

# Memorandum

**Subject: New Luxeon White Binning Structure**

**Date: June 20, 2003**

Dear Customer,

In an effort to further enhance the ease of use of Lumileds white Luxeon products for lighting applications, Lumileds is pleased to announce the introduction of a new white binning structure for white Luxeon, Luxeon III and Luxeon V Portable emitters and arrays. The introduction of this new color binning structure does not affect Lumileds current flux and forward voltage binning structures.

## **Rationale for Development of New White Binning Structure**

With the introduction of Luxeon, LEDs are rapidly finding adoption into new market segments not previously serviced by solid-state light sources. The specifications of LEDs required to penetrate these markets are not necessarily the same as those required to serve historical markets for LEDs, requiring a change in the philosophy of how LEDs are manufactured, tested, categorized, and sold.

The existing Luxeon white color binning structure is based on lines of constant color temperature (CCT) only. Product is tested and binned by color temperature, but not by offset from the Planckian (Black Body Locus). Feedback received from customers indicates that the existing binning structure may not adequately define the color of our products, introducing challenges in using white Luxeon products in their applications. Increasing the resolution of our binning structure to mitigate perceived color differences within a color bin will aid in resolving this concern. In an effort to increase the ease of use of our white Luxeon products, a new binning structure has been developed and introduced.

## **Development of the New Luxeon White Binning Structure**

Investigation into prior art in the field of color science was conducted to determine if an existing framework could be used to create an improved white binning structure. MacAdam ellipses are typically used in color science to define areas in color space in which there exists no detectable difference in color to the human observer. Typically these ellipses are created using focus group studies, where the color of the test device is varied until a difference is observed compared to the control source.

Based on previous perception studies, a new graphical framework was defined which accounts for not only variations in color temperature, but also offset above and below the Planckian. This framework was then used to develop a new white binning structure proposal through the use of focus group studies. Once developed, this proposal was tested through customer viewing

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sessions, resulting in a solution that will be suitable for various lighting, signage, and signaling applications.

## Comparison of Existing and New Luxeon White Binning Structures

As stated previously, the existing binning structure Lumileds uses to test and bin white product is based on lines of constant color temperature. Table 1 lists our existing white binning structure.

Bin	Min CCT	Max CCT
1	4500 K	5000 K
2	5000 K	5500 K
3	5500 K	6000 K
4	6000 K	7000 K
5	7000 K	8000 K

Table 1: Existing Luxeon white binning structure

This binning structure may be graphically portrayed in x,y color space, as in figure 1 below.

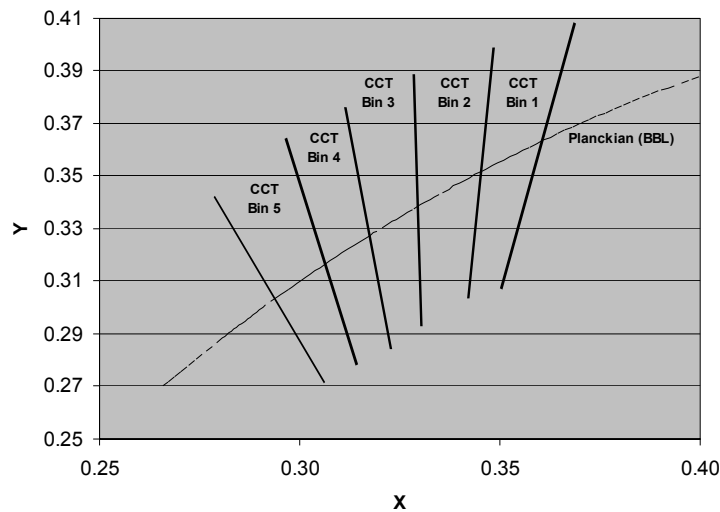


Figure 1: Graphical representation of existing white binning structure

It can be observed from figure 1 that although bin boundaries are drawn using lines of constant color temperature, there exists no gradation with respect to offset above or below the Planckian. Focus group studies resulted in a better understanding of human perception of differences in perceived color. Results from these studies indicated that for solid-state light sources a greater

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sensitivity exists with respect to offset from the Planckian, typically referred to as tint, than to that of variation in CCT.

Table 2 lists the x,y coordinates and typical CCT values for the new Luxeon white color binning structure.

Bin	x	y	Typical CCT
V0	0.346	0.359	5350 K
	0.344	0.344	
	0.329	0.331	
	0.329	0.345	
V1	0.367	0.400	5000 K
	0.362	0.372	
	0.329	0.345	
	0.329	0.369	
W0	0.329	0.345	6050 K
	0.329	0.331	
	0.317	0.320	
	0.316	0.333	
WA	0.329	0.331	6300 K
	0.330	0.310	
	0.311	0.293	
	0.308	0.311	
X0	0.316	0.333	6700 K
	0.317	0.320	
	0.308	0.311	
	0.305	0.322	
X1	0.329	0.369	6300 K
	0.329	0.345	
	0.305	0.322	
	0.301	0.342	
YA	0.308	0.311	8000 K
	0.311	0.293	
	0.290	0.270	
	0.283	0.284	
Y0	0.303	0.333	8000 K
	0.308	0.311	
	0.283	0.284	
	0.274	0.301	

Table 2: Coordinates of new Luxeon white binning structure

A graphical representation of this new color binning structure may be seen in figure 2.

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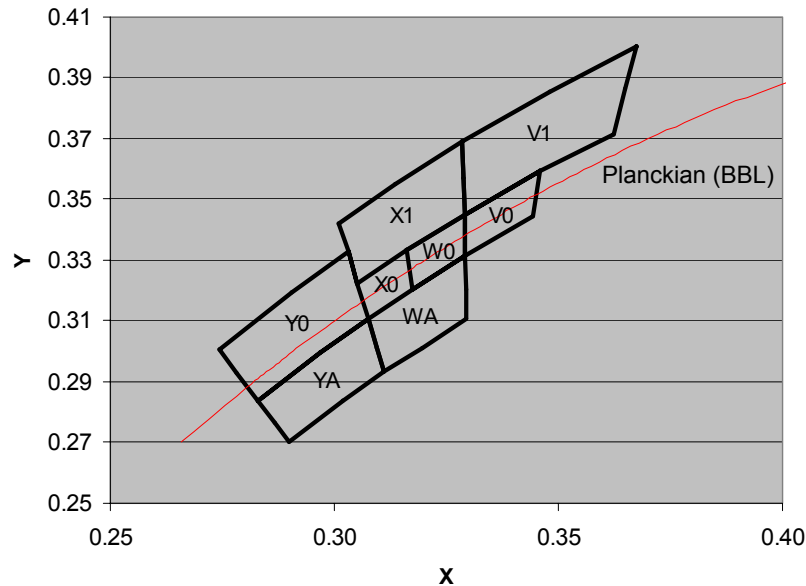


Figure 2: Graphical representation of new white binning structure

From figure 2 the additional delineations parallel to the Planckian may be observed. The combination of lines of constant color temperature (perpendicular to the Planckian) and those parallel to the Planckian offer additional resolution in the color space covered by white LEDs. This results in newly defined white color bins in which no noticeable color difference can be observed, increasing the ease of use of white LEDs for many applications.

Figure 3 exhibits an overlay of the existing Luxeon white color binning structure and the new white binning structure. With the exceptions of bins Y0 and YA, which extend the acceptable area further into the high color temperature range, the lines of constant color temperature align between the two binning structures. Focus group studies determined the acceptability of extending the product color range while maintaining color uniformity across the color bins.

The new Luxeon white color binning structure results in improved color homogeneity within a color bin. Products contained within a color bin will consistently appear identical in color to the human observer. For some applications the consistency of color delivered from products tested and binned to Lumileds existing white color binning structure was not adequate, presenting challenges to customers in using white Luxeon products.

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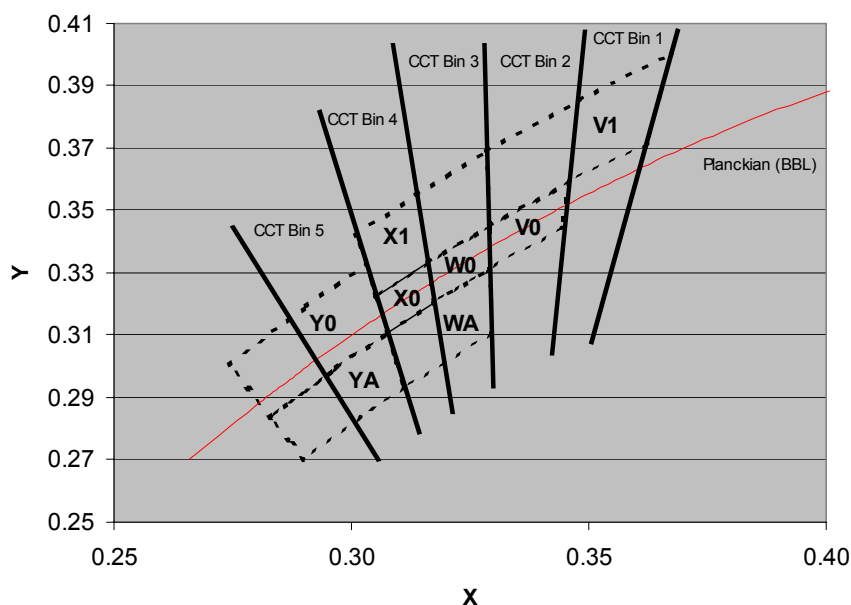


Figure 3: Overlay of existing and new white binning structures

### Implementation Plan for New White Binning Structure

Lumileds will begin shipments of Luxeon products tested and binned to the new white binning structure WW27 2003 (June 29<sup>th</sup>.) Beginning WW36 2003 (August 30<sup>th</sup>) affected products will be tested and binned solely to the new white binning structure.

The new white binning structure will use a two-digit code to depict the color bin. Application Brief 21 (Luxeon Product Binning and Labeling) has been updated to reflect all pertinent changes to the Luxeon binning and labeling structure.

Customers purchasing affected Luxeon products (see table 3) will see a rise in the number of color bins received from 5 (per existing CCT binning structure) to 8 based on this new binning structure. Luxeon products will still be tested for flux and forward voltage, with these binning structures remaining unchanged.

It is our belief that this new binning structure will increase the ease of use of Luxeon white products through delivering a product without perceptible color differences within a color bin. While the resolution we have selected may be overly fine for some applications, the proposal should enable applications currently hindered by the lack of granularity of our existing binning structure. Customers should find that through the adoption of this new binning structure their

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ability to successfully mix and match products for various application requirements will be dramatically improved.

### Part Numbers Affected

Not all white Luxeon products will be tested and binned to the new white color binning structure. The part numbers listed in table 3 will transition to this new binning structure (see figure 2) beginning WW27 2003.

Part Number	Description
LXHL-PW01	White Luxeon Lambertian Emitter
LXHL-DW01	White Luxeon Side Emitting Emitter
LXHL-PW03	White Luxeon V Portable Lambertian Emitter
LXHL-DW03	White Luxeon V Portable Side Emitting Emitter
LXHL-MW1D	White Luxeon Lambertian Star
LXHL-FW1C	White Luxeon Side Emitting Star
LXHL-MW1B	White Luxeon Lambertian Star/C
LXHL-LW6C	White Luxeon V Portable Lambertian Star
LXHL-FW6C	White Luxeon V Portable Side Emitting Star

Table 3: Affected Luxeon part numbers transitioning to new binning structure

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Table 4 lists the part numbers that will not be affected by this change, and will continue to be tested and binned to the existing white binning structure as shown in figure 1.

Part Number	Description
LXHL-BW01	White Luxeon Batwing Emitter
LXHL-MW1C	White Luxeon Batwing Star
LXHL-MW1A	White Luxeon Batwing Star/C
LXHL-NW98	White Luxeon Star/O
LXHL-MW1E	White Luxeon Batwing Star/IDC
LXHL-NW99	White Luxeon Line
LXHL-NW97	White Luxeon Ring 6-Up
LXHL-NW96	White Luxeon Ring 12-Up
LXHL-MWCA	White Luxeon Batwing Flood 12-Up
LXHL-MWJA	White Luxeon Batwing Flood 18-Up

Table 4: Part numbers not affected by new white binning structure

The part numbers not affected are white products that do not incorporate Lumileds recently developed proprietary phosphor coating technology. Lumileds will release new white batwing products that incorporate this phosphor coating technology beginning in July 2003. These new products will be tested and binned in accordance with the new white binning structure. Customers interested in taking advantage of the increase in color binning resolution provided by the new white binning structure may wish to migrate to these new product offerings for future orders. Additional information on these new products will be made available in the near future.

New white product introductions, such as Luxeon III and the warm white Luxeon products, will be released in accordance with the new white binning structure. A similar framework and binning structure is currently under development to support warm white products, which cover a different area of color space due to their lower color temperature.

Thank you for your attention to these changes. Please consult your Lumileds authorized distributor or Lumileds sales representative for further information.

Sincerely,

Mr. Jason Posselt  
Product Marketing Manager