Automatic Solar Street Light Using Arduino

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Abstract— **This paper suggests energy efficient of automatic street light by using Arduino. The main objective is to design energy efficient automatic streetlight for energy conversation in present streetlights of rural area, urban area and completely for smart cities. The system LED, solar panel, charge controller, Battery, Arduino. The system is set to automatically turn OFF during the hours of daylight and only operate during the night.**

1.INTRODUCTION

The solar street lights absorb the solar energy during daytime. The solar energy gets converted into electrical energy by the photovoltaic cells, which is stored in the battery. During night-time the lamp starts automatically and the electricity already stored in the battery gets consumed. The system is to design and provide an automatic control facility. Street light controllers are smarter versions of the mechanical or electronic timers previously used for street light on-off operation.

By using this system Energy consumption is also reduced because now-a-days the manually operated street lights are not switched off properly even the sunlight comes and also not switched on after sunset.

1.1 BLOCK DIAGRAM:

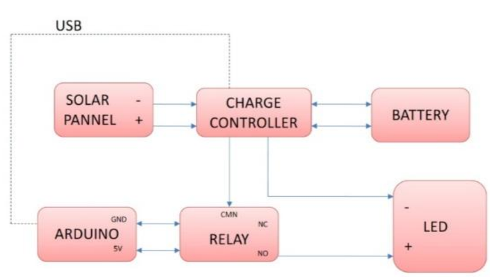

Fig.1.1 Block diagram

2. SOLAR PANEL

Solar panel is one of the most important parts of solar street lights, as solar panel will convert solar energy into electricity. There are 2 types of solar panel: monocrystalline and poly-crystalline. Conversion rate of monocrystalline solar panel is much higher than polycrystalline.

Fig2.1Solar panel

3.ARDUINO

Arduino is an open-source platform based on microcontroller board having the ATmega32 series controllers and Integrated Development Environment for writing and uploading codes to the microcontroller. It has input and output pins for interaction with the outside world such as with sensors, Switches, Motors and so on. To be precise it has 14 digital input/output pins, 6 analog inputs, a 16MHz quartz crystal, a USB connection, a power jack, an ISCP header and a reset button It contains everything needed to support the microcontroller. It can take supply through USB or we can power it with an AC-to-DC adaptor or a battery. It takes inputs from the LDR, process the data and gives the output to LEDS directly or through a relay and a transistor mechanism.

The Uno differs from all preceding boards in that it does not use the FTDI USB to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. Uno board has a resistor pulling the SU2 HWB line to ground, making it easier to put into DFU mode.

3.1FEATURES OF ARDUINO:

5v pin may supply less than five volts and the board may be unstable. If using more than 12v, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The input voltage to the Arduino board when it using an external regulated power source You can supply the voltage through this pin or if supplying voltage via the power jack, access it through this pin.

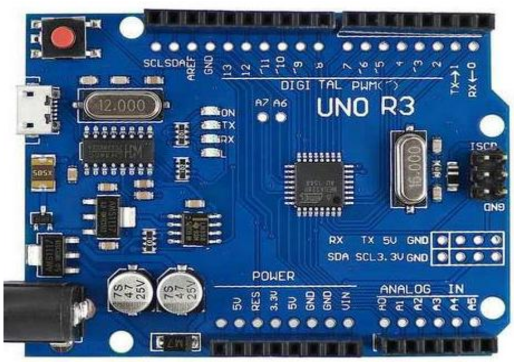

Fig3.1 Arduino UNO

4.RELAY

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combinations thereof.

Fig.4 Relay.

Every electromechanical relay consists of

1. Electromagnet.
2. Mechanically movable contact.
3. Switching points.
4. Spring.

5.SOLAR CHARGE CONTROLLER

A charge controller or alternatively a 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 and going to the battery. Most “12 volt” panels produce about 16 to 20 volts, so if there is no regulation, the batteries will be damaged from overcharging. The obvious question then comes up – “why aren’t panels just made to put out 12 volts?” The reason is that if you do that, the panels will provide power only when cool, under perfect conditions and full sun. This is not something you can count on in most places. The panels need to provide some extra voltage so that when the sunlight is low in the sky, or you have heavy haze, cloud cover, or high temperatures, you still get some output from the panel, so the panel has to put out at least 12.7volts.Under worst case conditions. The primary function of a charge controller is to maintain the battery at highest possible state of charge. The charge controller protects the battery from overcharge and disconnects the load to prevent deep discharge. Ideally, charge controller directly controls the state of the battery. The controller checks the state of charge on the battery between pulses and adjusts itself each time. This technique allows the current to be effectively “tapered” and the result is equivalent to “constant voltage” charging.

5.1 Types of Solar Charge Controllers:

The two types of charge controllers most commonly used in today’s solar power systems are

- Pulse width modulation (PWM) and
- Maximum power point tracking (MPPT).

5.1.1 Pulse Width Modulation (PWM) Charge Controller:

Pulse width modulation (PWM) charge controller is the most effective means to achieve constant voltage battery charging by adjusting the duty ratio of the switches (MOSFET). In PWM charge controller, the current from the solar panel tapers according to the battery's condition and recharging needs. When a battery voltage reaches the regulation set point, the PWM algorithm slowly reduces the charging current to avoid heating and gassing of the battery; yet charging continues to return the maximum amount of energy to the battery in the shortest time. The voltage of the array will be pulled down to near that of the battery. A PWM controller is not a DC to DC transformer. The PWM controller is a switch which connects the solar panel to the battery.

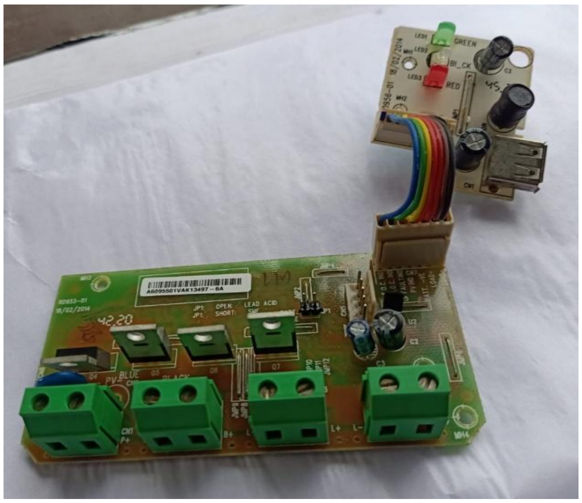

Fig5.1.1 PWM Charge controller

When the switch is closed, the panel and the battery will be at nearly the same voltage. Assuming a discharged battery, the initial charge voltage will be around 13V, and assuming a voltage loss of 0.5V over the cabling plus controller, the panel will be at Vpwm = 13.5V. The voltage will slowly increase with increasing state of charge of the battery. When absorption voltage is reached, the PWM controller will start to disconnect and reconnect the panel to prevent overcharge (hence the name; pulse width modulated charge controller).

5.1.2Maximum Power Point Tracking (MPPT) Charge Controller:

Nowadays, the most advanced solar charge controller available is the Maximum Power Point Tracking (MPPT). It is more sophisticated and more expensive. It has several advantages over the PWM charge controller. It is 30 to 40% more efficient at low temperature. The MPPT is based around a synchronous buck converter circuit. It steps the higher solar panel voltage down to the charging voltage of the battery. It will adjust its input voltage to harvest the maximum power from the solar panel and then transform this power to supply the varying voltage requirement of the battery plus load. It is generally accepted that MPPT will outperform PWM in a cold temperature climate, while both controllers will show approximately the same performance in a subtropical to tropical climate. The MPPT charge controller is a DC to DC transformer that can transform power from a higher voltage to power at a lower voltage. The amount of power does not change, therefore, if the output voltage is lower than the input voltage, the output current will be higher than the input current, so that the product P=VI remains constant. Hence, in order to get the maximum out of a solar panel, a charge controller should be able to choose the optimum current-voltage point on the current voltage curve: the Maximum Power Point.

6. LED

Light Emitting Diodes (LEDs):

Light Emitting Diodes (LEDs) are semiconductors p-n junction operating under proper forward biased conditions and are capable of emitting external spontaneous radiations in the visible range (370 nm to 770 nm) or the nearby ultraviolet and infrared regions of the electromagnetic spectrum.

6.1 General Structure:

LEDs are special diodes that emit light when connected in a circuit. They are frequently used as "pilot light" in electronic appliances in to indicate whether the circuit is closed or not.

The structure and circuit symbol. The two wires extending below the LED epoxy enclose or the "bulb" indicate how the LED should be connected into a circuit or not.

- The negative side of the LED is indicated in two ways (1) by the flat side of the bulb and (2) by the shorter of the two wires extending from the LED.
- The negative lead should be connected to the negative terminal of a battery. LEDs operate at relative low voltage between 1 and 4 volts, and draw current between 10 and 40 milliamperes. Voltages and current substantially above these values can melt a LED chip.

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Fig.6.1LED

- The most important part of a light emitting diode (LED) is the semiconductor chip located in the centre of the bulb and is attached to the top of the anvil. The chip has two regions separated by a junction. The p region is dominated by positive electric charges, and the n-region is dominated by negative electric charges. The junction acts as a barrier to the flow of electrons between the p and n-regions. Only when sufficient voltage is applied to the semi-conductor chip, can the current flow and the electrons cross the junction into the p-region. In the absence of large enough electric potential difference (voltage) across the LED leads, the junction presents an electric potential barrier to flow of electrons.

7. BATTERY

A storage cell is the one, which can operate both as a voltaic cell and as an electrolytic cell. When it acts as a voltaic cell, it supplies electrical energy and becomes "run down". When it is recharged, the cell operates as an electrolytic cell. Description A lead - acid storage battery consists of a number of (3 to 6) voltaic cells connected in series to get 6 to 12 V battery. In each cell, the anode is made of lead. The cathode is made of lead dioxide PbO_2 or a grid made of lead, packed with PbO_2. A number of lead plates (anodes) are connected in parallel and a number of PbO_2 plates(cathodes) are also connected in parallel. Various plates are separated from the adjacent ones by insulators like rubber or glass fiber. The entire combinations is then immersed in dil. H_2SO_4 (38% by mass) having a density of 1.30gm/ml.

Fig.7 Battery

7.1 Working (Discharging):

When the lead - acid storage battery operates, at the anode lead is oxidized to Pb^{2+} ions and insoluble $PbSO_4$ is formed. At the cathode PbO_2 is reduced to Pb^{2+} ions and $PbSO_4$ is formed. Cell reactions: At anode: Lead is oxidized to Pb^{2+} ions, which further combines with forms insoluble $PbSO_4$. Overall anode Reaction: At cathode: PbO_2 gains electrons ie.Pb undergoes reduction at the cathode from +4 to +2. The Pb^{2+} ions then combines with ions forms insoluble $PbSO_4$. Overall Cathode Reaction Overall cell reaction during use (discharging) At anode: At cathode: Overall cell reaction: From the above cell reaction it is clear that,

$PbSO_4$ is precipitated at both the electrodes and H_2SO_4 is used up. As a result, the concentration of H_2SO_4 decreases and hence the density of H_2SO_4 falls below 1.2gm/ml. So the battery needs recharging. Recharging the battery the cell can be charged.

8.WORKING

The basic operation of solar street lights is that it automatically turns on and off at a specified parameter set into its controller that controls the circuit. When dusk arrives, the voltage decreases to approximately 5V. This signals the LED lamp to switch on and use the electrical.

Solar lights work on the principle of photovoltaic effect. Solar panels absorb sunlight with the help of solar cells and convert this solar energy into direct electrical current which is stored into solar batteries via a charge controller for later use.

Fig.8 solar street light

Photo voltaic solar cells convert the radiation of sun light into electrical energy. The received electrical energy is stored in batteries through charge controller. Charge controllers are generally used to protect the battery. The circuit is made automatic by using Arduino which creates the required time delay, which helps in turning off the light in day time and turn on in night time.

If the days have been cloudy, most of the time, it is unlikely that the solar cells have charged themselves abundantly. This will mean weak electricity production from these batteries, which in turn, will imply that the lights will not sustain through the night. However, if the sky becomes overcast suddenly, the photoreceptors will kick in to switch on the lights.

9.CONCLUSION

The paper describes an automatic solar panel based LED street lighting system; it integrates latest technology such as LED technology and Renewable Energy Source in order to reduce power consumption, cost and manual controlling method. 20-25% of power consumption and maintenance cost is reduced through this prototype. This street lighting system is appropriate for rural and urban areas. The designed system is flexible, extendable and fully adjustable to user needs.

The proposed streetlight automation system is a cost effective and the safest way to reduce power consumption. It helps us to get rid of today's world problems of manual switching and most importantly, primary cost and maintenance can be decreased easily. The LED consumes less energy with cool-white light emission and has a better life than high energy consuming lamps. Moving to the new & renewable energy sources, this system can be upgraded by replacing conventional LED modules with the solar-based LED modules. With these efficient reasons, this presented work has more advantages which can overcome the present limitations. Keep in mind that these long-term benefits; the starting cost would never be a problem because the return time of investment is very less. This system can be easily implemented in street lights, smart cities, home automation, agriculture field monitoring, timely automated lights, parking lights of hospitals, malls, airport, universities and industries etc.

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