Application Note

AN000614

Understanding Ambient Light Source Flicker

Sensors with ALS, Flicker and Proximity Detection

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Content Guide

1 Introduction

Temporal light artifacts are undesired effects in the visual perception of a human observer induced by temporal light modulations. Two well-known examples of such unwanted effects are flicker and stroboscopic effect. The tern ‘flicker’ refers to directly visible light modulations at relatively low frequencies (<80 Hz) and small modulation levels. Many terms are used when referring to this time-variation, including flicker, clutter and shimmer.

All conventional light sources including incandescent, high intensity discharge, and fluorescent modulate luminous flux and intensity, whether perceptible of not. The flicker produced by electric ambient light sources can be a function of how it converts AC electricity to light, or the result of noise or transient events on AC distribution lines. Electrical flicker should not be confused with photometric flicker which is modulation that is characteristic of the light source itself, rather than disturbances to its electrical input. Light source characteristics that can affect photometric flicker vary by technology; examples include filament thickness for incandescent, phosphor persistence for fluorescent and coated metal halide, and circuit designs for electronically ballasted or driven sources.

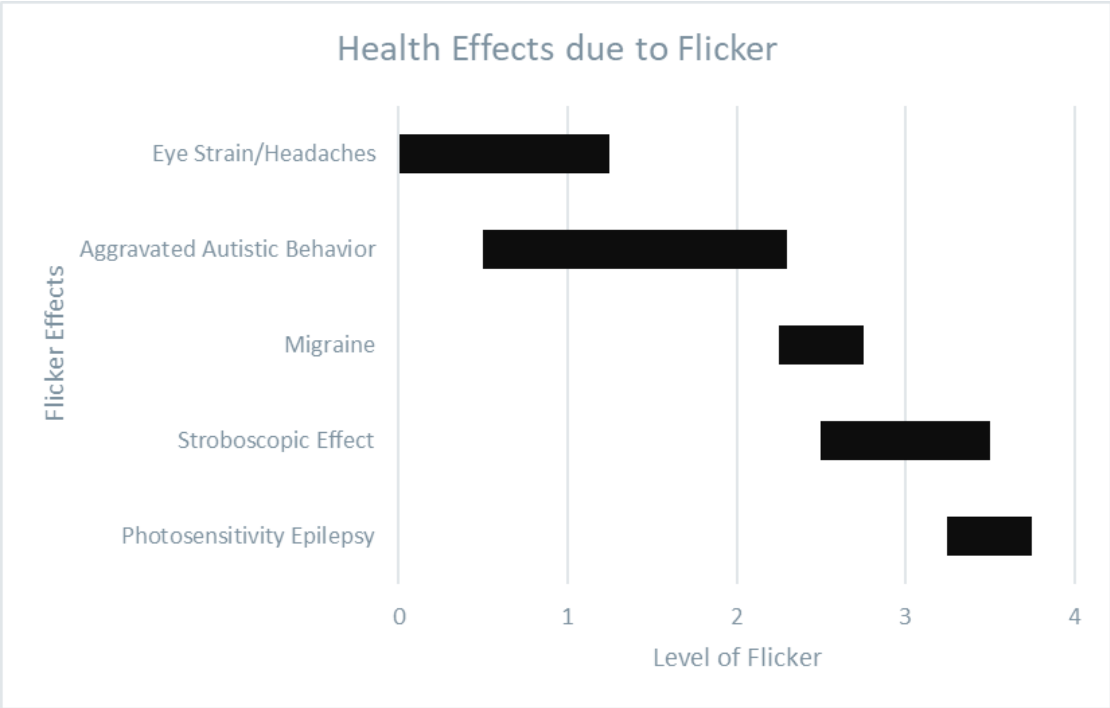
LED flicker characteristics are primarily a function of the LED driver. Different circuit architectures present different sets of performance trade-offs for a driver designer, with cost and form factor restrictions further limiting the choices available. For example, a low cost requirement for a small integral lamp may force a fundamental trade-off between flicker and power-factor. Dimming an LED source can increase or induce flicker when pulse-width modulation (PWM) is employed within the driver to reduce the average light output from the LED source.

2 Why Flicker Matters

Photometric flicker from magnetically-ballasted fluorescent, metal halide, and high-pressure sodium lamps has been a concern of the lighting community because of its potential human impacts, which range from distraction or mild annoyance to neurological problems. The effects of flicker are dependent on the light modulation characteristics of the source, the ambient light condition, the sensitivity of the individuals using the space, and the tasks being performed. Low-frequency flicker can induce seizures in people with photosensitive epilepsy, and the flicker in magnetically-ballasted fluorescent lamps used for office lighting has been linked to headaches, fatigue, blurred vision, eyestrain and reduced visual task performance for certain populations.

When discussing the potential human impacts of flicker, it is important to understand the difference between sensation and perception. Sensation is the physiological detection of external conditions that can lead to a nervous system response, while perception is the process by which the brain interprets sensory information. Some sensory information is not perceived, and some perceptions do not accurately reflect the external conditions. As a result, some people who suffer from flicker sensitivity may not be aware that flicker is the reason they are suffering, or even that the light source responsible for their suffering is flickering. Furthermore, not all human observers are equally sensitive to the potential effects of flicker. Populations that tend to be more susceptible to the effects of flicker include children, people with autism, and people with migraines. While the sizes of some specific at-risk populations have been characterized; approximately 1 in 4000 humans suffer from photosensitive epilepsy, for example.

Figure 1:
Potential Human Impact of Flicker

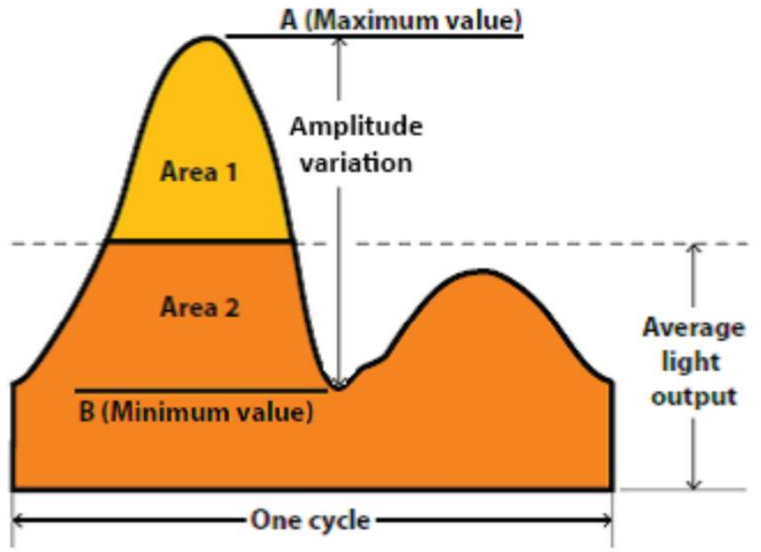


Levels of Flicker	
0 - 1	Mild
1 - 2	Harmful
2 - 3	Severe
> 3	Catastrophic

3 Quantifying Flicker

The photometric flicker found in electric light sources is typically periodic, with its waveforms characterized by variations in amplitude, average level, periodic frequency, shape and in some cases duty cycle. Percent flicker and Flicker Index are metrics historically used to quantify flicker. Percent Flicker is best known and easier to calculate, but Flicker Index has the advantage of being able to account for differences in waveform shape. Both metrics account for amplitude variation and average level, but since both are based on the analysis of a single waveform period, neither is able to account for differences in periodic frequency. An example of a periodic waveform is shown in the Figure 2, along with equations for both flicker metrics.

Figure 2:
Periodic Waveform Characteristics Used in the Calculation of Flicker Metrics(1)



$$\text{Percent Flicker} = 100\% \times \frac{A - B}{A + B} \qquad \text{Flicker Index} = \frac{Area\ 1}{Area\ 1 + Area\ 2}$$

(1) Modified from IES Lighting Handbook, 10th Edition

Measuring and reporting flicker is not a standard practice for commercial light sources. Although industry bodies have developed flicker metrics, they have not produced complementary standardized measurement procedures to ensure appropriate comparisons of reported values. Conventional lighting technologies exhibit little variation in flicker for a given source type; for example, all incandescent A19 lamps behave similarly. However for fluorescent lights, the type of ballast has a substantial affect, although just knowing whether it is magnetic or electronic has usually been sufficient for flicker characterization. As a result, there has historically been little need for measuring and reporting the flicker performance of a specific product.

4 Types of Flicker

4.1 Periodic

This type of flicker can often be intentional, e.g. PWM or a consequence of AC power. Shown in the following figures.

Figure 3:
AC Power Waveform

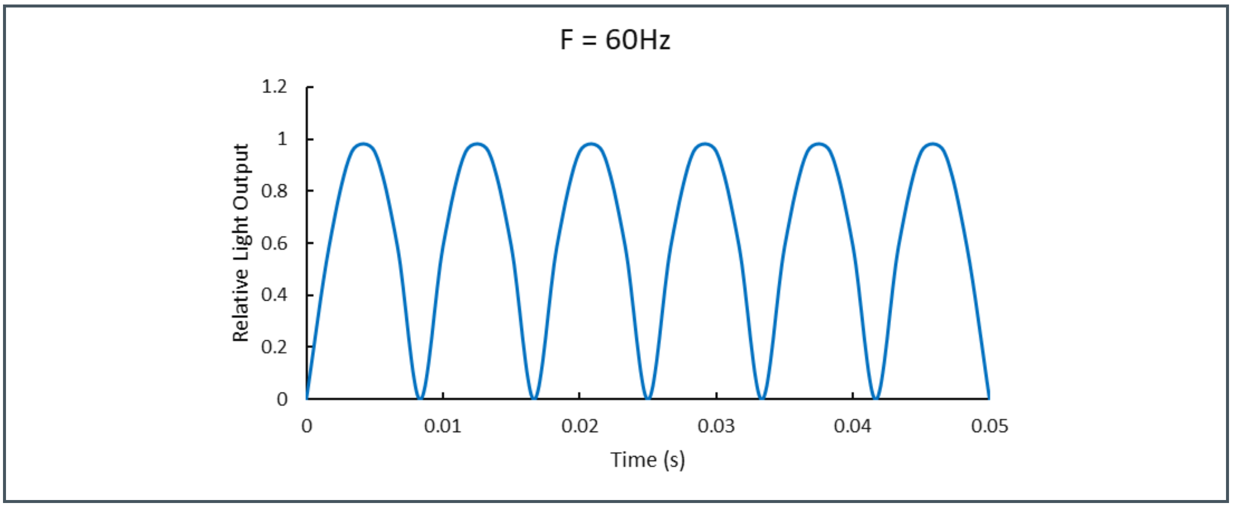
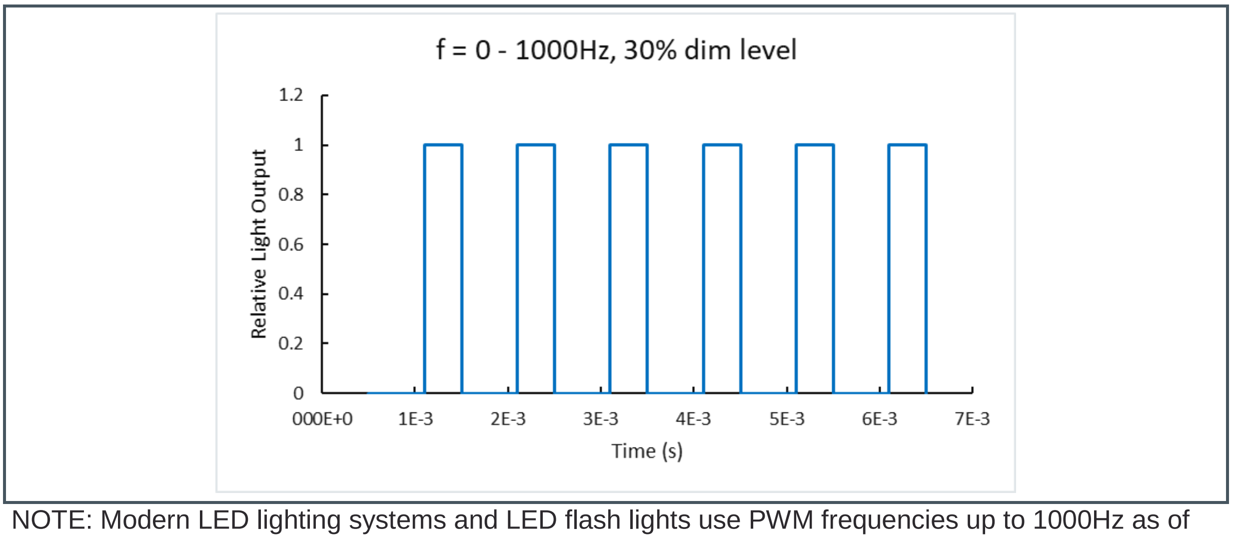


Figure 4:
Electronic Pulse Width Modulation Waveform

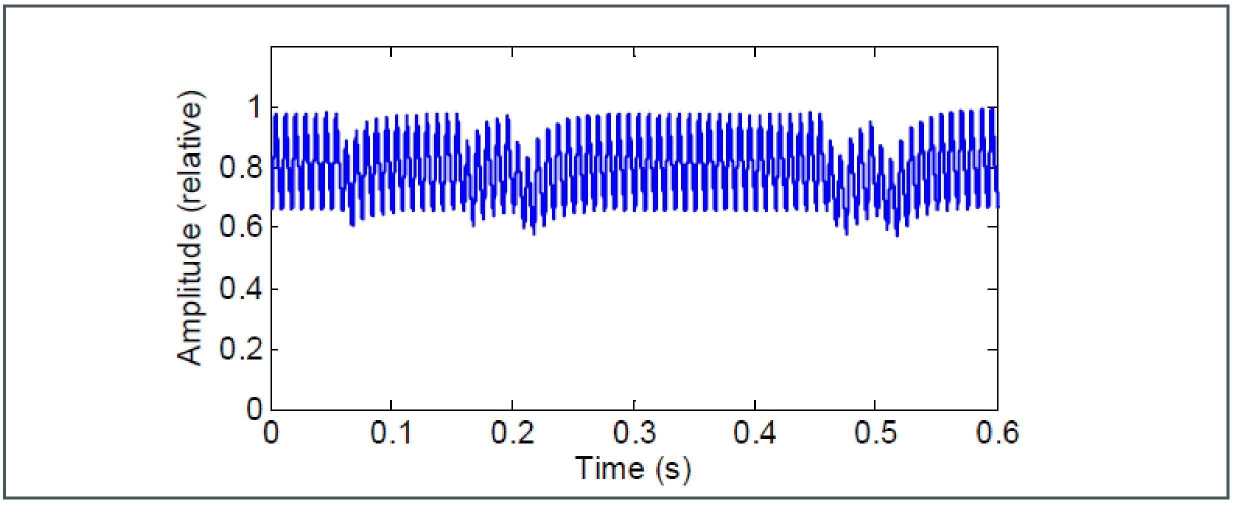


NOTE: Modern LED lighting systems and LED flash lights use PWM frequencies up to 1000Hz as of 2020.

4.2 Non-Periodic

This type is unintentional and usually the result of something not working properly, such as end of life driver/dimmer/lamp, or power line disturbances.

Figure 5:
Unintentional Non-Periodic Waveform



5 Summary

Flicker is an unusual phenomenon that is found in various ambient lighting situations and can be difficult to manage. **ams** provides on-chip flicker detection functionality in the many devices, the primary application for the flicker detection function would be flicker-immune camera operation. These efforts can make it easier to minimize flicker-induced problems.

6 References

For further information, please refer to the following documents:

- Bierman, Andrew. “Measuring and Assessing Light Source Flicker.” Lighting Research Center, Rensselaer Plytechnic Institute. (2016). Pg 2 - 5 https://www.energystar.gov/sites/default/files/asset/document/Bierman%20-%20Flicker%20-%20Measuring%20and%20Assessing%20Light%20Source.pdf
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- “IES Lighting Handbook: The Standard Lighting Guide”. Illuminating Engineering Society (1947). https://archive.org/details/ieslightinghandb00inillu
- U.S. Department of Energy. “Flicker Fact Sheet”. PNNL-SA-94791. (2013) https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/flicker_fact-sheet.pdf

7 Revision Information

Changes from previous version to current revision v1-01	Page
Initial version	

- Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
- Correction of typographical errors is not explicitly mentioned.

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