

Power Systems Design

E U R O P E

Empowering Global Innovation

May 2009



PowerLine ▶
Power ▶ **Player**
MarketWatch
TechTalk
Design Tips



Special Report - Lighting Systems

ISSN: 1613-6365

Taking a Dim View

Solutions to simplify dimming of fluorescent lamps

There is much in the news these days about LED lighting and the circuits developed to drive them. Fluorescent lamps however, are still widely used and are energy efficient. The drawbacks in the past have been the difficulties associated with adjusting the light output from these lamps. This article looks at the requirements for dimming fluorescent lamps and highlights how a new generation of control ICs can simplify future designs.

By Tom Ribarich, Director of Lighting Design, International Rectifier

Designers employ a variety of techniques to provide users with the ability to dim fluorescent lamps. Common approaches include DALI (digitally addressable lighting interface), triac-based wall dimmers, power line communication, 1VDC-10VDC interfaces and even wireless control. These all, however, require additional wiring at the electronic ballast during installation. Now new IC technologies are set to remove the need for this additional wiring and, therefore, speed, simplify and reduce the cost of

dimnable fluorescent designs.

Driving and Dimming Fluorescent Lamps

Fluorescent lamps require a current to preheat the filaments, a high voltage for ignition, and a high-frequency AC current during operation. An electronic ballast circuit must first perform a low-frequency AC-to-DC conversion at the input, followed by a high-frequency DC-to-AC conversion at the output.

ballast for such a lamp, including a dimming circuit that combines a dimming reference signal, a lamp current sensing and feedback signal, and a summing circuit for closed-loop lamp current control.

After passing through an EMI filter to block switching noise, the AC mains voltage is full-wave rectified and then peak-charges a capacitor to produce a smooth DC bus voltage. The DC bus voltage is then converted into a high-frequency, 50% duty-cycle, AC square-wave voltage

Figure 1 shows a block diagram of a

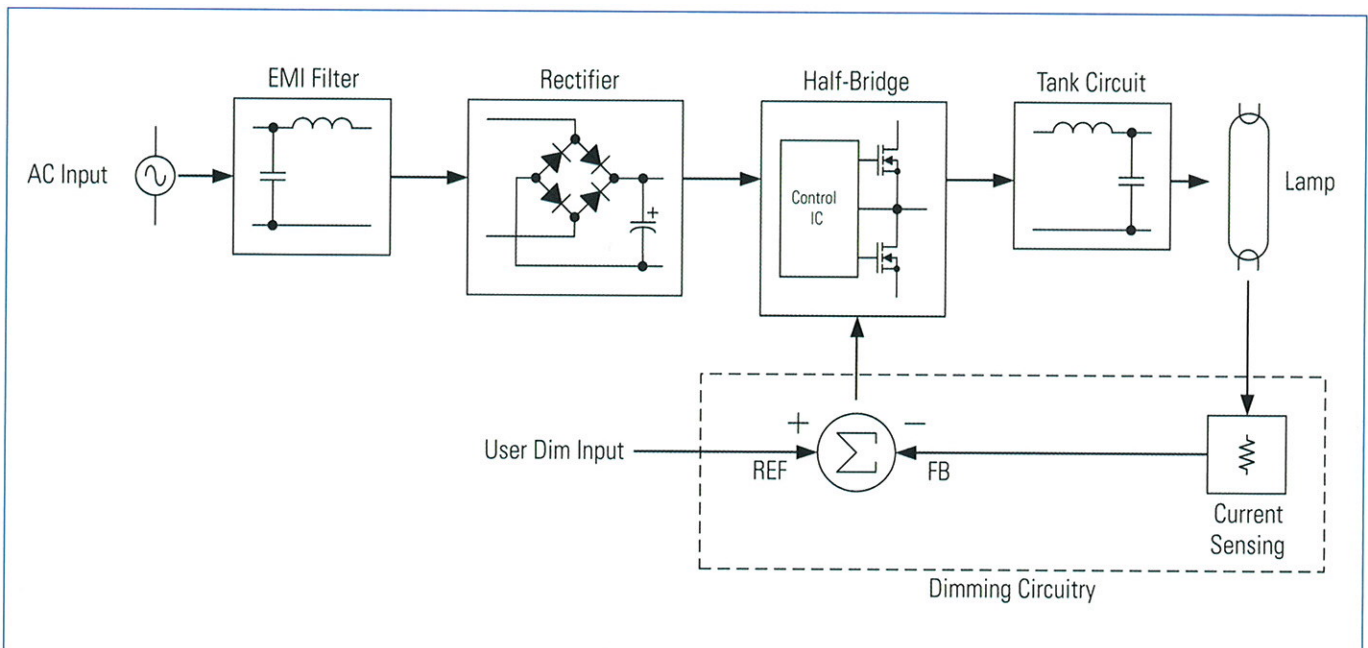


Figure 1: Dimming electronic ballast block diagram.

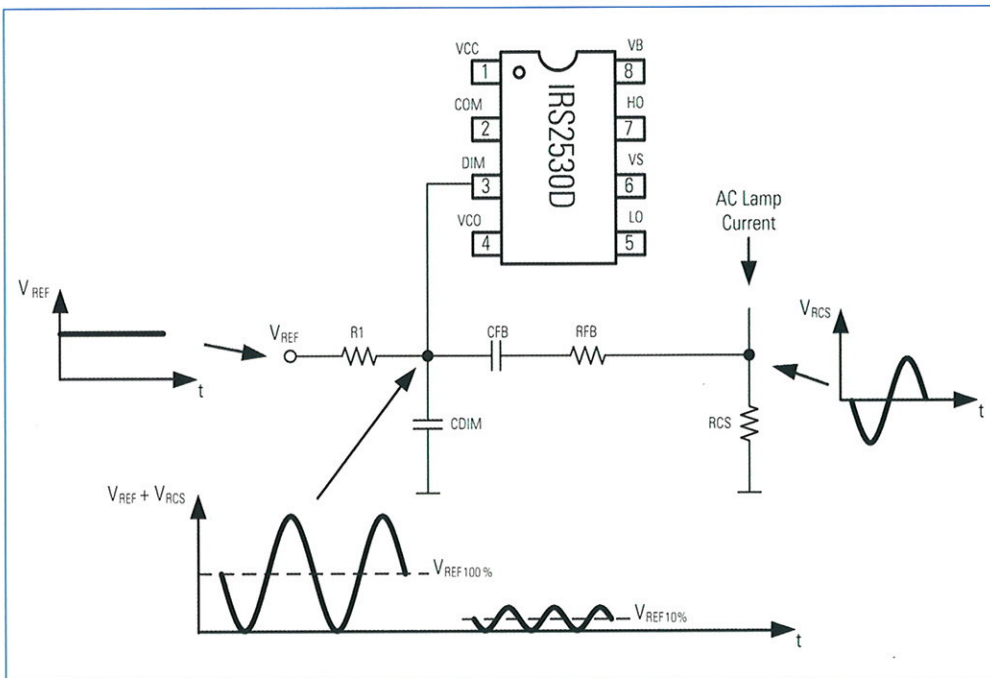


Figure 2: IRS2530D AC+DC dimming control method.

using a standard half-bridge switching circuit. The high-frequency AC square-wave voltage then drives the resonant tank circuit to produce a filtered sinusoidal current and voltage at the lamp.

During operation the resonant tank,

which is a series-LC circuit with a high Q-factor during the pre-ignition phase, becomes a series-L, parallel-RC circuit with a Q-factor somewhere between a high and low value depending on the lamp dimming level. When the CFL is first turned on, the control IC sweeps

the half-bridge frequency from the maximum frequency towards the resonance frequency of the high-Q ballast output stage. The lamp filaments are preheated as the frequency decreases and the lamp voltage and load current increase. As the frequency decreases the voltage rises and the lamp ignites when lamp ignition voltage threshold is reached. Lamp current is then controlled to maintain the correct power and brightness level.

Increasing the frequency of the half-bridge reduces resonant tank circuit gain, leading to decreased lamp current and, therefore, lamp dimming. The closed-loop feedback circuit measures the lamp current and continuously adjusts the half-bridge frequency to

regulate it to the dimming reference level.

Control IC

Choice of control IC for a dimming application is clearly important and Inter-

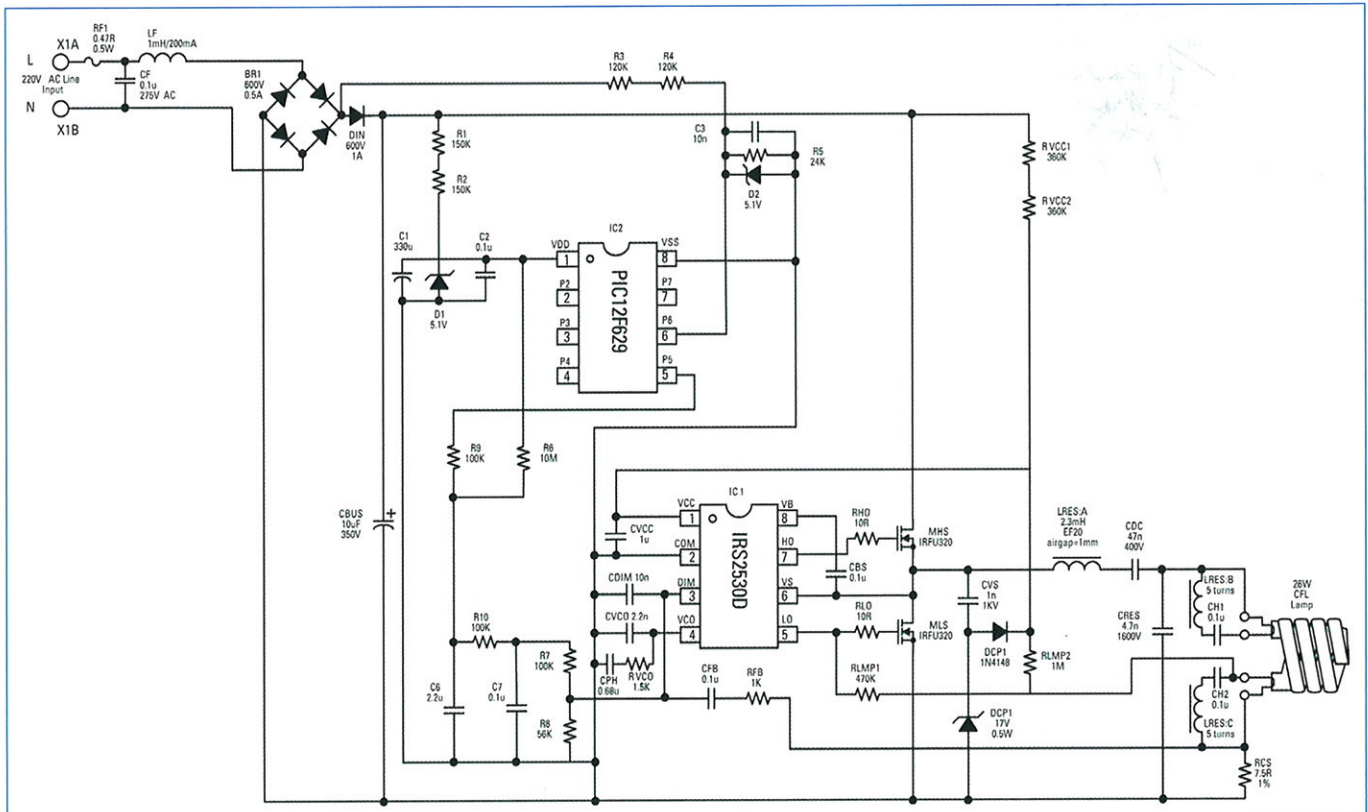


Figure 3: Schematic of quad-level dimming circuit.

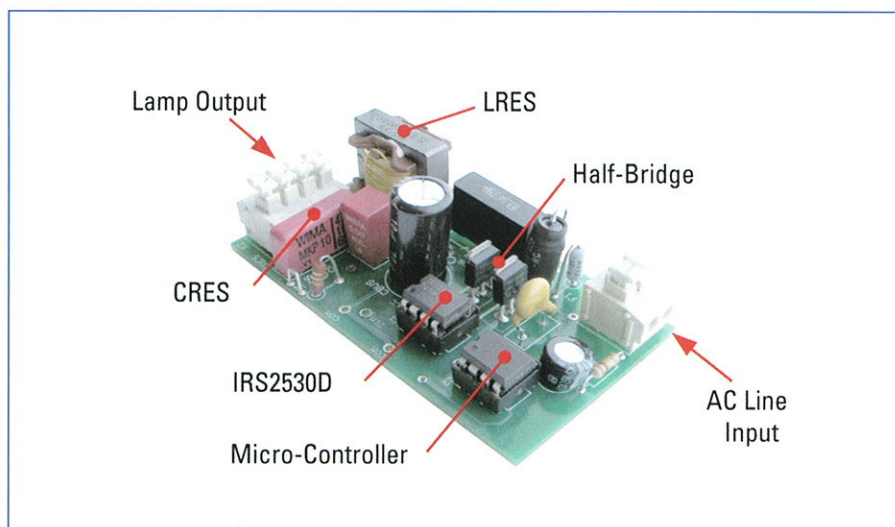


Figure 4: Quad-level fluorescent dimmer reference design.

national Rectifier's IRS2530D provides a good example of the current state of play. This device incorporates all of the functions to preheat and ignite the lamp, and a variety of protection against fault conditions such as open filament failures, lamp non-strike and mains brown-out.

Figure 2 shows how the AC lamp current measurement across the sensing resistor RCS is coupled onto the DC dimming reference through a feedback capacitor CFB and resistor RFB. This allows the dimming function to be realized by combining the AC lamp current measurement with the DC reference voltage at a single node. The IC's feedback circuit continuously adjusts the half-bridge frequency so as to regulate the valley of the AC+DC signal to COM as the DC dimming level is increased or decreased. This causes lamp current to increase or decrease for dimming.

Quad-Level Dimming

Now let's consider how a device such as the IRS2530D can be used to implement a four-level dimming design that will help to reduce the problem of additional ballast wiring mentioned earlier.

Figure 3 shows a schematic of the quad-level switch dim ballast design that combines an EMI filter, a full-bridge rectifier and smoothing DC bus capacitor, the IRS2530D "DIM8™" dimming control IC, a switching half-bridge and resonant tank circuit to preheat, ignite and run the lamp. In this design a microcontroller is used to set and store the

dimming level, and a pulse detection circuit to detect when the AC input voltage turns on and off.

The lamp arc current is detected through RCS after ignition and coupled onto a DC reference voltage to provide an AC signal with a DC offset at the DIM pin of the IRS2530D. During DIM mode, the IRS2530D adjusts the oscillator frequency in order to maintain the amplitude of this feedback signal and control the lamp current for dimming. The frequency of the HO and LO gate driver outputs is set by the voltage at the VCO pin of the IRS2530D and the Capacitor CPH is used to program the frequency sweep time for preheat and ignition of the lamp.

At turn-on, the voltage at the VCO pin will ramp up from 0V causing the frequency to decrease from the maximum frequency down to the minimum frequency. As the frequency continues to fall towards the resonance frequency of the tank circuit, the lamp voltage increases until the lamp ignites. The lamp arc current begins to flow and a feedback signal is produced at the current sense resistor RCS. If ignition fails then the IRS2530D will shut down, going into a low VCC current fault mode.

The DC dimming reference at the DIM pin is derived from an RC-filtered square wave voltage generated by the microcontroller. This microcontroller controls the four dim levels by using a fixed frequency signal at four separate duty-cycle modes of 100%, 66%, 33%

and 10%. Highest brightness level is achieved with the highest duty cycle.

Pin 6 of the control IC is connected to the AC line input voltage through a fast delay circuit, which is used to detect fast on/off cycles of the AC line input. When the AC line is switched off the IC - which can continue to run for more than one second after removal of the AC line thanks to the VDD supply capacitor - detects this and starts a timer. Restoring power within one second reduces the output square-wave duty-cycle and, therefore, the dimming by one step (unless the dimming level is already at minimum then it cycles back to maximum). If the AC line is removed for more than one second, the dimming level will not change. After the supply capacitor has discharged below the minimum operating voltage of the control IC the microcontroller will shut off.

Summary

Implementing a ballast circuit based on the IRS2530D dimming control IC, a microcontroller and a pulse detection circuit as described above provides an elegant solution for delivering four different levels of brightness by sensing the on/off switching of the AC mains voltage. The IC itself incorporates complete ballast control, dimming feedback loop and fault protection, simplifying overall design and leaving the engineer free to concentrate on other aspects of the design.

To help designers evaluate and implement quad-level dimming solutions as described here, International rectifier is offering a complete reference design (Figure 4) based on a two-layer PCB with small form factor that is suitable for driving a 26W fluorescent lamp.

www.irf.com