# Photo-flash charger minimizes parts count

*STEVEN CHENETZ, MICREL SEMICONDUCTOR, SAN JOSE, CA*

Photo-flash and strobe devices operate by discharging a high-voltage capacitor into a bulb. Charging the capacitor from a battery or other low-voltage source requires a step-up dc/dc converter to boost the voltage, typically to 300V. One way to generate the high voltage is to use a flyback converter. The circuit in **Figure 1** provides a simple and reliable way to charge a high-voltage capacitor. The flyback converter performs two functions: It boosts the low-voltage input and provides isolation between the input (battery) and output (high voltage). Its main components are the power transformer; the output diode; the output capacitor; and the MIC3172 controller chip, which combines the switching transistor, voltage regulator, and control logic.

The transformer stores energy when the internal transistor of the MIC3172 turns on, allowing current to flow through the transformer's primary. When the transistor turns off, the stored energy flows through the output rectifying diode and into the capacitor. The voltage across the capacitor increases with each switching cycle until it reaches the preset voltage. The resistive divider $R_2/R_2/R_3$ and the 1.24V reference in the IC determine the preset output voltage: $V_{OUT}=V_{REF}(R_1+R_2+R_3)/R_3$.

Once the capacitor voltage reaches the preset value, the MIC3172 stops switching. Current flow in the output components cause the capacitor to discharge. The MIC3172 provides occasional energy pulses that keep the capacitor fully charged. When the capacitor discharges into the bulb, the charging process repeats. $D_1$ and $D_2$ clamp any voltage spikes on the collector of the MIC3172 switch node, caused by leakage inductance on the transformer. When the IC's internal transistor turns off, the voltage across the transformer's primary approximately equals the output voltage divided by the turns ratio. The voltage at the transistor collector node (Pin 7) equals the reflected voltage plus the input voltage, plus the voltage spike caused by the leakage energy in the transformer: $V_{SW}=(V_{OUT}/N)+V_{IN}+V_{LEAKAGE}$.

The collector-node voltage must always be less than 65V. The zener-diode voltage is set greater than the maximum reflected voltage at the transformer primary. For **Figure 1**, the reflected voltage is 10V. The zener diode is a 12V device, approximately 20% greater than the reflected voltage. The maximum reverse voltage across $D_2$ equals the maximum input voltage. This diode must be an ultrafast or Schottky device, to prevent excessive losses in the diode.

The energy stored in the capacitor is $0.5CV^2$. The output power that the flyback converter requires to charge the capacitor in a period T is $(0.5CV^2)/T$. The following formula gives the approximate charging time for the converter circuit:

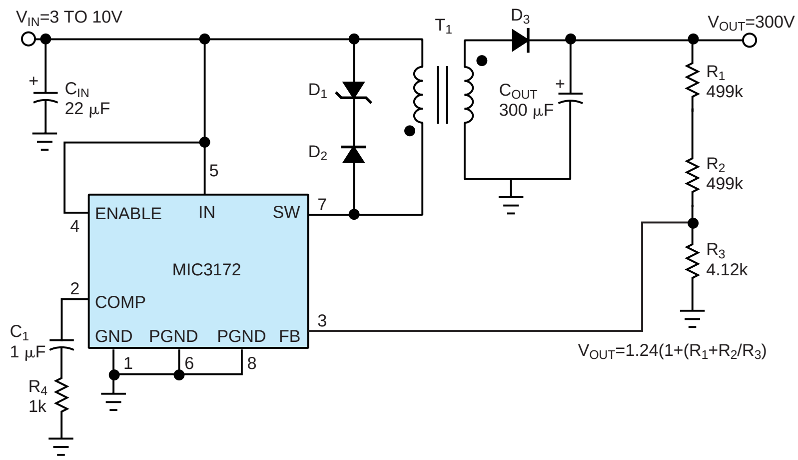
$$T_{CHARGE}=\frac{C_{OUT}V_{OUT}^2}{2V_{IN}I_{PK}\eta},$$

where $I_{PEAK}$ is the peak current level of the MIC3172 control chip (typically, 1.8A); D is the maximum duty cycle (approximately 0.6); and η is the efficiency of the flyback converter (0.5).

Charging a 300-μF capacitor to 300V from a 5V input requires $(300\ \mu F\times 300V^2)/(2\times 5V\times 0.6\times 0.5)=5$ sec. For the circuit in **Figure 1**, the output voltage is potentially lethal. At 300V, the energy in the output capacitor is 27J, more than enough to ruin an otherwise good day. When you lay out the circuit, be sure to provide adequate spacing between the high- and low-voltage sections. The power transformer, such as the Coiltronics CTX04-13770, must have the proper spacing and insulation between the high-voltage secondary and low-voltage primary.

The circuit uses two resistors, $R_1$ and $R_2$, in the upper section of the output to reduce voltage stress, because most commonly available resistors are rated at 200 to 300V—too close to the limit for reliable, long-term operation. If $R_1$ or $R_2$ should open or if $R_3$ shorts, the converter runs open-loop at its maximum duty cycle. This failure mode boosts the voltage far above the preset limit and causes the output capacitor to vent. The circuit in **Figure 2** provides overvoltage protection.

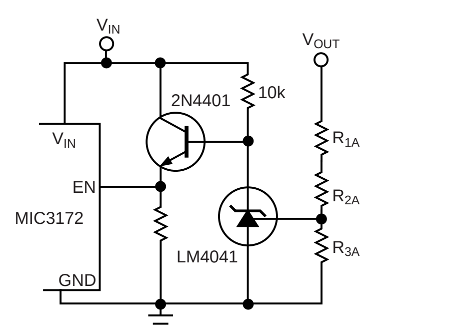
**FIGURE 1**




**NOTES:** IC=MICREL MIC3172BM BOOST-CONVERTER IC.
$C_{IN}$=AVX TPS SERIES TANTALUM.
$T_1$=1-TO-30 STEP-UP FLYBACK TRANSFORMER; LPRI=35 μH; COILTRONICS P/N CTX04-13770.
$D_1$=MOTOROLA 1SMB5927BT3, 12V ZENER.
$D_2$=MOTOROLA MBRS130LT3, 1A, 30V.
$D_3$=MOTOROLA MURS160T3, 1A, 600V.
$R_1$ TO $R_4$=METAL-FILM RESISTORS, 1206 (200V RATED).
$C_1$=CERAMIC CAPACITOR, X7R SERIES.

Generate 300V from a low-voltage source, using this simple, low-parts-count circuit.

**FIGURE 2**




Avoid the exploding-capacitor syndrome by using this overvoltage-protection circuit with the circuit of Figure 1.

Be sure that the resistor divider for the overvoltage circuit is separate from the voltage-regulation divider. Set the overvoltage level 15% higher than the output-voltage setting, and make sure it does not exceed the capacitor's voltage rating. (DI #2266).

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