Energy Efficient LED-Based Lighting of Multipurpose Outdoor Environments with Power Factor & Efficiency Correction

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Abstract— Nowadays, street lighting accounts for 53% of outdoor lighting use, and the market is continuously increasing. In the context of rising energy prices and growing environmental awareness, energy efficiency is becoming one of the most important criteria for street lighting systems design. LED-based lights have become the primary option for replacing conventional light bulbs, being digitally controllable, small, highly efficient, and cheap to manufacture. Advanced control strategies adapted to ambient conditions are needed to combine low energy consumption and high-quality light ambience according to changing specifications. This paper describes an outdoor lighting solution aimed at energy efficient performance in the context of multipurpose outdoor environments, where control is crucial in achieving efficiency improvements. The work addresses efficiency at the component level, by optimizing the performance of LED drivers, and at system level, defining the control strategy and associated hardware infrastructure. The approach designed was tested in a real environment. The performance of the lighting installation was assessed using the web-based monitoring application, providing real-time consumption information and aggregated historical data.

Keywords—LED lighting, resonant converter, web services, energy efficiency, smart lighting

I. INTRODUCTION

Outdoor lighting is an important functional and decorative component of built environments. Street lighting helps to ensure the safety of people in traffic and to prevent crimes. It even enables the efficient use of street space through informal self-regulation of the crowd. Nowadays, street lighting accounts for 53% of outdoor lighting use worldwide. Furthermore, the outdoor lighting market continues to grow.

In a context of rising energy prices and growing environmental awareness, the aforementioned trends call for improvements in street lighting efficiency. The two common approaches to efficiency and environmental friendliness in street lighting entail replacing light bulbs with more efficient ones and implementing advanced control scenarios considering multiple aspects of the designated areas. As far as retrofitting is concerned, LED-based luminaries are being more widely adopted for better luminous efficacy and the option for digital control.

Local governments have already recognized the cost reduction potential of outdoor lighting systems according to the PLUS project report, upgrading of the old conventional lights to LED in the German city of Leipzig achieved 74% energy savings. Controllable lights enable interactive lighting, which helps to optimize energy-saving schemes. In these cases, technological solutions are often accompanied with campaigns targeting environmental awareness, which has been proved to facilitate the acceptance of reduced lighting levels.

As LED becomes state-of-the-art technology in street lighting, it is very important to take full advantage of the technology and to avoid losing the cost-saving potential through excessive use of lighting. Control scenarios adapted to the environmental conditions are seen as the main solution to this problem. These scenarios leverage LED dimming capabilities and require a precise response to control commands. Therefore, the factors allowing efficiency improvement beyond the LED performance characteristics are: 1) LED luminaries driver performance; 2) control scenarios; and 3) control and communication infrastructure.

This presents a description of an outdoor lighting solution aiming at an energy-efficient performance in the context of multipurpose outdoor environments. Special attention is paid to power management of the light source and dimming command execution as well as high-level adaptive control intended to provide lighting according to the environmental conditions and activities detected in the area.

II. RELATED WORK

Light-emitting diodes (LEDs) have favorable features of smaller size, longer lifetime, lower maintenance costs, greater strength against breakage, and being mercury-free and therefore less harmful to our environment than traditional lighting sources [1]-[5]. Thus, LEDs have become increasingly common in our daily lives. They are well suited to indoor and outdoor energy-saving lighting applications, such as traffic lighting, background lighting, displays, street lighting, automotive and motorcycle lighting, decorative lighting, and so on [9]-[13]. The installation of street lights is closely related to the development of one area or region, and they represent the financial success of a city.

For street-lighting applications, the traditional lighting sources are high-intensity-discharge (HID) lamps, such as high-pressure sodium lamps and high-pressure mercury lamps. Recently, LEDs are commonly being used as new sources for street-lighting applications due to their attractive characteristics of good color rendering index (CRI), energy-savings, being mercury-free, quickly turning on and off, that they do not require a high striking voltage for starting the lamp up and an extra-high ignition voltage in the hot-restart status, and that they offer a long lifetime in comparison to their traditional counterparts [17]-[20].

Table I shows some comparisons between traditional and new lighting sources for street-lighting applications. The traditional lighting source is a high-pressure sodium lamp, and the new one is an LED lamp as an alternative option for street-lighting circumstances.

Table 1: Comparisons between traditional and new lighting sources for street-lighting applications

Items	Traditional	New
Lighting Source	High Pressure Sodium Lamp	LED
Lamp Model	OSRAM NAV-E 150	AcBel LM9003-003 G/GT
Power Consumption	150W	157.3W
Output Luminous Flux	14500 lm	12000 lm
Luminous Efficacy	97 lm/W	83 lm/W
Color Temperature	2000 K	5000~6300 K
Color Rendering Index (CRI)	≤25	70
Lamp Life	> 24000 hours	> 50000 hours

As shown in Table I, the LED lamp consumes less power and has better color-rendering index and longer lamp life than the traditional one. Instead of traditional HID lighting sources such as high-pressure sodium lamps and high-pressure mercury lamps, LED, which offers features of satisfying lighting efficiency, reduced power consumption, and long lifetime, will play an important role for streetlight applications in the future [6]-[8]. The conventional isolated driver for powering an LED street-lighting module with a rated lamp power of greater than 70 W is a two-stage topology [16], and consists of a boost power-factor-correction (PFC) DC-DC converter for input current shaping, and a half-bridge-type LLC DC-DC resonant converter for powering the LED street-lighting module [14].

Another traditional two-stage isolated driver for supplying an LED street-lighting module with a rated power of larger than 70 W; this version consists of an interleaved boost PFC AC-DC converter and a half-bridge-type LLC DC-DC resonant converter for powering the street-lighting module [15].

These conventional LED drivers are suitable for operating in a wide input utility-line voltage range and the voltage across the DC-linked capacitor can be controlled. However, more power switches and components are required in these conventional drivers, and the circuit efficiency is limited due to the two-stage power conversion. In response to these challenges, this paper presents a novel single-stage high-efficiency cost-effective driver with power-factor-corrections for supplying an LED street-lighting module.

III. PROPOSED WORK

The Energy provides two reference definitions used in defining energy policy and planning: 1) energy efficiency and 2) energy intensity. According to this definition, energy efficiency improves when the given level of service is provided with reduced amounts of energy inputs or services are enhanced for a given amount of energy input. Energy efficiency, is proposed in, where it is considered as a measurement of the performance of a device or system and defined as the ratio of output-to-input energies. So, we work on to increase the efficiency.

Energy-efficient performance of outdoor lighting systems has become a compulsory requirement. high-level adaptive control techniques are considered in connection with the process of dimming command execution. The important factor that should we increase is power factor. All this factor is related to led drivers. Another consideration for energy efficiency is to control light as per real time by the web monitoring.

The sensor monitors the environment and present light intensity and send data to server, then end user control the led based outdoor product as per real time light requirement for the energy saving. This can be achieved by sending end user signal to controller and this controller control the led driver for the required light of led product as shown in following figure 1.

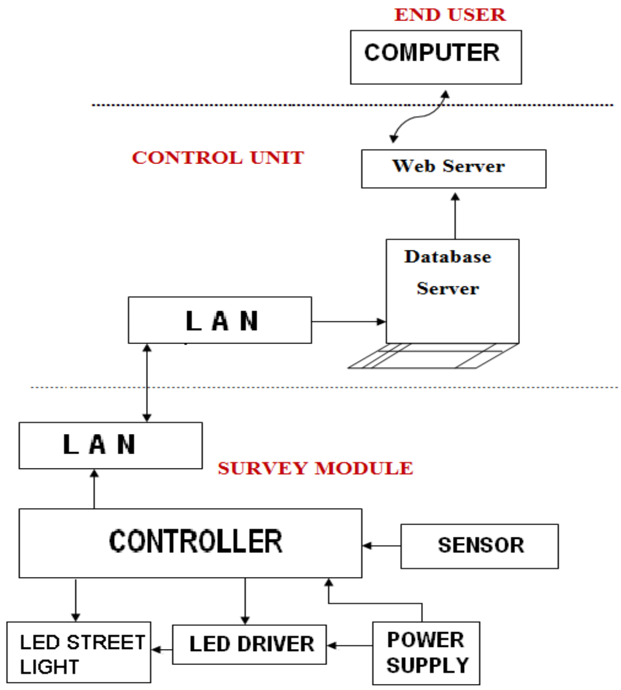

Figure 1: System Architecture

IV. CONCLUSION

Energy efficient performance of outdoor lighting systems has become a compulsory requirement. Adaptive distributed control is a crucial part of solutions aimed at energy efficiency. In this paper high-level adaptive control techniques are considered in connection with the process of dimming command execution. While the proposed approach demonstrably reduced energy consumption, future work should concentrate on enhancing user comfort, extending supported use-cases, and optimizing the communication infrastructure

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