# Understand compatibility, performance, and dimming issues with LED lighting


LED-based solid-state lighting (SSL) offers many potential benefits such as energy savings, long life, low operating temperature and new fixture options that enable them to be used in almost any application. However, the technology does come with new challenges such as compatibility with legacy dimming controls.

LED unlike CFL, has been able to more closely match the design and colour temperature of conventional lamps. This has increased consumer acceptability, but has also created expectations that dim ability is on a par with conventional lamps. This is where a lack of accurate information can lead to disappointing results. Moreover, lighting specifiers and designers need to understand the unique properties of LEDs to realize optimal performance in installations.

Let us consider the rationale behind dimming and discuss some key questions that can lead to lighting systems that dim to project requirements and yield satisfied customers.

It is a common misconception that all LED lamps can be dimmed with an LED dimmer. In reality, the driver circuitry in the lamp must be designed with dimming in mind. Therefore, it is essential to choose lamps that the manufacturer describes as 'dimmable'. However, not all dimmable LED lamps are created equal and there is a lot of variation in the dimming performance, under test, of LED lamps described as "dimmable". In particular, the smooth dimmable range, cut-off point and stability of output are the features most likely to disappoint with lower priced OEM lamps.


Some manufacturers are happy to label their lamps as dimmable even if they can deliver only the smallest change in brightness. It is best to choose lamps from established lighting manufacturers. Aside from dimming considerations, established brands are also more likely to offer better product warranties, longer lamp life and more customer support.

The dimming range of a product, either a lamp or a fixture, is based solely on the driver. Choosing the right dimmer will allow you to reduce flicker and may affect your ability to achieve the desired dimming range, but the

dimmability, low-end light level, and performance of the product are determined by the ‘LED driver’.

LEDs are inherently low-voltage devices that need additional electronic components to convert the mains supply voltage to the low-voltage needed to drive them. These devices are referred to as LED drivers and, if "dimmable", it will detect the dimmer type and interpret the phase information accordingly to providing dynamic brightness control. The latest generation LED Drivers are two-stage, high-performance AC/DC off-line, constant output current power supply controllers, using the quasi-resonant flyback mode.


The difference between a quality dimmable LED lamp with a wide flickerless dimming profile and a fast dimmer setting response, and a poorly operating one, can nearly always be traced back to the brand/ type of control chip inside the driver. The newer and more expensive chips have excellent dimming profiles, while the older chips are poorer and in some cases can hardly be considered dimmable at all.

Lamp resellers can specify the driver chip that the OEM manufacturer uses in the driver in a particular lamp. However, if solely driven by cost the manufacturer may default to the lowest cost device available unless requested otherwise.


Latest generation dimmable LED driver chips for a lamp reseller to ask their manufacturer for are: i-Watt, Cirrus Logic & Marvell.. LED lamps available at www.dimmer.co.uk contain these latest generation chips with their superior dimming profiles.

To avoid frustration, specifiers and their customers should engage a lighting control manufacturer who has already done the appropriate testing and research, and can provide services to ensure successful implementation. The manufacturer should be able to provide a lamp testing service and, if necessary, a mock-up installation to ensure confidence that a good solution has been reached. This will eliminate many of the common concerns and issues that are seen with LED installations.

## THE BENEFITS OF DIMMING LEDs

As with conventional lamps there are many benefits to dimming LEDs. They create ambiance, enhance flexibility, maximize energy savings, extend system life, increase productivity, and provide a safe, comfortable environment.

Dimming any lamp enhances ambiance so, whether in a restaurant, hotel lobby, conference room, theater or residence, the environmental ambiance can be created as the lighting designer originally intended.

While it is true that LEDs are already very efficient compared to almost any other light source, you save even more energy by dimming them. Dimming LEDs saves energy at roughly a 1:1 ratio. For example, if LEDs are dimmed down to 50% of their light output, the saving is nearly 50% of the associated energy usage. So not only is there a saving by using a more efficient light source, more energy can by saved by dimming that light source.

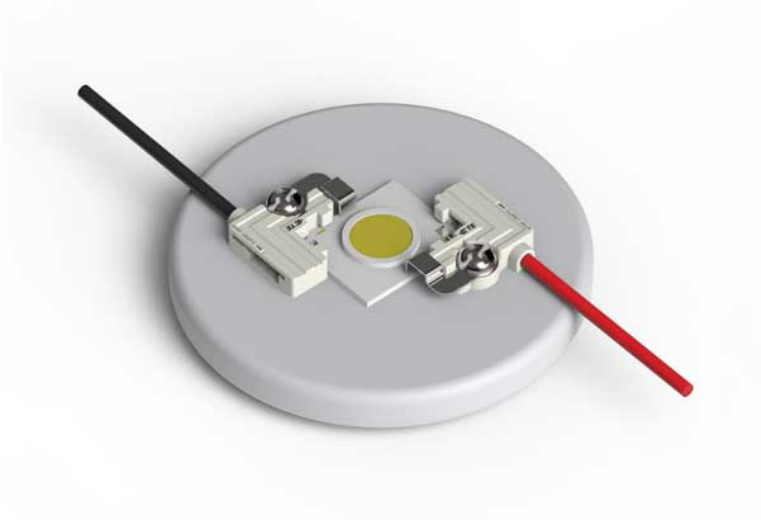
Additionally, dimming LEDs also makes them run cooler, which extends the life of the electronic components of the driver, as well as the yellow phosphor in the LED. Just one single excursion of over 90 degrees on the LED die temperature can seriously impact the long term brightness of the lamp. Dimming potentially doubles or triples the useful life of the LED lamp, and also increases the life span over which it can maintain its maximum level of brightness compared to when it was new.

## Why is it so important to use lighting controls with LEDs ?

A wide range of controls are available, from a single dimmer switch to a more sophisticated programmable dimmer. These dimmers, often known as scene dimmers, have many advantages over manual ones including better control of LEDs, increased flexibility, energy savings and reduced lamp replacement costs.

Intelligent lighting facilitates pre-programing according to use and other factors such as time of day. Light fittings can be controlled individually or grouped together in circuits. Each circuit or fitting can be set at a different level of brightness. These levels are then stored as a “scene”. After set-up, scenes can be easily recalled manually from wall switches, touch screen, infra-red or wireless remote controls. They can be recalled automatically by time clock, or according to occupancy. Once a new scene is selected, the lighting will fade to the new set of levels at a pre-determined fade rate.

## Matching LED products to the project



There are two distinct types of LED lighting: the LED retrofit lamp and the integral LED fixture often known as COB (LED Chip-On-Board).

LED replacement lamps typically have socket bases meant to replace standard incandescent or CFL lamps making them compatible with existing light fittings; for example, screw-in (ES) / twist-in (GU10) or push-in (MR-16) (capsule). In all cases, the bases of these lamps have integral drivers that determine whether or not the lamp is dimmable, and also determine dimming performance. Lamps with drivers are available that can dim LEDs from 100% to 1% light, offering smooth continuous dimming.

LED fixtures (COB) vary from cove lights, to down-lights, pendant lights and linear recessed lights, and usually have a driver mounted within the housing or remote from the LED source. Fixture manufacturers should offer different driver options (for the same fixture) to support different control technologies (phase-control, 1-10v, DALI or DMX) or applications (dimmable or non-dimmable). You may even be able to specify the driver chip or an optimal drive from another manufacturer that includes the desired feature set.

## Non-dimmable LEDs

The most basic form of control is simply switching off the mains power to the fitting or circuit of fittings. Switching can be used in energy-management systems with occupancy and daylight sensing. Areas or zones powered by multiple control circuits can also utilize multi-level switching. In a multi-level switching installation, portions of a fixture or zone of lights can be turned off or based on the needs of the space. Since switching causes an abrupt on/off of the illumination, it tends to be used where aesthetics are unimportant as in storage, warehouse or outdoor facilities.

## Dimmable LEDs

All incandescent lamps can be dimmed smoothly and down to a very low level, so this sets the expectation for all dimmed light sources. Conversely, the dimming range of an LED lamp or fixture can vary greatly from one device to another. Some LEDs may dim to a minimum level of only 20% before cutting off, while another may dim all the way down to 1%. Additionally, manufacturers will quote measured light levels (eg, 10% where measured light output is the quantifiable value of light sensed by a light meter) whereas, in reality, the light perceived by the customer is the amount of light the eye interprets as a result of pupil dilation. The eye's pupil dilates at lower light levels, causing the amount of light to be perceived higher than measured. For example, 20% measured light is equivalent to 45% perceived light as documented in the IESNA handbook.

LEDs are making great strides, and LED products now exist for replacing almost any lamp/ fixture type. However, to achieve optimal performance, a combination of fixtures, drivers, and controls must be chosen to match specific project requirements.  It is recommended to choose lamps that use the latest generation chip and have the capability to dim down smoothly. The price differential is small compared with the cost dealing with the issues that may arise otherwise.

If LED products with older/ lower cost driver chips are used, then the end result can be "dimmable" products that do not work as claimed. These lamps may never turn off completely, flicker, pop-on, drop-out or exhibit dead travel, all leaving the end-user with a poor perception of dimmable LEDs.

It’s not that a quality LED driver/ chip will just dim down lower, it will have markedly better performance throughout the entire dimming range.

## LED/ DRIVER SELECTION PROCESS

*Question: What type of lamp should be used in a new or existing installation?*

Answer:  New construction enables you to use either LED lamps or LED fixtures and offers a wide variety of control options. For example 1-10v, or DMX can be considered. Retrofit applications are often limited to LED replacement lamps, and the control options will likely be limited to phase control.

*Question:  What type of control should be used?*

Answer: There are many types of controls and control systems from high voltage (traditional forward phase control or reverse phase control) to low voltage (0-10V, DALI or DMX) and even some new entries with embedded wireless connectivity in the lamp/fixture.

As a legacy hangover from incandescent lamps and pre-installed 2-wire lamp cabling, the most common type of control by far is still a phase-control dimmer. NEMA estimates that there are 150 million of these installed in US homes, and that these legacy devices will represent the bulk of dimming devices for replacement LED fixtures. With this set-up, the same wire that provides power to the light source also conveys the dimmed voltage, or dimming signal. Unless quality equipment is used, this can interfere with the functioning of both the LED device and the dimmer.

In a new install, where LED fittings are being used, it’s possible to run a second control cable to each fitting. Installing dedicated wiring that sends dimming information to the dimming device can alleviate compatibility issues because it enables the dimmer and source to operate with little or no interference from each other. However, these types of dimming systems also tend to be more complex and expensive, which may explain why they are more common in commercial applications than residential.

The communication protocol used can be (0-10V, DALI or DMX), the most popular being 1-10v control for LED fittings and DMX for coloured LEDs. 0-10V control has been utilized in the lighting industry for many years as a means of interfacing dimmer controls with loads (drivers/ fluorescent ballasts) from different manufacturers. 0-10v technology standard has thus continued into the LED arena as a means of integrating LED fixtures with controls from varying manufacturers.

DMX512 was created initially for use in nightclub and theatrical applications, and has been in popular use since the 1970s. In the last few years, as the use of coloured lighting has grown, DMX has become the defacto standard for coloured architectural lighting applications. LED fixtures enabled with DMX are built with a combination of the following multiple colours: RGBA/WW/CW/UV (Red/Green/Blue/Amber(yellow)/Warm White/ Cool White/Ultra Violet). The tunable white colours allow LED lighting in general illumination applications to dynamically change their colour temperature throughout the course of the day.

DALI is a standard that was introduced for the control of fluorescent lamps. Recently, its specification was extended to include the use of tunable white LEDs. However, it does have some drawbacks as its speed of operation is too slow for fast dynamic colour changes and using DALI controls and DALI drivers from multiple manufacturers does not ensure compatibility or matched dimming performance. To get around the limitations of the standard, some manufacturers have added extensions to the DALI protocol which only work when controls and loads from the same manufacturers are used.

*Question: How many fixtures/lamps can be connected to one dimmer?*

Answer: LED lamps convert AC mains power to low-voltage DC power using an in-built power supply. The supply uses components like capacitors and a transformer which creates a start-up, in-rush current or repetitive current during every half-cycle. This current can be far in excess of the lamp's continuous rated wattage. For example, a 15W LED lamp may appear to the dimmer as a 100W incandescent load from the perspective of in-rush current thus stressing the dimmer, shortening its lifespan and leading to poor LED dimming performance.

Overloading the dimmer is a common problem with LED system operation. When using LEDs with phase control dimmers, designers should decrease the maximum load rating of the dimmer (usually given in watts) to minimize stress to dimmer electronics.

NOTE: It is not as simple as dividing the maximum dimmer rating by the LED's lamp wattage to determine how many lamps can be used on that circuit.

The real peak wattage needs to be accessed and the dimmer load downgraded to match that. Typical de-rating percentages are around 30% of the dimmer-rated power. Furthermore, placing too many LED lamps on a circuit can create sufficient line noise between the LED lamps that they are unable to detect the phase angle information and thus leads to poor dimming performance.

Similarly, some LED lamps may not perform well if the minimum line loading is not met in which case it will be necessary to add a 'Dummy Load' to the

circuit to increase the required minimum load (by means of a resistive load) and improve dimming performance.

## SUMMARY

There are LEDs available for almost every type of application, both residential and commercial. However, in order to meet energy-saving performance and aesthetic expectations, it is essential to carefully choose the model of LED and work closely with a quality dimmer manufacturer.

Lighting has become a "system" where the LED module, the LED driver and the LED dimmer must be chosen specifically with system compatibility in mind. It is best to specify a proven LED source and dimmer combination; if that's not possible for a particular lamp source, then the only alternative is to ask the manufacturer to perform a mock-up.

It is important to understand that the dimming range of any LED product is based almost entirely on the LED's driver chip. The integral driver of a screw-in LED retrofit lamp and the external driver of a COB fixture will determine the smoothness and dimming range of the lamp. Furthermore, different drivers may produce different dimming curves, even if they can dim to the same range. Often, there is no guarantee that relative light levels will match between LED products from different manufacturers, even at the same dimmer level. Even if the driver is capable of providing outstanding

dimming performance, it can still be compromised by using a low quality dimmer due to incompatibility between the driver and control.

Repeated testing has shown that LED loads, in many cases, will cause higher stresses on a control than an incandescent load of the same wattage. Therefore it is imperative that a quality dimmer with sufficient headroom is specified.

## PRODUCT RELIABILITY & LIFESPAN

Because lighting is a life safety system, and one which is installed within the fabric of a building, it is important to consider the installed lifetime of the system. Unless careful choices are made with long term reliability in mind, the final cost of ownership may turn out to be much higher than anticipated.

From initial design through eventual replacement, the specifier should consider the components (and sub-components) of the system and how defective product and performance issues will be resolved.

Important questions to ask include:

- What is the duration and terms of the product warranty?
- How many years has the company been in business?
- Does the company have a good reputation in the market?

• Does the company support the products throughout the entire lifecycle with a proven track record in the support of legacy systems?

• Does the company provide test facilities and technical support?

The Futronix LED Demonstration Center has tested hundreds of different fixture/driver/control combinations. Please see the following document for more information:

Futronix_compatible_ dimmable_LED's v32(xx).pdf

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