DI-162 Design Idea
TOPSwitch®-HX

Set Top Box Power Supply

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
Set Top Box	TOP257PN	30 W	85 – 265 VAC	12 V	Flyback

Design Highlights

- Low cost, low component count, compact and lightweight power supply
- Highly energy efficient
- Low no-load and standby power consumption
  - No-load power consumption <250 mW at 265 VAC
- Delivers 30 W at 50 °C ambient without requiring an external heat sink
- 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
- Excellent line and load regulation (see Figure 2)
- Meets EN55022 and CISPR-22 Class B conducted EMI with >10 dBµV margin (see Figure 3)

Operation

The isolated flyback converter shown in Figure 1 was designed around a member of the TOPSwitch-HX IC family, the TOP257PN (U2). A device in the P package (8-pin DIP) was selected to minimize cost by eliminating external heatsinks. It is intended to be an external adapter (where the further multi outputs conversion is performed by several DC/DC directly internally) for set top box power supplies, which typically require low standby and no-load power consumption.

The AC input is rectified (D4–D7), filtered (C6 and C11) and connected across the primary side power components (T1 and U2). EMI filtering is provided by C5, C12 and common-mode choke L2. Thermistor RT1 limits the inrush current drawn by the circuit upon application of input AC.

To optimize efficiency under all load conditions, U2 employs multi-mode operation. From no-load to full load, these are: 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. Diode D3, C2, R1 and VR1 form the primary clamp circuit and ensure that the maximum voltage on the drain node of U2 is below 700 V.

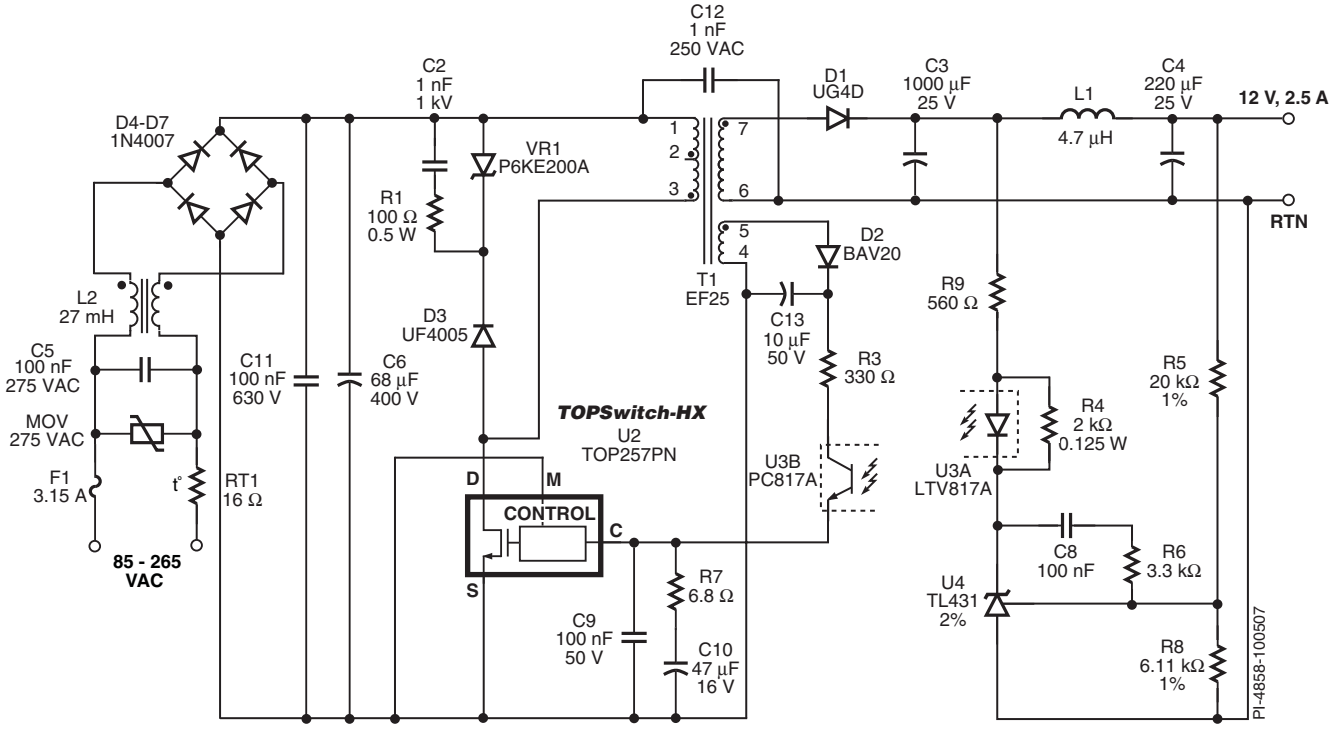

Figure 1. Schematic of a 30 W Set Top Box Power Supply Using TOP257PN.

The voltage generated by the secondary of T1 is rectified by D1 and filtered by C3 to provide the 12 V output voltage. An LC post filter (C4, L1) is connected to this output in order to reduce switching frequency output ripple.

The output voltage is controlled using a TL431 voltage reference (U4). Resistor R4 provides the bias current for U4. Low frequency feedback to U4 is derived from a voltage divider network R5 and R8. The center point of this network is tied to the 2.5 V_{REF} pin of U4. Capacitor C8 and resistor R6 roll off the high frequency gain of U4. Resistor R9 sets the loop gain.

Key Design Points

- Design the RCD clamp (C2, R1 and D3) for normal operation, thereby maximizing efficiency at light load. Zener diode VR1 provides a defined maximum clamp voltage and typically only conducts during load transients or during an overload condition.
- A fast recovery diode such as a FR106, may be used in place of D3 to increase leakage inductance energy recovery and maximize efficiency.
- The power supply is designed to operate in continuous mode with a K_P of 0.5.
- The M pin is shorted to the SOURCE pin, programming the current limit to be equal to the internal device current limit.

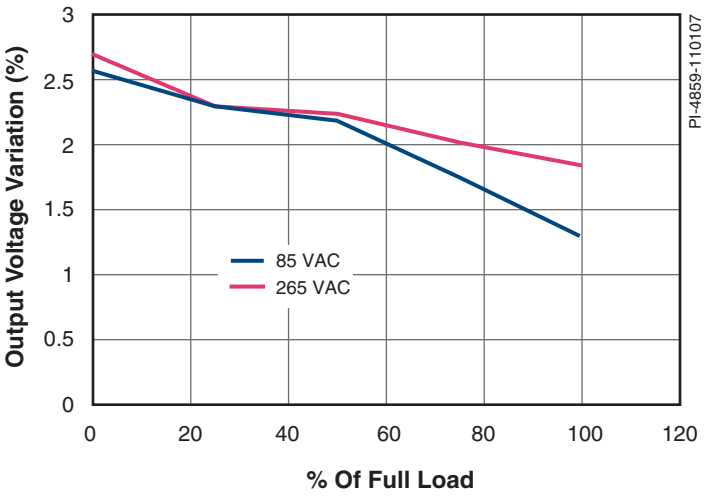

Figure 2. Worst Case Line and Load Regulation.

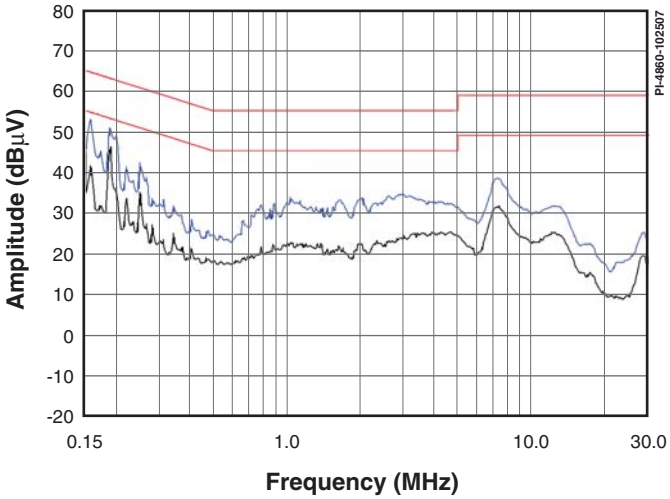

Figure 3. Worst Case Conducted EMI (230 VAC) Artifical Hand Connected to Output RTN.

Transformer Parameters

Core Material	EF25 NC-2H or equivalent, gapped for ALG of 141 nH/t^2
Bobbin	EF25, 10 pin, Horizontal
Winding Details	Primary: 41T × 1, 0.32 mm, tape Bias: 15T × 2, 0.32 mm, 3 layers, tape 12 V: 12T × 3, 0.40 mm (TIW), 3 layers tape Primary: 41T × 1, 0.32 mm, 2 layers tape
Winding Order	Primary-1 (3-2), Bias(5-4), 12 V (7-6), Primary-2 (2–1)
Primary Inductance	1030 µH, ±10%
Primary Resonant Frequency	700 kHz (minimum)
Leakage Inductance	30 µH (maximum)

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

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