Power Saving Solar Street lights

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Abstract –This project is based on the idea of maintaining maximum utilization and minimum loss of available energy. The plenty of solar energy available during the day time is stored in a solar cell and the stored energy is used to glow the street lights during the whole night. Also the system provides a power saving mode of operation by adapting the method of automation. A dark sensor and a light sensor provides the automatic "ON"/"OFF" facility to the street lights, so that it will glow automatically when it is required(i.e. when the surrounding will be dark) and it will be turned "OFF" automatically if sufficient light is available in the surrounding. Again the auto intensity control mechanism has been applied by the help of a microcontroller to control the light intensity of the luminaries as per the requirement. Hence the loss of energy due to unnecessary glow of the street lights can be avoided.

Index Terms – PV module, DS1307, intelligent Street light, LDR (Light depending Resistor), IR Sensor (Infra red Sensor).

1. INTRODUCTION

The gradually growing requirement of energy and the limited resource of traditional energy sources has become a challenge for both developed and developing countries. For this reason, in policy makers' agenda, energy efficiency and sustainability are given the first priority for any project to be installed. Solar street lighting system is an effective way to reduce power consumption and CO2 impact on the environment with the maintenance of the safety standards of the road. Electric street lighting consumes 114 TW h annually, leading to the emission of 69 million tones of CO2 [1]. By PV (Photovoltaic) effect the solar radiation can be directly converted into electrical energy. This energy is stored in a rechargeable battery and supplied to the luminary when it is required to glow. The system is designed to provide an automatic control facility. This control may be of three types. First one is optical control method, by using light/dark sensor the street lights can be automatically turn "ON" in the evening after dark, turn "OFF" automatically after dawn in the morning, but the night street lighting is too bright and also a wastage of energy [2]. Second one is time control method, in which the light will be glow time to time automatically as per the adjustment [3] and the third one is time-optical control, in which the lights will glow automatically from time to time with automatically controlled intensity[4]. Thus the unnecessary power wastage is reduced up to a large extent.

Figure 1 Stand alone Solar streetlight

2. POWER SAVING FEATURES OF AUTOMATIC SOLAR STREET LIGHT

The solar street light has been designed after too much research work. Its uniqueness and best features can make it the most preferable choice in rural area. With gradual development in this research, new features are being added to increase the efficiency. The proposed model may be considered as the third generation of street light which is also known as intelligent street light. The intelligent street light control system uses the latest international intelligent street light energy-saving control technology [5]. The main aim behind the research of designing the system is to find a way for maximum utilization of available energy with minimum

wastage or loss. To achieve this, the methodologies adapted in such a manner and each and every circuit component is so chosen that the available energy utilization is optimized as per the expectation. The main features of a solar street light those provide the power saving facility are-

- Use of solar energy
- Automatic "ON/OFF" mechanism
- Auto intensity control
- LED Luminary

A brief discussion about each of the above is given below.

2.1. Use of Solar Energy

Photovoltaic (PV) is the method of generating electrical energy from solar radiation. Photovoltaic energy generation involves a PV module which is constructed from the semiconductor material showing photovoltaic effect. These modules become more and more attractive for obtaining "green" electricity because of their flexibility, ease of installation, constant reduction of production costs, and continuous increase of performance[6],[7].

Solar radiation is the most important and major renewable energy source. During the whole day plenty of solar energy is radiating being unused. If this energy can be stored in a battery in form of electrical energy by using these PV modules and later can be used to run the electrical appliances (such as street light) then no doubt this is the best utilization of the available solar energy.

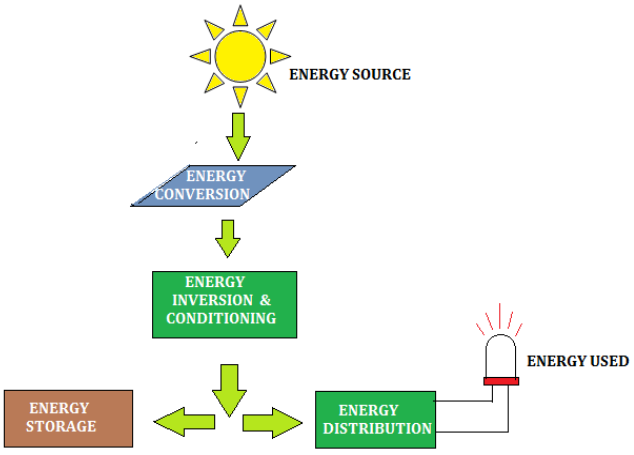

Figure 2 Flow of Energy in a Solar PV System

The above diagram represents the entire energy flow process carried out within a solar street light system. Energy conversion is done by the PV panel. During the day time the solar PV module absorbs the solar radiation of high intensity to convert it into electrical energy. Energy inversion and conditioning is done to achieve the requirement of the load. The direct current coming from the solar panel can be used to charge the battery or to drive any DC load but if there is any AC load is to be driven then an inverter is used to supply AC. The energy storage indicates the battery backup. The light energy converted into electrical energy by the PV module is stored in a battery and supplied to the load when it is needed. When the stored energy in the battery will be used to drive a load, obviously it will be discharged, but again it can be charged by solar energy which is available free of cost. No need of supplying electricity. Hence electricity is saved, solar energy is utilized properly and the maintenance cost is reduced.

2.2. Automatic ON/OFF Mechanism

The street lights should be illuminating when there is darkness & in presence of day light these should remain off. In case of manually operated street lights, people can realize easily when to turn it "ON" as soon as the darkness spreads from the evening, but usually they forget to turn it "OFF" even if the day light rises sufficiently. No doubt, this is the unnecessary wastage of power. So the best solution to this problem is automation.

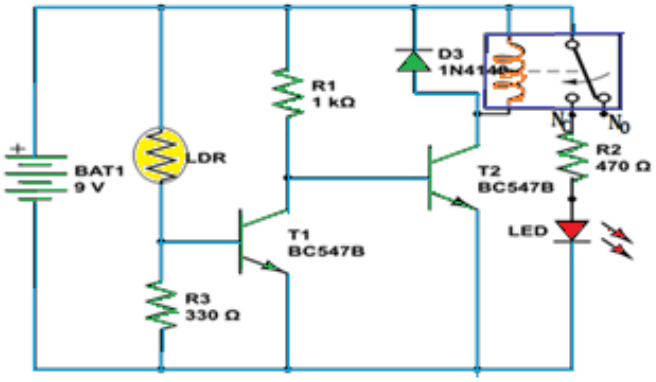

Figure 3 Automatic switching circuit

The above diagram represents the automatic switching circuit. Initially, the relay switch connects to N0. The two transistors T1 and T2 are in bistable state; means when one of them is in "ON" state the other will be "OFF". During the day time when the solar light of sufficient intensity falls on the LDR, its resistance falls down and it provides a conducting path for the incoming current. This current enters to the base of T1, making the base-emitter junction forward bias. So no current flows through the coil. As the relay switch is open, no current will pass through LED. So the LED will not glow.

Gradually, when the intensity of the sun light decreases the resistance of the LDR increases. So during the night time no current will pass through the LDR, hence transistor T1 will be "OFF". So the circuit current will pass through the coil and also some current will flow through the transistor T2, so it

will be “ON”. When current passes through the coil, magnetic flux is generated that attracts the relay switch and the switch connects to Nc . Hence the LED will glow.

Thus the above circuit provides automatic switching scheme to the solar light.

2.3. Auto Intensity Control

It is not necessary for the lights to glow with same intensity all the time. The lights to glow in a high intensity also consume more energy than a light glowing with a relatively lower intensity. So by controlling the intensity some more saving of energy is achieved. This auto-intensity control mechanism is achieved by using microcontroller.

In the purposed model, the street light controls its intensity automatically according to intensity of the surrounding light. For example in evening as the intensity of light starts decreasing, the street light starts increasing its intensity. When there is no intensity of light after evening, street lights remain “ON” with full intensity till midnight at 12:00 am. DS1307 is use to keep information of time during day and night. So real time clock DS1307 is interfaced with microcontroller to keep information of real time.

After 12.00 am, the operation of the street light is controlled by the vehicles passing on the road. Means, the lights will remain of and will turn “ON” only when any vehicle will pass on the road. This is done by using an Infra red sensor.

An infra red sensor is analogous to human visionary sense. In this project, the IR sensors have been used to detect the movement in the street. In this device, emitter and receiver are in one unit. When light from the emitter strikes the target and the reflected light is diffused from the surface at all angles then if the receiver receives enough reflected light, the output will switch states. When no light is reflected back to the receiver the output returns to its original state.

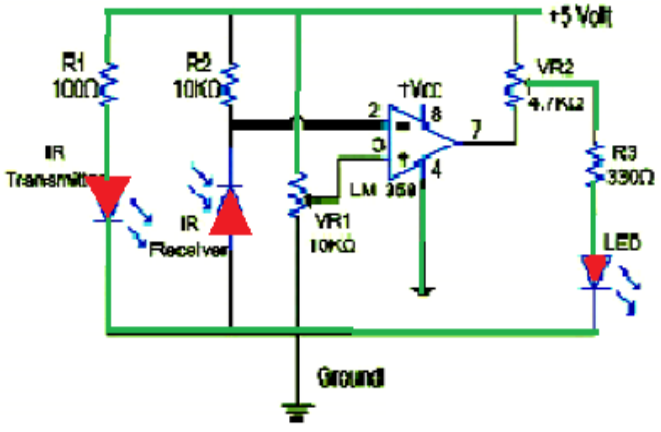

Figure 4 Circuit Diagram of IR Sensor

2.4. LED Luminary

An LED (Light Emitting diode) comprises of a chemical compound which radiates light of visible range when direct current (DC) from the battery passes through it. The life time of LED is usually up to 50,000 hour. LED provides much higher lumens with lower energy consumption. As compared

to the HPS (High Pressure Sodium) fixture used in traditional street lights, the energy consumption of an LED fixture is at least 50% lower. Also wastage of energy in form of heat is negligible in case of LED. Hence the lamp used here also saves up to 50% of energy as compared to the traditional street lights.

3. PORPOSED MODELLING

The arrangement of all the system components are shown in the block diagram in figure 5.The whole day, sun light falls on the solar panel which consists of PV modules. The solar panel converts it into electrical energy which is stored in the battery. The current produced by the PV module flows through a charge controller circuit before charging the battery. The charge controller is used to prevent overcharging and to protect the battery from overvoltage which could reduce the battery life. The streetlights are equipped with a light sensor and a road-user sensor [8],[9]. The light/dark sensor is used to detect the surrounding light intensity and send the information to the microcontroller, so that it can decide whether the street lights should be turned “ON” or “OFF”. Another sensor here used is an IR sensor which can also be called as vehicle detector or road-user sensor. This sensor is activated for particular time duration (i.e. after 12:00am to

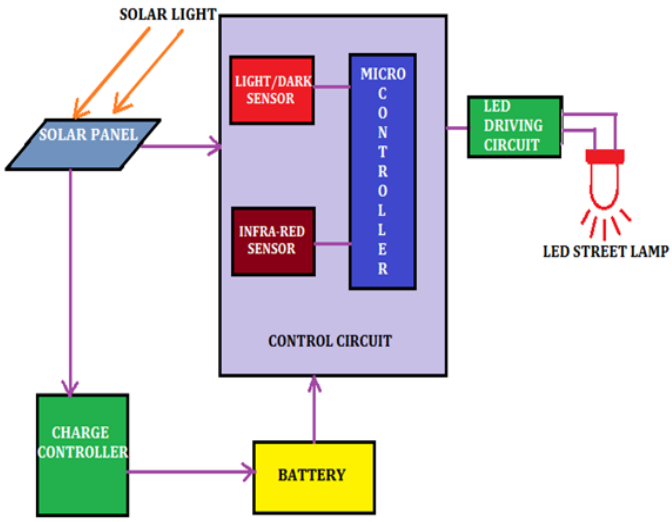

Figure 5 Block Diagram of Auto intensity control Solar Streetlight

5:00am for this case). After 12:00am, when the street light turns "OFF", the IR sensor gets activated as per the timer setting. When any vehicle or person comes along the road, then it detects the presence of an object and sends the information to the microcontroller; then as per the command send by the microcontroller the lights turn "ON". Then after the object passes the road, the lights again turns "OFF" automatically.

The detection range of the sensor node is assumed to be 13m [9]. Each Street light has its own sensor to detect the moving object. Before the object reaches the light it turns "ON" by sensing the coming object. Then after the moving object crosses the light and move on forward, the light turns "OFF" by gradual dimming intensity and the next light's sensor starts its operation.

Figure 6 Location of the IR Sensor

4. RESULTS AND DISCUSSIONS

Providing street lighting is one of the most important and expensive responsibilities of a city. Lighting can account for 10–38% of the total energy bill in typical cities worldwide. The energy demanded for various schemes of street lights can be evaluated by the following equation-

$$e(N) = \sum_{n=0}^{N} P_{\max} \varphi T \; . \qquad \text{.....(1) [10]}$$

Where, e(N)= Energy consumed by the street light

N= Discrete time steps

Φ= luminance output of the street light

P_{max}= Maximum power rating of the light source

T= Duration of single time step n

From the above equation(1), it can be clearly detected that the energy consumed by the street light is directly proportional to its luminance output and also it is directly proportional to the time duration of illumination. As in the proposed model a strong emphasis has been done on the control of these two factors, hence our model can meet the expectation of optimum energy saving.

Compared with other control systems, it has better application prospects, especially easy to integrate itself with wind/photovoltaic-LED/fuel cell/solar energy system [11],[12].

5. CONCLUSION

So far from the discussion, the effectiveness of the proposed street light model can be considered as a best proposal from energy saving point of view. It is not only the way to save energy but also an idea to make a proper utilization of available solar energy which is radiating everyday without being used. Though the initial investment is very high, still it can be considered as to be economic if we will think about a long term period, because we are using here the solar energy, which is available free of cost. Hence after the installation no more payment is to be given regarding electricity. Also the automatic solar street light system is completely Noiseless, Smoke-free and free from fire hazards. Hence it will not only save the electricity bill but also will illuminate the path in an eco-friendly way.

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