Digital Automation in Monitoring of Life Test setup of LED lamps using Embedded Systems

Vinay Kumar Mangalagiri, Nikhil S. Gujar, P. Srinivasa Varma

Abstract*: Indian Standard (IS 16102-2: 2017), stipulates test procedures to categorize the self-ballasted LED lamps. These procedures include life test and performance test. At present, life test procedure of LED lamps is being carried with manual supervision, camera observation and a digital timer. This paper proposes a new method to test the life of lamp based on automation. This paper also discusses about current sensing methods. The developed system will give LED lamp life. This entire test process is monitored and controlled using a Graphical User Interface which shows lamp status, life of lamp in hours, remaining time of test and test result. Developed system will minimize the human errors, removes manual supervision and gives accurate test results.

Index Terms*: IS 16102-2:2017, LED, embedded systems, automation, GUI.

I. INTRODUCTION

Light Emitting Diode (LED) is a type of semiconductor device which emits light when a sufficient potential difference is applied across it. When the current passes through the potential barrier, the electron-hole pair recombination takes place and the energy is released in the form of light.

Electroluminescence was discovered in 1907 by H.J. Round of Marconi Labs. In 1927, Oleg Losev reported the creation of first LED. In 1955, Rubin Braunstein reported on infrared emission using GaAs and other semiconductor materials, further an excellent observation is made by him that IR emitted by normal diode structure is detected by PbS diode up to specific distance by which optical communication was evolved, which is applied for the domestic appliances in their remote controllers.

In 1962, the first visible spectrum from the spectra of photon energy had been developed by a scientist named Nick Holonyak Jr. at General Electric. After this achievement, many other scientists developed the other ranges of spectral emission such as green, orange, red-orange, blue, yellow through diodes.

In the recent past with the improvements in the technological aspects, the LED based lamps are predominantly available in the market compared to other lighting devices. Due to several advantages in the LED such as low cost, high efficiency and more life span people are very much accustomed to these kinds of lamps rather than the conventional ones [1].

As the applications for LEDs are increasing day by day there is a need to improve the quality of LED to meet the demands of the several customers. For improvement in the quality of LED, they should undergo several testing procedures. The testing methods and their procedures are prescribed by Indian Standards. Two of the important testing procedures of LEDs in Indian Standards are life test and performance test. IS 16102-2:2017 [2] [3] clause 13 illustrates about the former. Before starting the testing procedure, the initial lumens of lamp are to be measured and the lamp is then made to glow for a period of 1000 hours after which the luminous intensity measured is noted down again. The procedure mentioned above continues till the duration of 6000 hours. Life of lamp is considered such that the lamp should provide 70% of its rated luminous intensity for a specific amount of time under standard test conditions. Previously the above described test procedure was carried out manually in which a dedicated engineer would monitor the time stamp of each lamp, in case of any failure of the lamps at any stage of testing, the visuals can be recorded by a highly sensitive camera placed inside the laboratory setup. There are several disadvantages with the manual operation of the test setup such as human error, less accuracy, etc. To overcome the above disadvantages the testing procedure, need to be switched from manual operation to automatic operation. In this paper a detailed discussion is carried out about automated life test setup of LED lamp using embedded systems.

II. DEVELOPED SYSTEM

The proposed system in this paper is a self-intelligent system which have the capability to make a decision based on lamp condition. Once the lamps are placed in the testing conditions the engineer initializes the command switch from GU interface, the system monitors the lamp conditions for a period of 1000 working hours.

A. Block Diagram

The schematic block diagram of the proposed system is shown in fig. 1. Microcontroller acts a main operating unit of the system to send command signals to relay module and also sense current signals from current sensor. It also displays lamps life in hours, lamp status, remaining test time and test result after the test is completed in a well-designed unique GUI. Microcontroller is powered with DC supply of 5V as shown in fig. 1. General Purpose Input Output expander is used to have control over more lamps. Microcontroller [4] uses I2C communication protocol to have more GPIO expanders to interface, optocoupler is used to sense the current drawn by lamp.

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When a command signal is given to microcontroller from GUI, microcontroller sends a signal to GPIO expander to close the relay. Opto-coupler detects the presence of current in the circuit as shown in fig.2. The signal from current sensor is sent to microcontroller, which reads time from RTC. After that, microcontroller monitors the signal from current sensor continuously for 1000 hours. If lamp is failed in between the test process, microcontroller sends trip signal to the relay module and resets the timer. Similarly, if lamp completes 1000 hours test, controller sends trip signal to relay, simultaneously sends lamp life and test result data to GUI in either cases of lamp failure or completion of test [5].

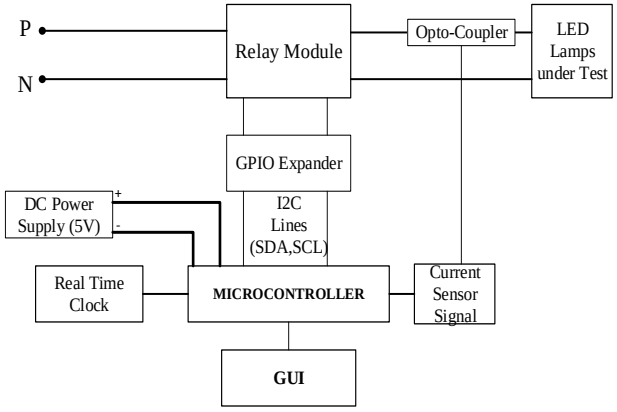

Fig. 1 Block Diagram

B. Microcontroller

Developed system contains microcontroller from AVR family. Arduino Mega 2560 shown in fig. 2 is good enough for this application. It is 8-bit RISC based microcontroller with a flash memory of 256Kb. It has 54 GPIO pins, 15 PWM pins, 6 internal timers, I2C, SPI communication protocols and a 10-bit 16 channel ADC [6].

Using I2C communication, controller performs following functions such as communication with GPIO expanders to have control over a greater number of GPIO pins, receives data from the Real Time Clock.

Using UART communication protocol, the transmission and reception of data from the GUI is done.

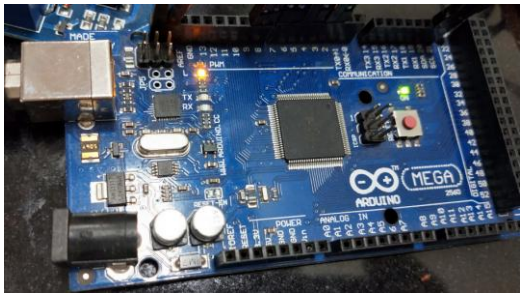

Fig. 2 Arduino Mega 2560

C. GPIO Expander

A simple and economical way to monitor and control several peripheral signals is to use General purpose input and output expanders. In the proposed system, PCF8575 chip based GPIO Expander as shown in fig. 3 is used. PCF8575 [8] GPIO has an operating voltage range of 2.5-5.5 V. It is a 24-pin IC which can be addressed using 3 hardware address pins combinations. The I/O ports of the device is designed in such a way that 16-bit address can be transmitted or received from a two-line bidirectional bus, each quasi bidirectional I/O can be used as an input or output port. Using this we can overcome the barrier of limited GPIO pins in the controller board.

GPIO expanders receive signal from controller and control the relay module. Using these GPIO expander, system can have control over 128 lamps i.e. each IC can control 16 lamps and microcontroller can control 8 ICs with different addresses from (0x20 – 0x27).

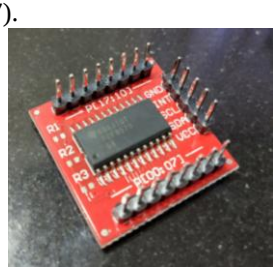

Fig. 3 GPIO Expander (PCF8575)

D. Real Time Clock (RTC)

The Real Time Clock (DS3231) as shown in fig. 4 is a low cost, accurate device which requires a voltage of 3.3V and is incorporated with a 3V battery input (CR2025) to maintain accurate time counting even if the power supply to the device is interrupted.

Fig. 4 Real Time clock

E. Current Sensing Unit using Opto-coupler (PC814)

Current sensing unit as shown in fig. 5 is developed using opto-coupler (PC814) to sense the flow of current through LED lamp.

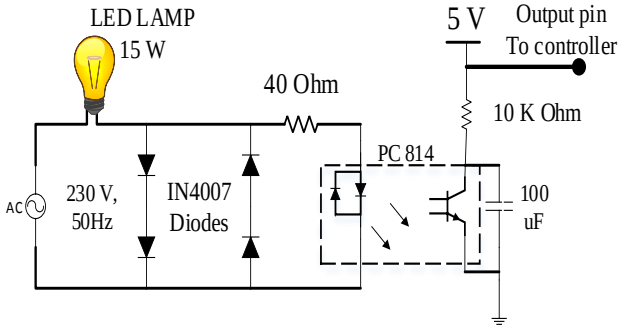

Fig. 5 Current sensing unit using Opto-coupler

There are various current sensing methods like using shunt resistor, current transformer and hall effect sensor. Shunt resistor method is the most economic method but it doesn't provide isolation between high voltage and low voltage circuit. Hall effect sensors and Current transformer sensors provide isolation, but they are expensive. So, a cost effective isolated current sensing unit is developed using opto-coupler [7] to detect the presence of current flowing through the circuit as shown in fig. 5

F. Relay Card

Relay card is a connection of number of relays in parallel controlled by a microcontroller unit. The basic operating principle of a relay is to make or break the circuit by receiving the command signal from the controller. An 8-channel relay card [9] is used in the developed system as shown in fig. 6.

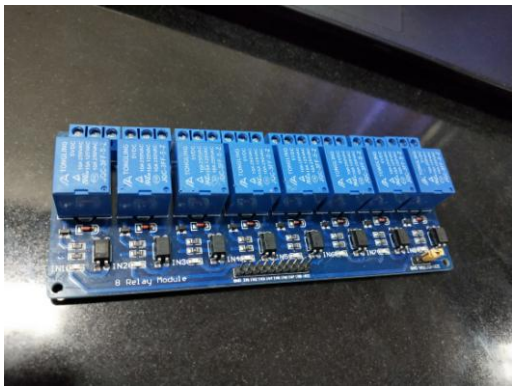

Fig. 6 8-Channel Relay Card

G. Graphical User Interface

GUI is a user interface used to ease the operation of electronic devices by the user through graphical icons and visual indicators. The GUI used in the proposed system is Azande studio which is best suited for Arduino applications. The microcontroller transmits data regarding the lamp status, lamp life in hours, remaining test time in hours, test result to GUI and receives commanding signal of switch from GUI [10] as shown in the fig. 7.

Fig. 7 GUI to monitor and control 8 lamps

III. SYSTEM OPERATION

The proposed system operation is discussed in this section with the help of a flow chart as shown in the fig. 8. The system is initialized along with the GUI unit using a command prompt signal. After the initialization of the GUI, it checks for the condition that whether the signal for switching the lamp is given or not. If the signal is not given, then the controller waits for the signal. If the condition is satisfied then the relay is made to close and lamp status, lamp life in hours and remaining test time in hours is displayed in the GUI.

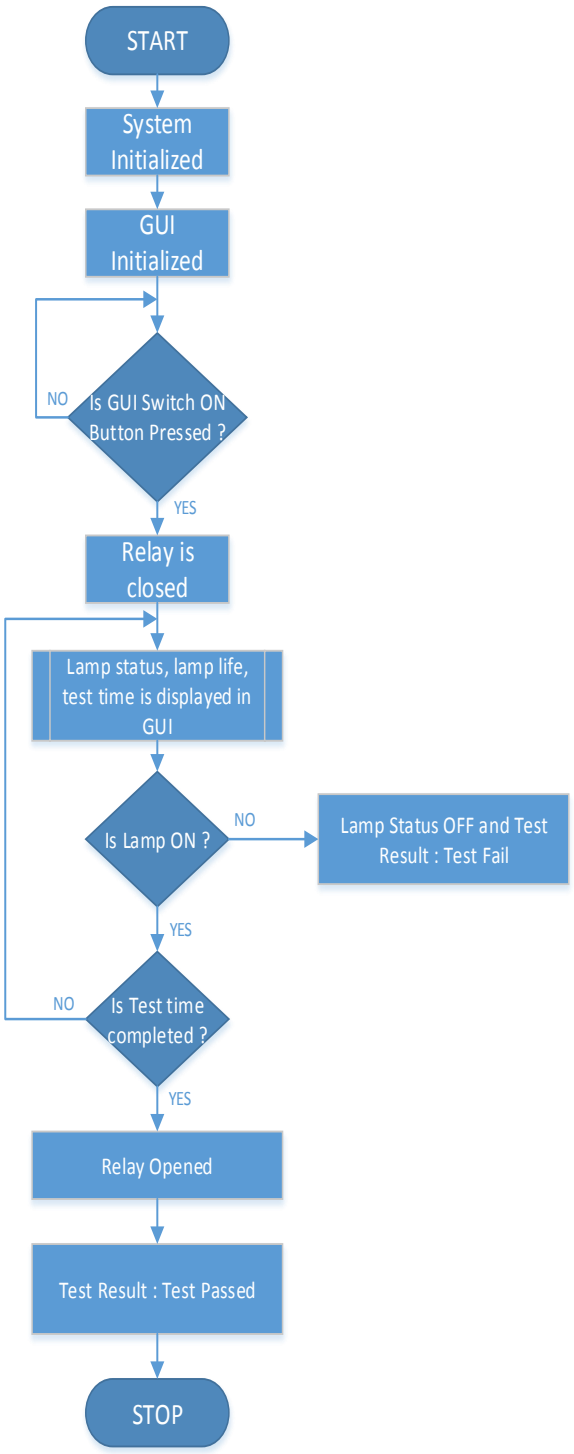

Fig. 8 Flow Chart

Once the data is registered in the memory, the controller verifies whether the lamp is in ON state of operation or not. If the lamp is not in ON state, lamp status OFF & the test result is declared as TEST FAIL by the controller and is displayed in the GUI screen. Otherwise the controller compares the remaining test time with the reference time which is 1000 hours. If the test time reaches the reference time then the relay is opened, the test result is declared as TEST PASSED and the process stops. Else, iterates in the same loop as shown in fig. 8.

IV. EXPERIMENTAL SETUP

An experimental setup is developed to test 8 lamps as shown in fig. 9. Microcontroller is interfaced with PCF8575, RTC, relay card and current sensing unit. For experimental purpose 8 lamps are arranged in the test setup. AC supply of 230V is supplied to both lamps and also to SMPS which is shown in fig. 9.

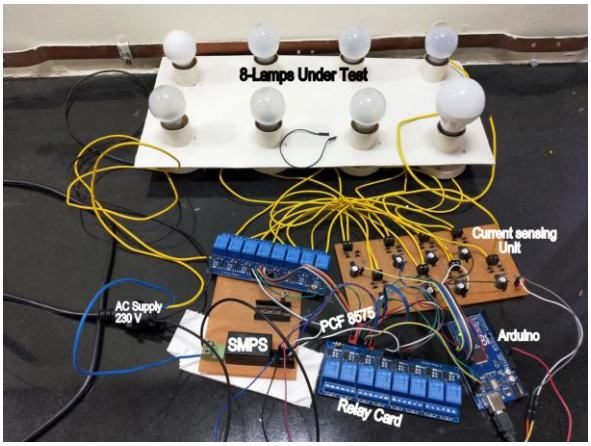

Fig. 9 Experimental Setup

V. RESULTS

A. Controlling and monitoring lamps using GUI

LED lamps are switched ON for testing, the time period of testing is 1000 hours by pressing the switches in GUI. Controller turns ON the particular lamp by receiving command signal from GUI. All lamps are turned ON. Simultaneously their lamp status, lamp life in hours and remaining test time in hours are displayed in GUI as shown in fig. 11. Test runs continuously for 1000 hours. Incase of lamp failure relay of that lamp is opened and its life is displayed in lamp life column.

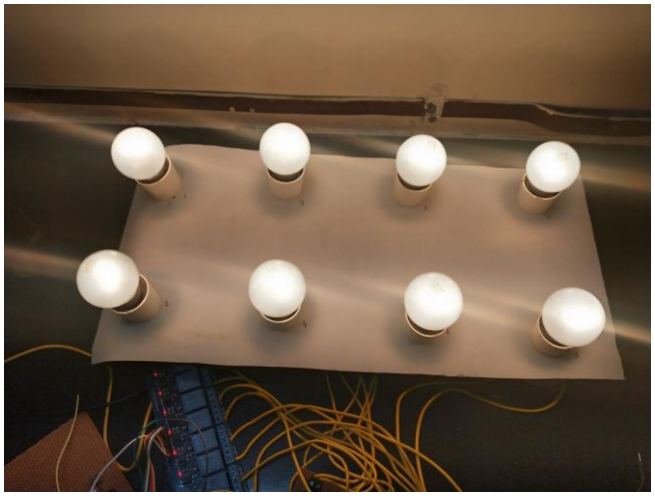

Fig. 10 Switching of lamps

As shown in Fig. 12, lamp1 is failed, the report is shown in the GUI screen as lamp status is OFF. The test result is given as test FAIL, while the test for the other lamps are running continuously without any interruption. Fig. 13 shows the test report for lamp1 as FAIL and its lamp life is computed and shown as 4 hours.

Fig. 11 GUI with lamp status, lamp life, with respect to fig. 10

Fig. 12 Lamp 1 failed to glow for 1000 hours

Fig. 13 Lamp1 failed and test result displayed

The remaining lamps completes their test successfully without any failure. The report is shown in the GUI screen as the lamp status OFF and the test result is given as test PASS,

Fig. 14 shows the completion of the test process and the test report for these lamps are shown in Fig. 15.

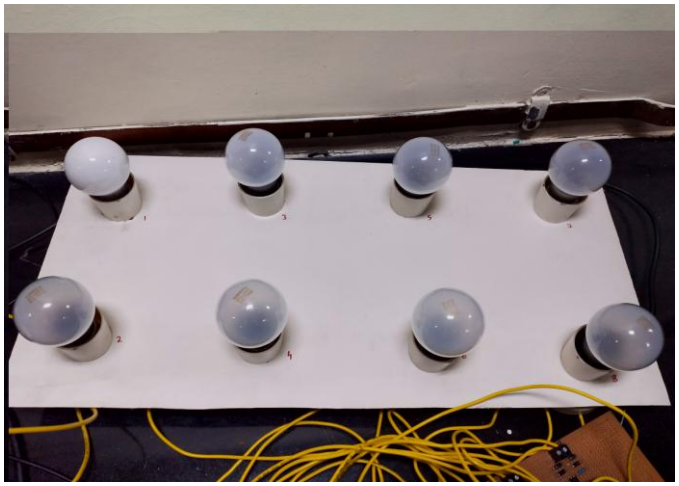

Fig. 14 All lamps completes 1000hours test

All the lamps status is OFF in fig. 15 with respect to the fig. 14, lamp life of the failed lamp and also test passed lamps are shown in the lamp life column. Test results for the tested lamps are shown in the test result column.

Fig. 15 Lamps completes 1000hours test and test result is displayed as pass.

VI. CONCLUSION

In this paper, IS 16102-2:2017 LED life testing method is discussed and an automated system is developed. This system is proposed for the life test setup of LED lamps, which minimizes the human errors during the test procedure.

A novel current sensing method is developed using optocoupler which is most cost effective when compared with other current sensing methods.

The developed system is controlled and monitored in a GUI which eases the life testing of led lamps. Developed system is discussed in detail with results.

This system can be further developed using IoT by sending test result report through emails to concerned supervisor.

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