DI-176 Design Idea
TinySwitch®-III

20 W Air Conditioner Power Supply

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
Air Conditioner	TNY279PN	20 W	200 – 400 VDC	12 V, 15 V	Flyback

Design Highlights
- Simple, low part-count design
- Very high efficiency: >80% over line voltage
- One isolated and one primary referenced output ideal for white good applications
- Hysteretic thermal shutdown

Operation
The TinySwitch-III supply shown in Figure 1 provides 20 W of output power. The 15 V output is capable of delivering up to 50 mA of current and is typically used to supply the primary side driver for a brushless DC (BLDC) motor as it is referenced to the source of the MOSFET internal to U1 (primary side). The 12 V regulated isolated output, delivering up to 1.6 A, can be used to drive a microcontroller, relays, and a stepper motor.

The supply uses a large input capacitor, C1, to maintain a constant voltage source for the BLDC motor. It is assumed that this supply will be placed after all necessary EMI filtering and AC rectification, and thus none of these components are shown. However, Y-capacitor C10 is shown as part of the EMI filtering that may be necessary.

The TNY279PN device is used in a flyback topology. During the on time of U1's internal MOSFET, current rises linearly in the primary winding of transformer T1. While current builds in the primary, energy is stored in the transformer. Once the current through the MOSFET reaches the device's current limit, or DC_{MAX} is reached, the MOSFET turns off. The flyback portion of the conduction cycle now begins. During this period a voltage is induced in the secondary winding, and the energy stored in the transformer is transferred to the output capacitors and the load.

During the supply's flyback period, an RCD snubber circuit keeps the voltage at the drain node below the device's BV_{DSS} limit. The snubber circuit is comprised of fast-blocking diode D1, capacitor C2, and resistor R1.

Diode D2 rectifies the 15 V secondary output while capacitor C4 filters and smoothes. Inductor L1, and capacitors C6 and C7 all form a post filter, helping to eliminate switching frequency ripple. Resistor R2 acts as a preload and improves regulation at no load.

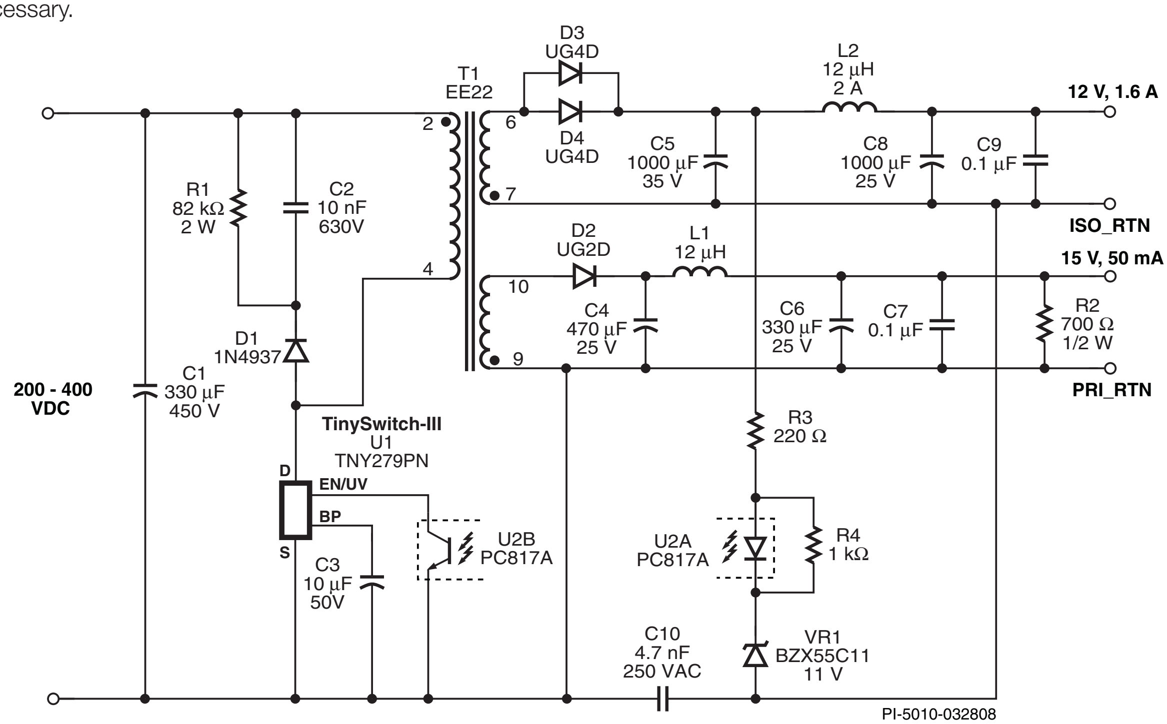

Figure 1. 20 W TNY279PN Flyback Power Supply.

Diodes D3 and D4 rectify the 12 V output while capacitor C5 filters the output. Inductor L2 and capacitors C8 and C9 also form a post filter, reducing any switching frequency ripple on this output.

The 12 V output is the output from which feedback information is derived. Resistor R3 sets the gain of the feedback loop. Resistor R4 biases the Zener voltage reference VR1 with about 1 mA of current.

Output regulation is achieved using the TinySwitch-III's On/Off control scheme. At the leading edge of each internal clock cycle, the current out of the EN/UV pin is sampled. If this current is in excess of 115 μA, then the subsequent switching cycle is disabled (skipped) for this period, otherwise the cycle is enabled. During each clock cycle this process is repeated. By adjusting the ratio of enabled and disabled pulses, regulation is maintained. This also optimizes the efficiency of the converter over the entire load range.

Key Design Points

- Connecting a series diode and 33 kΩ resistor from 15 V output to the BP pin can significantly reduce no-load input power.
- Selecting a fast diode vs. an ultra-fast diode for D1 will improve efficiency by recovering some of the leakage energy.
- The selectable current limit of U1 allows the current limit and device size to be optimized for the thermal environment. For example, for this design, the TNY280PN part could be used by changing bypass capacitor C3 from 10 μF to 0.1 μF.
- Dual diodes (D3 and D4) reduce losses and improve efficiency. However, single diode use is acceptable electrically.

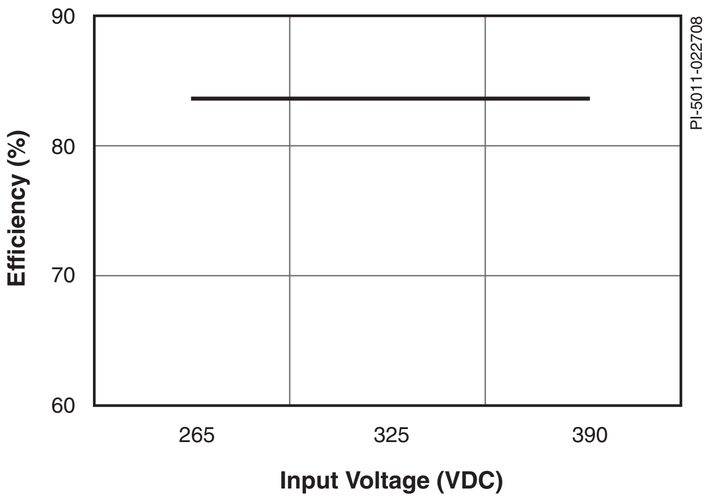

Figure 2. Full Load Efficiency Over Line.

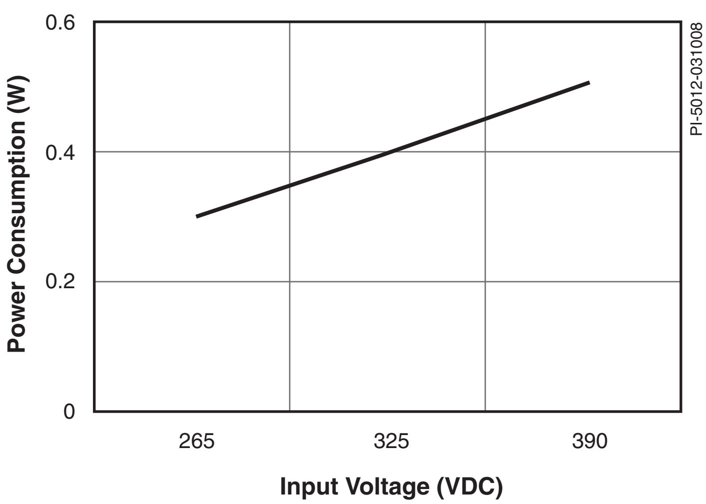

Figure 3. No Load Input Power.

Transformer Parameters

Core Material	PC40EE22-Z or equivalent, gapped for ALG of 127 nH/t²
Bobbin	EE22, Vertical
Winding Details	Primary: 40T, 0.3 mm, 3 layers tape Secondary-1: 9T × 2, 0.4 mm T.I.W., 2 layers tape Secondary-2: 10T, 0.5 mm T.I.W., 3 layers tape Primary: 40T, 0.3 mm, 3 layers tape
Winding Order	Primary (2–3), Secondary-1 (7–6), Secondary-2 (9–10), Primary (3–4)
Primary Inductance	812 μH, ±7%
Primary Resonant Frequency	800 kHz (minimum)
Leakage Inductance	60 μH (maximum)

Table 1. Transformer Parameters. (AWG = American Wire Gauge, TIW = Triple Insulated Wire)

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