DI-177 Design Idea
TinySwitch®-III

9 W, High Ambient Temperature Supply for Oven Control

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
Oven Control	TNY279PN	9 W	165 – 265 VAC	9 V	Flyback

Design Highlights

- High ambient temperature operation (T_{AMB} = 105 °C)
- Highly energy efficient
  - Meets CEC 2008 requirements for active mode efficiency (82% vs 68.8% requirement)
  - No-load input power <150 mW at 265 VAC
- Extended protection features
  - Hysteretic over-temperature shutdown protection
  - Auto-restart functionality provides output short-circuit protection
- Meets EN55022B limits with >8 dBμV of margin

Operation

The high operating ambient temperature requires the supply to have high efficiency to reduce self heating. The TinySwitch-III is an excellent choice for such applications, in providing a high efficiency and low-cost solution.

The flyback power supply shown in Figure 1 can operate over an input voltage range of 165 - 265 VAC. It provides 9 V at 1 A of output current and is ideal for applications such as oven control, where high ambient temperatures are often encountered.

The AC input voltage is rectified by D1-D4 and then filtered by C1 and C2. Fuse F1 provides protection against catastrophic failure. Inductors L1, L3, and capacitors C1, C2 and C9 provide differential filtering. Common mode filtering is provided by Y capacitor C4.

The controller in U3 receives feedback from the secondary through optocoupler U2, and based on that feedback, it enables or disables the switching of its integrated MOSFET to maintain output regulation. Based on the output voltage, a current flows through VR2, R6, and the LED in U2. A proportional current is pulled out of the EN/UV pin. A switching cycle is skipped if the current out of the EN/UV pin exceeds the disable threshold current of 115 μA. When the current out of the EN/UV pin falls below the disable threshold, the subsequent switching cycle is enabled.

The disable threshold is modulated to reduce group pulsing and ensure evenly spaced-current pulses, thereby improving output ripple and overall efficiency. By adjusting the ratio of enabled and disabled pulses, regulation is maintained. This also optimizes the efficiency of the converter vs load.

To improve efficiency, U3 is operated in the reduced current limit mode. By adjusting the value of bypass capacitor C5, the device internal current limit can be programmed to a lower value. In the reduced current limit mode, the $R_{DS(ON)}$ losses of the MOSFET are reduced, which also increases the overall efficiency that is critical in this application.

Components D5, R1, R2, VR1 and C3 form the clamping circuit. This series arrangement of VR1 and R1 reduces clamp losses at

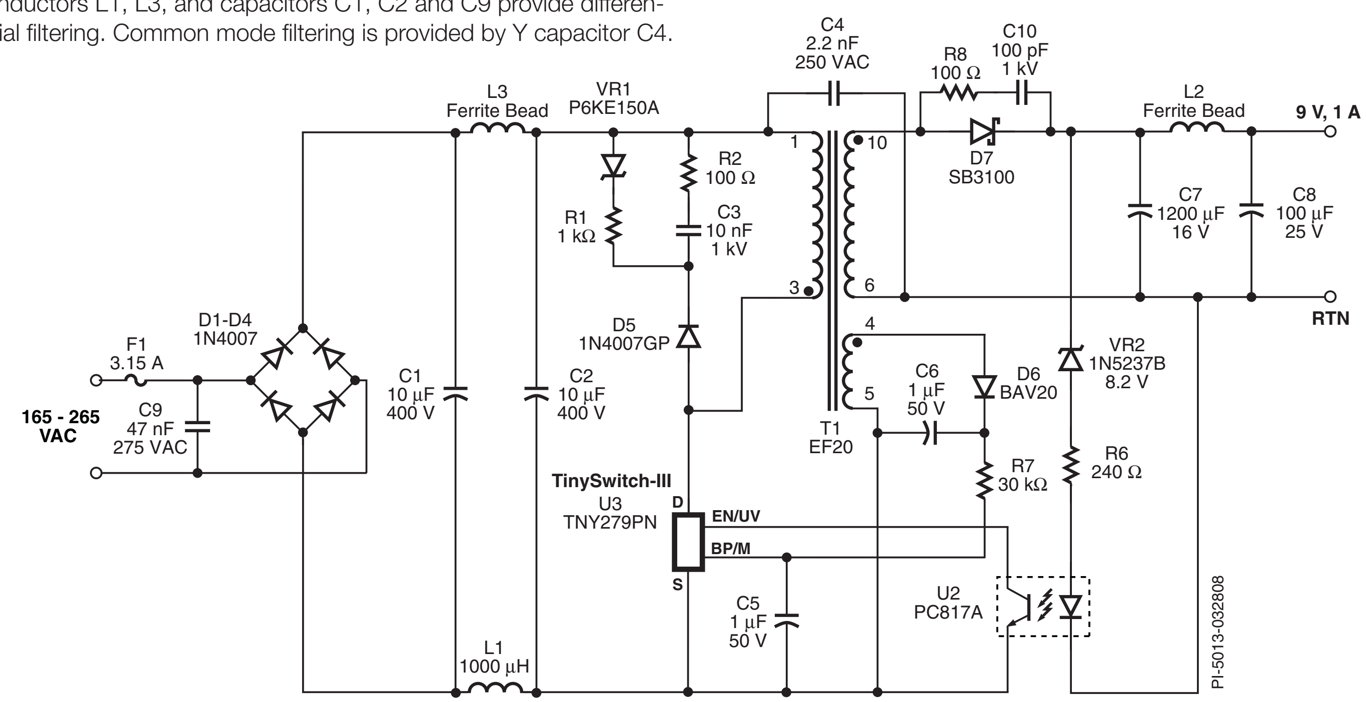

Figure 1: Schematic of 9 W Power Supply Using a TNY279PN in High Ambient Temperature Applications.

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no-load and standby. Resistor R2 damps excessive ringing, thereby improving EMI margin.

The output is rectified by diode D7 and filtered by low ESR capacitor C7. Post filtering (L2 and C8) further reduces switching ripple and noise on the main output.

The bias winding is also used to supply current to U3's BP/M pin during steady state operation. The value of R7 is selected to deliver the IC supply current to the BP/M pin, thereby inhibiting the internal high-voltage current source that normally charges the BP/M pin capacitor (C5). This results in reduced input power consumption under light load and no load conditions.

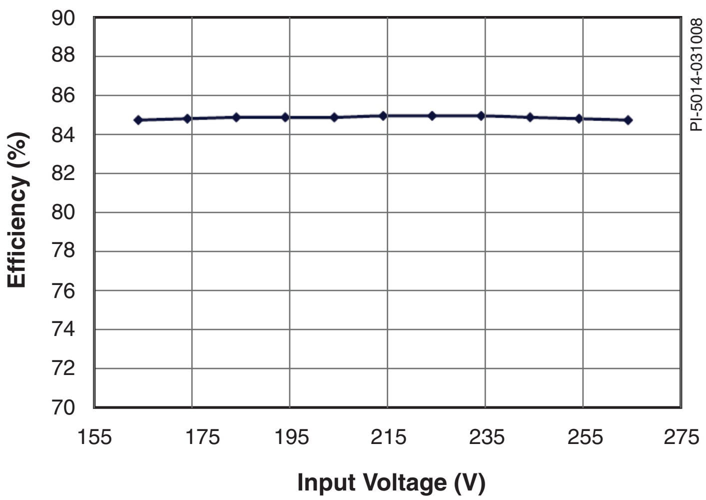

Figure 2. Efficiency vs Line Voltage.

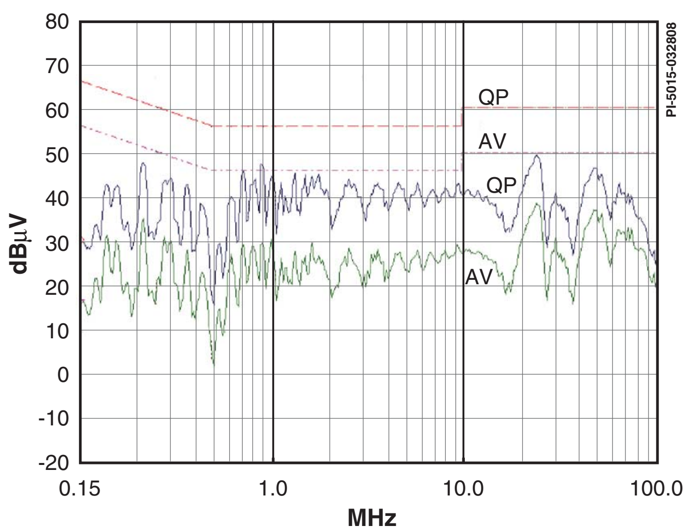

Figure 3. Worst Case EMI Measured at 230 VAC, With Artificial Hand Connected to Secondary Ground. EN55022B Limits Also Shown.

Key Design Points

- To improve efficiency, a larger device than required for power delivery was selected.
- Resistor R2 allows the use of a slow, low cost rectifier diode by limiting the reverse current through D5 when U3 turns on. The selection of a slow diode also improves conducted EMI immunity, but the diode should be a glass-passivated type with a recovery time of ≤2 µs. If glass passivated (1N4007GP) is unavailable, an FR107 may be used.
- Resistor R8 and capacitor C10 form the secondary snubber and help to reduce high frequency (radiated) EMI.
- Thermal design of the supply should be made such that the hottest component on the board is U3. The hysteretic temperature shutdown feature of U3 can thus ensure that overall temperature of the board is within acceptable limits.

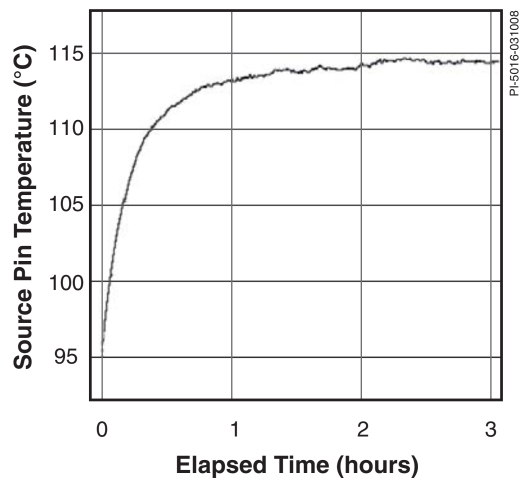

Figure 4. Source Pin Temperature vs Time Measured at Full Load and 165 VAC Input. (Ambient Temperature = 105 °C).

Transformer Parameters

Core Material	EF20 NC-2H or equivalent, gapped for ALG of 212 nH/t²
Bobbin	EF20, 10-pin Vertical
Winding Details	Primary: 57T × 1, 0.16 mm, tape Bias: 10T × 3, 0.25 mm, 2 layers tape 9 V: 9T × 2, 0.45 mm T.I.W., tape
Winding Order	Primary-1 (3–1), Bias (4–5), 9 V (10–6),
Primary Inductance	686 µH, ±12%
Primary Resonant Frequency	1 MHz (minimum)
Leakage Inductance	30 µH (maximum)

Table 1. Transformer Parameters. (TIW = Triple Insulated Wire)

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