

Abstract

LED luminaires for modern day lighting application should be smart, wattage-independent in a given output power range, dimmable and fault adaptive to provide uninterrupted, energy-efficient, and cost-effective operation. On the other hand, the light controllers used in conjunction with the dimmable LED luminaires should be able to provide wireless control, fault-monitoring and spectral tuning to improve the features of the LED luminaire. However, all of these improvements should not come at the cost of electrical and photometric performance. Therefore, the performance of LED luminaires with or without light controllers should comply with the recommended standards. In this proposed research work, attempts are made to improve the features and performance of a LED luminaire and light controllers used in various lighting applications.

In the first stage, the design and performance evaluation of a smart, wattage-independent, fault-adaptive dimmable LED luminaire that has a wide output power range and is free from current imbalance of LED chips in the LED luminaire is performed. A Simulink model of the LED luminaire is simulated in Matlab-Simulink platform to test its electrical performance and verify its compliance with recommended standards. A mathematical model of the LED driver unit of the luminaire is also formulated to perform stability analysis. The operation of the simulated LED luminaire is satisfactory, stable in steady state and in compliance with relevant standards.

In the next stage, three light controllers with improved features and performance compared to previous light controllers are developed and tested.

The first one is a Fuzzy Logic Inference System (FIS) based closed-loop light controller that can control the position of window blind and amount of light output from artificial luminaires depending upon the amount of available daylight. The FIS is implemented inside a micro-controller and not on a computer, hence eliminating the need for dedicated computer and interfacing accessories. The developed FIS is validated through simulation in DIALux 4.13 lighting design software.

The second light controller is capable of varying the light output from the artificial luminaire based on ambient light and the presence of the user through wireless communication. It can also detect the place of origin of the fault (LED driver unit or lamp module unit) and convey the result to the operator. A hardware prototype of the designed controller is fabricated and tested in the laboratory and its performance is found to be satisfactory.

The third light controller possesses the ability to manually or automatically vary the luminous flux and CCT of light separately or simultaneously from multiple tunable-white LED luminaires using Bluetooth wireless communication with the help of a dedicated mobile app. The developed controller remains unaffected by wireless communication failure and input power failure. A hardware prototype of the light controller is developed and tested in real time for an indoor lighting scheme installed inside a test room. The results of the real-time testing show that the light controller is able to vary the luminous flux and CCT satisfactorily and has deviation within the recommended tolerable limits.