

TinySwitch-III[®]

13 W (17.2 W Peak) Non-Isolated Power Supply for White Goods: <150 mW No-load Power Consumption

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
White Goods	TNY279P	13 W / 17.2 W Pk	85-265 VAC	-5 V, 2.0 A / -12 V, 0.25 A / 0.6 A Pk	Flyback

Design Highlights

- Low cost, low component count solution
- Impedance free path from Neutral to output RTN, ideal for applications driving triacs
- <150 mW no-load consumption at 230 VAC input
- Both outputs exhibit good cross regulation
- Maximum ambient temperature of up to 70 °C
- Meets CISPR-22 Class B/EN55022 B EMI limits without an input common mode choke

Operation

The non-isolated flyback converter shown in Figure 1 uses a TNY279 to provide two output voltages: -5 V at 2 A and -12 V at 250 mA continuous and 600 mA peak.

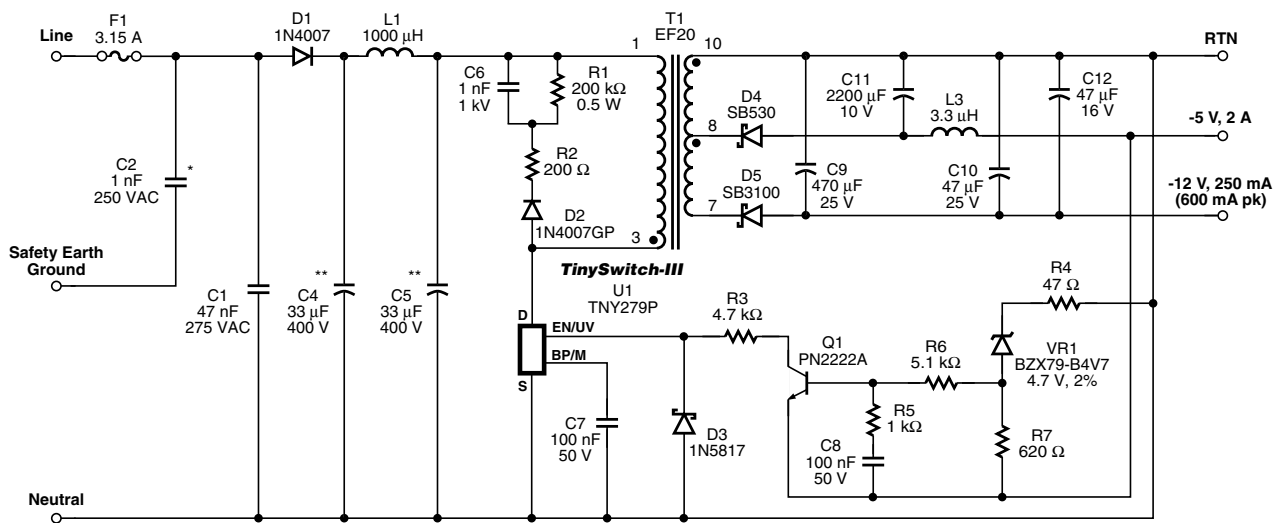
The MOSFET integrated within U1 switches the primary of transformer T1. Each time it turns on, the primary current ramps until it reaches an internal current limit and the MOSFET is turned off. During the off time, the energy stored in T1 transfers to the secondary where it is rectified and filtered by D4 and C11 and D5 and C9. The primary side RCD clamp (D2, C6, R1 and R2) limits the peak DRAIN voltage spike caused by transformer leakage inductance.

Feedback is taken directly from the -5 V output. Once the output exceeds the voltage defined by the V_{BE} of Q1 and rating of VR1, Q1 is biased on. This pulls current out of the EN/UV pin of U1 and disables the next switching cycle. By adjusting the number of enabled to disabled cycles, output regulation is maintained.

The value of R7 sets the bias current through VR1, operating the Zener closer to its specified test current. Resistor R6 limits the base current of Q1, R5 and C8 roll-off of high frequency gain and R3 limits the current out of the EN/UV pin.

Diode D3 ensures the EN/UV pin is clamped to > -0.3 V with respect to the SOURCE pin of U1.

Power Integrations *E-Shield*[™] transformer construction techniques, the RCD clamp, a simple π filter (C4, C5 and L1), small X-type (C1) and Y-type (C2) capacitors and the frequency jitter function of the *TinySwitch-III* family, provide good EMI margin (see Figure 3). Using a one square inch metal shield, located underneath U1 and T1 (connected to the SOURCE pin of U1) can further reduce EMI noise generation.



*One square inch metal shield (connected to the S pin of U1) under U1 and T1 eliminates the need for C2.
 **For high-line only operation (180 VAC input, minimum), 10 µF (400 V) capacitors can be used for C4 and C5.

Figure 1. TinySwitch-III 13/17.2 W White Good Power Supply.

PI-4498-112906

Key Design Points

- The secondary side bias current, set by R7, should be kept low to minimize light load and no-load power consumption.
- The output voltage that is reflected across the transformer (V_{OR}) should be kept low to minimize the losses in the primary side RCD clamp.
- Optimize the turns ratio of the two outputs for voltage centering.
- For good output cross regulation, design for continuous conduction mode (minimize the value of K_p in the *PI Xls* spreadsheet).
- Use a Schottky diode for D3 to limit EN/UV pin > -0.3 V.
- As the forward drop of D3 is a function of temperature, diode type and current, use a schottky diode. Do not reduce the value of R3, and verify EN/UV pin absolute maximum ratings are observed at low temperatures ($\sim < -10^\circ\text{C}$).

	-5 V	-12 V
20% on -5 V, 100% on -12 V	-5.05 V	-11.49 V
100% on -5 V, 20% on -12 V	-5.03 V	-12.95 V
100% on -5 V, 5% on -12 V	-5.02 V	-13.90 V

Table 1. Worst Case Cross Regulation at 85 VAC.

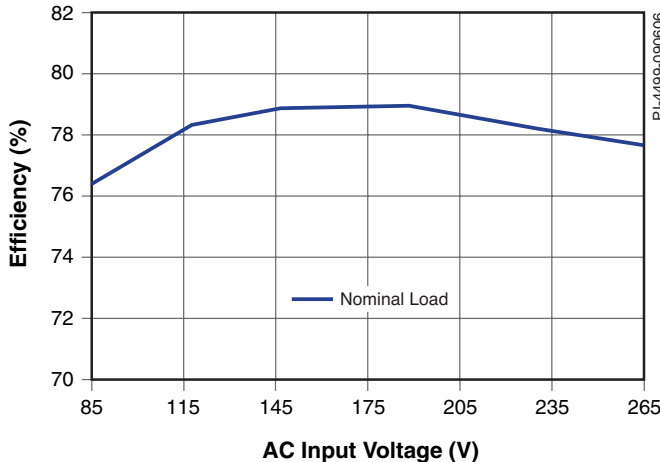


Figure 2. Full Load Efficiency vs. Input Voltage.

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- The value of R4 can be used to make small output voltage adjustments.
- The regulation point is the sum of the voltage rating of VR1, $V_{BE(Q1)}$ and the voltage across R4 ($(V_{BE(Q1)}/R7) \times R4$).
- Biasing the Zener below its test current lowers its voltage drop, in this case to ~ 4.3 V.
- Select transformer wire gauge sizes so that each winding layer occupies the entire bobbin width (lowers leakage inductance and improves output cross regulation).
- Use option to add *E-Shield* windings in *PI Transformer Designer* software to reduce conducted EMI noise generation.
- No-load power consumption can be lowered by adding a bias winding to feed the supply current of U1 into the BP pin.

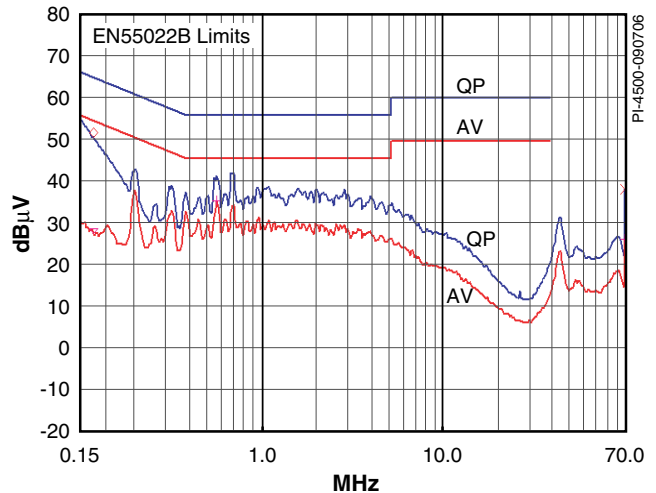


Figure 3. Conducted EMI at 230 VAC, Full Load.

TRANSFORMER PARAMETERS	
Core Material	EF20 TDK PC40, or equivalent A_{LG} of 142 nH/T ²
Bobbin	EF20, 10 pin (5 + 5)
Winding Details	Shield: 23T, Primary: 95T Shield: 9T (trifilar), -5 V: 5T, -12 V: 7T
Primary Inductance	1.28 mH $\pm 10\%$

Table 2. Transformer Construction Information.

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