Precision Dimming Design Guide

INTRODUCTION

When operated in parallel strings, as is common in many linear LED designs, LEDs driven at relatively low currents (e.g., less than 20 mA for 3-V mid-power LEDs) will exhibit unacceptable light output and hue variations across the strings. These light output variations are caused by normal production variations in characteristics of LEDs and can be reduced substantially with proper system design.

Lighting designers, specifiers, architects and end users have observed this inconsistency issue while dimming in many common linear-style LED designs, including cove accent lighting, wall texture graze lighting, indirect lighting and in some recessed linear general illumination.

Other LED manufacturers address LED inconsistency by sorting the forward voltage of the LEDs twice: once at the binning current and again at a lower current. This approach results in additional voltage bins that may be difficult to manage in production.

TABLE OF CONTENTS

Cree LED / 4001 E. Hwy. 54, Suite 2000 / Durham, NC 27709 USA / +1.919.313.5330 / www.cree-led.com

PRECISION DIMMING DELIVERS CONSISTENT DIMMING

Cree LED tapped into our extensive LED performance and manufacturing knowledge to address this issue of inconsistent LED dimming. Our engineering team has developed a new method to bring consistency for low-input intensity and color performance-critical applications. Industry standard 3-dimensional binning (chromaticity, voltage and flux) is greatly improved by the introduction of a simple fourth dimension that Cree LED calls Precision Dimming.

Precision Dimming provides the easiest solution to manufacturers of no-compromise, specification-grade lighting. There are only four total Precision Dimming bins: J, K, L & M. In addition, each CCT & CRI combination of an LED with Precision Dimming will only ever have two Precision Dimming bins.

PRECISION DIMMING CONTROLS FOR TM-30 METRICS

Precision Dimming also gives more consistent fixture-to-fixture scores in TM-30 specifications at all operating currents. You can have confidence that each fixture will consistently meet the same specifications as your first if you follow the guidelines in this document.

In our testing, the range of Rf and Rg measured on a 4x5 array was narrowed to about 1/3rd of the range in arrays not using Precision Dimming. Note that these values are relative and recorded for one CCT/CRI combination. The trend and range may change in other situations.

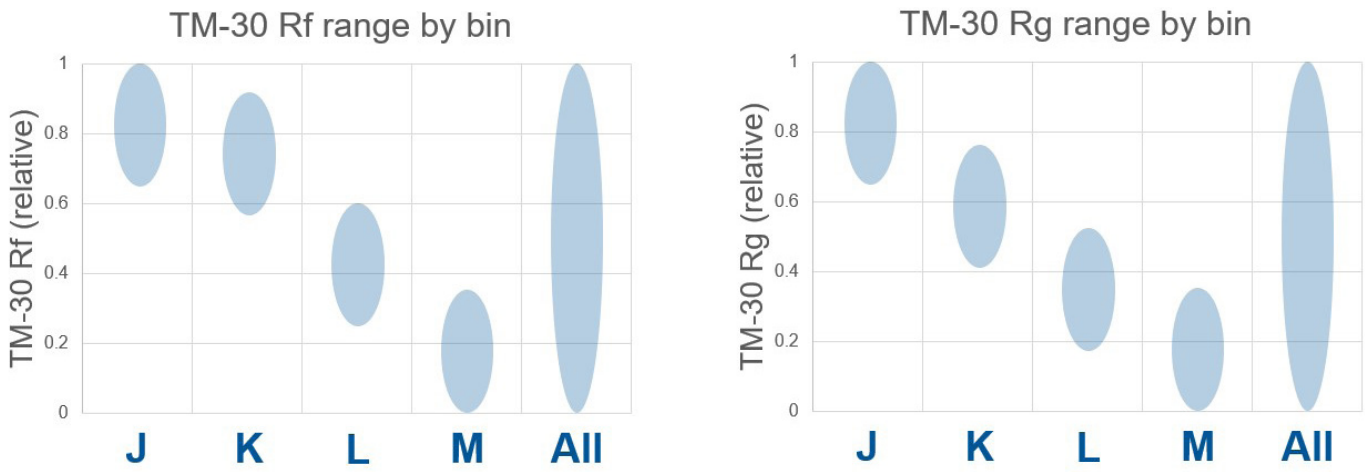

Figure 1: TM-30 metrics Rf and Rg are more consistent between fixtures when using only one or two Precision Dimming bins. Compared to un-binned LEDs (the "All" segment above), the range of fixture measurements possible from building with a single bin is narrowed to roughly 1/3rd of the original range.

CASE STUDY: USING PRECISION DIMMING BINNING

Three test boards were built using Precision Dimming bins J, K, L and M (the full range of bins) in different configurations. Please note that only two consecutive bins are used in each CCT/CRI combination, making it even easier for you to design and build.

Each board had the same electrical configuration: 4 parallel strings of 5 LEDs each. Each string of 5 LEDs was constructed from only one bin but the strings of each bin were mixed in parallel to simulate what can happen if boards are built without controlling for binning, or incorrectly building with binning.

- Board 1: J-K-L-M (Worst case of mixing a full range of bins)
- Board 2: J-J-M-M (Worst case of mixing highest and lowest bins)
- Board 3: K-K-K-K (All strings use single Precision Dimming bin)

Below are false color intensity images, true color images and line graphs of individual component intensity values for 3500 K LEDs.

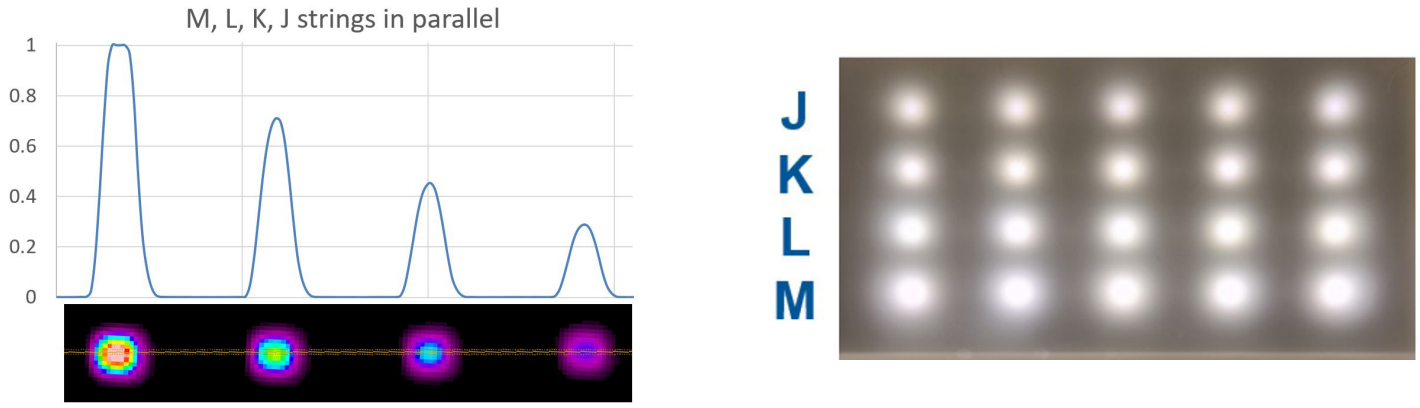

Figure 2: Board 1 uses one parallel string of each Precision Dimming bin and shows a 34% average change in relative intensity between each string at 0.5 mA. This demonstrates what can happen in the applications if Precision Dimming is built incorrectly or if the application uses another manufacturer's sorted products.

CASE STUDY: USING PRECISION DIMMING BINNING - CONTINUED

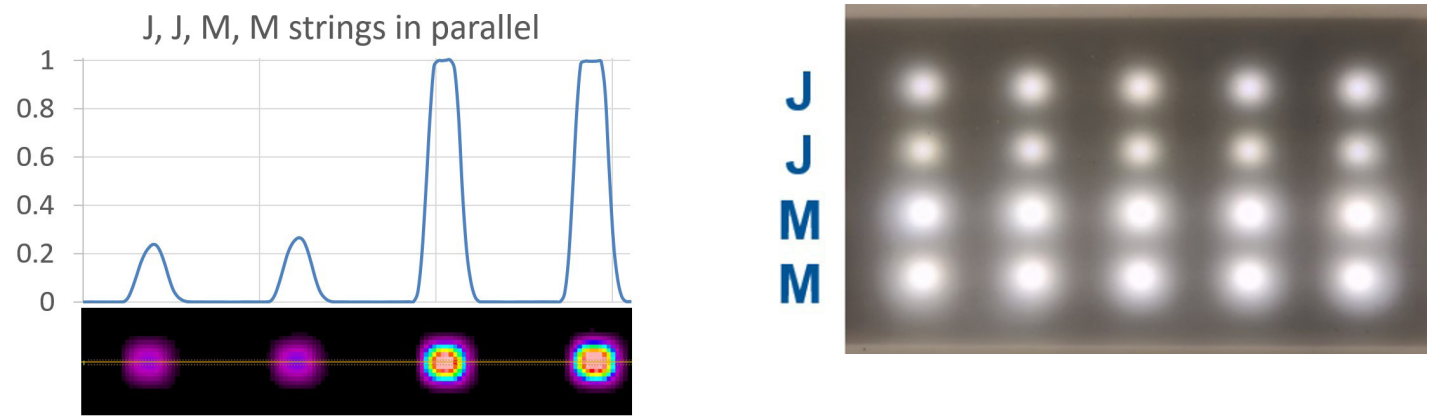

Figure 3: Board 2 uses two parallel strings of the most dissimilar Precision Dimming bins (J and M) and show a 71% change in relative intensity at 0.5 mA. This is the worst-case scenario that can occur when Precision Dimming is used incorrectly or another LED manufacture's sorting method is utilized. Only the two most similar Precision Dimming bins are sold in each CCT/CRI combination to eliminate the risk of this scenario.

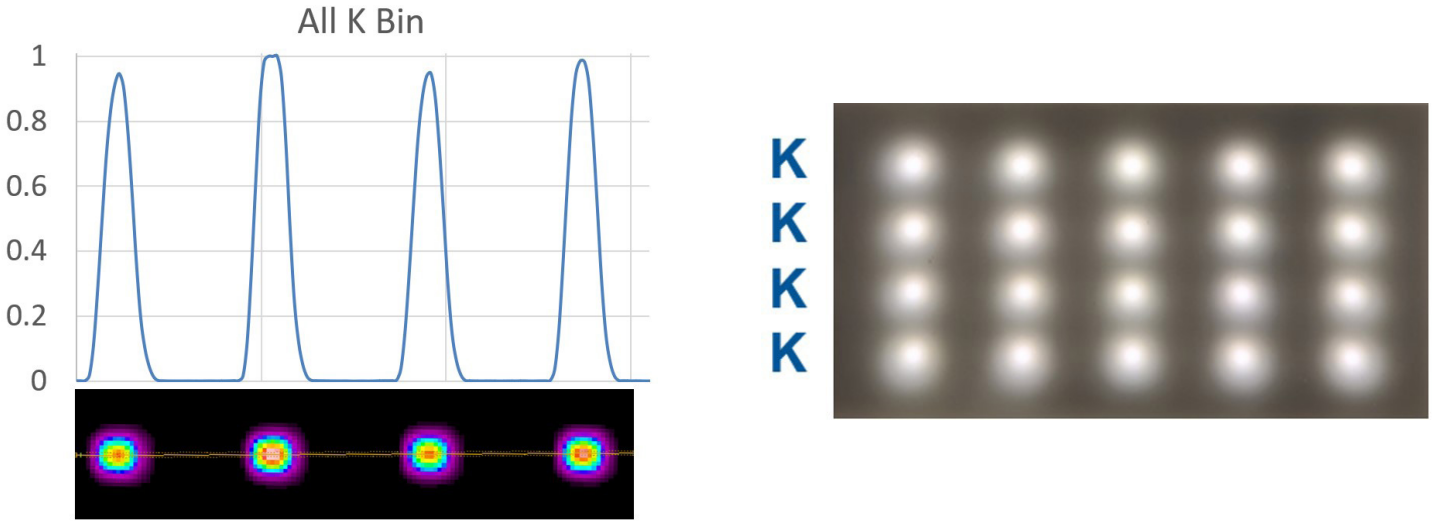

Figure 4: Board 3 shows a single Precision Dimming bin used in all 4 parallel strings giving a nearly imperceptible 5% change in relative intensity. Similar results are expected when identical quantities of unique Precision Dimming bins are mixed in each parallel string.

ARRAY DESIGN GUIDELINES USING PRECISION DIMMING

Your manufacturing process can effectively use both available Precision Dimming bins to reduce or eliminate inconsistent dimming with the right planning.

1. **Do not** use dissimilar Precision Dimming bins in parallel strings when each string is a single bin.
2. **Do** use a single Precision Dimming bin and CCT/CRI bin for an entire board build.
3. **If mixing bins, only** mix equal numbers of each Precision Dimming bin and CCT/CRI bin in each parallel string.

For illustration, here is an example circuit (4 parallel strings of 5 LEDs) in configurations that do and do not build with Precision Dimming properly. Assume each bin (J, K, L, M) has a numerical value where J=4, K=3, L=2, M=1. These bin codes can be found on the label of the received LED reel. For the best outcome, every parallel string's Precision Dimming bins should sum to the same total number. This assumes the same number of LEDs per string, i.e., 1+1+1 does not equal 1+2.

If you have a more complicated design that is not covered below, please reach out to your Cree LED application engineer for guidance.

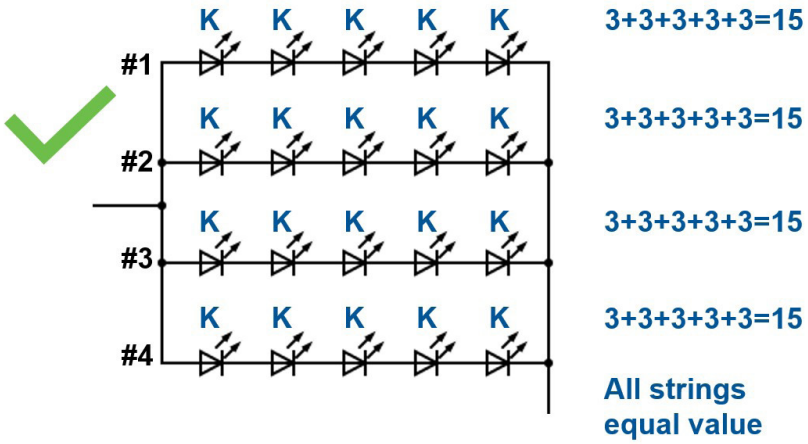

Figure 5: Using only one Precision Dimming bin to build parallel strings will minimize the brightness differences at low currents.

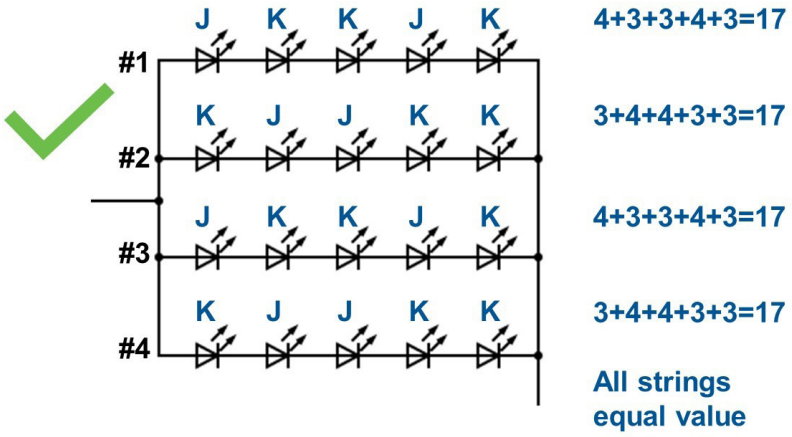

Figure 6: When mixing two Precision Dimming bins, ensure that equal numbers of LEDs from each bin are in each parallel string. The order of the bins in the string does not affect the dimming performance, so a checkerboard pattern is possible.

ARRAY DESIGN GUIDELINES USING PRECISION DIMMING - CONTINUED

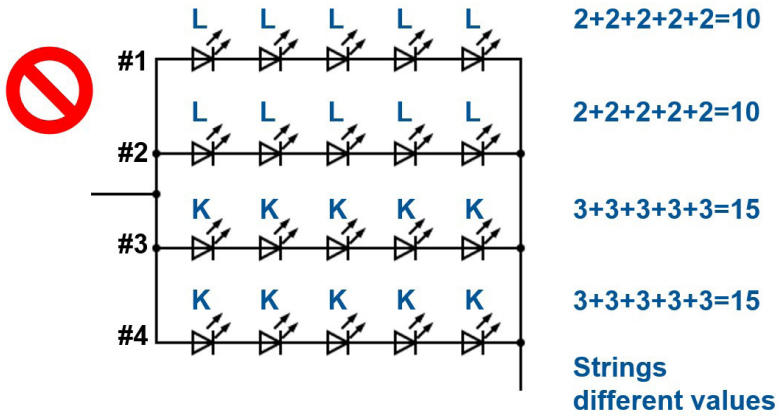

Figure 7: This configuration will cause the "K" strings to be visibly less bright at low currents. When building with two Precision Dimming bins, mix equal numbers of each bin in every string.

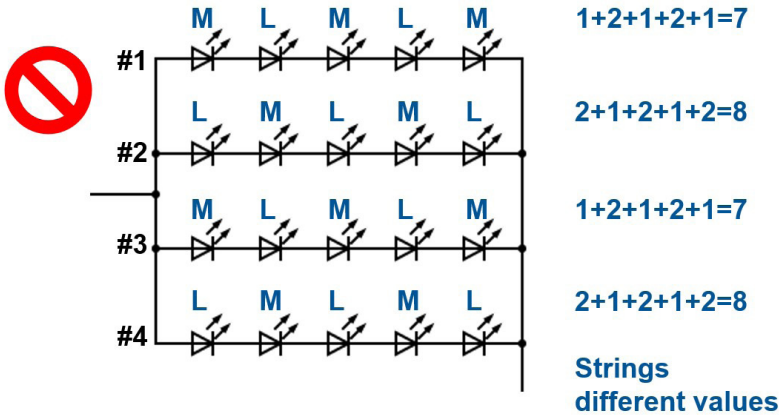

Figure 8: Two Precision Dimming bins are mixed in a checkerboard pattern between all parallel strings, but the odd number of LEDs per string causes an unequal numbers of each bin per string. Strings #2 and #4 will be slightly less bright than Strings #1 and #3 at low currents.

SUMMARY

Industry experts have suggested that a 10% delta in hue and 20% delta in intensity is the maximum acceptable LED-to-LED performance variation. Precision Dimming is the easiest way to stay well within these acceptability targets and enables our specification-grade customers to build products that produce no-compromise illumination for their demanding customers.

Contact your Cree LED distributor or Cree LED sales director for more information on Precision Dimming and to request samples.