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Design Note – DN05010/D

Accelerated NCL30000 Line Dimming

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCL30000	LED Lighting	Various	Up to 60W	Hi PF Single Stage	Applies to Isolated or Non-isolated

Overview

The NCL30000 LED Driver can be configured to dim LED current by using a standard phase cut (leading edge or trailing edge) wall dimmer. The most commonly used dimmers use a TRIAC circuit to “chop” a portion of the input AC waveform thus reducing the RMS input voltage into the driver. Details on implementing TRIAC and electronic dimmer control can be found in application note AND8448 at onsemi.com and in many cases the driver can be dimmed across a current range of greater than 200:1.

Unfortunately, not all dimmers have wide conduction angle adjust ranges and this limits the dynamic range over which the LED current can be reduced. This design note describes a simple circuit enhancement that changes the shape of the dimming curve of the NCL30000 to allow better current control range over a narrow range of conduction angle.

Key Features

- Provides accelerated ‘power curve’ dimming
- Simple circuit consisting of four parts
- Smooth dimming response
- Improves dimming range of some dimmers

Circuit Description

As discussed in AND8448, the basic control principle for line dimming the NCL30000 is to limit the maximum on time such that as the RMS input voltage is reduced, the power delivered to the load is bounded. Once the limit point is reached, any further adjustment of the dimmer results in LED current reduction.

The dimming function described above provides an almost linear relationship between the conduction angle of the dimmer control and the LED current and provides smooth dimming that takes full advantage of the complete travel of the dimmer with no dead spots once dimming has started. Since some dimmers do not have a wide conduction range, this control scheme can be easily modified to achieve a non-linear dimming relationship that provides a more rapid reduction of current as the dimmer setting is reduced followed by a more gradual change as the dimmer approaches the minimum setting.

In February 2011, the National Electrical Manufacturing Association (NEMA) of the United States published SSL-6 “*Solid State Lighting for Incandescent Replacement Dimming”* which establishes a clear set of guidelines for dimming LED products. It includes a specification for the dimming characteristic of an LED light source versus input line conduction angle as well as illustrates how an incandescent bulb behaves within the standard.

The accelerated dimming characteristic can be implemented on the NCL30000 controller by adding a simple circuit shown in Figure 1. This dimming characteristic more closely emulates an incandescent bulb.

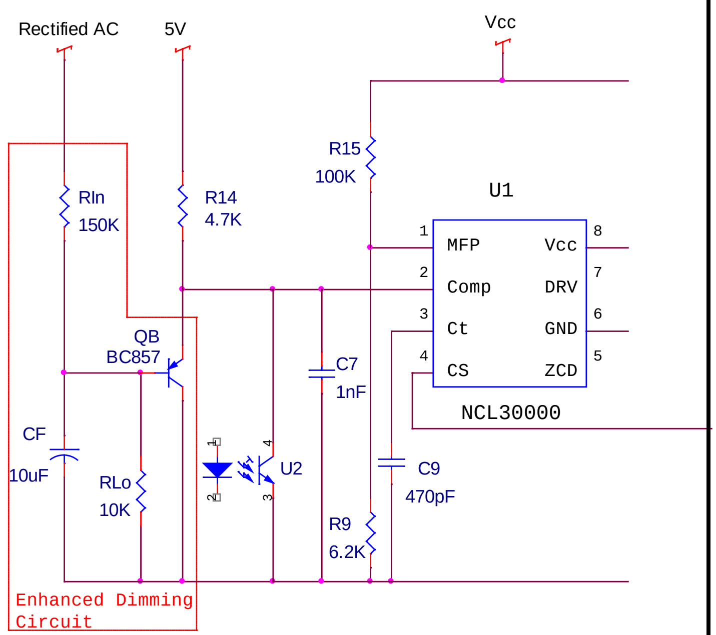

Figure 1: Partial Schematic of Enhanced Dimming Circuit Modification for isolated control

The NCL30000 COMP pin is controlled by feedback and is compared to an internal ramp to establish FET switch on-time and the current delivered to the LEDs. The COMP pin voltage reaches a maximum of about 5.5 volts as the dimmer conduction angle and therefore applied input voltage is reduced. Since the peak power delivered is limited by the maximum on-time, any further reduction in applied voltage as the dimmer is decreased reduces the power delivered to the LEDs.

The circuit shown in Figure 1 modifies the dimming slope by reducing the COMP pin level as a function of the average input voltage. This in turn reduces the FET switch on-time.

The circuit of Figure 1 is a voltage divider with a filter capacitor providing a DC level proportional to the average AC line voltage applied to the LED driver. The filter smoothes the chopped waveform created by the phase-cut dimmer. The PNP transistor QB acts as an impedance buffer and isolation diode coupling the filtered DC level to the COMP pin.

Resistor Rin should be selected depending on the input line voltage. Consider the dissipation and voltage stress for the selected device. A value of 150 kΩ is suggested for 115 Vac applications and 300 kΩ is used for 230 Vac applications. Two 150 kΩ resistors may be required to remain within the voltage rating if 1206 surface mount devices are selected.

Resistor RLo is selected to establish the AC input voltage where the COMP pin will begin to affect on-time. Typically, the threshold will be 5.5 volts, but must be corrected for the emitter-base voltage of QB. Typical values for the lower resistor range from 6.8 kΩ to 10 kΩ. The selection depends on the desired dimmer position where accelerated dimming begins.

To demonstrate the improvement, the circuitry described above was added to an existing 11 W PAR30 Driver design. Details on the design can be found in application note AND8463.

The graph in Figure 2 shows dimming characteristics for the 115 Vac NCL30000 PAR30 LED lamp controlled by a Leviton Sureslide® dimmer. Shown are the original and the accelerated characteristic achieved with the added circuit. Note the LED current diminishes rapidly as the dimmer setting or conduction angle is reduced.

As the conduction angle drops below 80 degrees the slope of the LED current reduces. This flattening provides better adjustment resolution. Additionally, some dimmers have a narrow range of conduction angle; some are limited to 60º minimum. So at 60º conduction angle with the improved dimming curve, the LED current is more than 60% less than the standard dimming curve. Moreover with the improve circuit the LED current reached 2 mA (230:1 dimming) at 46º versus the standard curve where that same point is reached at 29º. This is important as many dimmers do not have the wide adjustment range of the example test dimmer from Leviton.

Similar results are obtained with a 230Vac PAR30 LED lamp. Figure 3 shows dimming response for the unmodified lamp and two values of RLo. The effect of when accelerated dimming begins is clearly shown.

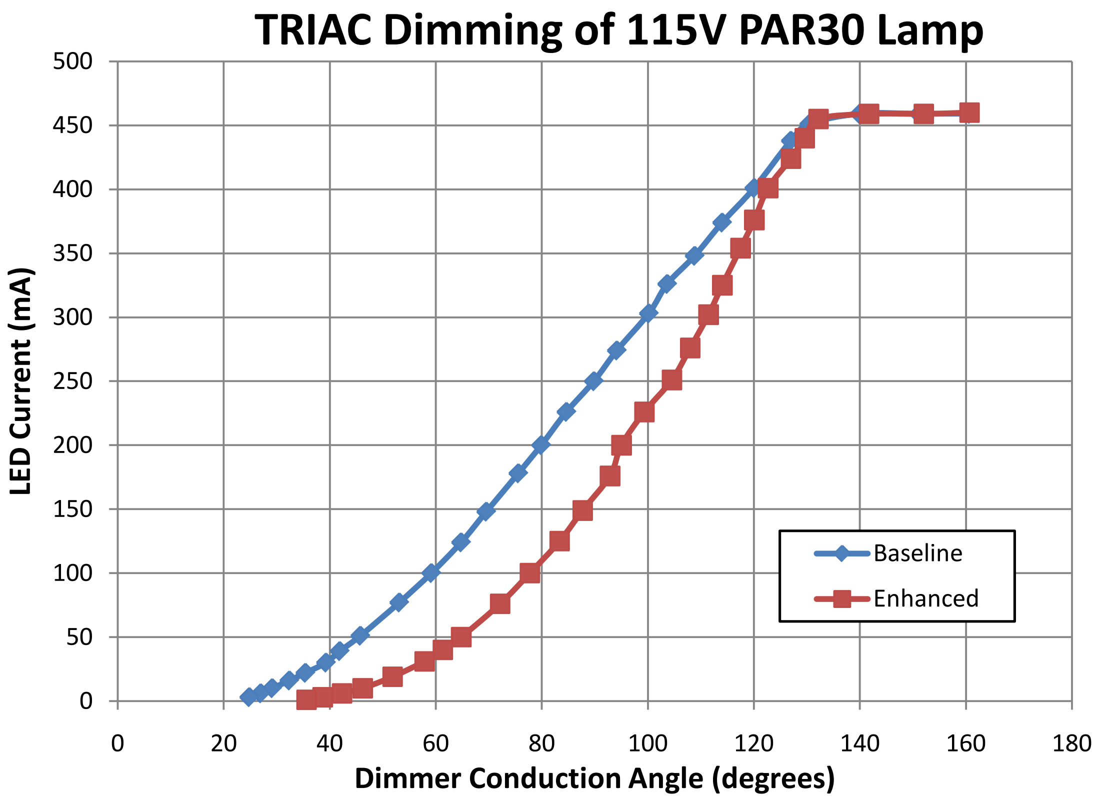

Figure 2: 115 Vac Dimming Characteristics (Rin = 150 kΩ)

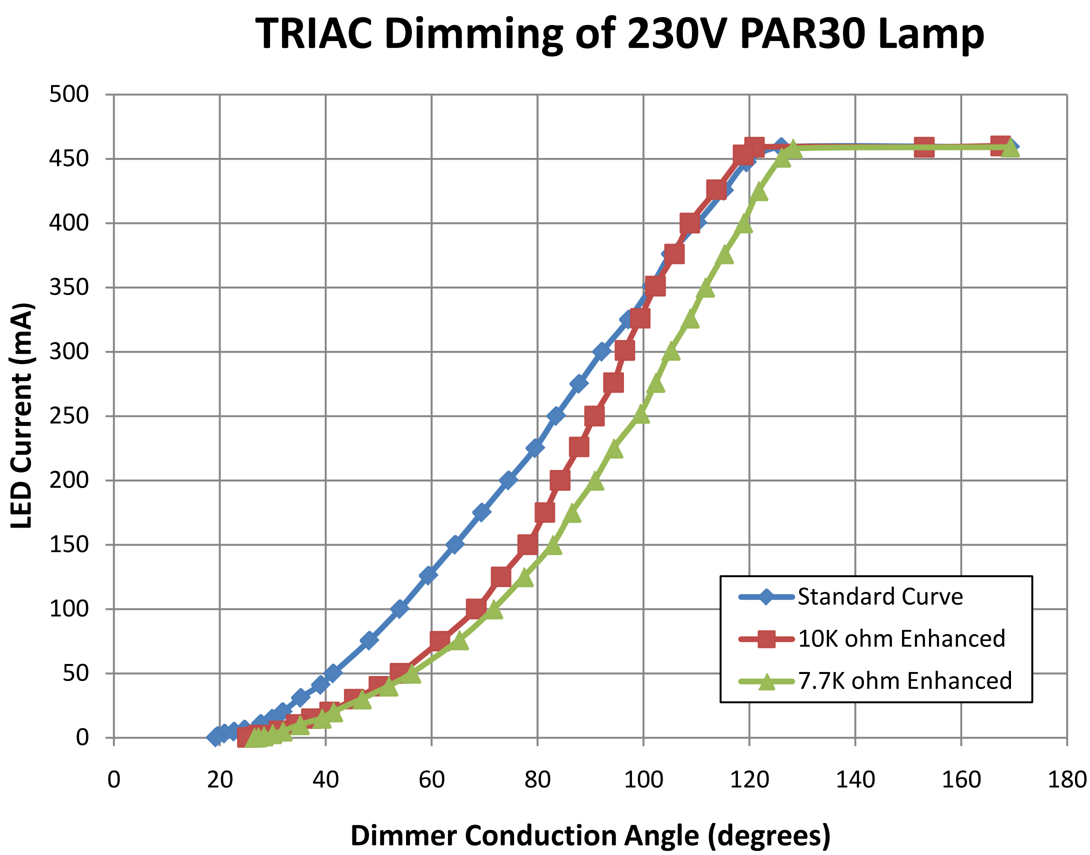

Figure 3: 230 Vac Dimming Characteristics (Rin = 300 kΩ)

References:

- ON Semiconductor Application Note AND8448; Configuring the NCL30000 for TRIAC Dimming
- ON Semiconductor Application Note AND8463; 11 Watt TRIAC Dimmable PAR30 LED Lamp Driver
- NCL30000; Power Factor Corrected Dimmable LED Driver Data Sheet
- NEMA SSL-6 Solid State Lighting for Incandescent Replacement Dimming (http://www.nema.org/stds/ssl6.cfm)

Design note created by Jim Young, e-mail: james.young@onsemi.com