



# LED WATCH

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## A SPECIFIER'S GUIDE TO COLOR-TUNABLE LIGHTING

Be sure to check all the boxes when investigating the array of new products

**L**ED luminaires with the ability to deliver varying light color have been on the architectural lighting market since the early days of solid-state lighting (SSL), but only recently have they become a hot topic for indoor applications. Despite many recent improvements in the technology, though, color-tunable lighting remains a work in progress and requires a certain amount of homework by the specifier if the installation is to be successful. To that end, here follows a brief crash course that considers the advantages and pitfalls of the three basic categories of color-tuning products:

### 1. Full-Color-Tuning Products.

Sometimes referred to as spectrally tunable or color-changing, these have three or more different-color LEDs that can be individually varied in output to create a mixture that can range from white, to a colored shade of white, to a pale hue, to an intense color. Typically, the LED colors include red, green and blue (RGB), but they can be augmented with amber (RGBA), or with a white-light LED (RGBW), or with other chip colors.

One advantage of a full-color-tuning product is its ability to move beyond different colors of white light—so that, for example, it could deliver consistent 4000K office light during the day and then be tuned for a purple-themed after-hours cocktail party. This makes it well-suited for applications ranging from theaters to theme parks to restaurants. Another advantage of full-color-tuning is the ability to match any other light source's chromaticity (color of the light). And the

control of individual LED colors offers the option of tuning the spectrum to enhance colors for retail applications—for example, making red apples in the produce aisle really “pop” in appearance.

There are downsides to full-color-tuning, however. Not only may system efficacy be lower than with fixed-color white LED products, but the wide color variability of full-color-tuning products requires a user interface that may be more complicated than a simple slide dimmer. The luminaire is powered separately from the dimmer/color control signal, and DMX, DALI or wireless control with high resolution is required. Initial programming and reprogramming of the controls may not be intuitive and thus may require training someone to do it or hiring a specialist.

In theory, matching one full-color-tuning product to another luminaire is straightforward, but there are several potential pitfalls. First, knowing a nominal CCT, such as 3000K, is insufficient,

because that designation covers a wide range of chromaticities. Second, even if the chromaticity is a perfect match, the spectra of the two sources may not be, and that can make objects look different (because of different color rendering). With RGBW fixtures, for example, the same luminaire can be made to render object colors in a variety of ways—from oversaturating to desaturating—all while the color of the light doesn't change.

**2. Dim-to-Warm.** Also known as warm-dim, black-body dimming and incandescent-like dimming, products in this category mimic the color-shift over dimming exhibited by incandescent or halogen lamps, whose color and dimming quality is prized for restaurants, hotel lobbies, ballrooms, theater venues, hotel guest rooms and residential spaces. Dim-to-warm products are usually designed for 2700-3000K at full output and drop along the black-body curve as the light output is reduced, down to as low as 1800K (roughly the color of candlelight). Like incandescent lamps, their light color becomes increasingly warm in appearance (i.e., more yellow and red) as the product dims.

Because the dimming is linked to the color change, there need be only one controller per group of dim-to-warm luminaires that dim together. Some systems



Photo: Courtesy/Acuity Brands Lighting

**Tablet-based graphical user interface for full-color-tuning lighting.**

can achieve this function with a phase-cut dimmer, but this approach may not have as much dimming resolution or smoothness as a control system using 0-10-V, DALI or DMX protocols, all three of which require separate wiring for dimming/color signal and power to the luminaire. Alternatively, dim-to-warm luminaires can be equipped with a wireless receiver for control by a wireless transmitter using Zigbee, Wi-Fi, Bluetooth or other protocol, and hardwired to building power. For applications such as hotel conference rooms, where it would be desirable to dim lighting without changing color for a business seminar but employ the dim-to-warm feature for a wedding-rehearsal dinner, it may make sense to separate dimming control from color change.

Some dim-to-warm systems use only white LEDs with amber LEDs to create the warmer colors. At the very low end of the dimming range, only the amber LEDs are producing light—which, while warm

in appearance, can make skin tones and room finishes look odd. If this is a concern, the designer and client should see the dimmed output in a mock-up to evaluate its color acceptability.

**3. White-Tuning.** Also known as tunable-white and Kelvin-changing, these products have at least two sets of controllable LEDs, but may have more. At the most basic, there's one with a warm-white color (typically around 2700K) and another with a cool-white color (typically 5000-6500K). By raising and lowering the output of the two sets of LEDs, white colors between the two color points can be created, relatively close to the black-body locus. White-tuning products with more than two LED colors can be preprogrammed to follow a more precise path along the black-body locus, using only the input of one controller, such as a 0-10-V dimmer.

White-tuning lets users provide apparent cooling or warming to the room (e.g., to counteract exterior temperatures),

match finish selections, suit the preferences of a new tenant or owner, simulate daylight or candlelight to set a mood, match the color of daylight in a windowed lobby, and even affect occupants' behavior (e.g., to calm or invigorate) and normalize their circadian rhythms.

Controls are a critical element in white-tuning systems. The most successful products have clever algorithms for tuning from one CCT to another without changing the total light output over the color range. The system requires separate power for the LED driver and the control signal, so it's common to see the equivalent of two dimmers for each system—one for power and intensity level, and a second for color. Some white-tuning products use separate control sliders for the warm LED set and the cool LED set, but this requires fiddling with two sliders to achieve both the desired CCT and the desired light output. Wiring of white-tuning luminaires and controls may be more complex than for fixed-color LED luminaires.

Color-tuning potential is one of the characteristics that set SSL apart from other lighting technologies. The U.S. Department of Energy is taking a deeper dive into this important topic by conducting a series of studies, which will be published soon at [www.ssl.energy.gov](http://www.ssl.energy.gov).

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