

# Temporal Light Artefacts (Flicker) A Quality Requirement for GSLs

FORTALECIMIENTO DE ESTÁNDARES DE EFICIENCIA ENERGÉTICA EN ILUMINACIÓN  
Primera Reunión y Taller Presencial del Grupo Técnico de Eficiencia Energética (GTEE)

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**Overview of the Problem**

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**Products Tested**

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**Requirements Proposed**

# Light Variation with Time

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- Temporal variation in light output from a light source known as Temporal Light Modulation (TLM)
- TLM can have visual and non-visual effects on a person.
- The term for these effects, as defined by CIE, is Temporal Light Artefacts (TLA).
- There are three main situations where TLAs are visually perceivable.

# Flicker

-  Light source: stationary but varies in intensity or colour
-  Observer's eyes: not moving (ie without saccades)
-  Illuminated object: stationary
  - Variation in light: above threshold of visual perception
  - Visual effect: light is flashing



# Stroboscopic Effect



Light source: stationary but varies in intensity or colour

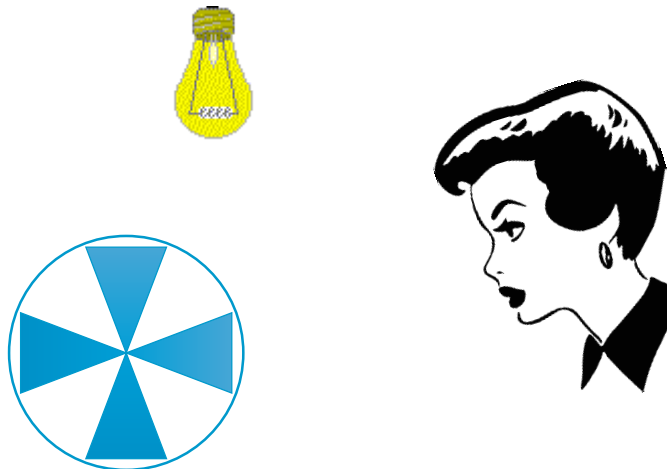


Observer's eyes: not moving (ie without saccades)



Illuminated object: moving (translation or rotation)

- Variation in light: above the threshold of visual perception
- Visual effect: impression that the object is moving at a different rate to its actual translation or rotation speed



# Phantom Array Effect (Ghosting)



Light source: stationary but varies in intensity or colour

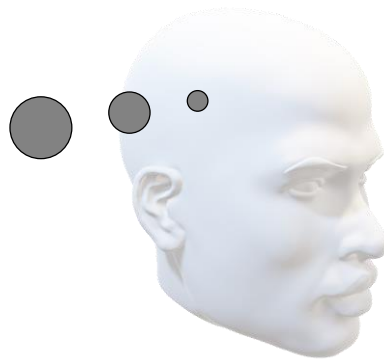


Observer's eyes: moving (eg large eye movement known as saccades)



Illuminated object: stationary

- Variation in light: above the threshold of visual perception
- Visual effect: gives the impression of a ghosting trail of the object in a person's vision.



# Human Health Effects

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- Non-visual effects have been reported as physiological and psychological manifestations including:
  - Migraine
  - Eyestrain
  - Seizures
  - Reduction in task performance
  - Anxiety
  - Autistic behaviour
  - Vertigo
- Research activities on visual and non-visual effects of TLAs have endeavoured to establish the:
  - light modulation frequencies and
  - associated thresholds of activation

# Human Health Effects

Biological Effect	Frequency range reported	Other conditions reported	Suggested low risk level requirements
<b>Visible flicker</b>	<ul style="list-style-type: none"> <li>0.5 – 35 Hz (8.8 Hz peak sensitivity)</li> </ul>	<ul style="list-style-type: none"> <li>Low threshold for % modulation</li> </ul>	<ul style="list-style-type: none"> <li>Short-term flicker metric, <math>P_{st} LM &lt; 1</math> (IEC 61000-4-15)</li> </ul>
<b>Photosensitive seizures</b>	<ul style="list-style-type: none"> <li>3 – 65 Hz (15-25 Hz peak sensitivity)</li> </ul>	<ul style="list-style-type: none"> <li>Visual field <math>\geq 0.006</math> sr</li> <li>Luminance change <math>\geq 20</math> cd.m<sup>-2</sup></li> </ul>	<ul style="list-style-type: none"> <li><math>\leq 5\%</math> Light modulation (frequency independent)</li> </ul> <p>or</p> <ul style="list-style-type: none"> <li><math>\leq 20</math> cd.m<sup>-2</sup> variation for 3 – 65 Hz</li> </ul>
<b>Stroboscopic effect (moving object)</b>	<ul style="list-style-type: none"> <li>50 – 2000 Hz</li> </ul>	<ul style="list-style-type: none"> <li>High % modulation</li> <li>Low duty cycles for PWM</li> </ul>	<ul style="list-style-type: none"> <li>Stroboscopic effect Visibility Measure, <math>SVM \leq 1.6</math> (NEMA 77)</li> </ul>
<b>Phantom array (eye movement: Saccades)</b>	<ul style="list-style-type: none"> <li>50 – 3000 Hz</li> </ul>	<ul style="list-style-type: none"> <li>High % modulation</li> <li>Longer saccades</li> </ul>	<ul style="list-style-type: none"> <li>More research required</li> </ul>

Source: “Recommendations of Metrics and Limits for Flicker from LED Lighting Products”, Prepared by Light Naturally for Department of the Environment and Energy, Commonwealth of Australia, September 2017

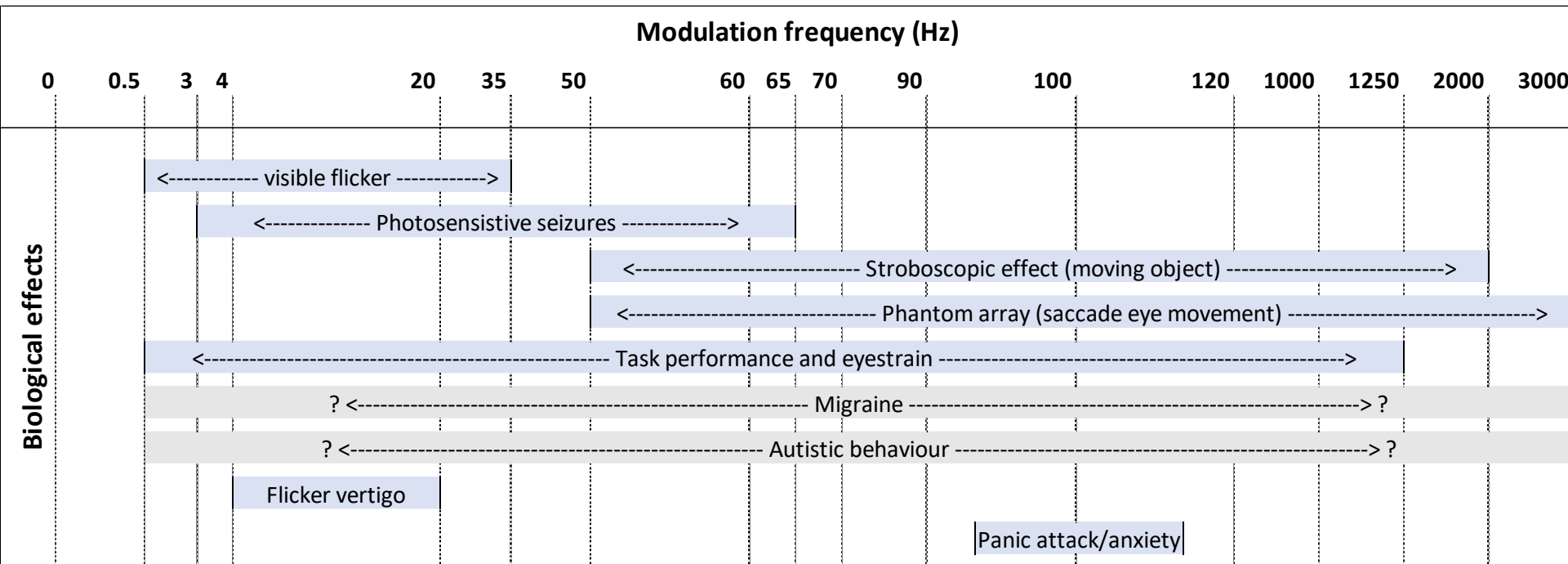


# Human Health Effects

Biological Effect	Frequency range reported	Other conditions reported	Suggested low risk level requirements
<b>Migraine</b>	<ul style="list-style-type: none"> <li>Unknown (But flicker confirmed as trigger)</li> </ul>	<ul style="list-style-type: none"> <li>None</li> </ul>	<ul style="list-style-type: none"> <li>More research required</li> </ul>
<b>Autistic behaviour</b>	<ul style="list-style-type: none"> <li>Unknown (But indication of flicker as trigger)</li> </ul>	<ul style="list-style-type: none"> <li>None</li> </ul>	<ul style="list-style-type: none"> <li>More research required</li> </ul>
<b>Task performance and eyestrain</b>	<ul style="list-style-type: none"> <li>&lt; 1250 Hz</li> </ul>	<ul style="list-style-type: none"> <li>% modulation</li> <li>Duty cycle for Pulse Width Modulated light output</li> </ul>	<ul style="list-style-type: none"> <li>≤ 1% Light modulation (frequency independent)</li> <li>or</li> <li>Frequency ≥ 1250 Hz</li> </ul>

Source: "Recommendations of Metrics and Limits for Flicker from LED Lighting Products", Prepared by Light Naturally for Department of the Environment and Energy, Commonwealth of Australia, September 2017

# Mapping the Effects with Frequency Regions



# CIE Recommendations

## ***CIE TN 006: 2016. CIE Technical Note: Visual aspects of time-modulated lighting systems – Definitions and measurement methods.***

### *Scope:*

- Visibility of temporal light artefacts

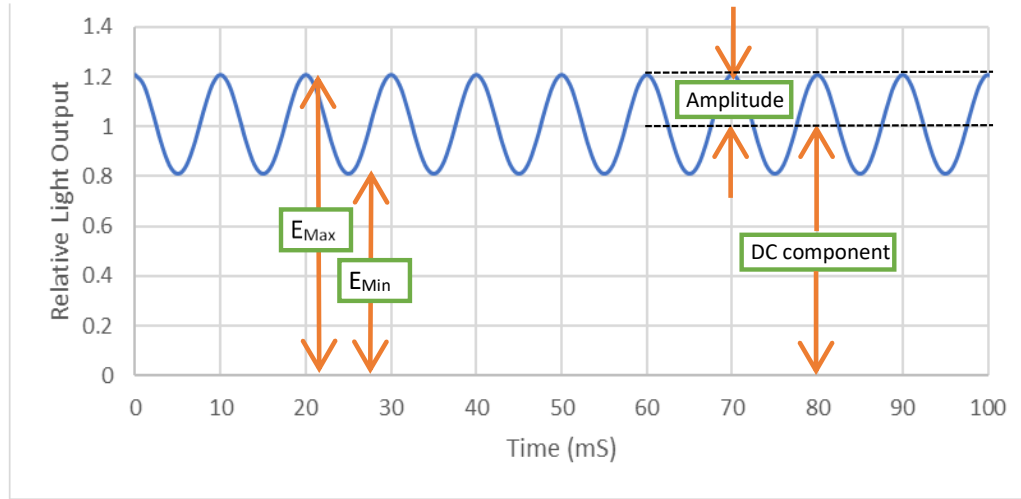
### *Out of scope:*

- Application specific acceptability thresholds
- Non-visual effects
- Chromatic flicker
- Recommends Short Term Flicker metric,  $P_{st}^{LM}$  (from IEC)
- Defines and recommends Stroboscopic Visibility Measure (SVM)
- Defines Phantom Array effects

**NOTE:  $P_{st}^{LM}$  and SVM are normalised parameters such that a value of 1.0 is when a person with normal vision will perceive the effect 50% of the time.**

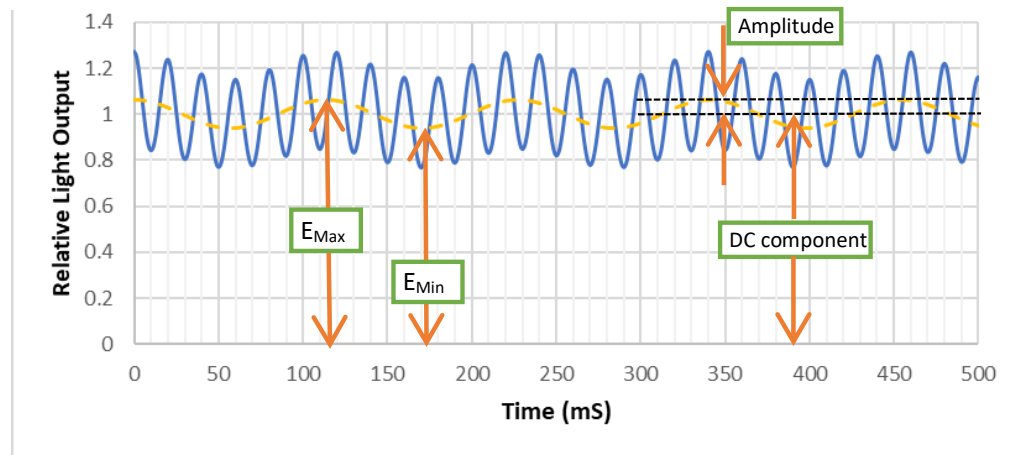
# % Modulation metric

Simple waveforms

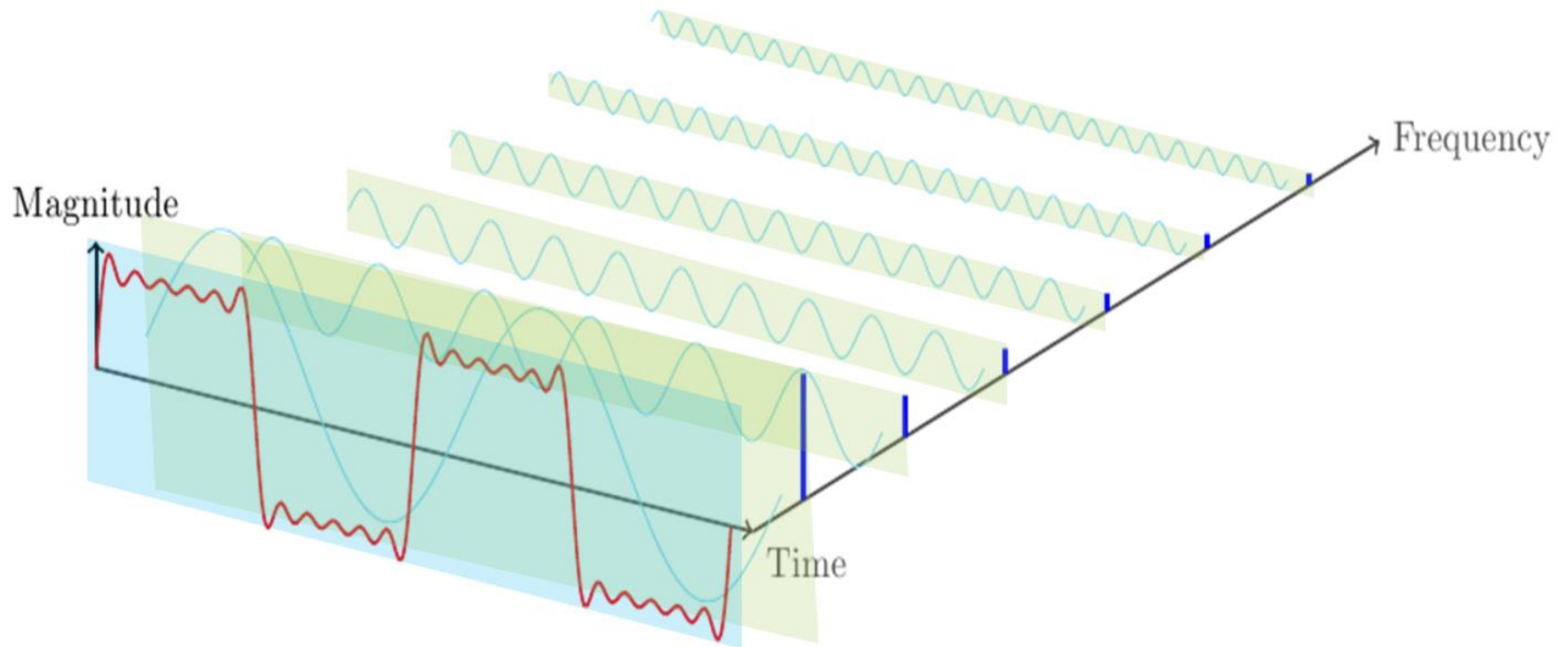


$$\% \text{ Modulation} = \frac{\text{Amplitude}}{\text{DC component}} = \frac{(E_{Max} - E_{Min})}{(E_{Max} + E_{Min})}$$

Complex waveforms



# Determining Frequency Elements of Complex Waveforms



## Possible causes for temporal light modulation

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- Light source technology and its driver topology (poor product design)
- Dimming technology of externally applied dimmers or internal light level regulators (poor compatibility)
- Mains voltage fluctuations intentionally applied for mains-signalling purposes (poor immunity)
- Mains voltage fluctuations caused by electrical apparatus connected to the mains (conducted electromagnetic disturbances) (poor immunity)

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# IEC TR 61547-1 Ed 2 2017: Short term Flicker, $P_{st}^{LM}$

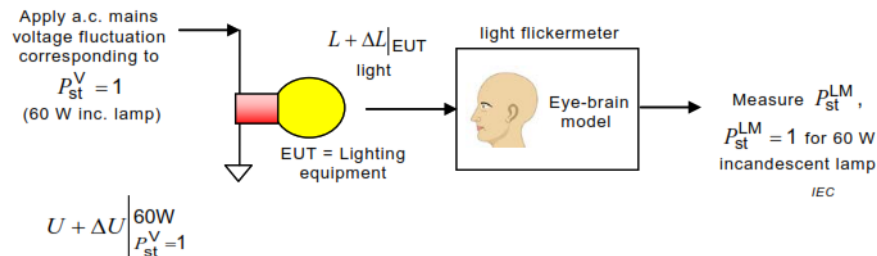
## ***Equipment for general lighting purposes – EMC immunity requirements – Part 1: An objective voltage fluctuation immunity test method***

### **1 Scope**

This part of IEC 61547 describes an objective light flickermeter, which can be applied for the following purposes:

- testing the intrinsic performance of all lighting equipment without voltage fluctuations;
- testing the immunity performance of lighting equipment against (unintentional) voltage fluctuation disturbance on the AC power port;
- testing the immunity performance of lighting equipment against intentional voltage fluctuation on the AC power port arising for example from ripple control systems.

- Describes an objective light flickermeter, including test conditions
- $P_{st}^{LM}$  calculation is a weighted percentile formula based on voltage variations creating perceptible flicker from a 60W incandescent lamp



b) – Voltage fluctuation immunity test specified in this document

**Figure 1 – Full EMC approach for mains voltage fluctuations**



# IEC TR 63158 2018: Stroboscopic Visibility Effect Measure, SVM

## ***Equipment for general lighting purposes – Objective test method for stroboscopic effects of lighting equipment***

### **Scope**

The type of equipment under test (EUT) may depend on the purpose of the test. For instance the following different application tests may be considered (see Figure 2):

- Testing the intrinsic performance of lighting equipment such as luminaires, controlgear or integrated lamps;
- Testing the performance of lighting equipment under dimming conditions.

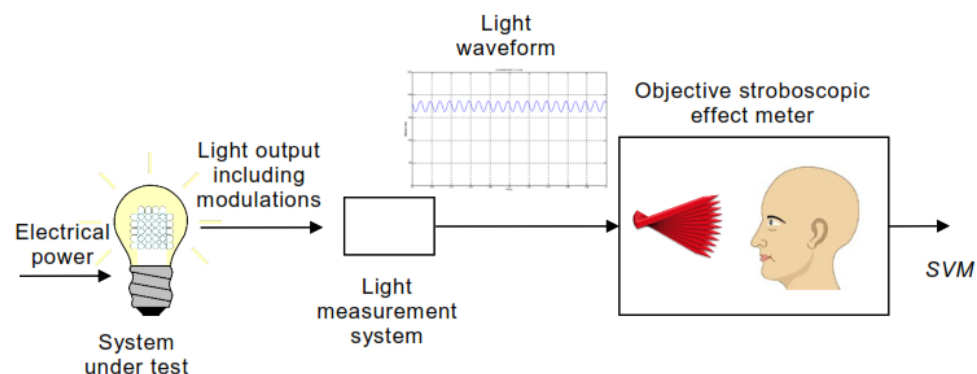


Figure 1 – Schematic of the stroboscopic effect measurement method

Source: IEC TR 63158: 2018

# Guidance on Limits

- IEC TR 61547-1 does not provide guidance on PstLM limits
- IEC TR 63158-1 does not provide guidance on SVM limits
- NEMA 77:2017 guidance is  $SVM \leq 1.6$  (page 30, Table 6 in Section 7: Recommendations):

**Table 6**  
**Guidelines for Pst and SVM Acceptance Criteria**

<b>Application area</b>	<b>P<sub>st</sub> limit</b>	<b>SVM limit</b>
Outdoor	$\leq 1.0$	None
Indoor	$\leq 1.0$	$\leq 1.6$

Source:  
NEMA  
77:2017

- This level relates to the SVM limit on linear fluorescent lamps on magnetic ballasts ( $SVM \approx 1.4 - 1.6 @ 100 \text{ Hz}$ ).
- This would mean the majority of the population would experience stroboscopic effects

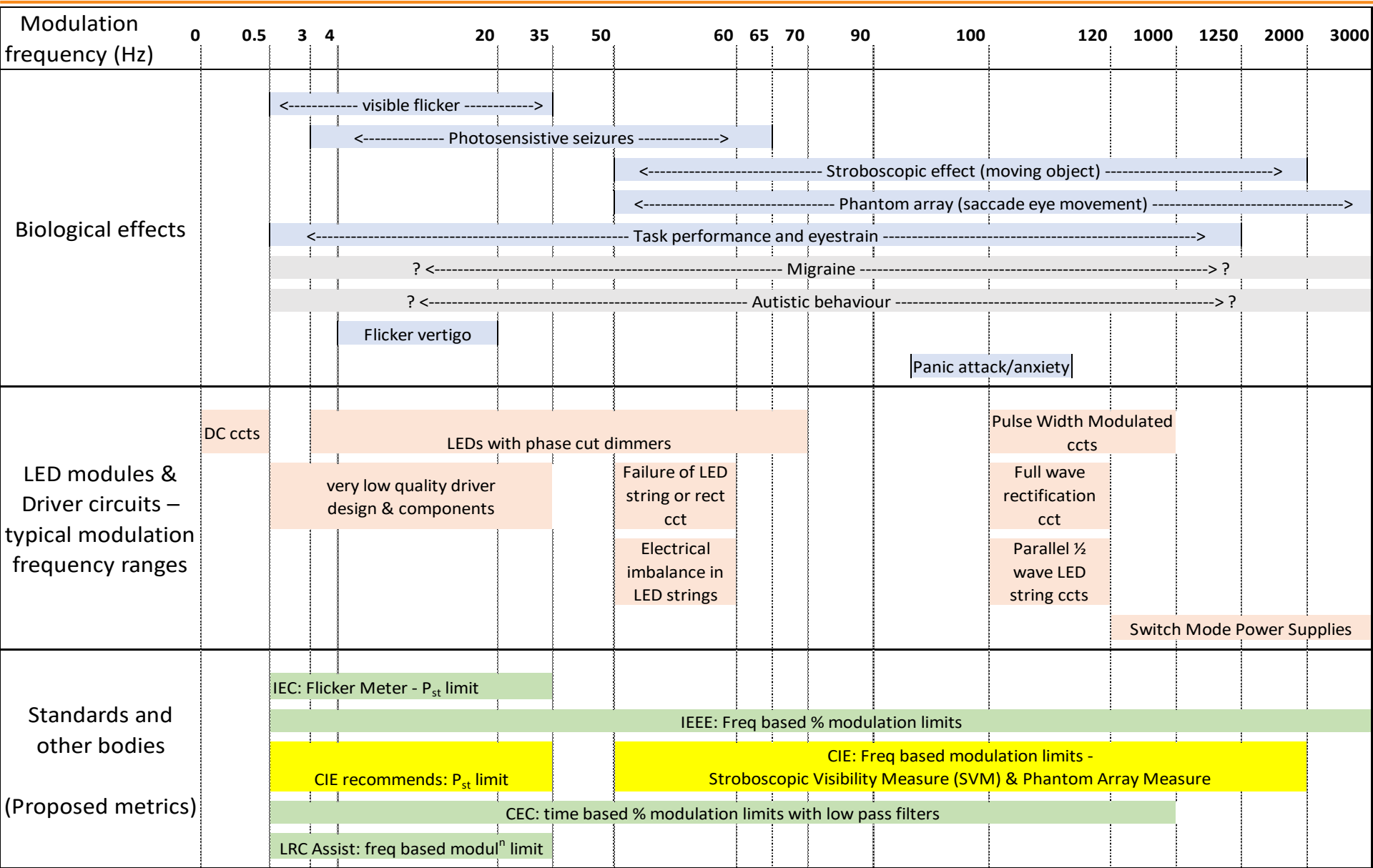
# Limit thresholds and proportion of population affected

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Another important point is the probability levels assigned to thresholds differ in terms of the proportion of the population affected. The threshold limit levels are defined as:

- 50<sup>th</sup> percentile of the population, or
- Low risk level (possibly 90<sup>th</sup> – 95<sup>th</sup> percentile of the population)
- No observable effect level (possibly 99<sup>th</sup> – 100<sup>th</sup> percentile of the population)
- SVM and  $P_{st}^{LM}$  limits of 1 are defined for a person with normal vision observing the phenomenon 50% of the time.

# Mapping All Elements with Frequency Regions



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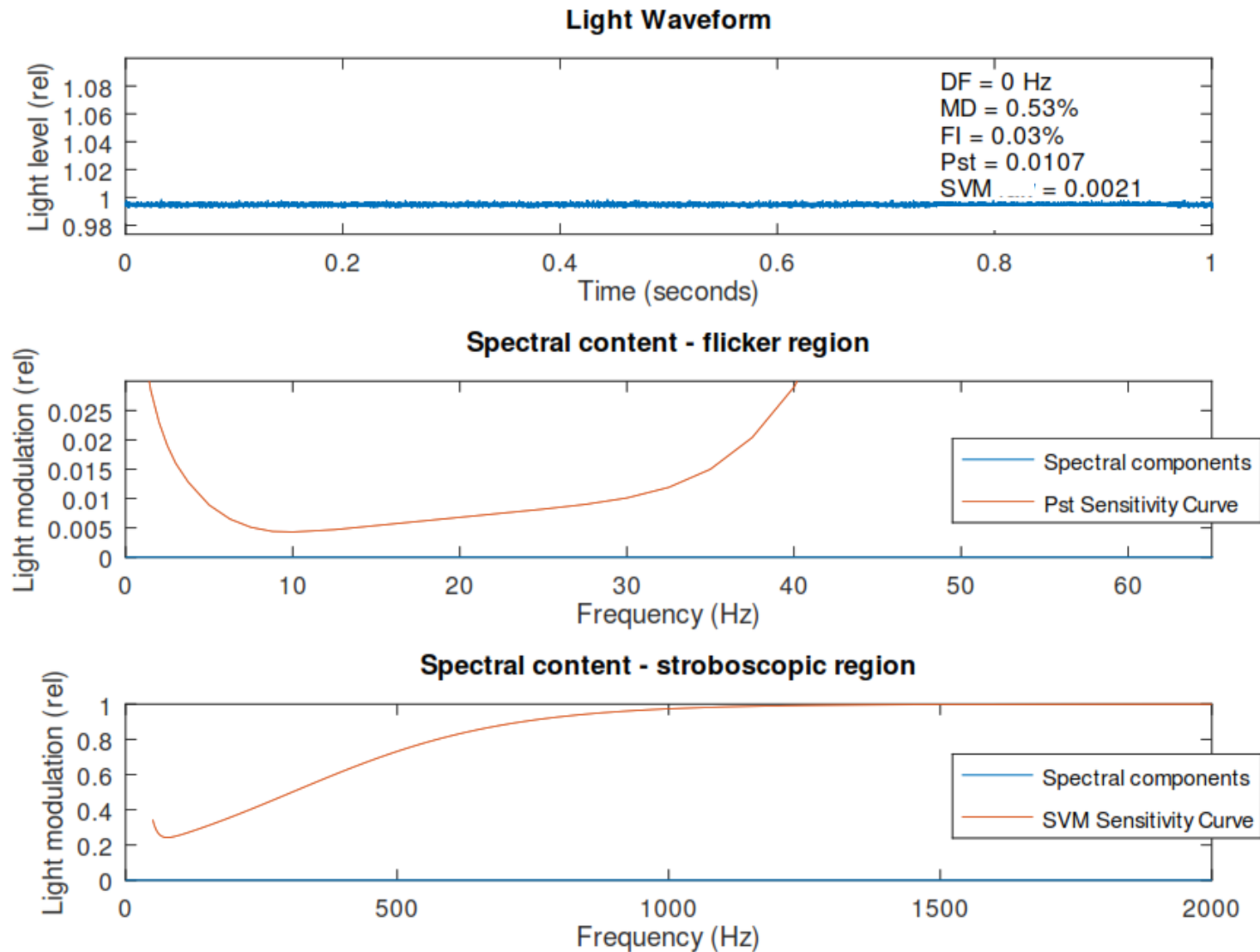
3

Products Tested

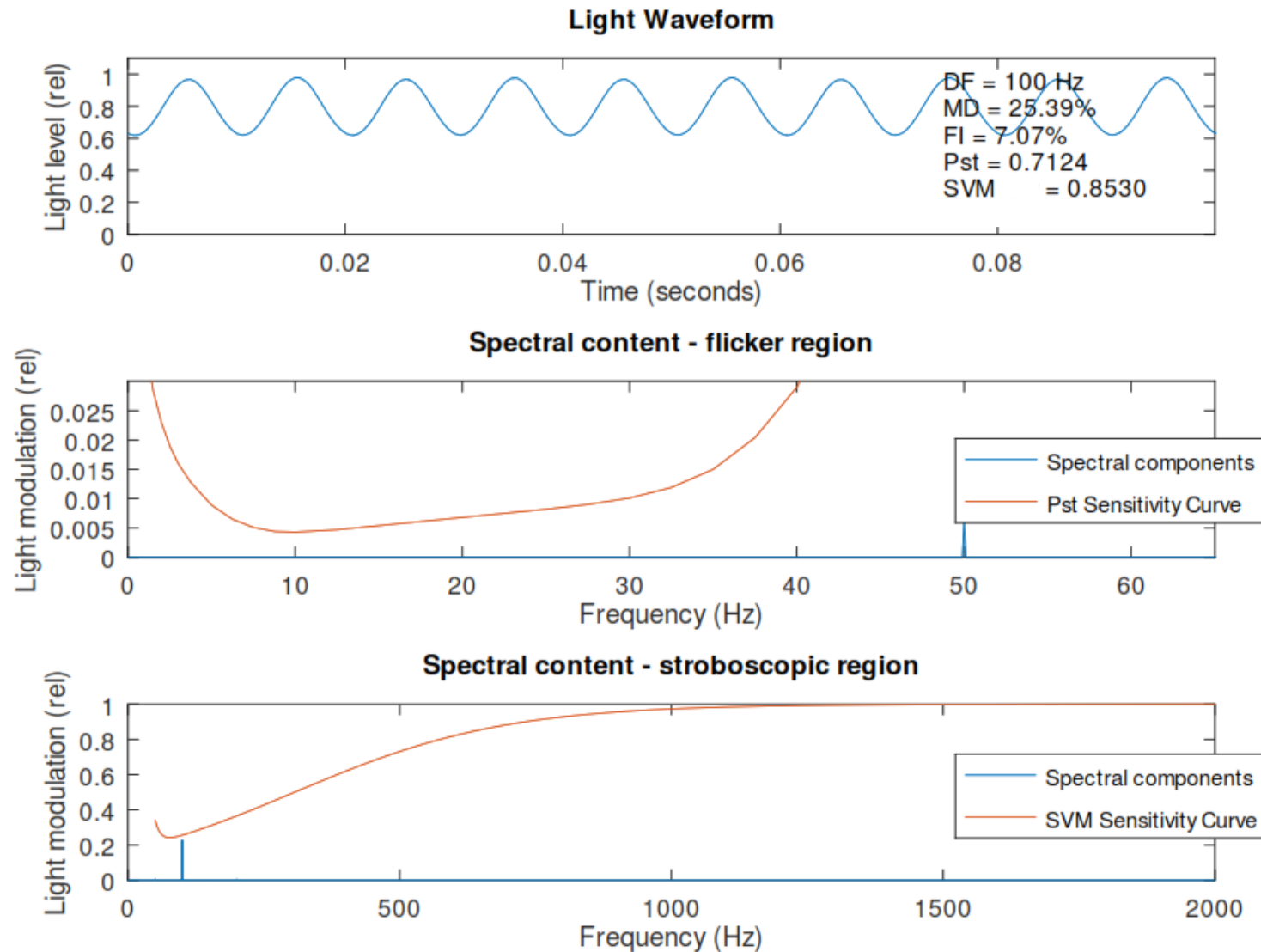
4

Requirements Proposed

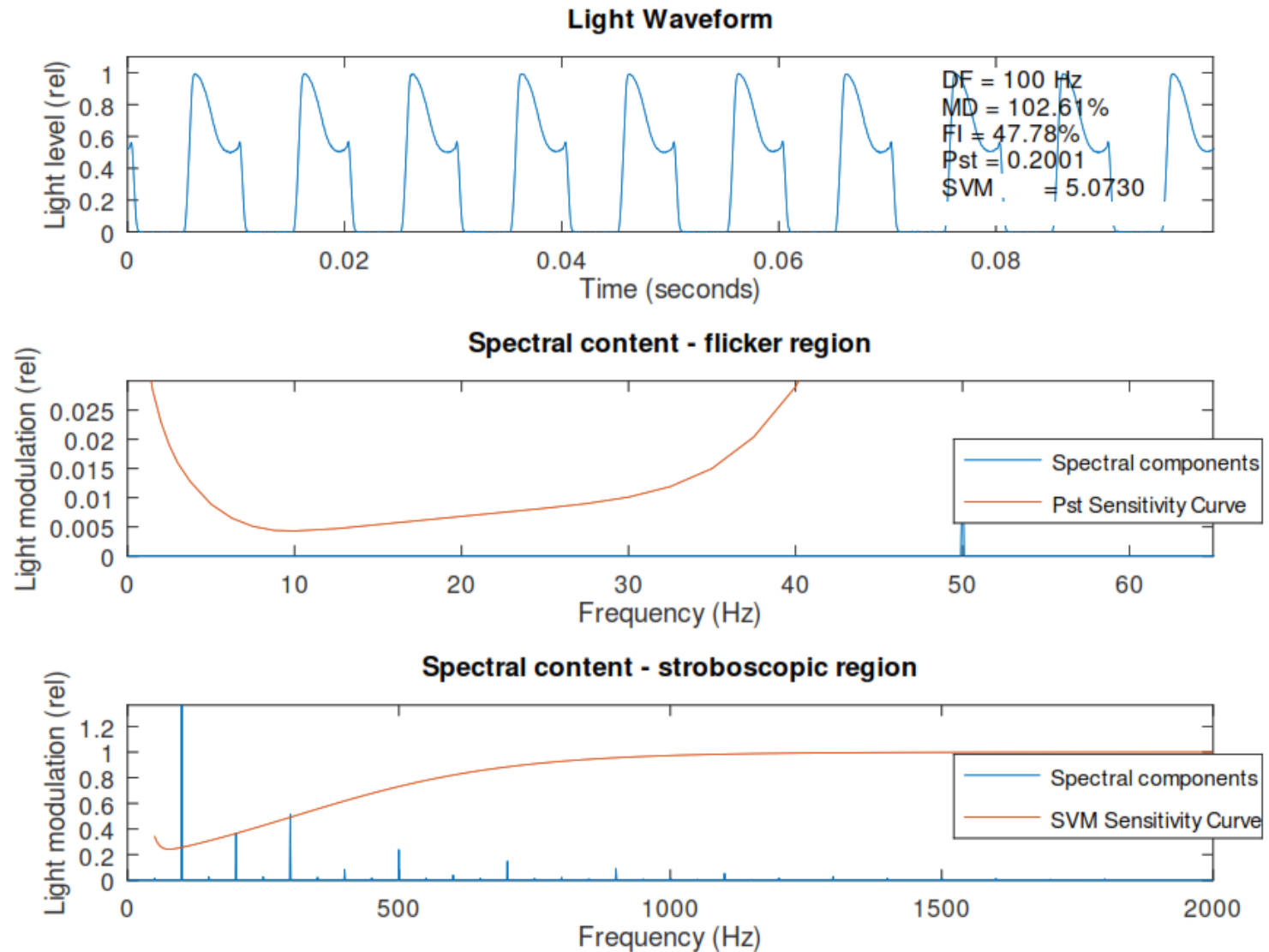
# Test results on lamps



# Test results on lamps

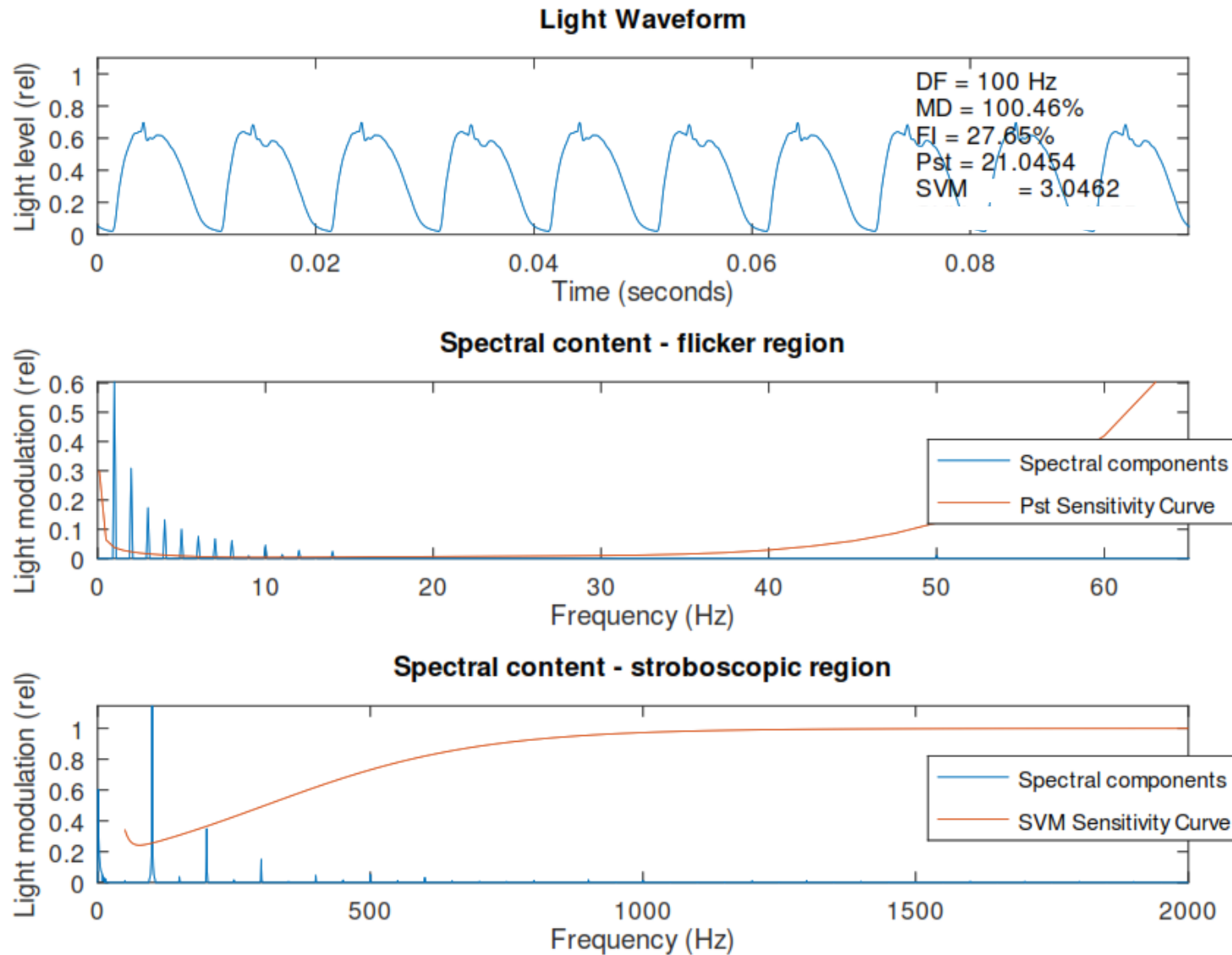


# Test results on lamps

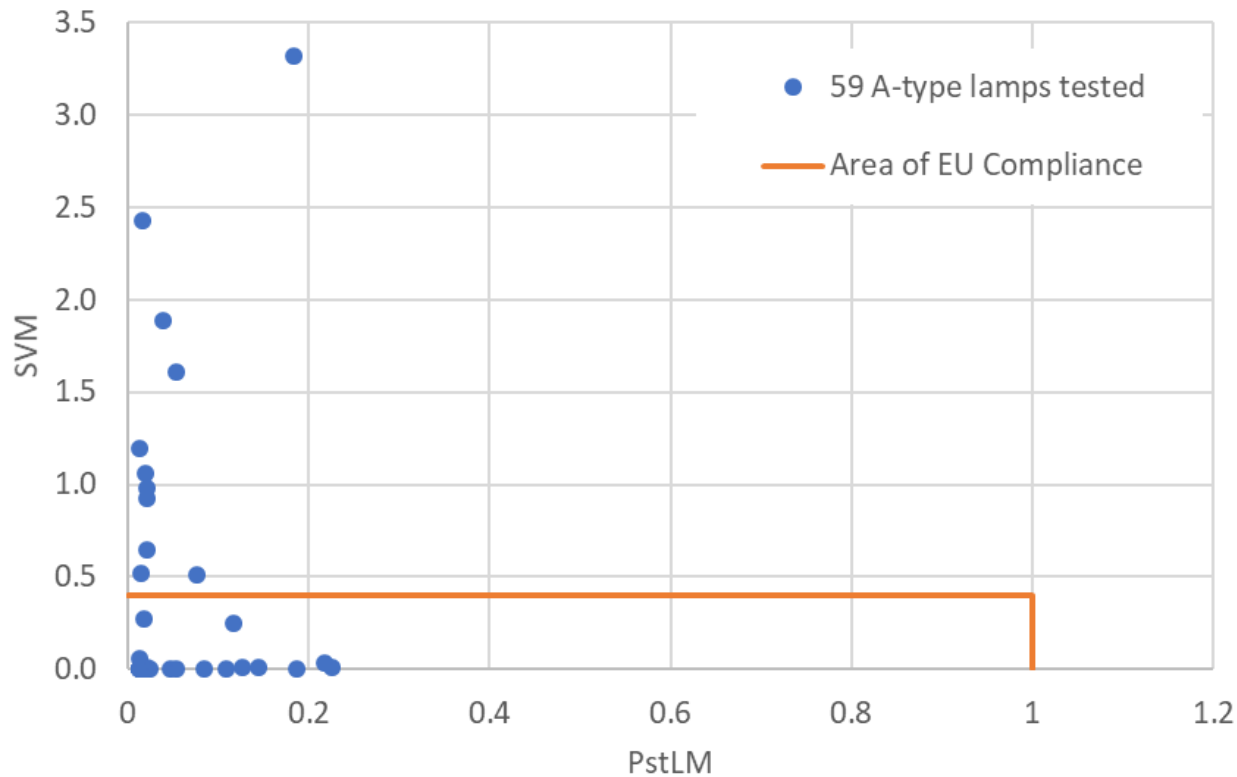




# Test results on lamps



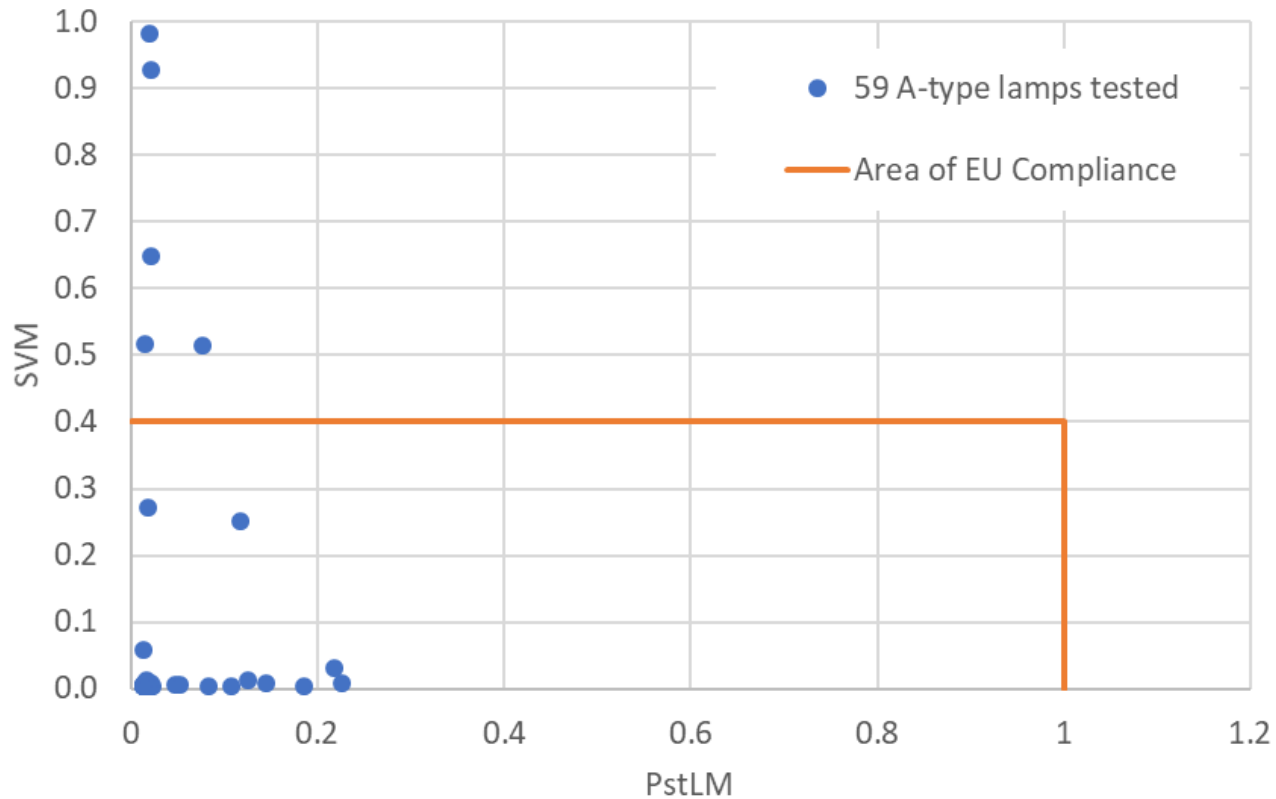
# European Lamps Tested by CLASP



	All	PstLM ≤ 1.0
All	59	59
SVM ≤ 0.4	47	47

80% models tested  
already compliant with  
requirements

# European Lamps Tested by CLASP (...zoom in)



Should the PstLM value be made more ambitious?

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# Recommended draft MEPS

- Draft requirements contained in draft MEPS document

Metric	Mandatory Requirements
Harmonics	Compliance with IEC 61000-3-2
Short term flicker indicator ( $P_{stLM}$ ) (for non-CFL)	$\leq 1.0^1$ at full load and a sinusoidal input voltage. Note: compliance with IEC 61547-1
Stroboscopic effect visibility measure (SVM)	$\leq 0.4$ at full load and a sinusoidal input voltage. Note: compliance with IEC TR 63158
<b>Photobiological risk group</b>	For the blue light hazard: PC0 or PC1 are allowed

# Thank you, any questions?

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