APPLICATIONS INFORMATION

Application Note
29501.2A

A PRIMER ON DRIVING INCANDESCENT LAMPS

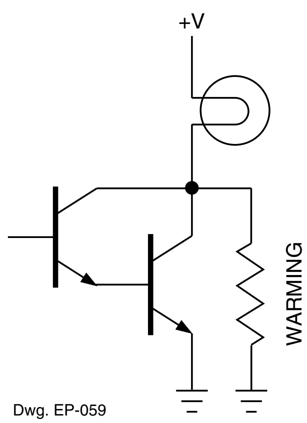

Figure 1 — Lamp “Warming” Resistor

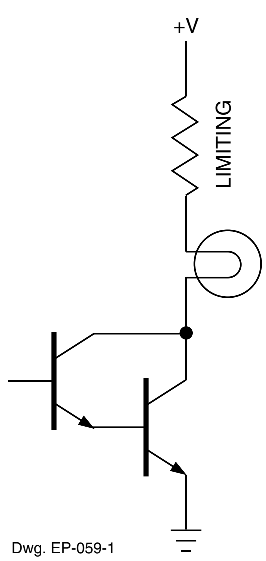

Figure 2 — Current-Limiting Resistor

Tungsten-filament incandescent lamps exhibit a very-high positive temperature coefficient of resistance with the cold filament resistance being approximately 10% of the hot filament resistance. When an incandescent lamp is initially turned on, the cold filament is at minimum resistance and will normally allow a 10x to 12x peak current. Within 3 to 5 ms the current falls to approximately 2x the hot current. This high lamp turn-on current (commonly called “in-rush” current), can contribute to poor lamp reliability and can destroy semiconductor lamp drivers. Even if the active part of the driver output could survive the short-duration peak current, the internal bonding wires can “fuse” open. High-current drivers or paralleled drivers, rated to handle the peak inrush current, may prove cost prohibitive.

Two simple methods are shown here for controlling the lamp in-rush current in standard power driver applications.

Warming resistors (Figure 1) protect both driver and lamp by preheating the lamp to between the cold and hot values. A general recommendation is to provide a warming current of 25% of the rated operating current. This will reduce the in-rush current to approximately 4x. Depending on the amount of warming current, a dim lamp “glow” might be visible under low-light conditions. This method also provides reduced filament breakage due to vibration but adds significant power consumption when the lamp is off.

Alternatively, an inexpensive current-limiting resistor (Figure 2) can be used to protect the lamp and driver, which will dissipate only a small amount of power when the lamp is on. The minimum resistor value is easily calculated as

$$R_S \geq \frac{V_{CC} - V_{CE(sat)}}{I_{cm}} - \frac{V_L}{10 \times I_L}$$

where I_L = rated lamp current

I_{cm} = rated peak driver current

V_{CC} = supply voltage

$V_{CE(sat)}$ = driver saturation voltage at rated peak current

V_L = rated lamp voltage

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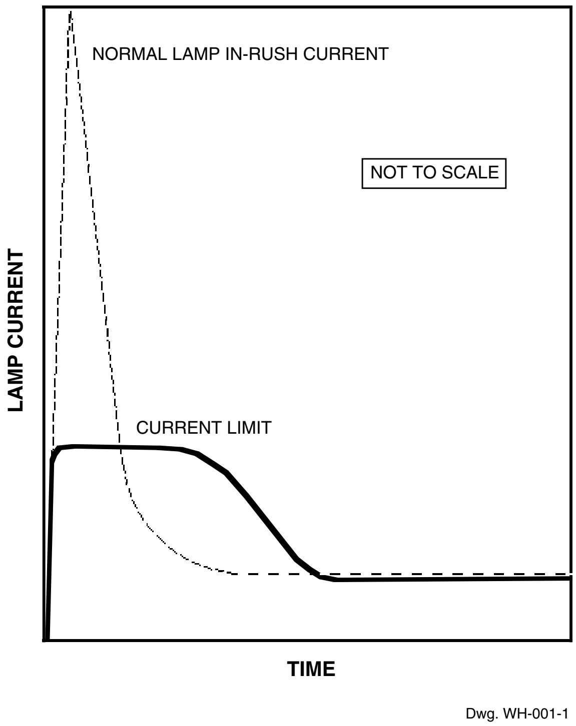

Figure 3 — Lamp Current vs Time

The required resistor power rating is determined by the hot filament current and is usually 1/4 or 1/2 W ($P_S = I_L^2 \times R_S$). The slightly reduced lamp voltage, caused by the series resistor voltage drop ($I_L \times R_S$), should have minimum effect on lamp brightness and will prolong lamp life. If brightness is an important concern, the supply voltage can be increased* to compensate for the driver saturation voltage and the series resistor voltage drop or, alternatively, a negative-temperature coefficient resistor can be used where R_S is its cold resistance.

Lamps can also be efficiently driven by current-limited power drivers without the need for warming or current-limiting resistors. Allegro current-limited drivers are listed below. With these drivers, during turn-on, the high in-rush current is sensed by an internal low-value resistor and/or a thermal-gradient sensing circuit. During this transition period, the output stage is driven in a linear fashion, limiting the current while the filament resistance increases to its hot value (Figure 3). As the lamp current falls, the output stage goes into saturation and applies full supply voltage to the lamp.

Allegro Lamp Driver(s)	Channels per Driver	Maximum Continuous Current	Current Limit Value
UDx2543B/EB	4	700 mA	1.0 A
UDx2547B/EB	4	600 mA	1.3 A
UDx2549B/EB	4	600 mA	1.0 A
A2557xEB/LB	4	300 mA	500 mA
UDx2559B/EB	4	600 mA	1.0 A
UDx2559LB	4	400 mA	1.0 A
UGQ5140K Hall	1	300 mA	900 mA

Some Allegro drivers, with over-current protection in the form of a fault latch (as in the UDN2987A), cannot be used in lamp driver applications except with stringent design efforts. In applications controlling multiple lamp filaments, the internal clamp diodes may be connected together through an appropriate current-limiting resistor to a simple “lamp test” switch. A side-effect with any current-limiting method is that lamp turn-on time will increase, but generally this is unimportant and not noticeable.

* Multiplexed lamps must typically be operated at a voltage $\sqrt{N}$ times the nominal dc operating voltage (where N is the number of digits), to obtain sufficient brightness.

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For reference, as approximations, the light output of an incandescent lamp (other than long life [>5000 hrs] or halogen-cycle lamps) varies as the 3.5 power of the applied voltage-to-design voltage ratio, the lamp current varies as the 0.55 power of the voltage ratio, and lamp life varies inversely as the 12th power of the voltage ratio (Figure 4).

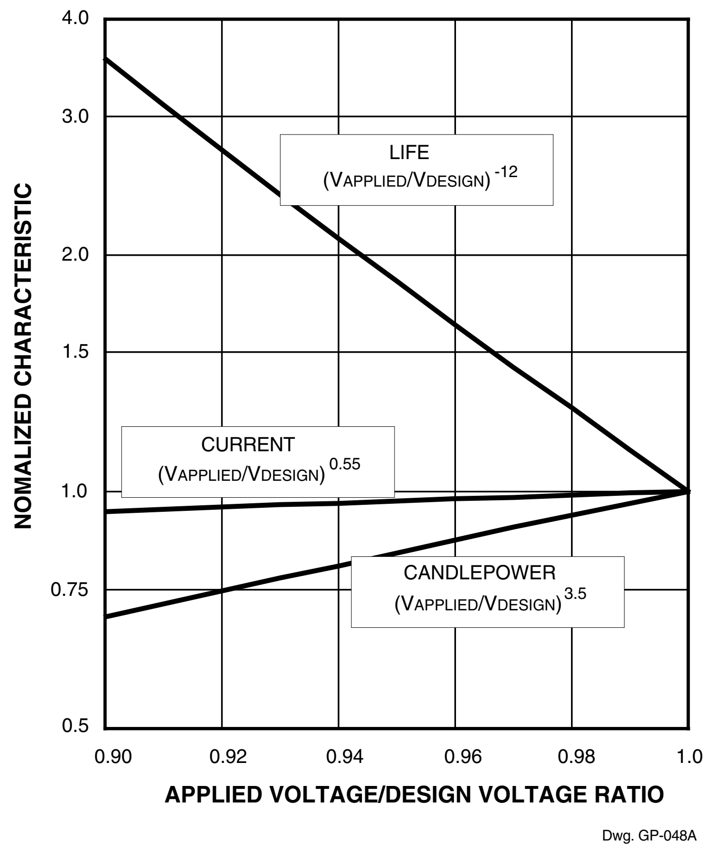

Figure 4 — Lamp Characteristics at Reduced Voltage

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