International Journal of Latest Technology in Engineering, Management & Applied Science (IJLTEMAS)
Volume VII, Issue VI, June 2018 | ISSN 2278-2540

Designing of Model Predictive Control System For LED Flood Lighting

Nitin Mishra[1], Dr. Uday Panwar[2]
[1, 2]*Electronics & Communication, SIRT, Bhopal, MP, India*

Abstract: **- Model predictive control is a widely used method in process control. This paper presents a Novel MPC approach for the LED flood lighting system that handles the excessive heat generates due to LED operation by controlling the speed of fans attached. Apart from chemical, power system and power Electronics fields, first-time MPC system has been used for LED Flood lighting. As MPC requires very high computational speed for controlling the device under control therefore in this paper, FPGA is used as a controller.In order to calculate the performance of the proposed system both hardware (using T&M instruments) and software (simulation software) has been used.**

Keywords:**-Model Predictive control (MPC), Field Programmable Gate Array (FPGA), Analog to Digital Converter (ADC), Pulse Width Modulation (PWM), Light Emitting Diode (LED), PLC (Programmable Logic Controller).**

I. INTRODUCTION

Light emitting diode (LED) is a very commonly used light source today. Whether its office, home or in parties LED is now replacing conventional Light sources (such as incandescent light bulbs, CFL) everywhere. Its cheap reliable, lower power consumption with higher lumens. The table no 1 shows the comparison of a LED with conventional light sources.

Table No 1: Comparison of Light Sources

Bulb Type	Incandescent	CFL	LED
Lifespan (average)	1,200 hours	8,000 hours	50,000 hours
Watts of electricity	60 W	13-15 W	6-8 W
Lumens	800	800	800
Carbon Dioxide Emissions (30 bulbs per year)	4,500 pounds/year	1,051 pounds/yea r	451 pounds/year
Energy Efficiency	Very Low	High	Very High
Heat Emitted	8.5 BTU per hour	30 BTU per hour	3.4 BTU per hour

No doubt LED in every aspect is proving to be the best light source available with few exceptions (excessive heat Emission). Most of the low power LEDs that we use in day to day life is looks to be very cool during operation. But in reality, that's not true the radiant efficiency (total optical output power divided by total electrical input power) of LEDs is typically between 5 and 40%, meaning that 60-95% of the input power is lost as heat [1].

LED for a smaller system having less number of low power LEDs will emit very little heat, and this is perfectly fine and allowable. Ignoring heat emission for the bigger system having a large number of high power LEDs like led Flood lighting may not only results in loss of the complete system but may also the cause of serious hazards.

To address excessive heat emission in LED Flood lighting we have used the Model predictive control system that not only monitors the state and conditions of the system but also take the effective measure to make its temperature within a predefined set limit.

II. MODEL PREDICTIVE CONTROL ARCHITECTURE

Basically, Model Predictive Control System Consists of an MPC Controller, Device under control (in this case LED Flood Lighting System), System Model state estimator and Constraints as depicted in Fig 1.InitiallyMPC, is used only in medical, power and chemical industries because of their low speed but nowadays with high speed computing devices like FPGA, microcontrollers (32 bit) and PLC, it can easily be applied to any applications [2].

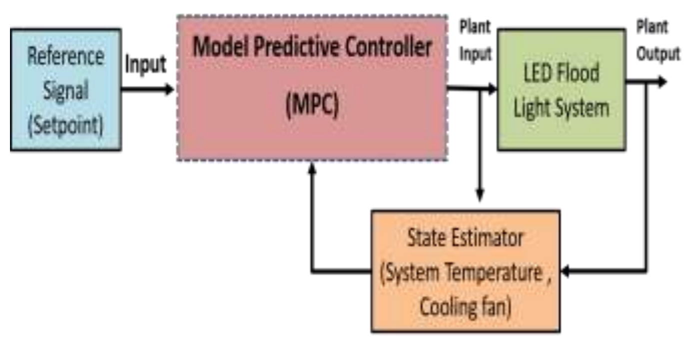

Fig 1: Architecture of Proposed Model Predictive Control system

III. OVERVIEW OF LED FLOOD LIGHTING SYSTEM

As discussed for high power LEDs (100-600 W) proper cooling arrangement must be installed before operation otherwise the efficiency of the system degrades. It must be noted that there are two types of cooling arrangement for LEDs they are:

(i) Passive cooling system: In Passive cooling methods the heat sink and thermal adhesives are uses to removes the generated heat.

(ii) Active cooling system: In active cooling external devices such as fans and proper housing removes the generated heat. It improves the life and performance of the system. But are costlier than the passive cooling system.

It must be noted that active cooling due to its superior performance over passive cooling is used.

Fig 2: Front View of Proposed LED System

The front view of the proposed system is shown in figure 2. It consists of total 8 High power LEDs connected both in and parallel connections to produce a very bright light for the outdoor environment.

Fig 3: Back View of Proposed LED System

While in Figure 3 Back view of the proposed system is shown. Here as described active cooling method is used. Therefore, two high speed fans are fixed at the back of the

IV. METHODOLOGY

The complete architecture of proposed MPC for LED Flood lighting is shown in figure 4. Here FPGA due to its high processing speed is used as the Master controller. While Atmega32 microcontroller is acts as a slave controller it takes the Analog readings of two LM35 Temperatures sensors (internal and external) and sends this to FPGA.FPGA on the basis of this further instructs microcontroller to set different cooling speeds of fans.

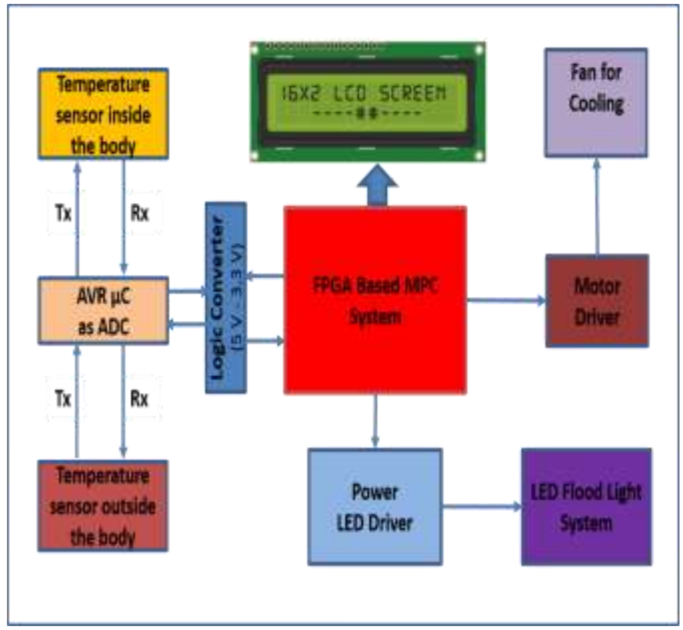

Fig 4: Architecture of Proposed MPC for LED Flood Lighting

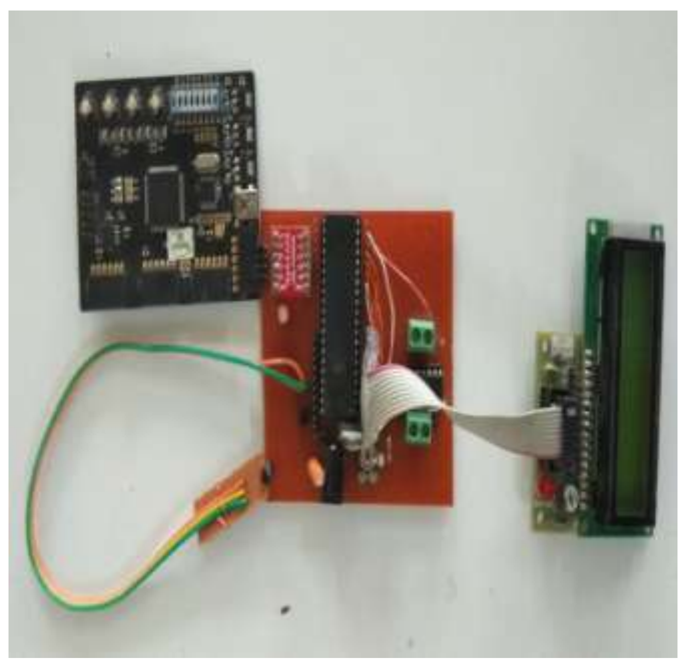

Fig 5: Complete circuit of LED Flood Lighting

V. SIMULATION RESULTS

The simulation results are shown in figure 6. As shown there are two temperature sensors (LM35) is used in the Internal and external area of the structure. On the basis of difference, various duty cycle has been selected.Information related to various levels is shown in table no 2.

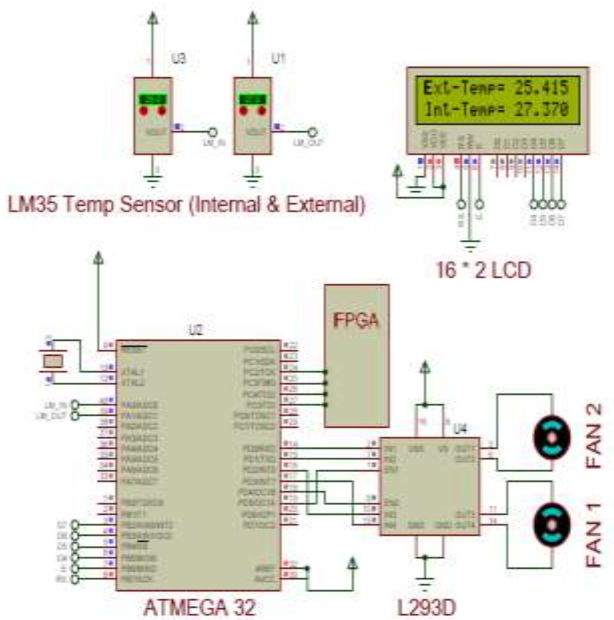

Fig 5: Complete circuit of LED Flood Lighting

Table No 2: Speed of Fans on the basis of Levels

Level	Temperature Difference (T_Int – T_Ext)	Duty Cycle
One	0°C to 10°C	25 %
Two	10°C to 20 °C	50 %
Three	20°C to 30 °C	75 %
Four	30 °C to 40 °C	100 %

VI. CONCLUSION

After developing MPC System for LED, it has been observed that very effective cooling is achieved by using the active cooling method. Also, a very small amount of energy is used for controlling speeds of the fan.

REFERENCES

[1] Taylor Scully https://www.ledsupply.com/blog/why-you-need-an-led-heat-sink
[2] Sergio lucia, Denisnevarro, Oscarlucia, Pablo Zometa, Ralph Findeisen "Optimized FPGA Implementation of Model Predictive Control for Embedded Systems Using High-Level Synthesis Tool " *IEEE Transactions ,2018.*
[3] Amir Hajiloo, Mohammad Keshmiri, Wen-Fang Xie, and Ting-Ting Wang "Robust Online Model Predictive Control for a Constrained Image-Based Visual Servoing" *IEEE Transactions On Industrial Electronics,2016*
[4] Yadollah Rasekhipour, Amir Khajepour, Shih-Ken Chen, and Bakhtiar Litkouhi presented a paper "A Potential Field-Based Model Predictive Path-Planning Controller for Autonomous Road Vehicles"*IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS*,2016
[5] Mike Huang, Kevin Zaseck, Ken Butts, Ilya Kolmanovsky presented a paper on "Rate-Based Model Predictive Controller for Diesel Engine Air Path: Design and Experimental Evaluation", *IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS,2015*
[6] Ozan Gulbudak, Janosch Marquart and Enrico Santi presented a paper on "FPGA-Based Model Predictive Current Controller for 3x3 Direct Matrix Converter" *IEEE TRANSACTIONS ON CONTROL SYSTEMS TECHNOLOGY,2014*