

LEDs MAGAZINE

TECHNOLOGY AND APPLICATIONS OF LIGHT EMITTING DIODES

lighting | DIMMING

Controlling consumers' expectations of LED lighting: why dimming is so important

Manufacturers of LED lighting products need to consider the control options for their products and understand the applications in which their products will be used, say **CHRIS SALVESTRINI** and **AMANDA BEEBE**.

The US Census Bureau estimated that there are over 75 million owner-occupied homes (2007) and almost 5 million commercial buildings (2003) in the United States. Many of these buildings, both commercial and residential, already have dimmers installed. These existing dimmers are controlling a multitude of light sources, from incandescent to fluorescent and now LEDs, which is why the capacity to dim must be designed into an LED product from the beginning. Consumers, professionals, teachers and occupants expect to have control of their lights, and LEDs must meet this expectation if LED lighting solutions are going to succeed.

Why dim?

The story of why to dim your lights has been around for a long time, and many people know that lighting controls can improve personal comfort, increase occupant productivity, extend luminaire lifetime and save energy. However, with the introduction of new lighting technologies it seems that this story is often forgotten, at least until the market is full of disgruntled consumers and building occupants.

The LED industry is heading toward the same negative experiences as the screw-in CFL industry and needs to correct its course now, before consumers become averse to LEDs. LEDs are a promising new technology that will eventually influence, and even change, the lighting indus-

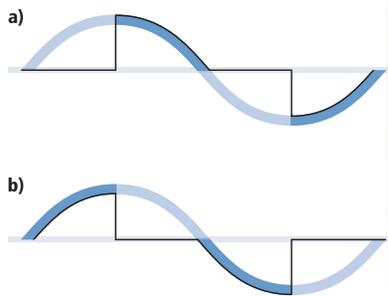


FIG. 1. a) Forward phase control and b) reverse phase control. Light blue shows when the control is open (off) and dark blue shows when the control is closed (on).

try. However, they will not reach that point as quickly as their potential suggests unless the industry begins to pay attention to consumer expectations. So what are those expectations?

In the home, consumers expect their light source to act like the incandescent lamp that they have lived under for 100 years, meaning that they want two things — color, and ambiance created with dimming. The screw-in CFL lamp continues to fall short of expectations because it has failed to meet either of these criteria. Some LED makers understand the desire for the perfect color temperature and are creatively using technology to provide the exact color of light that a consumer wants. However, these same manufacturers do not

understand that dimming is equally as important as color — consumers want just the right amount of light for whatever they are doing.

Commercially, the lights are on in a building to allow people to be productive. Too often we think of energy-saving techniques that are only about turning the lights off. However, this tactic does not apply when a building or space is occupied, which makes the ability to dim an equally important energy-saving technique.

Dimming can be a manual choice by a user, a tuning decision by a building owner, or an automatic change due to the amount of sunlight. However, no matter which dimming technique is used, it will save energy. While additional energy savings for an LED (which already save energy by replacing a 100-W incandescent with a 25-W LED array) may seem less important, consumers do not agree. They are looking for every possible way to save energy, and dimming will save an additional 20%-30% on average without sacrificing comfort.

In addition to energy savings, the occupants of these buildings are the same people who expect control in their homes, so why should they sacrifice this control at work? Dimming allows for increased productivity, which is paramount in a working environment. Everyone has different visual abilities and comfort levels, and being able to optimize your environment goes a long way.

Now that you understand why dimming is important, you should also know that simply being “able to dim” is not good enough. Dimming is a quantifiable term and it should always be



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Dimming: critical term definitions

Measured vs. perceived light:

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 due to dilation. The eye's pupil dilates at lower light levels, causing the amount of perceived light to be higher than measured (e.g. 20% measured = 45% perceived). The equation for determining perceived light is to take the square root of the measured light percentage (e.g. $\sqrt{0.2} = 0.447$) – see figure.

Pop-on:

If the voltage at which a light source begins operation is higher than the voltage of the dimmer's lowest setting, then the lights will initially "pop-on". This means there will be a section of the dimmer that will not turn on the light until suddenly the light "pops-on."

Drop-out:

If the voltage at which a light source stops

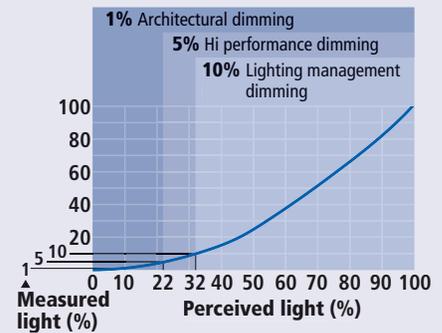
operating is higher than the lowest setting on the dimmer, the light source will turn off before the dimmer has turned off. The lights will effectively "drop-out" before the slider on the dimmer reaches the bottom.

Flicker:

Flicker is the unexpected modulation of light level that is visible to the human eye. Flicker can be caused by multiple factors, including: line noise, control noise, circuit noise, component tolerance, and circuit design. Flicker can be continuous (happening all of the time), or intermittent (only happening some of the time).

Smooth and continuous:

Smooth and continuous describes the expectation of performance based on the public's knowledge of incandescent dimming. A proportional change in 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.



Determining perceived light. Source: IESNA Lighting Handbook, 9th Edition (New York, 2000), 27-4.

Dead travel:

Dead travel is the amount of change in the control before there is any change in the light source. In a vertical slide dimmer, if you can slide the dimmer halfway down before the light starts to dim, there is 50% "dead travel" on the dimmer. ◀

associated with a dimming range, such as 100% to 1% of light output, as well as other terms that describe that range (e.g. smooth and continuous). An LED array manufacturer would never merely state that their product "provides light" because that doesn't tell the user anything, and the same goes for saying a fixture is simply "dimmable."

LED control types

Once you have accepted that high-quality dimming is an essential part of any good lighting solution, and understood some of the critical terms (above), the next step is to gain awareness of what types of dimming controls currently exist. Selecting the appropriate control depends on the light source, the degree of flexibility needed in the space, and whether an interface (ballast, driver, or transformer) is needed. Below is an overview of each of the main control types that exist today, indicating where they are most commonly used:

a) Two-wire control

Two-wire control is the most commonly used control method today, and simply indicates that there is a single wire between the device and the light source. It is the control type of a standard light switch, where power comes into the switch through one wire and leaves through another. Within two-wire control there are two different control methodologies:

i) Forward phase control: The more prominent of the two, it is also called leading-edge control. In this control scheme the control begins each

half-cycle in the open position and then turns on and remains on for the remainder of the half-cycle. This is illustrated in Fig. 1a, where the light blue shows when the control is open (off) and the dark blue shows when the control is closed (on). This method works well for controlling inductive loads, and as a result forward phase control is required to control magnetic low-voltage lighting transformers. It is also the dominant method used to control incandescent lights.

ii) Reverse phase control: Also called trailing-edge control, it is used to control electronic low-voltage light sources. As shown in Fig. 1b, this is the exact opposite of forward phase control. While this control type can be used on incandescent lights it typically provides the ideal control signal for capacitive loads, such as many LED drivers.

b) Three-wire controls

Three-wire controls are primarily used to control fluorescent light sources because the power requirements of the ballast will not impact the dimming performance of the light source. One of the wires provides power to the light source whenever it is on, regardless of the light level, while the other wire provides the control signal that sets the light level at which the fixture should be operating.

In all of the following approaches (0-10V, DALI, and DMX), the control exists on an isolated low voltage link from the power to the light source. One of the benefits of this is that the system can be interfaced with a variety of

other devices such as occupancy sensors, daylight sensors, and infrared receivers.

c) 0-10V control

0-10V control is an analog control that sets the voltage to the light source between 0V (minimum light output) and 10V (maximum light output). IEC standard 60929 specifies exactly what control requirements exist for this control type.

d) Digital control

i) DALI: This Digital Addressable Lighting Interface control standard, which emerged from Europe, allows for digital control of separate fixtures. This added level of control provides increased space flexibility, especially in commercial spaces.

ii) DMX: This digital control type came from theater lighting control, and allows for multiple channels of light (both color and intensity) to be controlled. It is typically used when trying to achieve complicated lighting effects such as LED color mixing.

Conclusion

LEDs are a promising new light source for general illumination, but they will never excel unless manufacturers understand consumer expectations. Having control is a basic human desire, and lighting is no exception. Stereos would be limited without volume controls; ovens would be dysfunctional without temperature controls, so why should lights be used without controls? ◉



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