DI-190 Design Idea
TOPSwitch®-HX

Very Low No-load Consumption Standby Power Supply

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
PC Standby / Auxillary Supply	TOP256MN	20 W	100 – 375 VDC	5 V	Flyback

Design Highlights

- Very low no-load power consumption <150 mW over entire input voltage range
- High efficiency
  - >84% efficiency over line and load
    - Easily meets CEC/ENERGY STAR 2.0
    - 81% and EU CoC
    - 83% average efficiency requirements
  - 77% efficiency at 0.25 A load
    - Easily meets Energy Star 5.0 2 W input power limit
  - 81% efficiency at 0.60 A load
    - Easily meets Energy Star 5.0 4 W input power limit
- Integrated safety/reliability features:
  - Accurate, auto-recovering, hysteretic thermal shutdown function maintains safe PCB temperatures under all conditions
  - Auto-restart protects against output short circuits and open feedback loops

Operation

The power supply shown in Figure 1 is a universal input, 20 W output flyback power supply using the TOP256MN device. Typical applications include PC standby power supplies and other designs needing very low no-load and standby power consumption.

The design is DC input, the rectification/PFC boost stage and EMI filtering provided by the main converter. However the design can be converted to AC input by adding an input inrush thermistor, fuse, bridge rectifier and common mode choke. The efficiency data presented included these components (1 A fuse, 5 Ω thermistor, 10 mH common choke and 1 A bridge recifier) to account for any additional losses. The 450 V rating of C1 was selected to provide margin when the supply is fed from a 385 V (nominal) output PFC stage.

Resistors R1 and R2 program the nominal undervoltage (UV) lockout and over-voltage (OV) shutdown limits to 103 VDC and 450 VDC respectively. Resistors R4, R5, and R10 set the current limit over line voltage.

To optimize efficiency under all load conditions U1 operates in one of four modes, from no-load to full load: multi-cycle modulation, fixed frequency PWM (30 kHz), variable frequency PWM and fixed frequency PWM (66 kHz). In all modes the controller maintains a linear relationship between duty cycle and control pin current so that the transition between modes is seamless. For extremely low power levels, U1 operates in the multi-cycle modulation mode (MCM) for excellent low load efficiency and no-load standby operation.

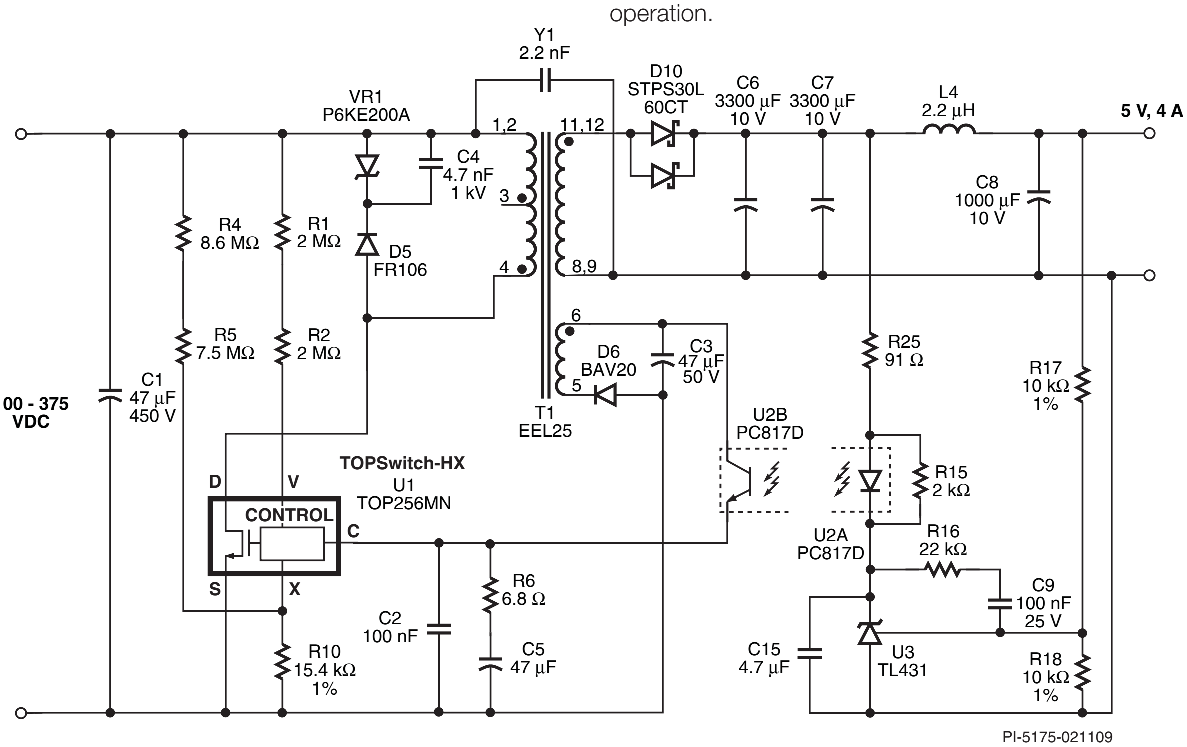

Figure 1. Universal Input, 20 W Output, PC Standby Power Supply, Using a TOP256MN Device.

Resistor R16, R17 and C9 set the frequency compensation of the feedback loop. Resistor R25 is the gain limiting resistor which controls the DC gain of the loop. The system bandwidth at 100 VDC is 2 kHz with a phase margin of 45°. At 400 VDC the bandwidth is 3.6 kHz with a phase margin of 60 °.

Key Design Points

- Clamp capacitor C4 in conjunction with fast diode D5 (FR106, t_{RR} = 500 ns) recycles some of the leakage inductance energy. The observed efficiency gain over a regular Zener clamp is approximately 0.4%. The capacitor also reduces the peak drain voltage by approximately 20 V.
- Optocoupler U2 has a high CTR of 300-600%. This reduces the current drawn from the secondary required to move the TOPSwitch-HX into variable frequency, low frequency mode or MCM mode during light load, standby load and no-load conditions.
- The transformer T1 is designed such that the design runs in the continuous conduction mode throughout the input voltage operating range. This helps minimizing MOSFET RMS current and thus improves efficiency.
- Transformer T1 uses a split two layer primary winding which is wrapped around the bias winding and the secondary winding. This minimizes leakage inductance and primary winding capacitance to improve no-load and standby performance.
- To minimize no load consumption, the bias winding turns are selected such that under worst case conditions of load and line the bias voltage is 8 V.
- Option:
  Using a TLV431 (U3) reduces minimum cathode current for regulation from 400 µA to 55 µA and would remove the need for R15. This would save an additional 10 mW from no-load. requirement.

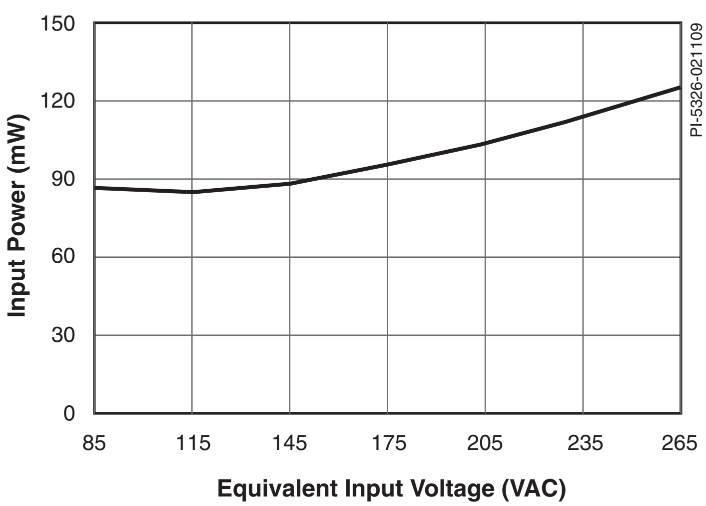

Figure 2. No Load Power Consumption Over Line.

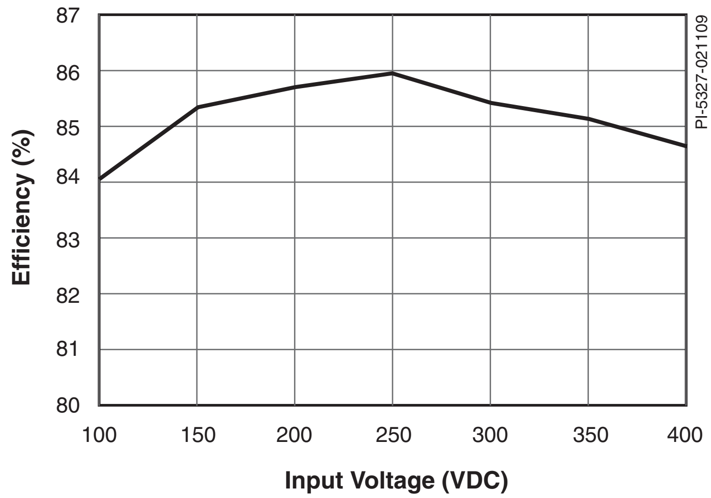

Figure 3. Full Load Efficiency Measured Over Line.

Transformer Parameters	
Core Material	EEL25 NC-2H or equivalent, gapped for ALG of 265 nH/t²
Bobbin	EEL25, 12 pin Vertical
Winding Details	3 mm margins on both sides of bobbin to meet safety Primary-1: 47T × 1, 0.25 mm, tape Bias: 12T × 1, 0.45 mm, 3 layers, tape 5 V: 5T × 4, 0.45 mm, 3 layers, tape Primary-2: 47T × 1, 0.25 mm, tape
Winding Order	Primary (4–3), Bias (6–5), 5 V (11,12–8,9), Primary (3–2)
Primary Inductance	2200 µH, ±10%
Primary Resonant Frequency	1600 kHz (minimum)
Leakage Inductance	20 µH (maximum)

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

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