EMPIR Call 2020 – Fundamental, Industry and Normative

Selected Research Topic number: **SRT-n02**
Version: 1.0

Title: Metrology for temporal light modulation

Abstract

Modern LED lamps show fluctuations in the light output, which above certain limits, are known to have adverse effects on human health, well-being, performance and safety. This has been recognised by the European Commission, that has recently adopted the Ecodesign 'Single Lighting Regulation' with strict limits on the acceptable amount of flicker and stroboscopic effect. Consequently, guidance on accurate and reproducible quantitative measurements of temporal light modulation (TLM) is needed. Proposals addressing this SRT should target the development of standardised measurement methods and conditions to quantify TLM, which can support industry in their efforts to comply with regulations and investigate further the impact of TLM on humans.

Keywords

Temporal light modulation; temporal light artefacts; flicker; stroboscopic effect; phantom array effect; LED; solid-state-lighting; health & safety; Ecodesign regulation; photometry

Background to the Metrological Challenges

The introduction of solid-state lighting (SSL) covering the entire spectral range of vision has revolutionised the way indoor and outdoor environments are illuminated. The high energy efficiency of SSL (which is dominantly LED-based lighting) contributes to energy saving and reduces the environmental impact of lighting. However, SSL devices are known to show temporal variation of the light output. These temporal modulations of light generate effects, which above given thresholds, have negative impacts on human health, well-being and safety. International standards that provide guidance to regulatory bodies and manufacturers with appropriate limits on TLM and temporal light artefacts to serve human needs, are currently not available. Additionally, the traceability of TLM sources and sensors to national measurement standards, including uncertainty budgets verified by interlaboratory comparisons, is currently not realised.

Visual effects of TLM are known as temporal light artefacts. Flicker, the most well-known light artefact, is the direct perception of temporal changes of the light, while the stroboscopic effect, another temporal light artefact, is observed as a discretised motion of moving objects, resulting from illumination by a temporally modulated source. A third effect resulting from TLM is the phantom array effect (or ghosting), which corresponds to change in perceived shape or spatial position induced by saccadic eye movements across a temporally modulated light source. Currently, a general approach to measure and analyse TLM, based on the measurement and analysis of waveforms is missing. Consistency between measurements and reporting protocols of TLM waveform measurement would greatly improve the comparability of research results. While metrics for flicker and the stroboscopic effect have been recommended by CIE, no metric currently exists for the phantom array effect. Additional experiments are required to determine the visibility threshold of the phantom array effect and its dependency on properties of the light source, the environment and the eye movements. The lack of quantitative and traceable measurements with appropriate uncertainty budgets, and the need for worldwide harmonised measurements, has triggered the International Commission on Illumination, CIE, to put forward a research priority on metrology for TLM and to establish technical committees to work on this (CIE/TC2-89 and CIE/TC1-83).

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

The JRP shall focus on metrology research necessary to support standardisation in measurement of temporal light modulation.

The specific objectives are

1. To establish methods for traceable TLM measurement of individual light sources and luminaires with a focus on flicker and stroboscopic effect. These should be based on IEC TR 61547-1 and IEC TR63158 and include: (i) methods for generating and measuring optical waveforms in the time-domain and power spectra in the frequency-domain, (ii) calibration and characterisation of TLM measurement devices and the evaluation of uncertainty budgets, (iii) quality metrics (e.g. frequency response, dynamic range of signal) for the classification of TLM measurement instruments.
2. To validate the traceable TLM measurement methods, developed in Objective 1, through an interlaboratory comparison between metrology institutes and industrial stakeholders, whilst ensuring compliance with the new EU Eco-Design 2019/2020 regulation. To develop a recommendation on associated standardised measurement conditions.
3. To develop novel methods for measuring TLM of the illuminated environment in extended scenes (e.g. offices, roads or tunnels) and for multispectral TLM measurement of light sources.
4. To develop a model for the visibility of the phantom array effect based on perception experiments that measure the visibility threshold for various lighting conditions (e.g. modulation frequency, amplitude, shape of the modulation and light level). This model should be used to propose a suitable metric for the phantom array effect, to relevant technical committees such as CIE/TC1-83
5. To facilitate the take up of methods, technology and measurement infrastructure developed in the project by the standards developing organisations (e.g. CIE) and end-users (e.g. regulatory bodies, lighting industry and instrument manufacturers). This should include providing input to CIE/TC2-89 and CIE/TC1-83 and support for a new CIE/TC for addressing the measurement of spatially resolved TLM and colour TLM.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Regulatory body or Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects. The proposal must name a “Chief Stakeholder”, not a member of the consortium, but a representative of the user community that will benefit from the proposed work. The “Chief Stakeholder” should write a letter of support explaining how their organisation will make use of the outcomes from the research, be consulted regularly by the consortium during the project to ensure that the planned outcomes are still relevant, and be prepared to report to EURAMET on the benefits they have gained from the project.

Proposers should establish the current state of the art, and explain how their proposed research goes beyond this.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.8 M€, and has defined an upper limit of 1.0 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution across all selected projects in this TP.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the lighting sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically, the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work.

Time-scale

The project should be of up to 3 years duration.

Additional information

CIE identified this topic as one of their priorities. Details are available at:

https://msu.euramet.org/current_calls/pre_norm_2020/documents/cie_priority_001.pdf