# SEMI D62-0611
# MEASUREMENT METHOD OF LED LIGHT BAR FOR LIQUID CRYSTAL DISPLAYS

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## 1 Purpose

1.1 This measurement standard defines measurement methods and reporting requirements for various characteristics of light emitting diode (LED) light bar for liquid crystal displays (LCDs). This Standard will be helpful to unify methodologies measurement used for electro-optical and mechanical characteristics which can be used to improve the quality of integrated LED backlight units and track conformity to original design rules.

## 2 Scope

2.1 This Standard is a generic specification for electro-optical and mechanical measurement methods of LED light bar used for LCDs.

2.2 This Standard is intended to be generally useful for many common types of LED light bar designs.

2.3 This Standard is suitable for common types of LED light bars of the edge (or side) type backlight unit design.

2.4 This Standard is suitable for both side-view and top-view surface mount device (SMD) LEDs.

2.5 The Standard includes practical methodologies of flux, intensity, color, and geometric specification measurements. The measured optical characteristics are appropriate for the practical operational conditions using as an extended source, rather than a multi-point-source.

**NOTICE:** SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

## 3 Referenced Standards and Documents

3.1 *SEMI Standards and Safety Guidelines*

SEMI D36 — Terminology for LCD Backlight Unit

3.2 *CIE Standards*[1]

CIE 15:2004 — Colorimetry, 3rd edition

CIE 84:1989 — The Measurement of Luminous Flux

CIE 127:2007 — Measurement of LEDs

**NOTICE:** Unless otherwise indicated, all documents cited shall be the latest published versions.

## 4 Terminology

4.1 *Abbreviations and Acronyms*

4.1.1 *CRM* — certified reference material

4.1.2 *LED* — light emitting diode

4.1.3 *LGP* — light guide plate

4.1.4 *PCB* — printed circuit board

[1] International Commission on Illusion; http://www.cie.co.at/cie/



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4.1.5 *SMD* — surface mount device

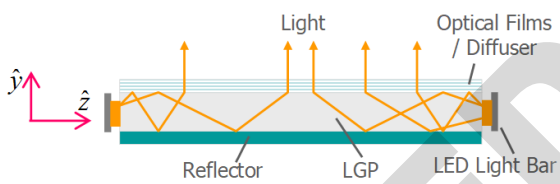
4.2 *Definitions*

4.2.1 *edge (or side) type LED backlight unit* — a backlight unit with one or more LED light bars coupled with one or more edges of the LGP of backlight unit. Light emits originally from the edge (rather than from bottom to top) of LGP (shown in Figure 1).

4.2.2 *LED light bar* — a strip light source with multiple LEDs (SMD or other package type LED) mounted along on a strip PCB. In general, all the LEDs emit the chief optical radiation in the same direction.

4.2.3 *side-view SMD LED* — a SMD LED whose (optical radiation) emitting surface is normal to the PCB surface (shown in Figure 2).

4.2.4 *top-view SMD LED* — a SMD LED whose (optical radiation) emitting surface is parallel to the PCB surface (shown in Figure 3).




#1 The light bar may be populated with either top-view or side-view SMD LEDs.

**Figure 1**
**Structure of the Edge Type LED Backlight Unit Showing the Coordinate System for the Left Edge LED Light Bar**

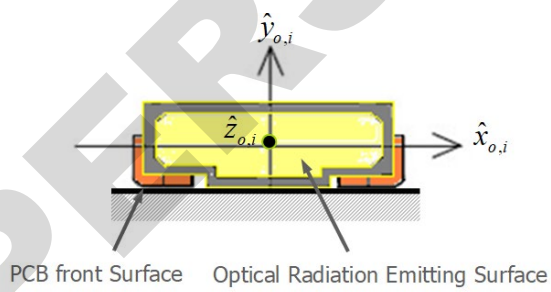



**Figure 2**
**Cross Section of Side-view SMD LED, Optical Radiation Axis is Z-axis**

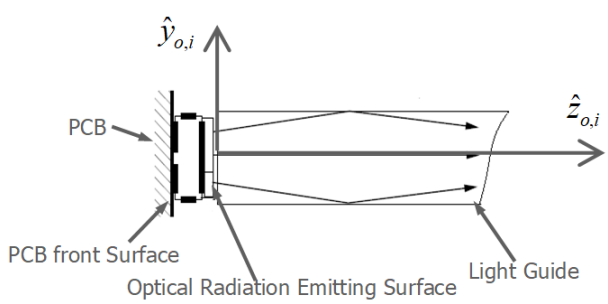



**Figure 3**
**Cross Section of Top-view SMD LED Coupling with a Light Guide Plate**

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## 5 Summary of Method

5.1 This test method consists of two distinct parts of measurements.

5.1.1 The first part of measurements is the mechanical characteristics to define a coordinate system for the light bar.

5.1.2 The second part of measurements is the optical characteristics to define photometric and colorimetric properties of the light bar.

## 6 Related Definitions for LED Light Bar Measurement

6.1 *Mechanical/Optical Definitions*

6.1.1 *Alignment Mark* — An auxiliary mark used to indicate the LED specific mounting position on the PCB (shown in Figure 4).

6.1.2 *Major Axis* — An axis $\hat{x}_{major}$ with direction defined by PCB alignment from left to right or through each alignment mark centers of all LEDs (shown in Figure 4).

6.1.3 *Specific Origin* — A center coordinate (*x-y* plane) for the official designed mounting position of LED on the PCB. The specific origin of i$^{th}$ LED is denoted as $O_i(x_i, y_i)$. The specific origins of all LED can refer to their alignment marks on the PCB.

NOTE 1: For testers that intend to get the absolute coordinate, in general the global coordinate origin (0,0) is recommended to be the center of the left-most alignment mark.

6.2 *Definitions of Measurement Parameters*

6.2.1 *Mechanical Characteristic Measurement Parameters*

6.2.1.1 *Mechanical Origin* — A center coordinate (*x-y* plane) of the emitting surface feature of a LED used as the reference for the mounting position of a LED on the PCB. The mechanical origin coordinate for i$^{th}$ LED is denoted as $O_{m,i}(x_{m,i}, y_{m,i})$ (shown in Figure 4) (i is the ordinal number of LED).

6.2.1.2 *Mechanical Origin Deviation* — An *x-y* plane distance between each mechanical origin and the relative LED specific origin. It is used as the reference for mounting axis of a LED. The mechanical origin deviation for i$^{th}$ LED is denoted as $d_{m,i}(x_{m,i}, y_{m,i})$.

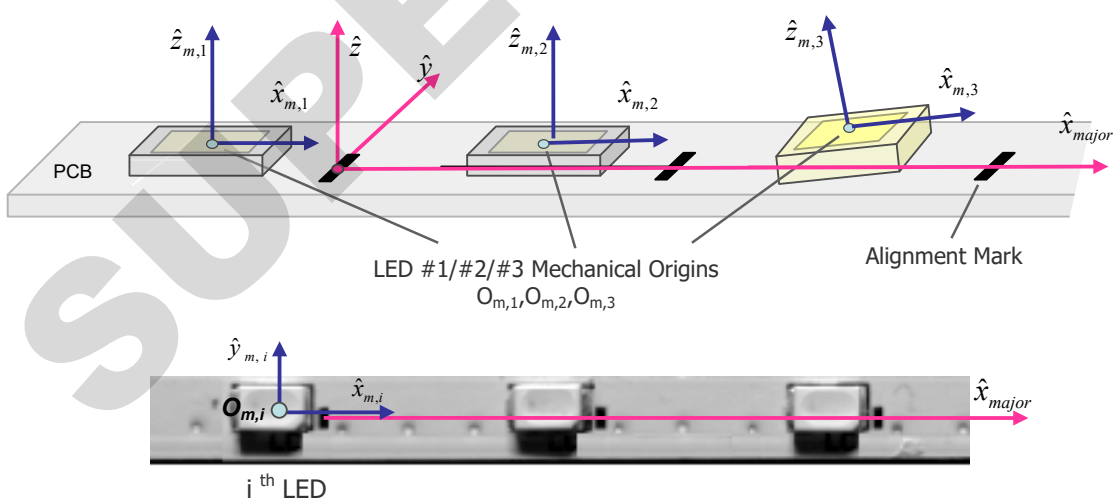


**Figure 4**
**Diagram of Major Axis of LED Light Bar (Image of Unlighted LED Light Bar), Mechanical Axis, Mechanical Origins, Alignment Marks**

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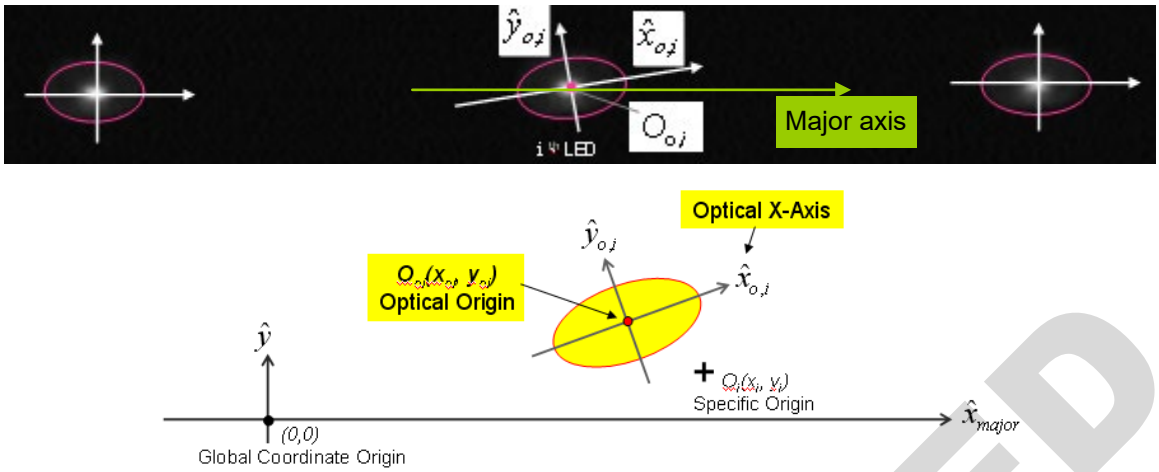


#1 The Lower Diagram is an Exaggerated Drawing for Demonstrating the Deviation of Optical Origin and Optical Axis from Specific Origin (Black Cross Mark), and Major Axis.

**Figure 5**
**Diagram of Luminance Spatial Distribution (Image of Lighted LED Light Bar), Global Coordinate Origin (Black Dot), Optical Origins (Red Dot), and Optical Axis of i$^{th}$ LED**

6.2.1.3 *Mechanical X-axis* — An axis along the longer LED edge, direction following the PCB major axis from left to right. It is denoted as $\hat{x}_{m,i}$ for i$^{th}$ LED.

6.2.1.4 *Mechanical X-axis Deviation* — The angle between each mechanical x-axis and the major axis of LED light bar. It is denoted as $\Delta\theta(\hat{x}_{m,i}, \hat{x}_{major})$ or $\Delta\theta_{m,i}$ for i$^{th}$ LED.

6.2.1.5 *Optical Origin* — A center-of-gravity coordinate (*x-y* plane) of the optical radiation on the emitting surface of a LED used as the reference for the mounting position of a LED on the PCB. The optical origin coordinate for i$^{th}$ LED is denoted as $O_{o,i}$ $(x_{o,i}, y_{o,i})$ (shown in Figure 5).

6.2.1.6 *Optical Origin Deviation* — An *x-y* plane distance between each optical origin and the relative LED specific origin. It is used as the reference of the accuracy of LED radiation distribution. The optical origin deviation for i$^{th}$ LED is denoted as $d_{o,i}$ $(x_{o,i}, y_{o,i})$.

6.2.1.7 *Optical X-axis* — An axis through optical origin with maximum light spread, direction followed PCB major axis from left to right. It is used as the reference of the LED radiation distribution. The optical *x*-axis for i$^{th}$ LED is denoted as $\hat{x}_{o,i}$ (shown in Figure 5).

6.2.1.8 *Optical X-axis Deviation* — The angle between each optical *x*-axis and the major axis of LED light bar. It is used as the reference for the accuracy of LED radiation distribution. It is denoted as $\Delta\theta(\hat{x}_{o,i}, \hat{x}_{major})$ or $\Delta\theta_{o,i}$ for i$^{th}$ LED.

6.2.2 *Optical Characteristic Measurement Parameters*

6.2.2.1 *Color* — The chromaticity coordinate of single LED or LED light bar under the measurement condition of partial, total, or $2\pi$ luminance flux, or average intensity. The measurement report shall illustrate the measurement condition.

6.2.2.2 *Color Non-uniformity* — The maximum color difference, (i.e., the maximum Euclidean distance $\Delta u'v'$ or $\Delta xy$ in CIE 1976 $(u',v')$ or CIE 1931 $(x,y)$ color space respectively) between any two LEDs of the light bar. The measurement report shall illustrate the measurement condition.

6.2.2.3 *Forward $2\pi$ Luminous Flux* — The amount of luminous flux in $2\pi$ solid angle of each LED in forwards direction over the specific origin.

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6.2.2.4 *Luminous Intensity* — The partial flux divided by the relative solid angle, or the illuminance divide by the square of the measurement distance (under certain illumination area with certain measurement distance for each single SMD LED of LED light bar over its specific or mechanical origin position). The measurement report shall illustrate the measurement condition.

6.2.2.5 *Luminous Intensity Uniformity* — The minimum and maximum ratio of average intensity among LEDs of the LED light bar (measurement report shall illustrate the measurement condition).

6.2.2.6 *Partial Luminous Flux* — The amount of luminous flux under a certain solid angle of each LED in a forward direction over the specific origin.

6.2.2.7 *Partial/Forward 2π Luminous Flux Uniformity* — The minimum and maximum ratio of partial/forward 2π luminous flux among LEDs of the LED light bar.

6.2.2.8 *Total Luminous Flux* — The total luminous flux in 4π solid angle of a LED light bar.

## 7 Set-Up

7.1 All tests and measurements shall be carried out in rooms with illuminance under 10 lux. All tests and measurements shall be carried out in ambient temperature (25 ± 3)°C, relative humidity (60 ± 20)% RH.

7.2 LEDs shall be driven from constant current switching regulators.

NOTE 2: The variation of driving current should be within ±0.5% for during of measurement period. As an alternative, testers should make sure that the driving current variation does not cause more measurement uncertainty than what is required.

7.3 *Warm-Up Time*

7.3.1 Warm-up time is the period from power-on to reach light intensity or its color to stability (or some other optical parameters with which testers may be concerned).

7.3.2 Specify the typical warm-up curve (e.g., relative intensity and chromaticity vs. light-on period shown in Figure 6) for each type LED light bar.

7.3.3 Specify the warm-up time for each type of optical characteristics measurement.

7.3.4 Specify the variation of intensity or color (or some optical parameters with which testers may be concerned) for during of measurement period. (In the case of Figure 6, the warm-up time is set to be 180 seconds (3 minutes) for the intensity/intensity uniformity measurement, with intensity variation less than 0.3% during the measurement period of 2 minutes.)

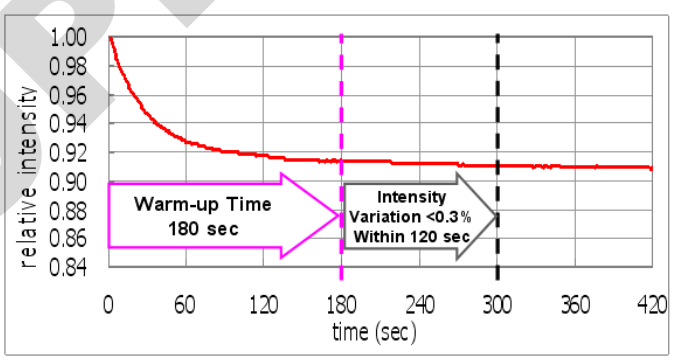


**Figure 6**
**The Typical Warm-Up Curve of Relative Average Intensity vs. Light-on Time of SMD LED for LED Light Bar**

7.4 The optical axis of the optical measurement device shall be perpendicular to the LED light bar under test.

NOTE 3: The uncertainty in axis alignment is specified to be ±0.3° as a goal. As an alternative, testers should make sure that the alignment error does not cause more measurement uncertainty than what is required. The uncertainty in locating measurement

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