Product How-to: Drive LEDs with fluorescent ballasts (part 1)

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With the rapid development of high brightness LEDs, SSL (Solid State Lighting) is no longer a niche market. In commercial buildings and department stores LED fixtures are chosen over fluorescents because of efficiency, fast startup, easy dimming, low maintenance, and even style. However, the cost of replacement of fluorescent is not only the cost of LED fixture, but also the labor cost.

It takes a long time to remove the fluorescent ballast, so the cost of labor and down time is a significant portion of the total cost. There is a need to drive LEDs directly from electronic ballasts. Part 1 of the article describes an AC/DC converter without active LED current control. Part 2 of the article will introduce a method for active LED current control.

Fluorescent tubes require an AC current source to drive them. If a voltage source is used, the circuit is unstable due to the lamp’s negative resistance characteristic. Lamp current is specified by the tube manufacturer, and the ballast must produce that current over a range of lamp voltage.

LEDs require a DC current source. A simple bridge rectifier circuit will allow operation of an LED string from the ballast output, if the LED current and voltage are reasonably close to the fluorescent tube’s characteristics. The high frequency current from electronic ballasts will require fast recovery diodes, such as ST’s STTH102 or STTH1R02. The LEDs themselves will limit the diode reverse voltage. Figure 1 shows the schematic.

Figure 1 Rectifying ballast AC current to DC current

The bridge at each end of the tube takes care of the filament windings in some types of ballast. If the ballast has only one output for each end, one pair of diodes at each end can be eliminated.
If the output current of the ballast is $I_{\text{ballast}}$, typically it is rated in RMS value. We can calculate the LED current will be:

$$I_{\text{LED}} = \frac{2 \sqrt{2}}{\pi} I_{\text{ballast}}$$  \hspace{1cm} (1)

For long life, the capacitor must be present to reduce the ripple current applied to the LEDs. Its value can be determined from the LED voltage and current. Fortunately, a small film capacitor can be used since the ballast operates at a frequency of about 40 KHz.

Because the electronic ballast is a current source, there is a problem if the LED load opens. The voltage can go extremely high, and this can damage the circuitry (especially on the bench, during experimentation...). So the LED driver needs to provide open load protection. Figure 2 shows one method. If the LED string is disconnected or open, the voltage across the SCR will be over the threshold voltage set by D5, the SCR will be triggered and the circuit is shorted. The circuit will stay shorted until the power is removed from input. The ballast will not be damaged - it is protected from short circuits.

A transformer is shown in the figure above to match two low-voltage LED strings to the ballast’s designed voltage and current. To avoid disturbing the ballast’s resonant inverter, the magnetizing inductance (open-circuit inductance) of the ballast-side winding should be greater than 20mH. Autotransformers are the best solution for minimum size.
Part two will cover the AC/DC converter with active LED current control, dealing with high harmonic input current and maximum LED string lengths for ballast types.