

Controlling LEDs— How to Achieve Expected Performance

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Light-emitting diode (LED) lamps and fixtures provide an exciting alternative to existing light sources for general illumination, such as incandescent and compact fluorescent lamps, because of their long life and energy-saving capabilities. LED products are improving rapidly and are appearing on shelves from lighting showrooms to your nearby supermarket.



High-performing LEDs add drama and flexibility. SAP America Inc., Newtown Square, Pennsylvania, courtesy of Lutron Electronics Co., Inc.

Before you commit yourself or your customer to investing in this promising technology, however, you need to understand its limitations, especially when it comes to dimming control compatibility.

Many LED manufacturers are new to the lighting industry and are not familiar with the multitude of control types and the corresponding product design requirements that accompany them. This has resulted in “dimnable” products that

do not work as claimed, that never turn off completely, or that flicker. These are major problems that need to be addressed so that consumers do not associate all LEDs with poor performance and become averse to using them.

High-performing LED products do exist, but you need to ask the right questions to make sure you have chosen one of those products appropriately.

One of the easiest ways to find out how a product will operate on a dimmer is to call 1-877-DIM-LED8, a dedicated Lutron hotline that provides information on LED control options. This LED control center is a great place to start asking questions and to determine exactly what your options are before finalizing your LED source or control selection. You can learn about compatibility testing results for many LED fixtures and lamps, trade-offs between dimming performance, installation costs, and other topics.

If you prefer to start by doing your own research, you should begin by asking the following questions. The answers to these five questions will allow you to confidently purchase and install an LED fixture or lamp and ensure that your expectations will be met.

1 What is the dimming range of your fixture?

Incandescent lamps dim to below one percent perceived light, which appears as the filament glow you are familiar with. An LED lamp or fixture could dim to a minimum level of only 50 percent, while a different product may dim to one percent. Additionally, manufacturers will quote measured light numbers, but consumers are familiar with perceived light. What is the difference?

Measured light output is the quantifiable value of light measured by a light meter or similar device. This is the dimming percentage indicated on LED product specification sheets. Perceived light is the amount of light that your eye interprets because of pupil dilation. The eye’s pupil dilates at lower light levels, causing the amount of light to be perceived higher than measured (e.g., 20 percent measured equals 45 percent perceived). The equation for determining perceived light is to take the square root of the measured light percentage (e.g. $\sqrt{0.2} = 0.45$).

You need to select the dimming range of your fixture or lamp that will meet your expectations. A product that dims to 20 percent measured light (45 percent perceived) wouldn’t make sense in a media room, but may be the energy-saving solution necessary for an office.

2 What type of dimmer does your LED product operate on?

The answer should fall into one of the following categories, which include the popular control protocols that have been used for decades and/or have associated standards. This will ensure that the LED product will operate correctly and safely on the corresponding dimmer.

- **Incandescent/Forward Phase Control**
Typically used for incandescent and MLV (magnetic low voltage) light sources, this is the most common control method. There are more than 100 million forward phase-control dimmers installed, and it is likely that many of these will end up controlling LED replacement lamps. This type of control is also a great retrofit solution

because it does not require a neutral wire in the wall box unit. However, forward phase-control dimmers pose challenges to proper dimming of many LED loads.

● **Electronic Low Voltage (ELV)/ Reverse Phase Control**

Used to control ELV light sources, it is best for capacitive loads, which include LED drivers. While it does not have the installed base that incandescent dimmers do, this control type is usually more successful at dimming LEDs without flicker.

● **Three-Wire Control**

Primarily used for fluorescent lighting, this control type has an installed base of more than two million circuits. These circuits are primarily in commercial buildings where fluorescent ballasts are controlled.

● **0–10V Control**

This analog control standard has been used in energy management controls, like occupancy and daylight sensors, and is now becoming popular with many LED products. This control type is isolated from line voltage, enabling it to be safe to the touch and allowing for simplified wiring. There are alternate, incompatible implementations of 0–10V products, however, that do not follow the established IEC standard.

● **DALI**

This digital standard originated in Europe but is now commonplace in commercial buildings in the U.S. It allows for digital control of individual fixtures, maximizing the users' control and productivity.

● **DMX**

Typically used in theatrical applications, DMX remains popular with RGB (Red Green Blue) LED applications, where high speed and multiple channels are necessary.

3 **Is the dimming range smooth and continuous? Is the light level stable at every dimmed level, or are there points of flicker?**

Each manufacturer defines dimming in a different way, but what you need to know is if the dimming will be distracting or will have noticeable unexpected drops in light. The public's experience with incandescent dimming is that it is smooth and continuous. Specifically, a change in the control (dimmer) position should be reflected by an equal change in light level. There should be no abrupt change in light level as the light source is being dimmed.

Even more important than smooth and continuous dimming is ensuring that there are no points of flicker in the dimming range. Flicker is the unexpected modulation of light level that is visible to the human eye. Flicker can come from many sources, including: line noise, control noise, component tolerance, and LED driver circuit design. Flicker can be continuous (happening all of the time), or intermittent (only happening some of the time or at certain levels). A good lamp should account for all of these factors and still provide flicker-free, smooth, and continuous dimming.

4 **What is the minimum or maximum number of fixtures/lamps that can be connected to one dimmer?**

While this may seem like an easy question to answer, it is not as simple as looking at your 600-watt dimmer and dividing 600 by the 10-watt LED lamp you have selected to determine that 60 lamps can be used on a circuit. While the LED lamp may only draw 10 watts continuously, it may have an inrush current spike during every half-cycle that makes it appear much different. Neglecting this inrush performance can put significant stress on the dimmer and can cause premature product failure. This, among many other reasons, may limit the number of lamps you can install on one dimmer.

A minimum number of fixtures may be required to operate a dimmer because of the 25-watt to 60-watt minimum load that most incandescent dimmers require to operate correctly under all conditions. When using incandescent bulbs, the minimum load requirement was easily met with usually only a single bulb. However, with LEDs, four or more loads may be needed on a dimmer in order to meet the required minimum load.

5 **Have you tested multiple dimmers from multiple control manufacturers?**

The last and most important question to ask LED manufacturers pertains to product testing. Have they tested their products on different dimmers from different manufacturers? Did they test for flicker or minimum/maximum lamp requirements on all of these dimmers? Have they been working with any of the control manufacturers to ensure that their testing was adequate and accurate? If the manufacturer cannot answer these questions you should consider how much testing or how many problems may end up on your plate in the future.

Conclusion

The above questions are guidelines for avoiding the compatibility problems that befall many customers. Their answers will allow you to select high performance products that meet your satisfaction. If you have any LED control questions during this product selection process, call 1-877-DIM-LED8 for assistance.

Keep in mind that if you are replacing an incandescent bulb with an expensive LED lamp, or if you are changing your CFL downlight to an LED downlight, you will expect it to perform at least as well as the source it replaced. Dimming plays a major role in that expectation. Lutron's experience has shown that answering the questions above will help to resolve problems before you install your new LED product, not after. ☉