Flicker Explained

guide to IEC for the lighting industry

Lindén, Johannes; Dam-Hansen, Carsten

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Flicker explained

Guide to IEC 61547 for the lighting industry

JOHANNES LINDÉN | LTH, LUND UNIVERSITY
CARSTEN DAM-HANSEN | TECHNICAL UNIVERSITY OF DENMARK

Table of contents

Introduction

Flicker, or more precisely temporal light modulation (TLM), has re-emerged as a problem with the introduction of LED-based lighting technology. TLM, meaning variations in light intensity over time, may have negative effects on human health, causing annoyance, headaches, eyestrain and migraine. In addition to the unnecessary suffering TLM causes in individuals, the negative consequences of TLM create an obstacle to broad and rapid adaptation of the new LED-technology and consequently also an obstacle to potential energy savings.

The EU's new eco-design regulations entered into force in September 2021. These include, for the first time (in Europe) regulatory limits for TLM parameters for light sources and refers to new standards for measuring them. This creates an urgent need to spread awareness of TLM and information on how to measure it quickly, easily and correctly. However, the standards that describe the measures are technically complicated and are not aimed at industry professionals.

This guide gives an introduction to TLM, what it is and how it is measured. The effect of TLM on health is concluded, and also the state of knowledge in its research area. An extended part of this guide discusses the flicker measure short-term flicker indicator, P_{st}, and the technical report describing it, TR IEC 61547-1:2020[1] (henceforth referred to as IEC 61547, unless otherwise stated). This report describes the equipment, method and measures required to assess flicker. It is, however, technically complicated and could be very hard to interpret by non-technical readers. For a more detailed investigation and recommended amendments of the IEC 61547, see "Flicker explained – Interpretation of the Technical Report IEC 61547" which is another product of the project Flicker Explained. For a general guide on TLM measurements, please consult the technical note published by International Commission on Illumination, CIE TN 012:2012[2].

The purpose of this guide is to increase knowledge about flicker in particular and TLM in general, taking the technical report IEC 61547 as a starting point. This work aims to bridge the gap between technical standards and reports on the one hand and the lighting industry on the other. This is with the aim of ensuring that the new EU eco-design regulations are followed which in turn will mitigate health issues caused by TLM and support a sustainable transition to LED technology.

The publication of the guide is supported by the Swedish Energy Agency and is a collaboration between Lund University and DTU (Technical University of Denmark).

What is TLM?

Temporal light modulation means light intensity that varies (modulates) over time (temporally). TLM was a problem in fluorescent tubes for a period during the late 20th century when magnetic ballasts were used, however, this was solved at the time by the introduction of high frequency electronic ballasts. The reason that TLM has now re-emerged as a problem is because of the introduction of LED-based lighting technology.

First a few comments about the word *flicker*. Colloquially we use it to describe what a lamp *does* – "the lamp is flickering". Strictly speaking, and based on how the word flicker is defined, this usage is incorrect.

> **Flicker is not something a lamp *does* – it is something you *see***

Flicker is not something a lamp *does* – it is something you *see*, something you *perceive*. What the lamp does is that it emits light which is *temporally modulated* and this can give rise to different effects, of which one is flicker.

Figure 1 gives an overview of different effects caused by TLM.

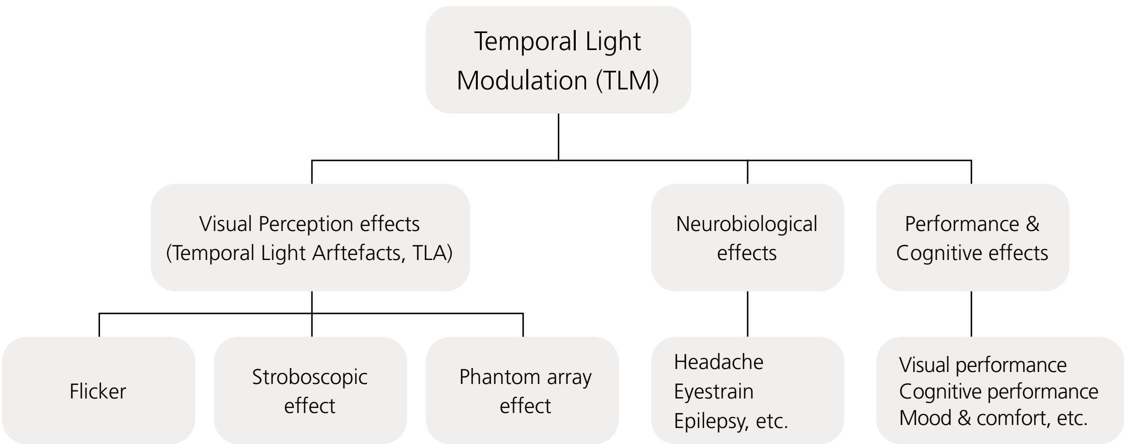

Figure 1: Overview of temporal light modulation (TLM) and its effects.

If exposed to TLM there are three different visual effects that can be perceived:

1. Flicker

If you look at a lamp and see that the light intensity is varying, then you are perceiving flicker. However, this is only valid as long as you don't move your eyes, and if the light source is not moving. In technical terms, flicker is defined as "perception of visual unsteadiness induced by a light stimulus the luminance or spectral distribution of which fluctuates with time, for a static observer in a static environment". Consequently, flicker is only perceptible if the modulation frequency is below about 90 Hz. At higher frequencies our eyes cannot resolve the temporal variations. And as can be seen from the definition, flicker is a subjective rather than an objective phenomenon.

2. Stroboscopic effect

If movement is involved, e.g., the light source is moving or some object is moving in the light (such as a hand or a pencil) and a pattern emerges, the observed effects are called Stroboscopic effects (see Figure 2).

Figure 2: Illustration of stroboscopic effect. Photo: J.Rydeman

3. Phantom array effect

Finally, there is a third effect, which appears during saccades (simultaneous rapid movements of the eyes). If you see a pattern during the very short period of time you move your eyes, then you are seeing phantom arrays (see Figure 3).

Both stroboscopic effects and phantom array effects are visible at much higher frequencies than 90 Hz. Stroboscopic effects are visible at frequencies up to 2000 Hz and phantom array effects at frequencies as high as 11 000 Hz[3].

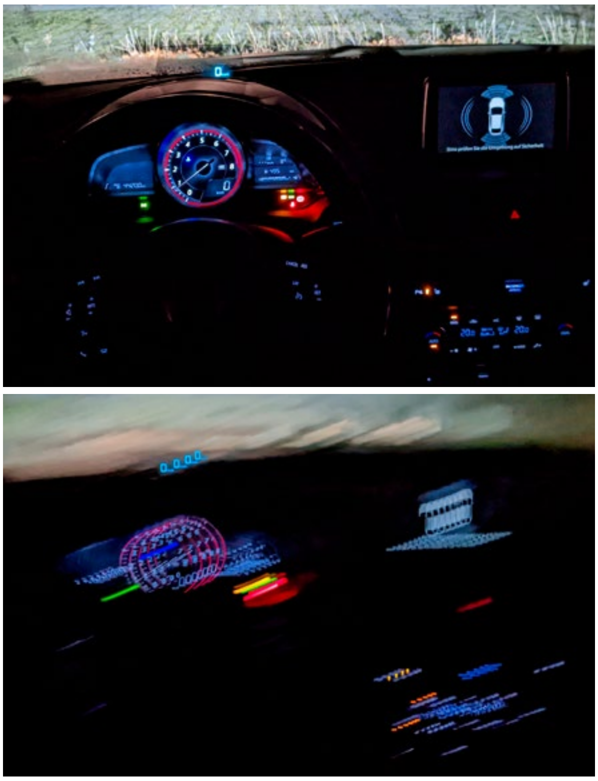

Figure 3: Illustration of phantom array effect. Photo: J.Ledig

All three effects mentioned above – flicker, stroboscopic effects and phantom array effects – are examples of Temporal Light Artefacts or TLAs and are, as said, caused by TLM.

As can be seen in Figure 1 above, TLM may also have effects other than the visual perception ones. It has also been shown that TLM can cause non-visual effects. This is elaborated on in the section TLM and health.

Beyond the effects TLM can have on humans, it has also been shown to have negative effects on animals such as hens[4], and it can also cause interference with imaging devices for photography and video. These effects are however not considered in this work.

How is TLM measured?

For many decades it has been possible to quantify TLM using measures such as Percent Flicker (also known as Modulation Depth) and Flicker Index. However, these measures were developed at a time when light sources, if modulated at all, were modulated at a frequency of 100 Hz (or 120 Hz in north America), and the light sources involved were mainly incandescent bulbs or fluorescent tubes. In other words, these measures do not take account of frequency and are thus not suitable for light sources that modulate at other frequencies.

Currently, there are two methods that have become standard for measuring TLM: short-term flicker indicator P_{st}^{LM} for flicker (up to 90 Hz), and the Stroboscopic effect Visibility Measure M_{VS} for stroboscopic effects (up to 2000 Hz). Note: the symbol M_{VS} for Stroboscopic effect Visibility Measure is often confused with the abbreviation of the same: SVM. Both P_{st}^{LM} and M_{VS} are measures designed so that if the measurement result equals 1, it means that the probability of observation of the effect for a standard observer is 50%. A higher measurement result means a higher probability. Currently there are no measures for Phantom arrays.

In September 2021, the European Union updated its eco-design directives, including, for the first time, regulations and limits for TLM in lighting products. They state that P_{st}^{LM}cannot exceed 1 and M_{VS} cannot exceed 0.9 (which will be lowered to 0.4 by 2024). These limits apply to full load of the light source, that is, undimmed.

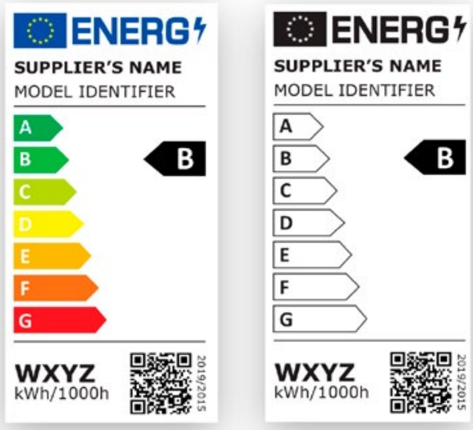

Figure 4: Example of the new EU energy label for lighting products

In connection with the updated eco-design directives, the European Union has introduced a new energy label for electrical products. This label includes a QR-code which when scanned directs to additional information about the product in the EPREL database (European Registry for Energy Labelling), see Figure 4. For light sources, this information includes values for "Flicker metric" (short-term flicker indicator) and "Stroboscopic effect metric" (stroboscopic effect visibility measure). It should be noted, however, that the information in the EPREL database is as of today's date not totally reliable. Many light sources state the value of 0, or the value of 1.0 for P_{st}^{LM} and 0.4 for M_{VS}, i.e. exactly on the legislation limit. It's highly unlikely that these are the actual measurement results.

TLM and health

As mentioned, the three TLM effects specified above – flicker, stroboscopic effects and phantom arrays – are examples of *Temporal Light Artefacts* or TLAs (remember Figure 1). These three light artefacts are by definition visual. However (also illustrated by Figure 1), it has also been shown that TLM can cause non-visual effects such as headache, migraine and eyestrain[5,6]. It has also been shown that TLM can affect cognitive performance and reading speed[7,8]. Furthermore, it has been seen that children and highly sensitive persons are more affected than others.

These neurological and cognitive effects are probably more severe than the visual effects, since those that suffer from them aren't necessarily aware that it is a light source that is causing them problems.

The problem with TLM is the still unanswered question of how important the non-visual effects are compared to the visual ones. It appears that the importance of TLM for these effects is large for a subset of susceptible individuals in the population, about 20-30 percent. But more evidence-based guidelines are needed.

Testing the visual effects is relatively easy. It is more difficult with the non-visual, but from the research that has been done it has been seen that complaints of headaches and eye problems were reduced when switching from magnetic ballasts to high frequency electronic ballasts for fluorescent tubes[6]. The effect was marginal in the test subjects as a whole, but the effect was pronounced for those with a tendency to experience headaches and eyestrain. It is difficult to detect this hypersensitive subgroup. Veitch and McColl[7] observed a non-visual effect of TLM when subjects were asked to perform difficult, visual tasks. Sekulovski et al.[9] did not see a difference in the incidence of headache, but did not screen out possible hypersensitive subjects, which may have missed this group. In addition, there were varying circumstances regarding window location and time of day that made it difficult to observe the TLM effects. Veitch and Martinsons[10] observed that highly sensitive individuals reported greater irritation on the TLM, and the results indicate that sensitive individuals should be the focus of future research. Brown and Wilkins[3] also showed that people with higher visual sensitivity detect phantom array effects more easily than less sensitive people. Zhao et al.[11] saw that more TLM meant a higher brain activity, and in some cases, greater difficulty in performing certain tasks, even when cognitive performance was not affected.

The rapid transition to LED lighting has created a pressure to develop recommendations and limitations on TLM, and more publications point out this problem[12]. Answers to the following questions would benefit the discussions regarding methods of measurement and which limits should apply to TLM:

- What are the effects of TLM on the subgroup of people who are more sensitive than others to visual stress?
- What effects do different TLM conditions have on areas other than the visual, i.e. physiological, behavioral and wellbeing?
- How important are other parameters besides the fundamental frequency and modulation depth for the effects? What about different duty cycles or other types of waveforms?

Further research with these questions as a starting point would form a basis for better and more evidence-based discussions on the subject of TLM and its effects on people's wellbeing. In the meantime, it would be wise to apply the precautionary principle.

P_{st} and IEC 61547

The flicker measure *short-term flicker indicator*, symbol P_{st}, is described in the technical report IEC TR 61547, issued in 2020 by the International Electrotechnical Commission (IEC). The current version is the third edition, the first being issued in 2015. Even though IEC 61547 is a report (TR stands for Technical Report), and not a standard, it is used as a standard in practice.

The technical report IEC 61547 was published as a consequence of the introduction of LED lamp technology. Among other things, it contains a description of a *light flickermeter* and its outcome P_{st}. The light flickermeter described in IEC 61547 is a further development of the IEC *flickermeter* described in the standard IEC 61000-4-15[13], with associated limits and recommendations as per the standard IEC 61000-3-3[14], which was published in 1994. Henceforth the instrument described in IEC 61000-4-15 will be referred to as the *IEC Flickermeter* and the instrument described in IEC 61547 as the *IEC Light Flickermeter*.

The short-term flicker indicator, symbol P_{st}, which is one output of the IEC Flickermeter and is described in IEC 61000-4-15, was developed at the time when incandescent light bulbs were the most common light source in residential homes. The purpose of the development of the IEC Flickermeter and P_{st} was to achieve a tool for assessing voltage fluctuations in the power supply in order to avoid visible flicker from lamps and complaints from electric power customers, as at that time complaints mainly concerned unsteadiness of light levels from lamps. P_{st} is therefore based on the 60 W incandescent light bulb.

According to the original standard IEC 61000-4-15 and the IEC Flickermeter described therein, the voltage fluctuations need to be logged for 10 minutes to obtain a value for the short-term flicker indicator P_{st}t. Note here that the fact that it is necessary to monitor the voltage to assess the light flicker has led to some confusion and differences of opinion: is P_{st} a measure of voltage or light? In the electrical community P_{st} is sometimes viewed as a measure of supply voltage fluctuations, and in the lighting community as a measure of flicker. P_{st} is a measure of flicker.

However, in order to obtain a value you need to monitor the voltage by using the IEC Flickermeter. By doing so, the IEC Flickermeter *models* the light fluctuations as they would have appeared from a 60 W incandescent lamp connected to that voltage. This was reasonable at the time, because there was more or less a direct link between the fluctuations of the voltage supply and the light fluctuations. Therefore, measuring the voltage was regarded equivalent to measuring the light.

With this in mind, you might say that "P_{st} is a measure of the supply voltage quality expressed in terms of the light flicker from a 60 W incandescent lamp", or that the IEC Flickermeter is only a measure of flicker from such a lamp.

It is worth noting here that P_{st} is in fact used as a characteristic of power supply voltage quality and that the parameter is used as a requirement level for other electrical appliances.

It follows that in the case of the IEC Flickermeter and P_{st}: what you "measure", or monitor (in this case the voltage), is not what you get a "measure of" (the light flicker). This is actually the case in many situations where any quantity is measured, for example when measuring temperature, which can be done either using an alcohol thermometer or a thermocouple, or some other kind of device. However, it is worth pointing out in this case to avoid confusion. From the time it was introduced, the IEC Flickermeter was incorporated into voltage measurement devices which were connected to a voltage power line (either directly or by the use of current clamps) and then a simulation was performed of the behaviour of an incandescent 60 W light bulb to obtain a value for the short-term flicker indictor P_{st}.

Since P_{st} was developed at the time when incandescent lamps were the most commonly used light source, this modelling of light fluctuations based on voltages fluctuations made sense, since there was more or less a direct link between the fluctuations on the voltage supply and the light fluctuations.

Around the beginning of 21st century however, with the introduction of LED lighting technology, there was no longer a (simple) connection between the voltage and light fluctuations. Suddenly there were LED lamps introduced to the market showing very low sensitivity to voltage fluctuations, but also LED lamps that inherently generated significant level of flicker, regardless of the quality of the supply voltage. With this came a need to assess the light intensity variations emitted from any light source, regardless of the power supply voltage.

This need is the origin of the IEC 61547 and the IEC *Light* Flickermeter. It describes a flickermeter which uses the *light variations* as direct input, in contrast to the original IEC Flickermeter, which takes the *voltage* as an input, and *models* the light from a 60 W incandescent lamp.

In order to clarify which instrument is being used in the measurement procedure, a second symbol for the short-term flicker indicator was introduced in IEC 61547, P_{st}^{LM}, where LM stands for "Light Measurement". Therefore, the IEC Flickermeter takes the voltage as input and the output short-term flicker indicator is denoted as P_{st}, while the IEC *Light* Flicker meter takes the light intensity as input, and the output short-term flicker indicator is written P_{st}^{LM}, see Figure 5.

Note that P_{st} and P_{st}^{LM} are still measures of the same thing: flicker, only obtained using slightly different instruments (just as you can measure temperature, or any other quantity, by using different instruments – a mercury thermometer or a thermocouple).

In order to "avoid confusion", or to "be extra clear about which instrument has been used", yet a third symbol is introduced in IEC 61547: P_{st}^{V}, where V indicates it is the voltage that has been used as input, hence it's the IEC Flickermeter that has been used. In other words: P_{st}^{V} is exactly the same thing as P_{st}.

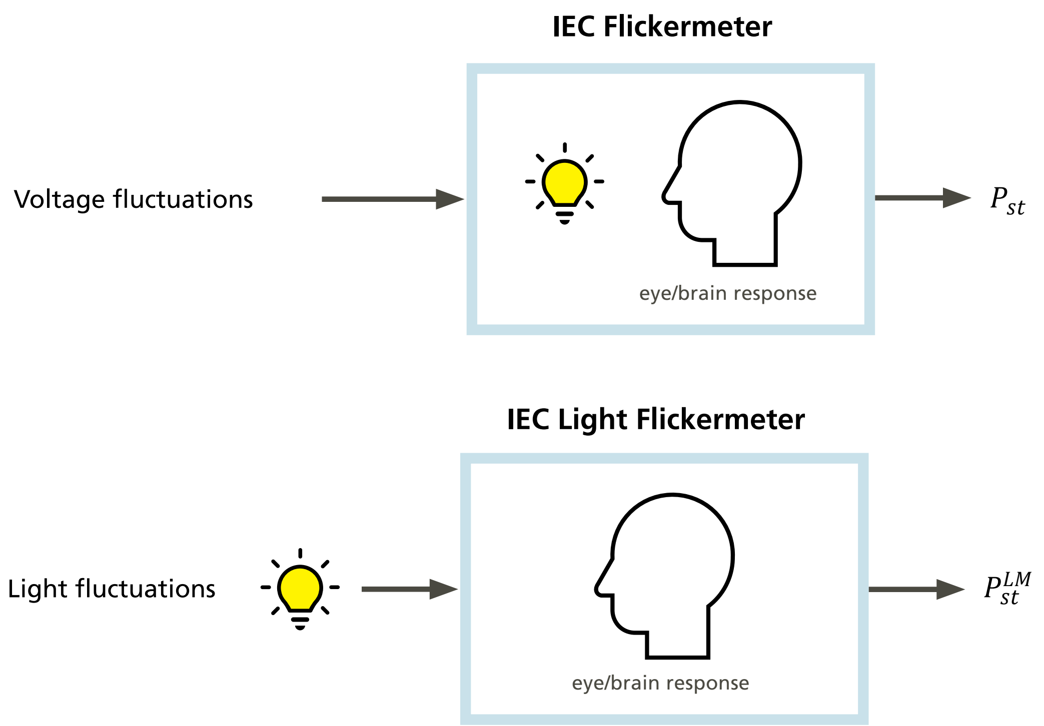

Figure 5: Two versions of flickermeters, with different input, but with the same resulting measure.

Just as P_{st} is implemented in several voltage measurement devices, P_{st}^{LM} is now more frequently implemented in light measurement devices. The duration for logging the voltage using the IEC Flickermeter to obtain P_{st} is 10 min. For P_{st}^{LM}, using the IEC Light Flickermeter however, the recommended duration of the logging of light intensity variations is 3 minutes or 180 seconds.

Despite the best intentions of trying to avoid confusion, the introduction of different symbols might give the impression of inconsistency. One possible explanation might be the fact that the report is created at the intersection of disciplines – the electrical and lighting community.

The risk of difficulties in communication is increased by the inconsistent use of terminology in IEC 61547.

In addition to being referred to as "short-term flicker *severity*" in IEC 61000-4-15 and IEC 61000-3-3, many different names are used for the short-term flicker indicator throughout the report: *short-term flicker value, intrinsic flicker, intrinsic flicker performance of lighting, intrinsic flicker performance of a light source, flicker severity value, flicker performance, flicker metric,* and *short-term flicker metric*.

Throughout IEC 61547 it is also left out what the P in P_{st} stands for. It is not obvious, but it probably stands for "Perceptibility".

The table below summarises, with some notes, the important information about the two TLM measures mentioned in this work, short-term flicker indicator P_{st} and stroboscopic effect visibility measure M_{VS}.

Quantity / Phenomenon	**Name of measure**	**Symbol**
Flicker	Short-term flicker indicator*	P_{st}**
Stroboscopic effect	Stroboscopic effect visibility measure (SVM)	M_{VS}***

* In IEC 61000-4-15 and IEC 61000-3-3 the alternative term "short-term flicker severity" is used.

** For clarity, the symbol P_{st}^{LM} can be used to indicate that the IEC Light Flickermeter was used (i.e., the light was detected), or the symbol P_{st}^{V}, to indicate that the IEC Flickermeter was used (i.e. the voltage was detected).

*** SVM is used as an abbreviation for Stroboscopic effect Visibility Measure, but also, incorrectly, sometimes as its symbol.

State of knowledge

The research area of TLM is a highly active one. With the implementation of TLM limits in the updated eco-design directives, and as the measures of P_{st}^{LM} and M_{VS} are being introduced, discussions of improvements are being held.

Mainly the discussions consider improvements of the measures at hand, but also development of measure of the non-visual effects – the ones giving rise to neurobiological and cognitive effects.

In a recent publication, the history of the technology and research of TLM and its quantifying measures are reviewed[15].

In the correspondence article by Veitch et al[12] the state of knowledge regarding the effects of TLM is presented. Much of this content is presented in the section *TLM and health* in this guide.

The international commission of illumination – CIE – has also recently published more detailed documents on the topic. The technical note "Guidance on the Measurement of Temporal Light Modulation of Light Sources and Lighting Systems"[2] provides respective recommendations, setting the stage for an understanding of the new metrics. It also provides guidelines for the correct measurement of these metrics. The technical report "Visual Aspects of Time-Modulated Lighting Systems"[16] gives a more detailed introduction to the visual and perceptual effects of TLM and description of the methods used to quantify these.

Issues relating to uncertainty and reproducibility[17–19] have also recently been observed in the calculation of both M_{VS} and P_{st}^{LM}. These issues have an impact on interlaboratory comparisons and verification on the compliance to EU legislations. These issues are subject to further investigations and will be considered in future updates. An interlaboratory comparison (IC 2022) is in the planning stage of the Solid State Lighting (SSL) Annex under the International Energy Agency (IEA).*

Updates of both IEC 61547 and CIE TN 012:2021 are expected within a few years.

* www.iea-4e.org/ssl/our-work/testing-standards

Terms, Definitions and Symbols

The following section will present terms, definitions and symbols, in some cases slightly amended and supplemented compared to the IEC 61547 or elsewhere. The terms, definitions and symbols have been adjusted to be more consistent and clearer, making them more accessible to a broader audience. Text in purple indicates amendment and/or supplement to the original definitions than can be found in IEC 61547, CIE TN 016[20], IEC 63158[21] or elsewhere.

flicker

perception of visual unsteadiness induced by a light stimulus the luminance or spectral distribution of which fluctuates with time, for a static observer in a static environment.

Note 1 to entry: The fluctuations of the light stimulus with time include periodic and non-periodic fluctuations and can be induced by the source itself, the power source or other influencing factors.

Note 2 to entry: Here flicker is defined as something *perceptible*, which differs from the colloquial use of the word flicker, which tends to refer to an objective property of light or a light source – something the light *does*.

stroboscopic effect

change in motion perception induced by a light stimulus the luminance or spectral distribution of which fluctuates with time, for a static observer in a non-static environment.

Note 1 to entry: The stroboscopic effect is a type of temporal light artefact.

Note 2 to entry: A static observer and a non-static environment are minimal requirements for the detection of the stroboscopic effect, but they are not limiting. This means that the stroboscopic effect can also be detected by a non-static observer.

short-term flicker indicator

Symbol: P_{st}

measure of flicker evaluated over a specified time interval of a relatively short duration.

P stands for *Perceptibility* and *st* stands for *short-term.*

Note 1 to entry: The duration is typically 10 min, in accordance with IEC 61000-4-15.

Note 2 to entry: The alternative term "short term flicker severity" is used in IEC 61000-3-3 and IEC 61000-4-15.

Note 3 to entry: The short-term flicker indicator can also be denoted P_{st}^{V} or P_{st}^{LM}, to indicate and clarify whether the IEC flickermeter or IEC light flickermeter was used to obtain the result. *V* stands for voltage (as the voltage is used as input in the IEC flickermeter) and *LM* stands for Light Measurement (as luminous variation is used as input in the IEC light flickermeter).

stroboscopic effect visibility measure

Symbol: M_{VS}

Abbreviation: SVM

measure of stroboscopic effect visibility evaluated over a specific duration.

Note 1 to entry: The duration is typically 1 second (minimum), in accordance with CIE TN 006:2016.

IEC flickermeter

instrument designed to measure any quantity representative of flicker using voltage as input.

Note 1 to entry: Specifications of the IEC Flickermeter can be found in IEC 61000-4-15.

Note 2 to entry: One of the outputs of the IEC Flickermeter is P_{st}, which also could be denoted P_{st}^{V} to clarification that the IEC Flickermeter was used in the procedure.

IEC light flickermeter

instrument designed to measure flicker resulting from temporal changes in the intensity of light, using luminous variation as input

Note 1 to entry: The IEC Light Flickermeter is a modification of the IEC Flickermeter.

Note 2 to entry: One of the outputs of the IEC Light Flickermeter is P_{st}^{LM}, which is the same as P_{st} but with the superscript LM added in order to clarify that the IEC Light Flickermeter was used in the procedure.

SYMBOLS

P_{st} – short-term flicker indicator

P_{st}^{V} – short-term flicker indicator, P_{st}, where *V* indicates measurements are performed using an IEC flickermeter, which uses the voltage as input

P_{st}^{LM} – short-term flicker indicator, P_{st}, where the superscript *LM* indicates measurements are performed using an IEC Light Flickermeter, which uses the luminous variation as input

M_{VS} – stroboscopic effect visibility measure

Conclusions

Temporal light modulation (TLM), colloquially known as "flicker", creates an obstacle to potential energy savings and constitutes a threat to human health and wellbeing. The EU's new eco-design directives aim to regulate the degree of TLM in light sources on the EU market, however, the standards and reports describing the background are technically complicated.

This document is a product of the project "Flicker Explained" with the objective of bridging the gap between the technical documents and the lighting industry. Furthermore, the project is motivated by the new eco-design directives and the limits on the measures of stroboscopic effect visibility measure (M_{VS} < 0.9) and short-term flicker indicator (P_{st}^{LM} < 1). Note that by September 2024 the limit on stroboscopic effect visibility measure will be even stricter (M_{VS} < 0.4).

Colloquially the word "flicker" is used to describe something a lamp *does*, as in "the lamp is flickering". Strictly speaking, this usage is incorrect based on how the word flicker is defined. Flicker is not something a lamp *does* – it is something you *see*. What the lamp does is emit light which is *temporally modulated* and that can give rise to different effects, of which one is flicker.

Part of the reason for the confusion is the origin of the IEC Flickermeter and the flicker measure it puts out: the short-term flicker indicator P_{st}. This was developed with the purpose of being a tool to assess voltage fluctuations in the power supply in order to avoid visible flicker from incandescent light bulbs, which was the most common light source at the time. In a sense you can say that in the case of the IEC Flickermeter and P_{st}, what you "measure", or monitor (the voltage), is not what you get a "measure of" (the light flicker).

Below is a list of some possible "pit falls" that it is good to be aware of when working with TLM, flicker and the measures P_{st} and SVM.

- Flicker is defined as something subjective, but is assessed in an objective way.
- The word *temporal* can in a medical context refer to the side-area of the brain/skull that is near the *temples*. However, in TLM *temporal* refers to something that has to do with *time*.
- P_{st}, P_{st}^{LM} and P_{st}^{V} are symbols for the same measure: short-term flicker indicator, which is a measure of flicker. The different symbols are used to indicate which measurement procedure was used: P_{st}^{LM} indicates that the IEC Light Flickermeter was used (i.e., the light was detected), and P_{st}^{V} indicates that the IEC Flickermeter was used (i.e. the voltage was detected).
- P stands for "Perceptibility".
- st stands for "short-term".
- LM stands for "Light Measurements".
- The correct term for P_{st} is "short-term flicker indicator". However, it has many names in the literature, including *short-term flicker severity, short-term flicker value, intrinsic flicker, intrinsic flicker performance of lighting, intrinsic flicker performance of a light source, flicker severity value, flicker performance, flicker metric*, and *short-term flicker metric.*
- The symbol M_{VS} of Stroboscopic effect Visibility Measure is often confused with the abbreviation of the same: SVM.

It is worthy of mention that the research area of TLM is a very active one. It needs to be emphasised that SVM and P_{st}^{LM} are measures of visual effects, only. At the moment there are no measures for non-visual effects, such as headache, migraine and eyestrain or the effect on cognitive performance and reading speed. These neurological and cognitive effects are probably more severe than the visual effects, because those that suffer from them are not necessarily aware that a light source could be contributing to their problems. More research is needed in this field.

The project Flicker Explained has also produced a document "Flicker explained – Interpretation of the Technical Report IEC 61547", containing suggestions on improvements and amendments of both text and figures in IEC 61547, together with an instruction on how to build a TLM measurement setup.

The report is available online via www.design.lth.se/lightinglab

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CONTACT

Johannes Lindén, Research engineer
Design Sciences, Faculty of Engineering
at Lund University

johannes.linden@design.lth.se

Carsten Dam-Hansen, Senior researcher
DTU Electro, Technical University of Denmark

cadh@dtu.dk

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