the power supply.

The primary clamp (D1, VR1, C3 and R3) limits the maximum peak drain voltage to less than the 700 V BV_{DSS} rating of the internal MOSFET. Resistor R3 reduces high-frequency leakage inductance ringing and thereby EMI. On the secondary side, the output is rectified and filtered by diodes D2, D3 and C6.

Key Design Points

- Selecting a fast diode vs. an ultra-fast diode for D1 will improve efficiency by recovering some of the leakage energy.
- Capacitor C9 is used to improve EMI.
- Resistor R10 is selected to provide a supply current of 1 mA to U3 at a minimum output voltage of 6 V.
- The selectable current limit of U1 allows the current limit and device size to be optimized for the thermal environment. For example, to reduce dissipation, the TNY280GN device could be used in the same design by changing C4 from 1 μF to 0.1 μF . Alternatively, in a less thermally challenging environment, the TNY278GN could be used by changing C4 from 1 μF to 10 μF .
- The supply correctly operates over an LED string voltage of 6 V to 20 V. However, lower string voltages result in lower output power as output current remains constant.

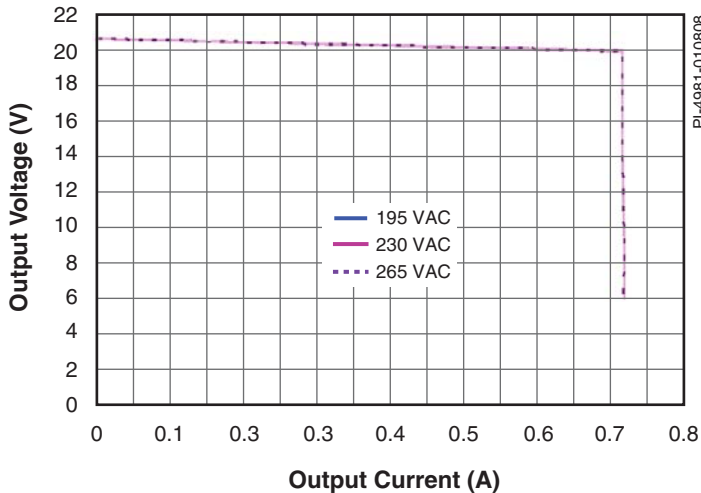


Figure 2. Measured Output CVCC Characteristic.

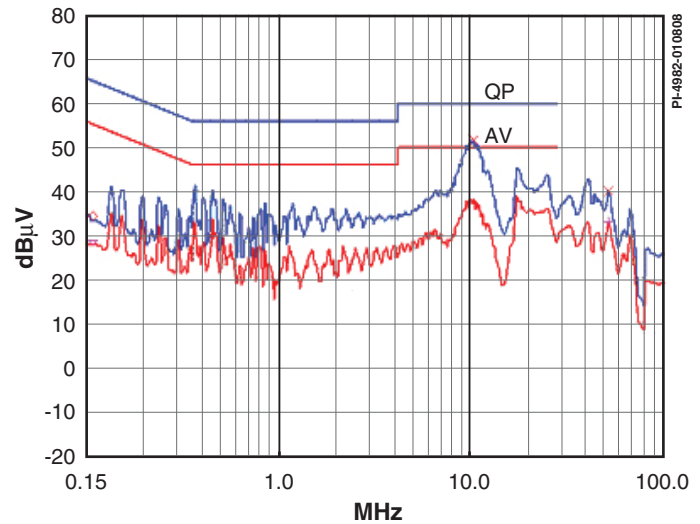


Figure 3. Conducted EMI Scan to EN55022 B Limits. Measurements Made at 230 VAC With Output RTN Connected to Earth Ground Representing Worst Case Conditions.

Transformer Parameters

Core Material	EF16 NC-2H or equivalent, gapped for ALG of 73 nH/t ²
Bobbin	EF16, 12 pin, Horizontal
Winding Details	Primary-1: 61T × 1, AWG31, tape 20 V: 20T × 2, AWG27, tape Primary-2: 61T × 1, AWG31, tape
Winding Order	Primary-1 (4–3), 20 V (9–11), Primary-2 (3–6)
Primary Inductance	1082 μH , $\pm 10\%$
Primary Resonant Frequency	1 MHz (minimum)
Leakage Inductance	30 μH (maximum)

Table 1. Transformer Parameters.
(NC = No Connection)

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