Tunable Lighting

1. What is Tunable White Lighting?

Tunable white lighting technology is defined as the ability to control a light source's colour temperature. It is also referred to as "Variable White", "Dim to White", "Hybrid White" or "Dynamic White" by different manufacturers.

This is done by manufacturing the light fixture or LED strip with different colour temperature LEDs.

Using a remote control or external control system, you are able to select the desired colour of white anywhere between the available colour temperature range.

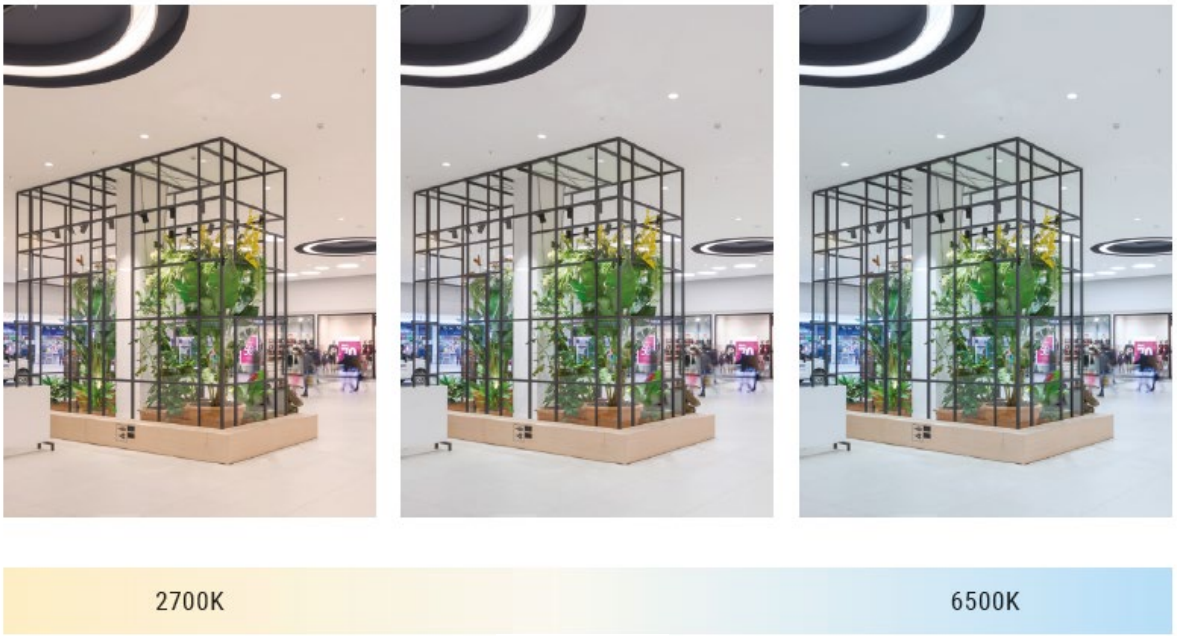

Image 1-1

2. The Technology

2.1. Tunable white uses colour mixing

Standard LED colour-mixing uses red, green and blue channels that are adjusted to deliver the entire range of the colour spectrum. Tunable-Whites work in the similar way, using of a number of controllable channels to adjust the colour temperature of the luminaire's white light output. The channels in a tunable-white system all produce white light, but with varying colour temperatures, from a warm tone to a cool tone depending on the requirement or the manufacturers availability.

2.2. Simple systems use two lines of LEDs

The cheapest tunable whites work in a way that a warm white LED is kept next to a cool white LED and is cross-dimmed between the two (see Image 2.2-1)

The most basic tunable linear systems use LED strips mounted side-by-side. One channel will be close to 2700K in colour temperature, with the other up around a cool 6000K. The LED strips are mounted inside an aluminium extrusion fitted with an opal diffuser, which does the colour mixing as the light passes through it. It's very simple engineering but satisfies a basic market with low performance expectations.

Image 2.2-1

2.3. Multi-chip versions

More products are using ‘multi-chips’ where a number of tiny LED chips are combined into the same module. This means that the colour mixing occurs as the light leaves the module. Their very small size means that tunable-white products can be made much smaller, so we’re starting to see downlights using the technology as well as linear systems. These multi-chips tend to have a higher performance specification than the individual LED strips.

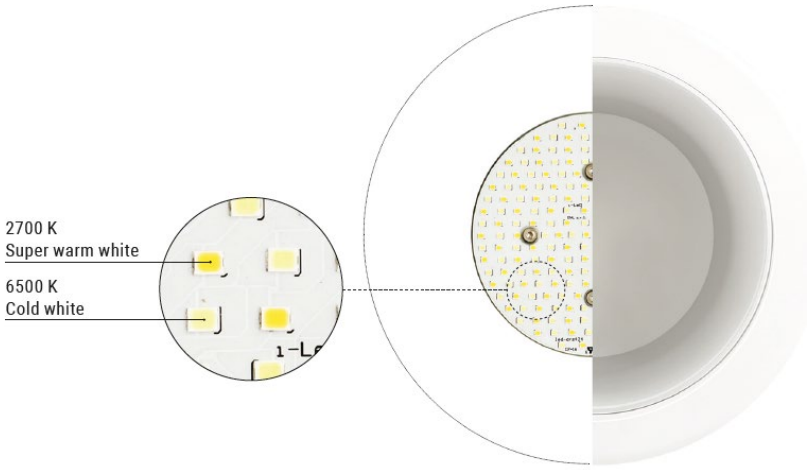

Image 2.3-1

3. Types of Tunable Light

3.1. Warm Tune / warm dim, or incandescent-like dimming

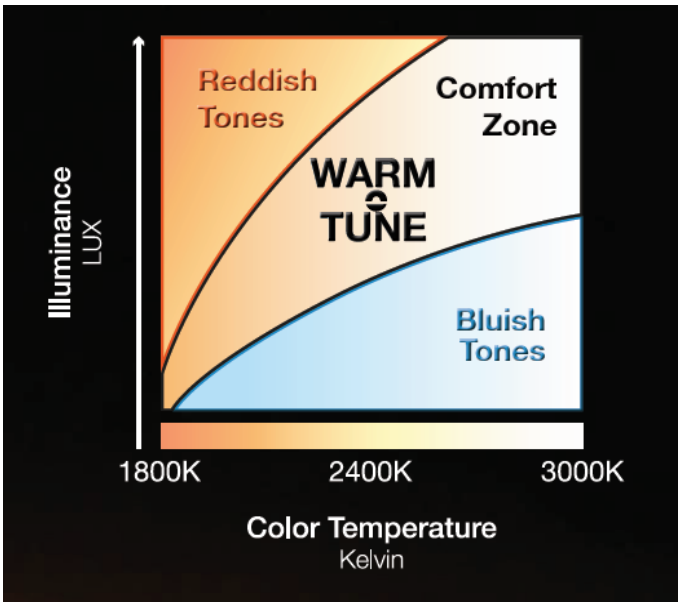

Image 3.1-1

Some tunable controls are designed to replicate the effect of dimming on a filament source, where two things happen at the same time. As the light output is dimmed, the lamp warms up in the same way as a traditional tungsten filament lamp. This is still a manual control method, but has the benefit of mimicking a filament light source. This is usually designed for 2700-3000K at full output with a decrease in correlated colour temperature (CCT) as the output is reduced, down to as low as 1800K (the colour of candlelight). As with incandescent lamps, the light colour becomes increasingly warm in appearance (i.e., more yellow and red) as the product dims.

Image 3.1-2

Some Potential problems of Warm Tune

- Sometimes users want to reduce light output without changing colour. In these situations, (such as in a conference room), it would be helpful to have dimming control that's separate from colour change.
- Dim-to-amber. Some dim-to-warm systems use only white LEDs along with narrow-band amber LEDs to create the warmer colours. At the very low end of the dimming range of such systems, only the amber LEDs are producing light – which, although warm in appearance, can make skin tones and room finishes look as eerie as they would under high-pressure sodium lamps.
- The efficacy of the system is significantly lower than that of fixed-white LED luminaires at, for example, 2500K or 2700K.

3.2. Tunable White / White Tuning or Dynamic White

In this method there are two sets of controllable phosphor-coated LEDs: one with a warm-white colour (usually around 2700K) and the second with a cool-white colour (usually 5000K to 6500K). By individually raising and lowering the output of the two coloured "LED primaries", white colours between the two colour points can be created.

Relative dimming of these arrays changes CCT while also allowing light-intensity control. The manufacturer may add other colours to provide good colour fidelity and, potentially, a broader choice of colour. Some tunable white products are also capable of dim-to-warm operation

This is a more sophisticated control strategy which is designed to manipulate the circadian rhythm of room occupants. This means that the lighting settings are programmed into the control architecture. Shifts in colour temperature and light level can be pre-set or can be instigated by a manual override.

3.3. Full Colour Tunable / RGBW

These products allow a range of saturated colours as well as white-light CCTs based on RGB plus amber or white LEDs. The manufacturer may add other colours according to the requirement. White light is challenging for these systems, notably in regards to colour rendering.

4. Circadian Rhythm Manipulation Through Lighting (Human Centric Lighting)

Circadian Rhythm is your body's clock. Your body naturally knows when to wake up and when to sleep. At all times of the day, your body is supposed to have a natural rhythm that guides your alertness, sleeping, and eating patterns.

Studies of the Circadian Rhythm have shown that the intensity, timing, duration, and wavelength of light can affect the biological clock of humans. In other words, our circadian rhythm can be interrupted by our constant use of bright man-made lighting (using your bright phone screen at night in bed is an example).

Disruptions in this rhythm can result in health issues such as obesity, cardiovascular and neurological problems like sleep disorders. Researchers have found that Brighter "cool" lights keep us alert and awake. This, in turn, prevents us from resting our bodies and recharging for the next day's activities.

Image 4-1

Tunable white LED lighting enables us to return to our natural circadian rhythm by giving us that range of lighting in either our homes or in the workplace. In the daytime when you need to focus, you can change the lighting to 6000K while in the evening before bed, you can decrease the CCT to 2700K, promoting the natural release of melatonin to help you sleep.

Apart from preventing health issues, tunable white LED lighting can also help regain healthy habits and normality in hospital patients. Many hospitals worldwide are now utilizing tunable white LED lighting not only as an energy saver, but they find that bright blue lighting increases a healthy appetite, increase in temperature and heart rate, and increased cognitive function. At night, warmer lighting allows for the calm low hormone levels and healing of patients. Not only that, but having a warmer lighting allows for medical staff to complete rounds without disrupting a patients sleep.

When using lighting to assist in maintaining your circadian rhythm, you'll likely be more productive and have better sleep. Your body uses sunlight to tell when certain things should happen, such as waking up or sleeping. So, if you're indoors most of the day, circadian rhythm lighting can help your body function at its best and then start winding down at the right time to help you have the best sleep at night.

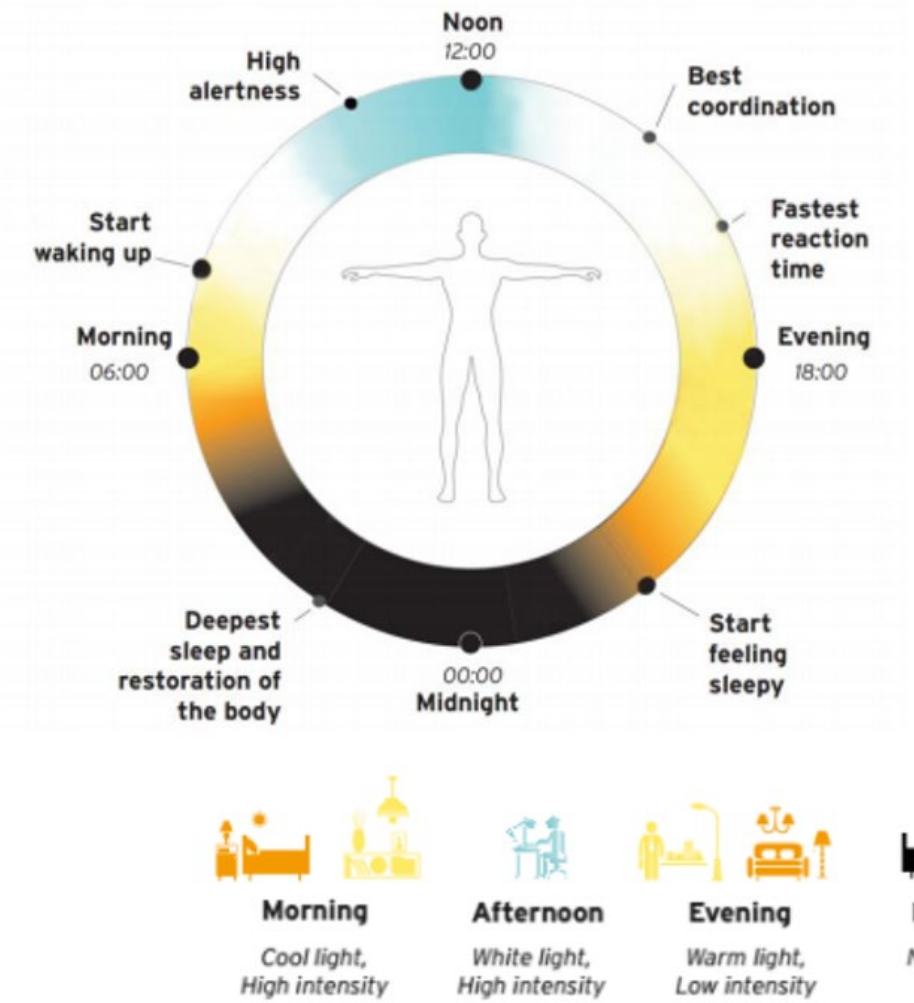

Image 4-2

Sources:

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