Design Idea DI-12

TOPSwitch®-GX 16 W, Universal Input, Lead Acid Battery Charger

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
Battery Charger	TOP244P	16 W	85-265 VAC	13.55 V at 25 ˚C	Flyback

Design Highlights

- Lowest cost and low component count solution
- Universal input voltage replaces the need for multiple linear based designs
- High efficiency: >75%
- Integrated line undervoltage detection (UV) and overvoltage (OV) power system surge protection
- Constant voltage / constant current (CV/CC) output
- Temperature compensated output voltage
- Monitor input to allow state of charge measurements

Operation

The circuit shown in Figure 1 provides a CV/CC output for charging lead-acid batteries in applications such as fire/burglar alarms and emergency lighting.

The design utilizes many of the features of the *TOPSwitch-GX* family. Line undervoltage and overvoltage (100 V and 450 V, respectively) are implemented using a single resistor (R13). Line undervoltage detection eliminates power-up/down output glitches, while overvoltage shutdown provides protection for short line transients and longer duration power system surges, removing the need for an input MOV. The DIP8 package of the TOP244P requires no external heatsink, using the PC board instead.

During the first 10 ms of operation, internal soft-start is enabled, lowering stresses on the internal power MOSFET, clamp and output rectifier. Built-in switching frequency jitter reduces conducted EMI, allowing the design to meet EN55022B limits with simple input filtering. Diode D1 and Zener VR1 clamp the leading edge drain voltage spike caused by transformer leakage inductance.

Lead acid batteries for standby use are normally charged at ~2.3 V per cell and 0.1 A per Ah of capacity. Resistor R1, U2, C9, Q1, R3, R4 and R5 form the current limit circuit. Resistor R3 controls the current limit (1.2 A typical). Resistor R5 ensures sufficient voltage to drive the opto LED, even with the output shorted. Capacitor C9 and R4 provide compensation and limit Q1 base current. The output voltage is controlled using a TL431 voltage reference (U3). Resistors R7, R8, R9 and RT1 program output voltage as a function of temperature (Figure 3) to approximate that required by the lead-acid battery. During CV operation, DC gain is set by R6. Capacitor C8, C5 and R10 provide loop compensation. Bias for U3 is provided by R2.

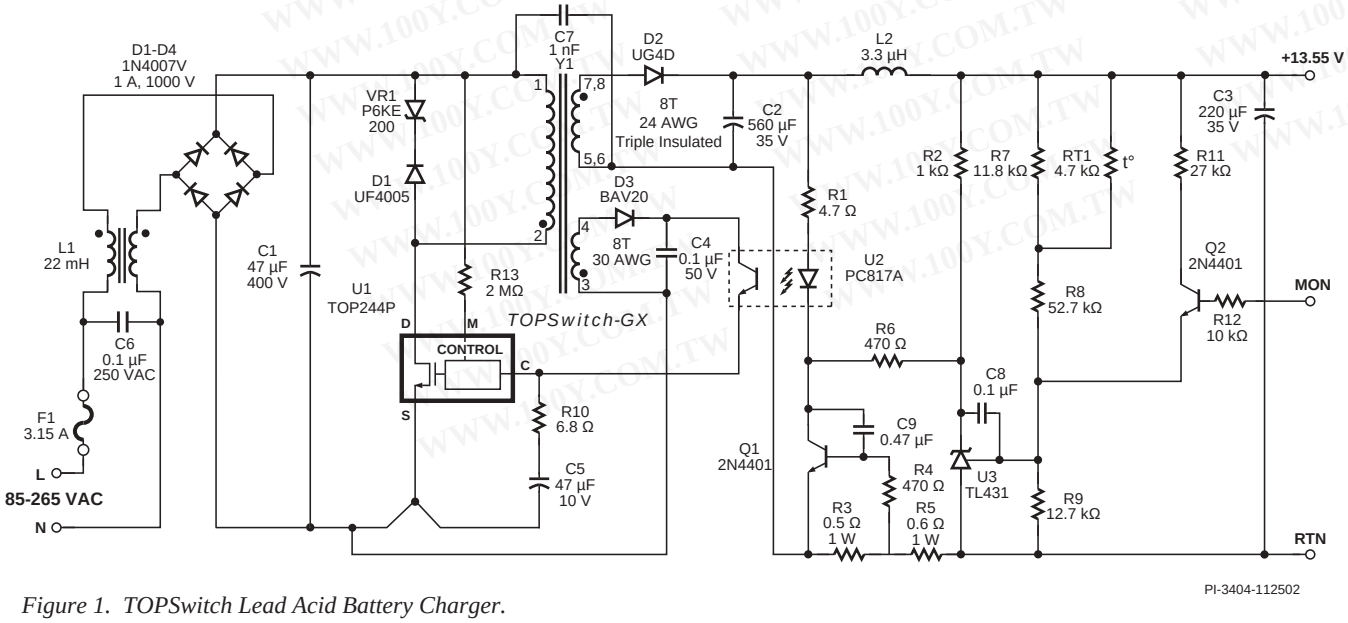

Figure 1. TOPSwitch Lead Acid Battery Charger.

For battery detection and monitoring, R11, R12 and Q2 reduce the output voltage to approximately 8 V when a 5 V signal is applied to R12. This allows the battery voltage to be measured, giving the state of charge.

Key Design Points

- The value of R3 sets the typical output current limit threshold given by: R3 = 0.6 / I_{LIMIT}.
- Rate R3 and R5 accordingly for power dissipation (1 W).
- Ensure total voltage across R3 and R5 is greater than 1.5 V at I_{LIMIT} if control to 0 V (output shorted) is required.
- Ensure voltage at cathode of D3 is >6 V at I_{LIMIT}. Add additional bias winding turns, if necessary, to maintain output current control to 0 V (output shorted).
- RT1: Philips part # 2322-640-54472.
- Select tolerance of U2, R7, R8 and R9 to give the desired overall CV tolerance (R7, R8 and R9 as 0.1%; R10 as 1% and U2 as 0.5% gives overall tolerance <2%).

TRANSFORMER PARAMETERS	
Core Material	TDK PC40 EE22/29/6-Z, Gap for A_{LG} = 145 nH/T^2
Bobbin	YC 2204 (Ying Chin)
Winding Details	Primary: 56T, 30 AWG Bias: 8T, 2 x 30 AWG Secondary: 8T, 28 AWG T.I.W. (T.I.W. = Triple Insulated Wire)
Winding Order (Pin Numbers)	Primary (2-1), tape, Bias (4-3), tape, Secondary (7,8-5,6)
Inductance	Primary: 475 µH ±10%, Leakage: 35 µH (maximum)
Primary Resonant Frequency	300 kHz (minimum)

Table 1. Transformer Construction Information.

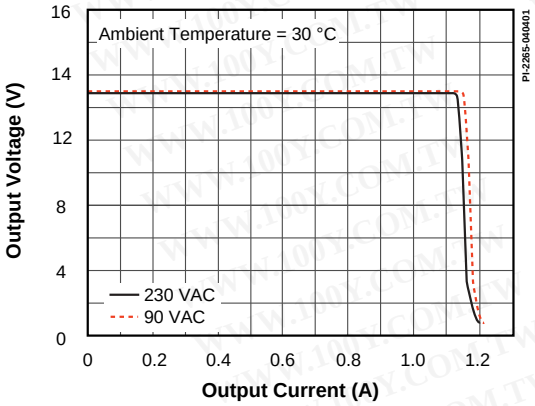

Figure 2. Output Characteristic (V_{OUT} vs I_{OUT}).

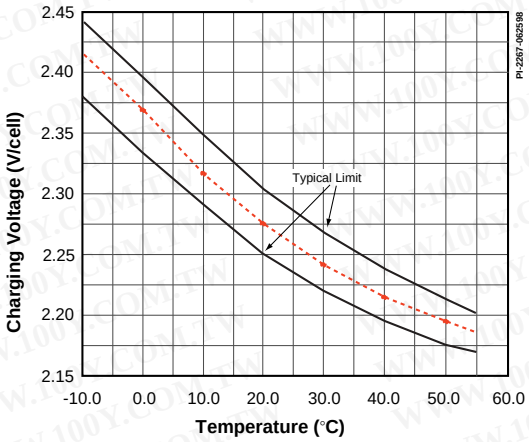

Figure 3. Cell Charging Voltage vs Temperature.

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