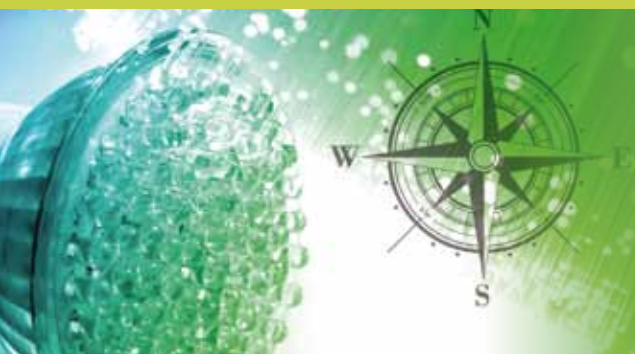


Navigating the World of LED Controls

Simplify the process with this guide to reliable and high performance LED dimming

Amanda Beebe, Lutron Electronics Co., Inc., LED Product Manager

Controlling LEDs is not as simple as controlling incandescent light. Incandescent lamps are all inherently dimmable without the need for additional circuitry. In addition, all incandescent bulbs dim smoothly and continuously to a 0.1 percent measured light level.

LED lamps, on the other hand, perform differently in terms of dimming performance and control compatibility, requiring additional information to be acquired before an LED bulb can be successfully controlled.

Below are questions that need to be answered in order to dim LEDs properly.

Are you using an LED lamp or an LED fixture?

LED luminaires come in two distinct types: LED lamps (also called LEDi, or retrofit lamps) and LED fixtures.

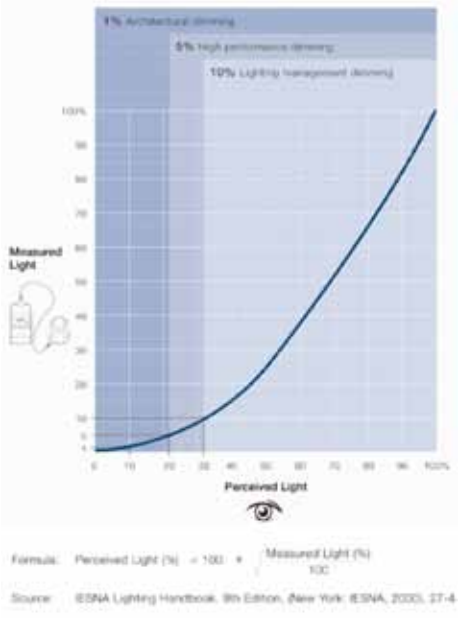
LED lamps have Edison-base sockets and are meant to replace standard incandescent or screw-in CFL bulbs. The bases of these bulbs have integral drivers that determine if they are dimmable, and if so, what the dimming performance is.

LED fixtures can vary from cove lights to downlights and usually have an external driver. A driver is essentially the same component in an LED fixture as the ballast in a fluorescent fixture. The driver is needed to operate and vary the intensity of light output from an LED lamp source by regulating the voltage and current. Some drivers are manufactured to operate specific LED devices or arrays, while others can operate most commonly available LEDs.

Often, a fixture manufacturer will offer different driver options on the same fixture to support different control technologies or applications such as dimmable vs. non-dimmable or dimmable via a 0–10V signal or DALI (see control options below).

What is the dimming range of the product?

The dimming range of an LED lamp or fixture can vary greatly from one device to another. Some may dim to a minimum level of only 50 percent, while a different product may dim to one percent. Select the dimming range of your fixture or lamp that will be suitable for your application. A product that dims to 20 percent measured light (45 percent perceived) would not make sense in a media room, but may be the energy-saving solution necessary for an office.



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What affects dimming performance?

Experience with incandescent dimming means customers expect smooth and continuous performance, with no points of flicker in the dimming range. Other undesired behaviors include:

- **Pop-On**: After being dimmed to a low light level and switched off, the LED bulb does not turn on until the dimmer's slider is adjusted. This can be particularly hazardous in three-way situations where lights can be turned off by a dimmer at one end but not turned on by a switch at the other end.
- **Drop-Out:** The light should only turn off when the switch is turned off; lights should not "drop out" (turn off) while the dimmer's slider is being adjusted. This can be avoided by utilizing the low end trim settings available on many wallbox and system level dimmers.
- **Dead Travel**: Adjusting the control without a corresponding change in light level and often confuse or frustrate the dimmer's user.
- **Audible Noise**: Buzzing, from the lamp or the dimmer can be caused by the components within the LED driver or lamp.

How many fixtures or lamps can I use per dimmer?

The number of lamps able to be installed on a single dimmer may seem like an easy question to answer. However, it is not as simple as looking at a 600-watt dimmer and dividing 600 by the 10-watt LED lamp to determine that 60 lamps can be used on a circuit.

While the LED lamp may only draw 10 watts continuously, it may have a start-up inrush current or repetitive current during every half-cycle that makes it appear much worse. Neglecting this transient current can put significant stress on the dimmer and can cause premature product failure or undesired system performance (such as excessive noise).

A minimum number of fixtures may also be required to operate a dimmer because of the 25-watt to 40-watt minimum load that most incandescent dimmers require. When using incandescent bulbs, the minimum load requirement was easily met with a single bulb. However, with LEDs, four or more loads may be needed on a dimmer in order to meet the required minimum load.

What are my control options?

Control technology is a term that refers to the signal and wiring between the control on the wall and the fixture or lamp. LED retrofit lamps generally only use forward or reverse phase control methods. LED fixtures may use any method, from phase control to 0–10V and DALI.

In order to ensure compatibility between a dimmer and a particular LED fixture, both must use the same control method. Here are some common ones.

- **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 is also a great retrofit solution because it does not require a neutral wire in the wall box unit. Forward phase control dimmers pose many challenges to proper dimming of many LED loads.

The right combination of LED fixtures and controls brings energy savings and flexibility to commercial applications. Photo courtesy of Lutron Electronics Co., Inc.

- **Reverse Phase Control:** Used to control ELV (electronic low voltage) 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 2 million circuits. These circuits are most often used in commercial buildings where fluorescent ballasts are controlled; three-wire LED drivers may be used to retrofit them.

- **0–10V Control**: An analog control standard used for fluorescent lighting, sensors, and more has an established IEC standard accompanying it. This standard helps to ensure compatibility between products but does not define dimming performance.

- **DALI:** A digital standard originating in Europe that is now commonplace in commercial buildings in the U.S. DALI allows for digital control of individual fixtures while maximizing the user's control and productivity.

All of these control standards can be used successfully to control LED lamps and fixtures if the proper products are selected and performance is defined. Using control products with a neutral wire and low end trim capability often help to optimize the dimming performance.

What is Good Dimming?

The only way to be certain if a particular LED lamp or fixture will work with a particular dimmer is to undergo testing. Whether testing involves a mock up or testing by the manufacturer, it is necessary to determine compatibility and acceptable performance.

Keep in mind that you do not have the ability to visually determine the inrush current of an LED product, so you must find out from the manufacturer or limit the number of lamps you are using to avoid overloading the dimmer.

Many manufacturers (both LED luminaire manufacturers and control manufacturers) conduct compatibility testing of their products. It is up to you to determine if that manufacturer's assessment of "good dimming" will meet your customer's needs.

Amanda Beebe manages all LED driver and ballast product families at Lutron and coordinates the relevant marketing, sales, and engineering efforts. She also leads Lutron's educational efforts through the LED Control Center of Excellence.