

**POWER QUALITY IMPROVEMENTS IN LIGHTING
SYSTEMS**

by

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CERTIFICATE

It is certified that the thesis entitled “**Power Quality Improvements in Lighting Systems,**” being submitted by **Mr. Ashish Shrivastava** for award of the degree of **Doctor of Philosophy** in the Department of Electrical Engineering, Indian Institute of Technology Delhi, is a record of the student’s own work carried out by him under my supervision and guidance. The matter embodied in this thesis has not been submitted for award of any other degree or diploma.

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ABSTRACT

In the quest of energy efficiency improvement, researchers have developed many new artificial sources of light, right from early incandescent lamps to present generation light emitting diodes (LEDs). Incandescent light bulbs have been used for many decades, but they are inefficient as the bulk of electrical energy is converted into heat rather than light. High efficiency and low cost of fluorescent lamps make them an integral part of indoor and outdoor lighting in domestic, commercial, industrial, institutional and retail applications. Due to reduced size, compact fluorescent lamps (CFL) have been preferred in comparison to fluorescent lamps, but they are more costly. From past couple of years, LED lighting is growing at an incredible pace, as general purpose lighting due to many advantages such as high luminous efficacy, long life time, eco-friendliness (because of the absence of hazardous mercury contents), resistance to shock and vibration. It is also gaining wider acceptance in the automotive industries, decorative lightings, traffic lightings, aircraft lightings etc.

This research work aims at power factor correction in electronic ballast and LED driver for various low power lighting applications with universal AC mains. Fluorescent lamps and CFLs require electronic ballast for their ignition and stabilized current flow after starting under steady state condition. LED lamps require a driver circuit for controlling the current flow in them, as they do not require high ignition voltage. Efficient electronic ballast and LED driver should not have any adverse effects on the AC mains and the life of lamp load. The conventional electronic ballast and LED driver are fed from single-phase AC mains, through a diode bridge rectifier followed by a DC capacitor, which draws an uncontrolled charging current resulting into a pulsating current drawn from AC mains. This arises many power quality (PQ) issues such as poor input power factor (PF), high total harmonic distortion of AC mains current (THD_i) and high crest factor (CF). Moreover, various stringent international standards such as IEEE 519, IEEE 1159 and IEC 61000-3-2 impose limitations on the harmonic current emissions by various loads. Therefore, front-end power factor correction (PFC) converter based electronic ballast and LED driver are essential for different lighting loads in domestic and commercial applications.

Investigation has been carried out through Matlab simulation for the selection of most suitable PFC converter based topology for feeding T8 fluorescent lamp and compact

fluorescent lamp with an emphasis on power quality improvement (PQI) at universal AC mains. There are many DC-DC converter topologies available which can be used as PFC converters such as buck, boost, buck-boost, Cuk, SEPIC and Zeta converters. The control schemes used for power factor correction with these converters are current multiplier control in continuous conduction mode (CCM), voltage follower control in discontinuous conduction mode (DCM) and border line control in boundary conduction mode (BCM) of operation. The current multiplier control and border line control yield good results as compared to the voltage follower control at universal AC mains. In low power lighting applications, BCM is preferred as it utilizes lower inductor value as compared to CCM and lower peak current as compared to DCM. Moreover, BCM eliminates diode reverse recovery loss as compared to CCM, and hence it provides better converter efficiency.

In this research work, analysis, design, modeling, simulation and implementation of various PFC converters based LED lamp drivers for power quality improvement (PQI) at universal AC mains are also aimed for low power LED lighting applications. The other major emphasis has been given on investigation of better control and development of low component count, low cost and energy efficient LED lamp drivers. Optocoupler-less single-stage single-switch topologies based LED lamp drivers both in CCM and DCM are investigated for improvement in PQ at wide AC mains voltage variations. A new primary side sensing control (PSSC) with pulse frequency modulation (PFM) technique is implemented to operate both isolated and non-isolated PFC converters based LED lamp drivers in DCM with improved power quality at universal AC mains. Test results of the developed PFC converters based LED drivers have validated the simulation results and are within the mandatory regulation limits of international standards of lighting for low power applications.

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