Design Idea DI-118

TinySwitch®-III

4.5 W CV/CC Charger with <260 mW No-Load Consumption

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
Charger	TNY276P	4.5 W	90-265 VAC	5.7 V, 800 mA	Flyback

Design Highlights

- Simple, low cost, low parts count CV/CC solution
- Low input power at no-load: <260 mW at 265 VAC
- Efficiency >65% at 90 VAC
- Meets CEC / ENERGY STAR requirements for active mode efficiency (66.8 % vs 62.6 % requirement)
- Compact design using small, low cost EE16 core size
- >15 dBµV margin to EN55022B conducted EMI limits
- No Y-capacitor: <10 µA line frequency leakage current

Operation

The CV/CC charger circuit shown in Figure 1 was designed as a Flyback converter, using TNY276P (U1). The device has its four SOURCE pins on one side of its 8-pin package, which simplifies the layout of the PCB copper for heatsinking. Additionally, the value of C3 selects the reduced current limit of U1. Both factors allow U1 to deliver full power from within a sealed enclosure, at an external ambient temperature of 40 °C. In less thermally challenging applications, a TNY275P operating at its standard current limit (C3 = 0.1 µF) could be used to reduce cost, without any other changes.

The internal MOSFET within U1 conducts current through the primary winding of T1 during each enabled switching cycle. When the primary current reaches the MOSFET current limit, the controller turns it off, and the energy in T1 is transferred to the output. Schottky diode D6 and capacitor C5 rectify and filter the output. Inductor L3 and capacitor C7 attenuate the switching ripple on the output.

The primary clamp (D5, R2, C4 and R1) limits the maximum peak drain voltage to less than the 700 V BV_{DSS} rating of the internal MOSFET. Resistor R2 reduces high-frequency leakage inductance ringing and thereby EMI. The tightly controlled tolerances of U1 allow this configuration to still meet low no-load input power levels.

The pi filter formed by C1, L1, L2 and C2 attenuates conducted EMI while C8 and R8 on the secondary side reduce high frequency ringing. The integrated frequency jitter feature of U1 along with *E-Shield*™ techniques allow such simple EMI filtering to ensure compliance with EN55022B, even without a Y capacitor across the primary to secondary isolation barrier.

The output is regulated using optocoupler feedback. During CV operation, reference IC U3 senses the output

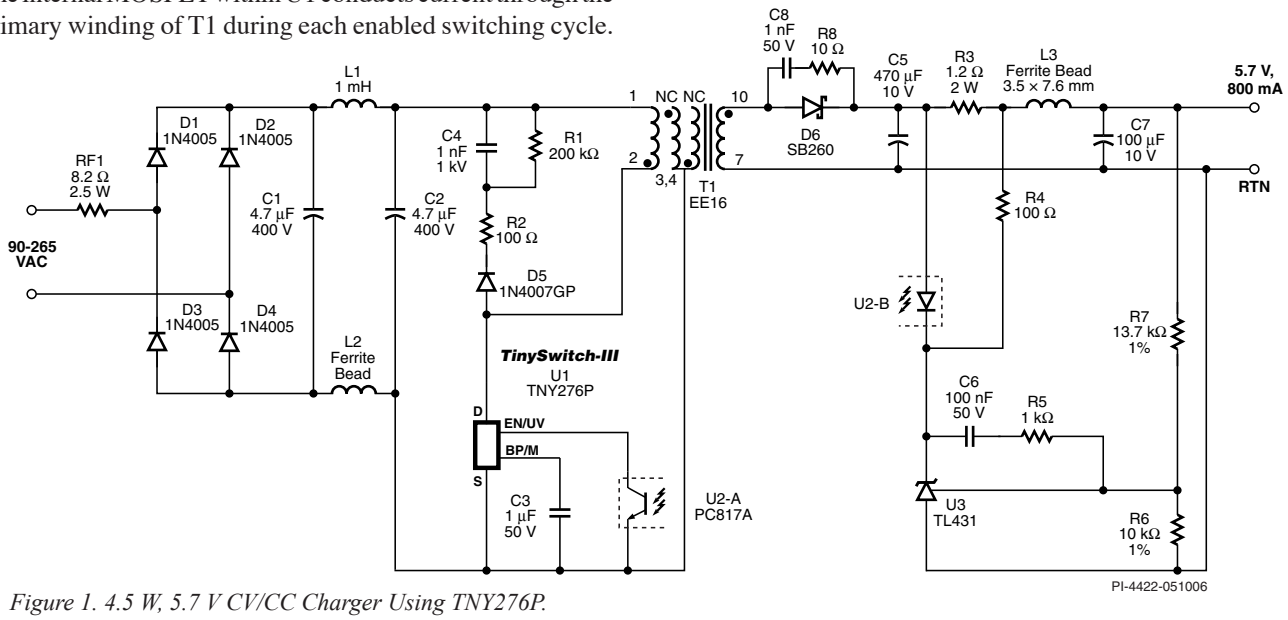


Figure 1. 4.5 W, 5.7 V CV/CC Charger Using TNY276P.

voltage via R6 and R7 and drives the optocoupler. However, the control shifts to CC mode of operation when the voltage across R3 exceeds the forward drop of the photo-diode in U2. *TinySwitch-III* allows this simple CC sensing scheme to be used, while still meeting active mode efficiency requirements.

Key Design Points

- Verify that the maximum drain voltage is <650 V at high line and maximum overload condition. Adjust the values of R1 and C4 as necessary. However, avoid making the clamp circuit too large (ie. low value of R1 and high value of C4), as this will increase the no-load power consumption.
- Selecting a fast diode vs. an ultra-fast diode for D5 will improve efficiency by recovering leakage energy. If glass passivated (1N4007GP) is unavailable a FR107 may be used.

TRANSFORMER PARAMETERS	
Core Material	EE16, NC-2H material or equivalent, gap for A_{LG} of 156 nH/T²
Bobbin	5+5 pin horizontal
Winding Details	Shield: 28T, 2 ×33 AWG Primary: 120T, 33 AWG Shield: 8T, 2 ×27 AWG 5.7 V: 10T, 25 AWG T.I.W.
Winding Order (pin numbers)	Shield (3-NC), tape, primary (2-1), tape, shield (NC-3), tape, 5.7 V (10-7), tape
Inductance	Primary: 2.25 mH ±12% Leakage: 45 µH (max)
Primary Resonant Frequency	850 kHz (min)

Table 1. Transformer Design Parameters.

T.I.W.: Triple Insulated Wire, NC: No Connection

- For consistent EMI performance in production, manufacturing variations in transformer T1 must be minimized from unit to unit. This is especially important in designs that do not use a Y-capacitor.
- Place tape between the primary winding layers to reduce intra-winding capacitance. This will help reduce the no-load consumption.

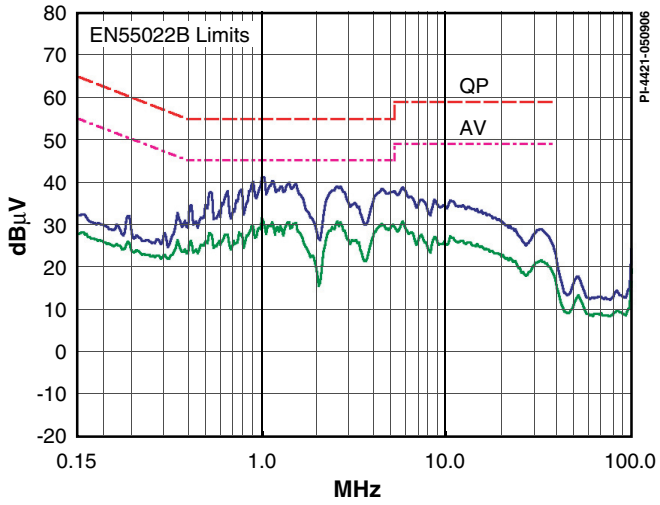


Figure 2. Worst-Case Conducted EMI (Output RTN Connected to Artificial Hand Input of LISN).

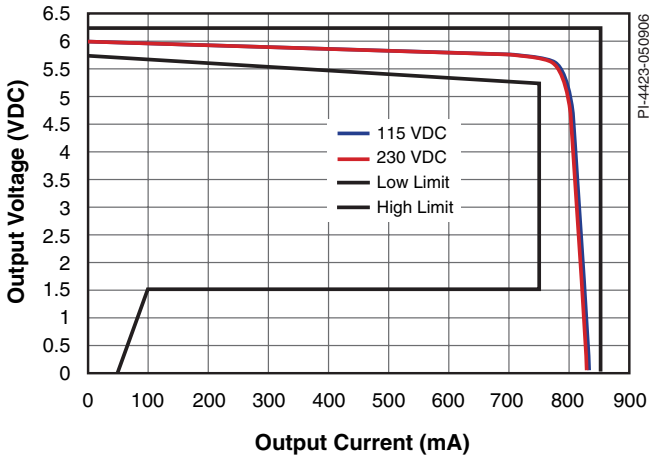


Figure 3. Typical Output Characteristics.

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