# دور اضاءة الليد فى تطوير الانتاج التليفزيونى

# The Role of LED lighting in The Television Production Development

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**Abstract:**

LED lighting is one of the latest technology considered as green (environmentally friendly). They are small, flat, lightweight, and require very little voltage. LED fixtures can usually be handled with bare hands. LED is a cool lighting with many pros such as low power consumption, cheap price, usage with either AC or batteries. LED is very tolerant of vibration, durable, and has a very long useful life (50,000 hours as compared to 2000 hours, at best, for a tungsten lamp). As is commonly the case when a new technology comes to the market, the marketing of LED products puts a little spin on the scientific data, which has a tendency to cloud the real issues like energy savings, color rendering and color temperature, useful life, and so on. This study discuss the limitations of LED fixtures such they do not render the full spectrum, they have spikes and gaps. Also this study shows how to measure the color accuracy of LED fixtures and clarify how old systems of measuring color accuracy are not suitable with LED. The study explain a new system (Extended color rendering index) to measure LED Lighting color accuracy with more concern to three important colors. R9 saturated red, R13 light skin tone, and R15 medium skin tone, the study shows that LEDs with high rating Extended CRI can replace tungsten fixtures due to less power consumption of LEDs.

## Keywords:

LED – Blue LED- RGB color systems- Color Rendering index (CRI) - Television Consistency Lighting Index (TCLI) - Extended Color Rendering Index.

**Statement of the problem:**

Although the LED technology is one of the newest lighting technologies and it has many advantages, but some LED fixtures have many flaws for example LED is not a full spectrum it has gaps and spikes resulting in some colors being poorly rendered, meaning they either have lack or too much of certain wavelengths of light, hence most color meters can't be trusted with today's LED technology. A central dilemma for all LED fixtures designers is how to manage the color spectrum of their fixtures.

**Research Methodology:**

The researcher will use the descriptive analysis by explaining the two methods for producing white LED light, the pros and cons of each method. The difference between ideal lights –sun, tungsten- and LED in terms of color spectrum distribution. Also clarifying the different types of LED fixtures according to the usage. This study will explain different methods in measuring the color accuracy of LED light fixtures, like CRI, TCLI and Extended CRI. Showing which one is the best for gauging LED light rendering.

**Objectives:**

1- Explaining the difference between LED lighting and ideal lights.

2- Explaining different systems in measuring color accuracy and which one is suitable for LED.

## 1- Introduction:

Although the LEDs has been used from sixties to produce green and red lighting but it did not used in motion pictures because they could not produce the white light at that time. But few years ago the first efficient blue LEDs were developed, paving the way for RGB and white phosphor LEDs. Subsequent advances in brightness, optics, heat management, and electronic control finally made these tiny light sources viable as small illumination devices. In 2014 Isamu Akasaki, Hiroshi Amano and Shuji Nakamura are awarded Nobel Prize for enhancement in LEDs technology.[1]

The fact that a LEDs is a solid-state light emitter has more implications than one may at first realize. They are small, flat, lightweight, and require very little voltage, and so can easily be powered by battery. LEDs technology has evolved beyond all recognition and it is expected to be widely used in ENG cameras, Drama, studios productions due to the less power consumption which is the most important factor in television production. Also LEDs do not generate much heat which give LEDs privilege because disposing of excess heat in a conventional studio is a major problem, involving lots and lots of air conditioning. Although it might not seem to be a major factor to the average event videographer or documentarian, it's a huge factor if you're a studio manager.[2]

For any television studio that is in daily use, air conditioning costs constitute a major slice of the operating budget. Anything that can cut that bill is pure profit for the station.

## 2- How do LEDs Work:

LEDs (light emitting diodes) are solid-state lighting devices that produce light when a forward voltage is applied. An LED consists of a semiconductor diode packaged in a clear epoxy or silicone gel. The diode contains two slightly different materials: a P-type semiconductor and an N-type semiconductor. The P-type semiconductor has "holes" created by a lack of electrons, producing a positive charge. Conversely, the N-type material has an excess of electrons, resulting in a negative charge. The P- and N-type semiconductors are placed in direct contact in the diode and the region where they meet is referred to as the PN junction. When an electric current passes through the device, electrons flow toward the P region and holes flow toward the N region. Near the PN junction electrons and holes combine Figure (1). And the electrons shed the extra energy they acquired from the electric current. This energy is released in the form of a photon, the basic unit of light. In this way, an LED emits visible light. The energy of the photons corresponds to the color of the light emitted. In the visible light spectrum, blue and purple light results from the greatest energy emission whereas yellow and red light is a result of the lowest energy emission. By utilizing materials with different band gaps, engineers can alter energy emission and thus the color of light produced by an LED.[3]

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[1] The Nobel Prize in physics / Blue LEDs filling the world with new light. (2014).Retrieved from https://www.nobelprize.org/nobel_prizes/physics/laureates/2014/popular-physicsprize2014.pdf

[2] Jackman John (2010). Lighting for digital video and television .London: Focal press .pp147-148

[3] LED: Technology for energy efficient, flexible lighting solutions. (2014). Retrieved from http://www.osram.com/osram_com/news-and-knowledge/led-home/professional-knowledge/led-basics/basic-knowledge/index.jsp

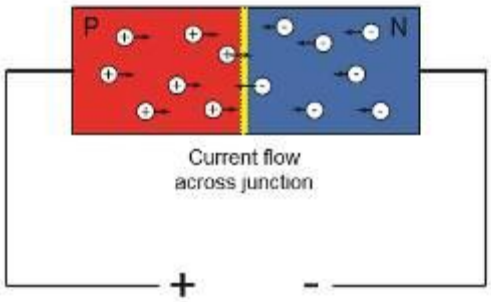


**Figure 1 Current Flowing**

## 3- LED Fixtures types:

There are different types of LEDs Varies according to usage such as:

**3-1 -**Litepads from Rosco are the thinnest they are only 8mm thick Daylight balanced LEDs (6000 K) the maximum size is 48* 96 in. A light pad can be easily hidden or placed in hard to light nooks and crannies of set pieces, the dashboard or ceiling of a car, taped to the screen of a computer monitor or TV, or just taped to the wall of the set. [1]

**3-2** For medium and small size studios DEDO light offered the Felloni 2 fixture which is very perfect in color rendition , Now Several studios have been lit with Felloni2 such as the United Nation studio , One of the best feature of Felloni2 it blends with Tungsten lights smoothly .

**3-3** Some LED fixtures such as DELD 2 IR- 960 produce infrared light. [2]Which can be used in the scientific research, wildlife shooting. Figure (2)

**Figure 2 Using LED light produces infrared make texts visible in the right side of the photo**

**3-4** LiteGear offered a very unique ligting called LiteRibbon, it is very adaptable implementation of LED technology with an adhesive back. Figure (3 ) They can be bent to curve with the surface they are mounted on—into a circle as small as a 1-in. radius. They can be

[1] Box, H. (2010). Set lighting technician's Handbook: Film lighting Equipment, Practice, and Electrical Distribution. London: Focal press. P234
[2] Ired zilla (2015). Retrieved from http://www.dedolight.com/dedolight/default.php?la=0&pg=050000OO&id=DL-DLOBML-IR860&mode=search&section=0

hidden in the set, stuck to the ceiling of a car, used for display shelf lighting, tucked in a sofit, used as instrument lights at a control desk, or in a vehicle or aircraft. [1]


**Figure 3 LiteRibbon can be made any length up to 16-ft.**

## 4- Methods for producing white LED light:

There are two methods for producing white LED light: Blue LED and RGB color System.

**4-1 Blue LEDs (Phosphor-based white LED):** It is the more common technology in producing the white color for photography, cinematography and video shooting purposes. This method utilizes a thin phosphorus layer applied on top of a blue LED. The LED's shortwave energy-rich blue light stimulates the phosphorus layer to light up and it emits lower-energy yellow light. Part of the blue light is thus transformed into white light. The white light's color tone can vary with the metering of the phosphorus colorant. Different white tones, such as warm white, neutral white or cold white are thus produced.[2]

**4-2 RGB color systems:** This method for producing white LED light is based on the principle of mixing red, green & blue light (RGB) at different wavelengths. The advantage of this method is as follows: The light color can be changed by specified control. But it is unsuitable for motion picture because the lack of some colors like blue Congo. [3]

### 5- The Difference in the color spectrum distribution for continuous light fixtures and LEDs

Daylight and tungsten light have continuous color spectrum distribution, so they are the two most accurate sources of light we call them the ideal lights, because they are able to render all colors .Figure (4)

[1] Led Lite Ribbon. (2014). Retrieved from http://www.litegear.com/wp-content/uploads/2014/03/LiteGear_VHO-PRO_2014sm.pdf

[2] http://www.osram.com/osram_com/news-and-knowledge/led-home/professional-knowledge/led-basics/light-colors/index.jsp

[3] Box, H. (2010). Set lighting technician's Handbook: Film lighting Equipment, Practice, and Electrical Distribution. London: Focal press. PP 228-233

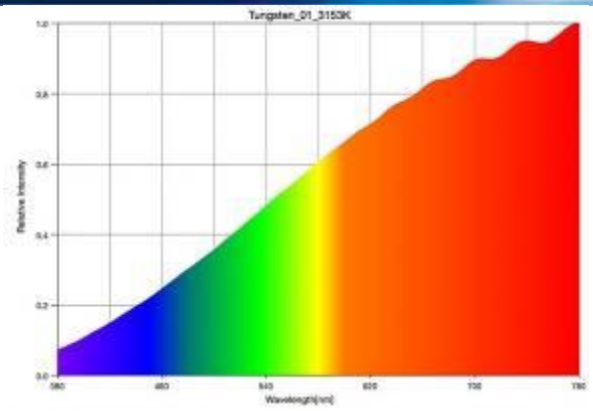

**Figure 4 the color spectrum for tungsten light notice that it doesn't has any spikes or gaps**

But in the central dilemma for all LED fixture designers is how to manage the color spectrum of their fixtures. This turns out to be a complex puzzle to solve, because LED don't have continuous color spectrum distribution, it suffers from gaps and spikes.[1] Which means it cannot render color accurately especially skin tones. Figure (5)

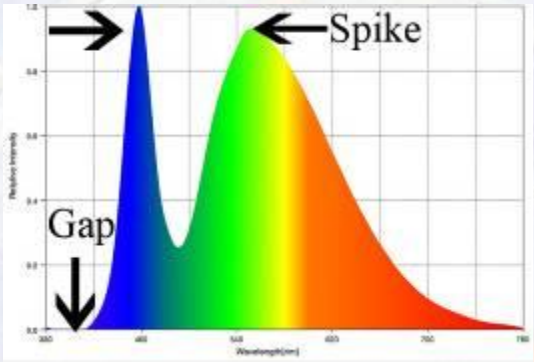


**Figure 5 the color spectrum for LED light notice that it suffers from spikes and gaps**

## 6- Measuring LED Color Accuracy:

We will discuss how to measure the color accuracy for LEDs by using new systems like CRI, TLCI, and Extended CRI. And we will explain which one is the best for measuring the color accuracy.

**6-1 Color Rendering index** (**CRI**): is a quantitative measure of the ability of a light source to reveal the colors of various objects faithfully in comparison with an ideal or natural light source –Tungsten, Sunlight-The CRI scale ranges from 0 to 100. The larger the number, the more faithful and color accurate the light source will be.[2]

Light sources with a high CRI are desirable in color-critical applications such as neonatal care, photography, video and cinematography. It uses eight color samples. Figure (6)

[1] Rayan E Walters. (2015, July). Retrieved from http://indiecinemaacademy.com/is-cri-relevant-in-an-led-world/#tab-id-2

[2] Keely Nielsen (2015, Feb25). CRI for LED: Using the color rendering index for retrofits. Retrieved from http://solutions.borderstates.com/cri-for-led-retrofits

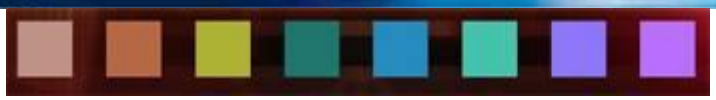

**Figure 6 the colors used in CRI system**

But the CRI (Color Rendering Index) has many flaws and is unreliable even when used for its original intended purpose, assessing lighting for industrial and architectural situations. It is even less meaningful if used in a television environment. The solution is the TLCI (Television Lighting Consistency Index).

**6-2 Television Consistency Lighting Index (TCLI):** was developed to overcome the shortcomings of CRI with light sources like LEDs. Like CRI, TCLI is based off of a scale of 0 to 100, with the best light sources being above 85. TCLI use 24 color patches to gauge light. Figure (7)

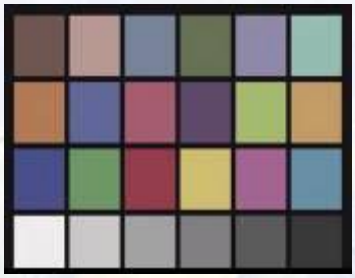

**Figure 7 TCLI colors**

| | |
|---|---|
| **85 – 100** | errors are so small that a colorist would not consider correcting them |
| **75 – 85** | a colorist would probably want to correct the color performance, but could easily get an acceptable result |
| **50 – 75** | a colorist would certainly want to correct the errors, and could probably achieve an acceptable result, but it would take significant time to get there |
| **25 – 50** | the color rendering is poor, and a good colorist would be needed to improve it, but the results would not be to broadcast standard |
| **0 – 25** | the color rendering is bad, and a colorist would struggle for a long time to improve it, and even then the results may not be acceptable for broadcast |

**Table 1 Displays TCLI Measurements** [1]

But unfortunately many LEDs manufacturers TLCI didn't approve it, because it is adopted for broadcast cameras and not for consumer cameras. So a new system called Extended CRI has been introduced.

[1] TLCI results. Retrieved from http://www.gtc.org.uk/tlci-results.aspx

**6-3 Extended Color Rendering Index**: it measures light accuracy by using 15 colors. Figure (8), and there are three very important colors in this scale, the first is R9, a saturated red. It is actually quite difficult for an LED light to emit a lot of red. And since our mind's eye knows when red is really red, it's important to get it right, especially since it is a key component of skin tone. The two other important colors are R13, which is a light skin tone, and R15, which is a medium skin tone. [1]

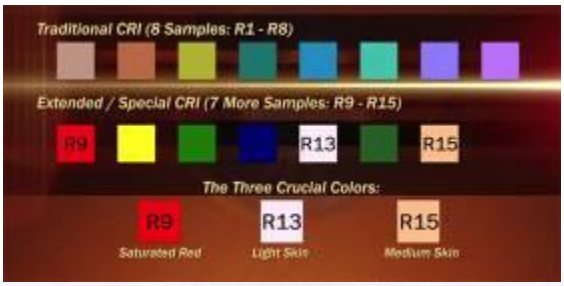


**Figure 8 Extended Color Rendering Index**

For Getting great looking colors and skin tones with LEDs use only LEDs that have high rating for R9, R13, and R15 colors. If those values fall in the 70 – 90 range you'll get good results; if they are in the 90+ range you'll get excellent results.

## 7- Database of LED Fixtures:

The researcher has cited the Indie Cinema Academy readings at the National Association Broadcaster (NAB) 2015 because of three reasons first, NAB showroom is the biggest all the over the world . Second, NAB is a great place to sample a wide range of LEDs in an efficient manner. Third, all of the LEDs were in the same environment. Assuming that every manufacture brought the best of their LED inventory to NAB. Indie Cinema Academy used the color meter Sekonic c-700 placed directly in front of the light source (approximately 12 inches away).The Sekonic c-700 has many features like reading the color spectrum distribution for LEDs with more concern to the Values for R9 saturated red, R13 light skin tone, and R15 medium skin tone they are important for proper skin tones. Here are the results list for the top five lighting fixtures arranged by average Extended CRI values.[2]

## 1- Lumos 500MK Fixture.

| CRI | Extended CRI | R9 | R13 | R 15 |
|---|---|---|---|---|
| 97.2 | 96.2 | 90.0 | 97.4 | 96.0 |

**Table 2 displays the Extended CRI for Lumos 500k Fixture.**

## 2- Fillex Q 1000 Fixture.

| CRI | Extended CRI | R9 | R13 | R 15 |
|---|---|---|---|---|
| ٩٦.٧ | ٩٥.٦ | ٩١.٥ | ٩٦.٣ | ٩٤.٢ |

**Table 3 displays the Extended CRI for Fillex Q 1000 Fixture**

[1] Rayan E Walters. (2015, July). Retrieved from http://indiecinemaacademy.com/is-cri-relevant-in-an-led-world/#tab-id-2

[2] Rayan E Walters. Retrieved from http://indiecinemaacademy.com/led-color-rendering-database-the-results/

### 3- ARRI L7-C Fixture.

| CRI | Extended CRI | R9 | R13 | R 15 |
|---|---|---|---|---|
| 94.2 | 93.8 | 95.5 | 95.8 | 96.2 |

**Table 4 displays the Extended CRI for ARRI L7-C Fixture.**

### 4- NanGuang CN200F Fixture.

| CRI | Extended CRI | R9 | R13 | R 15 |
|---|---|---|---|---|
| 95.1 | 93.6 | 95.5 | 99.1 | 94.2 |

**Table 5 displays the Extended CRI for NanGuang CN200F Fixture.**

### 5- Westcott Flex 1-Light Daylight Fixture.

| CRI | Extended CRI | R9 | R13 | R 15 |
|---|---|---|---|---|
| 95.3 | 93 | 78.8 | 95.2 | 90.3 |

**Table 6 displays the Extended CRI for Westcott Flex 1-Light Daylight Fixture.**

## Research Results:

1- The Main difference between ideal lights and LED, Ideal lights are able to render all colors because they have continuous color spectrum, But LED suffers from gaps and spikes in the color spectrum.

2- CRI (Color Rendering Index) system has many difficulty in measuring the color accuracy for LED fixtures because it uses only eight colors and doesn't measure all colors, Since LED suffers from gaps so we cannot trust CRI in measuring the color accuracy for LED. Also the Television Consistency Lighting Index (TCLI) system which depends on 24 colors, three times more than CRI is adopted only for broadcast cameras and doesn't support consumer cameras, hence we cannot also use TCLI in measuring the color accuracy for LED Fixtures.

3- The extended Color rendering Index is the suitable system in measuring the color accuracy for LED because it depends on the traditional CRI plus seven more samples colors with more concern to three colors, The saturated red R9 because it is very difficult for LED to render this color, the other two colors are R13 light skin tone, R15 medium skin tone.

4- LED lighting can be used in different television production application areas such as Electronic News gathering because they are small, flat, lightweight, and require very little voltage, and so it can easily be powered by battery. Also we can use LED lighting in studios, Due to the less power consumption of LED which is the most important factor in television Production.

5-We can use LEDs lighting which produce infrared in the scientific research and wild life shooting.

6- LED fixture with very low CRI has many flaws which it cannot be fixed because they are suffering from gaps in the color spectrum, hence we cannot compensate colors doesn't exist.

7- The research showed the importance of using lighting modifier (diffuser) in front of LED to convert it from point source to soft source.

8- LED Lighting with high Extended CRI values can replace tungsten lights due to the less power consumption of LED.

## 8- Conclusions and Discussions:

1- LED lighting is a solid-state product. This offers such features as vibration resistance, the emitter is a solid chunk of semiconductor; there's no lamp to break, no delicate filament. LED is durable, and has a very long useful life 50,000 hours.

2- The LED light is also much easier controlled and will not cause light pollution like other light sources. It is very well controlled and can be re-claimed and placed where needed. The LED is small in size and can be combined for high power applications when needed.

3- LED lighting offers many benefits and features that were difficult, if not impossible to offer with other lighting technologies. Many of the obvious benefits, such as substantial operating energy and cost reductions, longer life, and lower overall heat generation.

4- Another feature that allows for dramatic appearance and productivity benefits now and in the future, involves the ability to change the color temperature subtly of the light produced by LED Fixtures.

5- The most important step to getting great looking colors and skin tones with LEDs is to only use LEDs that have high rating for R9 saturated red, R13 light skin tone, and R15 medium skin tone, If those values fall in the 70 – 90 range you'll get good results; if they are in the 90+ range you'll get excellent results.

6- Although LED is more expensive than the traditional light sources, the energy saving for one year can offset the cost of LED light source and create a short Return on Investment (ROI).

7- The marketing of LED products puts a little spin on the scientific data, which has a tendency to cloud the real issues like color rendering and color temperature so it is very crucial to measure your lighting fixture by using new light meter specifically designed for LEDs with more concern to high rating for R9 saturated red, R13 light skin tone, and R15 medium skin tone.

8- LEDs' unique advantages are attracting a lot of attention around the globe. In the USA, it is predicted that LEDs will replace 55% of incandescent lights and 55% fluorescent lights within the next 15 years. This will save $35 billion annually in electricity costs.

9- Using LED will prevent the emission of hundreds million pounds of carbon dioxide.

10- The future of LED lighting is very promising: LEDs are considered the best market in this coming decade on a global scale.

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