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Performance Evaluation of a Solar Powered, Vehicle Detect Auto Intensity Controlled Street Lighting System

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Abstract*—The focus of this project is to make the most efficient use of the energy received from the sun to power street lights in the city. Solar Panels mounted on the street lamps will collect the energy from the sun during day time, driving the LED lamps at night. The system we would be looking for designing includes operation in the main streets of some major cities of Bangladesh which is to be equipped with solar powered street lamps effective in regulating the amount of load voltage depending on the intensity of traffic present. The project is regarding the development and fabrication of the circuit that is able to charge the lead acid battery during day time by using solar energy as the source. The process would require the use of a microcontroller, namely PIC16F73, to control many of the circuit functionalities including switching, controlling driver circuit, and integrating sensor output etc. LED is the preferred lighting source in consideration with its photometric such as efficacy, life span, cost, efficiency and power consumption. Traffic detection will be done through the concept of integrating sensor using the IR Sensor.

Keywords- Solar energy, Solar radiation, PV module, Microcontroller, Performance analysis

1. INTRODUCTION

Consumption & use of energy is the burning issue in the present world. That's with the all conventional energy as a supplementary source the using of renewable energy is increasing day by day. Sunray is the main source of renewable energy. By using the solar panel we can convert this sun ray into electricity. Cheap solar can bring electricity to a major chunk of subcontinent's people who still live off grid, bypassing the need of installation of expensive grid lines. So if we reduce the power consumption then we supply more power to the people. For this reason many developed country use some smart and intelligent lighting system in home and road. Smart lighting is a lighting technology designed for energy efficiency.

The first patent requests for intelligent street lighting system from the late 1990s. But it wasn't until April 7, 2006, that Europe experienced the first large scale implementation of a control and monitor street lighting application. The implementation took place in Oslo (Norway) and it was expected to reduce energy usage by 50 percent, improve roadway safety, and minimize maintenance costs. The Oslo project stimulated interest from all other cities of Europe forming the basis of other sustainability initiatives, such as the E-Street initiative. The project calls for the installation over the next three years of 55,000 intelligent street light ballasts that communicate over existing power lines. For a typical European city, the energy used by the outdoor lighting system can consume up to as much as 38% of the total energy demand for lighting. The City of Oslo provides a good working template for the E-Street initiative because the project leverages existing power line infrastructure, both CENELEC and ANSI certified technology [1]. In October 2013 government has launched a project named "Solar Photovoltaic Powered LED (Light Emitting Diode) Street Lighting" to electrify the streets of Dhaka using only solar panels. Under the prevailing project, 122 LED lights, each of 30W are installed to electrify approximately 2 km streets. But after implementation, it has been founded that 60-100W LED light is required for adequately illuminating the streets which will allow the ADB (Asian Development Bank) fund to cover only 250-300 km streets.

In this paper we proposed a new method to develop smart, energy efficient street lights that are powered by renewable energy and are operated at required intensities such that they are economically viable for the energy sector of Bangladesh with that the use of solar panels implemented more efficiently by adding concentrators and using integrated battery. The main objective of our project is Outdoor lamps contribute to a major amount of electricity consumption from the main power lines of Chittagong city. When solar power acting as an alternative source to conventional power supply to the street lamps, operating them in full power only when required adds a two-fold cost and energy saving scheme to this project. At empty streets with no or minimum presence of traffic, the street lamps need only operate at low threshold intensity. The project aims at limiting the large amount of energy wasted without purpose in such conditions by accomplishing automated detection, and powering the LED lamps with appropriate brightness level for providing the illumination with respect to the amount of cars presentation the road. This system improves the total output of solar panel by maximum utilization of available photovoltaic energy and maximum utilization of the duration for which solar power is available based on concentration and thereby we hope that it will help to enhance the total street coverage with in the budget.

2. PERSPECTIVE OF SOLARENERGY

The annual demand of energy of the country is 13% as per government's estimation of 7%. In Bangladesh the average demand of electricity was 5660MW and generation 5500MW and average load shedding 160MW on January01, 2014 [2][3]. Around 60% people can have access to the electricity. The geographical placement of Bangladesh is very important for solar radiation. As NASA Surface meteorology and Solar Energy RET Screen Data imply that, Bangladesh got a great future in the field of solar energy generation. Figure 1 unfolds the data of daily solar radiation of Dhaka city [4].

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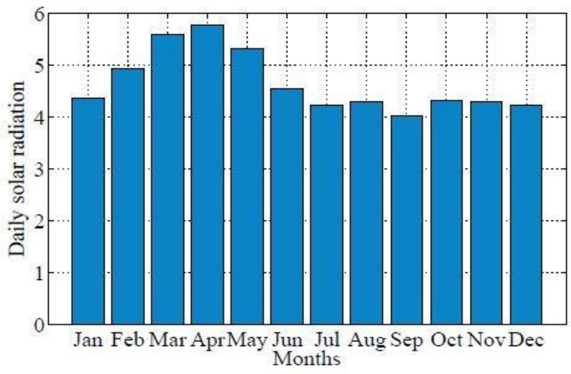

Figure: 1 Bar plot of daily solar radiation data[4]

As can be seen from the graph at the left, recent solar module prices have experienced a dramatic price reduction. From 2006 to 2012, a six year span, worldwide average module prices have dropped about 75% from $3.25 per watt to about$.80 per watt, an incredible drop. [5]

The main reason of dropping crystalline silicon module prices so much was because of the raw material polysilicon price, which makes up a very significant part of the total cost, dropped so tremendously. Back in 2007 there was a worldwide polysilicon shortage and prices increased to about$400/kg. Polysilicon supplier's profited lot of money along with the added tons of capacity so that there was a huge polysilicon capacity oversupply by 2010. Over a three year period from 2008 to 2011, polysilicon prices dropped from about $400 per kilogramto$25/kg. There continues to be a major overhang of polysilicon supply which is expected to continue for several more years.

In addition to the polysilicon issue, the decline is also being driven by a) the increasing efficiency of solar cells (ratio of electrical energy produced to sunshine energy) b) dramatic manufacturing technology improvements, c) economies of scale and d) intense competition which lead to module oversupply. The incredible solar growth rate of 55% per year over the last 5 years allowed manufacturing efficiencies that

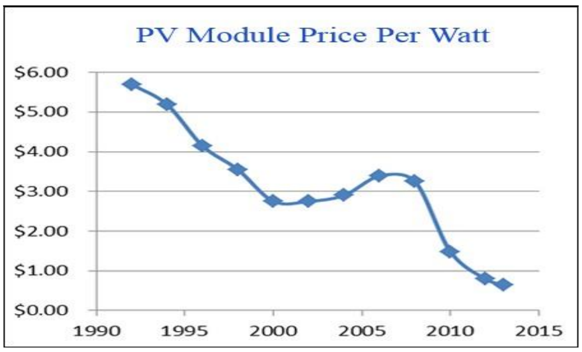

Figure: 2 PV module price per watt[5]

are unheard of in other industries. In addition, there are way too many competitors jousting for major contracts which are also driving prices down precipitously.

3. METHODOLOGY

A. Theory

There are parameters that related to solar cell. Those are open circuit voltage (Voc), short circuit current (Is), maximum power point (MPP), efficiency of solar cell (η) and fill factor (FF). Increase in the intensity of light falling on the panel increase both open circuit voltage & short circuit current of the solar cell. This is given by the formula:

$$V_{oc} = \left(\frac{nKT}{q}\right)\ln\left(\frac{I}{I_s}+1\right)$$

B. Hardware part

a. System programming*:* The micro controller used in this circuit is PIC16F73 and is ready for ADC converter. The PIC16F73 features are 192 bytes of ROM data memory, self-programming, 28-pin count and features 8 channels for the 8- bit Analog-to-Digital (A/D) converter an, operating voltage range 2 to 5.5volt.

Light sensor: In the system for sensing sun light uses the cadmium sulfide (CdS) photocell. This is the least expensive and least complex component. The resistance of CdS photo cell is inversely proportional to the light intensity. It means with increasing the light intensity the resistance of the photocell is getting decrease &vice versa. Figure 3 illustrates the photo cell circuit.

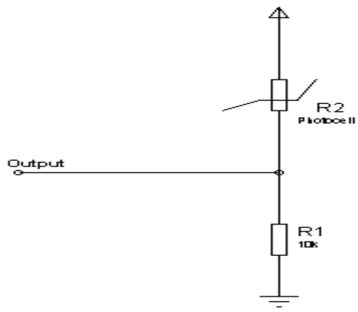

Figure: 3 Cds photocell circuit

b. Light Emitting Diode*:* A light-emitting diode (LED) is basically a two-lead semiconductor light source. It has a pn-junction diode. It illuminates light when activated. When a fitting voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons that's called electro luminescence. An LED is often small in area and integrated optical components may be used to shape its radiation pattern.

c. IRLED*:* It's widely known as IR transmitter, it's mainly used for the transmission of is a special purpose infrared rays within the range of 760 nm wavelength. This can be two types gallium arsenide & aluminum gallium arsenide.

C. Block Diagram

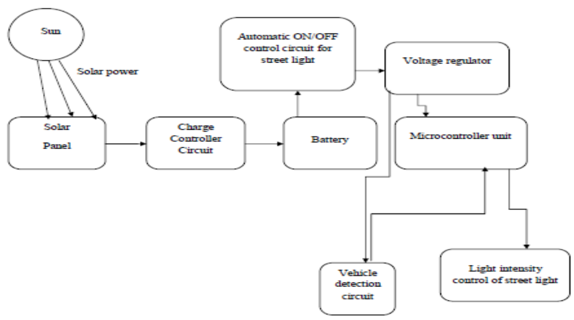

Figure: 4 Solar Powered Vehicle Detect Auto Intensity Controlled

D. Street Lighting System

Here we see the solar power at first fall into a solar panel. Then it generates a voltage which is higher than the batteries rated voltage. The V_{max} of a solar panel is lower than the open circuit voltage of a solar panel. Because the V_{max} must be the 7or 8% of the open circuit voltage. So if we charge the battery under this condition the battery may be damage or reduce the life time. That's why we use a charge controller circuit which is connected with both the solar panel and the battery. It helps us to charge the battery in a minimum rated which is tolerable by the battery. Then the charge storages in a battery. At night the street lights are turn on automatically by the auto on off circuit using LDR by sensing the day or night light. A charge controller, or charge regulator is basically a voltage and/or current regulator to keep batteries from overcharging. It regulates the voltage and current coming from the solar panels by a voltage regulator we regulate the voltage for the IR sensor and the microcontroller which is 5V fixed. When LDR automatically get on the street light then the IR sensor also automatically in progress. When it sensing a vehicles movement then the intensity of the lights of the street are increased. For controlling the intensity we use a microcontroller unit. The PWM (Pulse Width Modulation) pin of the micro controller are used for the output.

E. Charge Controller

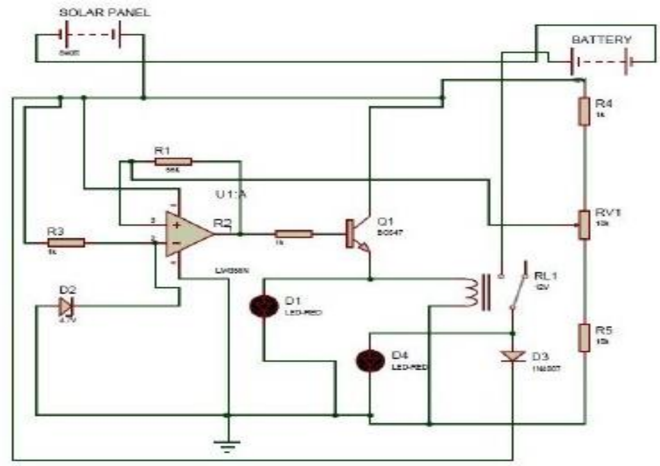

Figure: 5 Charge controller circuit diagram

The circuit above shown is the charge controller circuit of our project.

F. Automatic ON-OFF Controlling Circuit Using LDR

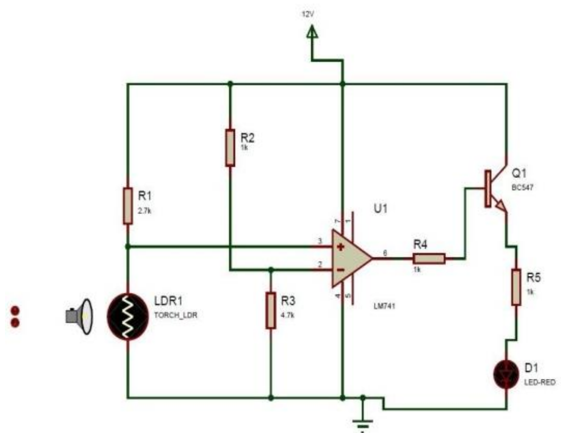

Figure: 6 Automatic ON-OFF control circuit diagram

The circuit above shown is the automatic on-off control circuit of our proposed design.

G. **Light Controller Circuit**

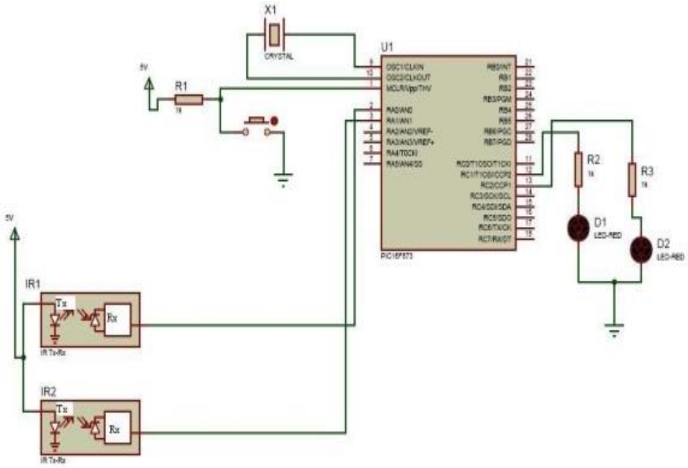

Figure: 8 Light controller circuit diagram using microcontroller

This circuit shown the working procedure of light controller circuit. All this simulation has performed on the proteus (VSM7.1 SP4) software.

4. COST & RESULTANALYSIS

Table: 1 High Pressure Sodium Lamp Street Lamp Expenses Cost [6]

Component	Quantity	Price in BDT	Total amount (BDT)
200 Watt (W) high pressure sodium vapor lamps	1000	1090	10,90,000
Light Pole	1000	7,500	75,00,000
Transformer	1	3,00,000	3,00,000
Cable	30,000 m	35 x 3.28 x 30,000	34,44,000
Labor cost	1000	5000	50,00,000
Installation charge	1000	2200 x 1000	22,00,000
Miscellaneous cost	2000	2000 x 1000	20,00,000
Initial investment cost			2,15,34,000

Table: 2 Solar LED Street Light Expenses [7]

Components	Quantity	Price in BDT	Total amount (BDT)
100 Wp solar PV panel	1000	9500	95,00,000
Led lamp 40 w	1000	4400	44,00,000
150 Ah, 12 volts	1000	18000	1,80,00,000
Charge controller	1000	5000	50,00,000
Pole	1000	12000	1,20,00,000
Lamp bracket	1000	1500	15,00,000
Battery box	1000	700	7,00,000
Labor cost	1000	1000	10,00,000
Installation charge	1000	2200	22,00,000
Miscellaneous cost	1000	2000	20,00,000
Initial investment cost			5,63,00,000

The operation and maintenance cost is considered 10% and for solar system it is 5% of the total capital cost .

Conclusion

Our designed solar powered traffic sensitive automated outdoor LED lighting system is efficient in several aspects like: power saving, in traffic sensing system etc. Base on the comparative studies on several lighting system, the solar base LED lighting arrangement not only makes this system further energy efficient but also makes this cost effective &reliable. In our system we also integrate the auto bright and dim technique, that's makes our system more operative & identical than the traditional street lighting system in Chittagong City Corporation. In Bangladesh, such detailed practical implementation is a first and further improvement can certainly enhance its efficiency and performance in the future.

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