An Approach to Implement Lamp Dimmer System Using PSoC 3

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Abstract: **Today, people are more concerned about home automation which is the residential extension of "building automation". A home appliances control system integrates control of many electrical devices in a house with a single control. With the invention of the microcontroller, the cost of electronic control can be reduced rapidly. Remote and intelligent control technologies can be adopted as they offer the end user easily accessible and/or greater control of home appliances. The aim of this project is to build home appliances control system such as the controlling brightness of lamps and speed of fans at lowest prices using PSoC CY8C38KIT development kit by 'Cypress Semiconductors'. Proposed system includes wired control of lighting with various degrees of intelligence and automation which also provides greater degree of comfort, ease and energy efficiency.**

Keywords: **Maximum Power Point Tracking, Sun Tracking, Battery Health Management, Monitoring, Overall System Design.**

I.   INTRODUCTION

Home automation has been a feature of science fiction writing for many years, but has only become practical since the early 20th Century following the widespread introduction of electricity into the home, and the rapid advancement of information technology. Home automation refers to the use of computer and information technology to control home appliances and features (such as fans or lighting). Such systems can range from simple remote control of home appliances to complex computer/micro-controller based network control with varying degrees of intelligence and automation. Home appliances control is adopted for reasons of ease, security and energy efficiency. In modern construction in industrialized nations, most homes have been wired for electrical appliances. Many household tasks can be automated by the development of specialized appliances. As the number of controllable devices in the home rises, interconnection and communication becomes a useful and desirable feature.

An automated home can be a very simple grouping of controls, or it can be heavily automated where any appliance that is plugged into electrical power is remotely controlled. Costs mainly include equipment, components, furniture, and custom installation. Ongoing costs include electricity to run the control systems, maintenance costs for the control and networking systems, including troubleshooting. Increased complexity may also increase maintenance costs for networked devices. Besides the upcoming standardization of home automation hardware, there is also the issue of the control software. In older systems (and some contemporary ones), the control of each home appliances control system needed to be done separately, and there was thus no central control system. This sometimes led to a great amount of remote controls, one being needed to control each individual part of the system. However, with the help of microcontrollers such as Programmable System on Chip (PSoC), the central control for all home appliances can be provided. Adopting capacitive sensing of PSoC as an interface technology in high-volume, high-visibility applications create demand in more conventional consumer electronics. This demand has led to significant innovation in home appliances control systems.

Since the invention of the light bulb, the ability to control the brightness of lights has been important and convenient in households and facilities around the world. These common devices are able to regulate voltage levels to the light source and subsequently, control light intensity. Since the first standard light dimmer was built in 1961, many different types of dimmers have been put in use. Earlier dimmers were controlled by larger panels, leading to high levels of power

consumption and greater risk of accident. Thyristor dimmers were introduced to solve these problems, using smaller and less powerful cables. Today's modern dimmers are controlled through a digital control protocol system, enabling one wire to control multiple light devices. Our own dimmer is controlled by PWM (Pulse-Width Modulator) which regulates the voltage sent to the LED, thus causing it to "dim" or "brighten" [10].

How does the flip of a switch or the slide of a finger change the brightness of lamp? The solution is an embedded system that combines any computer programming language with compatible hardware. Lighting control in home appliances control system can be used to control household electric lights. These switches turn on/off lamp providing additional service functions, such as brightness control, gradual lamp turn-on/off for better visual effects and prolonging incandescent lamp life, or remote lamp control[6]. Examples include extinguish all the lights of the house at a predetermined time and date range, turn the light on or off with the use of a wired or remote wireless device, control the brightness of the lights according to the level of ambient light available or other criteria and change the ambient brightness of a room via the lights used (mood control).Fan control in home appliances control system can be used to control household electric fans. Examples include extinguish all the fans of the house, turn the fan ON or OFF with the use of a wired or remote wireless device and control the speed of the fan.

PSoC CY8C32KIT development kit is a true system level solution providing microcontroller unit (MCU), memory, analog, and digital peripheral functions in a single chip. The PSoC CY8C38KIT development kit offers a modern method of signal acquisition, signal processing, and control with high accuracy, high bandwidth, and high flexibility. It can handle dozens of data acquisition channels and analog inputs on every general-purpose input/output (GPIO) pin. It is also a high-performance configurable digital system with some part numbers including interfaces such as USB, and multi master inter-integrated circuit (I2C). In addition to communication interfaces, it has an easy to configure logic array, flexible routing to all I/O pins, and a high-performance single cycle 8051 microprocessor core. Only few external components would be required[3].

II.   LIGHTING CONTROL

Light Dimmer Block Diagram: The Light Dimmer consists of the following blocks: AC zero crossing detector, PSoC's CPU core for general control, power supply, CapSense slider for load power control[1].
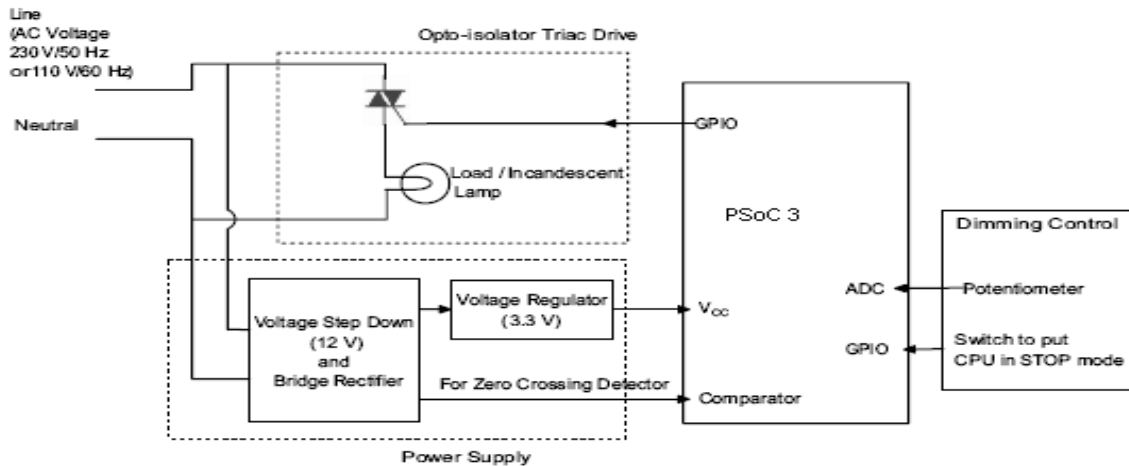

Figure 1. Block diagram of Lamp Dimmer

III.   PHASE-ANGLE ADJUSTMENT POWER CONTROL

Control techniques for mono phase motors or any AC load are based on phase-angle adjustment. The phase control operation principle lies in controlling triac turning on phase within AC supply period. This principle is shown in *Figure 2*. The delay variation between AC Zero Crossing signal and triac turning on time is used to control the amount of power provided to lamp.

The TRIAC is turned ON by the control signal coming from the microcontroller with some delay after the zero crossing, and automatically turned OFF when its current reaches a zero value. This behavior is the same for positive and negative voltage.
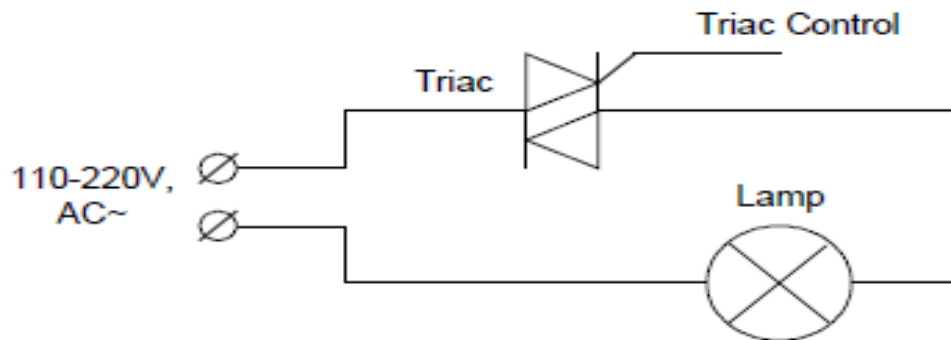
Figure 2. An interconnection circuit of Triac and Lamp

IV. POWER SUPPLY CIRCUIT

A dimmer power supply is implemented using the LM 315 AC-DC regulator, from Power Integrations [1]. Usage of CapSense requires stable PSoC power supply [2]. That is why the linear regulator has been used to form the clear 5 V supply.

The F1 self-recovered fuse serves two functions: it protects from possible over currents and its resistance limits the inrush current at power-on. The versatility of the board allows for the EMI filter to be designed as a CLC connection (Π element) to reduce the noise coming from the board to the mains[5].

V. ZERO CROSSING DETECTORS

The zero crossing detector is made using OPAMP OP07N and the output signal of zero crossing detector is connected to the P3[0] of the PSOC 3. The connector is provided on the board to program the PSOC 3, making it easier to configure the switch feature. The zero crossing detection operation is shown on Figure
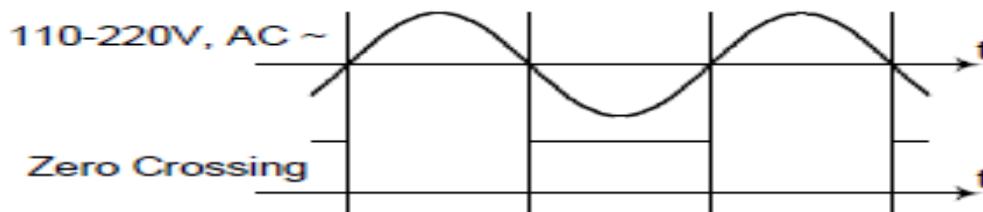

Figure 3. The Timing Diagram of "Zero Crossing" Signal

VI. DRIVING THE TRIAC

Solid-state light dimmers work by varying the "duty cycle" (on/off time) of the full AC voltage that is applied to the lights being controlled. For example, if the voltage is applied for only half of each AC cycle, the light bulb will appear to be much less bright than when it get the full AC voltage, because it gets less power to heat the filament. Solid-state dimmers use the brightness knob setting to determine at what point in each voltage cycle to switch the light on and off. There are two types of control normally used:

On-off control — TRIAC switches connect the load to the AC source for a few cycles and then

disconnect it for another few cycles of the source voltage.

In phase control — TRIAC switches connect the load to the AC source for a moment in each cycle.[5]

Here, the on-off control is used. the exact time when the triac is triggered relative to the zero crossings of the AC power is used to determine the power level. When the the triac is triggered it keeps conducting until the current passing though it goes to zero (exactly at the next zero crossing if the load is purely resistive, like light bulb). By changing the phase at which the triac is triggered will change the duty cycle and therefore the brightness of the light.

Several ports of the PSOC 3 have high-current capability of up to 41 mA, which in some applications is enough current to drive the TRIAC directly with just one port. Triac is driven by short pulses for power consumption optimization. These pulses are generated by PSoC and are differentiated by CR network. Triac is turned on by series from 3 pulses. At full brightness triac turning on time is some delayed from zero-crossing event to guarantee reaching the minimum triac turning on voltage. This scheme provides stable operation if AC mains signal is noised.

VII.   DIMMER FIRMWARE- TRIAC CONTROL

The controllable delay between zero-crossing signal and triac turning on is used to control the brightness of fluorescent lamp. The delay is generated by a 16 bit fixed function Timer user module for low-jitter operation. The interrupt is triggered at the rising edge of the system clock on timer count. The interrupt handler restarts the Timer with appropriate period value, depends on required delay.

Initially PWM generates a first pulse with delay, set by expected brightness level. Once delay

Interval expiration, the PWM registers are reloaded for generation series triac turning on pulses with 340us pulse duration and 170us interval between them. After 3 pulses generation PWM disables itself and is re-enabled by following zero-crossing interrupt.

VIII.   LAMP LIGHT INTENSITY LINEAR CONTROL

The incandescent lamp power is not linearly proportional to the triac turning on delay (shown in Figure) due sinusoidal AC mains current waveform nature. The human eye has logarithmic visible brightness vs. lamp brightness; also lamp visible brightness is non-linear function from applied voltage RMS value via variation lamp resistance due lamp coil temperature change[3].

The proper components such as an LCD (Liquid Crystal Display), CapSense Module, and PWM (PulsWidth Modulator) are placed in top design of the project and are configured as per the requirement. The LCD displays a output device number as well as the percentage of brightness of lamp. The board understands where the finger is because of the CapSense Module, which allows programmable touch-sensing[2].
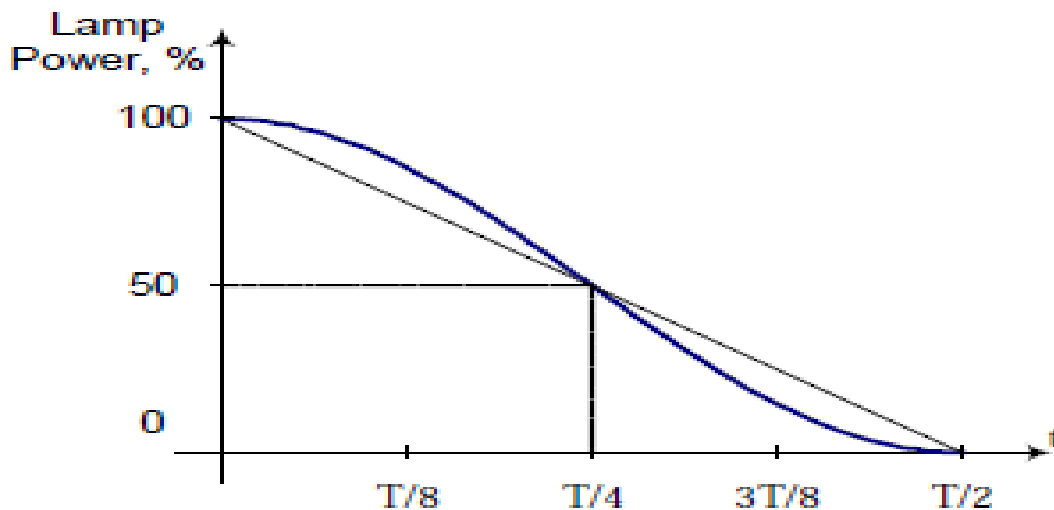

Figure 4. Lamp Power vs. Triac Turning on Delay

This technology is developed by Cypress semiconductors consists of two buttons and a slider which detect the position of any touch, which it takes in as the input. We programmed touches at five spots of the slider to cause the lamps to brighten or dim to a certain level, which is the device's output[2].

The Lamps' brightness is controlled by the PWM. The PWM is an internal element of our PSoC board, and is simply a means of controlling how much voltage is sent where within a certain time. We used the PWM to alter the Lamp's brightness by turning electrical signals on and off at different rates in certain periods[2].

IX.   HARDWARE

Cypress' CY8C32KIT PsoCEval Board contains several unique components – CapSense Sensors, an LCD module, and an ICE Cube USB connector port to name a few. For this project, an advantage of the CapSense technology is taken to create a device that controls the intensity of a lamp. The CapSense sensors detected touches at various spots, causing the LEDs to change in brightness. Finally, the LCD module displays where the touch occurred.

X.   SOFTWARE & FLOWCHART

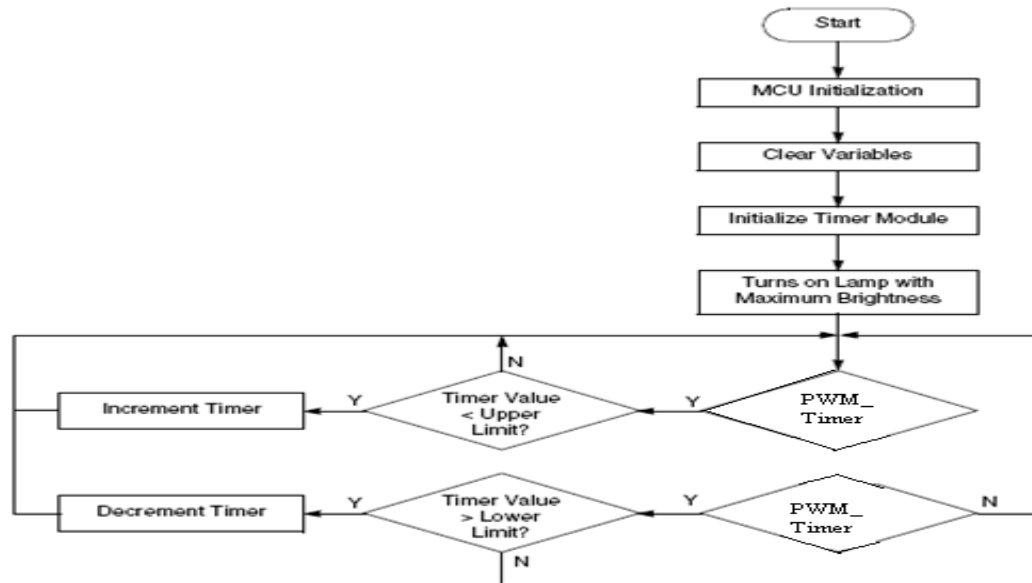The flowchart for proposed system is drawn below in fig.

Figure 5. Flowchart of Lamp Dimmer system

We have written the code using PSoC Creator 1.0. We programmed our software to our device using the program PSoC Programmer 3.12.5. This program was designed by Cypress Microsystems and relies on C Programming code as its programming language as well as the ImageCraft compiler. PSoC Programmer 3.12.5 is not a perfect program – it containSs several bugs, such as an inconsistent debugger– but adequately helped to implement the necessary code to create a finished working product.

XI.   CONCLUSION

Although there are many ways to dim any light, there exists one method that is most efficient: Pulse width modulation, or PWM, can effectively control the pulse width and duty cycle causing the lamp light to vary its intensity. This technique works by turning the lamp off for a certain period. To produce an increased dimming effect, the lamp will remain off even longer.

Originally, dimmer has been designed for incandescent lamps control. Without any modifications device can be used for control speed of universal motors in various applications. That is good chance to replace the potentiometers with capsense control.

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