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IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers

IEEE Power Electronics Society

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IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers

Sponsor

Standards Committee
of the
IEEE Power Electronics Society

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Abstract: This document includes a definition of the concept of modulation frequencies for light-emitting diodes (LEDs), a discussion on their applications to LED lighting, a description of LED lighting applications in which modulation frequencies pose possible health risks to users, a discussion of the dimming of LEDs by modulating the frequency of driving currents/voltage, and recommendations for modulation frequencies (flicker) for LED lighting and dimming applications to help protect against known potential adverse health effects.

Keywords: flicker, headaches, health, IEEE 1789™, LED lighting, migraines, modulation, perception, power electronic drivers, seizure, stroboscopic

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Introduction

This introduction is not part of IEEE Std 1789-2015, IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers.

The IEEE P1789 Working Group was formed in December 2008. Prior that time, the impact of flicker in light-emitting diode (LED) lighting was not being discussed. New technologies were being developed in LED lamps that introduced high levels of flicker. Occasionally, under special circumstances, some lamps would fail and cause flicker that could introduce seizures in the small percentage of the population that suffers from photosensitive epilepsy. One of the initial reasons to form the working group was to bring together a diverse community of experts to discuss the effects of flicker: members from the medical community, lighting community, photobiologists, electrical engineers, and many more. Without the community discussing the issue of flicker, it would not be possible for developers of LED lighting to fully understand any health effects that might be related to their design. The intent of this document is to explain what is known about flicker in LED lighting and to provide recommended practices that can help mitigate possible adverse biological effects of light flicker, when such mitigation is desired.

This document was written through the following procedure:

a) Creation of an outline of topics using teleconferences and web board discussions;
b) Drafting of various publications and other working documents by primary authors;
c) Presentation and editing of the working documents by subcommittees composed of experts in lighting, health, and flicker;
d) Approval of the working documents of the subcommittees to be presented to all members of the working group;
e) Presentation of the working documents to all members of the working group by teleconferences and electronic media;
f) Solicitation of comments and edits from all members of working group;
g) Revision of the working documents to include member comments;
h) Merging of all the working documents into this formal recommended practices document;
i) Inclusion of additional material into the merged document, written by primary authors and necessary to make the recommended practices more complete;
j) Obtaining of comments and edits from subcommittees on the recommended practices;
k) Revision of the recommended practices document according to subcommittee comments;
l) Submission of the recommended practices document for comments to all members of the working group;
m) Revision of the recommended practices document according to the comments from working group members; and
n) Submission of the recommended practices document for ballot, following the official IEEE standards balloting process for approval (not described here).

The IEEE P1789 Working Group effort is an open process. All official comments or proposed edits from working group members for this document were formally entered onto a comment form. Regardless of whether a comment was fully accepted, partially accepted, or rejected, the reasons for the decision were also entered on the form. As a matter of transparency and ethics, only comments submitted through comment forms or in official working group meetings/teleconferences were reviewed by working group members.

The process to develop this document took longer than initially anticipated. While the material in Clause 5 and Clause 6 was developed by the working group carefully and in a timely fashion, the group wanted to carefully weigh all the available scientific data in an objective and fair manner before it developed any recommended practice. It was decided that the working group members should develop a hazard and risk analysis for flicker using a formal process. The development of the material in Clause 7 was led by the same authors that developed the European Union Commission's policy on consumer product recall. That is, the material in Clause 7 was carefully developed over a one- to two-year period by experts in hazard

analysis who accumulated research data and scientific references and flew around the world (at their own expense) to interview experts in flicker, LED lighting, and human vision—all to prepare the material in Clause 7.

Similarly, the philosophy of the working group was to recruit experts in diverse research fields whenever necessary to help develop material. To create a comprehensive and precise set of recommended practices, it was necessary to include in the working group research experts in the fields of power electronic drivers, risk analysis, photobiology, vision, lamp design, psychology, LEDs, and many other areas. The result was a diverse field of experts, able to interpret scientific studies in medical fields, vision, electrical engineering, hazard analysis, and lighting. Many of the authors of the original scientific studies that are discussed in this document also contributed to, and authored text in, this document; this collaboration leads to a strong confidence in the scientific accuracy of IEEE Std 1789.

Each clause was developed by separate subcommittees, and then input and comments were received from the entire IEEE 1789 community about the individual clauses. Brad Lehman, chair, served as editor-in-chief of the entire document, but he also served as editor of Clause 1–Clause 3 and Clause 5 and co-editor of Clause 6 and Clause 8. Jennifer Veitch served as editor of Clause 4. Clause 7 had three co-editors: Bob Altkorn, Xiao Chen, and Gene Rider. Additionally, Arnold Wilkins served as co-editor of Clause 6 and Clause 8. Dozens of IEEE members contributed technically to the document, but major writing contributions of this document were performed by Sam Berman, Faisal Khan, Naomi Miller, and Michael Poplawski in addition to the previously listed editors.

A goal of this working group and recommended practices document is to aid all standards groups that want to develop suitable standards or certification processes about flicker in LED lighting. Observers from various agencies were included in the working group (ENERGY STAR, NEMA, IEC, CIE, OSHA, and many others). The working group plans to continue to work with these agencies and remain a resource for them in their processes (see http://grouper.ieee.org/groups/1789/).

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IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers

1. Overview

1.1 Scope

The scope of this recommended practices document is to

- Define the concept of modulation frequencies for light-emitting diodes (LEDs) and discuss their applications to LED lighting.
- Describe LED lighting applications in which modulation frequencies pose possible health risks to users.
- Discuss the dimming of LEDs by modulating the frequency of driving currents/voltage.
- Present recommendations for modulation frequencies (flicker) for LED lighting and dimming applications to help protect against known potential adverse health effects.

1.2 Purpose

Presently, there are no standards on safe modulating frequencies for high-brightness LEDs. Vendors suggest various driving frequencies—some at low frequencies and others at high frequencies. In the late 1980s and early 1990s, studies showed that office fluorescent lighting with magnetic ballasts modulating at twice the ac line frequency increased the incidence of health-related problems, such as headaches, eyestrain, and, when the lamps were in failure, epileptic seizures. The detrimental effects depend on factors such as brightness, angle of viewing, wavelength, and depth of modulation, among others. The purpose of this document is to describe some possible health risks associated with low-frequency modulation of