DI-153 Design Idea
TinySwitch®-III

1.25 W, Low Input Voltage Range Power Supply for Industrial Controls

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
Industrial Controls	TNY274PN	1.25 W	18 – 30 VAC	5 V	Flyback

Design Highlights
- Low Input Voltage Range (18 – 30 VAC)
- Highly energy efficient
  - 65% efficiency
  - Extremely low no-load power consumption (<100 mW at 30 VAC)
- Auto-restart indefinitely withstands shorted output condition

Operation
Figure 1 shows a flyback converter using the TNY274PN device. The input AC is low voltage in the range of 18 to 30 V, and output DC is 5 V at 250 mA. Applications of such a power supply include auxiliary power supplies for industrial controls.

The AC mains are rectified and doubled by the input voltage doubler formed by D1, D2, C1 and C2 (Greinacher voltage doubler). Capacitors C1, C2 and C3 are of relatively large value. This ensures that the minimum DC bus voltage is above 50 V, the datasheet limit for minimum drain voltage to guarantee proper startup and functionality.

The TinySwitch-III (U1) uses on/off control, which offers a very simple feedback scheme and very fast dynamic response.

The controller in U1 receives feedback from the secondary through optocoupler U2, enabling or disabling the switching of its integrated MOSFET to maintain output regulation. The current through the LED in U2 represents the output voltage. A proportional current is then pulled out of the EN/UV pin. Switching cycles are skipped once the EN/UV disable threshold current (115 µA) is exceeded. When the current out of the EN/UV pin falls below the disable threshold, switching cycles are re-enabled.

To improve efficiency at light loads, a bias winding is used. The bias winding disables the internal high voltage current source, which normally powers the IC from the DRAIN pin, thereby reducing power consumption. Diode DX1 and capacitor CX1 maintain the bias winding voltage. Resistor RX1 is sized so that IC supply charging current flows into the BP/M pin, disabling the internal current source at no-load.

Diode D4 rectifies the output of T1. Output voltage ripple is minimized by using a low ESR capacitor for C7. A post filter, comprising L2 and C8, attenuates the high frequency switching noise.

The output voltage is determined by the series sum of the voltages across VR1, R5, and the LED in U2. The values of R5 and R6 can be adjusted to fine-tune the output voltage of the supply. A TL431 can be used in place of VR1 for tighter output voltage regulation.

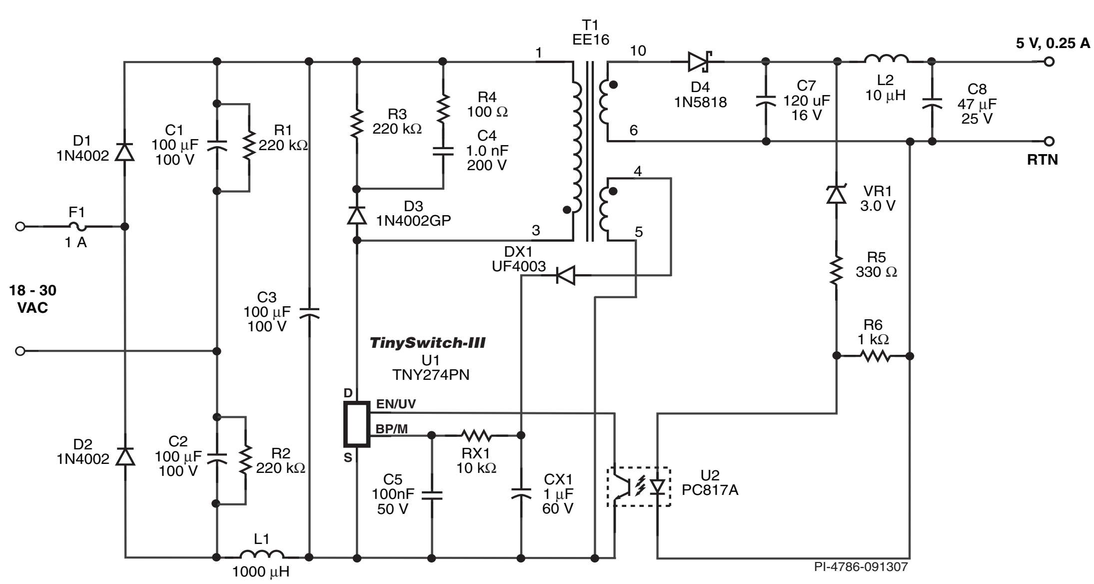

Figure 1. Schematic of a Wide Range Input, 5 V, 250 mA Power Supply Using TinySwitch-III

Key Design Points

- In the PIXls spreadsheet, the value of AC input voltage should be twice the input voltage to represent a voltage doubler input.
- Use a slow blocking diode D3 in the clamp circuit. Use only a glass-passivated (GP) diode type to ensure a reverse recovery time of 2 μs or less. If a GP diode is unavailable, a fast diode, such as FR107, may be used instead. These diode selections recycle some of the clamp energy and improve no-load efficiency.
- Capacitor C4 and resistors R3 and R4 form the snubber network. For maximum leakage energy recovery, maximize the value of R3 while maintaining peak drain voltage below 650 V.
- Design the bias winding circuit to provide approximately 600 μA at no load to the BP pin.
- Design the transformer with relatively high value of reflected output voltage (VOR) for better efficiency. However, do not design with a VOR greater than the minimum DC bus voltage.
- Resistors R1 and R2 are voltage balancing resistors to compensate for the tolerances of electrolytic capacitors (C1 and C2).

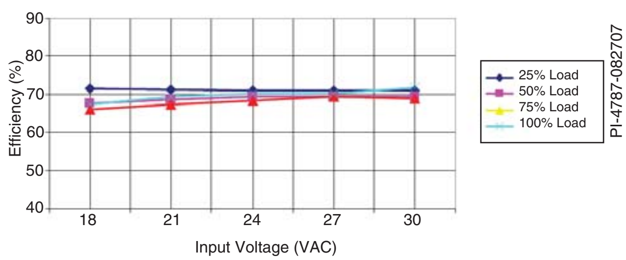

Figure 2. Efficiency vs AC Input Voltage

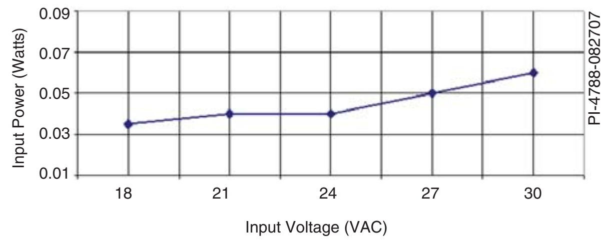

Figure 3. No-Load Input Power Consumption

Transformer Parameters	
Core Material	EE16 NC-2H or equivalent, gapped for ALG of 193 nH/t²
Bobbin	EE16, 10 pin, Horizontal
Winding Details	Bias: 32T x 2, AWG30, tape Primary: 64T x 1, AWG30, 3 layers of tape 5 V: 10T x 1, AWG28, TIW, 1 layer, tape
Winding Order	Bias (4-5), Primary (3-1), 5 V (10-6)
Primary Inductance	780 μH, ±12%
Primary Resonant Frequency	1 MHz (minimum)
Leakage Inductance	80 μH (maximum)

Table 1. Transformer Parameters. (NC = No Connection, TIW = Triple Insulated Wire)

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