

DI-181 Design Idea

TinySwitch-PK

Multiple Output Power Supply With Peak Power Capability

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
Air Conditioner	TNY380PN	17.7 W, 29.7 W peak	90 – 265 VAC	5 V, 12 V, 16 V	Flyback

Design Highlights

- Multiple output power supply
- Universal input range allows single design to be used worldwide
- Highly energy efficient
 - Low load power consumption (<160 mW at 265 VAC)
 - Meets CEC 2008/ENERGY STAR requirements for active mode efficiency (80% vs 74.9% requirement)
- Thermal Performance
 - High ambient temperature operation ($T_{AMB} = 85^{\circ}\text{C}$)
 - Accurate hysteretic thermal shutdown protection
- Meets CISPR-22/EN55022B conducted EMI limits >10 dB μ V margin
- Auto-restart withstands shorted output condition indefinitely

Operation

The TinySwitch-PK multiple output power supply shown in Figure 1 provides 17.7 W of continuous output power and 29.7 W of peak power. Ideal applications include air conditioners or other applications where peak power is required. The two galvanically isolated 16 V outputs are ideal for driving the IGBTs in the half bridge. The 12 V output drives the evaporating fan in the compressor, while the 5 V output powers the microprocessor. Both the 5 V and 12 V outputs are non isolated from the AC input.

Diodes D1, D2, D3 and D4 and capacitors C1 and C2 rectify and smooth the AC input. Capacitors C20, C1, C2 and common mode inductor L1 provide differential as well as common-mode EMI filtering.

The controller in U1 receives feedback from the output via Q1, and based on that feedback, it enables or disables the switching of its integrated MOSFET to maintain output regulation. Feedback from the 5 V output is fed into the shunt regulator (U2), which controls the current through Q1 and Q2. A proportional current is then pulled out of the EN/UV pin. Switching cycles are skipped once the EN/UV disable threshold current (115 μ A) is exceeded. When the current out of the EN/UV pin falls below the disable threshold, switching cycles are re-enabled. Under continuous power operating conditions, the TinySwitch-PK operates at 132 kHz. A unique peak mode feature boosts the current limit level by 30% and doubles the switching frequency to 264 kHz under peak load conditions. To support the high ambient temperature operation (85 $^{\circ}$ C), a small heat-sink was used with U1.

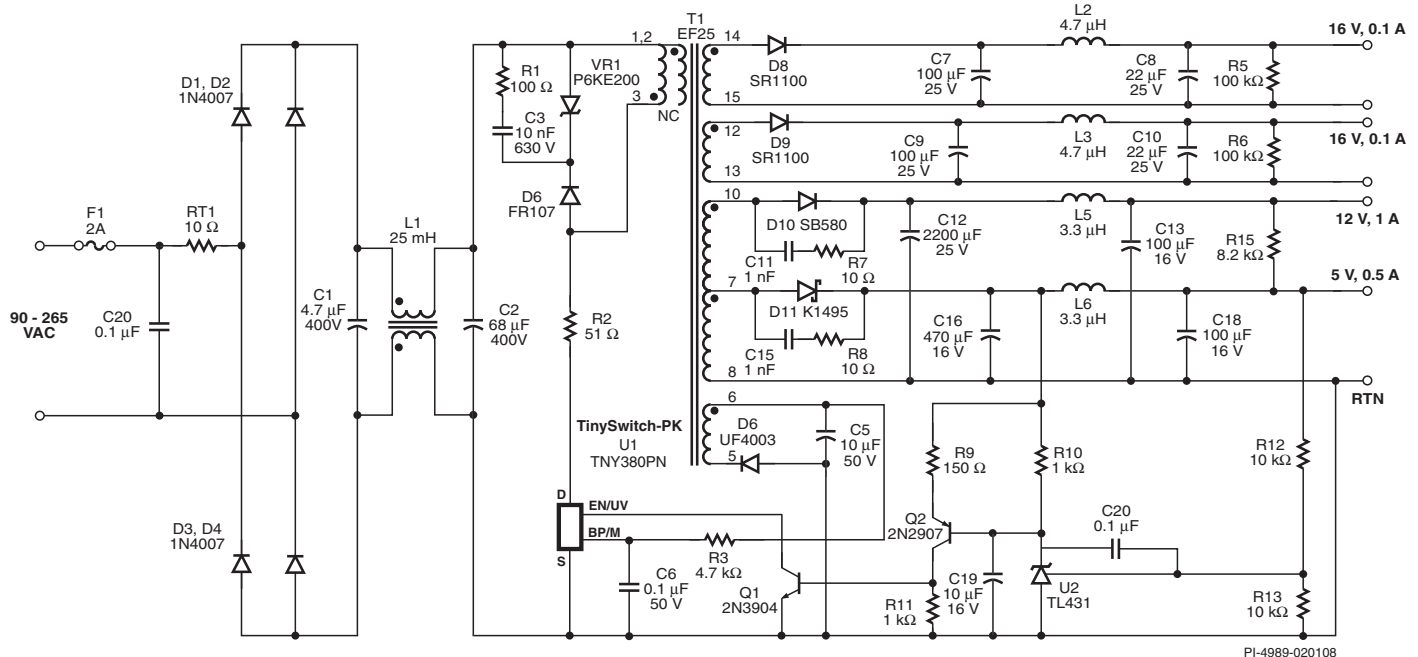


Figure 1. Schematic of a 17.7 W Air Conditioner Multiple Output Power Supply Using TNY380PN.

Key Design Points

- Components D6, and VR1 form the TVS clamp circuit. Capacitor C3 helps recover some of the leakage energy.
- To reduce no-load input power and increase light-load efficiency, resistor R3 feeds the supply current for U1 from the auxiliary bias winding on the transformer.
- The secondary side snubber (R7, C11, R8 and C15) reduces high frequency (secondary side) diode ringing and improves EMI.
- Although this design is a non-isolated design, the feedback path can be isolated by using an optocoupler instead of transistors Q1 and Q2.
- This design uses a low turns-ratio (and hence lower V_{OR} ; $V_{OR} = 100\text{ V}$) to achieve better cross regulation between outputs.

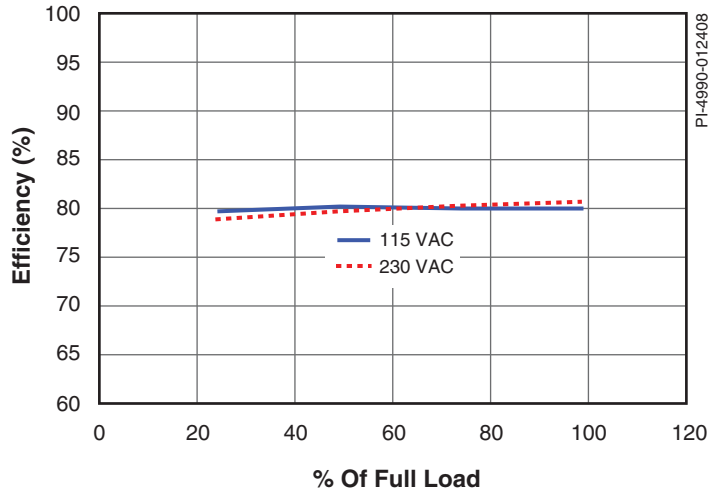


Figure 2. Efficiency vs Line Voltage (VAC).

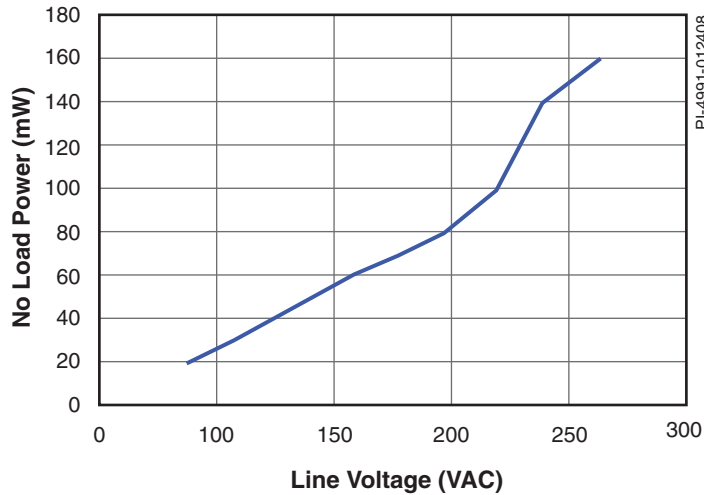


Figure 3. No-Load Input Power vs Line Voltage (VAC).

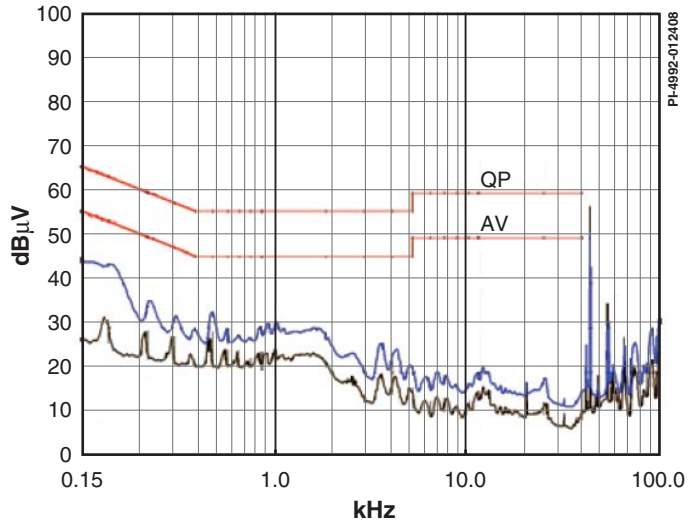


Figure 3. Conducted EMI at 230 VAC With Output Grounded (EN55.22B/CISPR-22 Limit Lines Shown).

Transformer Parameters

Core Material	EF25 NC-2H or equivalent, gapped for ALG of 155 nH/t ²
Bobbin	EF25, 14 pin, Horizontal 3 mm margins on both sides of bobbin to meet safety Shield: 21T × 2, 0.32 mm, tape Primary: 54T × 1, 0.5 mm, tape Bias: 8T × 4, 0.34 mm, 3 layers, tape
Winding Details	5 V: 3T × 2, 0.6 mm TIW, tape 12 V: 4T × 2, 0.5 mm TIW, tape 16 V: 9T × 1, 0.32 mm, TIW, tape 16 V: 9T × 1, 0.32 mm, TIW, tape
Winding Order	Shield (2-NC), Primary (3-2, 1), Bias (6-5), 5 V (7-8), 12 V (10-7), 16 V (12-13), 16 V (14-15)
Primary Inductance	453 µH, ±10%
Primary Resonant Frequency	1 MHz (minimum)
Leakage Inductance	20 µH (maximum)

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

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