Electronic transformer dims halogen lamp

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A typical, switched-mode power supply for a halogen lamp, commonly known as an electronic transformer, is a clever and simple device. However, it has some limitations, such as its inability to dim the lamp. Figure 1 shows a simplified schematic of a typical low-voltage halogen-lamp transformer without the protection circuits and EMI filter. Q₁ and Q₂ with C₂ and C₃ comprise a classic, half-bridge topology that works in self-oscillating mode. The circuit provides positive feedback by placing the primary windings of transformer T₁ in series with the bridge output. To achieve a high power-factor value, a rectified but unfiltered mains voltage supplies power to the circuit. The working frequency is approximately 30 to 40 kHz.

This simple circuit does not allow for correctly and conveniently dimming the lamp because any attempts to manipulate the time constant of the R₁/C₁ start-up circuit worsen the power factor. A possible solution that involves making taps in the primary winding of transformer T₂ is neither elegant nor convenient.

The circuit in Figure 2 provides a way to dim the lamp. In this circuit, a popular PWM IC controls a modified buck regulator. One modification is a change in the position of Q₁, which lets you control the regulator without using a pulse transformer, for example. A second modification significantly reduces the capacity of C₁ because the circuit should act similarly to an autotransformer to keep a high power factor. Therefore, the rectified mains voltage powers the regulator, which sits behind the bridge rectifier. The regulator produces the same output-voltage shape but of lower and regulated amplitude. C₁ has a low value, so, in conjunction with L₁, C₁ removes any switching products from the output voltage without filtering out 100-Hz ripples of the mains voltage.

Thus, the circuit is halfway between a buck regulator and a current source feeding an H-bridge converter. Using a classic current source to feed the bridge converter would be inconvenient because of the lamp power supply's self-oscillating mode and variable switching frequency.

Changing the duty cycle of Q₁’s pulses accomplishes the lamp dimming. You can use any one of many integrated PWM controllers to control the switching of Q₁. The only important point is that the PWM IC needs to work with the maximum pulse duty cycle, which is important if you want to keep the brightness of the halogen lamp close to maximal. The prototype uses a cheap controller, the UC3842, which operates in voltage mode because of the presence of the R₃/R₄ divider.

To operate the circuit, you need to supply the controller. On power-up, C₂ charges through R₁ and R₂, which starts the switching. To keep the controller running requires extra power to C₂. The additional, secondary windings on T₂ and the bridge rectifier support this function (Figure 3). Unfortunately, the core choke, L₁, can have no secondary windings because those windings can't
supply enough power to the controller under maximum-duty-cycle conditions.

After adding an EMI filter and bridge rectifier to the regulator input, the circuit can work in stand-alone mode. With the circuit in this mode, you can connect to the output more than a few parallel ready-made electronic transformers without making any changes. In such a case, you need to recalculate the values and types of power components according to the power load. (DI #2525)