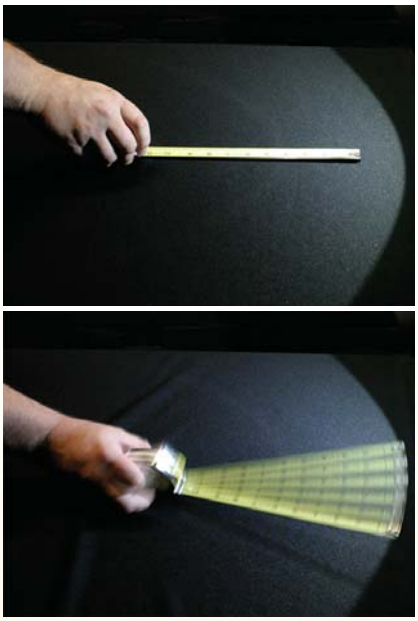
Minimizing Flicker from SSL Systems

All light sources flicker, but some LED lighting might be especially susceptible to unacceptable flicker because of the methods used to power and control LEDs. Frequency, duty cycle, modulation depth and waveform shape can affect the perception of flicker. Flicker can be perceived directly if the frequency is low enough (below 100 Hz). Even at higher frequencies where flicker cannot be directly perceived, it can be perceived indirectly through stroboscopic effects.

To assess direct and indirect perception of flicker and its impact on comfort, the LRC conducted laboratory studies under flickering patterns differing in frequency, modulation depth (difference between maximum and minimum light output), duty cycle (percent of time the light exceeds 10% of the maximum light output), and waveform shape.



The photographs above were taken under a flickering light source (at 120 Hz) with an exposure time of 1/15th of a second. In the top photo, the ruler is stationary and no stroboscopic effects are seen. In the bottom photo, multiple images are produced by each flicker cycle as the ruler moves across the scene.

Study 1: Effects of Flicker Characteristics from SSL on Detection, Acceptability and Comfort

Using a controllable LED task luminaire, study participants rated the visual environment and their overall comfort under lighting conditions with different flicker characteristics. The results showed that at frequencies of at least 100 Hz, direct perception of flicker was neither visible nor objectionable, but stroboscopic effects could be detected indirectly even at 300 Hz, the highest frequency studied. Mitigation of stroboscopic effects can be accomplished through decreasing modulation depth. Avoiding low duty cycles near 10% may help prevent visual discomfort.

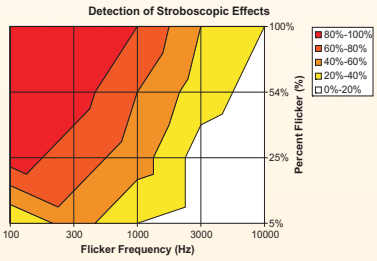
Study 2: Detection and Acceptability of Stroboscopic Effects from Flicker

The LRC performed a follow-up study to systematically evaluate the tradeoff between frequency and modulation depth. The study evaluated participants' detection and acceptability of stroboscopic effects under 20 combinations of frequency and flicker modulation depth. The results suggest that indirect perception of stroboscopic effects from flicker is systematically affected by both frequency and the amount of modulation of flicker. Although the trends for detection and acceptability are similar, they differ in one important way: even when many subjects were able to detect stroboscopic effects, they did not always judge the flicker to be unacceptable.

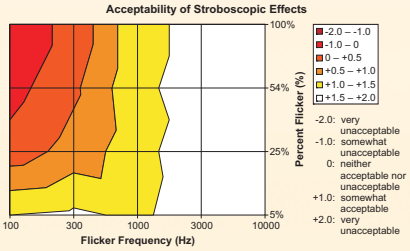
Further Details

Bullough J.D., K. Sweater Hickcox, T.R. Klein, and N. Narendran. 2011. Effects of flicker characteristics from solid-state lighting on detection, *Research and Technology* 43(3): 337-348.

Bullough J.D., K. Sweater Hickcox, T.R. Klein, A. Lok, and N. Narendran. In press. Detection and acceptability of stroboscopic effects from flicker. *Lighting Research and Technology.*



Contour plot figures show mean detection percentages (above) and mean acceptability ratings (below), both as a function of frequency and modulation depth in terms of percent flicker.



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Lighting Research Center, Rensselaer Polytechnic Institute • 21 Union Street • Troy, NY 12180 • (518) 687-7100 • www.lrc.rpi.edu

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