2025 10th International Conference
on Energy Efficiency and Agricultural Engineering
5-7 November 2025, Starozagorski Bani, Bulgaria

Impact of Thruster-Induced Power Disturbances on LED Lighting in Shipboard Power Systems

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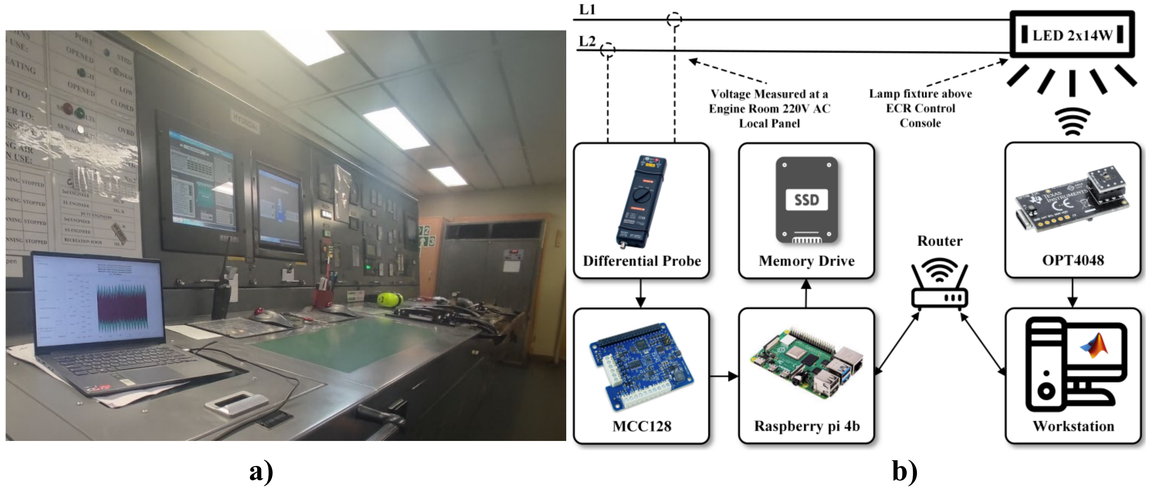
GOAL OF THE STUDY

The study investigates how thruster start-up operations affect LED lighting performance in shipboard power systems. Transient voltage sags caused by large propulsion loads can produce visible flicker and color instability. The goal is to quantify these effects through synchronized electrical and optical measurements onboard a cargo vessel, relating power disturbances to human-perceptible lighting fluctuations to guide the design of flicker-resistant marine lighting systems.

METHODOLOGY OF THE INVESTIGATION

Electrical and optical measurements were carried out in the ship's engine control room (ECR) at the engine control console (ECC), the workplace of the Engineer on Watch (EOW), during thruster operation (maneuverings). Line voltage was recorded using a differential probe and high-speed DAQ, while illuminance and chromaticity were measured with a calibrated OPT4048 sensor under LED lighting. Synchronized data allowed direct correlation between voltage, frequency, and light variations. Key parameters—voltage sag depth, percent flicker, flicker index, and chromaticity shift were analyzed against IEC/IEEE standards for perceptibility and compliance.



a) b)

Fig. 1. Engine control console (ECC) (a) and Measuring setup block diagram (b).

MAIN RESULTS FROM THE STUDY

During thruster start-up, a 6% voltage sag occurred, leading to a 23% reduction in illuminance and visible flicker with 18–20% modulation (Flicker Index ≈ 0.19). A slight chromaticity shift ($\Delta u'v' \approx 0.0048$) was observed, close to the human perceptibility threshold. Although voltage and frequency deviations remained within IEC and classification limits, the lighting variations were clearly noticeable to the crew, demonstrating that even compliant sags can produce visible flicker and color changes in LED lighting.

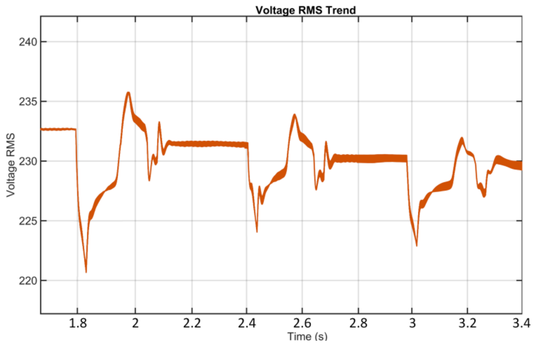


Fig. 2. . RMS voltage trend during three sequential thruster starts.

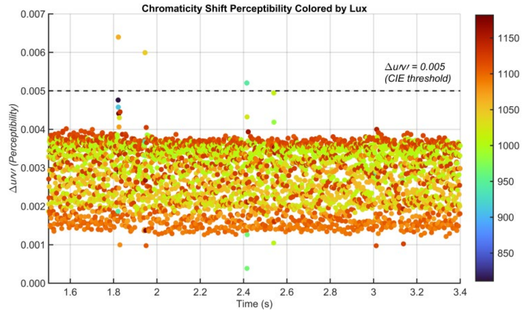


Fig. 3. Chromaticity perceptibility relative to CIE threshold.

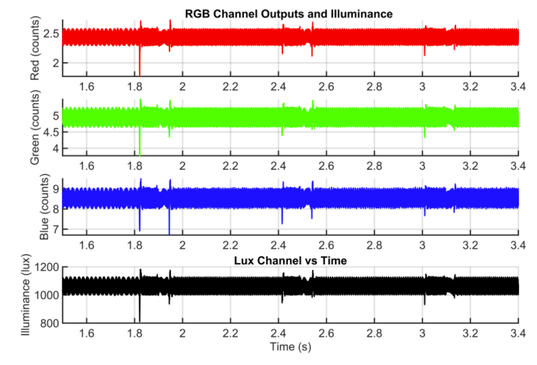


Fig. 4. Illuminance and RGB channel response in the ECRs.

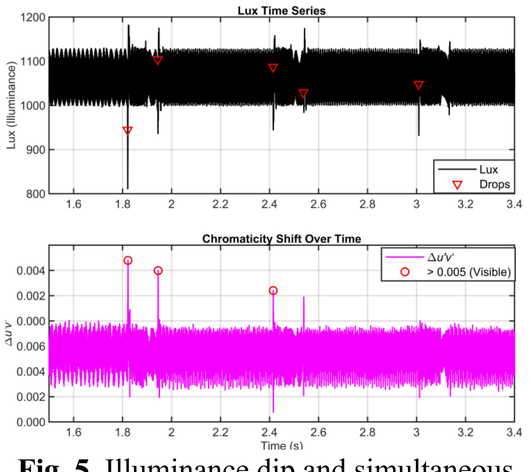


Fig. 5. Illuminance dip and simultaneous chromaticity variation.

CONCLUSIONS

The study confirms that transient voltage sags from thruster start-up can cause perceptible flicker and color variation in shipboard LED lighting, despite compliance with electrical standards. These findings highlight the need for improved transient mitigation, adaptive voltage regulation, and flicker-resistant LED drivers to enhance safety, comfort, and visual stability in marine environments.

ACKNOWLEDGMENT

This article was financed by the Ministry of Education and Science under the National Science Program "Security and Defense", carried out in implementation of the National

Strategy for the Development of Scientific Research 2017- 2030 and adopted by Decision of the Council of Ministers No. 731 of October 21, 2021. The material reflects only the author's opinion and the Ministry of Education and Science is not responsible for the content.