Design Idea DI-77
TinySwitch®-II 3 W Adapter: <200 mW No-Load Consumption

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
Adapter	TNY263P	3 W	85-265 VAC	9 V / 330 mA	Flyback

Design Highlights

- Replaces a linear transformer based power supply at the same or lower cost, but with much higher performance
- <200 mW no-load consumption (at 115/230 VAC)
- Meets CISPR 22-B with >15 dB margin, w/o Y capacitor
- Low cost, low component count solution: only 24 parts!
- *TinySwitch-II* On/Off regulation scheme produces ±5% output regulation over temperature with a 2% Zener
- Does not require a transformer bias winding

Operation

This *TinySwitch-II* based flyback converter produces an isolated 3 W, 9 VDC output from an 85 VAC to 265 VAC input. Fusible resistor RF1 gives short circuit fault protection and limits startup inrush current. Inductors L1 and L2 and capacitors C1 and C2 form a low-cost pi (π) filter that attenuates conducted EMI. In addition, the internal frequency jitter of the *TinySwitch-II*, the use of shield windings, an output RC snubber, and a primary-side RCD clamp makes the circuit meet CISPR-22 Class B conducted EMI limits without a Y capacitor, resulting in a very low value of AC leakage current (<300 µA).

The key performance characteristic of this circuit is the extremely low no-load power consumption of <200 mW (a similarly rated linear transformer adapter will typically consume approximately 1 W under no-load). This low no-load consumption is the result of the inherent cycle skipping feature of the *TinySwitch-II* and careful transformer design.

Key Design Points

- Minimize secondary-side power consumption. Zener diode VR1 receives its bias current from the opto-LED in U2. Using a low current device minimizes consumption while providing an output voltage tolerance of ±5%. A TL431 can be used for tighter output voltage accuracy.
- Minimize clamp losses: design the transformer to have a low reflected voltage (V_{OR}). In this case, V_{OR} was set to ≈ 90 V.
- Minimize leakage inductance: select wire gauge sizes that completely fill each winding layer of the transformer.
- Minimize intra-winding capacitance and no-load consumption: put a layer of tape between each primary winding layer.
- Use >200 kΩ resistor in the RCD clamp to further reduce power losses if the following two conditions are met: 1) the EMI performance is not compromised, and 2) there is enough drain voltage (BV_{DSS}) margin for the internal MOSFET.

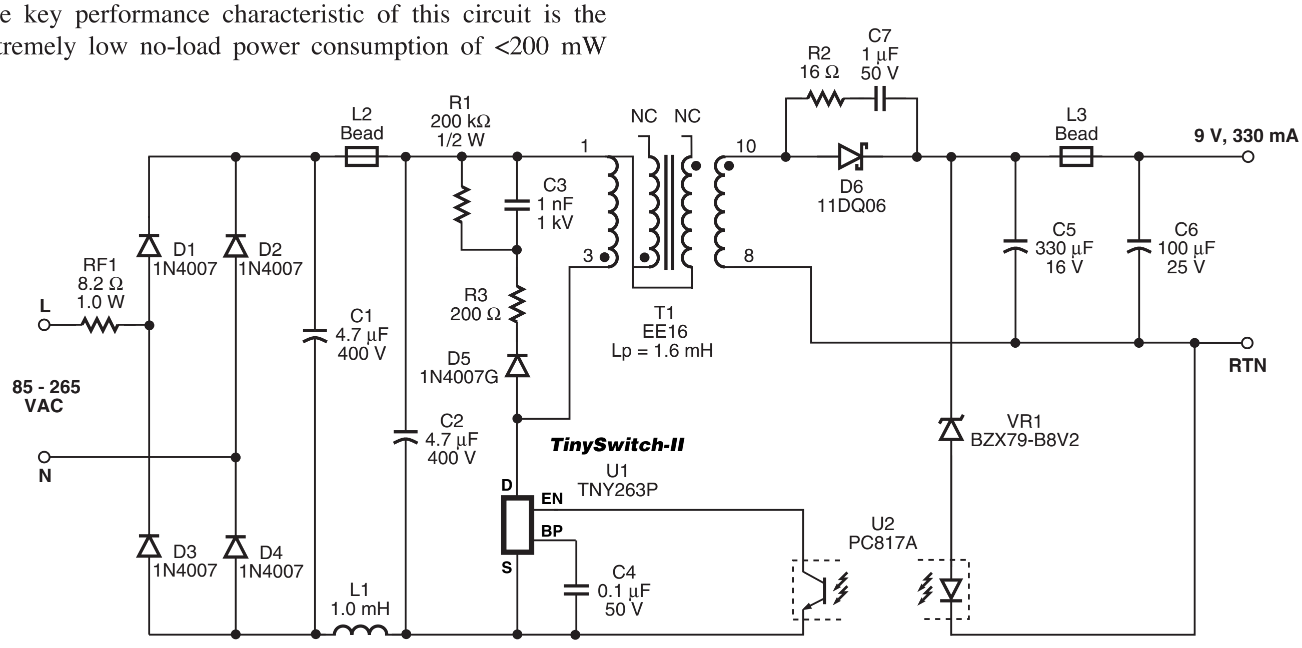

Figure 1. TinySwitch-II 3.0 W Adapter.

TRANSFORMER PARAMETERS	
Core Material	TDK PC40 EE16, A_L = 190 nH/T^2
Bobbin	EE16 Horizontal 10 pin
Winding Details	Core Cancellation: 26T, 2 x 36 AWG Primary: 46T + 46T, 35 AWG Shield: 8T, 2 x 26 AWG Secondary: 10T, T.I.W. 24 AWG
Winding Order (pin numbers)	Core Cancellation (1-NC), 2 x Tape, Primary (3-1), Tape, Shield (2-NC), 2 x Tape, Secondary (10-8)
Primary Inductance	1.60 mH ±10%
Primary Resonant Frequency	600 kHz (minimum)
Leakage Inductance	50 µH (maximum)

Table 1. Transformer Design Parameters.

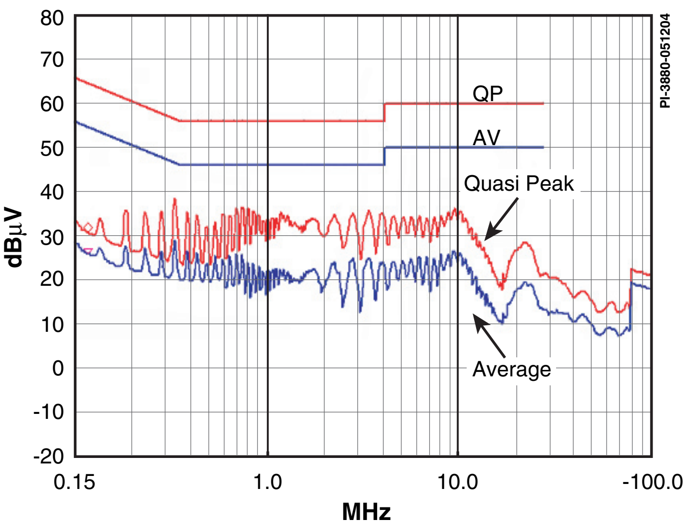

Figure 2. Conducted EMI, Full-Load, 230 VAC, Power Return Connected to "Artificial Hand" of LISN.

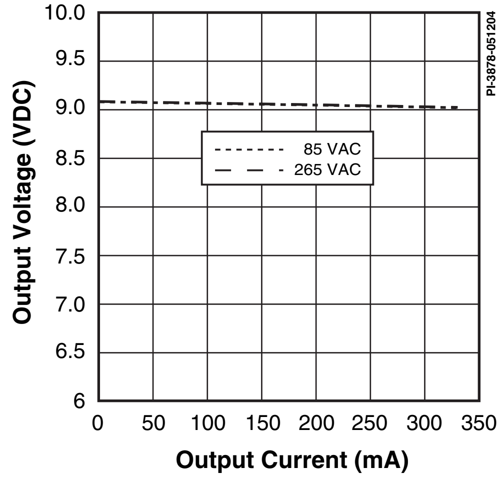

Figure 3. Load Regulation–CV Characteristics.

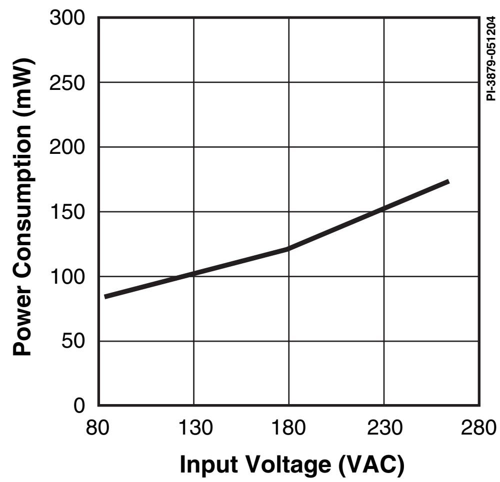

Figure 4. No-Load Input Power Variation with Input Voltage.

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