DI-145 Design Idea
TinySwitch®-PK

Portable Game Player Power Supply with Optional Latching OVP and OCP Shutdown

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
Portable Games	TNY377PN	10 W, 15 W Peak	90-265 VAC	5 V	Flyback

Design Highlights

- Highly energy efficient
  - Meets CEC/ENERGY STAR 2008 requirements for active mode efficiency (74.6 % vs. 70.5% requirement)
  - Very low no-load power consumption (<100 mW at 230 VAC)
- Meets CISPR-22/EN55022B conducted EMI limits with 10 dBμV margin (see Figure 3)
- Extended protection features
  - Optional latching Overvoltage Protection (OVP)
  - Optional latching Over-Current Protection (OCP)
  - Integrated hysteretic thermal shutdown provides over temperature protection (OTP)
- Auto-restart withstands shorted output condition indefinitely

Operation

The TinySwitch-PK power supply shown in Figure 1 provides 10 W of continuous output power and 15 W of peak power. Typical applications include portable game players or other equipment where peak power capability for short time durations is required.

Diodes D1, D2, D3, and D4 and capacitors C1 and C2 rectify and smooth the AC input. Capacitor C1, C2, L1, and L2 provide differential as well as common-mode EMI filtering.

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 U2A 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 (90 μA) is exceeded. When the current out of the EN/UV pin falls below the disable threshold, switching cycles are re-enabled. For improved ripple, the EN/UV pin threshold current is modulated to ensure evenly spaced enabled cycles. 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. This eliminates the need to increase the device or core size for peak power conditions.

The supply also has an optional over-voltage protection (OVP) circuit comprising R7 and VR1. In case of overvoltage on the output, the bias winding voltage increases, and current is pushed into the BP/M pin. When this current exceeds 7 mA, U1 latches off until the BP/M voltage drops below 4.8 V, after removal of input AC.

An optional over-current protection (OCP) circuit is shown in Figure 2. It comprises Q1, Q2, C14, R16, and R27. In case of overload (over-power), the output drops, and a loss of feedback current through the phototransistor of U2 turns off Q2. This in turn allows capacitor C14 to charge and turns on Q1, allowing for current into the BP/M pin through diode D9, thereby initiating a latching shutdown.

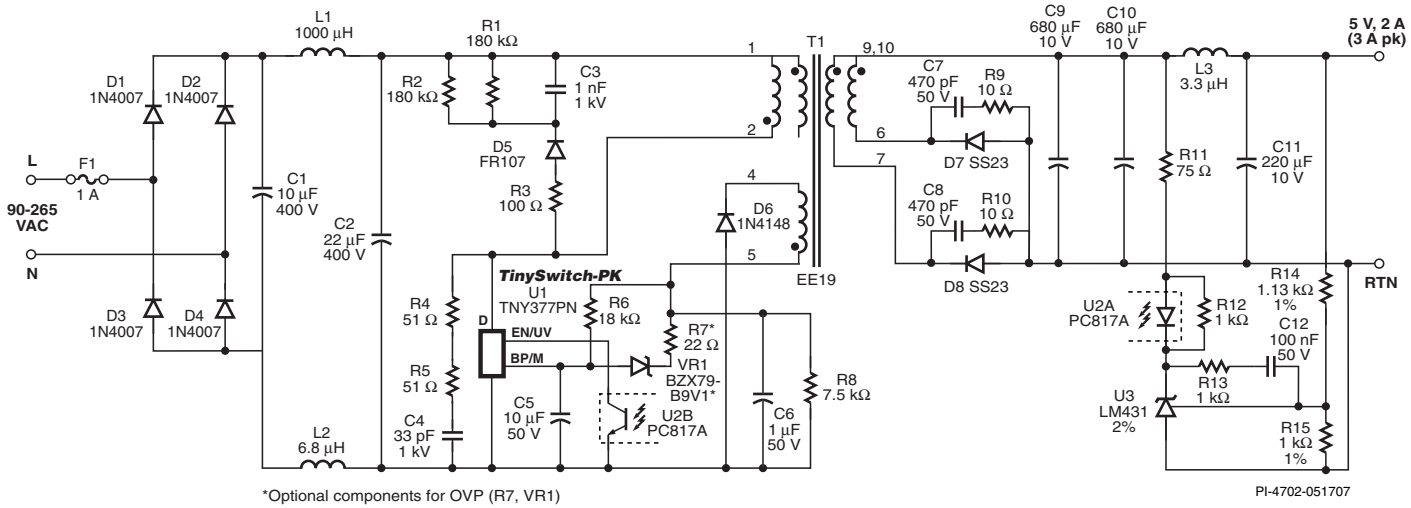

Figure 1. Schematic of Universal Input, 5 V, 2 A (3 A peak) Portable Game Player Power Supply.

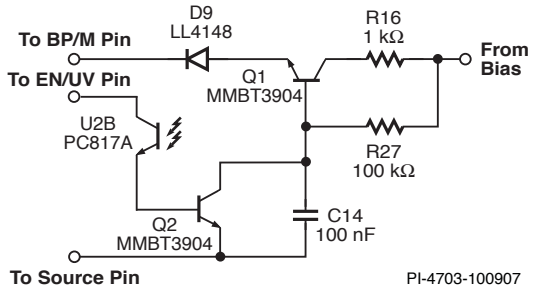

Figure 2. Optional Over-current Protection (OCP) Circuit.

Key Design Points

- Verify that the maximum drain voltage is < 650 V at high line and maximum overload condition. Adjust the values of R1, R2, and C3 as necessary. However, avoid making the clamp circuit too large (i.e., low value of R1 and R2 and high value of C3) as this will increase the no-load power consumption.
- Use a fast blocking diode (D5), such as the 1N4937 or FR107, with a 100 ohm series resistor (R3). Ensure that the diode has a reverse recovery time of 500 ns or less. These diode selections recycle some of the clamp energy, improving efficiency.
- The core size and the winding wire diameter sizes (see Table 1) were chosen based on the average of the peak and the continuous output power.
- An RC snubber (R4, R5 and C4) was added to reduce radiated EMI. Two series resistors were used to meet the required 700 V_{PK} voltage rating.
- Output diodes D7 and D8 are connected to separate secondary windings to share output current and improve efficiency.
- Frequency jittering feature and E-Shield™ technique in transformer allows elimination of Y capacitor and use of simple EMI filtering.
- Sealer adapter design with simple metal fin heatsink in contact with SOURCE pins (inserted into PCB slot).

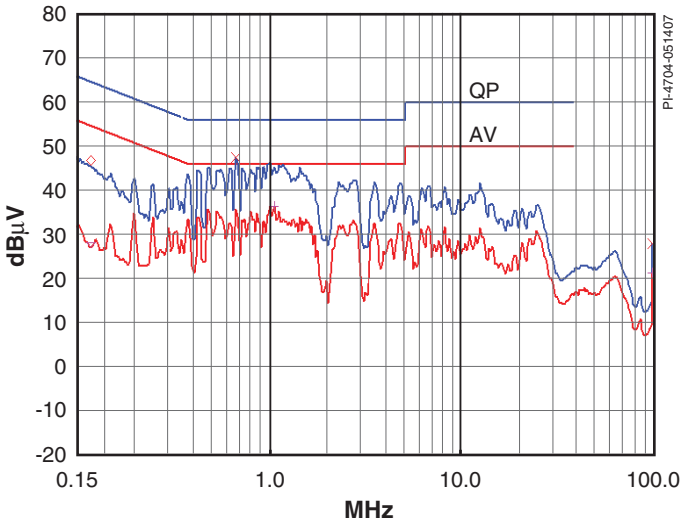

Figure 3. Conducted EMI at 230 VAC with Output Grounded (CISPR-22 / EN55022B Limit Lines Shown).

Transformer Parameters

Core Material	EE19, NC-2H or equivalent, gapped for ALG of 88.6 nH/t^2
Bobbin	EE19, 10 pin, Horizontal
Winding Details	Shield: 21T × 2, AWG33, tape Primary: 84T × 1, AWG33, tape Shield: 4T × 5, AWG26, 3 layers, tape 5 V: 5T × 2, AWG23, TIW, 3 layers, tape Bias: 12T × 2, AWG28, tape
Winding Order	Shield (1-NC), Primary (1-2), shield (1-NC), 5 V (6,7-9,10), Bias (4-5)
Primary Inductance	625 µH, ±5%
Resonant Frequency	600 kHz (minimum)
Leakage Inductance	45 µH (maximum)

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

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