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# Performance of integrated systems of automated roller shade systems and daylight responsive dimming systems

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ABSTRACT

Daylight responsive dimming systems have been used in few buildings to date because they require improvements to improve reliability. The key underlying factor contributing to poor performance is the variability of the ratio of the photosensor signal to daylight workplane illuminance in accordance with sun position, sky condition, and fenestration condition. Therefore, this paper describes the integrated systems between automated roller shade systems and daylight responsive dimming systems with an improved closed-loop proportional control algorithm, and the relative performance of the integrated systems and single systems. The concept of the improved closed-loop proportional control algorithm for the integrated systems is to predict the varying correlation of photosensor signal to daylight workplane illuminance according to roller shade height and sky conditions for improvement of the system accuracy. In this study, the performance of the integrated systems with two improved closed-loop proportional control algorithms was compared with that of the current (modified) closed-loop proportional control algorithm. In the results, the average maintenance percentage and the average discrepancies of the target illuminance, as well as the average time under 90% of target illuminance for the integrated systems significantly improved in comparison with the current closed-loop proportional control algorithm for daylight responsive dimming systems as a single system.



## 1. Introduction

Daylight responsive dimming systems have immense potential to significantly reduce energy consumption in buildings, especially high-rise buildings with glass curtain walls. Such systems can save 16–70% of current annual electric lighting consumption, according to past field measurements and simulations [1–4].

Despite their significant technical potential, daylight responsive dimming systems have been used in few buildings to date because they require improvements to improve reliability. The key underlying factor contributing to poor performance (that is, underlit spaces) is the variability of $M_D$ (the ratio of the photosensor signal to daylight workplane illuminance) in accordance with sun position, sky conditions, and fenestration conditions. When the system is commissioned under a given arbitrary sun position, sky condition, and fenestration condition, this $M_D$ in the current control algorithm is set to a fixed value, which results in the design illuminance being undershot under other solar and fenestration conditions.

For daylight responsive dimming systems to be able to capitalize on the available daylight, shading systems are needed to block direct sunlight and introduce available daylight without causing a discomfort glare to occupants. Although $M_D$ varies according to shading system conditions, such as different venetian blind angles and roller shade heights, the current control algorithm uses a fixed $M_D$ at daytime calibration. $M_D$ varies as according to sky conditions as well. Therefore, the variation of $M_D$ with sky and shading system conditions should be considered in designing the control algorithm of daylight responsive dimming systems. Hence, daylight responsive dimming systems should be integrated with automated shading systems to predict varying $M_D$ according to shading system conditions, and the control algorithm for the integrated systems should consider varying $M_D$ with shading system conditions as well as with sky conditions for the system performance.

## 2. Background

Currently in general use is a modified closed-loop proportional control algorithm based on the conventional closed-loop proportional control algorithm, in which $M_D$ and $E_{Em}$ (maximum electric

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