

Implementation of Lamp Dimmer and Fan Controller System: A PSOC Approach

Madhura Mohan Arole¹, Dr. Gengaje S.R.²

¹Department of Electronics Engineering

Walchand Institute of Technology,

Solapur, India, 413006.

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'. PSoC CY8C32KIT development kit is a true system level solution providing microcontroller unit (MCU), memory, analog, and digital peripheral functions in a single chip. 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:- Lighting Control, Phase-Angle Adjustment Power Control, Power Supply Circuit, AC Motor Speed Control, Dimmer Firmware- TRIAC Control, Lamp Light Intensity Linear Control

I. INTRODUCTION

In the age of communication and information technology there are tremendous impacts on globalization that affect our life. Undoubtedly electricity has played an important role in empowering our life towards better future and prosperity. There is about 99 percent of Indians use electricity in their daily life. For instance, we use electricity for many of the home appliances.

Light energy is a basic requirement for the existence and development of human life. Dimmers are devices used to lower the brightness of a light. By changing the voltage waveform applied to the lamp, it is possible to lower the intensity of the light output. Although variable-voltage devices are used for various purposes, the term dimmer is generally reserved for those intended to control light output from resistive incandescent, halogen, and more recently CFLs and LEDs. More specialized equipment is needed to dim fluorescent, mercury vapor, solid state and other arc lighting [2].

Early dimmers were directly controlled through the manual manipulation of large dimmer panels. This required all power to come through the lighting control location, which could be inconvenient and potentially dangerous for large or high-powered systems. Dimmers with direct manual control had a limit on the speed they could be varied at but this issue has been largely eliminated with modern digital units. AC voltage regulators have a constant voltage ac supply input and incorporate semiconductor switches which vary the rms voltage impressed across the ac load.

These regulators fall into the category of naturally commutating converters since their thyristor switches are

commutated by the alternating supply. In early days, typical AC voltage regulators were used to vary the speed of ceiling fan [4]. In modern technology, along with wired control using TRIACs, we can also remotely control the speed of AC fan. Various microcontrollers are available in market which can be used to control the brightness of fluorescent lamps as well as the speed of an AC fan and to switch it on and off [10].

Dimmers are devices used to lower the brightness of a light. By changing the voltage waveform applied to the lamp, it is possible to lower the intensity of the light output. Although variable-voltage devices are used for various purposes, the term dimmer is generally reserved for those intended to control light output from resistive incandescent, halogen etc. TRIACs are used instead of SCR thyristors in lower-cost designs but do not have the surge-handling capacity of back-to-back SCRs and are only suitable for loads less than about 20 amps. The switches generate some heat during switching and can cause interference. Large inductors are used as part of the circuitry to suppress this interference [2].

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. 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. Electronic and electrical equipment in the home or commercial buildings have largely been discrete and

independent systems – control and management of lighting, fans as well as various appliances have been carried out by control mechanisms. 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 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. With the use of microcontroller, the technology helps to control the brightness of lamp and the speed of fan as well.

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.

The objective of this project is to Design and Implementation of home appliances control system for controlling lightings and fans using PSoC-3. This system is will provide smooth control of the system as compared to the ordinary system.

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].

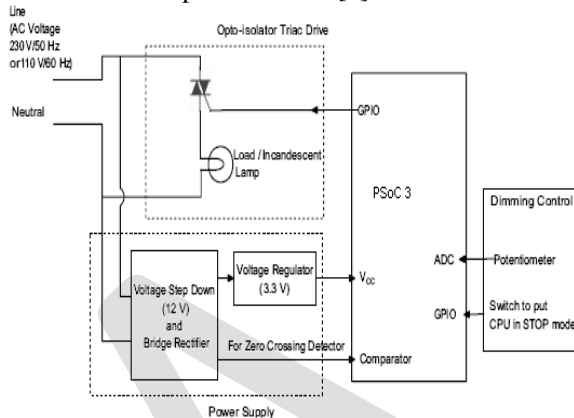
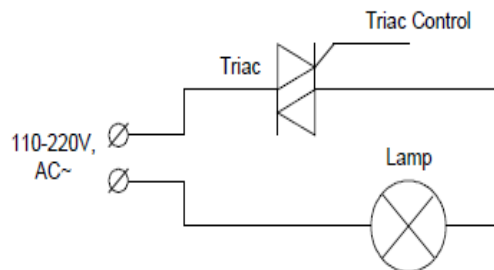


Figure 1. Block diagram of Lamp Dimmer

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. AC MOTOR SPEED CONTROL

➤ Wired Control

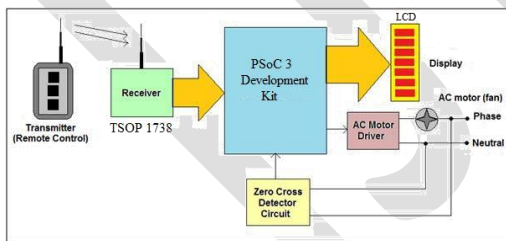
Controlling speed of AC motor is required in industries as well as in domestic use. In industries the required motion control is achieved by controlling speed of big and heavy AC motors. They use variable frequency drives (VFD) for speed control. In some other applications like fan, blowers, heaters etc another method for speed control is used that is phase angle control. By varying phase angle, the current supplied to motor can be varied. And by varying supplied current the speed of motor can be varied. [4]

In domestic application the phase angle control method is used. The best example is fan regulator. In domestic fan regulator TRIAC is used to vary phase angle of fan motor. This is very easiest method to vary AC motor speed.

Also the same principle can be applied to any heating element like heater. By changing the phase angle of AC waveform applied to heater the supplied current can be changed. The speed variation and motor ON / OFF control can also be done through RF remote control.

➤ Wireless Control

The same principle to vary the speed of any 1 phase AC motor by varying phase angle of applied AC waveform. The phase angle is varied using TRIAC only but TRIAC can be triggered by digital means using PSoC. This device can be used to remotely control the speed of an AC fan and to switch it on or off. The remote control is a cheap NEC Format remote, usually supplied with small DVD players.



AC Motor Speed Control

Five buttons are used to command the circuit. The UP key increases the fan's speed while the DOWN key decreases it. The PRESET key is used to switch on or off the fan. The LEFT and RIGHT keys are used to select the device either lamp or fan. The unit provides 5way speed control. The current speed is displayed on LCD of PSoC's kit.

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 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.

Figure 3
RF remote control

VIII. POWER PHASE CONTROL OF TRIAC FOR AC LAMP DIMMER & FAN CONTROLLER

The Light Dimmer uses the principal of power phase control, which is easy in implementation. The phase control operation principle lies in controlling triac turning on phase within AC supply period.

The delay variation between AC Zero Crossing signal and triac turning on time is used to control the amount of power provided to lamp. Triac is driven by short pulses for power consumption optimization. These pulses are generated by PSoC [1]. 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.

The controllable delay between zero-crossing signal and triac turning on is used for lamp brightness control. The delay is generated by PWM8 user module for low-jitter operation.

The both edges of zero-crossing signal are used for interrupt triggering. The interrupt handler restarts the PWM with appropriate period value, depends on required delay.

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.

Below is the Photograph showing Single Device Control Unit.

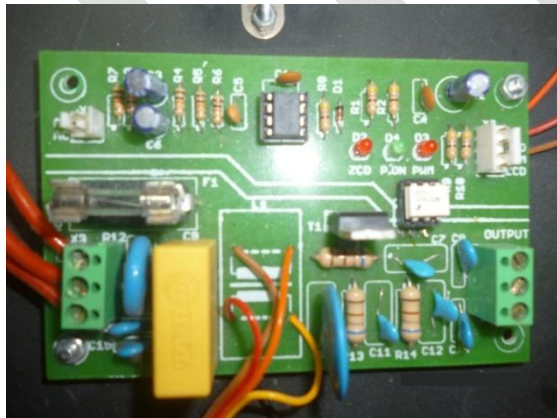


Figure 4 Photograph showing Single Device Control Unit.

The CapSense sensors detected touches at various spots, causing the LEDs to change in brightness. Finally, the LCD module displays where the touch occurred. The Circuit

Diagram of Lamp Dimmer and Fan Controller Unit is shown below.

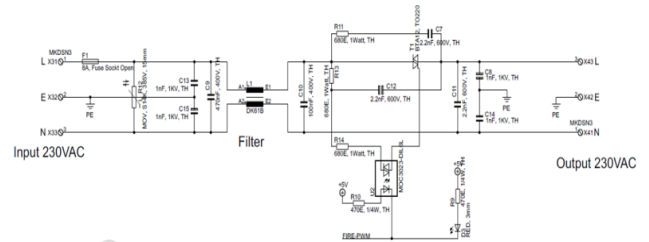


Figure 5 Circuit Diagram of Lamp Dimmer and Fan Controller Unit

X. SOFTWARE & FLOWCHART

The flowchart for proposed system is drawn below in fig.

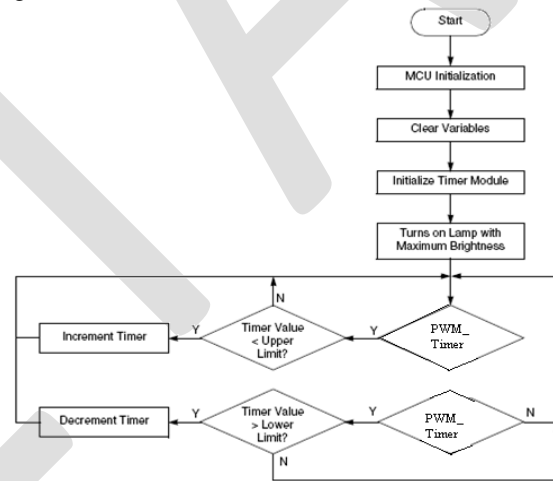


Figure 6 Flowchart of Lamp Dimmer system

The TopDesign.cysch will look as follows:

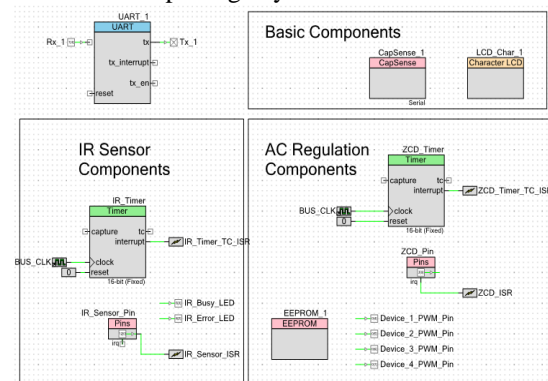


Figure 7 Snapshot of TopDesign.cysch

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 contains 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.

AUTHORS

First Author- Ms. Madhura Mohan Arole, Department of Electronics Engineering, Walchand Institute of Technology, Solapur, India, 413006.

Second Author- Dr. Gengaje S. R., Head, Department of Electronics Engineering, Walchand Institute of Technology, Solapur, India, 413006

REFERENCES

- [1]. Light Dimmer with Capsense Brightness Control by Petro Koblyuk Application engineer in the Ukraine Solution Center [2005]
- [2]. www.wikipedia.com/dimmer
- [3]. PSoC® 3: CY8C38 Family Datasheet by Cypress Semiconductors
- [4]. Single-Phase Motor Speed Control Using MC9RS08KA2 by: Cuauhtemoc Medina RTAC Americas [2008]
- [5]. Universal motor speed control and light dimmer with TRIAC and ST7LITE microcontroller application note [2007]
- [6]. The Intelligent Incandescent Lamp Switch by Andrey Magarita Senior Application engineer in the private company “Zuvs”.
- [7]. Implementing a Lamp Dimmer with an HC908Q Family MCU by Andre Luis Vilas Boas Alfredo Olmos Marcus Espindola Brazil Semiconductor Technology Center BSTC/SPS Jefferson Daniel de Barros Soldera[2004]
- [8]. Dimming AC Incandescent Lamps Using A PIC10F200 by Microchip, application note TB094