Design and Development of a Solar-Powered Lighting System Using Motion Sensing Detection

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***Abstract*—In this study, the proponents makes use solar energy to power up an automatic lighting system controlled by PIC microcontroller using assembly language in the program. The proponents used PIR motion sensor as a switch to turn on the lighting system, the motion sensor will send signal to the microcontroller to turn on the LED bulb by passing through the relay. The goal of the study is to design and develop an automatic lighting system with the help of a microcontroller, sensor, and relays, which is powered by solar energy.**

***Index Terms*—Solar Energy; Automatic Lighting System; PIC Microcontroller; Assembly Language; PIR Motion Sensor; Relays.**

I. INTRODUCTION

In the Philippines there are several power plants that uses renewable energy as there source of power, like hydroelectric, wind, steam/geothermal, nuclear, biogas and etc. But the price of electricity in the Philippines is expensive compared to other countries [1]. Since Philippines is a tropical country it is abundant in heat and sunlight, which means that solar energy is one of the most possible source of energy to be used as an alternative. Nowadays solar energy is one of the known alternatives source that can be used as a replacement for the electricity that you are paying for. Solar power comes from the energy of the sun converted into thermal or electrical energy. It is one of the cleanest and abundant energy sources available; it is a flexible energy technology that can be placed at much location as long as there is an abundant sunlight at said location. Solar energy can be harvested with the help of photovoltaic that were placed in the solar panel, photovoltaic converts light into electricity into atomic level with the help of materials that exhibit a property known as photoelectric effect. Photoelectric effect absorbs photons of light and release electrons, when the free electrons were captured, it will result into electric current that can be used as electricity. Solar energy can be stored in battery and can be used for a certain amount of time depending on the battery capacity and the equipment used [2][3].

One of the most used equipment in the world would be lighting/illumination. Illumination became important in every part of the world because it helps the people see and move in dark places and night. However, leaving the lights on for the rest of the night will increase the electricity bill especially those who are in business industries. In the business industries like schools/universities, they want to minimize the expenses as much as possible. With proper lighting system, the schools/universities will be able to conserve energy and reduce their electrical bill which will help the schools/universities to minimize their expenses.

At the present days, sensors had become more popular applying to many field of applications like Agriculture, Automotive, Civil Engineering (Construction), Domestic (Appliances), Distribution (Commerce, Finance), Environment (meteorology, security), Energy (Power), Information (Telecommunication), Health (Medicine), Marine, Manufacturing Recreation (Toys), Military, Space, Scientific Measurement, Transportation (excluding automotive) and Other. Sensor's purpose is to respond to an input physical property called stimulus and change it into an electrical signal suitable with electronic circuits [4]. Sensors that detect moving objects are called Motion Detector. Motion Detector are usually integrated as part of a system that is mostly used for security, automated lighting control, home control, energy efficiency, and other useful systems. Motion Detectors that have a range of 15 feet (5 meters) are usually inexpensive while the specialized detection has more range than the inexpensive one it is expensive [5].

To make an automated lighting system that uses motion sensors and powered by solar energy design, a microcontroller is needed for the system's programming. Microchip PIC® Microcontrollers is a microcontroller that have a powerful architecture, flexible memory technologies, comprehensive easy-to-use development tools, complete technical documentation and post design in-support through global sales and distribution. It comes with a performance range of 8-bit, 16-bit and 32-bit [6]. In this study the proponents will provide a lighting system that is powered by solar energy and uses a sensor to make the lights automatically turn on and off to conserve energy.

The main objective of this study is to design and develop an automated lighting system powered by solar energy.

Specifically, this study aims to:

1. design a lighting system powered by solar energy by the use of solar panels,
2. provide a lighting system controlled by PIC microcontroller and activated and deactivated by timer,
3. use motion sensor to identify the presence of motion in the detection area and transmit the signal to the PIC microcontroller and Use relays as a switch to trigger the lamp, and
4. test the prototype in LPU bridge that connects PHL building to JPL building.

II. METHODOLOGY

This project aims to design a lighting system that is automated by the use of motion sensor, and PIC microcontroller and at the same time powered by solar by the use of solar panel. General diagram of the system is shown in Figure 1.

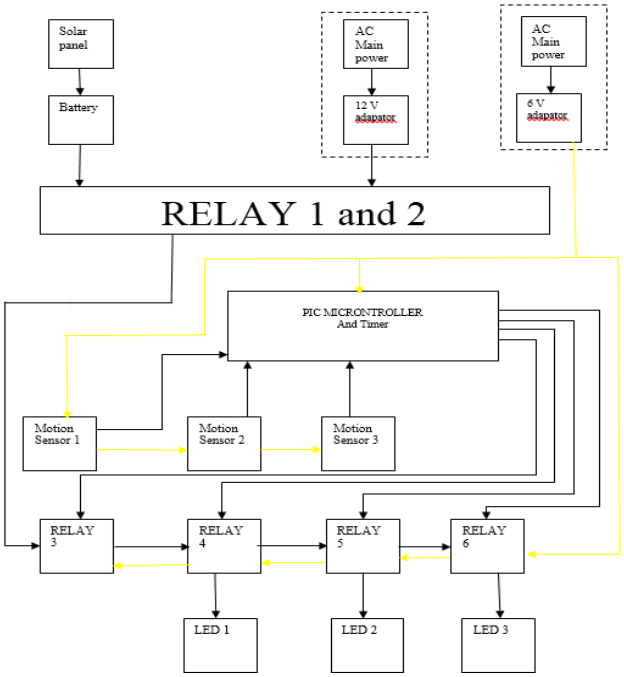

Figure 1: General diagram of the system

In Figure 1 the proponents use solar energy as source. The Solar energy that comes from the sun will be converted to electrical energy by the use of Photovoltaic cells whose output is a DC voltage. In case the solar panel does not harvested enough energy to power the system the proponents prefer a backup energy source, the proponents prefer AC main power and by the use power supply / adaptor the AC voltage will be converted to DC voltage which is where the system works at.

The system is activated 24 hours, on 6:00 – 17: 59 the system is charging the battery, absorbing the solar energy and converting it to electrical energy by the use of photovoltaic cell, and on 18:00 – 5:59 the system is on the discharging mode, using the harvested power to power the LED lamps to use in lighting up the area and to make it possible the proponents introduced two relays.

This flow chart is concern about the switching of the LED lamp. The timer (also program in PIC16F84A) is set at 6:00 – 17:59 charging and 18:00 – 5:59 discharging mode. Once the system is on discharging mode, the switching of the LED lamp is on and done by the relays that connected to PIC microcontroller and Motion sensor, the motion sensor sends the signal to PIC microcontroller and the PIC microcontroller output will send to the relays and trigger the lamp depends on what the motion sensor sense. .The switching of the relay is programmed in the PIC microcontroller that is based to the desired algorithm by the proponents.

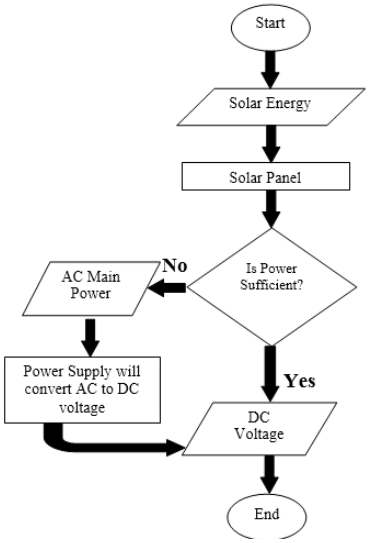

Figure 2: Selection of Source

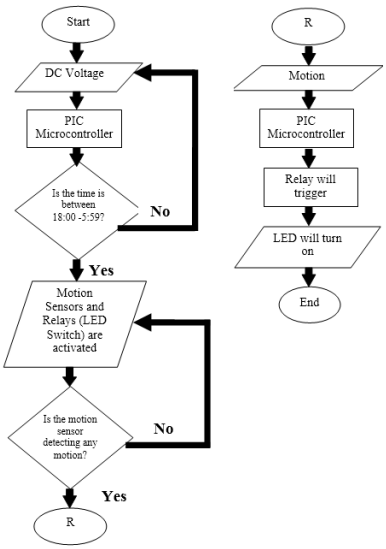

Figure 3: Flow Chart of the automated Lighting System

III. DESIGN CONSIDERATION

Figure 4 represents Waterfall Model which is a software developmental model that is used for the study, the events in sequence is shown blocks by blocks. The events shown in the Figure 4 will be shown and explain in the upcoming part of this chapter.

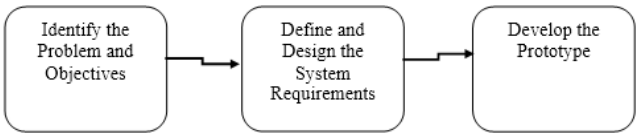

Figure 4: Research process block diagram

A. Identify the Problems and Objectives

This study is an important part of the curriculum of the proponents which have the thesis adviser's approval. The proponents have three topic prepared which the thesis adviser will pick only one from the three topics prepared by the proponents. The proponents made objectives out of the topic chosen and identify the problems of the said topic. The

objectives will be set as the guideline of the study to achieve the desired output of the study.

B. Define and Design the System Requirements

The proponents have gathered data from some research studies and some related literatures to make a design of a lighting system which functions according to the objective of the study. The proponents will show the system operates and what is the function of the components in the system.

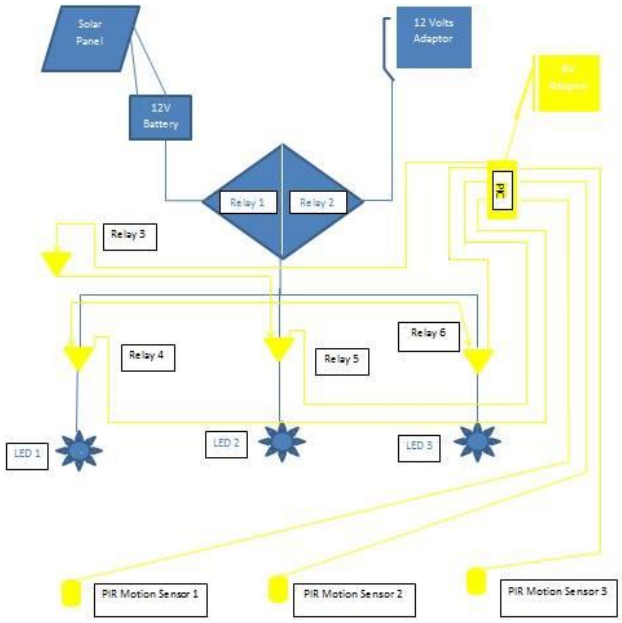

Figure 5: Block Diagram of the Lighting System

Figure 5 shows and represents the general block diagram of the whole system. It shows the interconnection of different components and how the system will operate. There are two sources for the lighting system one is the solar panel which harvest solar energy and the other is 12 volts adaptor which is connected to ac power outlet. Solar panel is used to charge the 12 volts 12 ampere-hour battery which is the primary source of the lighting system. The 12 volts adaptor which is connected to ac power outlet is the secondary/ backup source which is used if the battery doesn't have enough charge to operate the system. 12 volts battery is connected to Relay 1 while the 12 volts adaptor is connected to Relay 2, selecting source is the function of the two relays. The PIC microcontroller (PIC16F84A) is also powered by a 12 volts adaptor which is connected to ac power outlet.

The system main source comes from the 12 volts battery which is charge by a solar panel and the back-up source from 12 volts adaptor which is connected to ac power outlet, however the system is controlled by the PIC core which is also powered by 12 volts adaptor connected to ac power outlet.

The Figure 6 shows the function of relay 1 and relay 2, once relay 1 and relay 2 energized the relay will trigger. In left side of Figure 6, relay 1 and 2 is energized and triggered by battery having enough energy to power the load. The two relays switch from normally closed to normal open that's why connection from battery to the load connects. In the right side of Figure 6 shows that if the battery doesn't have enough energy to power the load the two relays doesn't energized and switch from normally open to normally closed it remains normally closed and connection from ac main power to the load remains. To show how the system works, the proponents made a flow chart illustrating how the system operates.

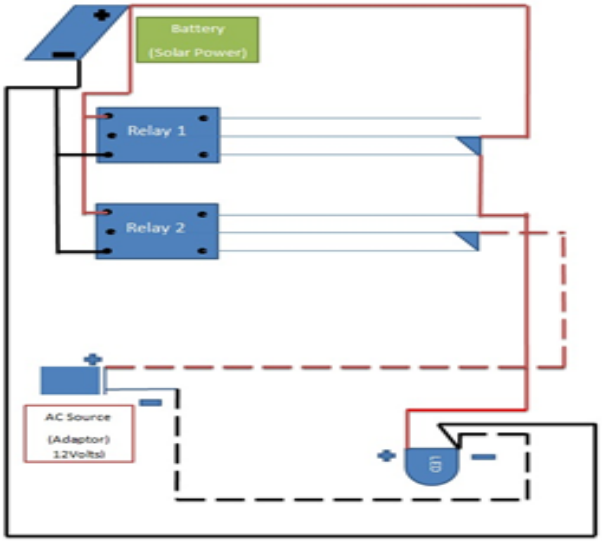

Figure 6: Research process block diagram

Figure 7 shows the process how the PIC core controls the system and how it works. The system starts when the PIR Motion Sensor 1, 2 or 3 sense motion from someone passing by, the PIR will sense the temperature change and will send a digital signal to the microcontroller/PIC core. After the PIC core received the signal, it will then transmit the signal to Relay 3, 4 or 5 that will turn on LED 1, 2 or 3 depending on the PIR Motion that sends the signal to the PIC core.

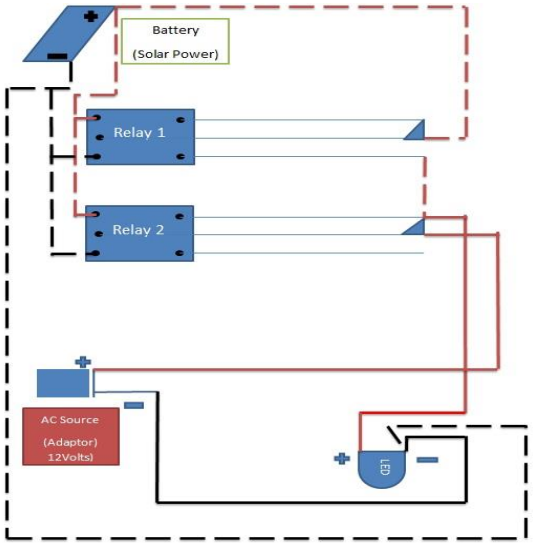

Figure 7: Lighting System's Operation

C. Develop the Prototype and the Software

This stage shows the hardware components that are used in the system. It also shows the software which is the program used in the system. In hardware, the proponents will show the circuit used to build the PIC core and the relay used in the system. While in the software, it will show the program used that is inputted in the PIC microcontroller (PIC16F84A).

Figure 8 is the circuit used to make the PIC core that is used to control the system that will turn on and off the light automatically. The microcontroller used is in the PIC core is PIC16F84A.

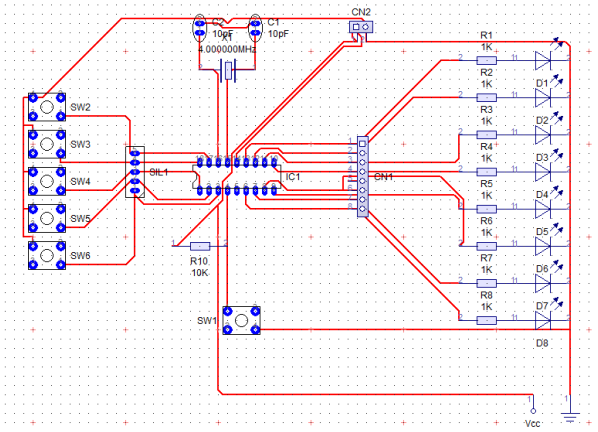

Figure 8: Circuit of PIC Core

On this program the algorithm of pole no.1 and pole no.3 is include, the algorithm is once the motion sensor sense motion the motion sensor sends 3 seconds input signal to the PIC microcontroller and 5 seconds delay time to un-energized or to simply disconnect the relay and turn off the led. There was a total of 8 seconds delay time to turn off the led in every pole.

The timer in this program is controlled timer. In every input the timer will counts. One input is equal to one hour.

The algorithm of pole no. 2 is included in this program, once the motion sensor sense motion the motion sensor sends 3 seconds input signal to the PIC microcontroller and 5 seconds delay time to un-energized or to simply disconnect the relay and turn off the led. There was a total of 8 seconds delay time to turn off the led in every pole.

IV. Experiments and Result Analysis

The lighting system works when a user is passing by and will get sense by the motion sensor which will send a signal to microcontroller to trigger a relay to turn on a led bulb automatically. This test is used to test the system as a whole which will test if the power source, wiring, motion sensor, relay, bulb, microcontroller and program operates properly as one lighting system. The lighting system was test in three ways, users passing starting from Pole 1 to Pole 3, passing from Pole 3 to Pole 1 and passing at Pole 1 & 3 at the same time having 15 trials each.

Table 1
Functionality Test Starting from Pole 1

Trials	Pole No.		
	1	2	3
1	√	√	√
2	√	√	√
3	√	√	√
4	√	√	√
5	√	√	√
6	√	√	√
7	√	√	√
8	√	√	√
9	√	√	√
10	√	√	√
11	√	√	√
12	√	√	√
13	√	√	√
14	√	√	√
15	√	√	√

Table 2
Functionality Test Starting from Pole 3

Trials	Pole No.		
	1	2	3
1	√	√	√
2	√	√	√
3	√	√	√
4	√	√	√
5	√	√	√
6	√	√	√
7	√	√	√
8	√	√	√
9	√	√	√
10	√	√	√
11	√	√	√
12	√	√	√
13	√	√	√
14	√	√	√
15	√	√	√

Table 3
Functionality Test Starting exactly at Pole 1 and Pole 3

Trials	Pole No.		
	1	2	3
1	√	√	√
2	√	√	√
3	√	√	√
4	√	√	√
5	√	√	√
6	√	√	√
7	√	√	√
8	√	√	√
9	√	√	√
10	√	√	√
11	√	√	√
12	√	√	√
13	√	√	√
14	√	√	√
15	√	√	√

Legends:
√ - If system works properly in each pole.
X - If system didn't works properly in each pole

Table 1 shows that starting from Pole 1 to Pole 3, the system works properly which the light turns on automatically when the motion sensor sensed the user passing by the lighting system. The light turns on Pole 1 turns on first followed by Pole 2 then Pole 3. Table 2 and Table 3 also show that the system works properly without the problem; the lights turn on from Pole 3 to Pole 2 the n Pole 1 in the test starting from Pole 3, while Pole 1 and Pole 3 exactly turn on and then Pole 2 in the test starting from Pole 1 and Pole 3.

V. Conclusion

Developed in this thesis is a Lighting System using motion and sensing detection which is powered by solar. It has been confirmed experimentally through testing and actual data analysis that the Solar- Powered Lighting System using Motion Sensing Detection works properly as stated in results in Section 4.

In this paper, the proponents introduced the use of solar energy as the main source to power the automated lighting system controlled by PIC Microcontroller, the PIC microcontroller is designed and program to automatically turn on the light when needed and turn the lights off when not. And this PIC Microcontroller is also programed and designed to act as the timer to automatically turns on the whole system and turn it off at the desired time of the proponents.

ACKNOWLEDGEMENT

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