Design Idea DI-2
TOPSwitch® Lead Acid Battery Charger

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
Battery Charger	TOP224P	20 W	85 - 265 VAC	13.55 V @ 25 ˚C	Flyback

Design Highlights

- Low cost
- Replaces low efficiency, bulky linear supply
- World wide input voltage range
- Efficiency >75%
- Adjustable current limited output
- Temperature compensated for lead acid batteries.
- Control input for sensing battery presence

Operation

The *TOPSwitch* generates a single isolated output voltage from a rectified AC input. This output can be used to charge a lead-acid battery in applications such as fire/burglar alarms and emergency lighting.

Lead acid batteries for standby uses are normally charged at ~2.3V/cell and current limited to 0.1 A per Ah of capacity. In addition the charging voltage of lead acid batteries is dependent on temperature.

The primary side of the circuit is almost identical to the RD5 board (20 W universal reference design board). D3 has been changed to a BAV20 with a higher breakdown voltage than the 1N4148.

D2, C2, L1 and C3 rectify and filter the output from the secondary. R1, U2, C9, Q1, R3, R4 and R5 form the current limit. When the voltage across R3 reaches ~0.6 V Q1 turns on, drawing current through U2 via R1. This will reduce the *TOPSwitch* duty cycle and hence the output current (constant current operation). R5 is added to ensure that there is always a voltage available to drive the optocoupler at low output voltages. C9/R4 adds compensation and limits base current.

The output voltage is controlled using a TL431 voltage reference (U3). Here the current through the opto (U2) is altered dependant on the output voltage. R7, R8, R9 and RT1 set up a voltage of 2.5 V at the reference pin of U3. R6 limits the maximum current through the opto. R2 is added as a minimum load to maintain regulation at light or no load. The addition of RT1 provides the temperature compensation.

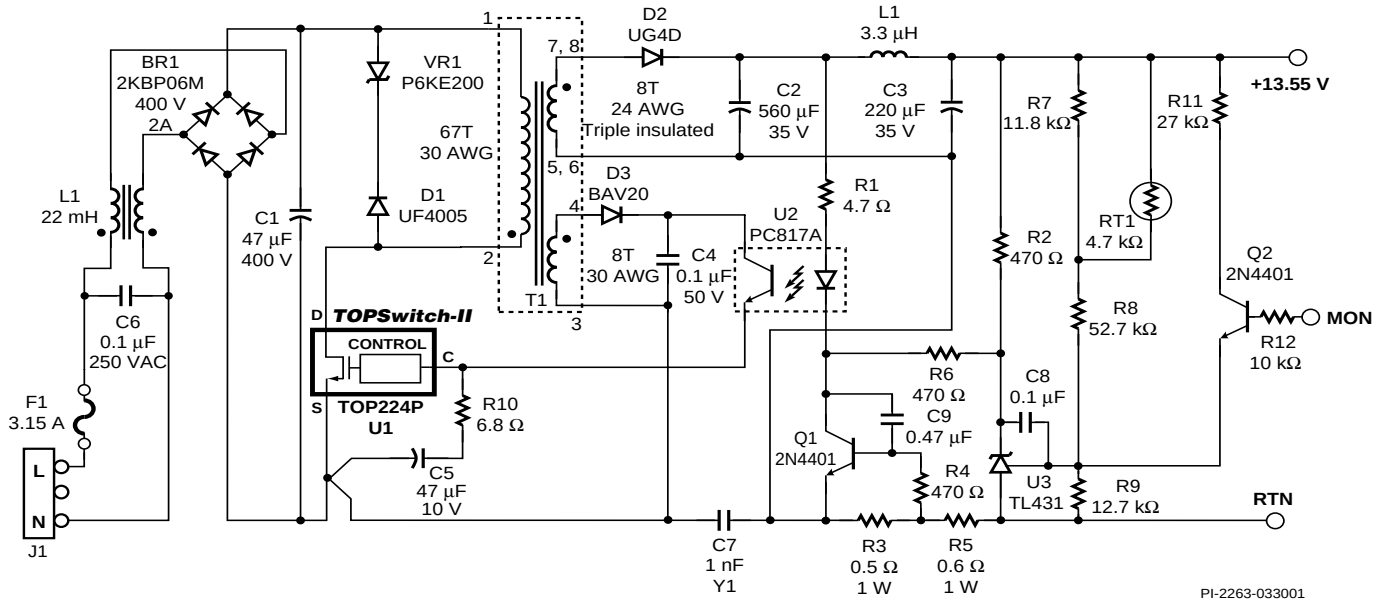
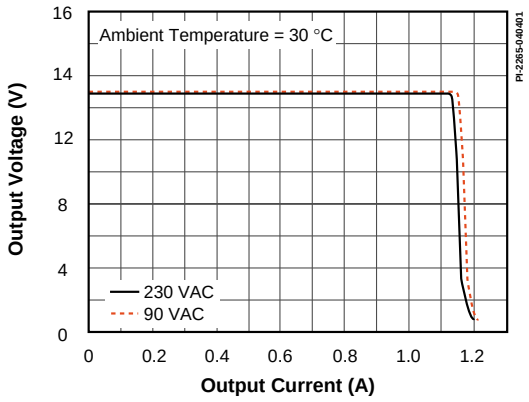


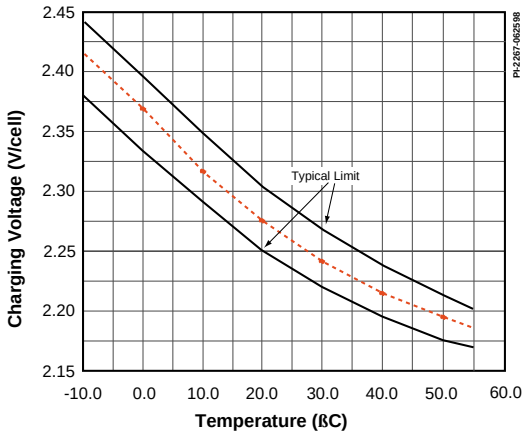
Figure 1. TOPSwitch Lead Acid Battery Charger.

R11, R12 and Q2 provide battery detection. By applying 5 V to R12, Q2 turns on, adding R11 to the existing resistor divider, and reducing the output voltage setpoint to approximately 8 V. This disables the charger, allowing the battery voltage to be measured. The exact battery voltage gives the state of charge.

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



Cell Charging Voltage vs. Temperature



Transformer Parameters	
Core Material	TDK PC40 EE22/29/6-Z Gap for A_L of 145 nH/T^2
Bobbin	YC 2204 (Ying Chin)
Winding Order	Primary (2-1), Tape, Bias (4-3), Tape, Secondary (7,8-5,6)
Primary Inductance (Pins 1-2, all others open)	650 µH ± 10% @ 100 kHz
Primary Resonant Frequency (Pins 1-2, all others open)	700 kHz minimum
Leakage Inductance (Pins 1-2, with Pins 5-7 shorted)	35 µH maximum

Key Design Points

- R3 sets output current limit threshold – value given by $0.6/I_{LIMIT}$.
- Rate R3 and R5 according to $I_{LIMIT}{}^2R$ dissipation.
- Ensure total voltage across R3 and R5 >1.5 V @ I_{LIMIT} if control to 0 V out is required.
- If output current rises or if instability at low output voltages verify cathode of D3 > 6 V, i.e. that there is sufficient voltage to drive the optocoupler. Add additional bias turns as needed.
- Choose tolerances of U2, R7, R8, R9 and R10 to give the desired overall tolerance (R7, R8, R9 = 0.1%; R10 = 1% and U2 = 1% for overall tolerance < 2%).
- Q1, Q2 can be any general-purpose transistor.
- Prototypes may be based on RD5 board (see *www.powerint.com*).
- Thermistor used is Philips part # 2322-640-54472.

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