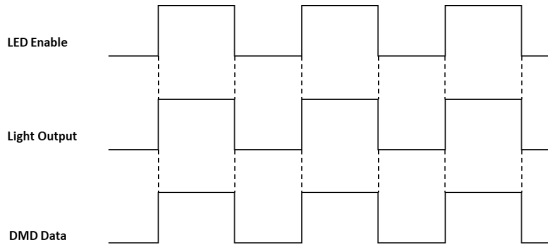
Technical Article

To Address Dark Field Color Deviation and Grayscale Discontinuity for DLP by Optimizing the LED Driver's Switching Delay

This document was translated from a simplified Chinese source. (ZHCTA03)

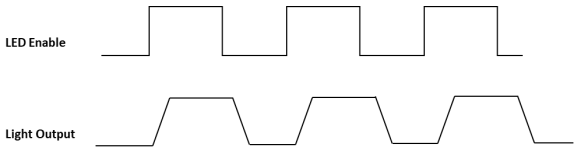
Many engineers may encounter issues such as dark field color deviation and grayscale discontinuity when developing a DLP system. A major solution for these issues is to optimize the switching delay of the LED driver. This article primarily discusses the impact of the LED driver's switching delay on the DLP display.

Ideally, the timing sequences of the LED enable signal should exactly correspond to the DMD control timing sequence, as shown in the figure below. As each frame of the DMD signal arrives, the LED of the right color lights up in time.



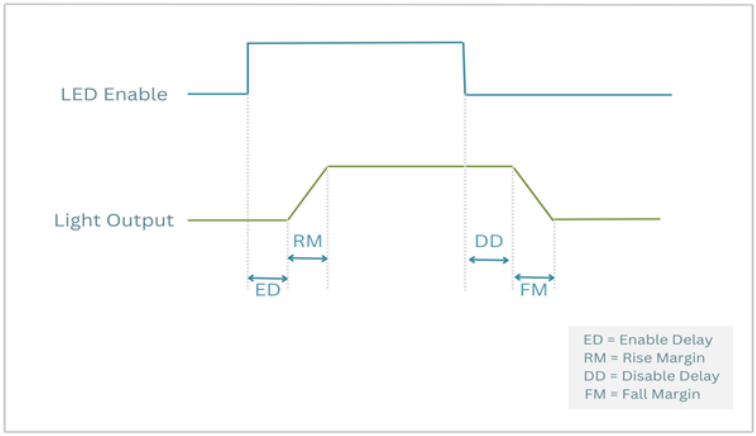
However, in reality, due to the inherent on-time delay of the LED driver, the timing sequence is shown as in the following figure.

If the LED illumination timing sequence is not aligned with the DMD control timing sequence, e.g., LED R has not turned off while the DMD is already transmitting the data for LED G, the green image will be mixed with red tints, resulting in discontinuity in certain green grayscale levels.



In DLP software, to compensate for the decreased image quality resulting from this delay, we can populate the measured relevant delay parameters into the project. Based on these appropriate parameters, the DLP controller will adjust the control signal for the LEDs to turn them on and off earlier in sync with the data link. LED driver delay can also lead to dark field color deviation, such as a reddish or bluish tint, and color deviation in solid color fields. These issues can be addressed by adjusting the following parameters.

Illuminator	Enable Delay (us)	Rise Margin (us)	Disable Delay (us)	Fall Margin (us)
Red	22	16	0	1
Green	22	12	0	1
Blue	22	14	0	1



However, if the periods of rising edge RM and the falling edge FM are excessively long, the illumination during these periods will be unstable. If DMD data transmission occurs during these periods, the projection effect of this data will deviate from the expected effect. The different grayscale displays of a DLP system are controlled by managing the flipping of the DMD and the ON/OFF duty cycle. For perfect grayscale continuity, it is required to maintain the stablest illumination when the DMD is flipped. While excessively long rising edge and falling edge periods can easily cause grayscale discontinuity, discarding the illumination during these periods may result in reduced brightness. Therefore, it is recommended to optimize the rising and falling edges of the LED driver based on the customer's image quality requirements; for example, for a system sensitive to grayscale, it is best to control the rising edge and falling edge periods to around 5us.

In addition, LED drivers vary in their delay performance at different current levels. Currently, most projectors are typically designed for the maximum current setting, so the values filled in the delay table are the LED driver delay parameters for this maximum current setting. If the performance of the LED driver varies too much across different current settings, issues like color deviation may arise at lower current settings due to parameter mismatch. Therefore, the DLP system imposes requirements on the consistency of the LED driver's switching delay.

In summary, DLP projection systems typically achieve ideal color and grayscale performance by compensating for the switching delay caused by the LED driver using DLP's internal algorithms, and by optimizing the LED driver's rise and fall delays and their consistency across different current settings.

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