

LED Performance and LED B/L Technology Required for LED Displays in Manufacturing Industry

SUGITANI Chouei, TAKAHASHI Kei

Abstract

A growing number of LCD displays for the manufacturing industry are being equipped with backlights that use LED as their light source instead of the conventional cold-cathode tube.

The LED backlight modules developed by NEC LCD Technologies, Ltd. achieve a slimmer profile, lighter weight, and lower power consumption than those that use a CCFL (Cold Cathode Fluorescent Lamp) as the light source.

In the future, we will continue to address the issues of extending luminosity longevity as well as improving backlight visual quality, putting full effort into the development of LCD display modules that meet the needs of our customers through various efforts such as upgrading backlight matching technology and tie-ups with LED manufacturers.

Keywords

display, manufacturing industry, LED, backlight, lifespan

1. Introduction

Remarkable advances have taken place in LED (Light Emitting Diode) technology over the last few years. LEDs offering emission efficiency that surpass that of fluorescent tubes have been developed, and they are being applied in the field of light fixtures. It is also a well-known fact that LED light sources played an important role in the improved thinness of LCD displays used in mobile phones.

Conventionally, Cold Cathode Fluorescent Lamps (hereinafter CCFL) have been used in LCD displays that are 5-inches or larger, but gradually new products that incorporate the benefits of LED are being released. This includes our 12.1-inch NL10276BC24-14 LCD display developed for commercial-use notebook PCs, and the 6.5-inch NL10276BC13-01C LCD display, which succeeded in achieving improved thinness and reduced power consumption, and have now entered the mass production stage.

We intend to expand our lineup of manufacturing industry products incorporating LED as the backlight (hereinafter LED B/L) in the future.

This paper introduces LCD displays that have adopted the LED B/L, as well as the various technical challenges that face LED B/L.

2. Introduction to LED B/L LCD Display

2.1 NL10276BC13-01C

Table 1 shows the basic specifications of NL10276BC13-01C.

(1) Low Power Consumption

The LED used in this module has an efficiency of around 65lm/W, which is at a level equivalent to that of the CCFL commonly used in backlights. And whereas CCFL radiates light outward along its circumference, requiring a reflector to reflect the light to the Light Guide Plate, LED emits light in one direction only so that light enters the Light Guide Plate more efficiently.

Table 1 Basic specifications of NL10276BC13-01C.

Item	Details
Drive System	a-Si TFT Active Matrix
Screen Size	16.5cm diagonally (6.5")
No. of Pixels	1024 (H) × 768 (V) [XGA]
Pixel Pitch	0.129mm
Screen Brightness	650cd/m ²
Power Consumption	3.9W (2.5 W of which is for backlight)
Backlight Operation Voltage	27.9V × 6 sectors
Module Exterior Dimensions	153.0 (W) × 118.0 (H) × 9.0 (D) mm
Mass	170g

LED Performance and LED B/L Technology Required for LED Displays in Manufacturing Industry

As a result, the backlight is able to maintain high luminosity of 650cd/m² while achieving a low power consumption of 2.5W, as opposed to the approximately 7W that presumably would be necessary to achieve the same brightness when using CCFL as the light source.

(2) Low-Voltage/Low-Current Operation

If CCFL is used as the light source, approximately 400V AC would be required. However, this module is composed of 6 blocks, each comprising a number of series-connected side-view type LEDs (i.e. light is emitted in a direction horizontal to the target screen), which offer a low operating voltage and current of about 28V/15mA per block.

Another benefit of using LED B/L is that there is no need for an inverter to produce high voltage as would be necessary to light up a CCFL.

(3) Thin and Lightweight Design

In most cases even the thinnest CCFL would have a diameter of 1.8mm. And since it is necessary to use two of them side-by-side to achieve high definition, the Light Guide Plate would therefore need to be over 4mm thick.

Our module, on the other hand, uses an LED that is only 0.8mm thick, thus realizing a Light Guide Plate that is only 1mm in thickness.

By using LED, we have succeeded in attaining a 15% reduction in thickness, and a 17% reduction in mass, compared to conventional CCFL B/L.

2.2 NL10276BC24-14

Table 2 shows the basic specifications of NL10276BC24-14.

(1) Low Power Consumption

This module uses an LED that offers an efficiency of 56lm/W.

The backlight uses a downward prism method in which light

Table 2 Basic specifications of NL10276BC24-14.

Item	Details
Drive System	a-Si TFT Active Matrix
Screen Size	30.7cm diagonally (12.1")
No. of Pixels	1024 (H) × 768 (V) [XGA]
Pixel Pitch	0.24mm
Screen Brightness	300cd/m ²
Power Consumption	4.5W (2.9W of which is for backlight)
Backlight Operation Voltage	29V × 5 sectors
Module Exterior Dimensions	260.0 (W) × 200.0 (H) × 6.5 (D upper) / 3.9 (D lower) mm
Mass	285g (typ.)

emitted from the LED is reflected at a predetermined angle through a pattern on the Light Guide Plate, making it possible for the downward prism sheet to gather light perpendicularly. As a result, the amount of light that is emitted in a useless direction has been reduced, thereby boosting the B/L efficiency by about 40% compared to conventional diffusion types.

Through the use of LED and as a result of implementing the above method, our module achieves a low power consumption of 2.9W, as opposed to the approximately 4.9W that would be required when using CCFL as the light source.

(2) Low-Voltage/Low-Current Operation

In order to achieve low-voltage and low-current operation, the LED connection structure is composed of 5 blocks of numerous series-connected LEDs.

As a result, low-voltage operation (29V/20mA) became possible.

(3) Thin and Lightweight Design

The backlight of this module uses 0.8mm thick LED, and adopted a Light Guide Plate with the same 0.8mm thickness.

And by adopting the downward prism method for the Light Guide Plate, it is able to offer the same performance using just two optical sheets where conventionally four would be required, and succeeded in attaining a 0.2mm thin profile.

By reducing the thickness of the Light Guide Plate, reducing the number of optical materials used, reducing the thickness of chassis materials as well as the thickness of the TFT glass substrate, we were able to achieve a thickness of 3.9mm (excluding signal layer) for a 46% reduction in thickness and 47% reduction in mass compared to conventional CCFL B/L.

3. Technical Issues facing LED B/L for LCD Displays in Manufacturing Industry

3.1 Extension of Luminance Longevity

Luminance longevity is among the most important factors required of LCD displays for the manufacturing industry. Since it will be incorporated into a variety of different manufacturing machinery, the LCD display's ability to maintain its brightness over a long period of time to allow continued use, is of crucial importance.

The CCFLs commonly used for LCDs in manufacturing offer a half-life (brightness degrades to half of original level) of about 50,000 to 60,000 hours, so the same level of luminance longevity would be expected for LED.

Being a semiconductor device, LED had long been considered to suffer little or no degradation of its characteristics.

However, in recent years as the study of LED efficiency has advanced, it has been discovered that deterioration of the package or dye bond resin due to intensification of the light beam emitted from the LED make it impossible for the original luminosity to be maintained.

To counter this, we are implementing various improvement methods including increasing the package's light resistance, doing away with dye bond and using eutectic bonding instead to mount the LED device, as well as attenuating package deterioration by shifting the light wavelength.

3.2 Technological Countermeasures to Uneven Light Entry

Since LED is a point light source, it faces certain challenges that are not associated with CCFL which is a linear light source. Specifically, it is how uneven light entry can occur at the light entry section of LED, a point light source, as shown in **Fig. 1**. Differences in brightness develop between sections where an LED is mounted and not mounted, which register as bright and dark areas on the LCD display screen.

This uneven light can be resolved by putting more distance between the LED and light-entry section, allowing the light to mix within the Light Guide Plate and making the uneven light less apparent. However, the demerit of this method is that it requires an enlarged frame for the LCD display.

The graph in **Fig. 2** shows the relationship between LED mounting pitch and uneven light entry. When the number of illuminated LEDs is small, it is necessary to enlarge the frame to make the uneven luminosity unnoticeable.

To overcome this problem, it is common practice to apply a prism cut pattern to the Light Guide Plate's light-entry section to refract and disperse light that comes in perpendicularly, and

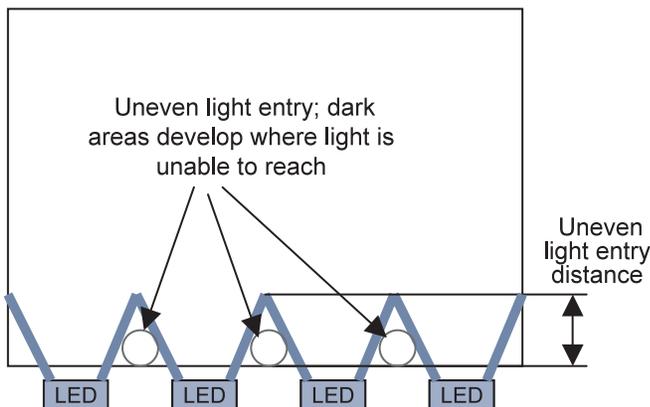


Fig. 1 Uneven light entry reference diagram.

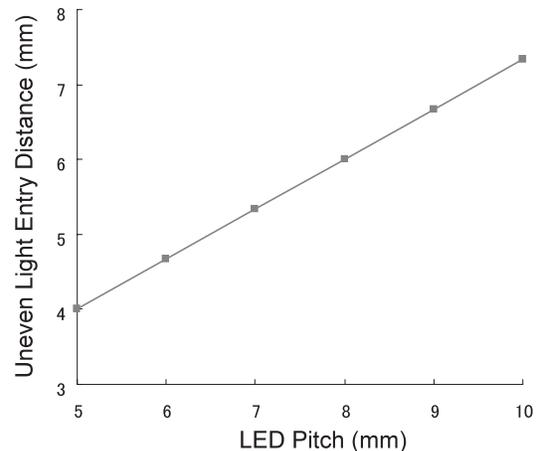


Fig. 2 Relationship between LED pitch and uneven light entry distance.

to pick up light entering from a wide angle into the Light Guide Plate as shown in **Fig. 3**, to attenuate the uneven intake of light.

We are investigating the possibilities of achieving an LCD display that looks beautiful and has a small frame, through matching the design of the Light Guide Plate in accordance with the LED and pitch array that will be used.

3.3 Differences among Individual LEDs

The LEDs used in LCD displays for the manufacturing industry are called pseudo-white LEDs. To produce their white color, the blue light emitted from the LED device is shined onto a yellow fluorescent material to induce an excited luminescence, and the blue and yellow colors are combined to create a white light.

Inevitably, the various factors involved in manufacturing the

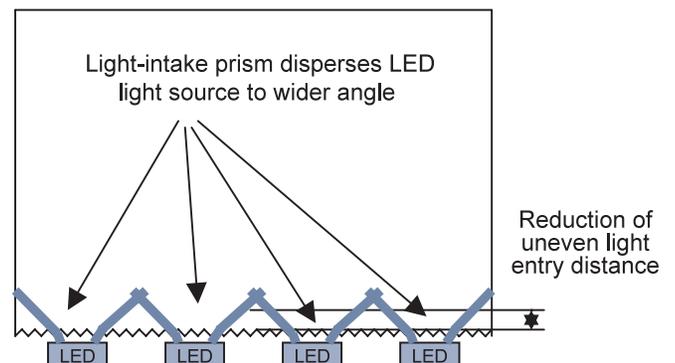


Fig. 3 Light guide plate light-intake prism.

LED Performance and LED B/L Technology Required for LED Displays in Manufacturing Industry

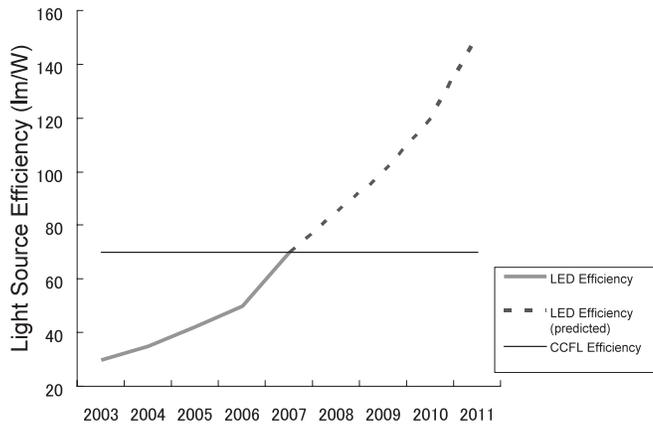


Fig. 4 Roadmap for white LED light source efficiency (lm/W).

LED such as the wavelength and output level of the LED's blue light, and the density of the fluorescent material, are not uniform and thus lead to inconsistencies in the luminance and color between individual LEDs.

When these LEDs, which include inconsistencies in their luminance and color from one LED to the next, are combined into a single LCD display without due consideration, their inconsistencies become visible on the screen as luminance and color irregularities.

Therefore, it is necessary to sort and select LEDs according to their luminance and coloration.

3.4 High Luminosity and High Efficiency

LED efficiency has improved each year as shown on the Roadmap in Fig. 4, and now it has reached an efficiency level on a par with CCFL. There is still room for more improvement in LED efficiency, and assuming that those improvements will continue to be applied in the future, we can see that LED efficiency is on course to surpass that of CCFL in another year or two.

However, since package deterioration accelerates as light intensity increases, improvements in that area need to be pursued in tandem. By applying longevity improvement measures in conjunction with efficiency improvement, we will be developing high-performance modules that would not have been possible using CCFL.

4. Conclusion

NEC LCD Technologies, Ltd. has succeeded in developing and mass producing two LCD display modules that use LED as the light source, achieving a thin profile and light weight, as well as reduced power consumption.

In the future, we intend to overcome the issues associated with LED, and develop LCD display modules that capitalize on the benefits of LED.

Authors' Profiles

SUGITANI Chouei
Technology Manager,
Module Design Department,
Technology Division,
NEC LCD Technologies, Ltd.

TAKAHASHI Kei
Engineer,
Module Design Department,
Technology Division,
NEC LCD Technologies, Ltd.