Daylight And Solar Energy Optimization Thru Smart Lighting Management System With Manual Override

Antonino D. Carpena
Flocerfida L. Amaya

College of Engineering, University of Perpetual Help System Laguna,
City of Binan, Laguna, Philippines

ABSTRACT

This study was development to optimize daylight and solar energy. The prototype used four 4 watts Light Emitting Diode (LED) bulb as experiment load. The project is capable of counting the number of persons entering the room and determining the lux produced by the sun. The lamps automatically turn on when it detected a person enters a room at the same time when the lux produced by sun is low. The lamps automatically turn off when it detected that there are no person inside the room or the lux produced by the sun is high. This automated device reduce energy consumption compared to normal lighting system and can be used either in residential or any type of establishments.

Keywords: Daylight, Solar Energy, Smart Lighting Management System

INTRODUCTION

Energy management systems have been extensively studied for almost 40 years. The researchers from the National Taipei University of Technology in Taipei, Taiwan looked at 276 papers written on the topic of EMS between 1976 and 2014 and broke them down into three categories:

- **Building EMS**, covering areas such as scheduling control, tariff and load control, and the smart home/building/environment.
- **Industrial, company and factory EMS (I/C/F EMS)**. The key function here is management, which converts manufacturing behavior from the production-driven activity to the consumer-oriented one.
- **Equipment EMS** for heating, ventilation and air conditioning, refrigeration equipment, lighting systems and motors. For EMS for motors, variable frequency control plays the key role in determining energy efficiency. For EMS for lighting systems it is optimization of the lighting intensity and reduction of the artificial lighting system by daylight assisted energy management. [1]

Daylight-responsive electric lighting controls are absolutely essential to any daylighting system. No daylighting design will save any energy unless the electric lights are dimmed or turned off when there is sufficient illumination from daylight. Indeed, if daylighting features such as windows and skylights are not paired with daylighting functionality such as daylight-responsive dimming controls, then the daylighting-enhanced building will more than likely use more energy, not less, than a comparable building without any daylighting features. Daylight-responsive lighting controls consist of continuous dimming- or stepped-ballasts in the light fixtures, and one or more photocells to sense the available light and dim or turn off the electric lighting in response. [2]

The adoption of embedded **systems**, mobile devices and other **smart** devices keeps rising globally, and the scope of their involvement broadens, for instance, in **smart** city-like scenarios. [3]

Smart lighting is a lighting technology designed for energy efficiency. This may include high efficiency fixtures and automated controls that make adjustments based on conditions such as occupancy or daylight availability. Lighting is the deliberate application of light to achieve some aesthetic or practical effect. It includes task lighting, accent lighting and general lighting.

Smart lightning is the good way which enables to minimize and save light by allowing the householder to control remotely cooling and heating, lighting, and the control of appliances. This ability saves energy and provides a level of comfort and convenience. From outside the traditional lighting industry, the future success of lighting will require involvement of a number of stakeholders and stakeholder communities. The concept of smart lighting also involves utilizing natural light from the sun to reduce the use of man-made lighting, and the simple concept of people turning off lighting when they leave a room.

Houses usually have a light bulb that illuminates the entrance, patio or front yard. Since these lights are located outside the house, they were usually forgotten to turn off or left turned on for hours and hours in the day and sometimes for weeks, causing unnecessary power consumption. Thinking about solution to this problem, the researcher have designed an electronic device that is responsible for automatically turning off the light bulb when the sun sets and when there is a person inside a house.

The main objective of this study is to develop a Smart Lighting Management System to optimize daylight. This study aimed at creating a more efficient way of handling our lighting fixture to avoid unnecessary power consumption thus increasing electrical bills.

Specifically, this Smart Lighting Management System aims to: 1) develop Smart Lighting Management System that can optimize daylight, 2) develop a four level lighting illumination and to 3) determine the response of switch at different level of illumination with or without the presence of personnel.

The study covers the use of four 4 watts LED bulb as our experiment load. The project is capable of counting the number of persons entering the room and determining the lux produced by the sun. The study is limited to lamps that are automatically turn on when it detected a person enters a room at the same time when the lux produced by sun is low. The lamps automatically turn off once it detected that there are no movement inside the room or the lux produced by the sun is high.

Proper control using appropriate equipment can significantly reduce the energy consumption of lighting systems. For example, we can control the on/off, or/and light level of the lamps at specific time period and different situations. This section describes the energy efficient installations related to lighting control system.

A control system is a device or set of devices to manage, command, direct or regulate the behavior of other devices or systems. There are two common classes of control systems with many variations and combinations: logic or sequential controls and feedback or linear controls. Control system is a variable quantity or set of variable quantities made to adapt to a prescribed norm. It either holds the values of the controlled quantities constant or causes them to vary in a prescribed way. A control system may be operated by electricity, mechanical, fluid pressure (liquid or gas) or a combination of means. When a computer is involved in the control circuit it is usually more convenient to operate all of the control systems electrically, although intermixtures are fairly common.

A lighting control system is a wall switch occupancy sensor that has been designed specifically for homes to save energy. A lighting system could in its simplest form just one (1) manual switch for tuning the lights on and off. Here we however refer to more sophisticated system when we discuss Lighting Control System, often known as ‘Smart Lighting Control System’. The objectives of such system are to provide visual comfort and to lessen the energy consumptions. [4]

Automatic lighting controls do exist in the market, like the Manual Dimming, Photo sensors, Occupancy Sensors, Clock switches or timers and Centralized Controls. Manual Dimming controls allow occupants of a space to adjust the light output or luminance. This can result in energy savings through reductions in input power, as well as reductions in peal power demand, and enhanced lighting flexibility.

Manual lighting controls, range from a single switch to a bank of switches and dimmers that are actuated by toggles, rotary knobs, push buttons, remote control, and other means. Manual controls are the most cost-effective options for small-scale situations. However, as the size of the lighting system grows, manual controls lose their cost-effectiveness. But they can still be an important part of a larger plan, as evidenced by the effectiveness of task lighting with manual controls.

Figure 1. Photocell Sensor

Photocells can be used for automatic control of indoor lighting. A photocell is a type of resistor. When it strikes the cell, its resistance decreases and allows current to flow more freely. In contrast, its resistance increases when dark. Therefore, when applying in lighting control, a photocell can read the level of lighting, incorporating daylight influence, and automatically adjust the artificial lighting level of a single or a group of luminaires. Lighting system must be installed with dimmers in order not to induce abrupt change of lighting level. [5]

Figure 2. Occupancy Sensor

A typical occupancy is comprised of a motion detector, electronic control component, relay and power supply. Motion detectors are typically infrared type or ultrasonic sensors. Infrared sensors detect motion when the heat source moves from one zone to another. The sensors must have a direct line of sight to the occupants to detect motion. Ultrasonic sensors emit high-frequency waves in the range of 25-40 khz. These waves bounce off objects in the room and return signal and this shift is detected by the sensors. The electronic control sends signal to the relay, which opens or closes the power circuit, after receiving signals from the detectors. [5]

Figure 3. LED Bulb

An LED lamp is a light-emitting diode (LED) product that is assembled into a lamp (or light bulb) for use in lighting fixtures. LED lamps have a lifespan and electrical efficiency that is several times better than incandescent lamps, and significantly better than most fluorescent lamps, with some chips able to emit more than 100 lumens per watt. [6]

Some LED lamps are made to be a directly compatible drop-in replacement for consumption in watts, color temperature in kelvins or description (e.g "warm white"), operating temperature range, and sometimes the equivalent wattage of an incandescent lamp of similar luminous output. [6]

Figure 4. Mechanical Relay

Electromechanical relay switches are available in ice cube relay, octal relay, power relay, hazardous location relay, latching relay, and card relay styles for use in a wide range of applications. A variety of accessories are also available: including relay sockets, relay removers, protective covers, spare card relays, and metal oxide varistors (MOV) and diode circuits offered as convenient plug-in modules. [7]

Figure 5. Capacitor

Capacitors are components that are used to store an electrical charge and are used in timer circuits. A capacitor may be used a resistor to produce a timer. Sometimes, capacitors are used to smooth a current in a circuit as they can prevent false triggering of other components such as relays. The capacitor charges up when power is supplied to a circuit that includes a capacitor. When power is turned off, the capacitor discharges its electrical charge slowly. [8]

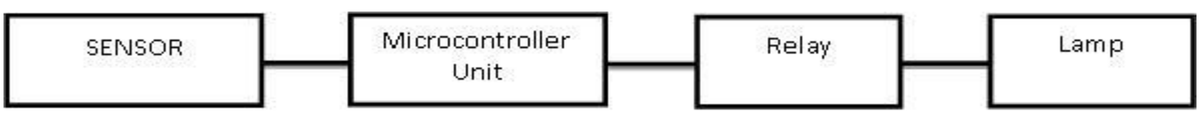

Figure 6. Conceptual Framework

The study is composed of an Input, Microcontroller unit, relays and the output stage which is the lamp. The input stage consists of Light Display Relay (LDR) that will provide the needed signal that the microcontroller will process. The microcontroller unit will provide signal to the relays which will control the number of lamps to be turned on. The first sensor counts the number of person enters the room and the second sensor counts the number of person leaves the room. LDR is used to measure the lux level produced by the sun.

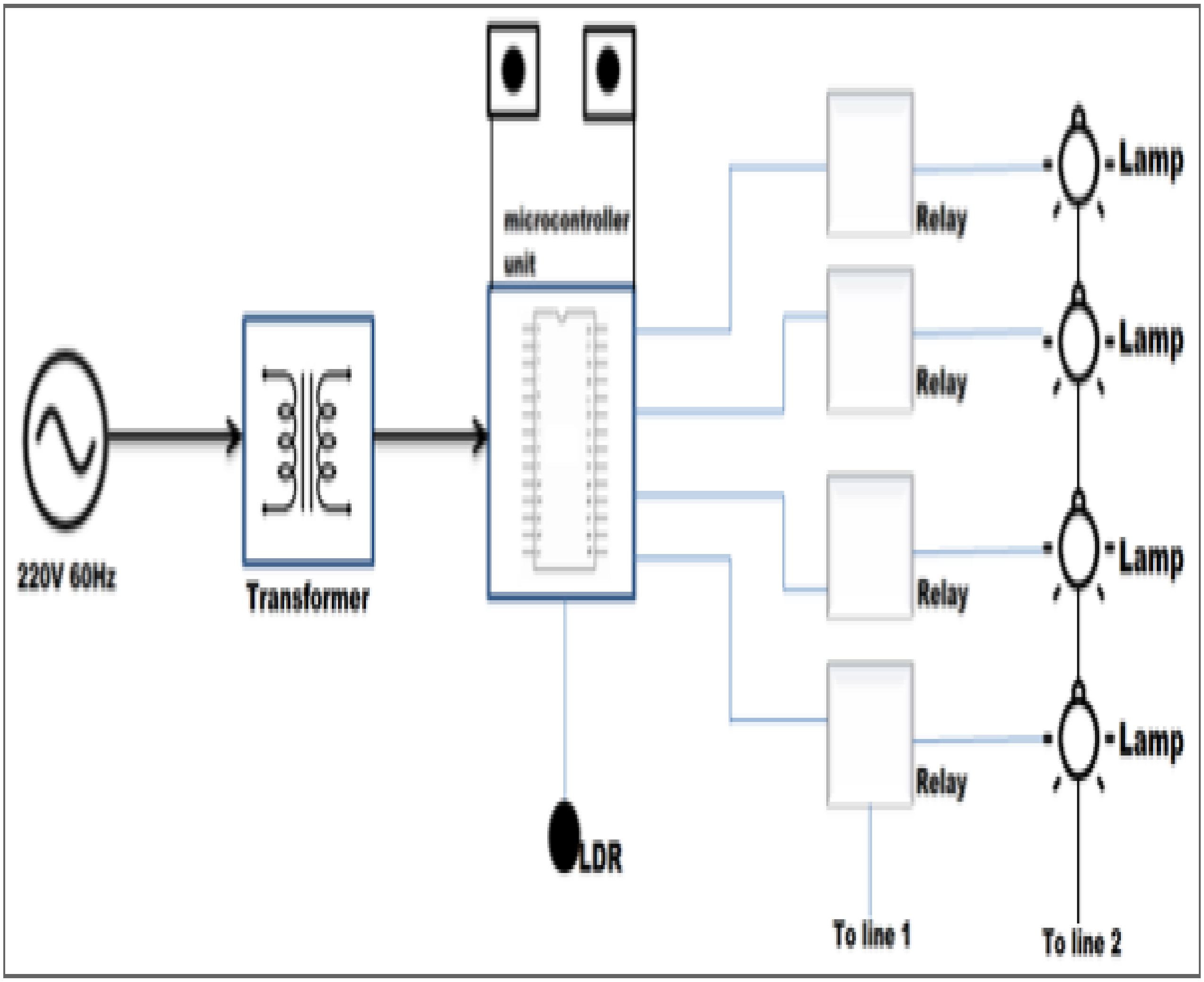

Figure 7. Block Diagram

The above figure shows the entire principle and operation of the smart lighting circuit. The LDR, microcontroller and relays have its own independent power supply through the transformer. Certain number of lamps turn on which depends on the number of person enters the room and the level of illumination the sun produces.

Table 1. Truth Table

Lux level of sun	No. of person inside the room	Lamp 1	Lamp 2	Lamp 3	Lamp 4
0 – 25	0	0	0	0	0
	1	1	1	0	0
	2	1	1	1	0
	3	1	1	1	1
	4	1	1	1	1
26 - 50	0	0	0	0	0
	1	1	0	0	0
	2	1	1	0	0
	3	1	1	1	0
	4	1	1	0	1
51 – 75	0	0	0	0	0
	1	1	0	0	0
	2	1	0	0	0
	3	1	1	0	0
	4	1	1	1	0
76 - 100	0	0	0	0	0
	1	0	0	0	0
	2	1	0	0	0
	3	1	1	0	0
	4	1	1	1	0

Table 1 shows the number of lamps turn on in a certain condition. It shows the outputs from all possible combination of input. This served as the reference table to determine whether the result / output is attained.

<u>MATERIALS AND METHODS</u>

The smart lighting is an innovation of an automatic light switch.

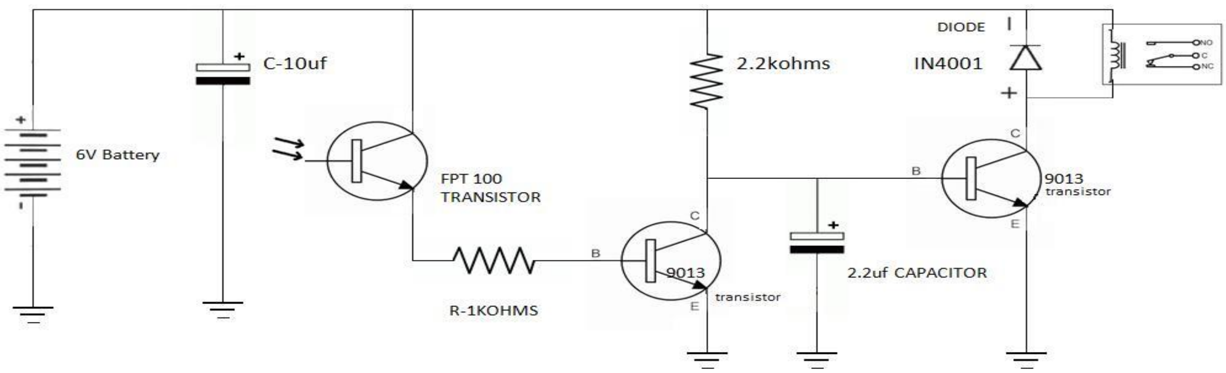

Figure 8. Automatic Light Switch Circuit Diagram

The figure shows the simple circuit diagram of an automatic light switch. It will simply turn on the light automatically when it is dark and will be turned off automatically when it is bright.

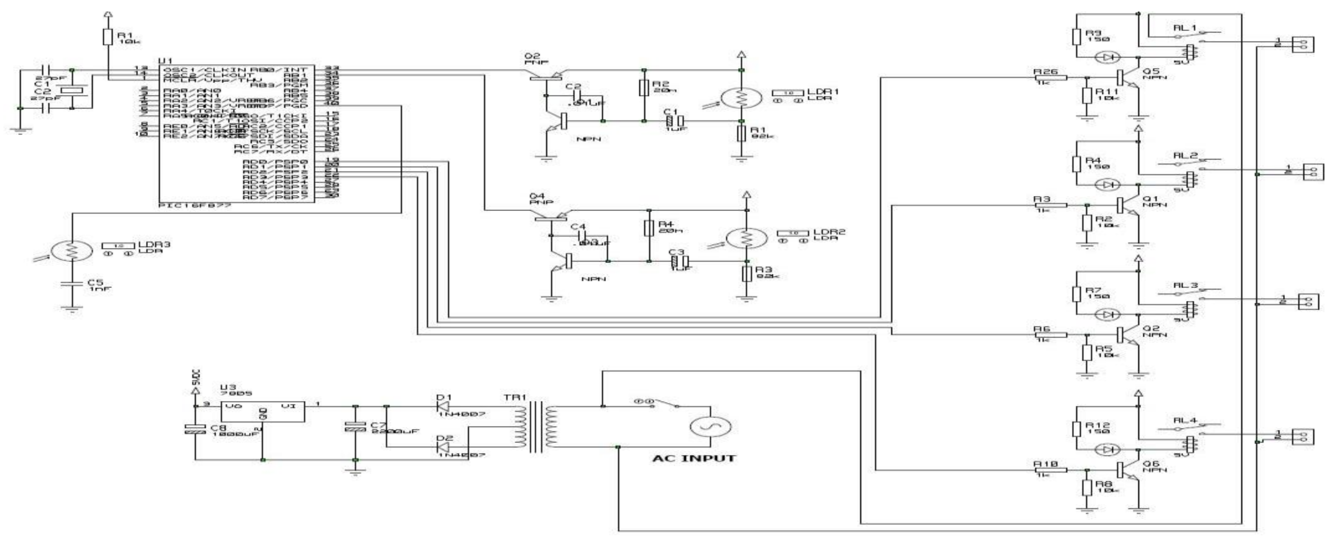

Figure 9. Schematic Diagram of Smart Lighting

The figure shows the schematic diagram of smart lighting. The modification of the automatic light switch consists of using microcontroller that will receive input signal from the sensor and LDR. It processes that signal as an output to control the relay circuits. With the modification that is applied, the automatic light switch is developed and turned from being a simple switch into something that is smart.

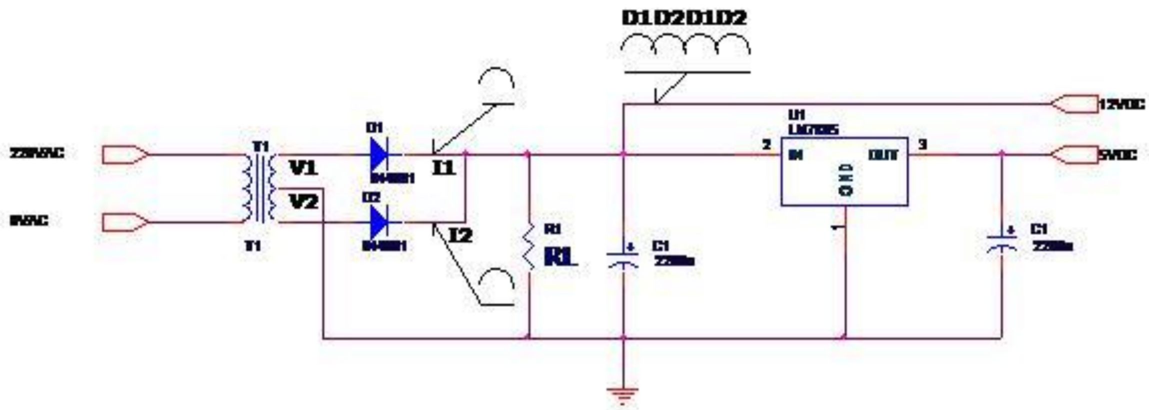

Figure 10. Power Supply Schematic Diagram

The Power supply is basic circuit of full wave rectifier driven from AC main and using resistive load and filter. The output winding of the power transformer is center tap. Hence the two diodes are equal in magnitude but opposite in phase.

During the first half cycle, V1 is positive. Hence diode D1 conducts and current I1 flows through the diode D1 and load resistor RL. Diode D2 remains non-conducting since V2 is negative. During the other half cycle, V2 is positive while V1 is negative. Hence diode D2 conducts and current I2 is flow through diode D2 and RL. Diode D1 remains non-conducting. The two current I1 and I2 flow through the load resistor RL producing the output voltage.

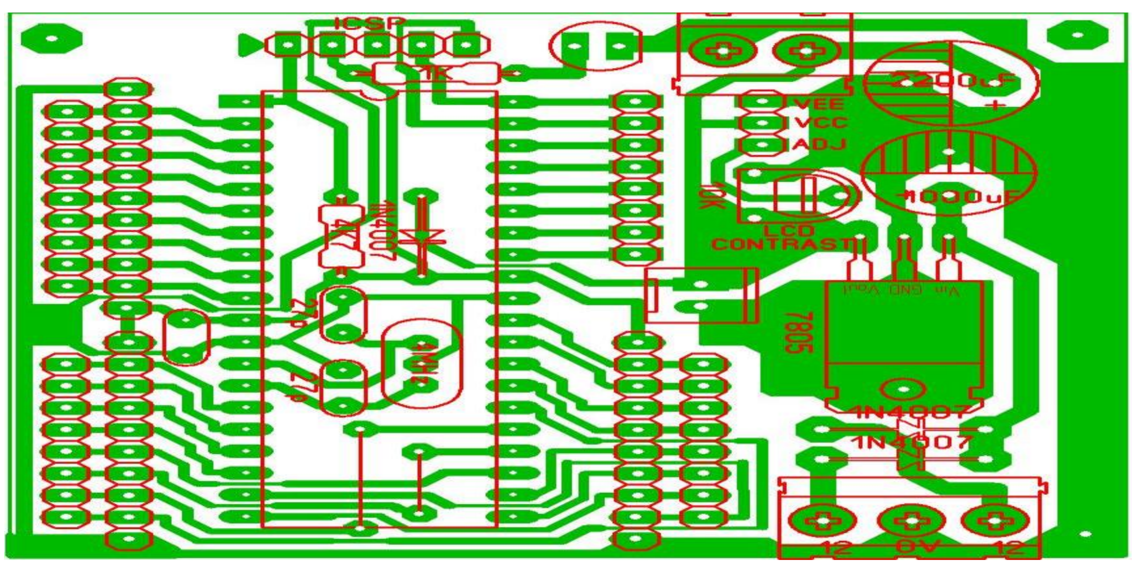

Figure 11. Microcontroller Unit PCB Layout

Figure shows the etching of the PCB for microcontroller unit from the schematic diagram.

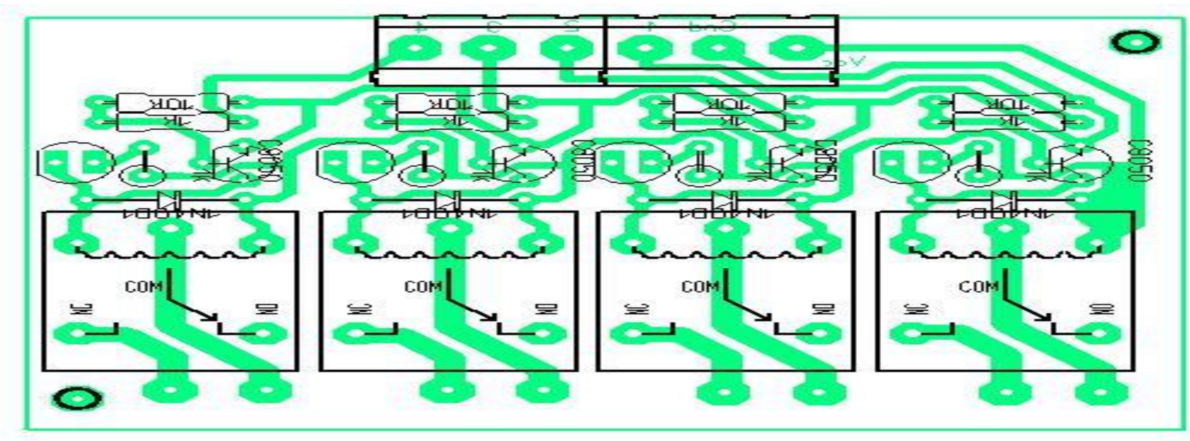

Figure 12. Relay Board Placement Layout

Figure shows the sketch of the PCB for relay part from the schematic diagram.

Programming the Microcontroller

The program of the microcontroller was created using Microchip MPLAB IDE Programming Language. The MPLAB Integrated Development Environment (IDE) is a free integrated toolset for the development of embedded applications employing dsPIC microcontrollers.

The program is compiled and burned to the microcontroller using PICProg. PICProg is a free software for programming the Microchip PIC 16F84 microcontroller using serial port of the computer.

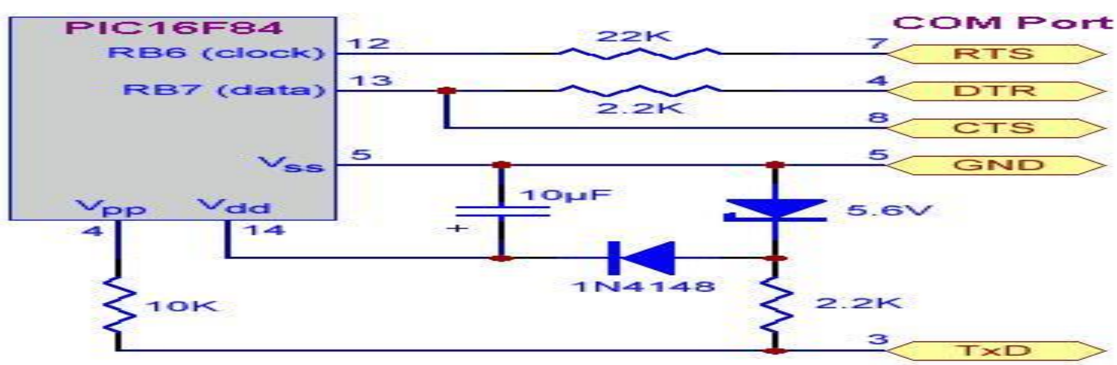

Figure 13. PIC 16F84 Programmer Schematic Diagram

The figure shows the schematic diagram provided by the PICProg in order to burn the compiled program to the microcontroller. This programmer is to be attached at the serial port of the computer.

RESULTS and DISCUSSION

The following results were taken from the experimental set-up where different number of person enters the room at different time of the day.

Location : Residential House in Cabuyao, Laguna
No. of Days : 5
Date : May 16 - 20, 2016
Time : 6:00-18:30

Table 2

Date	Time of the day	Lux level outside the room	No. of person inside the room	Lamp 1	Lamp 2	Lamp 3	Lamp 4
May 16, 2016	6:00	53	0	0	0	0	0
	7:00	100	1	0	0	0	0
	12:00	9794	4	0	0	0	0
	17:00	95	4	1	1	1	0
	17:30	54	4	1	1	1	0
	18:00	31	3	1	1	1	0
	18:30	15	2	1	1	1	0
May 17, 2016	6:00	71	2	1	0	0	0
	7:00	97	3	1	1	0	0
	12:00	9905	3	0	0	0	0
	17:00	84	4	1	1	1	0
	17:30	65	4	1	1	1	0
	18:00	42	3	1	1	1	0
	18:30	25	3	1	1	1	1
May 18, 2016	6:00	66	4	1	1	1	0
	7:00	90	3	1	1	0	0
	12:00	10460	2	0	0	0	0
	17:00	80	1	0	0	0	0
	17:30	68	0	0	0	0	0
	18:00	32	2	1	1	0	0
	18:30	13	3	1	1	1	1
May 19, 2016	6:00	53	2	1	0	0	0
	7:00	83	3	1	1	0	0
	12:00	9030	2	0	0	0	0
	17:00	90	1	0	0	0	0
	17:30	62	4	1	1	1	0
	18:00	37	1	1	0	0	0
	18:30	9	3	1	1	1	1
May 20, 2016	6:00	64	4	1	1	1	0
	7:00	84	4	1	1	1	0
	12:00	10405	1	0	0	0	0
	17:00	87	3	1	1	0	0
	17:30	61	1	1	0	0	0
	18:00	31	2	1	1	0	0
	18:30	20	4	1	1	1	1

Result of the tests shows that the prototype worked as stated as the truth table. When lux level of sun is between 0-25 and the number of person inside the room is 2, 3 lamps will light and if the number of person inside is either 3 or 4, all the 4 lamps will light. When lux level of sun is between 26-50, the number of lamp that will light corresponds to the number of person inside the house. When lux level of sun is between 51 to 75 and between 76 to 100, same number of lamp will light when 2 to 4 number of person is inside the house. The transition of the lamp from on and off is instant as the state condition of the room changes.

It is evident from the result that Smart Lighting Management System was able to optimize daylight, the four level of lighting illumination and response of switch at different level of illumination with or without the presence of personnel corresponds to the truth table which only shoes that the design of Smart Lighting Management System was effective.

CONCLUSION

After thorough examination and measurements, the following conclusions are hereby stated:

1. Smart Lighting Management System (SLMS) is capable of optimizing the use of daylight inside the house using automated control circuit with sensors.
2. The device SLMS is capable of controlling the four level lighting illuminations adequate to give comfort and convenience to households owners.
3. The device can efficiently response and automatically switch the lights at different level of illumination without any intervention that enables to save energy significantly.
4. The device can be automated so as to conserve light thus decreasing energy consumption compared to the normal Lighting System.

RECOMMENDATION

After all the measurements done in this study, the researchers found out that Development of Smart Lighting System can be applicable in commercial, industrial and domestic consumers and can really help not only lessen the energy usage but also increasing the energy efficiency. Almost 19% of the energy use in the world is lighting so it is better to apply Smart Lighting System in this stage of life because the more we conserve and wisely use energy, the more we can help the electricity status of our country in simple ways.

The Smart Lighting Management System (SLMS) device is highly recommended to all electricity user either at their own homes, offices or any type of establishment for comfort or convenience and economic factor. Further study be conducted to consider the different partitions or sections within the structure to determine the maximum number of lamps and to enhance the system to accommodate more lamps.

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Program Proper:

```
Device 16F877A
Declare Xtal4
All_Digital= TRUE
ADCON1 = 7
Hserial_Baud= 9600
Hserial_RCSTA= %10010000
Hserial_TXSTA=                  %00100100

Symbol T9600            =   84        NO_LIST

Symbol T4800            =   188       NO_LIST
Declare SERIAL_DATA 8
Declare LCD_DTPin                   PORTC.0
Declare LCD_RSPin                   PORTC.4
Declare LCD_ENPin                   PORTC.5
Declare LCD_Lines                   4
Declare LCD_Interface               4
TRISA = %000000
TRISB = %00000011
TRISC = %00000000
TRISD = %00000000
TRISE = %100
Dim counts As Byte
Dim LDR As Byte
Clear PORTA
Clear PORTB
Clear PORTC
Clear PORTD
Clear PORTE
Clear counts
START:
LDR = Pot PORTE.0 ,100
DelayMS250
Print At 1,1," Person:" ,Dec2 counts
Print At 2,1," LIGHT =", Dec3 LDR
If PORTB.0 = 1 Then
DelayMS500
While PORTB.0 = 1
Wend
counts= counts + 1
If counts >= 100 Then
```

```
counts= 100
            EndIf
EndIf
            If PORTB.1 = 1 Then
DelayMS500
While PORTB.1 = 1
Wend
counts= counts - 1
If counts <= 0 Then
counts= 0
            EndIf
EndIf
If LDR = 0 Andcounts = 0 Then
PORTD = %00000000
EndIf
If LDR >=1 Andcounts = 1 Then
PORTD = %00001111
EndIf
If LDR >=1 Andcounts >= 2 Then
PORTD = %00001111
EndIf
            If LDR >=1 Andcounts >= 3 Then
PORTD = %00001111
EndIf
If LDR >=1 Andcounts >= 4 Then
PORTD = %00001111
EndIf
If LDR >=26 Andcounts >= 1 Then
PORTD = %00001111
EndIf
If LDR >=26 Andcounts >= 2 Then
PORTD = %00000111
EndIf
If LDR >=26 Andcounts >= 3 Then
PORTD = %00001111
EndIf
If LDR >=26 Andcounts >= 4 Then
PORTD = %00001111
EndIf
If LDR >=50 Andcounts >= 1 Then
PORTD = %00000011
EndIf
```

```
If LDR >=50 Andcounts >= 2 Then
PORTD = %00000011
EndIf
If LDR >=50 Andcounts >= 3 Then
PORTD = %00000111
EndIf
If LDR >=50 Andcounts >= 4 Then
PORTD = %00000111
EndIf
If LDR >=100 Andcounts >= 1 Then
PORTD = %00000001
EndIf
If LDR >=100 Andcounts >= 2 Then
PORTD = %00000001
EndIf
If LDR >=100 Andcounts >= 3 Then
PORTD = %00000011
EndIf
If LDR >=100 Andcounts >= 4 Then
PORTD = %00000011
EndIf
GoToSTART
End
```